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DOE/WIPP-15-8866

Waste Isolation Pilot Plant Annual Site Environmental Report for 2014 - EMENDED

U.S. Department of Energy

September 2015

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2014 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2014 presents summary environmental data to (1) characterize site environmental management performance; (2) summarize environmental occurrences and responses reported during the calendar year; (3) confirm compliance with environmental standards and requirements; and (4) highlight the WIPP Environmental Management System (EMS), significant environmental programs, and accomplishments, including progress toward U.S. Department of Energy (DOE) Environmental Sustainability Goals.

It is important that the information we provide is easily understood, of interest, and communicates WIPP's efforts to protect human health and minimize our impact on the environment. We would like to know from you whether we are successful in achieving these goals. Your comments are appreciated and will help us to improve our communications.

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ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

AIB	Accident Investigation Board
Am	americium
ANOVA	analysis of variance
AO	Administrative Order
ASER	Annual Site Environmental Report
BLM	U.S. Department of the Interior, Bureau of Land Management
Bq	becquerel(s)
Bq/g	becquerels per gram
Bq/m^3	becquerels per cubic meter
Bq/sample	becquerels per composite air filter sample
CAP	Corrective Action Plan
CBFO	Carlsbad Field Office
C&D	construction and demolition
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	Code of Federal Regulations
cm	centimeter
Co	cobalt
Cs	cesium
CY	calendar year
DMP	Detection Monitoring Program
DOE	U.S. Department of Energy
DP	discharge permit
EDE	effective dose equivalent
EMS	Environmental Management System
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ft	foot or feet
ft^2/d	square feet per day
ft^3	cubic feet
FY	fiscal year
g/mL	gram per milliliter
GPS	global positioning system
HEAL	Hall Environmental Analysis Laboratory
HEPA	high-efficiency particulate air (filter)
in.	inch(es)
ISO	International Organization for Standardization

J	estimated concentration
K	potassium
km	kilometer(s)
km^2	square kilometers
L	liter(s)
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LMP	Land Management Plan
LWA	WIPP *Land Withdrawal Act of 1992 (as amended)*
LWB	Land Withdrawal Boundary
m	meter(s)
m^2	square meters
m^3	cubic meters
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MDL	method detection limit
MEI	maximally exposed individual
mg/L	milligrams per liter
mi	mile(s)
mi^2	square miles
MOC	management and operating contractor
mrem	millirem
MRL	method reporting limit
MS/MSD	matrix spike/matrix spike duplicate
mSv	millisievert(s)
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NRIP	National Institute of Standards and Technology Radiochemistry Intercomparison Program
NWP	Nuclear Waste Partnership LLC
PCB	polychlorinated biphenyl
Permit	WIPP Hazardous Waste Facility Permit
pH	measure of the acidity or alkalinity of a solution
Pu	plutonium
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control

rem	roentgen equivalent man
RER	relative error ratio
RLCS	reagent laboratory control sample
RPD	relative percent difference
SERC	State Emergency Response Commission
SNL	Sandia National Laboratories
SOO	samples of opportunity
SOP	standard operating procedure
SOW	statement of work
Sr	strontium
SSW	shallow subsurface water
Sv	sievert
SVOC	semivolatile organic compound
TAT	Technical Assessment Team
TDS	total dissolved solids
TOC	total organic carbon
TPU	total propagated uncertainty
TRU	transuranic
TSS	total suspended solids
U	uranium
U.S.	United States
U.S.C.	United States Code
UST	underground storage tank
UTLV	upper tolerance limit value
VOC	volatile organic compound
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant

SYMBOLS

˚C	degrees Celsius
˚F	degrees Fahrenheit
>	greater than
<	less than
≤	less than or equal to
µg	microgram
µg/L	microgram per liter
µm	micrometer or micron
µmhos	micromhos
%	percent
±	plus or minus
[RN]	radionuclide concentration
σ	sigma

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EXECUTIVE SUMMARY

PURPOSE

The purpose of the Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2014 (ASER) is to provide information required by U.S. Department of Energy (DOE) Order 231.1B, *Environment, Safety, and Health Reporting*. Specifically, the ASER presents summary environmental data to:

- Characterize site environmental management performance.
- Summarize environmental occurrences and responses reported during the calendar year (CY).
- Confirm compliance with environmental standards and requirements.
- Highlight significant environmental accomplishments, including progress toward the DOE environmental sustainability goals made through implementation of the WIPP Environmental Management System (EMS).

The DOE Carlsbad Field Office (CBFO) and the management and operating contractor (MOC) maintain and preserve the environmental resources at the WIPP facility. DOE Order 231.1B; and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, require that the affected environment at and near DOE facilities be monitored to ensure the safety and health of the public and workers, and preservation of the environment.

This report was prepared in accordance with DOE Order 231.1B, which requires DOE facilities to submit an ASER to the DOE Headquarters Chief Health, Safety, and Security Officer.

WIPP MISSION

The WIPP mission is to safely dispose of transuranic (TRU) waste generated by the production of nuclear weapons and other activities related to the national defense of the United States.

WIPP DISPOSAL FOR 2014

In 2014, only 731 cubic meters (m^3) of TRU waste was disposed of at the WIPP facility, due to operational inactivity resulting from two repository events in February 2014. From the first receipt of waste in March 1999 through the end of 2014, 90,983 m^3 of TRU waste has been disposed of at the WIPP facility.

FIRE AND RADIOLOGICAL RELEASE EVENTS

On February 5, 2014, a fire involving a salt haul truck occurred in the underground of the WIPP facility and on February 14, 2014, an incident in the underground repository occurred which resulted in the release of americium and plutonium from one TRU waste container into the underground mine and the ambient atmosphere within the facility boundary. Since the February 5 event, shipments of waste to the WIPP facility have been suspended and the project focus has been on (1) determining and addressing the root and contributing causes for the events and (2) establishing and implementing the plan for restoring the underground and resuming TRU waste disposal.

WIPP Environmental Management System

The WIPP EMS is the mechanism through which the WIPP project protects human health and the environment; maintains compliance with applicable environmental laws and regulations; and implements sustainable practices for enhancing environmental management performance. The EMS is described in the *Waste Isolation Pilot Plant Environmental Management System Description* (DOE/WIPP–05–3318). Measuring and monitoring to ensure the project meets these objectives are key elements in the EMS.

Monitoring for Environmental Impacts

The DOE collects data needed to detect and quantify potential impacts that WIPP facility operations may have on the surrounding environment. The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP–99–2194) outlines major environmental monitoring and surveillance activities at the WIPP facility and discusses the WIPP facility quality assurance/quality control (QA/QC) program as it relates to environmental monitoring.

WIPP facility employees conduct both effluent monitoring (i.e., point-source monitoring at release points such as the exhaust shaft) to detect radionuclides and quantify doses, and traditional pathway and receptor monitoring in the broader environment. The WIPP facility Environmental Monitoring Program is designed to monitor pathways that radionuclides and other contaminants could take to reach the environment surrounding the WIPP facility. Pathways monitored include air, groundwater, surface water, soils, sediments, vegetation, and game animals. The goal of this monitoring is to determine if the local ecosystem has been, or is being, adversely impacted by WIPP facility operations and, if so, to evaluate the geographic extent and the effects on the environment.

In response to the February 14, 2014 event, the environmental monitoring program sampling schedule was modified to collect more frequent samples at routine air sampling locations and to collect periodic (annual and semi-annual) samples as early as possible. In addition, air samplers were added at both the existing sampler locations and at discontinued locations that were previously used during WIPP baseline studies. During CY 2014, subsequent to a single positive air sample detection during the actual

event, none of the environmental sampling of air, water, soil, or biota was found to be above background for radioactivity originating at WIPP.

The *Waste Isolation Pilot Plant Land Management Plan* (DOE/WIPP–93–004) (LMP) identifies resource values, promotes multiple-use management, and identifies long-term goals for the management of WIPP project lands. The LMP includes a land reclamation program that addresses both the short-term and long-term effects of WIPP facility operations and includes monitoring for environmental impacts. WIPP environmental personnel also conduct surveillances in the region surrounding the site to protect WIPP facilities and land from inadvertent use.

The monitoring and surveillance programs implemented at the WIPP facility are listed below:

Environmental Radiological Monitoring Programs

- Effluent
- Airborne particulates
- Groundwater
- Surface water
- Sediments
- Soil
- Biota

Environmental Non-radiological Monitoring Programs

- Hydrogen and methane monitoring
- Land management
- Liquid effluent
- Meteorology
- Seismic activity
- Volatile organic compound (VOC) monitoring

Groundwater Protection Monitoring Programs

- Groundwater levels
- Groundwater quality
- Fluid density surveys
- Shallow subsurface water (SSW) levels
- SSW quality

In 2014, results of these programs, including observations and analytical data, demonstrated that (1) compliance with applicable environmental requirements was maintained, and (2) the operations at the WIPP facility have not had a negative impact on human health or the environment.

Environmental Compliance

The owner and operator(s) of the WIPP facility are required to comply with applicable federal and state laws, DOE orders and New Mexico Environment Department (NMED) Administrative Orders (AOs). In order to accomplish and document this compliance, the following documents were among those completed and submitted in 2014:

New Mexico Submittals

- WIPP Hazardous Waste Facility Permit (Permit)
  - Semiannual VOC, Hydrogen, and Methane Data Summary Reports
  - Mine Ventilation Rate Monitoring Report
  - Biennial Hazardous Waste Report
  - Waste Minimization Statement
  - Annual WIPP Culebra Groundwater Report
  - Semiannual Groundwater Surface Elevation Report
  - Geotechnical Analysis Report
  - Periodic (weekly, biweekly, monthly) reports required under NMED AOs Dated February 27, 2014 and May 12, 2014
  - Report of Implementation of the WIPP Facility RCRA Contingency Plan and first and second supplements to the plan
- Discharge Permit (DP–831)
  - Semiannual Discharge Monitoring Reports
- *Superfund Amendments and Reauthorization Act of 1986*
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report

U.S. Environmental Protection Agency (EPA) Submittals

- Delaware Basin Monitoring Annual Report
- 2014 Annual Polychlorinated Biphenyls Report
- WIPP Subsidence Monument Leveling Survey
- 2013/2014 Annual Change Report
- 2014 Compliance Recertification Application
- *Superfund Amendments and Reauthorization Act of 1986*
  - Emergency and Hazardous Chemical Inventory Report
  - Toxic Chemical Release Inventory Report

Carlsbad Field Office Submittals

- Delaware Basin Monitoring Annual Report

- WIPP Subsidence Monument Leveling Survey
- Quarterly Change Report

Other correspondence, regulatory submittals, monitoring reports, and the results of the EPA Annual Inspection and other inspections are described in Chapters 2 and 3 of this report.

The DOE maintains an in-depth, integrated evaluation program that consists of audits, assessments, surveillances, and inspections. In CY 2014, more than 135 evaluations were conducted that monitored for compliance with environmental requirements and compliance with the procedures that implement compliance programs. This program, coupled with the WIPP project corrective action programs, helps to identify potential issues and ensures corrective/preventive actions are tracked formally through completion.

The EPA's Radiation Protection Division staff provided on-site staff, process review, and ambient air monitoring in addition to being involved in review of initial off-site dose assessment documentation for the February 2014 airborne radioactive release event. Several improvement opportunities such as standardizing ambient air sampler installation physical characteristics and improving siting locales were noted, and acted upon by WIPP staff during CY 2014. EPA reviews confirmed that the exposure from the February 2014 release was well below the EPA 40 CFR 61 Subpart H regulatory limit of 10 millirem (mrem) annual dose and that the radiological release did not pose a public health or environmental hazard. The EPA review is consistent with the WIPP determination that DOE was in compliance with EPA standards.

In addition, EPA found that DOE's dose modeling and effluent monitoring for demonstrating regulatory compliance with public dose standards remain appropriate for that purpose. However, EPA reviews and inspections showed several areas where response and communications improvements would enhance DOE's ability to provide the best possible information to the public and its partner agencies during a release.

On December 6, 2014, the NMED issued Administrative Compliance Order HWB-14-21 for alleged violations of the Permit related to the February events. At the close of this reporting period, the Permittees had secured approval of an extension to the deadline for filing a response and request for hearing.

Excluding issues associated with the February events and the Compliance Order, the data provided in the required submittals and the evaluation program results confirmed the WIPP project maintained compliance with environmental requirements during 2014.

Sustainable Practices

The WIPP EMS objectives and targets support achievement of DOE sustainability goals. As would be expected, the disruption in routine mission operations has had an impact on environmental performance, including sustainable practices for the WIPP project. However, the project continued to contribute to these goals in 2014. Highlights included the following:

- A printer evaluation was conducted using a Lean Six Sigma process which resulted in the phased replacement of old copiers with networked, multi-function devices capable of scanning and double-sided printing, and curtailed purchase of new desktop printers. This change contributes to energy conservation, waste reduction and more efficient use of Information Technology support resources.
- An evaluation of lighting equipment in the underground identified a light-emitting diode fixture that will save 65,525 kilowatt-hours and $2,127 per year per fixture (based on 2014 dollars). Change out of the lights was interrupted by the February 2014 events, but will continue when normal underground operations resume.
- Continued emphasis on procurement of sustainable products resulted in
  - 65 percent of office supply funds spent on sustainable products.
  - Use of low VOC (less than or equal to 50 grams per liter VOCs) paints
  - Use of Design for the Environment® cleaner and degreaser, U.S. Department of Agriculture-certified biobased cleaner, Green Seal™ certified cleaner and handwash,
  - Leadership in Energy and Environmental Design approved wall panels and EnergyStar®-certified roof coating.
- The facility diverted 46 percent of construction and demolition (C&D) debris from landfills through reuse and recycling. Temporary (less than three years) modular office space was incorporated green requirements to the extent practicable.
- A 42 percent reduction in energy intensity (British thermal units per gross square foot) for WIPP site buildings compared to the fiscal year (FY) 2003 baseline, although a portion of this reduction was due operational shutdown. The percent reduction is expected to decrease for FY 2016 and beyond as operations resume.
- Scope 1 and 2 greenhouse gas emissions were 33 percent below the FY 2008 baseline and 21 percent below FY 2013 emissions. This significant reduction is not anticipated to continue for the long term as the facility returns to normal operations.
- Scope 3 greenhouse gas emissions were 44 percent below the FY 2008 baseline and 3 percent above 2013 emissions. Increased levels of business air and ground travel resulted from addressing February, 2014 events.

- Fleet petroleum consumption was 31 percent below the FY 2005 baseline and 27% below the FY 2013 consumption.

Environmental Management System Implementation

In May 2012, the WIPP EMS was recertified to the International Organization for Standardization (ISO) Standard 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use*. The recertification demonstrates that the WIPP project continues to meet the President's Council on Environmental Quality and DOE's requirements for full implementation of the EMS. Recertification of the WIPP EMS was achieved through the successful completion of an in-depth audit by the ISO-accredited registrar, Advanced Waste Management Systems, Inc. In 2014, the WIPP EMS successfully underwent two surveillancesconfirming the system continues to meet ISO requirements.

Significant accomplishments of the EMS for 2014 were as follows:

- Environmental monitoring data continued to demonstrate that there has been no adverse impact to human health or the environment from WIPP facility operations.
- Environmental objectives were evaluated in light of the February 2014 events and modified to recognize that emphasis for 2014 and 2015 will be on the following:
    - Improving operational controls for safe, environmentally sound emplacement of TRU waste through recovery projects.
    - Enabling long-term energy efficient WIPP operations through integration with recovery projects.
- Eighty-three percent of environmental targets were achieved.
- A climate change screening analysis was completed as a first step in understanding potential impacts to successful completion of the WIPP mission.

SUMMARY OF RELEASES AND RADIOLOGICAL DOSES TO THE PUBLIC

Doses to the Public and the Environment

The radiation dose to members of the public from WIPP facility operations was calculated from WIPP facility effluent monitoring results and demonstrates compliance with federal regulations.

Dose Limits

The environmental dose standard for the WIPP facility is established in Title 40 *Code of Federal Regulations* (CFR) Part 191, Subpart A, "Environmental Standards for Management and Storage." This standard requires that the combined annual dose

equivalent from all sources to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 mrem ("rem" is roentgen equivalent man) to the whole body and 75 mrem to any critical organ. In addition, in a 1995 memorandum of understanding between the EPA and the DOE, the DOE agreed the WIPP facility would comply with 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities," hereafter referred to as the National Emission Standards for Hazardous Air Pollutants (NESHAP) . The NESHAP standard for radionuclides requires that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem per year.

Background Radiation

Site-specific background gamma measurements on the surface, conducted by Sandia National Laboratories (SNL), showed an average dose rate of 7.65 microrem per hour (Minnema and Brewer, 1983), which would equate to the background gamma radiation dose of 0.67 millisieverts (mSv) per year (67.0 mrem per year). A comprehensive radiological baseline study before WIPP facility disposal operations began was also documented in *Statistical Summary of the Radiological Baseline for the Waste Isolation Pilot Plant* (DOE/WIPP–92–037), which provides the basis for environmental background comparison after WIPP facility disposal operations commenced.

Dose from Air Emissions

WIPP personnel have identified air emissions as the major pathway of concern for radionuclide transport during the receipt and emplacement of waste at the WIPP facility. To determine the radiation dose received by members of the public from WIPP facility operations, WIPP personnel use the EPA emission monitoring and test procedure (40 CFR §61.93, "Emission Monitoring and Test Procedure"), which requires the use of the EPA-approved CAP88-PC ([CAP88-PC, 2013] computer code for calculating both dose and risk from radionuclide emissions) to calculate the EDE to members of the public. CAP88-PC dose calculations are based on the assumption that exposed people remain at home during the entire year and all vegetables, milk, and meat consumed are home-produced. Thus, this dose calculation is a maximum dose that encompasses dose from inhalation, plume immersion, deposition, and ingestion of air-emitted radionuclides. A release from the underground repository occurred on February 14, 2014. The dose (0.0059 mrem to the maximally exposed off site individual) resuting from that event was approximately 0.06 percent of the 10 mrem standard, and did not measurably affect the public or the environment.

Total Dose from WIPP Facility Operations

The dose to an individual from the ingestion of WIPP facility managed radionuclides transported in water is virtually nonexistent because drinking water for communities near the WIPP site comes from groundwater sources that are a great distance away from WIPP facility operations and have an extremely low chance of being contaminated.

Game animals sampled and analyzed during 2014 included a quail composite, a deer, three rabbits, and three fish composite samples. The only radionuclides detected in any of the animal samples were naturally occurring uranium-233/234 ($^{233/234}$U) and uranium-238 (^{238}U) in one fish sample, and potassium-40 (^{40}K), which was detected in all the samples. By extrapolation, no dose from WIPP-related radionuclides has been received by any individual from this pathway (i.e., the ingestion of meat from game animals) during 2014.

Based on the results of the WIPP facility environmental sampling program and the effluent monitoring program, concentrations of radionuclides in air emissions did not exceed environmental dose standards set by 40 CFR Part 191, Subpart A, "Environmental Standards for Management and Storage," for radiological dose to a member of the public from all WIPP operations. For air emissions specifically, the standards of 40 CFR Part 61, Subpart H, "National Emission Standards for Hazardous Air Pollutants" were also met.

The results indicate that the hypothetical maximally exposed individual (MEI) who resides year-round at the point of highest concentration calculated at the fence line, 650 meters (m) (2,140 feet (ft)) west-northwest from the exhaust shaft, receives a dose of approximately 2.4E-03 mSv per year (2.4E-01 mrem per year) for the whole body and 4.8E-03 mSv per year (4.8E-01 mrem per year) to the critical organ.

These values are in compliance with the Subpart A standards specified in 40 CFR §191.03(b). For NESHAP (40 CFR §61.92) standards, the EDE potentially received by the MEI residing 7.5 kilometers (km) (4.66 miles (mi)) west-northwest of the WIPP facility was calculated to be less than 5.9E-05 mSv per year (5.9E-03 mrem per year) for the whole body. This value is in compliance with the 40 CFR §61.92 standards.

Chapter 4 of this report presents figures and tables that provide the EDE values from CY 2002 through 2014. These EDE values are below the EPA standards specified in 40 CFR Part 191, Subpart A, and limits in 40 CFR Part 61, Subpart H.

Dose to Nonhuman Biota

Dose limits that cause no deleterious effects on populations of aquatic and terrestrial organisms have been suggested by the National Council on Radiation Protection and Measurements and the International Atomic Energy Agency. These absorbed dose limits are listed below.

- Aquatic animals 10 milligrays per day (1 radiation absorbed dose per day)

- Terrestrial plants 10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial animals 1 milligrays per day (0.1 radiation absorbed dose per day)

The DOE requires discussion of radiation doses to nonhuman biota in the ASER using the DOE Technical Standard, DOE–STD–1153–2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. This standard requires an initial screening phase using conservative assumptions. This guidance was used to screen radionuclide concentrations observed around the WIPP site during 2014. The screening results indicate radiation in the environment surrounding the WIPP site does not have a deleterious effect on populations of nonhuman biota.

Release of Property Containing Residual Radioactive Material

There was no release of radiologically contaminated materials or property in 2014.

CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information needed by the U.S. Department of Energy (DOE) to assess the Waste Isolation Pilot Plant (WIPP) facility environmental performance and to make WIPP project environmental information available to the public. This report has been prepared in accordance with DOE Order 231.1B, *Environment, Safety, and Health Reporting*. This document gives a brief overview of the WIPP facility environmental monitoring processes and reports calendar year (CY) 2014 results.

The WIPP facility is authorized by the DOE National Security and Military Applications of Nuclear Energy Authorization Act of 1980 (Public Law 96–164). After more than 20 years of scientific study and public input, the WIPP facility received its first shipment of waste on March 26, 1999.

Located in southeastern New Mexico, the WIPP facility is the nation's first underground repository permitted to safely and permanently dispose of transuranic (TRU) radioactive and mixed waste generated through defense activities and programs. TRU waste is defined in the WIPP *Land Withdrawal Act of 1992* (LWA) (Public Law 102–579) as radioactive waste containing more than 100 nanocuries (3,700 becquerels [Bq]) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years except for: (a) high-level waste; (b) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; and (c) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with Title 10 of the Code of Federal Regulations (CFR) Part 61. Most TRU waste is contaminated industrial trash, such as rags and tools, sludges from solidified liquids, glass, metal, and other materials. The waste must meet the criteria in *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP–02–3122).

TRU waste is disposed of 655 meters (m) (2,150 feet [ft]) below the surface in excavated disposal rooms in the Salado Formation (Salado), which is a thick sequence of Permian evaporite salt beds. At the conclusion of the WIPP disposal phase, seals will be placed in the shafts. One of the main attributes of salt at the depth of the WIPP repository, as a rock formation in which to isolate radioactive waste, is the ability of the salt to creep, that is, to deform continuously over time. Excavations into which the waste-filled drums are placed will close eventually, and the surrounding salt will flow around the drums and seal them within the Salado. A detailed description of the WIPP geology and hydrology may be found in Chapter 6.

1.1 WIPP Mission

The WIPP mission is to provide for the safe, environmentally sound disposal of defense-generated TRU waste left from research, development, and production of nuclear weapons.

1.2 WIPP History

Government officials and scientists initiated the WIPP site selection process in the 1950s. At that time, the National Academy of Sciences undertook an evaluation of stable geological formations that could be used to contain radioactive wastes for thousands of years. In 1957, after this evaluation, salt deposits were recommended as a promising medium for the disposal of radioactive waste.

Salt deposits were selected as the host for the disposal of nuclear waste for several reasons. Most deposits of salt are found in geologically stable areas with very little earthquake activity, ensuring the stability of a waste repository. Salt deposits also demonstrate the absence of circulating groundwater that could move waste to the surface. If water had been present in the past or was currently present, it would have dissolved the salt beds. In addition, salt is relatively easy to mine. Finally, rock salt heals its own fractures because it behaves plastically under lithostatic pressure. This means salt formations at depth will slowly and progressively move in to fill mined areas and will seal radioactive waste within the formation, safely away from the biosphere.

After a search for an appropriate site for the disposal of radioactive waste throughout the 1960s, the salt deposits in southeastern New Mexico were tested in the early 1970s. Salt and other evaporite formations at the WIPP site were deposited in thick beds during the evaporation of the Permian Sea. These geologic formations consist mainly of sodium chloride in the form of solid rock. The salt formation that serves as the host rock for the WIPP repository is approximately 610 m (2,000 ft) thick, begins 259 m (850 ft) below the earth's surface, and constitutes a stable geologic environment.

In 1979, Congress authorized the construction of the WIPP facility, and the DOE constructed the facility during the 1980s. In late 1993, the DOE created the Carlsbad Area Office, subsequently redesignated as the Carlsbad Field Office (CBFO), to lead the TRU waste disposal effort. The CBFO coordinates the National TRU program throughout the DOE complex.

On March 26, 1999, the WIPP facility received its first TRU waste shipment, which came from the Los Alamos National Laboratory in northern New Mexico.

1.3 Site Description

Located in Eddy County in the Chihuahuan Desert of southeastern New Mexico (Figure 1.1), the WIPP site encompasses 41.4 square kilometers (km^2) or 16 square miles (mi^2). This part of New Mexico is relatively flat and is sparsely inhabited, with little surface water. The site is 42 kilometers (km) (26 miles [mi]) east of Carlsbad, New Mexico, in a region known as Los Medaños.

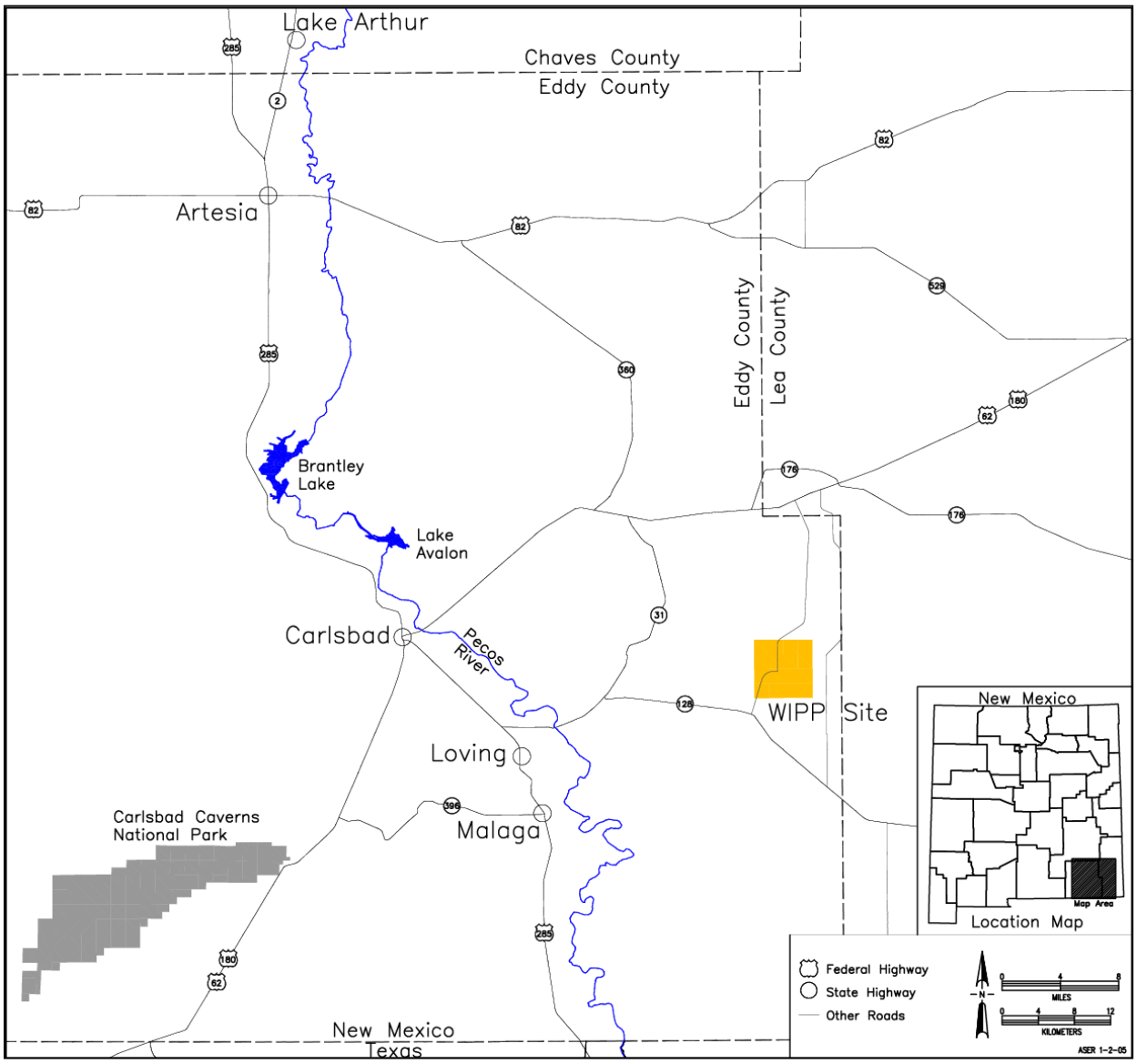


Figure 1.1 – WIPP Site Location

The WIPP LWA was signed into law on October 30, 1992, transferring the administration of federal land from the U.S. Department of the Interior to the DOE. With the exception of facilities within the boundaries of the posted 1.17 km^2 (0.45 mi^2) exclusive use area, the surface land uses remain largely unchanged from pre-1992 and are managed in accordance with accepted practices for multiple land use.

The majority of the lands in the immediate vicinity of the WIPP site are managed by the U.S. Department of the Interior Bureau of Land Management (BLM). Land uses in the surrounding area include livestock grazing, potash mining, oil and gas exploration and production, and recreational activities such as hunting, camping, hiking, and bird watching. The region is home to diverse populations of animals and plants.

1.3.1 WIPP Property Areas

Four property areas are defined within the WIPP site boundary (Figure 1.2).

Property Protection Area

The interior core of the facility encompasses 0.14 km^2 (0.05 mi^2) (35 acres) surrounded by a chain-link fence. Security is provided for this area 24 hours a day.

Exclusive Use Area

The exclusive use area comprises 1.17 km^2 (0.45 mi^2) (290 acres). It is surrounded by a barbed-wire fence and is restricted exclusively for the use of the DOE and its contractors and subcontractors in support of the project. This area is marked by DOE warning signs (e.g., “No Trespassing”) and is patrolled by WIPP facility security personnel to prevent unauthorized activities or uses.

Off-Limits Area

Prohibitions against unauthorized entry and introduction of weapons and/or dangerous materials are posted along the perimeter of the off-limits area, which encompasses 5.88 km^2 (2.27 mi^2) (1,454 acres). Grazing and public thoroughfare will continue in this area unless these activities present a threat to the security, safety, or environmental quality of the WIPP site. This area is patrolled by WIPP facility security personnel to prevent unauthorized activities or use.

WIPP Land Withdrawal Area

The WIPP site boundary delineates the perimeter of the 41.4 km^2 (16 mi^2) (10,240 acres) WIPP land withdrawal area. This tract includes the property protection area, the exclusive use area, and the off-limits area, as well as outlying areas within the WIPP site boundary.

Special Management Areas

Certain properties used in the execution of the WIPP project (e.g., reclamation sites, well pads, roads) are, or may be, identified as special management areas in accordance with the WIPP Land Management Plan (LMP) (DOE/WIPP–93–004), which is described further in Chapter 5. A special management area designation is made when resources and/or other circumstances meet the criteria for protection and management under special management designations. Unique resources of value that are in danger of being lost or damaged, areas where ongoing construction is occurring, fragile plant and/or animal communities, sites of archaeological significance, locations containing safety hazards, or sectors that could receive an unanticipated elevated security status would be suitable for designation as special management areas. No areas were designated as special management areas in 2014.

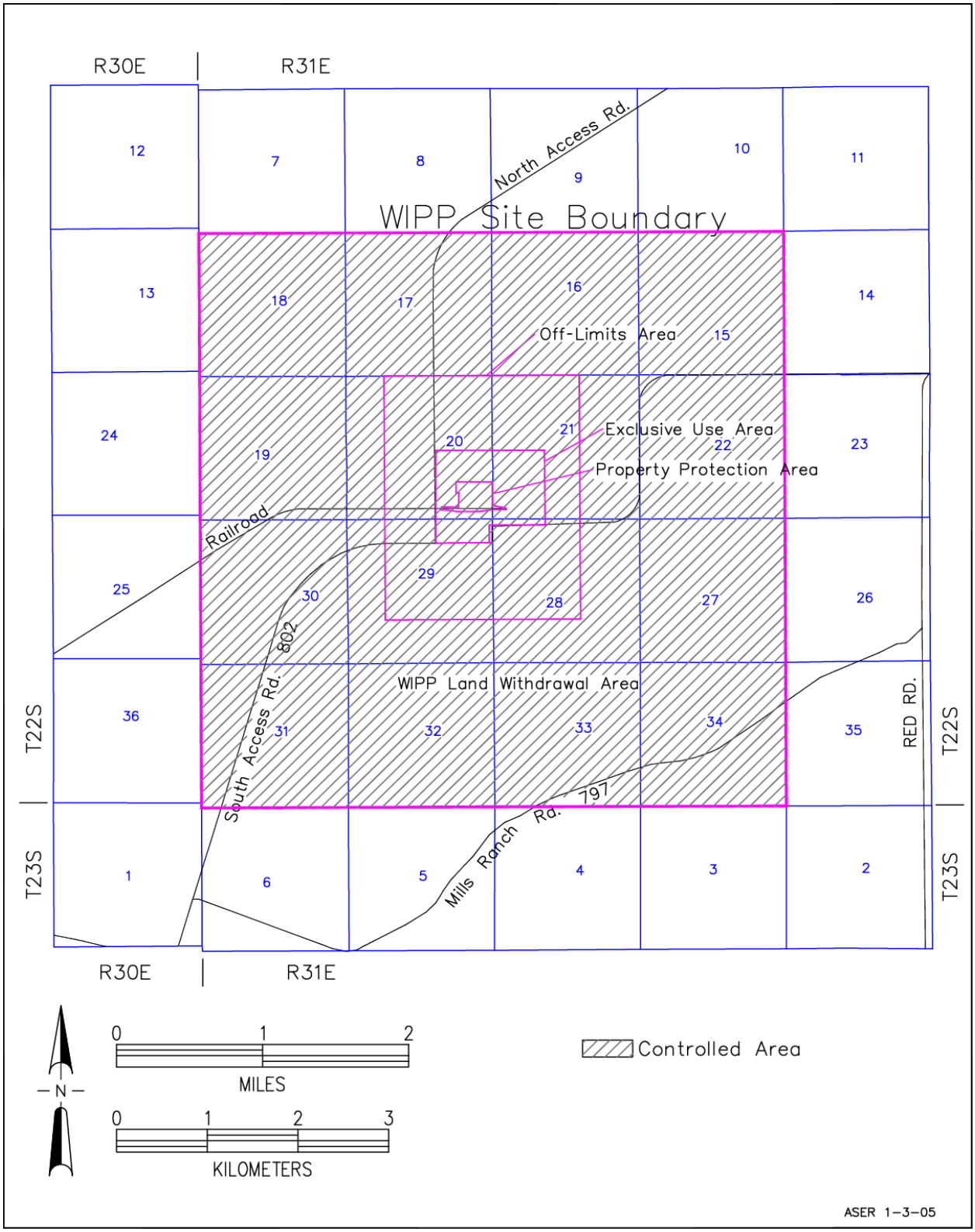


Figure 1.2 – WIPP Property Areas

1.3.2 Population

There are 19 permanent residents living within 16 km (10 mi) of the WIPP site (DOE/WIPP–93–004). This population is associated with ranching.

The majority of the local population within 80.5 km (50 mi) of the WIPP site is concentrated in and around the communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia, New Mexico. According to 2010 census data, the estimated population within this radius is 88,952. The nearest community is the village of Loving (estimated population 1,413), 29 km (18 mi) west-southwest of the WIPP site. The nearest major populated area is Carlsbad, 42 km (26 mi) west of the WIPP site. The 2010 census reported the population of Carlsbad as 26,138.

1.4 WIPP Environmental Stewardship

The DOE policy is to conduct its operations in compliance with applicable environmental laws and regulations, and to safeguard the integrity of the southeastern New Mexico environment. The DOE conducts effluent monitoring, environmental surveillance, land management, and assessments to verify that these objectives are met. Environmental monitoring includes collecting and analyzing environmental samples from various media and evaluating whether WIPP facility operations have caused any adverse environmental impacts.

1.4.1 Environmental Monitoring Plan

The *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP–99–2194) outlines the program for monitoring the environment at and around the WIPP site, including the major environmental monitoring and surveillance activities at the WIPP facility. The plan discusses the WIPP project quality assurance / quality control (QA/QC) program as it relates to environmental monitoring. The purpose of the plan is to specify how the effects of WIPP facility operations on the local ecosystem are to be determined. Effluent and environmental monitoring data are necessary to demonstrate compliance with applicable environmental protection regulations. The frequency of 2014 sampling is provided in Table 1.1.

The plan describes the monitoring of naturally occurring and specific anthropogenic (human-made) radionuclides. The geographic scope of radiological sampling is based on projections of potential release pathways from the waste disposed at the WIPP facility. The plan also describes monitoring of volatile organic compounds (VOCs), groundwater chemistry, and other non-radiological environmental parameters, and collection of meteorological data.

Table 1.1 – Environmental Monitoring Sampling[a]

Program	Type of Sample	Number of Sampling Locations[b]	Sampling Frequency
Radiological	Airborne effluent[a]	3	Periodic/confirmatory
	Airborne particulate[a]	7	Weekly
	Sewage treatment system (discharge permit [DP]-831)[c]	3	Semiannual
	H-19 evaporation pond (DP–831)[c]	1	Semiannual
	Liquid effluent	1 (Waste Handling Building [(WHB] sump)	If needed
	Biotic		
	Quail Rabbit Cattle/Deer Javelina Fish Vegetation	WIPP vicinity WIPP vicinity WIPP vicinity WIPP vicinity 3 6	Annual As available As available As available Annual Annual
	Soil	6	Annual
	Surface water	Maximum of 14	Annual
	Sediment	Maximum of 12	Annual
	Groundwater (Detection Monitoring Program [DMP])	6	Annual
Non-radiological	Meteorology	1	Continuous
	VOCs		
	VOCs—repository VOCs—disposal room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Hydrogen and methane	18 per filled open panel	Monthly
	Groundwater (DMP)	6	Annual
	Shallow groundwater (DP-831)	12	Semiannual
	Surface water (DP–831)	6 storm water infiltration control ponds	Annual and after major storm events
		4 sewage lagoons	Semiannual

Notes:

(a) The number of certain types of samples taken can be driven by site conditions. For example, during dry periods, there may be no surface water or sediment to sample at certain locations. Likewise, the number of samples for biota will vary. For example, the number of rabbits available as samples of opportunity will vary, as will fishing conditions that are affected by weather and algae levels in the water.

(b) Post February event sampling for effluent and ambient air was increased in frequency, and, for ambient air, sample locations added to enhance coverage. The basic program, however, retained the core routine sampling locations. One airborne effluent station airflow was re-directed, resulting in only two effluent air sampling points for the remainder of CY 2014.

(c) Includes a non-radiological program component.

1.4.2 WIPP Facility Environmental Monitoring Program and Surveillance Activities

Employees of the WIPP facility monitor air, surface water, groundwater, sediments, soils, and biota (e.g., vegetation, selected mammals, quail, and fish). Environmental monitoring activities are performed in accordance with procedures that govern how samples are to be taken, preserved, and transferred. Procedures direct the verification and validation of environmental sampling data.

The atmospheric pathway, which can lead to the inhalation of radionuclides, has been determined to be the most likely release pathway to the public from the WIPP facility. Therefore, airborne particulate sampling for alpha-emitting radionuclides is emphasized. Air sampling results are used to trend environmental radiological levels and determine if there has been a deviation from established baseline concentrations. The geographic scope of radiological sampling is based on projections of potential release pathways and nearby populations for the types of radionuclides in TRU wastes that are managed at the WIPP facility, and includes nearby communities and ranches.

Non-radiological environmental monitoring activities at the WIPP site consist of sampling and analyses designed to detect and quantify impacts of operational activities, and verify compliance with applicable requirements.

1.4.3 Description of the Radiological Release Event of February 14, 2014

On February 5, 2014, a vehicle fire occurred in the Waste Isolation Pilot Plant (WIPP) underground, resulting in the temporary suspension of normal operations including underground facility EM sampling and waste shipments from generator sites. On February 14, 2014, while the fire investigation was still underway, a continuous air monitor detected airborne radiation in the WIPP underground facility, causing the ventilation exhaust to automatically realign to high efficiency particulate air (HEPA) filtration mode. The ventilation system has been operating in filtration mode since that time. Entries into the underground to Panel 7 have confirmed one container from a nitrate salt bearing waste stream from Los Alamos National Laboratory is breached and is the source of the radioactive particulates. Detailed investigation by the DOE Accident Investigation Board (AIB) has determined that no other containers contributed to the release (AIB, 2015). Investigations by the Technical Assessment Team (TAT) have determined that the presence of incompatible materials, including nitrate salts, in an improper configuration in container LA00000068660 led to a thermal runaway. This container of waste is from waste stream LA-MIN02.001 (SRNL, 2015). Shipments of waste to the WIPP facility have been suspended.

The radiological release contaminated portions of the underground facility. The extent of the radiological contamination has been determined and activities have been initiated to remove or stabilize (referred to as fixing) the contamination so it does not become airborne when normal operations resume. Because of the radiological contamination, activities in the underground must be carefully planned and performed to ensure workers are not exposed to harmful levels of radiation.

In addition to addressing radiological contamination, recovery includes mine-related activities that must be performed, including the installation of panel closures and

resuming mine maintenance activities such as ground control bolting. In order to perform these activities, sufficient ventilation air must be provided to the underground working areas. Sufficient ventilation air is defined by the regulations promulgated for mines such as the WIPP facility by the U.S. Department of Labor, Mine Safety and Health Administration (MSHA).

The New Mexico Environment Department (NMED) has issued two Administrative Orders (AOs) to address certain activities relative to the WIPP Hazardous Waste Facility Permit (Permit) that cannot be performed because the underground is inaccessible for normal activities. The AOs provide requirements for monitoring and reporting to the NMED concerning the status of recovery from the two events. The first AO (AO1) issued on February 27, 2014, addressed above-ground compliance, and required a weekly report to be submitted with regard to surface-related requirements of the Permit. On May 12, 2014, a second AO (AO2) was issued to address, in part, Permit-required activities that cannot currently be performed due to restriction on access to the underground. The second AO changed the reporting period from weekly to biweekly, with additional information required to supplement the information required by AO1. A directive from the Secretary of the NMED was issued on August 29, 2014, which amended the reporting frequency from biweekly to monthly for reporting required under AO1 and AO2.

The mine is being ventilated in filtration mode. This means that under the current configuration, approximately 60,000 cubic feet per minute of ventilation air is available throughout the entire underground. This air is circulated through HEPA filters before it is discharged into the ambient atmosphere. This total flow is distributed throughout the underground using bulkheads, louvers, and other flow control devices to direct ventilation air to where it is needed.

The limited amount of ventilation air dictates the types and number of activities that can be performed at any given time in the underground. Until additional filtration capability is installed, the amount of ventilation air will remain limited to its current capacity.

1.5 Environmental Performance

DOE Order 436.1, *Departmental Sustainability*, describes the DOE commitment to environmental protection and pledges to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources. The provisions of DOE Order 436.1 are implemented via WIPP environmental policy and the Environmental Management System (EMS).

Implementation of the *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP–99–2194) fulfills the environmental monitoring requirements of DOE Order 436.1. Detailed information on WIPP programs is contained in the remaining chapters.

CHAPTER 2 – COMPLIANCE SUMMARY

The DOE is required to comply with the applicable regulations promulgated pursuant to federal and state statutes, DOE orders, and executive orders (EOs) with regard to the WIPP facility. Compliance with regulatory requirements is incorporated into facility plans and implementing procedures. Methods for maintaining compliance with environmental requirements include the use of engineered controls and written procedures, routine training of facility personnel, ongoing self-assessments, and personal accountability. The following sections list the environmental statutes and regulations applicable to the operation of the WIPP facility and describe significant accomplishments and ongoing compliance activities. A detailed breakdown of WIPP facility compliance with environmental laws is available in the *Waste Isolation Pilot Plant Biennial Environmental Compliance Report* (DOE/WIPP-14-3526).

A list of active WIPP environmental permits appears in Appendix B.

2.1 Comprehensive Environmental Response, Compensation, and Liability Act

The *Comprehensive Environmental Response, Compensation, and Liability Act* (42 U.S.C. [United States Code] §§9601, et seq.), or Superfund, establishes a comprehensive federal strategy for responding to, and establishing liability for, releases of hazardous substances from a facility to the environment. Any spills of hazardous substances that exceed a reportable quantity must be reported to the National Response Center under the provisions of *Comprehensive Environmental Response, Compensation, and Liability Act* and 40 CFR Part 302, “Designation, Reportable Quantities, and Notification.” Hazardous substance cleanup procedures are specified in 40 CFR Part 300, “National Oil and Hazardous Substances Pollution Contingency Plan.”

2.1.1 Superfund Amendments and Reauthorization Act of 1986

The DOE is required by the *Superfund Amendments and Reauthorization Act of 1986 Title III* (SARA) (42 U.S.C. §11001, also known as the *Emergency Planning and Community Right-to-Know Act*), which is implemented by 40 CFR Parts 355, 370, 372, and 373, to submit (1) a list of hazardous chemicals present at the facility in excess of 10,000 pounds for which Material Safety Data Sheets are required; (2) an Emergency and Hazardous Chemical Inventory Form (Tier II Form) that identifies the inventory of hazardous chemicals present during the preceding year; and (3) notification to the State Emergency Response Commission (SERC) and the Local Emergency Planning Committee of any accidental releases of hazardous chemicals in excess of reportable quantities. The list of hazardous chemicals and the Tier II Form have been submitted to the regional fire departments.

The list of chemicals provides external emergency responders with information they may need when responding to a hazardous chemical emergency at WIPP. The list of hazardous chemicals is a one-time notification unless new hazardous chemicals in excess of 10,000 pounds, or new information on existing chemicals, are provided.

The Local Emergency Planning Committee and the SERC are notified when a new hazardous chemical is received on site in excess of 10,000 pounds at any one time. The hazardous chemical is reported to the Local Emergency Planning Committee and the SERC within 30 days of receipt.

The Tier II Form, due on March 1 of each year, provides information to the public about hazardous chemicals above threshold planning quantities that a facility has on site at any time during the year. The Tier II Form is submitted annually to the Local Emergency Planning Committee and the SERC, and to each fire department with which the CBFO maintains a memorandum of understanding. The WIPP 2014 Tier II Form was submitted to the SERC, the Local Emergency Planning Committee, and fire departments prior to March 1, 2015, as required. Title 40 CFR Part 372, "Toxic Chemical Release Reporting: Community Right to Know," identifies requirements for facilities to submit a toxic chemical release report to the U.S. Environmental Protection Agency (EPA) and the resident state if toxic chemicals are disposed or released at the facility in excess of established threshold amounts. The Toxic Release Inventory Report was submitted to the EPA and to the SERC prior to the July 1, 2014, reporting deadline. Table 2.1 presents the 2014 *Emergency Planning and Community Right-to-Know Act* reporting status. A response of "yes" indicates that the report was required and submitted.

Table 2.1 – Status of Emergency Planning and Community Right-to-Know Act Reporting

***Emergency Planning and Community Right-to-Know Act* Regulations—40 CFR Parts**	**Description of Reporting**	**Status**
355	Planning Notification	Further notification not required
302	Extremely Hazardous Substance Release Notification	Not required
355	Material Safety Data Sheet / Chemical Inventory (Tier II Form)	Yes
372	Toxic Release Inventory Report	Yes

2.1.2 Accidental Releases of Reportable Quantities of Hazardous Substances

There were no releases of hazardous substances exceeding the reportable quantity limits during 2014.

2.2 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (42 U.S.C. §§6901, et seq.) was enacted in 1976. Initial implementing regulations were promulgated in May 1980. This body of regulations ensures that hazardous waste is managed and disposed of in a way that protects human health and the environment. The *Hazardous and Solid Waste Amendments of 1984* (Public Law 98–616, Stat. 3221) prohibit land disposal of hazardous waste unless treatment standards are met or specific exemptions apply. The amendments also emphasize waste minimization. Section 9(a) of the WIPP LWA

exempts TRU mixed waste designated by the Secretary of Energy for disposal at the WIPP facility from treatment standards. Such waste is not subject to the land disposal prohibitions of the *Solid Waste Disposal Act* (42 U.S.C. §§6901–6992, et seq.).

The NMED is authorized by the EPA to implement the hazardous waste program in New Mexico pursuant to the *New Mexico Hazardous Waste Act* (NMSA §§74–4–1, et seq., 1978). The technical standards for hazardous waste treatment, storage, and disposal facilities (TSDFs) in New Mexico are outlined in 20.4.1.500 New Mexico Administrative Code (NMAC), which adopts, by reference, 40 CFR Part 264, "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." The hazardous waste management permitting program is administered through 20.4.1.900 NMAC, "Adoption of 40 CFR Part 270" [EPA Administered Permit Programs: The Hazardous Waste Permit Program].

2.2.1 Hazardous Waste Facility Permit

The Permit authorizes DOE and the management and operating contractor (MOC) (collectively known as the Permittees) to receive, store, and dispose of contact-handled and remote-handled TRU mixed waste at the WIPP facility. Two storage units (the Parking Area Unit and the WHB Unit) are permitted for storage of TRU mixed waste. Eight underground hazardous waste disposal units or panels are currently permitted for the disposal of contact-handled and remote-handled TRU mixed waste.

On February 5, 2014, the WIPP facility experiences an underground fire that stopped normal operations including waste shipments to the WIPP. On February 14, 2014, a radiological event occurred from receipt of waste mixed with an incompatible sorbent. This receipt and disposal of non-conforming waste was self-reported by the Permittees to the regulator. A small release of radiological material from the underground resulted. Due to safety concerns, some permitted activities could not be performed. The New Mexico Environment Department issued three administrative orders providing some regulatory relief and directing certain actions from the Permittees. For example, the, extensions for storage of waste were issued as disposal operations were halted.

On April 11, 2014, the NMED was notified by the Permittees that the RCRA Contingency Plan, described in Permit Attachment D, had been implemented. The DOE self-reported the receipt and disposal of non-conforming waste, Hazardous Waste Number D001 for ignitability. Although daily teleconferences with the regulator providing them status of the investigation of the cause of the release were ongoing since the events, it was on July 25, 2014, the NMED was verbally notified of the Permittees' intent to provisionally apply D001 to the non-conforming containers. On July 30, 2014, the Permittees provided written notification of the provisional application of D001 on those containers.

On December 6, 2014, an administrative compliance order was issued against the Permittees. The NMED alleged that Permittees did not implement the Contingency Plan in a timely manner for both events, received non-conforming waste, failed to provide timely oral and written notification, failed to maintain and operate the facility,

failed to conduct adequately training, and verify the completeness and accuracy of the Waste Stream Profile Form.

2.2.2 Modification Requests

In 2014, the Permittees submitted permit modification notifications and permit modification requests to NMED, as described in Table 2.2.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2014

Class	Description	Date Submitted
1	Editorial changes in monitoring records text; editorial changes in Attachments C3 and C6; update Table L-4 of Active Environmental Permits; clarify text related to marking and labeling packages in Part 3; clarify Table E-1a; Revise Table 4.1.1; revise Table G-1	February 6, 2014
1	Update Co-Permittee project manager	March 18, 2014
1	Update chronology in Attachment A; change preventative maintenance procedure in Table E-1a	March 28, 2014
1	Contingency Plan Update – equipment used for internal communications; Contingency Plan Update editorial; Change in Attachment D, Section D-4d(10); Contingency Plan Update – contact information Tables D-8 and D-9; editorial change in Attachment C, Table C6-1, Item 28; Contingency Plan Update – Resource Conservation and Recovery Act emergency coordinator clarification	November 7, 2014

In accordance with Permit Part 1, Section 1.14, Information Repository, permit modification notifications and permit modification requests, along with associated responses from the regulator, were posted to the Information Repository on the Permittees' webpage within 10 calendar days. Additionally, other required Permit information was provided in the Information Repository.

2.2.3 Underground Storage Tanks

Title 40 CFR Part 280, "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)," addresses USTs containing petroleum products or hazardous chemicals. Requirements for UST management pertain to the design, construction, installation, and operation of USTs, as well as notification and corrective action requirements in the event of a release and actions required for out-of-service USTs. The NMED has been authorized by the EPA to regulate USTs and implements the EPA program through 20.5 NMAC, "Petroleum Storage Tanks."

The last UST inspection performed by the NMED was conducted on June 19, 2012. At this time, the inspector found no inconsistencies and the USTs were found to be in compliance with NMED petroleum storage tanks standards. No inspection was performed in 2014.

2.2.4 Hazardous Waste Generator Compliance

Non-radioactive hazardous waste is currently generated through routine facility operations. Mixed low-level radioactive wastes (i.e., low-level radioactive wastes that are known or suspected to contain hazardous constituents) may be generated at the WIPP site as a result of the cleanup from the February 2014 radiological release.

Hazardous wastes are managed in satellite accumulation areas; a less-than-90-day accumulation area on the surface, and a less-than-90-day accumulation area underground. Mixed low-level radioactive wastes are segregated from non-radioactive hazardous wastes, and are managed as hazardous waste.

Hazardous waste generated at the WIPP facility (whether radioactive or non-radioactive) is accumulated, characterized, packaged, labeled, and manifested to off-site TSDFs in accordance with the requirements codified in 20.4.1.300 NMAC, which adopts, by reference, 40 CFR Part 262, "Standards Applicable to Generators of Hazardous Waste." In addition, mixed low-level radioactive waste is managed to comply with DOE Order 435.1, "Radioactive Waste Management." Mixed low-level radioactive wastes are shipped off-site to TSDFs that are permitted and licensed to treat and dispose of these types of wastes.

2.2.5 Program Deliverables and Schedule

The Permittees are in compliance with the Permit conditions related to reporting as noted below.

- Permit Part 2, Section 2.14, Recordkeeping and Reporting, requires the submittal of the biennial hazardous waste report, as required by 20.4.1.500 NMAC (incorporating 40 CFR § 264.75). The biennial hazardous waste report is due by March 1st of even-numbered years. This report, which describes the amounts and types of hazardous waste generated, received, and/or shipped by the WIPP facility during CY 2013, was submitted to the NMED in February 2014. The next biennial hazardous waste report will be due by March 1st of 2016, for reporting of hazardous waste activities performed during CY 2015. Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires annual reports evaluating the geomechanical monitoring program and the mine ventilation rate monitoring program. The Permittees continued to comply with these requirements by preparing and submitting annual reports in October 2014, representing results for July 1, 2013, through June 30, 2014.
- Permit Part 4, Section 4.6, Maintenance and Monitoring Requirements, requires semiannual reports describing the results (data and analysis) of confirmatory VOC, hydrogen, and methane monitoring. The Permittees continued to comply with this requirement by preparing and submitting semiannual reports in April 2014, representing results for July 1, 2013, through December 31, 2013, and in October 2014, representing results for January 1, 2014, through June 30, 2014.

- Permit Part 5, Section 5.10.2.1 requires a report of the analytical results for annual DMP well samples and duplicates, as well as results of the statistical analysis of the samples showing whether statistically significant evidence of contamination is present. The report for sampling Round 36 was submitted to the NMED in November 2014. Sampling results are summarized in Appendices E and F of this Annual Site Environmental Report (ASER).
- Permit Part 5, Section 5.10.2.2 requires semiannual submittal of groundwater surface elevation results calculated from field measurements and freshwater head elevations calculated as specified in Permit Attachment L, Section L-4c(1). Semiannual reports were submitted to the NMED in May and November 2014 as required.
- Permit Part 5, Section 5.10.2.3 requires that groundwater flow data be included in the Annual Culebra Groundwater Report by November 30. The groundwater flow data were submitted in November 2014 as required.

2.3 National Environmental Policy Act

The *National Environmental Policy Act* (NEPA) (42 U.S.C. §§4321, et seq.) requires the federal government to use all practical means to consider potential environmental impacts of proposed projects as part of the decision-making process. The NEPA also requires that the public be allowed to review and comment on proposed projects that have the potential to significantly affect the quality of the environment.

NEPA regulations and requirements are detailed in 40 CFR Parts 1500–1508, "Council on Environmental Quality." The DOE codified its requirements for implementing NEPA regulations in 10 CFR Part 1021, "National Environmental Policy Act Implementing Procedures." Following completion of each environmental impact statement and its associated record of decision, 10 CFR §1021.331 requires the DOE to prepare a mitigation action plan that addresses mitigation commitments expressed in the record of decision. The CBFO tracks the performance of mitigation commitments in the WIPP project annual mitigation report. This report was issued June 27, 2014.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. Forty-three proposed projects were reviewed and approved by the CBFO NEPA Compliance Officer through the NEPA screening and approval process in 2014. Twenty-four of these projects were in response to either the underground truck fire or the radiological release, and 19 of these projects were maintenance or upgrades to WIPP facility structures and equipment. The approvals were in addition to routine activities determined to be bounded by existing NEPA documentation and that do not require additional evaluation by the CBFO NEPA Compliance Officer. The CBFO NEPA Compliance Officer routinely participates in the development of NEPA documents for other DOE offices and other federal agencies for proposed actions that may have environmental impacts on the WIPP project.

In response to the events in February 2014, CBFO initiated a supplemental analysis to temporarily store TRU waste prior to disposal at the WIPP facility. This supplemental analysis was completed in March 2014. Also in 2014, CBFO issued a categorical exclusion determination to dispose HEPA filters that were radiologically contaminated from the February event. A second categorical exclusion was issued to upgrade the ventilation exhaust system.

2.4 Clean Air Act

The *Clean Air Act* (42 U.S.C. §§7401, et seq.) provides for the preservation, protection, and enhancement of air quality. Both the State of New Mexico and the EPA have authority for regulating compliance with portions of the *Clean Air Act*. Radiological effluent monitoring in compliance with EPA standards is discussed in Chapter 4.

Based on an initial 1993 air emissions inventory, the WIPP facility is not required to operate under *Clean Air Act* permits. In 1993, the DOE obtained a New Mexico Air Quality Control (NMSA 1978 §74–2) Regulation 702 Operating Permit (recodified in 2001 as 20.2.72 NMAC, "Construction Permits") for two backup diesel generators at the WIPP facility. There were no activities or modifications to the operating conditions of the diesel generators in 2014 that required reporting under the conditions of the Operating Permit.

The *Clean Air Act* established National Ambient Air Quality Standards for six criteria pollutants: sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen dioxide, and lead. The initial 1993 WIPP air emissions inventory was developed as a baseline document to calculate maximum potential hourly and annual emissions of both hazardous and criteria pollutants. Based on the current air emissions inventory, WIPP facility operations do not exceed the 10 ton per year emission limit for any individual hazardous air pollutant, the 25 ton per year limit for any combination of hazardous air pollutant emissions, or the 10 ton per year emission limit for criteria pollutants except for total suspended particulate matter and particulate matter less than 10 microns in diameter. Particulate matter is produced from fugitive sources related to the management of salt tailings extracted from the underground. Consultation with the NMED Air Quality Bureau resulted in a March 2006 determination that a permit is not required for fugitive emissions of particulate matter that result from salt management at the WIPP facility. Proposed facility modifications are reviewed to determine if they will create new air emission sources and require permit applications.

For January 2014, VOC emissions from containers of TRU and TRU mixed waste that are vented to prevent the buildup of gases generated by radiolysis remained less than 10 tons per year for individual VOCs monitored under the Permit. After the underground truck fire of February 5, 2014, no VOC samples were taken in the underground due to safety concerns. Administrative orders from the NMED addressed inaccessibility of areas necessary to perform sampling of VOCs in the underground until recovery efforts have been completed. Surface VOC sampling is being conducted in lieu of underground sampling for repository emissions.

2.5 Clean Water Act

The *Clean Water Act* (33 U.S.C. §§1251, et seq.) establishes provisions for the issuance of permits for discharges into waters of the United States. The regulation defining the scope of the permitting process is contained in 40 CFR §122.1(b), "Scope of the NPDES [National Pollutant Discharge Elimination System] Permit Requirement," which states that "The National Pollutant Discharge Elimination System program requires permits for the discharge of 'pollutants' from any 'point source' into 'waters' of the United States."

The WIPP facility does not discharge wastewater or storm water runoff into waters of the United States and is not subject to regulation under the National Pollutant Discharge Elimination System program. Wastewaters generated at the WIPP facility are either disposed of off site or managed in on-site, lined evaporation ponds. Storm water runoff is also collected in lined detention basins. The management of wastewater and storm water runoff is regulated under the *New Mexico Water Quality Act* (NMSA 1978, §§74–6–1, et seq.), as discussed in Section 2.6.

2.6 New Mexico Water Quality Act

The *New Mexico Water Quality Act* created the New Mexico Water Quality Control Commission, tasked with the development of regulations to protect New Mexico ground and surface water. New Mexico water quality regulations for ground and surface water protection are contained in 20.6.2 NMAC, "Ground and Surface Water Protection." The WIPP facility does not discharge to surface water, but does have a discharge permit (DP) designed to prevent impacts to groundwater.

The DOE was issued DP–831 from the NMED Groundwater Quality Bureau for the operation of the WIPP sewage treatment facility in January 1992. The DP was renewed and modified to include the H–19 Evaporation Pond in July 1997. The H–19 Evaporation Pond is used for the treatment of wastewater generated during groundwater monitoring activities, water removed from sumps in the underground, and condensation from duct work in the mine ventilation system. The DP was modified in December 2003 to incorporate infiltration controls for salt-contact storm water runoff and in December 2006 to provide a more detailed closure plan. The DP was renewed on September 9, 2008. The DP was again modified on April 5, 2010, to include an additional evaporation pond to contain storm water running off the salt pile. An application for the 5-year renewal of the DP was submitted to the NMED Groundwater Quality Bureau on May 9, 2013. The new DP was received on August 1, 2014.

In accordance with DP requirements, monthly inspections are conducted of each of the infiltration control ponds and salt storage areas to ensure they are maintained in good condition. When deficiencies are observed, such as liner tears or significant erosion, appropriate repairs are conducted. The sewage lagoons and H–19 Evaporation Pond are inspected weekly for signs of erosion or damage to the liners even though the permit only requires monthly inspections. The distance between normal water levels and the top (known as "freeboard") of the sewage lagoons, the H–19 Evaporation Pond,

and all infiltration control ponds are monitored daily. The DP renewal added the requirement of inspecting the leak detection sumps in Salt Storage Ponds 2 and 3. The procedure for pond inspections was modified to include this new requirement. Note that the impoundment nomenclature has changed, as given by footnote to Table 5.7.

The DP requires the sewage lagoons and H–19 Evaporation Pond to be sampled semiannually and analyzed for nitrate, total Kjeldahl nitrogen, total dissolved solids (TDS), sulfate, and chloride. The infiltration control ponds must be sampled annually for TDS, sulfates, and chlorides. The results of this monitoring are reported in Section 5.7, Liquid Effluent Monitoring. In addition, the permit requires annual shallow subsurface water (SSW) water level contour mapping and semiannual groundwater sampling for sulfate, chloride, and TDS. SSW monitoring results are discussed in Chapter 6.

The DP requires semiannual reports to be submitted to the NMED in January and July. The reports included inspection results, water analyses, and sewage and storm water discharge volumes. Both semiannual reports were submitted in 2014.

2.7 Safe Drinking Water Act

The *Safe Drinking Water Act* (42 U.S.C. §§300f, et seq.) provides the regulatory strategy for protecting public water supply systems and underground sources of drinking water. New Mexico's drinking water regulations are contained in 20.7.10 NMAC, "Drinking Water," which adopts, by reference, 40 CFR Part 141, "National Primary Drinking Water Regulations," and 40 CFR Part 143, "National Secondary Drinking Water Regulations." Water is supplied to the WIPP facility by the City of Carlsbad. However, the WIPP facility is classified as a nontransient, noncommunity water system subject to New Mexico drinking water regulations.

Bacterial samples are collected and residual chlorine levels are tested monthly. Chlorine levels are reported to the NMED monthly. Bacteriological analytical results have been below the *Safe Drinking Water Act* regulatory limits. Disinfectant by-products testing per 40 CFR §141.132, "Monitoring Requirements," is conducted annually by facility personnel. Results of disinfectant by-products sampling are below regulatory limits.

2.8 National Historic Preservation Act

The *National Historic Preservation Act* (16 U.S.C. §§470, et seq.) was enacted to protect the nation's cultural resources and establish the National Register of Historic Places. No archaeological investigations were required within the WIPP land withdrawal area in 2014.

2.9 Toxic Substances Control Act

The *Toxic Substances Control Act* (15 U.S.C. §§2601, et seq.) was enacted to provide information about chemicals and to control the production of new chemicals that might present an unreasonable risk of injury to health or the environment. The act authorizes the EPA to require testing of old and new chemical substances and to regulate the manufacturing, processing, import, use, and disposal of chemicals.

Polychlorinated biphenyls (PCBs) are regulated by the *Toxic Substances Control Act*. The PCB storage and disposal regulations are listed in the applicable subparts of 40 CFR Part 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." On May 15, 2003, EPA Region VI approved the disposal of waste containing PCBs at the WIPP facility. The WIPP facility began receiving PCB-contaminated waste on February 5, 2005. The EPA renewed the disposal authority for a five-year period on April 30, 2008, and again renewed the authority for a five-year period on May 21, 2013.

The required PCB annual report, containing information on PCB waste received and disposed of at the WIPP facility during 2013, was submitted to EPA Region VI prior to the required submission date in 2014.

2.10 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* (7 U.S.C. §§136, et seq.) authorizes the EPA to regulate the registration, certification, use, storage, disposal, transportation, and recall of pesticides (40 CFR Parts 150–189).

All applications of restricted-use pesticides at the WIPP facility are conducted by commercial pesticide contractors who are required to meet federal and state standards. General-use pesticides are stored according to label instructions. Used, empty cans are managed and disposed of in accordance with federal and state regulations.

2.11 Endangered Species Act

The *Endangered Species Act of 1973* (16 U.S.C. §§1531, et seq.) was enacted to prevent the extinction of certain species of animals and plants. This act provides strong measures to help alleviate the loss of species and their habitats, and places restrictions on activities that may affect endangered and threatened animals and plants to help ensure their continued survival. With limited exceptions, the act prohibits activities that could impact protected species, unless a permit is granted from the U.S. Fish and Wildlife Service. A biological assessment and formal consultation, followed by the issuance of a biological opinion by the U.S. Fish and Wildlife Service, may be required for any species that is determined to be in potential jeopardy.

During 2014, no species of plants or animals that are protected by the *Endangered Species Act* were identified within the WIPP land withdrawal area.

2.12 Migratory Bird Treaty Act

The *Migratory Bird Treaty Act* (16 U.S.C. §§703, et seq.) is intended to protect birds that have common migratory flyways between the United States, Canada, Mexico, Japan, and Russia. The act makes it unlawful "at any time, by any means or in any manner, to pursue, hunt, take, capture, kill, or attempt to take, capture, or kill… any migratory bird, any part, nest, or eggs of any such bird" unless specifically authorized by the Secretary of the Interior by direction or through regulations permitting and governing actions

(50 CFR Part 20, "Migratory Bird Hunting"). In 2014, no activities involving migratory birds took place within the WIPP land withdrawal area.

2.13 Federal Land Policy and Management Act

The objective of the *Federal Land Policy and Management Act* (43 U.S.C. §§1701, et seq.) is to ensure that

> *…public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values; that, where appropriate, will preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife and domestic animals; and that will provide for outdoor recreation and human occupancy and use.*

Title II under the act, *Land Use Planning; Land Acquisition and Disposition*, directs the Secretary of the Interior to prepare and maintain an inventory of public lands and to develop and maintain, with public involvement, land use plans regardless of whether subject public lands have been classified as withdrawn, set aside, or otherwise designated for one more uses. The DOE developed, and operates in accordance with, the WIPP LMP, which is described in further detail in Section 5.2.

Under Title V, *Rights-of-Way*, the Secretary of the Interior is authorized to grant, issue, or renew rights-of-way over, upon, under, or through public lands. To date, several right-of-way reservations and land-use permits have been granted to the DOE. Examples of right-of-way permits include those obtained for a water pipeline, an access road, a caliche borrow pit, and a sampling station. Each facility (road, pipeline, railroad, etc.) is maintained and operated in accordance with the stipulations provided in the respective right-of-way reservation. Areas that are the subject of a right-of-way reservation are reclaimed and revegetated consistent with the terms of the right-of-way when they are no longer needed.

2.14 Atomic Energy Act

The *Atomic Energy Act of 1954*, as amended (42 U.S.C. §§2011, et seq.), initiated a national program with responsibility for the development and production of nuclear weapons and a civilian program for the development and the regulation of civilian uses of nuclear materials and facilities in the United States. Amendments to the act split these functions between the DOE, which is responsible for the development and production of nuclear weapons, promotion of nuclear power, and other energy-related work, and the U.S. Nuclear Regulatory Commission, which regulates the use of nuclear energy for domestic civilian purposes.

The statutory authority for the EPA to establish and generate applicable environmental radiation protection standards for management and disposal of spent nuclear fuel, high-level, and TRU radioactive waste is found in the *Atomic Energy Act of 1954*, Reorganization Plan Number 3 of 1970, and in the *Nuclear Waste Policy Act of 1982*

(42 U.S.C. §10101, et seq.). The EPA final rule, 40 CFR Part 191, was promulgated on December 20, 1993 (effective January 19, 1994), and consists of three subparts: Subpart A, "Environmental Standards for Management and Storage;" Subpart B, "Environmental Standards for Disposal;" and Subpart C, "Environmental Standards for Ground-Water Protection."

The results of both environmental and effluent monitoring and dose calculations have indicated that there have been no regulatory releases of radionuclides from the WIPP facility that may adversely impact the public. WIPP personnel have conducted confirmatory effluent monitoring since receipt of waste began in March 1999.

On February 14, 2014, a radiological release event occurred in Panel 7, Room 7 of the WIPP underground. The airborne release initiated a protective shift in the mine ventilation system to the filtration mode. Subsequent analysis documented radioactive particulate emissions to the ambient air. The final dose estimates for CY 2014 were consistent with the preliminary measurements immediately following the event, and verify that the calculated values are well below annual regulatory limits for the maximally exposed individual (MEI) member of the public for periodic confirmatory sampling. Results of the monitoring program demonstrating compliance with the dose limits discussed above are addressed in further detail in Chapter 4.

In response to the February 2014 radiological release, the EPA conducted an inspection at the WIPP from April 7 – 29, 2014, under the authority of 40 CFR §194.21, "Inspections". The inspection focused on actions taken by DOE and Nuclear Waste Partnership LLC (NWP), in response to the accidental release. EPA inspectors examined WIPP facility air emission monitoring devices and methods used to estimate radiation doses to the public. In addition, EPA inspected radiation sampling locations and equipment, observed sample processing, and reviewed the consequence assessment dose estimates. As a result of the inspection, the EPA made the following statements in its inspection report (EPA Air DOCKET No: A-98-49: II-B3-129; September 2014)

> *DOE should improve the design, positioning, maintenance and overall capability of its ambient environmental air monitoring network. At a minimum, DOE needs to modify the physical positioning of several samplers to eliminate the obstruction of airflow or particulate loading of filters. DOE could also increase the reliability of its sampling results by implementing a more formal maintenance and calibration system for its sampling equipment, and by upgrading to digital systems that provide more data on air flow rates and system failures.*
>
> *DOE needs to implement stricter sample collection and sample tracking procedures to provide the highest quality, most defensible data possible at all times. EPA found that tracking samples from their receipt at WIPP Laboratories to final results is clearly and thoroughly documented. However, EPA observed several instances during the incident in which sample handling departed from typical operating procedures. EPA*

inspectors were concerned by the handoff of sample collection responsibility from Environmental Monitoring to RadCon during an emergency. Although this change in responsibility is clearly documented in site procedures, the sudden staffing change can lead to errors. Specifically, during the lab visit EPA noted a deficiency in a sample control form for an ambient environmental sample filter collected by RadCon. EPA was likewise concerned that samples that would ordinarily be sent to WIPP Laboratories were evidently sent to SRS and Sandia National Labs. While some of these decisions were made for valid reasons, such as high sample radioactivity or backlogs of work at WIPP Laboratories, EPA is concerned that the decisions were made on an ad-hoc basis and not well documented.

EPA is particularly concerned by the handling of the filter from Skid A-3, which would have provided objective evidence that no release took place at Station A prior to the shift to filtration. After initial counting that was judged to be at background, the filter was sent for chemical analysis instead of isotopic analysis. The site has now collected a series of filters at Station B, only some of which have been subjected to a full suite of radiochemical analyses. DOE has valid reasons for preserving these samples as it investigates the incident. However, DOE will need to work with EPA to make sure that the analysis of effluent samples is conducted in a manner that is as consistent as possible with analyses previously performed to support the WIPP's NESHAPs [National Emission Standards for Hazardous Air Pollutants] compliance.

In response to the EPA's findings, the ambient air program was thoroughly reviewed and adjustments made both to standardize the existing sample installations and to add more locations to provide wider coverage of ambient air that could be affected by WIPP operations. The remaining post-event samples from the effluent monitors were analyzed for the key isotopes that were present in the airbornerelease, and the results used in calculating the CY 2014 dose to the public. The several effluent samples that were not fully analyzed were not recoverable, however, and administrative controls were implemented to avoid decisions that do not fully consider airborne emission compliance monitoring requirements.

The LWA requires the EPA to conduct recertification of continued compliance every five years after the initial receipt of TRU waste for disposal until the end of the decommissioning phase. The latest Compliance Recertification Application for the WIPP project was submitted to the EPA in March 2014.

2.15 DOE Orders

DOE orders are used to direct and guide project participants in the performance of their work and establish the standards of operations at the WIPP project. The DOE orders documented in this report require that emission, effluent, and environmental monitoring programs be conducted to ensure that the WIPP mission can be accomplished while

protecting the public, the worker, and the environment. The list of DOE orders identified for the WIPP facility is reviewed and updated annually.

2.15.1 DOE Order 151.1C, Comprehensive Emergency Management System

This order establishes requirements for emergency planning hazards assessment, categorization, classification, preparedness, response, notification, coordination control, public protection, and readiness assurance activities. The applicable requirements of this order are implemented through the WIPP Emergency Management Program, the Emergency Response Program, the training program, the Emergency Readiness Program, the Records Management Program, and the Resource Conservation and Recovery Act Contingency Plan.

On February 5, 2014, an underground fire involving an EIMCO Haul Truck (equipment number 74-U-006B) (salt haul truck) occurred at the DOE WIPP facility and on February 14, 2014, an unrelated event in the underground repository at the WIPP facility resulted in the release of americium and plutonium from one TRU waste container into the underground mine ventilation air and to the ambient atmosphere within the facility boundary.

In response to the salt haul truck fire on February 5, 2014, the Deputy Assistant Secretary for Safety, Security, and Quality Programs, DOE Office of Environmental Management, formally appointed an AIB to investigate the accident, which met Accident Investigation Criteria 2.d.1 of DOE O 225.1B, Accident Investigations, Appendix A. The investigation began on February 10, 2014, and was completed on March 8, 2014. The AIB submitted its findings to the Deputy Assistant Secretary for Safety, Security, and Quality Programs, Office of Environmental Management, on March 11, 2014. On March 14, 2014, the AIB Accident Investigation Report was formally transmitted to NWP.

In response to the February 14, 2014, radiological incident the Deputy Assistant Secretary for Safety, Security, and Quality Programs, DOE Office of Environmental Management, formally appointed a second AIB in accordance with DOE O 225.1B. The investigation began on March 3, 2014. Phase 1 of the investigation was completed on March 28, 2014. The AIB submitted the Phase 1 investigation report to the Acting Deputy Assistant Secretary for Safety, Security, and Quality Programs, DOE Office of Environmental Management, on April 1, 2014. The Phase 1 report covers the AIB conclusions relative to the release of TRU radionuclides from the underground to the environment. On April 24, 2014 the AIB report was published and made available to NWP.

The AIB released a report on Phase 2 of the investigation of the radiological event release in April 2015. Following the earlier March 2015 release of a TAT report on the physical and chemical aspects of the event, the AIB report was made public after a comprehensive review of the processes related to the event in Panel 7, Room 7, in which the radiological release occurred.

One of the contributing causes (i.e., events or conditions that collectively with other causes increased the likelihood or severity of an accident but that individually did not

cause the accident) of the February 2014 radiological release was described in the Phase 2 AIB report as follows:

> *NWP implementation of DOE O 151.1C, Comprehensive Emergency Management System, was ineffective. Personnel did not adequately recognize, categorize, or classify the emergency and did not implement adequate protective actions in a timely manner.*

The corrective actions and related tasks to ensure full compliance with DOE Order 151.1C are outlined in the DOE Corrective Action Plan (CAP) and NWP CAP. In the DOE CAP, the CBFO has directed and is coordinating with NWP to develop an integrated WIPP Emergency Management Program that is fully compliant with DOE Order 151.1C. The CBFO Safety Programs Division Director and staff will oversee and participate in the development of a new, fully compliant and integrated WIPP Emergency Management Program that will ensure that NWP and the CBFO can respond effectively and efficiently to operational emergencies. The new program will ensure emergencies are recognized, categorized, and as necessary classified promptly to ensure appropriate response measures are taken to protect workers, the public, and the environment. The CBFO Safety Programs Division Director and staff will oversee training and drills to ensure all elements of emergency response are exercised and that emergency response personnel demonstrate competence in the use of equipment and procedures.

The DOE CAP and the NWP CAP identify the corrective actions that will be taken to ensure full compliance with this order.

2.15.2 DOE Order 231.1B, Administrative Chg. 1, Environment, Safety, and Health Reporting

This order ensures the DOE receives timely and accurate information about events that could adversely affect the health, safety, and security of the public or workers, the environment, the operations of DOE facilities, or the credibility of the DOE. The order specifies the timely collection, reporting, analysis, and dissemination of data pertaining to environment, safety, and health that are required by law or regulation, or that are essential for evaluating DOE operations and identifying opportunities for improvement needed for planning purposes within the DOE. The order specifies the reports that must be filed, the persons or organizations responsible for filing the reports, the recipients of the reports, the format in which the reports must be prepared, and the schedule for filing the reports. This order is implemented in part at the WIPP facility through ASERs, environmental protection program reports, occupational injury and illness reports, the radiation safety manual, the dosimetry program, the fire protection program, and WIPP facility procedures.

2.15.3 DOE Order 414.1D Administrative Chg. 1, Quality Assurance

This order provides the criteria for establishing, implementing, and maintaining programs, plans, and actions to ensure quality in DOE programs. This order is implemented at the WIPP through the CBFO *Quality Assurance Program Document*

(DOE/CBFO–94–1012), which establishes quality assurance (QA) program requirements for quality-affecting programs, projects, and activities sponsored by the CBFO. Chapter 7 of this ASER provides additional details on the WIPP QA programs.

2.15.4 DOE Order 435.1, Chg. 1, Radioactive Waste Management

The objective of this order is to ensure that DOE radioactive waste, including TRU waste that is disposed of at the WIPP facility, is managed in a manner that is protective of workers, public safety, and the environment. In the event that a conflict exists between any requirements of this order and the WIPP LWA regarding their application to the WIPP facility, the requirements of the LWA prevail. The DOE implements the requirements of this order through the *Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant* (DOE/WIPP–02–3122), and procedures governing the management and disposal of TRU radioactive waste generated off site.

Occasionally, the WIPP facility generates low-level and mixed low-level waste which, according to the LWA, cannot be disposed of at the WIPP facility. Procedures governing the management and disposal of radioactive waste generated on site are *Low-Level and Mixed Low-Level Waste Management Plan* (WP 02-RC.05), and *Low-Level and Mixed Low-Level Waste Characterization for Off-Site Release for Disposal* (WP 02-RC3110). These procedures ensure that site-generated low-level waste and mixed low-level waste from the WIPP facility are disposed of off site in accordance with DOE O 435.1-1, Change 1, and DOE M 435.1-1 Administrative Change.

2.15.5 DOE Order 436.1, Departmental Sustainability

This order requires DOE sites to comply with the sustainability requirements contained in EOs 13423 and 13514 related to governmental sustainability. Project managers must also develop, and commit to implement, an annual site sustainability plan that identifies their respective contributions toward meeting DOE sustainability goals. The WIPP project EMS must be used for implementing the project sustainability plan. Project EMSs must maintain conformance to International Organization for Standardization 14001:2004. The WIPP project sustainability plan for fiscal year (FY) 2015 was issued on December 30, 2014. This fifth annual update addresses the WIPP project contribution toward meeting the DOE sustainability goals including the performance status for FY 2014 and planned actions for FY 2015. The project sustainability plan becomes a basis for establishing annual project environmental objectives and targets. WIPP project participants work toward achieving the sustainability goals through the EMS. The WIPP EMS was certified to the ISO 14001:2004 standard in May 2009 and recertified on May 28, 2012.

2.15.6 DOE Order 451.1B, Administrative Chg. 3, National Environmental Policy Act Compliance Program

This order establishes DOE requirements and responsibilities for implementing the NEPA of 1969, the Council on Environmental Quality regulations implementing the procedural provisions of NEPA (40 CFR Parts 1500–1508), and the DOE NEPA implementing procedures (10 CFR Part 1021). This order is implemented by the DOE

for the WIPP facility through the DOE site-specified NEPA procedure, compliance plans, and a screening procedure. These tools are used to evaluate environmental impacts associated with proposed activities and to determine if additional analyses are required.

In response to the events in February 2014, CBFO initiated a supplemental analysis to temporarily store TRU waste prior to disposal at the WIPP facility. This supplemental analysis was completed in March 2014. Also in 2014, CBFO issued a categorical exclusion determination to dispose HEPA filters that were radiologically contaminated from the February event. On November 17, 2014, the CBFO NEPA Compliance Officer provided a second categorical exclusion to upgrade the ventilation exhaust system.

2.15.7 DOE Order 458.1, Administrative Chg. 3, Radiation Protection of the Public and the Environment

This order establishes standards and requirements for DOE and contractor operations with respect to protecting members of the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of DOE pursuant to the *Atomic Energy Act of 1954*, as amended. Activities and analyses describing compliance with the applicable requirements of the order are contained in the *Waste Isolation Pilot Plant Documented Safety Analysis* (DOE/WIPP 07–3372). Monitoring activities to document compliance with the order are described in the WIPP Facility As-Low-As-Reasonably-Achievable Program Manual, the Records Management Program, and the Radiation Safety Manual.

Since the February 14, 2014, radiological release event, discussed in Section 2.15.1, the WIPP underground facility ventilation system is being operated in filtration mode, which effectively removes respirable particulate from the effluent air stream.

In addition, the DOE has taken the initiative to implement several improvements. The DOE prepared the “U.S. Department of Energy Plan for Addressing the Areas or Improvement Identified by the U.S. Environmental Protection Agency,” provided as Attachment B, that addresses the following areas identified by the EPA for improvement:

- Update the Ambient Environmental Monitoring Network
  - Improve the design, location, maintenance, and overall capability of its ambient environmental air monitoring network.
  - Increase the number of ambient environment air sampling locations from 7 to 16.
- Strengthen Emergency Response Protocols
  - Better integrate routine and incident procedures to enhance preparedness of multiple organization field and laboratory staff to respond to releases.
- Ensure the Highest Quality Laboratory Results

- Implement stricter sample collection, sample tracking, and documentation procedures to provide the highest quality, most defensible data possible, at all times.

2.16 Executive Orders

Executive orders are used by the President to direct federal agencies and officials in their execution of policies. Compliance is accomplished through the WIPP EMS as described in Chapter 3. Confirmation of compliance is accomplished through the WIPP assessment processes.

2.16.1 Executive Order 13423, Strengthening Federal Environmental, Energy, and Transportation Management

On January 24, 2007, EO 13423 was signed and it was codified into law by the *2009 Omnibus Appropriations Act*, which was signed on February 17, 2009. The order sets goals in the following areas:

- Energy efficiency and reductions in greenhouse gas emissions.
- Use of renewable energy.
- Reduction in water consumption intensity.
- Acquisition of green products and services.
- Pollution prevention, including reduction or elimination of the use of toxic and hazardous chemicals and materials.
- Cost-effective waste prevention and recycling programs.
- Increased diversion of solid waste.
- Sustainable design/high performance buildings.
- Vehicle fleet management, including the use of alternative fuel vehicles and alternative fuels and the further reduction of petroleum consumption.
- Electronics stewardship.

Accomplishments towards goals established in EOs are discussed in Chapter 3.

In addition, the order requires more widespread use of the EMS as the framework for managing and continually improving these sustainable practices. Requirements are implemented and integrated into WIPP operations through energy management, fleet and vehicle management, affirmative procurement, and pollution prevention programs.

2.16.2 Executive Order 13514, Federal Leadership in Environmental, Energy, and Economic Performance

This EO was signed on October 5, 2009. It expands on the energy reduction and environmental performance requirements for federal agencies identified in EO 13423.

This order establishes an integrated strategy toward sustainability in the federal government and to make reduction of greenhouse gas emissions a priority for federal agencies. Goals for improvements were established for federal agencies in the following areas:

- Greenhouse gas emissions, energy efficiency.
- Water use efficiency and management.
- Pollution prevention and waste elimination.
- Regional and local integrated planning.
- Sustainable federal buildings.
- Sustainable acquisition.
- Electronics stewardship.
- Environmental management.

The WIPP project complies with the EO through its EMS. Accomplishments toward goals established in the EO are discussed in Chapter 3.

CHAPTER 3 – ENVIRONMENTAL MANAGEMENT SYSTEM

The CBFO and the MOC consider protection of workers, the public, and the environment to be the highest priority during mission activities at the WIPP facility. This commitment is made public in the WIPP Environmental Policy. Protection of the environment is ensured through implementation of the WIPP EMS. Effectiveness of the EMS is demonstrated by the negligible effect of WIPP facility operations on the environment, reduced environmental risk from safe disposal of TRU and TRU mixed waste from generator sites at the WIPP facility, project compliance, and progress in sustainability.

This reporting period presented unique challenges to the EMS and environmental performance coupled with many opportunities for continuous improvement. Challenges and opportunities for improvement stem from the February 2014 salt haul truck fire and the release of americium and plutonium into the underground and the ambient atmosphere within the facility boundary. It is important to frame further discussion of the EMS challenges with respect to the two events by noting that extensive on-site and off-site environmental monitoring shows no significant impact on the environment or human health from the operation of the WIPP facility. Following are three of most significant challenges in terms of the EMS.

The first challenge was the cessation of TRU waste emplacement, which began on the date of the first event and continued through the end of the year. This interruption in waste emplacement halted progress in the most significant and positive impact of the WIPP mission: reduction in environmental risks achieved by eliminating storage of TRU wastes at generator sites.

The second challenge resulting from the events of February 2014 was stakeholder perception of regulatory compliance at the project. The project's commitment to full compliance with legal requirements has never wavered and the radiological release did not exceed any federal or state reporting quantities. However, the NMED issued Compliance Order HWB-14-21 on December 6, 2014, for alleged violations of the WIPP Permit related to the February events. The Permittees (CBFO and MOC) are currently following the legal process for addressing the issues in the order. While the ultimate disposition of the compliance order is yet to be determined, receipt of the compliance order is taken very seriously and is viewed as an opportunity to review and improve the adequacy of compliance programs.

The third challenge was in the sustainability arena. Because project resources were focused on recovery of site operations, less progress was made toward DOE sustainability goals.

While each of these challenges resulted from unexpected and undesired circumstances, the WIPP project is using lessons learned as well as issues identified in investigations and program reviews, as opportunities for improvement. Improvements are being implemented to strengthen the systems necessary to allow the Permittees to resume waste emplacement, maintain compliance, and to operate more sustainably. In many

cases, the improvements will also provide additional operational control for several aspects of operations that are determined as significant in the EMS. Examples of improvements are upgrades to the ventilation system and to the maintenance, emergency management, and training programs.

In 2014, the surveillance audits conducted by the ISO 14001 accredited registrar, Advanced Waste Management Systems, confirmed that the EMS continues to meet requirements, resulting in continued certification of the EMS. The EMS was last certified to ISO Standard 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use,* in May 2012. The certification demonstrates that the WIPP EMS continues to meet the President's Council on Environmental Quality and DOE requirements for full implementation of an EMS. Certification is based on an in-depth audit by the ISO-accredited registrar every three years. In the interim between certification audits, surveillance audits are conducted by the registrar.

3.1 EMS 2014 Highlights

Many of the highlights in this section reflect ongoing efforts to address the events of February 2014 and to implement improvements in site-wide programs that are part of the EMS. Completion of these efforts will enable resumption of TRU waste emplacement.

Environmental Aspects

Aspects were revised in 2014 as follows:

- Added four aspects, of which the following two were ranked as significant:
  - Design and construct ventilation systems (significant for energy use and waste diversion)
  - Manage site-derived wastes (significant for potential spill/release).
- Clarified that the aspect related to disposal of TRU waste includes temporary storage (TRU waste shipments received but not emplaced at the time of the February events are currently being stored in accordance with regulatory requirements).
- Clarified that the significant aspect of managing site-generated waste includes low-level wastes. Low-level wastes are being

generated from decontamination and cleanup of the underground repository.

- Recognized the significant aspects where controls are in the process of being strengthened to avoid negative impacts.

In addition, significance scores for all aspects/impacts were reevaluated. Changes in scoring did not cause any remaining impacts to become significant.

Legal and Other Requirements

During 2014, NMED issued three AOs to address WIPP Permit requirements that could not be met due to inaccessibility of areas in the underground where inspections and monitoring are necessary. The first two AOs provided requirements for monitoring and reporting to the NMED on the status of recovery from the two events. The third AO required the Permittees to submit the *WIPP Nitrate Salt Bearing Waste Container Isolation Plan* for identified nitrate salt bearing waste disposed at the WIPP facility.

On August 1, the NMED issued the renewal of the DP-831. This permit contained a few new requirements for which compliance actions are being incorporated into facility procedures.

Objectives, Targets, and Program(s)

The WIPP significant aspects and SSP provide the basis for establishing WIPP environmental objectives and targets. The process followed for establishing the targets remained the same; however, flexibility in the process was required in order to address the change in project operations.

FY 2014 performance resulted in completion of 83 percent of environmental targets supporting progress toward four of the five environmental objectives established at the beginning of the fiscal year. The changes to objectives and/or targets noted above are:

Objective 1 – Improve efficiency in TRU waste emplacement.

This objective was removed in February, as the project focus changed to recover the site and reestablish waste receipt and emplacement. During the EMS mid-year update, CBFO and MOC managers approved a replacement objective. The new objective is to “Improve operational controls for safe, environmentally sound emplacement of TRU waste through recovery projects.”

Objective 2 – Improve energy efficiency – reduce energy use by 1 percent per year.

WIPP’s energy use in FY 2014 was 19 percent below FY 2013 energy use because primary energy consuming equipment was not operated for the majority of the year. As a result, this objective

became less useful for improving energy efficiency. This objective was replaced with a new objective to better reflect the current operational status of the project and the energy efficiency opportunities that are part of recovery. The new objective is to "Enable long-term energy efficient WIPP operation through integration with recovery projects."

Objective 3 – Improve waste diversion to 50 percent by FY 2020.

In FY 2014, 32 percent of municipal solid waste (compared to 33 percent in FY 2013) and 46 percent of construction and demolition (C&D) waste (compared to 63 percent in FY 2013) were diverted.

Materials that would normally have been recycled were placed in the municipal solid waste facility for part of the year after the fire and radiological release events due to minimal accessibility of the site until it was cleared for the return of the full staff.

The decrease in diverted C&D waste was the result of 127 metric tons of concrete from the demolition of an underground concrete slab not being recyclable due to rebar content and salt contamination. WIPP would have had a 100 percent C&D diversion rate if the concrete had been recyclable.

Objective 4 – Improve use of sustainable products.

In FY 2014, 65 percent of dollars spent on office products were for products with recycled content, a 4 percent increase over FY 2013. The target supporting this objective, "identify sustainability reporting criteria and modifications needed (including cost) for the Integrated Financial Management System to facilitate sustainable procurement reporting" was not completed. Resources were diverted to support site cleanup and recovery efforts.

Objective 5 – Improve life-cycle management of electronics.

There were no changes to this objective. The target to virtualize an additional five percent of servers was exceeded. WIPP has now virtualized 70 percent of servers and achieved the virtualization practicable for the project. Ninety percent of the work to implement a hot/cold deck configuration in the Skeen-Whitlock Building data center was completed. The target to complete Phase I of the MOC's project to convert desktop computers to thin clients was not completed due to information technology support being needed for recovery.

Competence, Awareness, and Training

The investigation of the fire and radiological release events identified several training program inadequacies. In addition, an independent Safety Management Program evaluation of the training program identified required improvements. Actions to make necessary improvements were initiated and are scheduled for completion in 2015.

As in past years, every WIPP employee completed in-depth initial or refresher Conduct of Operations Training, which is fundamental to implementing the Operational Control Element of the WIPP EMS. All employees also completed EMS training through initial or annual refresher General Employee Training.

In FY 2014, Earth Day was celebrated by distribution of covered ceramic coffee cups to encourage employees to use reusable drink containers instead of disposable ones.

Pollution Prevention "P2" News publications were posted across the site and Skeen-Whitlock Building throughout the year. These publications contained articles on various timely EMS and sustainability topics.

Operational Control

External and internal evaluations resulted in ongoing and significant actions being taken to improve operational controls for several of WIPP's significant aspects and impacts. These included improvements in both physical controls (e.g., design and construct interim, supplemental and final ventilations systems, upgrades to central monitoring room, adding continuous air monitors and designing the interim closure of Panel 6 and Panel 7, Room 7) and programmatic controls (radiation protection, emergency management, maintenance and work control, performance assurance, and training programs). Actions to complete improvements will continue through 2015 and will be confirmed as fully implemented prior to the restart of TRU waste emplacement.

Emergency Preparedness and Response

The Emergency Management Program is undergoing significant upgrades to address deficiencies identified in internal and external evaluations after the fire and radiological release events. Many actions were completed in 2014 with the remainder to be completed in 2015. Improvements include revisions to the program and procedure documents as well as development of several additional procedures. Emergency management staff was increased and additional training requirements for staff were established and carried out. The drill/exercise program was strengthened, with 127 drills/exercises being conducted. Areas tested included dealing with contaminated patients, underground evacuations, addressing surface and underground fires, response to continuous air monitor alarms, and Central Monitoring Room operations.

Monitoring and Measurement	After the February 14 event, the WIPP Environmental Monitoring Program was supplemented with additional sampling across the full range of media potentially affected. Sampling included air, soil, surface water and sediment, and vegetation.
Evaluation of Compliance	CBFO and the MOC performed fewer overall compliance evaluations during 2014 than in past years. Even so, there were over 96 evaluations that included checks for compliance with regulatory and/or DOE requirements in areas that are part of the EMS. No regulatory noncompliance issues were identified from these evaluations.
Nonconformity, Corrective Action, and Preventive Action	The CBFO uses the ICE system, initially implemented in November, 2014, as the CBFO management tool for documenting and tracking identified issues through management evaluation, approval, resolution of actions, and ultimately, closure of the issue. The system supports issues management through use of e-mail systems to solicit input and assign actions for issue resolution. The ICE system implements applicable portions of U.S. Department of Energy (DOE) Order (O) 226.1B, Implementation of Department of Energy Oversight Policy; DOE O 422.1, Conduct of Operations; DOE/CBFO-94-1012, Quality Assurance Program Document; and DOE/WIPP-04-3299, CBFO Contractor Oversight Plan. The Issues Management and Corrective Action Request programs continued to be robust. These are the two fundamental programs for implementing this element of the EMS. Significant improvements, focused on simplifying the process while maintaining accountability for corrective action, were made to the Issues Management Program. These improvements will strengthen the program by focusing greater attention on significant issues that could affect WIPP compliance and protection of people and the environment, while continuing to ensure that corrective actions are implemented, reducing the paperwork burden for issues of lesser importance.
Internal Audit	The internal audit of the WIPP EMS was completed. One finding was identified, which noted that the reports for environmental compliance assessments performed in FY 2014 had not been issued and that the related program document was out of date. Actions necessary to address the issues are in progress.

Management Review	CBFO and MOC senior managers performed a mid-year review of EMS status and an end-of-year detailed review of the suitability and effectiveness of the EMS. Both resulted in refocusing objectives and targets so that they are aimed at ensuring operational control improvements are achieved and progress continues to be made in the sustainability area during the recovery period.

3.2 Significant Environmental Programs

Fundamental to the EMS are programs through which environmental protection is integrated with operations. These programs, with supporting procedures, translate the environmental policy's higher order commitments into practical actions for individual employees to take to protect the environment as they work. Significant WIPP facility environmental programs are described below.

Delaware Basin Drilling Surveillance

Surveillance of drilling activities within the Delaware Basin places specific emphasis on the nine-township area that includes the WIPP site. The surveillances build on the data used to develop modeling assumptions for performance assessment for the EPA Compliance Certification.

Environmental Monitoring

The Environmental Monitoring Program includes radiological and non-radiological monitoring, land management monitoring, and surveillance of oil and gas operations near the WIPP boundary. Radiological constituents are monitored in airborne effluent and particulates, sewage treatment and water disposal evaporation ponds, biotics, soils, surface water, sediment, and groundwater. Non-radiological monitoring includes meteorology, VOCs, groundwater, hydrogen, methane, nearby hydrocarbon drilling activity, and SSW.

As noted previously, routine monitoring was supplemented during 2014 to ensure there was a thorough and documented record of the impact from the radiological release event.

Environmental Compliance Audit

Audits and reviews of compliance are conducted via MOC environmental compliance assessments and CBFO and MOC QA assessments.

Groundwater Protection

Groundwater, which may potentially be affected by DOE operations, is monitored to detect and document the effects of operations on groundwater quality and quantity, and to show compliance with applicable federal and state laws and regulations.

Land Management

The land management program provides for management and oversight of WIPP lands under the jurisdiction of the DOE and lands used for WIPP activities outside of the WIPP boundary. It provides protocols that are used for the management and oversight of wildlife practices, cultural resources, grazing, recreation, energy and mineral resources, lands/realty, reclamation, security, industrial safety, emergency management, maintenance, and work control on these lands.

Environmental Compliance Review and NEPA Implementation

This program ensures that requirements of the NEPA are met prior to making decisions to implement work at or on behalf of the WIPP facility. In addition, it ensures that other environmental compliance requirements and sustainability are considered and addressed prior to implementing work.

Sustainability

This program promotes integration of energy and water efficiency; reduction in greenhouse gas emissions; sustainable buildings purchasing, waste minimization, recycling, reuse, and electronics management into the WIPP project.

Sustainable Procurement

This program provides a systematic structure for promoting and procuring sustainable products when they meet cost, availability, and performance needs. These include bio-based, recycled content, energy and water-efficient products, and products with fewer hazards or lower toxicity.

Waste Stream Profile Review and Approval

This is a critical program for ensuring that compliance requirements are met for wastes being disposed at the WIPP facility. Profiles for each waste stream are reviewed to verify that the generator's characterization information is complete and accurate, and that waste streams comply with the Permit and the waste acceptance criteria.

Waste Confirmation

Under this program, waste containers are confirmed to have no ignitable, corrosive, or reactive waste using radiography and/or visual examination of a statistically representative subpopulation of the waste in each shipment. This program is required by the Permit.

Waste Management

This program ensures that site-generated hazardous, universal, special, low-level, and mixed low-level radioactive wastes are properly handled, accumulated, and transported to approved disposal facilities in accordance with legal and internal requirements. It also includes provisions for proper management of site-derived TRU and TRU mixed waste.

3.3 Environmental Performance Measurement

Extensive monitoring and measurement is conducted by the facility staff to ensure that the WIPP mission is carried out in accordance with its environmental policy. This includes monitoring (1) impacts to environment, (2) EMS effectiveness, and (3) sustainability progress. Each of these is discussed in the following sections.

3.3.1 Environmental Impacts

There were no significant impacts on the environment from WIPP operations in 2014, as determined from extensive environmental monitoring for both radiological and non-radiological monitoring results. Detailed analyses and summaries of environmental monitoring results, including descriptions and results of the enhanced sample collection after of the February 2014 radiological release event, are included in Chapters 4, 5, and 6.

3.3.2 EMS Effectiveness

The CBFO and MOC managers jointly determine if the WIPP EMS continues to be suitable and effective for carrying out the WIPP mission in a manner consistent with environmental policy commitments. The determination for this reporting period was that the EMS is suitable with a caveat: it is imperative to implement and sustain the improvements identified in the aftermath of the February events so that incidents with potential impact on the environment are prevented and the project is prepared to effectively manage potential emergency events.

Effectiveness of the EMS is ultimately determined by how well environmental policy commitments are implemented in day to day operations. During the management review, it was determined that the EMS effectiveness was credible, but not as good as needed to fully implement the policy. The key factors considered in determining the effectiveness of the EMS are summarized below.

Policy Commitment	WIPP Performance
Comply with Environmental Requirements	Neither the fire event nor the radiological release resulted in exceedance of a reportable quantity. The NMED issued an administrative compliance order alleging non-compliance with Permit requirements. Although the final resolution has not been reached, the

	issuance of the order is viewed as significant and is a catalyst for redoubling efforts to ensure that compliance is maintained. The many regulatory compliance points of the project were met during the year, with the exception of a limited number of underground inspections and VOC monitoring data. As a result of the events of February, 2014, NWP and CBFO quickly worked with NMED to secure administrative orders that recognized and allowed for NOT completing Permit required underground inspections and VOC monitoring while the areas were not accessible. Overall, the DOE compliance posture with regard to the WIPP project was good throughout the year even as challenges from no or limited access to areas of the site and diversion of a large number of resources to implement the recovery plan were experienced.
Set objectives, targets, and measures to continually improve performance.	Eighty-three percent of FY 2014 targets were met even as significant resources were diverted to support response and recovery of the site. The ability of the EMS to be responsive to changing circumstances was demonstrated as objectives and targets were adjusted to reflect the changed focus of site operations.
Seek to achieve sustainable operations through safe, responsible and cost effective methods.	Progress in this area was not as strong as desired in the aftermath of the events of February 2014. However, it was recognized that the planned purchase of new and additional equipment presents a unique opportunity in the area of reducing energy use and sustainable procurement of products. Thus, a target was established to set performance specifications for new energy using equipment to be either Energy Star rated or in the upper 25 percent efficiency for the class of equipment (e.g., ventilation systems.)
Be an environmentally responsible neighbor.	Performance in this category did not fully meet this policy commitment during the early stages of managing the fire and radiological release events with respect to communicating with stakeholders (including regulators). Internally, we gauged our performance as not being as transparent as called for by the policy. This resulted not from intent but from a level of experience in managing the aftermath of events that generate significant level of interest from stakeholders.

After the early stages of event management, implementation of the policy commitment for transparency and communication has been particularly strong with extensive communication with regulators, local communities, and other stakeholders. Among the methods of communication are the following:

- Weekly teleconferences were held with regulators.
- Town hall meetings were conducted, first weekly, transitioning to bi-weekly and monthly, as the emergency phase of the response transitioned to the recovery phase.
- Sampling results were made available to the public as soon as possible after data were received and validated.
- The WIPP Recovery Website was established and maintained, providing stakeholders with easy access. to event-related information.

As summarized in Section 3.1, plans were initiated to accomplish needed improvements to several of the programs that implement the EMS as a result of event investigation and program evaluations.

3.3.3 Sustainability Progress (Continuous Improvement)

Continuous improvement in environmental performance is demonstrated by the project's contribution toward the DOE sustainability goals established under EOs 13514 and 13423. As shown in Figure 3.1, the WIPP project continued to make progress toward the 75 percent of DOE goals that are applicable to WIPP operations. Limited progress has been made relative to the DOE goals (remaining 25 percent) that are applicable, on a more limited basis, to the WIPP project or for which necessary infrastructure precludes cost effectiveness. Specific performance is summarized in the remainder of this section.

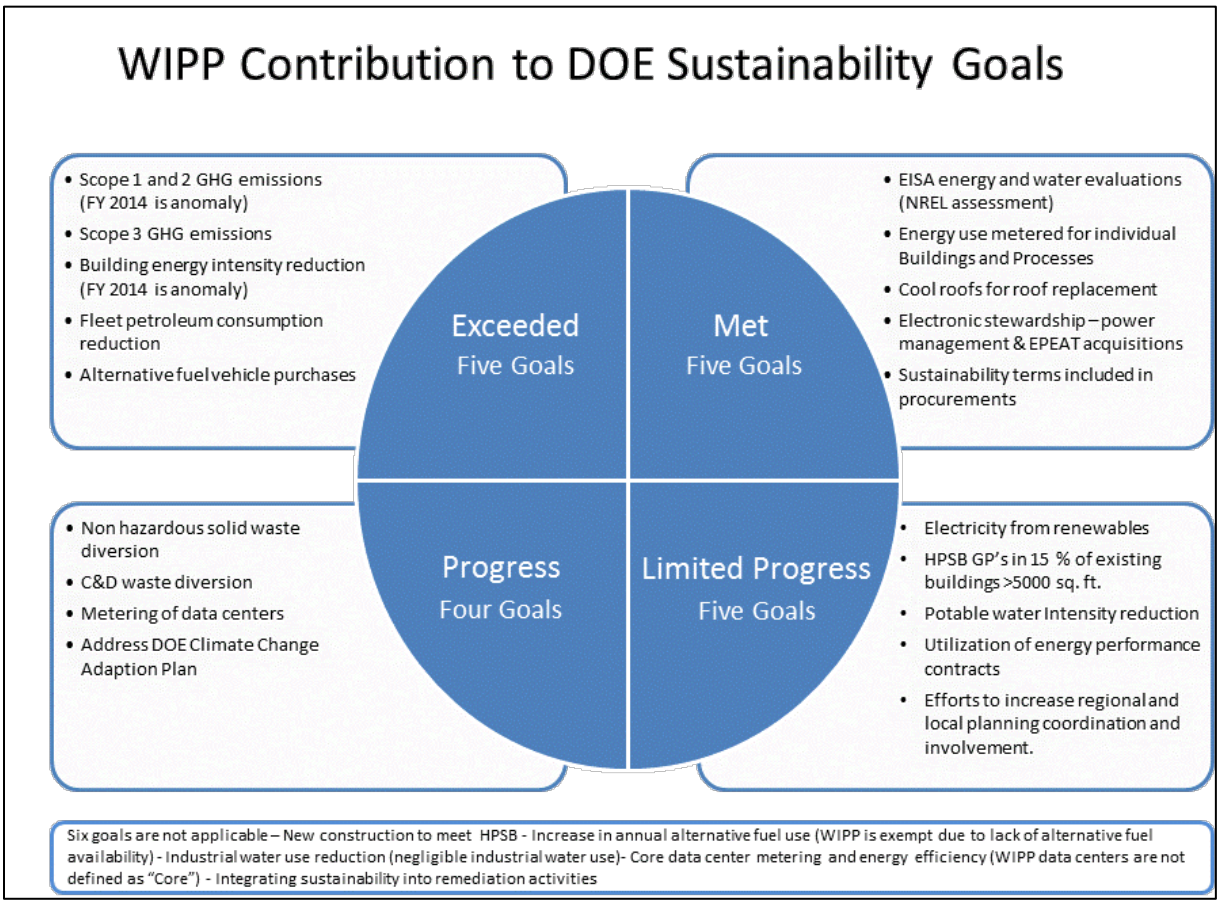


Figure 3.1 – WIPP Project Contribution to DOE Sustainability Goals

Reduce Greenhouse Gas Emissions

The WIPP project comprehensive greenhouse gas inventory (Figure 3.2) reveals that that the largest contributors to the WIPP project greenhouse gas footprint are electricity use (Scope 2) and business travel and employee commute to the WIPP site (Scope 3).

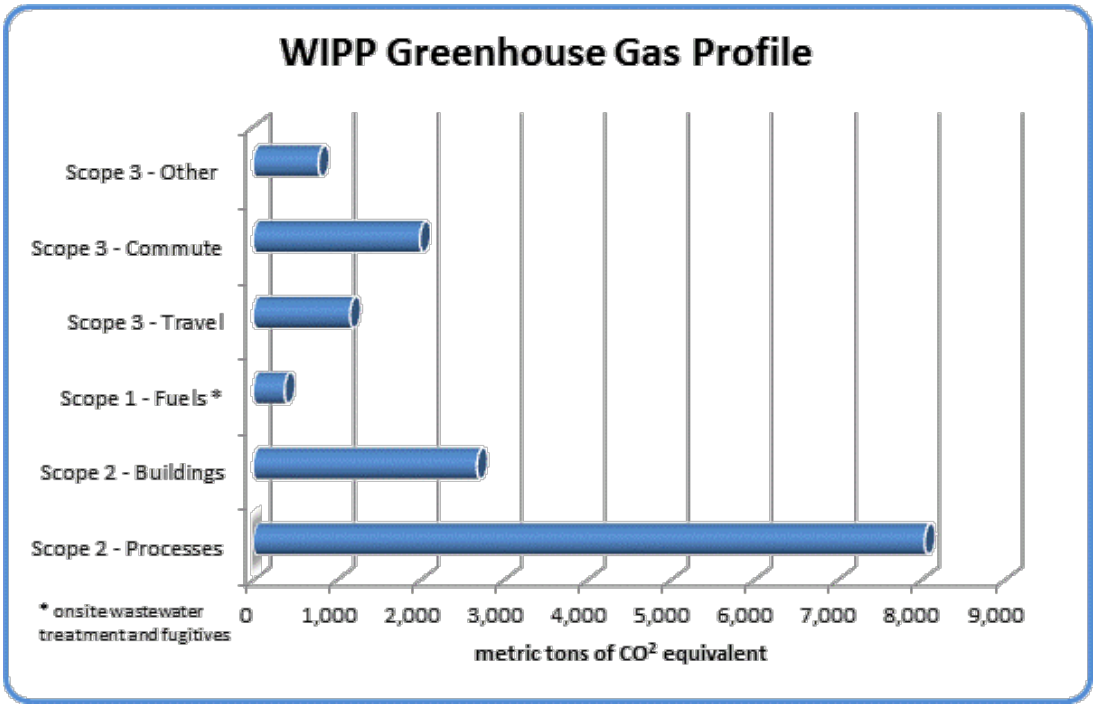


Figure 3.2 – WIPP Project Greenhouse Profile

Given the profile, the priority for greenhouse gas reduction at the WIPP project is electricity use, with secondary emphasis on business travel and petroleum fuel use.

Progress in reducing Scope 1 and Scope 2 greenhouse gas emissions is illustrated in Figure 3.3.

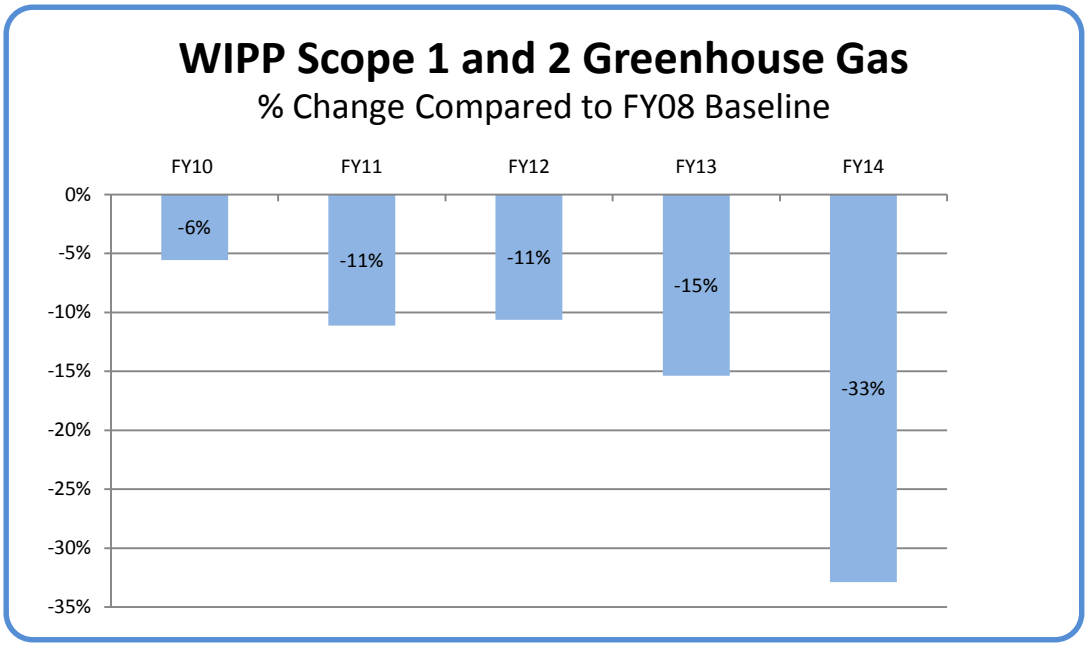


Figure 3.3 – Scope 1 and 2 Greenhouse Emission Trend

The significant reductions in Scope 1 and 2 greenhouse gas emissions in FY 2014 are a result of reduced operations at the WIPP facility, especially those involving process equipment, for a large portion of the year. This level of reduction cannot be expected in future years. Energy and fuel use will likely increase as additional ventilation systems are constructed and come online, as a large number of diesel-fueled equipment is replaced, and as additional new industrial equipment is put into operation. As equipment is upgraded or replaced, the DOE maintains its focus on energy and fuel efficiency.

Sustainability highlights for 2014 are:

Energy Efficiency Replacement of the heating, ventilation, and air conditioning system in Training Building 489 was completed using variable refrigerant flow technology. The new system replaced a 20-year-old traditional fan/coil system that used electric resistance heat. Initial savings are estimated to be 220,000 kilowatt hour per year (FY 2014 dollars). The new system significantly improved occupant comfort.

Building Metering Building meters were installed for measuring energy use in each of three temporary modular office buildings procured for housing additional personnel needed for recovery operations.

Overall, 100 percent of required buildings and 97 percent of process energy use is metered. WIPP facility advanced metering allows detailed monitoring of significant site loads for analysis of energy use.

Cool Roofs Cool roofs were specified for the three temporary modular buildings. The buildings are to be installed in CY 2015. Cool roof technology (increased roof insulation and reflective surface) has been applied on 13 existing buildings as part of roof repairs.

Fleet/Fuel Improvements Ninety-two percent of the WIPP fleet consists of alternative-fuel or hybrid vehicles.

Petroleum use was reduced by 31 percent compared to the FY 2005 baseline by consolidating/reducing trips, using more fuel-efficient or hybrid vehicles, and use of car pools for CBFO personnel traveling to the WIPP site. The reduced number of trips to the site for several months after the February events also contributed to the reduction.

Renewable Energy The WIPP project was not able to install the photovoltaic equipment planned for 2014. This project was carried forward as a FY 2015 environmental target.

As the graph in Figure 3.4 demonstrates, Scope 3 greenhouse gas emissions continue to decrease compared to the FY 2008 baseline. The overall Scope 3 reduction in FY 2014 was 44 percent, a significant improvement from baseline levels.

These reductions resulted from personnel increasing their use of options such as teleconferencing or webcasting. The small increases in business travel and employee commute compared to FY 2013 were a result of increases in travel needed to support recovery activities.

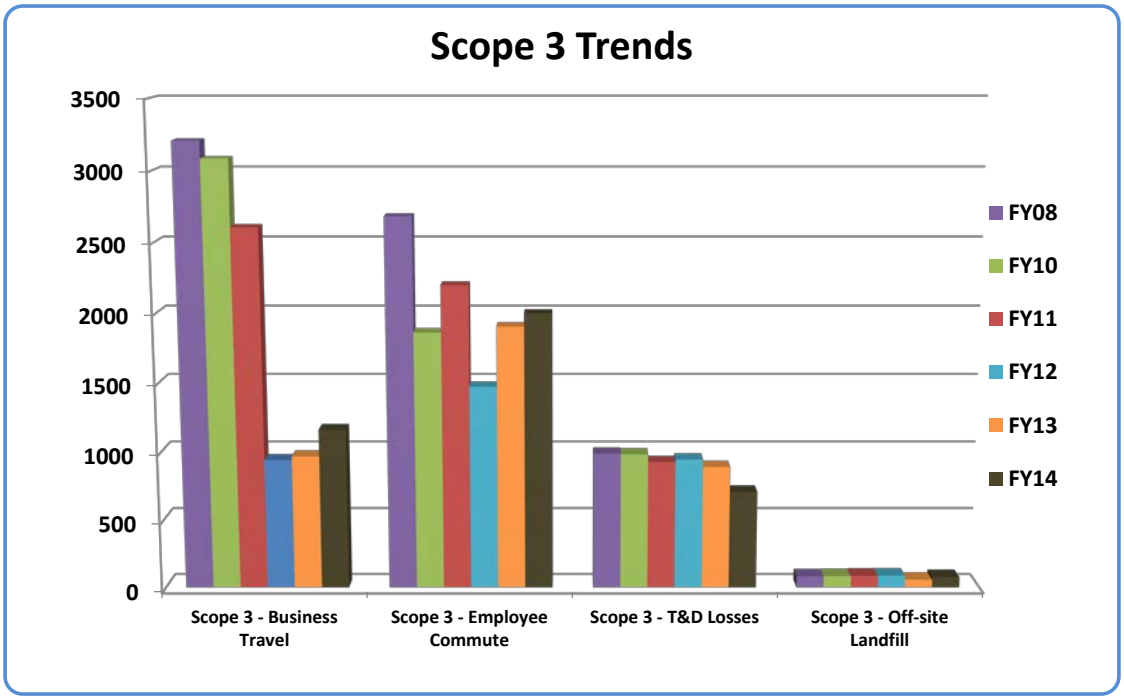


Figure 3.4 – Scope 3 Greenhouse Gas Trend

Water Efficiency and Management

WIPP facility water use is illustrated in Figure 3.5. The graphs show that reductions have been made in both total volume of water used (graph on left) and water used per employee per day (graph on right).

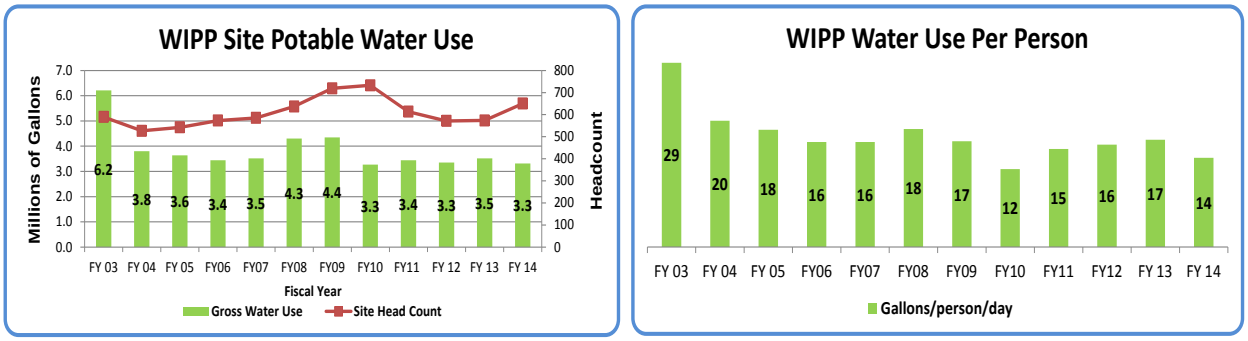


Figure 3.5 – WIPP Site Annual Potable Water Use

As shown in the figure, between FY 2003 and FY 2007 water consumption decreased significantly, then increased in FY 2008 and 2009, and has remained relatively constant from FY 2011 forward. The FY 2008 and 2009 increases were primarily due to a leak in a fire protection line and increases in site personnel to staff projects implemented to enhance the site's ability to accomplish its mission. Personnel increases related to mining and waste disposal in FY 2008, FY 2009, and portions of FY 2010 resulted in increased water use.

The WIPP project has dedicated resources to water distribution system maintenance and repair for the past seven years. The relatively consistent levels of water use from FY 2011 through FY 2014 are reflective of the unchanging headcount and progress in firewater system maintenance and identification and repair of leaks. Further significant water use reductions are unlikely.

The WIPP project monitors average water use per employee per day as an external reference point for gauging efficiency compared to other industrial facilities. As shown in Figure 3.5, water use at WIPP is low for an industrial operation, averaging 14 gallons per person per day in FY 2014. Average water use at comparable industrial facilities is 25 gallons per person per day, almost 45 percent higher than WIPP facility water use.

Recycling and Waste Diversion

Waste diversion and recycling are key components of the WIPP project sustainability program. WIPP waste streams that are recycled at regional recycling facilities include selected nonhazardous, C&D, hazardous, universal, and New Mexico special wastes.

As part of the project sustainability program, the WIPP facility recycles alkaline batteries, aluminum cans, cardboard, fencing, paper, plastic, metal, toner cartridges, used motor oil, antifreeze, universal batteries, electronics (e.g., ballasts, computers, circuit boards), wood pallets, and fluorescent tubes.

The DOE target to divert 50 percent of nonhazardous solid waste and C&D debris by FY 2015 is in alignment with EO 13514 expectations. Nonhazardous and C&D materials diverted at the WIPP facility and FY 2014 performance are highlighted in Figure 3.6.

Nonhazardous & C&D Wastes Recycled
Alkaline Batteries
Aluminum Cans
Cardboard
Fencing
Paper
Plastic
Toner Cartridges
Wood Waste
Metals

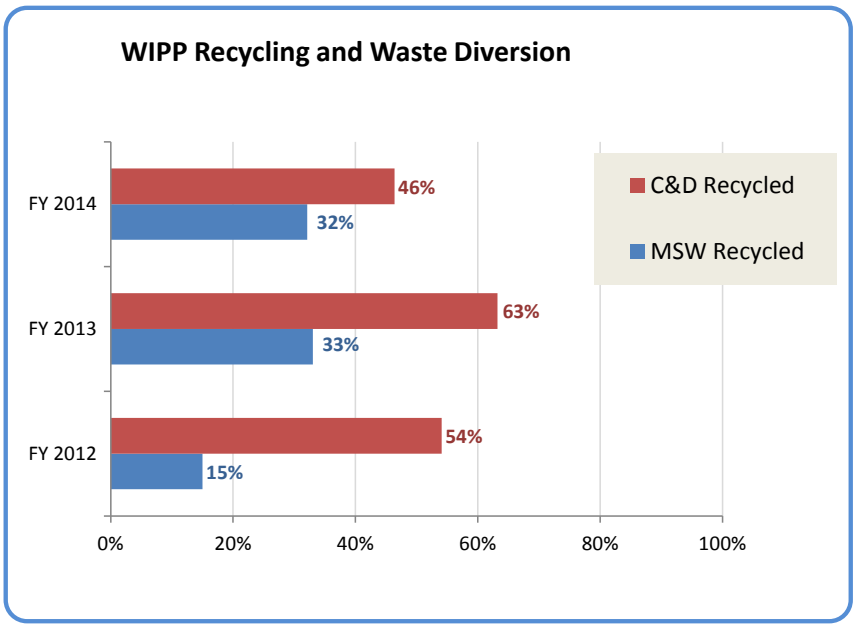


Figure 3.6 – WIPP Project Recycling and Waste Diversion

During the year DOE accomplished significant cleanup at several WIPP facility equipment storage yards. Figure 3.7 summarizes the results of the lay down yard cleanup.

Lay Down Yard Clean-up

	Weight (pounds)
Donated	56,000
Recycled	21,500
Total Diverted	77,500

Equipment Transferred to the Bureau of Land Management for Reuse.

Figure 3.7 – Lay Down Yard Cleanup

Recycling awareness was maintained through the distribution of the P2 News publication, which encouraged employees to use duplex printing, turn computers off at the end of shift, use electronic files when possible, segregate wood waste for reuse or recycling, participate in the recycling program, purchase sustainable products, and reduce energy and water use.

Sustainable Acquisition

Sixty-five percent of office products purchased in FY 2014 contained recycled content, compared to 61 percent in FY 2013. There continue to be no Class 1 ozone-depleting substances on site. The WIPP project participants continued to use 30 percent recycled content paper and sustainable janitorial products when those products meet cost, performance, and sustainability criteria.

Procedures are in place to ensure sustainable acquisition criteria are specified in applicable procurements and sustainable materials are used when they meet cost, availability, and performance criteria. Procurement procedures also ensure that ozone depleting substances are not purchased. Training for procurement card holders, purchase requisitioners, project personnel, and procurement personnel on sustainable purchasing continued in FY 2014.

Electronics Stewardship and Data Centers

WIPP project participants continued to use sustainable life-cycle management of electronics as demonstrated in Figure 3.8.

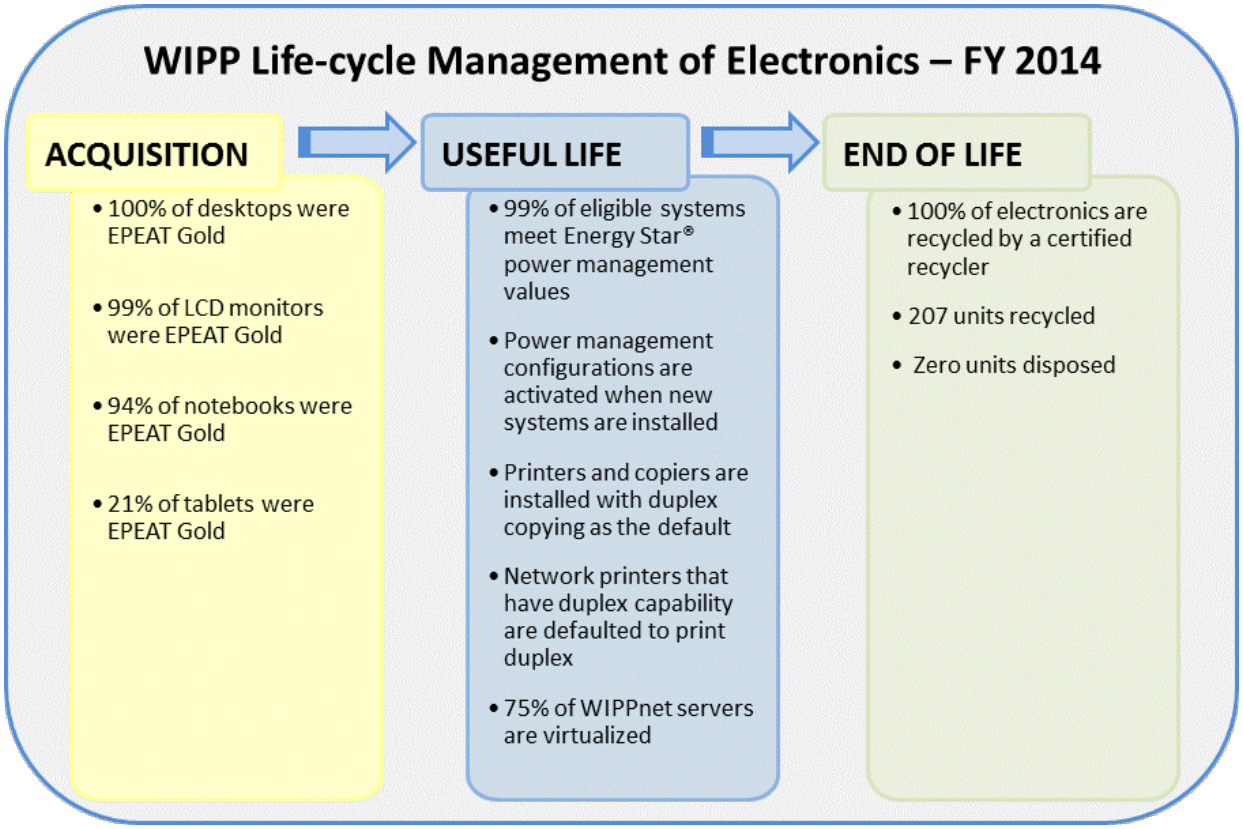


Figure 3.8 – Life-Cycle Management of Electronics at the WIPP Project

3.4 EMS Awards

The WIPP project did not receive any environmental or EMS awards during this reporting period.

CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

DOE Order 458.1 states that the DOE must conduct radiological activities to ensure that

- exposure to members of the public is maintained within the dose limits established in the order;
- the radiological clearance of DOE real and personal property is controlled;
- potential radiation exposures to members of the public are as low as is reasonably achievable;
- DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public and;
- protection of the environment from the effects of radiation and radioactive material is provided.

Radionuclides present in the environment, whether naturally occurring or human-made, may result in radiation doses to humans. Therefore, environmental monitoring around nuclear facilities is imperative to characterize radiological baseline conditions, identify any releases, and determine the effects of releases should they occur.

Personnel at the WIPP facility sample air, groundwater, surface water, soils, sediments, and biota to monitor the radiological environment around the facility. This monitoring is carried out in accordance with the *WIPP Environmental Monitoring Plan*. The radiological effluent monitoring portion of this plan meets the requirements contained in DOE/EH–0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*.

For the WIPP facility, the DOE, is required to comply with environmental radiation protection standards in 40 CFR §191.03, Subpart A, which applies to management and storage of radioactive waste. The standards in 40 CFR §191.03(b) state that management and storage of TRU waste at DOE facilities shall be conducted in a manner that provides reasonable assurance that the annual radiation to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed specified limits. Based on analysis of WIPP facility operations, the DOE has identified air emissions as the only plausible pathway for radionuclide transport during receipt and emplacement of TRU waste Waste operations, including the underground TRU waste disposal areas and the WHB, are monitored through the WIPP airborne effluent monitoring program.

The environmental dose standards for the WIPP facility can be found in 40 CFR Part 191, Subpart A, which specifies that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not

exceed 25 mrem to the whole body and 75 mrem to any critical organ. In a 1995 memorandum of understanding between the EPA and the DOE, the DOE agreed that the WIPP facility would comply with 40 CFR Part 61, "National Emission Standards for Hazardous Air Pollutants" (NESHAP), Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities." The NESHAP standard (40 CFR §61.92) states that the emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (EDE) of 10 mrem.

The *Statistical Summary of the Radiological Baseline for the Waste Isolation Pilot Plant* (DOE/WIPP–92–037) summarizes the radiological baseline data obtained at and near the WIPP site during the period 1985 through 1989, prior to the time that the WIPP became operational. Radioisotope concentrations in environmental media sampled under the current ongoing monitoring program are compared with this baseline to gain information regarding annual fluctuations. Appendix H presents data that compare the highest concentrations of radionuclides detected to the baseline data.

The sampling media for the Environmental Monitoring Program include airborne particulates, soil, surface water, groundwater, sediments, and biota (vegetation and animals). These samples are analyzed for 12 radionuclides, including natural uranium ($^{233/234}$U, ^{235}U, and ^{238}U); ^{40}K; TRU actinides expected to be present in the waste (plutonium [^{238}Pu, $^{239/240}$Pu], and americium [^{241}Am]); major fission products (cesium [^{137}Cs] and strontium [^{90}Sr]); and reactor structural materials (cobalt [^{60}Co]). Environmental levels of these radionuclides could provide corroborating information on which to base conclusions regarding releases from WIPP facility operations.

Table 4.1 lists the target radionuclides included in the Environmental Monitoring Program along with their radiation type, method of detection, and reason for monitoring. The WIPP airborne effluent monitoring program also monitors for these same radionuclides with the exception of ^{235}U, ^{40}K, and ^{60}Co.

Radionuclides are considered detected in an environmental sample if the measured concentration or activity is greater than the total propagated uncertainty (TPU) at the 2 sigma (σ) TPU level, and greater than the minimum detectable concentration (MDC). This methodology was patterned after that described in "Hanford Decision Level for Alpha Spectrometry Bioassay Analyses Based on the Sample-Specific Total Propagated Uncertainty" (MacLellan, 1999). The MDC is determined by the analytical laboratory based on the natural background radiation, the analytical technique, and inherent characteristics of the analytical equipment. The MDC represents the minimum concentration of a radionuclide detectable in a given environmental sample using the given equipment and techniques with a specific statistical confidence (usually 95 percent). The TPU is an estimate of the uncertainty in the measurement due to all sources, including counting error, measurement error, chemical recovery error, detector efficiency, randomness of radioactive decay, and any other sources of uncertainty.

Table 4.1 – Radioactive Nuclides Monitored at the WIPP Site

Radionuclide	Radiation	Detection Method	Reason for Monitoring
$^{233/234}U$	Alpha	Alpha spectroscopy	Naturally occurring
^{235}U	Alpha	Alpha spectroscopy	Naturally occurring
^{238}U	Alpha	Alpha spectroscopy	Naturally occurring
^{40}K	Gamma	Gamma spectroscopy	Ubiquitous in nature
^{238}Pu	Alpha	Alpha spectroscopy	Component of waste
$^{239/240}Pu$	Alpha	Alpha spectroscopy	Component of waste
^{241}Am	Alpha	Alpha spectroscopy	Component of waste
^{137}Cs	Gamma	Gamma spectroscopy	Fission product/potential component of waste
^{60}Co	Gamma	Gamma spectrometry	Activation product of reactor structural materials
^{90}Sr	Beta	Gas proportional counting	Fission product/potential component of waste

Note: The radionuclides ^{243}Am, ^{242}Pu, and ^{232}U are used as tracers in the WIPP Laboratories.

Measurements of radioactivity in environmental samples are actually probabilities due to the random nature of the disintegration process. The radioisotope in the sample is decaying as it is being measured, so no finite value can be assigned. Instead, the ranges of possible activities are reported by incorporating the TPUs of the method.

For radionuclides in environmental samples determined by gamma spectroscopy (^{137}Cs, ^{60}Co, and ^{40}K), an additional factor considered in the determination of detectability is the identification confidence (ID confidence) with which the peak or peaks associated with the particular radionuclide can be identified by the gamma spectroscopy software. If the activity of the radionuclide is greater than 2 σ TPU and MDC and the ID confidence is greater than or equal to 0.90, the radionuclide is detected. If the sample activity is greater than the 2 σ TPU and the MDC, but the ID confidence is less than 0.90, the radionuclide is not detected. If the sample activity is less than the 2 σ TPU and/or the MDC even if the ID confidence is >0.90, the radionuclide is not detected. And it follows that if the sample activity is less than the 2 σ TPU and/or the MDC and the ID confidence is less than 0.90, the radionuclide is not detected. Note that in previous ASERs the lab reported a few gamma detections based soely on an ID confidence greater than or equal to 0.9 without consideration of the sample activity realative to the toal propagated uncertainty and MDC. However, the identification criteria have been revised for 2014 as described above.

Sample results are also normalized with the instrument background and/or the method blank. If either of those measurements have greater activity ranges than the actual sample, it is possible to get negative values on one end of the reported range of activities. Additional information on the equations used is provided in Appendix D.

WIPP Laboratories performed the analyses for the 12 target radionuclides in environmental radiological samples. Highly sensitive radiochemical analysis and detection techniques were used that resulted in very low detection limits. This allowed detection of radionuclides at concentration levels far below those of environmental and

human health concerns. The MDCs attained by WIPP Laboratories were below the recommended MDCs specified in ANSI N13.30, *Performance Criteria for Radiobioassay*.

Comparisons of radionuclide concentrations in environmental samples were made between years and between locations using the analysis of variance (ANOVA) statistical procedure for those data sets containing a sufficient number of detects to make such comparisons statistically meaningful. When this or other statistical tests were used, the *p* value was reported. The *p* value is the probability under the null hypothesis of observing a value as unlikely as or more unlikely than the value of the test statistic. The *p* value is the significance level for ANOVA calculations. A value of $p > 0.05$ indicates no significant difference in the values from a data set, and a value of $p < 0.05$ indicates a significant difference in the values from a data set. In many cases, scientists have accepted a value of $p < 0.05$ as indicative of a difference between samples.

Interpretation of *p* values requires some judgment on the part of the reader, and individual readers may choose to defend a higher or lower value for *p* as the cutoff value. However, for this report, a *p* value of 0.05 was used.

The air monitoring for radionuclides is divided between two programs: the WIPP facility effluent monitoring program and the Environmental Monitoring Program. Descriptions of these two programs are provided in the following sections.

Effluent Monitoring Program

There are three airborne effluent monitoring stations in use at the WIPP facility: Stations A, B, and C. Each station employs one or more fixed air samplers, collecting particulates from the effluent air stream using an acrylic copolymer membrane filter. Fixed air samplers at Station A sample the unfiltered underground exhaust air. At Station B, samples are collected from the underground exhaust air after HEPA filtration, and sometimes from non-filtered air. At Station C, samples are collected from the exhaust air from the WHB after HEPA filtration.

As of the radiological release event on February 14, 2014, the Station A sampler is no longer representative of the emissions to the environment, since the airstream continues through HEPA filtration before being released through the Station B exhaust duct. Since the radiological release event, the Station B sampler is the sampler of record for the underground repository ventilation system. Station C was not affected by the release event, and continued to operate routinely during CY 2014.

For each sampling event, chain-of-custody forms are initiated to track and maintain an accurate written record of filter sample handling and treatment from the time of sample collection through laboratory procedures to disposal. During 2014, filter samples from the three effluent air monitoring stations were analyzed for ^{238}Pu, $^{239/240}Pu$, ^{241}Am, ^{90}Sr, ^{137}Cs, $^{233/234}U$, and ^{238}U.

Environmental Monitoring Program

The purpose of the radiological Environmental Monitoring Program is to measure radionuclides in the ambient environmental media. These data allow for a comparison of sample data to results from previous years and baseline data, to determine what impact, if any, the WIPP facility is having on the surrounding environment. Radiological monitoring at the WIPP site includes sampling and analysis of air, groundwater, surface water, sediment, soil, and biota. For each sampling event, chain-of-custody forms were initiated to track and maintain an accurate written record of sample handling and treatment from the time of sample collection through delivery to the laboratory. Internal chain-of-custody forms are used by the laboratory to track and maintain custody while samples are at the laboratory. The radionuclides analyzed were ^{238}Pu, $^{239/240}$Pu, ^{241}Am, $^{233/234}$U, ^{235}U, ^{238}U, ^{137}Cs, ^{60}Co, ^{40}K, and ^{90}Sr. Plutonium and americium isotopes were analyzed because they are the most significant alpha-emitting radionuclides among the constituents of TRU wastes received at the WIPP facility. Uranium isotopes were analyzed because they are prominent alpha-emitting radionuclides in the natural environment.

Strontium-90, ^{60}Co, and ^{137}Cs were analyzed to demonstrate the ability to quantify these beta and gamma-emitting radionuclides should they appear in the TRU waste stream. Potassium-40, a natural gamma-emitting radionuclide that is ubiquitous in the earth's crust, was also monitored.

The environmental sampling program was impacted by the release event on February 14, 2014. A large number of additional samples were collected in 2014 to support the evaluation of the event. The additional samples included air particulate filters, surface water, soil, and vegetation. Most of these samples were only analyzed for the radionuclides associated with the release event including ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, although a few samples were analyzed for the 12 target radionuclides.

The radionuclide analysis results for the traditional ASER samples are provided in this section of the ASER and in the appendices, while the data for the additional samples associated with the release event are provided in a separate report. WIPP Environmental Radiological Field Sampling Analytical Summary February 2014 to February 2015 (DOE/WIPP-15-3547) provides the data for the additional air particulate samples, as well as the data for the surface water samples of opportunity (SOO), soil data for the additional samples, and vegetation data for the additional samples. Pertinent information from the data in DOE/WIPP-15-3547 (e.g., any radionuclide detections) is discussed in the following sections.

4.1 Effluent Monitoring

4.1.1 Sample Collection

Stations A, B, and C use skid-mounted fixed air samplers at each effluent air monitoring station. The volume of air sampled at each location varied depending on the sampling location and configuration. Each system is designed to provide a representative sample using a 3.0-micrometer pore size, 47-millimeter diameter acrylic copolymer membrane filter.

Daily (24-hour) filter samples were collected from Station A from the unfiltered underground exhaust stream. Each day at Station A, approximately 81.3 cubic meters (m^3) (2,869 cubic feet [ft^3]) of air were filtered through the acrylic copolymer membrane filter. As of the radiological release event on February 14, 2014, Station A was no longer designated as an emissions sampler, and has been used since that time to track radioactivity concentrations in ventilation air from the repository before it enters the HEPA filtration system.

Prior to the February 14, 2014 radiological release event, weekly filter samples were collected at Station B, which operates 24 hours a day, seven days a week. Station B samples the underground exhaust air after HEPA filtration, and sometimes the nonfiltered air during maintenance. Each week at Station B, approximately 584.64 m^3 (20,646 ft^3) of air were filtered through the acrylic copolymer membrane filter. Based on the specified sampling periods, these air volumes were within plus or minus (±) 10 percent of the volume derived using the flow rate set point of 0.057 m^3/min (2 ft^3/min) for Stations A and B. As of the radiological release event on February 14, 2014, Station B became the primary emissions sample point of record, but the flow rates and sampler characteristics were not materially changed from before the event. Since the primary emission samples are collected daily, at Station B, 83.3 m^3 (2,941 ft^3) of air were filtered through the acrylic copolymer membrane filter at the average annual sample flow rate of 2.049 ft^3/min.

Weekly filter samples were collected at Station C, which samples the air from the WHB after HEPA filtration. The amount of air filtered through the Station C acrylic copolymer membrane filters during 2014 was 4,981.1 m^3 (175,905 ft^3). Even though there were several periods where sampling associated with Station C was interrupted during CY 2014, total air volume sampled was within the specified recovery limits. Associated WHB fixed air sampler results were assessed for those gaps to ascertain that no releases occurred during the sample interruptions. The calculated air volume for Station C was within ±10 percent of the average volume derived using the flow rate required for isokinetic sampling conditions. The sampling flow rate for Station C varied according to the exhaust air flow in the WHB in order to maintain isokinetic sampling conditions.

The Station C effluent air sampling system was designed in accordance with ANSI Standard N13.1 1969. The CY 2011 update of the flow control system replaced obsolete instruments with their current models. The isokinetic sampling configuration did not change, thus maintaining compliance with the 1969 standard. This was necessary since ANSI/HPS N13.12–1999 does not address isokinetic sampling.

The filter samples for Station C were composited each quarter. Because of the large quantity of filters from Station A, samples were composited monthly until the radiological release event in February. Since that time, Station B has been the sample point of record for emissions from the underground repository. During the post event assessment phase, samples were collected initially three times per day.

To track the emissions trend and to ascertain that no further unexpected releases occurred. After the individual filter analysis phase was completed for February post-event samples, the March and April sample filters were composited by week, and the May composite split into two groups, to stay under the maximum number of filters that could be analyzed per composite. Station B sample collection occurred daily starting in May through the end of CY 2014. Filter sample composites were radiochemically analyzed for ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs.

4.1.2 Sample Preparation

The samples collected daily and weekly were grouped into monthly and quarterly filter sample composites, respectively. For the initial three months after the event, the samples from Station B were collected more than once daily, so several composites were assembled each month in order to limit the number of samples per composite to about 40 filters. The composites were transferred to borosilicate beakers, spiked with appropriate tracers (^{232}U, ^{243}Am, and ^{242}Pu), and heated in a muffle furnace at 250 degrees Celsius (°C) (482 degrees Fahrenheit [°F]) for two hours, followed by two hours of heating at 375°C (707°F) and six hours of heating at 525°C (977°F).

The filters were ashed and cooled, and then transferred into polytetra-fluoroethylene beakers by rinsing with concentrated nitric acid and heated with concentrated hydrofluoric acid until completely dissolved. Hydrofluoric acid was removed by evaporation to dryness.

Approximately 25 milliliters (0.845 fluid ounce) of concentrated nitric acid and 1 gram (0.0353 ounce) of boric acid (to remove residual hydrofluoric acid) and carriers (strontium nitrate and barium nitrate) were added, and the samples were heated and evaporated to dryness. The sample residues were dissolved in 8 molar nitric acid for gamma spectroscopy and measurement of ^{90}Sr and the alpha-emitting radionuclides.

4.1.3 Determination of Individual Radionuclides

Gamma-emitting radionuclides were measured in the air filters by gamma spectroscopy. Strontium-90 and alpha-emitting radionuclides were measured by sequential separation and counting. Strontium-90 was counted on a gas proportional counter. The actinides were co-precipitated, separated on an anion exchange column, and analyzed by alpha spectroscopy.

4.1.4 Results and Discussion

From 24 total composite samples taken in 2014, 182 analyses were performed, as shown in Tables 4.2 through 4.9. The analytes of interest were ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs. For those 43 non-composited samples individually measured during the initial event assessment for key radionuclides (^{241}Am, ^{238}Pu, $^{239/240}$Pu), the remaining radionuclides were scaled to estimate the remaining radionuclides of interest (^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs). Those scaled values are included in Tables 4.4 through 4.6.

Radionuclides are considered detected in a sample if the measured activity is greater than the 2 σ TPU and MDC. Radioanalytical results of air filter samples representing WIPP facility air emissions in CY 2014 are shown in Tables 4.2 through 4.9. The CAP88-PC radioactivity input criterion was to compare the 2 σ TPU with the activity value. The higher result of the two was selected for the nuclide data input for the CAP88–PC dataset report, ensuring a conservative bias to the dataset.

A calibration check of Station C instrumentation in CY 2013 determined that, since the installation in May 2011, the equipment had developed a biased flow output signal, and was indicating a sample flow rate higher than actual. The bias correction applied to the sample-to-exhaust flow ratio resulted in an increase in overall facility emissions of about 11 percent more than what had been previously reported for CY 2012. The equipment was restored to proper specifications in late CY 2013, and the corrections are included in the CY 2013 source term compilation.

Table 4.2 – Station A Pre-Event CY 2014 Sample Results

Month	Nuclide	Activity	2σ TPU[a]	MDC[b]
		Bq/sample	Bq/sample	Bq/sample
January	^{241}Am	1.96E-04	4.81E-04	9.81E-04
February	^{241}Am	5.37E-04	9.10E-04	1.57E-03
Feb Special [c]	^{241}Am	-2.26E-04	1.46E-03	2.43E-03
January	^{238} Pu	-2.01E-04	3.10E-04	9.18E-04
February	^{238} Pu	-8.94E-05	2.41E-04	8.57E-04
Feb Special	^{238} Pu	-3.22E-04	6.29E-04	1.25E-03
January	$^{233/234}$U	9.07E-04	7.33E-04	1.01E-03
February	$^{233/234}$U	2.31E-04	4.21E-04	9.71E-04
Feb Special	$^{233/234}$U	3.67E-04	5.59E-04	7.96E-04
January	^{137}Cs	6.25E-02	5.14E-01	5.59E-01
February	^{137}Cs	4.77E-02	4.44E-01	4.81E-01
Feb Special	^{137}Cs	1.32E-01	3.66E-01	4.03E-01

Month	Nuclide	Activity	2σ TPU	MDC
		Bq/sample	Bq/sample	Bq/sample
January	$^{239/240}$Pu	-1.30E-04	2.48E-04	9.73E-04
February	$^{239/240}$Pu	-2.31E-05	3.89E-04	9.07E-04
Feb Special	$^{239/240}$Pu	8.77E-05	3.81E-04	7.77E-04
January	^{90}Sr	4.77E-03	3.85E-02	2.79E-02
February	^{90}Sr	-7.06E-03	2.81E-02	2.56E-02
Feb Special	^{90}Sr	-1.49E-02	3.66E-02	2.77E-02
January	^{238}U	1.18E-03	8.29E-04	7.22E-04
February	^{238}U	2.72E-04	4.50E-04	9.42E-04
Feb Special	^{238}U	-5.44E-05	1.76E-04	8.40E-04

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) Sub-composite for smoke analysis after February undergound fire

Table 4.3 – Station B Pre-Event CY 2014 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	-8.25E-04	1.07E-03	2.36E-03
	$^{239/240}$Pu	-5.14E-05	1.92E-04	8.73E-04
	$^{233/234}$U	1.51E-03	9.21E-04	9.81E-04
	^{137}Cs	-6.99E-02	3.66E-01	3.96E-01

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU	MDC
1st	^{238} Pu	-7.88E-05	2.39E-04	1.05E-03
	^{90}Sr	-7.25E-03	2.93E-02	2.08E-02
	^{238}U	9.51E-04	7.55E-04	9.10E-04

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.

Table 4.4 – Station B Post-Event CY 2014 Special WIPP Labs Sample Results

Sample ID	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
B130214140754	^{241}Am	8.98E+02	1.37E+02	2.87E+00
B130215140835 [c]	^{241}Am	1.15E+03	NA	NA
B130215141445	^{241}Am	1.36E+01	2.22E+00	4.97E-01
B130215142305	^{241}Am	4.00E+00	2.10E-01	5.47E-03
B130216140904	^{241}Am	1.95E+00	1.19E-01	4.98E-03
B130216141705	^{241}Am	7.85E-01	1.04E-01	5.73E-03
B130217140030	^{241}Am	4.75E-01	5.58E-02	6.70E-03
B130217140805	^{241}Am	7.82E-01	6.53E-02	8.25E-03
B130217141600	^{241}Am	1.07E+01	1.70E+00	2.58E-01
B130218140030	^{241}Am	4.00E-01	5.05E-02	7.63E-03
B130218140901	^{241}Am	5.25E-01	4.73E-02	7.72E-03
B130218141655	^{241}Am	2.98E-01	3.70E-02	7.98E-03
B130221141600	^{241}Am	6.40E-01	6.30E-02	6.88E-03
B13102114 [d]	^{241}Am	9.07E-01	7.15E-02	4.95E-03
B130214140754	^{238} Pu	5.70E+00	7.51E-01	NR
B130215140835 [c]	^{238} Pu	7.31E+00	NA	NA
B130215141445	^{238} Pu	9.21E-02	2.67E-02	1.78E-02
B130215142305	^{238} Pu	2.63E-02	1.49E-02	1.78E-02
B130216140904	^{238} Pu	2.29E-02	1.38E-02	1.78E-02
B130216141705	^{238} Pu	6.03E-03	8.03E-03	1.80E-02
B130217140030	^{238} Pu	-2.24E-05	1.72E-03	1.77E-02
B130217140805	^{238} Pu	5.18E-03	1.12E-02	1.78E-02
B130217141600	^{238} Pu	6.77E-02	2.43E-02	1.70E-02
B130218140030	^{238} Pu	1.52E-03	7.70E-03	1.72E-02
B130218140901	^{238} Pu	6.18E-03	8.95E-03	1.65E-02
B130218141655	^{238} Pu	2.03E-03	4.66E-03	1.62E-02
B130221141600	^{238} Pu	2.92E-03	6.81E-03	5.65E-03
B13102114 [d]	^{238} Pu	1.15E-02	3.74E-03	1.08E-03
B130214140754	$^{233/234}$U	4.18E-02	2.88E-02	1.15E-02
B130215140835 [c]	$^{233/234}$U	5.37E-02	NA	NA
B130215141445	$^{233/234}$U	6.33E-04	7.10E-05	NP
B130215142305	$^{233/234}$U	1.86E-04	6.73E-06	NP
B130216140904	$^{233/234}$U	9.08E-05	3.81E-06	NP
B130216141705	$^{233/234}$U	6.81E-04	3.25E-04	NP
B130217140030	$^{233/234}$U	4.12E-04	1.74E-04	NP
B130217140805	$^{233/234}$U	6.78E-04	2.04E-04	NP
B130217141600	$^{233/234}$U	9.29E-03	5.30E-03	NP
B130218140030	$^{233/234}$U	3.47E-04	1.57E-04	NP
B130218140901	$^{233/234}$U	4.56E-04	1.48E-04	NP
B130218141655	$^{233/234}$U	2.59E-04	1.15E-04	NP
B130221141600	$^{233/234}$U	5.56E-04	1.96E-04	NP
B13102114 [d]	$^{233/234}$U	2.75E-03	1.78E-03	9.52E-04
B130214140754	^{137}Cs	-1.29E-01	6.62E-01	3.48E-01
B130215140835 [c]	^{137}Cs	-1.66E-01	NA	NA
B130215141445	^{137}Cs	-1.95E-03	1.63E-03	NP
B130215142305	^{137}Cs	-5.75E-04	1.55E-04	NP
B130216140904	^{137}Cs	-2.80E-04	8.76E-05	NP
B130216141705	^{137}Cs	-3.46E-02	2.21E-01	NP
B130217140030	^{137}Cs	-2.09E-02	1.19E-01	NP
B130217140805	^{137}Cs	-3.45E-02	1.39E-01	NP
B130217141600	^{137}Cs	-4.72E-01	3.61E+00	NP
B130218140030	^{137}Cs	-1.76E-02	1.07E-01	NP
B130218140901	^{137}Cs	-2.31E-02	1.01E-01	NP
B130218141655	^{137}Cs	-1.31E-02	7.87E-02	NP
B130221141600	^{137}Cs	3.20E-02	1.64E-01	8.80E-02
B13102114 [d]	^{137}Cs	6.70E-02	7.33E-01	3.82E-01

Sample ID	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
B130214140754	$^{239/240}$Pu	1.11E+02	3.48E+00	NR
B130215140835 [c]	$^{239/240}$Pu	1.42E+02	NA	NA
B130215141445	$^{239/240}$Pu	2.16E+00	1.42E-01	5.58E-03
B130215142305	$^{239/240}$Pu	6.81E-01	7.51E-02	6.65E-03
B130216140904	$^{239/240}$Pu	4.00E-01	5.85E-02	5.65E-03
B130216141705	$^{239/240}$Pu	2.28E-01	4.44E-02	6.10E-03
B130217140030	$^{239/240}$Pu	1.01E-01	2.90E-02	6.12E-03
B130217140805	$^{239/240}$Pu	1.98E-01	3.96E-02	6.10E-03
B130217141600	$^{239/240}$Pu	2.31E+00	1.54E-01	5.32E-03
B130218140030	$^{239/240}$Pu	9.47E-02	2.64E-02	4.90E-03
B130218140901	$^{239/240}$Pu	8.95E-02	2.72E-02	5.57E-03
B130218141655	$^{239/240}$Pu	5.18E-02	2.05E-02	5.83E-03
B130221141600	$^{239/240}$Pu	1.17E-01	3.17E-02	4.53E-03
B13102114 [d]	$^{239/240}$Pu	2.40E-01	1.94E-02	7.13E-04
B130214140754	^{90}Sr	-6.66E-02	1.47E-01	4.10E-02
B130215140835 [c]	^{90}Sr	-8.55E-02	NA	NA
B130215141445	^{90}Sr	-1.01E-03	3.63E-04	NP
B130215142305	^{90}Sr	-2.97E-04	3.44E-05	NP
B130216140904	^{90}Sr	-1.45E-04	1.95E-05	NP
B130216141705	^{90}Sr	-1.39E-03	1.80E-02	NP
B130217140030	^{90}Sr	-8.40E-04	9.66E-03	NP
B130217140805	^{90}Sr	-1.38E-03	1.13E-02	NP
B130217141600	^{90}Sr	-1.89E-02	2.94E-01	NP
B130218140030	^{90}Sr	-7.07E-04	8.74E-03	NP
B130218140901	^{90}Sr	-9.28E-04	8.19E-03	NP
B130218141655	^{90}Sr	-5.28E-04	6.40E-03	NP
B130221141600	^{90}Sr	-1.13E-03	1.09E-02	NP
B13102114 [d]	^{90}Sr	-9.44E-03	8.77E-02	2.72E-02
B130214140754	^{238}U	3.59E-03	9.36E-03	7.98E-03
B130215140835 [c]	^{238}U	4.61E-03	NA	NA
B130215141445	^{238}U	5.44E-05	2.31E-05	NP
B130215142305	^{238}U	1.60E-05	2.19E-06	NP
B130216140904	^{238}U	7.80E-06	1.24E-06	NP
B130216141705	^{238}U	4.81E-04	2.89E-04	NP
B130217140030	^{238}U	2.91E-04	1.55E-04	NP
B130217140805	^{238}U	4.79E-04	1.81E-04	NP
B130217141600	^{238}U	6.56E-03	4.71E-03	NP
B130218140030	^{238}U	2.45E-04	1.40E-04	NP
B130218140901	^{238}U	3.22E-04	1.31E-04	NP
B130218141655	^{238}U	1.83E-04	1.02E-04	NP
B130221141600	^{238}U	3.92E-04	1.74E-04	NP
B13102114 [d]	^{238}U	1.24E-03	1.18E-03	6.93E-04

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) Scaled from B130214140754 gross alpha
(d) Separately analyzed, not included in October composite
(NR) Statistic not reported
(NA) Statistic not available because central value was scaled from gross alpha
(NP) Statistic not provided because central value was scaled from ^{241} Am

Table 4.5 - Station B Post-Event CY 2014 Special Sandia Labs Sample Results (1 of 2)

Sample ID	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
B130219140105	^{241}Am	2.32E-01	8.60E-03	NR
B130219140900	^{241}Am	3.78E-01	1.31E-02	NR
B130219141627	^{241}Am	4.00E-01	1.17E-02	NR
B130220140035	^{241}Am	6.88E-01	1.88E-02	NR
B130220140852	^{241}Am	1.42E+00	3.33E-02	NR
B130220141654	^{241}Am	4.83E-01	1.34E-02	NR
B130221140038	^{241}Am	3.92E-01	1.11E-02	NR
B130221140820	^{241}Am	5.18E-01	1.43E-02	NR
B130222140019	^{241}Am	2.17E-01	8.68E-03	NR
B130222140810	^{241}Am	2.68E-01	1.06E-02	NR
B130222141615	^{241}Am	2.37E-01	9.73E-03	NR
B130222142356	^{241}Am	1.98E-01	8.35E-03	NR
B130223140810	^{241}Am	2.22E-01	9.33E-03	NR
B130223141605	^{241}Am	2.30E-01	9.35E-03	NR
B130224140015	^{241}Am	1.51E-01	6.42E-03	NR
B130219140105	^{238} Pu	1.27E-03	4.88E-04	NR
B130219140900	^{238} Pu	2.43E-03	4.82E-04	NR
B130219141627	^{238} Pu	2.80E-03	4.87E-04	NR
B130220140035	^{238} Pu	3.63E-03	6.13E-04	NR
B130220140852	^{238} Pu	7.15E-03	9.05E-04	NR
B130220141654	^{238} Pu	2.60E-03	5.40E-04	NR
B130221140038	^{238} Pu	2.25E-03	4.97E-04	NR
B130221140820	^{238} Pu	3.52E-03	6.00E-04	NR
B130222140019	^{238} Pu	1.98E-03	4.85E-04	NR
B130222140810	^{238} Pu	2.15E-04	4.55E-04	NR
B130222141615	^{238} Pu	6.65E-04	4.42E-04	NR
B130222142356	^{238} Pu	5.97E-04	3.45E-04	NR
B130223140810	^{238} Pu	1.13E-03	3.93E-04	NR
B130223141605	^{238} Pu	1.78E-03	5.08E-04	NR
B130224140015	^{238} Pu	7.05E-04	2.87E-04	NR
B130219140105	$^{233/234}$U [c]	9.06E-05	1.21E-05	NP
B130219140900	$^{233/234}$U	1.48E-04	1.84E-05	NP
B130219141627	$^{233/234}$U	1.56E-04	1.65E-05	NP
B130220140035	$^{233/234}$U	2.69E-04	2.64E-05	NP
B130220140852	$^{233/234}$U	5.55E-04	4.68E-05	NP
B130220141654	$^{233/234}$U	1.89E-04	1.88E-05	NP
B130221140038	$^{233/234}$U	1.53E-04	1.56E-05	NP
B130221140820	$^{233/234}$U	2.03E-04	2.01E-05	NP
B130222140019	$^{233/234}$U	8.47E-05	1.22E-05	NP
B130222140810	$^{233/234}$U	1.05E-04	1.49E-05	NP
B130222141615	$^{233/234}$U	9.25E-05	1.37E-05	NP
B130222142356	$^{233/234}$U	7.76E-05	1.17E-05	NP
B130223140810	$^{233/234}$U	8.67E-05	1.31E-05	NP
B130223141605	$^{233/234}$U	8.99E-05	1.31E-05	NP
B130224140015	$^{233/234}$U	5.92E-05	9.01E-06	NP
B130219140105	^{137}Cs [c]	-4.60E-03	8.24E-03	NP
B130219140900	^{137}Cs	-7.51E-03	1.25E-02	NP
B130219141627	^{137}Cs	-7.94E-03	1.12E-02	NP
B130220140035	^{137}Cs	-1.37E-02	1.80E-02	NP
B130220140852	^{137}Cs	-2.82E-02	3.19E-02	NP
B130220141654	^{137}Cs	-9.60E-03	1.28E-02	NP
B130221140038	^{137}Cs	-7.78E-03	1.06E-02	NP
B130221140820	^{137}Cs	-1.03E-02	1.37E-02	NP
B130222140019	^{137}Cs	-4.30E-03	8.32E-03	NP
B130222140810	^{137}Cs	-5.33E-03	1.02E-02	NP
B130222141615	^{137}Cs	-4.70E-03	9.32E-03	NP
B130222142356	^{137}Cs	-3.94E-03	8.00E-03	NP
B130223140810	^{137}Cs	-4.40E-03	8.94E-03	NP
B130223141605	^{137}Cs	-4.57E-03	8.95E-03	NP
B130224140015	^{137}Cs	-3.00E-03	6.15E-03	NP

Sample ID	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
B130219140105	$^{239/240}$Pu	2.37E-02	1.77E-03	NR
B130219140900	$^{239/240}$Pu	4.13E-02	2.40E-03	NR
B130219141627	$^{239/240}$Pu	3.97E-02	2.08E-03	NR
B130220140035	$^{239/240}$Pu	9.05E-02	4.43E-03	NR
B130220140852	$^{239/240}$Pu	1.88E-01	8.23E-03	NR
B130220141654	$^{239/240}$Pu	5.75E-02	3.28E-03	NR
B130221140038	$^{239/240}$Pu	4.98E-02	2.93E-03	NR
B130221140820	$^{239/240}$Pu	6.23E-02	3.35E-03	NR
B130222140019	$^{239/240}$Pu	2.55E-02	1.95E-03	NR
B130222140810	$^{239/240}$Pu	2.92E-02	2.13E-03	NR
B130222141615	$^{239/240}$Pu	2.32E-02	2.05E-03	NR
B130222142356	$^{239/240}$Pu	2.02E-02	1.62E-03	NR
B130223140810	$^{239/240}$Pu	2.25E-02	1.82E-03	NR
B130223141605	$^{239/240}$Pu	3.57E-02	2.25E-03	NR
B130224140015	$^{239/240}$Pu	1.92E-02	1.57E-03	NR
B130219140105	^{90}Sr [c]	-1.85E-04	6.70E-04	NP
B130219140900	^{90}Sr	-3.01E-04	1.02E-03	NP
B130219141627	^{90}Sr	-3.19E-04	9.13E-04	NP
B130220140035	^{90}Sr	-5.48E-04	1.47E-03	NP
B130220140852	^{90}Sr	-1.13E-03	2.60E-03	NP
B130220141654	^{90}Sr	-3.85E-04	1.04E-03	NP
B130221140038	^{90}Sr	-3.12E-04	8.67E-04	NP
B130221140820	^{90}Sr	-4.13E-04	1.12E-03	NP
B130222140019	^{90}Sr	-1.73E-04	6.77E-04	NP
B130222140810	^{90}Sr	-2.14E-04	8.29E-04	NP
B130222141615	^{90}Sr	-1.89E-04	7.59E-04	NP
B130222142356	^{90}Sr	-1.58E-04	6.51E-04	NP
B130223140810	^{90}Sr	-1.77E-04	7.28E-04	NP
B130223141605	^{90}Sr	-1.83E-04	7.29E-04	NP
B130224140015	^{90}Sr	-1.21E-04	5.00E-04	NP
B130219140105	^{238}U [c]	6.40E-05	1.07E-05	NP
B130219140900	^{238}U	1.04E-04	1.63E-05	NP
B130219141627	^{238}U	1.10E-04	1.46E-05	NP
B130220140035	^{238}U	1.90E-04	2.35E-05	NP
B130220140852	^{238}U	3.92E-04	4.16E-05	NP
B130220141654	^{238}U	1.33E-04	1.67E-05	NP
B130221140038	^{238}U	1.08E-04	1.39E-05	NP
B130221140820	^{238}U	1.43E-04	1.79E-05	NP
B130222140019	^{238}U	5.98E-05	1.08E-05	NP
B130222140810	^{238}U	7.41E-05	1.33E-05	NP
B130222141615	^{238}U	6.54E-05	1.21E-05	NP
B130222142356	^{238}U	5.48E-05	1.04E-05	NP
B130223140810	^{238}U	6.12E-05	1.16E-05	NP
B130223141605	^{238}U	6.35E-05	1.17E-05	NP
B130224140015	^{238}U	4.18E-05	8.01E-06	NP

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) Scaled from sample B130214140754 ^{241}Am value
(NR) Statistic not reported
(NP) Statistic not provided because central value was scaled from ^{241} Am

Table 4.6 – Station B Post-Event CY 2014 Special Sandia Labs Sample Results (2 of 2)

Sample ID	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
B130224140846 [d]	^{241}Am	1.31E-01	1.22E-02	NR
B130224141635	^{241}Am	1.01E-01	4.65E-03	NR
B130225140016	^{241}Am	1.56E-01	7.87E-03	NR
B130225140902	^{241}Am	1.01E-01	5.38E-03	NR
B130225141652	^{241}Am	8.70E-02	4.58E-03	NR
B130226140010	^{241}Am	2.22E-01	1.03E-02	NR
B130226140921	^{241}Am	1.04E-01	5.47E-03	NR
B130226141616	^{241}Am	6.28E-02	3.68E-03	NR
B130227140030	^{241}Am	2.52E-02	2.02E-03	NR
B130227140806	^{241}Am	1.20E-01	6.17E-03	NR
B130228140012	^{241}Am	6.45E-02	3.97E-03	NR
B130228140927	^{241}Am	6.27E-02	3.67E-03	NR
B130228141705	^{241}Am	4.92E-02	2.97E-03	NR
B130301140144	^{241}Am	4.15E-02	2.68E-03	NR
B130301140915	^{241}Am	7.07E-02	3.98E-03	NR
B130224140846 [d]	^{238} Pu	6.23E-04	4.88E-04	NR
B130224141635	^{238} Pu	9.78E-04	3.27E-04	NR
B130225140016	^{238} Pu	1.16E-03	3.52E-04	NR
B130225140902	^{238} Pu	3.42E-04	2.55E-04	NR
B130225141652	^{238} Pu	6.77E-04	3.00E-04	NR
B130226140010	^{238} Pu	8.68E-04	4.08E-04	NR
B130226140921	^{238} Pu	0.00E+00	2.35E-04	NR
B130226141616	^{238} Pu	2.40E-04	2.08E-04	NR
B130227140030	^{238} Pu	5.87E-04	2.60E-04	NR
B130227140806	^{238} Pu	7.78E-04	2.93E-04	NR
B130228140012	^{238} Pu	5.67E-04	2.78E-04	NR
B130228140927	^{238} Pu	2.58E-04	1.92E-04	NR
B130228141705	^{238} Pu	4.12E-04	2.47E-04	NR
B130301140144	^{238} Pu	3.75E-04	2.10E-04	NR
B130301140915	^{238} Pu	-1.01E-04	1.75E-04	NR
B130224140846	$^{233/234}$U	5.12E-05	1.72E-05	NP
B130224141635	$^{233/234}$U	3.94E-05	6.53E-06	NP
B130225140016	$^{233/234}$U	6.10E-05	1.10E-05	NP
B130225140902	$^{233/234}$U	3.96E-05	7.56E-06	NP
B130225141652	$^{233/234}$U	3.40E-05	6.44E-06	NP
B130226140010	$^{233/234}$U	8.67E-05	1.44E-05	NP
B130226140921	$^{233/234}$U	4.08E-05	7.68E-06	NP
B130226141616	$^{233/234}$U	2.46E-05	5.17E-06	NP
B130227140030	$^{233/234}$U	9.84E-06	2.83E-06	NP
B130227140806	$^{233/234}$U	4.67E-05	8.66E-06	NP
B130228140012	$^{233/234}$U	2.52E-05	5.57E-06	NP
B130228140927	$^{233/234}$U	2.45E-05	5.15E-06	NP
B130228141705	$^{233/234}$U	1.92E-05	4.17E-06	NP
B130301140144	$^{233/234}$U	1.62E-05	3.77E-06	NP
B130301140915	$^{233/234}$U	2.76E-05	5.59E-06	NP
B130224140846	^{137}Cs	-2.60E-03	1.17E-02	NP
B130224141635	^{137}Cs	-2.00E-03	4.45E-03	NP
B130225140016	^{137}Cs	-3.10E-03	7.53E-03	NP
B130225140902	^{137}Cs	-2.01E-03	5.16E-03	NP
B130225141652	^{137}Cs	-1.73E-03	4.39E-03	NP
B130226140010	^{137}Cs	-4.40E-03	9.82E-03	NP
B130226140921	^{137}Cs	-2.07E-03	5.24E-03	NP
B130226141616	^{137}Cs	-1.25E-03	3.53E-03	NP
B130227140030	^{137}Cs	-5.00E-04	1.93E-03	NP
B130227140806	^{137}Cs	-2.37E-03	5.91E-03	NP
B130228140012	^{137}Cs	-1.28E-03	3.80E-03	NP
B130228140927	^{137}Cs	-1.24E-03	3.51E-03	NP
B130228141705	^{137}Cs	-9.76E-04	2.84E-03	NP
B130301140144	^{137}Cs	-8.24E-04	2.57E-03	NP
B130301140915	^{137}Cs	-1.40E-03	3.81E-03	NP

Sample ID	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
B130224140846 [d]	$^{239/240}$Pu	1.70E-02	1.79E-03	NR
B130224141635	$^{239/240}$Pu	1.30E-02	1.23E-03	NR
B130225140016	$^{239/240}$Pu	1.50E-02	1.33E-03	NR
B130225140902	$^{239/240}$Pu	1.17E-02	1.26E-03	NR
B130225141652	$^{239/240}$Pu	8.02E-03	1.01E-03	NR
B130226140010	$^{239/240}$Pu	2.05E-02	1.55E-03	NR
B130226140921	$^{239/240}$Pu	1.03E-02	1.18E-03	NR
B130226141616	$^{239/240}$Pu	3.72E-03	6.93E-04	NR
B130227140030	$^{239/240}$Pu	2.15E-03	4.75E-04	NR
B130227140806	$^{239/240}$Pu	1.41E-02	1.29E-03	NR
B130228140012	$^{239/240}$Pu	9.75E-03	1.12E-03	NR
B130228140927	$^{239/240}$Pu	5.83E-03	7.47E-04	NR
B130228141705	$^{239/240}$Pu	5.02E-03	6.73E-04	NR
B130301140144	$^{239/240}$Pu	6.08E-03	7.92E-04	NR
B130301140915	$^{239/240}$Pu	6.67E-03	8.62E-04	NR
B130224140846	^{90}Sr	-1.04E-04	9.53E-04	NP
B130224141635	^{90}Sr	-8.03E-05	3.62E-04	NP
B130225140016	^{90}Sr	-1.24E-04	6.13E-04	NP
B130225140902	^{90}Sr	-8.06E-05	4.20E-04	NP
B130225141652	^{90}Sr	-6.93E-05	3.57E-04	NP
B130226140010	^{90}Sr	-1.77E-04	7.99E-04	NP
B130226140921	^{90}Sr	-8.31E-05	4.26E-04	NP
B130226141616	^{90}Sr	-5.01E-05	2.87E-04	NP
B130227140030	^{90}Sr	-2.00E-05	1.57E-04	NP
B130227140806	^{90}Sr	-9.52E-05	4.81E-04	NP
B130228140012	^{90}Sr	-5.14E-05	3.09E-04	NP
B130228140927	^{90}Sr	-4.99E-05	2.86E-04	NP
B130228141705	^{90}Sr	-3.92E-05	2.31E-04	NP
B130301140144	^{90}Sr	-3.31E-05	2.09E-04	NP
B130301140915	^{90}Sr	-5.63E-05	3.10E-04	NP
B130224140846	^{238}U	3.62E-05	1.53E-05	NP
B130224141635	^{238}U	2.78E-05	5.80E-06	NP
B130225140016	^{238}U	4.31E-05	9.82E-06	NP
B130225140902	^{238}U	2.79E-05	6.72E-06	NP
B130225141652	^{238}U	2.40E-05	5.72E-06	NP
B130226140010	^{238}U	6.12E-05	1.28E-05	NP
B130226140921	^{238}U	2.88E-05	6.82E-06	NP
B130226141616	^{238}U	1.74E-05	4.60E-06	NP
B130227140030	^{238}U	6.95E-06	2.52E-06	NP
B130227140806	^{238}U	3.30E-05	7.69E-06	NP
B130228140012	^{238}U	1.78E-05	4.95E-06	NP
B130228140927	^{238}U	1.73E-05	4.58E-06	NP
B130228141705	^{238}U	1.36E-05	3.70E-06	NP
B130301140144	^{238}U	1.15E-05	3.35E-06	NP
B130301140915	^{238}U	1.95E-05	4.97E-06	NP

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.
(c) Scaled from B130214140754 gross alpha
(d) Average of two analyses of same sample
(NR) Statistic not reported
(NP) Statistic not provided because central value was scaled from ^{241} Am

Table 4.7 – Station B Post-Event CY 2014 Sample Results March-April

Month	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
Mar Wk 1	^{241}Am	2.79E+00	5.00E-01	6.18E-01
Mar Wk 2	^{241}Am	1.71E+00	4.59E-01	9.14E-01
Mar Wk 3	^{241}Am	1.12E+00	3.36E-01	6.88E-01
Mar Lst Wk	^{241}Am	2.62E-01	2.42E-02	3.62E-03
Apr Wk 1	^{241}Am	1.42E-01	9.32E-03	1.10E-03
Apr Wk 2	^{241}Am	2.76E-01	1.85E-02	1.09E-03
Apr Wk 3	^{241}Am	3.70E-01	2.18E-02	1.30E-03
Apr Lst Wk	^{241}Am	5.70E-02	6.18E-03	1.17E-03
Mar Wk 1	^{238} Pu	1.20E-02	2.35E-03	6.62E-04
Mar Wk 2	^{238} Pu	8.77E-03	2.00E-03	5.88E-04
Mar Wk 3	^{238} Pu	3.92E-03	1.37E-03	6.85E-04
Mar Lst Wk	^{238} Pu	1.54E-03	8.73E-04	7.47E-04
Apr Wk 1	^{238} Pu	6.11E-04	7.14E-04	9.73E-04
Apr Wk 2	^{238} Pu	9.73E-04	8.92E-04	8.21E-04
Apr Wk 3	^{238} Pu	1.47E-03	8.25E-04	5.92E-04
Apr Lst Wk	^{238} Pu	3.34E-04	4.85E-04	7.44E-04
Mar Wk 1	$^{233/234}$U	3.85E-04	4.85E-04	8.95E-04
Mar Wk 2	$^{233/234}$U	5.44E-04	5.18E-04	8.88E-04
Mar Wk 3	$^{233/234}$U	2.09E-04	3.89E-04	9.40E-04
Mar Lst Wk	$^{233/234}$U	3.40E-05	4.51E-04	9.29E-04
Apr Wk 1	$^{233/234}$U	8.95E-05	2.58E-04	1.37E-03
Apr Wk 2	$^{233/234}$U	5.55E-04	5.88E-04	1.45E-03
Apr Wk 3	$^{233/234}$U	4.40E-05	3.16E-04	1.39E-03
Apr Lst Wk	$^{233/234}$U	8.21E-05	2.71E-04	1.38E-03
Mar Wk 1	^{137}Cs	2.04E-01	3.01E-01	3.52E-01
Mar Wk 2	^{137}Cs	-2.74E-01	4.26E-01	4.55E-01
Mar Wk 3	^{137}Cs	1.68E-01	3.10E-01	3.59E-01
Mar Lst Wk	^{137}Cs	-6.11E-02	3.52E-01	3.81E-01
Apr Wk 1	^{137}Cs	7.25E-02	3.03E-01	3.53E-01
Apr Wk 2	^{137}Cs	-2.32E-02	4.22E-01	4.66E-01
Apr Wk 3	^{137}Cs	2.82E-01	3.06E-01	3.57E-01
Apr Lst Wk	^{137}Cs	-3.74E-02	4.33E-01	4.77E-01

Month	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
Mar Wk 1	$^{239/240}$Pu	3.11E-01	1.78E-02	7.59E-04
Mar Wk 2	$^{239/240}$Pu	2.24E-01	1.45E-02	7.62E-04
Mar Wk 3	$^{239/240}$Pu	8.88E-02	6.96E-03	8.29E-04
Mar Lst Wk	$^{239/240}$Pu	4.03E-02	4.37E-03	8.03E-04
Apr Wk 1	$^{239/240}$Pu	2.20E-02	3.48E-03	7.66E-04
Apr Wk 2	$^{239/240}$Pu	3.57E-02	4.40E-03	8.25E-04
Apr Wk 3	$^{239/240}$Pu	4.37E-02	4.88E-03	7.88E-04
Apr Lst Wk	$^{239/240}$Pu	6.11E-03	1.64E-03	8.10E-04
Mar Wk 1	^{90}Sr	7.73E-03	3.70E-02	2.43E-02
Mar Wk 2	^{90}Sr	-5.07E-03	3.32E-02	2.41E-02
Mar Wk 3	^{90}Sr	1.98E-02	3.32E-02	2.42E-02
Mar Lst Wk	^{90}Sr	-2.50E-02	3.18E-02	2.41E-02
Apr Wk 1	^{90}Sr	-3.74E-02	3.47E-02	2.40E-02
Apr Wk 2	^{90}Sr	-8.10E-03	3.39E-02	2.39E-02
Apr Wk 3	^{90}Sr	-2.58E-02	3.15E-02	2.38E-02
Apr Lst Wk	^{90}Sr	-2.26E-03	3.38E-02	2.40E-02
Mar Wk 1	^{238}U	2.19E-04	3.24E-04	6.62E-04
Mar Wk 2	^{238}U	-2.32E-05	1.01E-04	6.81E-04
Mar Wk 3	^{238}U	3.56E-04	4.51E-04	7.25E-04
Mar Lst Wk	^{238}U	2.97E-04	4.66E-04	7.36E-04
Apr Wk 1	^{238}U	6.81E-04	5.92E-04	9.32E-04
Apr Wk 2	^{238}U	5.00E-04	6.11E-04	1.08E-03
Apr Wk 3	^{238}U	2.75E-05	3.27E-04	1.08E-03
Apr Lst Wk	^{238}U	4.59E-04	4.85E-04	9.36E-04

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.

Table 4.8 – Station B Post-Event CY 2014 Sample Results May-December

Month	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
May 1st Half	^{241}Am	2.36E-01	1.80E-02	1.64E-03
May 2nd Half	^{241}Am	3.89E-02	4.44E-03	1.15E-03
June	^{241}Am	1.32E+00	3.42E-01	7.14E-01
July	^{241}Am	9.40E-02	8.47E-03	1.16E-03
August	^{241}Am	6.11E-02	7.25E-03	1.54E-03
September	^{241}Am	2.89E-01	1.69E-02	1.48E-03
October	^{241}Am	4.00E-01	2.42E-02	1.34E-03
November	^{241}Am	4.40E-01	2.07E-02	1.23E-03
December	^{241}Am	8.10E-02	6.96E-03	1.29E-03
May 1st Half	^{238} Pu	1.58E-03	9.92E-04	7.81E-04
May 2nd Half	^{238} Pu	4.22E-04	6.40E-04	9.14E-04
June	^{238} Pu	6.22E-03	2.09E-03	1.13E-03
July	^{238} Pu	2.74E-04	4.29E-04	6.66E-04
August	^{238} Pu	7.14E-04	7.99E-04	9.18E-04
September	^{238} Pu	2.20E-03	1.10E-03	9.47E-04
October	^{238} Pu	2.53E-03	1.11E-03	7.62E-04
November	^{238} Pu	2.79E-03	1.22E-03	1.17E-03
December	^{238} Pu	1.01E-03	7.84E-04	8.10E-04
May 1st Half	$^{233/234}$U	2.77E-04	4.51E-04	9.32E-04
May 2nd Half	$^{233/234}$U	9.88E-05	2.59E-04	9.03E-04
June	$^{233/234}$U	6.44E-04	6.14E-04	9.10E-04
July	$^{233/234}$U	2.22E-04	3.96E-04	9.47E-04
August	$^{233/234}$U	6.22E-05	2.59E-04	9.14E-04
September	$^{233/234}$U	2.34E-04	3.69E-04	9.21E-04
October	$^{233/234}$U	4.26E-04	5.51E-04	9.40E-04
November	$^{233/234}$U	1.98E-04	3.43E-04	8.95E-04
December	$^{233/234}$U	6.44E-04	2.13E-03	1.04E-03
May 1st Half	^{137}Cs	-2.26E-01	4.03E-01	4.33E-01
May 2nd Half	^{137}Cs	-2.10E-01	3.20E-01	3.57E-01
June	^{137}Cs	2.14E-01	3.45E-01	3.81E-01
July	^{137}Cs	-1.12E-01	3.92E-01	4.51E-01
August	^{137}Cs	2.18E-01	3.05E-01	3.54E-01
September	^{137}Cs	1.92E-02	4.03E-01	4.48E-02
October	^{137}Cs	-5.62E-02	5.37E-01	5.88E-01
November	^{137}Cs	-3.92E-01	4.22E-01	4.63E-01
December	^{137}Cs	1.17E-01	3.50E-01	3.85E-01

Month	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
May 1st Half	$^{239/240}$Pu	2.59E-02	3.81E-03	1.05E-03
May 2nd Half	$^{239/240}$Pu	4.48E-03	1.51E-03	8.21E-04
June	$^{239/240}$Pu	1.22E-01	1.04E-02	1.03E-03
July	$^{239/240}$Pu	1.00E-02	2.15E-03	8.29E-04
August	$^{239/240}$Pu	1.06E-02	2.33E-03	1.10E-03
September	$^{239/240}$Pu	3.14E-02	4.18E-03	8.51E-04
October	$^{239/240}$Pu	5.74E-02	5.81E-03	9.21E-04
November	$^{239/240}$Pu	5.48E-02	5.11E-03	7.81E-04
December	$^{239/240}$Pu	1.31E-02	2.64E-03	8.70E-04
May 1st Half	^{90}Sr	-4.88E-03	4.51E-02	2.46E-02
May 2nd Half	^{90}Sr	9.84E-04	2.89E-02	2.23E-02
June	^{90}Sr	2.65E-03	2.98E-02	2.24E-02
July	^{90}Sr	5.14E-03	2.73E-02	2.21E-02
August	^{90}Sr	-3.89E-03	3.02E-02	2.21E-02
September	^{90}Sr	7.55E-03	2.97E-02	2.19E-02
October	^{90}Sr	7.03E-03	2.92E-02	2.19E-02
November	^{90}Sr	-6.14E-03	2.68E-02	2.18E-02
December	^{90}Sr	-9.18E-03	2.89E-02	2.16E-02
May 1st Half	^{238}U	6.36E-05	2.82E-04	7.22E-04
May 2nd Half	^{238}U	1.78E-04	3.77E-04	7.92E-04
June	^{238}U	8.62E-04	7.07E-04	8.77E-04
July	^{238}U	1.08E-04	2.82E-04	7.51E-04
August	^{238}U	1.99E-04	3.21E-04	7.03E-04
September	^{238}U	3.21E-04	4.66E-04	8.25E-04
October	^{238}U	5.37E-04	6.11E-04	9.14E-04
November	^{238}U	3.14E-04	4.11E-04	7.29E-04
December	^{238}U	3.36E-05	3.26E-04	9.07E-04

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.

Table 4.9 – Station C CY 2014 Sample Results

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	1.14E-03	1.25E-03	1.74E-03
2nd	^{241}Am	4.51E-05	4.59E-04	1.37E-03
3rd	^{241}Am	3.23E-04	5.96E-04	1.52E-03
4th	^{241}Am	-7.77E-05	2.25E-04	1.27E-03
1st	$^{239/240}$Pu	-1.52E-04	2.90E-04	8.55E-04
2nd	$^{239/240}$Pu	-6.62E-05	3.81E-04	9.77E-04
3rd	$^{239/240}$Pu	3.70E-04	4.74E-04	6.25E-04
4th	$^{239/240}$Pu	-5.00E-05	1.62E-04	6.62E-04
1st	$^{233/234}$U	3.06E-04	5.51E-04	1.06E-03
2nd	$^{233/234}$U	5.18E-05	3.35E-04	9.40E-04
3rd	$^{233/234}$U	4.18E-04	5.48E-04	9.88E-04
4th	$^{233/234}$U	6.85E-04	7.59E-04	1.07E-03
1st	^{137}Cs	-1.34E-01	5.81E-01	6.07E-01
2nd	^{137}Cs	3.36E-02	3.81E-01	4.18E-01
3rd	^{137}Cs	2.18E-01	5.44E-01	5.77E-01
4th	^{137}Cs	1.25E-01	2.93E-01	3.43E-01

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU	MDC
1st	^{238} Pu	3.39E-04	9.73E-04	1.41E-03
2nd	^{238} Pu	-9.62E-05	2.14E-04	7.51E-04
3rd	^{238} Pu	-6.73E-05	1.86E-04	7.59E-04
4th	^{238} Pu	-2.56E-05	4.00E-04	9.25E-04
1st	^{90}Sr	-2.12E-02	2.58E-02	2.43E-02
2nd	^{90}Sr	-2.39E-02	2.56E-02	2.43E-02
3rd	^{90}Sr	8.18E-03	2.49E-02	2.42E-02
4th	^{90}Sr	-1.76E-02	2.71E-02	2.45E-02
1st	^{238}U	5.33E-04	5.81E-04	9.55E-04
2nd	^{238}U	3.05E-04	5.07E-04	1.05E-03
3rd	^{238}U	2.66E-04	4.51E-04	9.88E-04
4th	^{238}U	3.74E-04	5.99E-04	1.11E-03

(a) Total propagated uncertainty.
(b) Minimum detectable concentration.

Evaluation of the 2014 filter sample results using the latest EPA-approved CAP88-PC code in effect during CY 2014 indicated that there were no detectable releases from the WIPP facility that resulted in a dose that exceeded 25 mrem to the whole body and 75 mrem to any critical organ in accordance with the provisions of 40 CFR §191.03(b). In addition, there were no detectable airborne releases from the WIPP facility that resulted in a dose that exceeded the 10 mrem per year limit, as specified in 40 CFR §61.92, and the 0.1 mrem per year limit for periodic confirmatory sampling required by 40 CFR §61.93(b)(4)(i).

4.2 Airborne Particulates

4.2.1 Sample Collection

Weekly airborne particulate samples for event evaluation were collected from seven locations on or near the WIPP site (Figure 4.1) using low-volume air samplers. Locations were selected based on the prevailing wind direction. A second sampler was co-located with each of the primary samplers following the release event. These samplers were termed event evaluation samplers, and the air sample filters were to be taken for analysis in the case of a suspected or actual release event for screening, leaving the primary sampler to continue to integrate the sample at that location according to the normal schedule.

Two additional sets of low-volume air samplers were installed following the release event. The first set of samplers was comprised of an inner ring of four on-site samplers that sampled the ambient air both inside and outside the property protection area. The

locations were within several hundred meters of the property protection area fence and were selected to fill in gaps not covered by the primary samplers.

The second set of low-volume event evaluation samplers was installed at or near six previously used preoperational monitoring locations. The locations ranged from 10 to 50 mi from the WIPP site. Data from these locations could then be compared with the pre-operational baseline data.

Airborne particulate sampling was thus performed at 17 locations using 24 samplers. The 17 sampling locations are illustrated in Figure 1 of DOE/WIPP-15-3547. The frequency of analysis of the additional samples varied over the course of the year. Following the release event, all the samples were analyzed for the three radionuclides of interest on a weekly basis. The samples were later analyzed as monthly composites (in contrast to quarterly composites) and then archived as backup samples for radionuclide analysis as needed. The monthly composite samples are designated as "comp" with the month listed. The date is the collection date of the first filter in the composite.

The normal schedule of compositing 13 weekly air filters from each of the seven original locations was disrupted following the release event. In the case of the first quarter of 2014, the quarterly composite only consisted of six samples collected on January 7, January 15, January 22, January 28, February 5, and February 11, 2014. The rest of the weekly first quarter samples were analyzed individually using destructive analysis and were not available for compositing. The data from samples individually are provided in DOE/WIPP-15-3547.

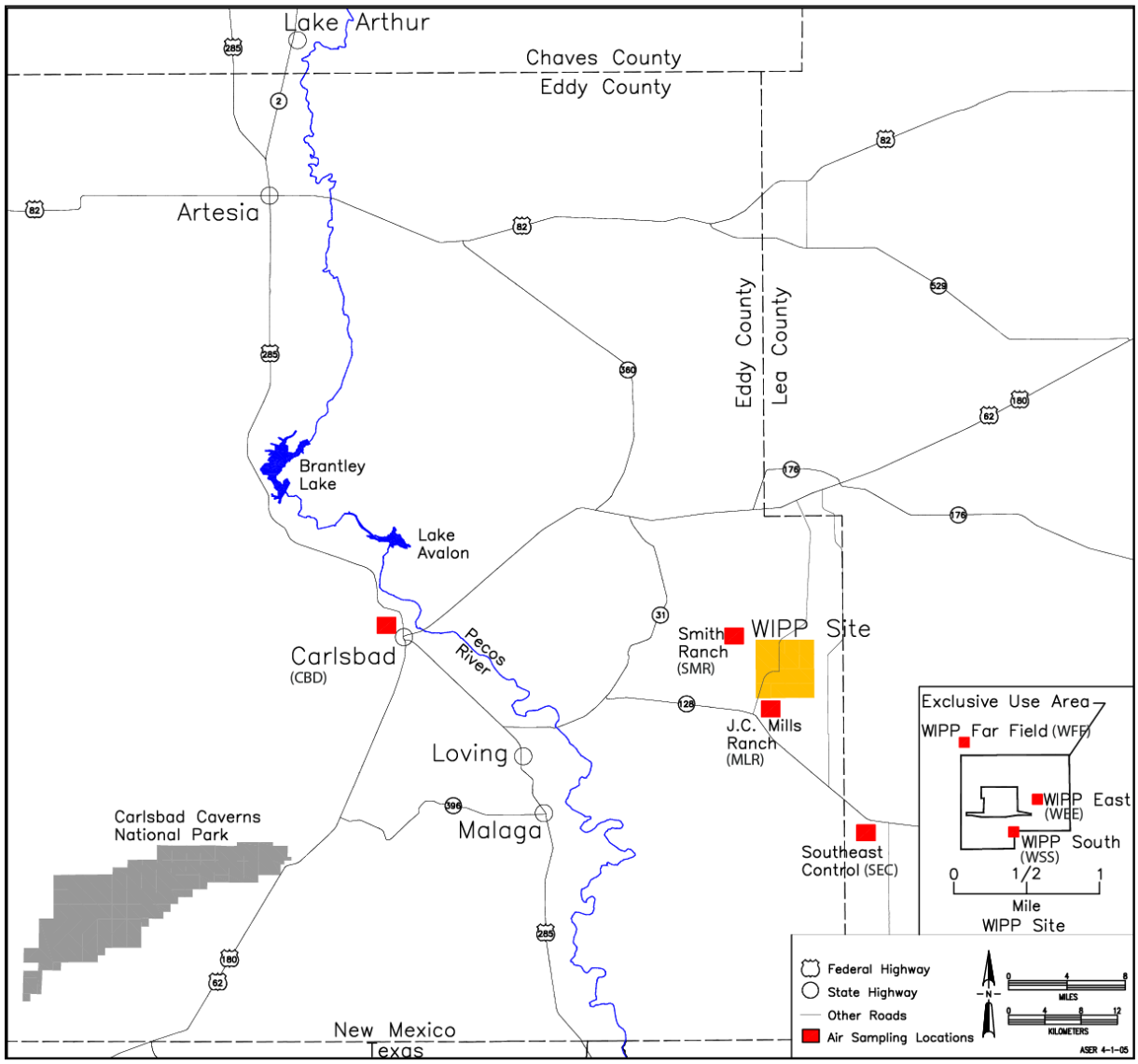


Figure 4.1 – Air Sampling Locations On and Near the WIPP Site

During the second quarter of 2014, the quarterly composite sample consisted of only seven samples, collected on May 21, May 28, June 3, June 10, June 17, June 24, and July 1. The earlier weekly samples were also analyzed individually using destructive analysis for the three radionuclides of interest following the release event. The data from samples analyzed individually are provided in DOE/WIPP-15-3547.

The third and fourth quarter air filter composite samples contained a full set of 13 weekly samples initially analyzed by gross alpha/beta. The reason for adding event evaluation samplers was to alleviate disruption of the quarterly composite samples and provide additional coverage.

Location codes are shown in Appendix C. Each week at each sampling location, approximately 600 m^3 (21,187 ft^3) of air was sampled through a 4.7-centimeter (cm)

(1.85-inch [in.]) diameter glass microfiber filter using a continuous low-volume air sampler.

4.2.2 Sample Preparation

Weekly air particulate samples were analyzed for gross alpha and beta using a gas flow proportional counter and then composited for each quarter. The first two quarterly composites of 2014 included fewer samples following the release event as noted above. The composite samples were transferred into a borosilicate beaker and spiked with tracers including ^{232}U, ^{243}Am, ^{242}Pu, and ^{22}Na (a tracer for the gamma isotopes). A stable strontium carrier was added to determine the recovery of ^{90}Sr. The samples were heated in a muffle furnace at 250°C (482°F) for two hours, followed by heating for two hours at 375°C (707°F), and heating for six hours at 525°C (977°F).

The filters were wet-ashed and cooled, and then transferred into polytetrafluoroethylene beakers by rinsing with concentrated nitric acid. The mixture was then heated with concentrated hydrofluoric acid until completely dissolved. Most of the hydrofluoric acid was removed by evaporation to dryness.

Approximately 25 milliliters of concentrated nitric acid and 1 gram of boric acid were added to buffer the remaining hydrogen fluoride. The boric acid step was followed by digestion in aqua regia (one part nitric acid, three parts hydrochloric acid) to neutralize and reduce boric acid.

4.2.3 Determination of Individual Radionuclides

The acid digestates of the filter composite samples were split into two fractions using Class A pipettes and volumetric flasks. One-half of the sample was brought to 500 milliliters in a Marinelli beaker for gamma analysis of ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was transferred to a glass beaker and taken to dryness. The residue was dissolved in 6M nitric acid (where M = molarity), and then 2M aluminum nitrate solution was added. The oxidation states of the target radionuclides (uranium and TRU isotopes) were adjusted with various reagents, and the radiochemical separations were performed using stacked resin cartridges and elution with various reagent solutions.

The alpha emitters were microprecipitated with neodymium trifluoride and mounted onto 0.1-micron porosity commercial radionuclide chromatographic separation resin filters on planchets for analysis by alpha spectroscopy for the uranium/transuranic isotopes. The strontium was eluted from the strontium resin with nitric acid solutions and precipitated as strontium carbonate to determine the recovery gravimetrically. The ^{90}Sr was then analyzed by gas proportional counting.

4.2.4 Results and Discussion

The data and discussion are separated into the quarterly air filter composite samples, typically reported in the ASER, and the event evaluation samples consisting of weekly air particulate samples analyzed individually as well as in monthly composite samples.

Most of the data were initially reported as disintegrations per minute at the request of the WIPP Response Team following the event. The units have been converted to Bq so that they are consistent with previous ASERs.

Quarterly Composite Samples

Appendix G, Table G.1 contains the results for the standard quarterly air filter composite samples, although the data for the first and second quarters did not contain all the weekly samples. Blank filter composite samples were prepared and analyzed, and results were reported separately for each quarter. A "Q" (qualifier) column is included in the data tables in Appendix G to show whether the radionuclide was detected, i.e., whether the activity of the radionuclide is greater than the 2 σ TPU and MDC. The identification (ID) confidence was also provided for gamma analyses. If the ID confidence is greater than or equal to 0.90 and the activity of the sample is greater than 2 σ TPU and MDC the gamma radionuclide is detected.

Table G.1, shows that none of the target radionuclides were detected in any of the four quarterly composite samples not associated with the radiation release event. Thus, had the event not occurred, it is unlikely that any of the quarterly composite samples would have contained any target radionuclides. In past years the air filter composite samples typically only contained low levels of some uranium isotopes and often the uranium isotope activities were about the same on the blank air filters and in the air filter composite samples. Pu-239/240 has been detected in some air filter composite samples in past years.

There were six regular weekly samples included in the first quarter composite sample and seven regular weekly samples included in the second quarter composite sample. Seven weekly samples collected during the first quarter and six regular samples collected during the second quarter were analyzed individually as a result of the radiation release event and were not available for inclusion in the composite samples. The dates for the first quarter samples analyzed individually include February 18 and 26; March 4, 11, 18, and 25; and April 1, 2014. The dates for the second quarter samples analyzed indivually include April 9, 16, 23, and 30 and May 5 and 7, 2014. The first post-event weekly sample included in the second quarter air filter composite sample was collected on May 21, 2014. The dates for the analysis results for the event evaluation samples discussed below generally correlate with these dates. Additional event evaluation samples continued to be analyzed until October 22, 2014. Event evaluation samples continued to be collected and archived through the end of the year.

The average concentrations of the quarterly composite samples are reported for those locations where duplicate samples were collected using low-volume air samplers. A "Q" (qualifier) column is included in the data in Table G-1 to show whether the radionuclide

was detected in the sample. Table G-2, shows the becquerels/sample converted to becquerels per cubic meter (Bq/m^3) by dividing the sample activity in Bq by the total quarterly air volumes sampled.

The fact that samples are missing from the quarterly composite samples leads to the desire to estimate the impact of missing data and make predictions about the concentrations of the target radionuclides in the missing samples. The missing weekly samples from the quarterly air filter composite samples were analyzed separately. Most of these samples were analyzed for the three radionuclides of primary interest following the radiation release event including, ^{238}Pu, $^{239/240}Pu$, and ^{241}Am. However, a few of the individual samples were analyzed for all the target radionuclides including a sample from WFF collected on March 11, 2014, and samples collected from WEE, WSS, MLR, SMR, SEC (duplicates), CBD, MET, SLT, and southeast of the Training Building on March 18, 2014 (see Appendix C for sampling location codes). The analysis results for these samples help ensure that information is available about the concentration of any radionuclides in the ambient air near the WIPP site. The data for these samples is provided in DOE/WIPP-15-3547 and discussed in the "Event Evaluation Samples" section below.

Since there were no detections of any radionuclides in the 2014 air filter composite samples, no ANOVA comparisons were performed between years or between locations.

Table 4.10 shows the combined mean, minimum, and maximum measured activities in the air filter composite samples in units of becquerels per composite air filter sample (Bq/sample) along with the location and sampling quarter for the minimum and maximum activities.

As there were no detections in any of the quarterly air filter composite samples, all of the measured activities were less than the 99 percent baseline confidence interval concentration. However, individual detections of ^{238}Pu, $^{239/240}Pu$, and ^{241}Am in the event evaluation samples did exceed the 99 percent baseline confidence interval concentrations as discussed in the section Event Evaluation Samples below and shown graphically in Appendix H.

The precision of the combined sampling and analysis steps for the air filter composite samples was determined by collecting field duplicate samples at one location each quarter. During 2014, field duplicate samples were taken from location SEC during the first quarter, location CBD during the second quarter, location SMR during the third quarter, and location WFF during the fourth quarter. Table 4.11 presents the precision data for all the field duplicate air filter composite samples. The precision, as relative error ratio (RER), is reported for all the radionuclides in the air filter composite samples even though there were no detections in the samples. The precision of the combined sampling and analysis procedures was good, as demonstrated by all but one RER being less than two.

Table 4.10 – 2014 Average, Minimum, and Maximum Concentrations in Air Filter Composite Samples

Radionuclide		[RN][a]	2 σ TPU[b]	MDC[c]	Location	Quarter	Number Weekly Samples in Quarterly Composite
$^{233/234}$U	Mean [d]	2.03E-03	3.42E-03	1.09E-02	NA (f)	NA (f)	NA (f)
	Minimum [e]	-9.37E-04	1.99E-03	1.09E-02	WEE	1	6
	Maximum [e]	4.51E-03	3.86E-03	1.09E-02	CBD	4	13
^{235}U	Mean [d]	1.62E-04	8.54E-04	1.34E-03	NA	NA	NA
	Minimum [e]	-5.88E-04	9.18E-04	1.26E-03	MLR	3	13
	Maximum [e,f]	1.05E-03	1.14E-03	1.28E-03	CBD	4	13
^{238}U	Mean [d]	2.79E-03	3.24E-03	9.83E-03	NA	NA	NA
	Minimum [e]	-9.93E-05	2.11E-03	9.67E-03	CBD	4	13
	Maximum [e,f]	6.44E-03	2.59E-03	1.00E-02	SMR	2	7
^{238}Pu	Mean [d]	-2.33E-04	5.05E-04	9.88E-04	NA	NA	NA
	Minimum [e]	-6.35E-04	6.18E-04	1.21E-03	WEE	4	13
	Maximum [e,f]	2.52E-05	4.18E-04	7.10E-04	MLR	1	6
$^{239/240}$Pu	Mean [d]	-1.51E-04	5.04E-04	8.52E-04	NA	NA	NA
	Minimum [e]	-7.92E-04	7.31E-04	9.99E-04	WSS	4	13
	Maximum [e,f]	4.05E-04	6.98E-04	1.08E-03	WEE	3	13
^{241}Am	Mean [d]	-3.39E-05	9.09E-04	1.24E-03	NA	NA	NA
	Minimum [e]	-7.69E-04	9.50E-04	1.56E-03	MLR	2	7
	Maximum [e,f]	7.47E-04	8.11E-04	1.00E-03	WSS	4	13
^{40}K	Mean [d]	1.86E+01	6.66E+00	7.85E+00	NA	NA	NA
	Minimum [e]	-2.03E+00	6.40E+00	7.00E+00	WSS	3	13
	Maximum [e,f]	4.01E+02	7.15E+00	8.20E+00	MLR	4	13
^{60}Co	Mean [d]	1.12E-01	6.96E-01	7.92E-01	NA	NA	NA
	Minimum [e]	-6.29E-01	7.30E-01	7.31E-01	MLR	4	13
	Maximum [e,f]	8.50E-01	5.68E-01	7.42E-01	WSS	1	6
^{137}Cs	Mean [d]	-4.00E-02	6.97E-01	7.71E-01	NA	NA	NA
	Minimum [e]	-6.24E-01	9.88E-01	9.91E-01	MLR	2	7
	Maximum [e,f]	6.54E-01	7.39E-01	9.01E-01	CBD	1	6
^{90}Sr	Mean [d]	1.26E-03	2.61E-02	2.36E-02	NA	NA	NA
	Minimum [e]	-1.76E-02	2.46E-02	2.49E-02	MLR	2	7
	Maximum [e,f]	1.88E-02	2.96E-02	2.29E-02	SMR	3	13

Notes:

NA Not applicable.

(a) Radionuclide concentration. Values taken from 7 locations and 4 quarterly composite samples as shown in Appendix G, Table G.1.

(b) Total propagated uncertainty at the 2 σ level.

(c) Minimum detectable concentration.

(d) Arithmetic average for concentration, 2 σ TPU, and MDC.

(e) Minimum and maximum reported concentrations for each radionuclide are based on [RN], while the associated 2 σ TPU and MDC were inherited with the specific [RN].

(f) Maximum concentration still undetected because activity was less than 2 σ TPU, and/or MDC.

Table 4.11 – Precision as RER of 2014 Duplicate Air Filter Composite Samples
Units are in Bq/Sample

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]
1	SEC	$^{233/234}$U	3.44E-03	1.40E-03	1.56E-03	1.20E-03	1.076
1	SEC	^{235}U	1.64E-04	3.64E-04	-2.23E-04	2.54E-04	0.722
1	SEC	^{238}U	6.71E-04	1.30E-03	1.91E-03	1.08E-03	0.736
1	SEC	^{238}Pu	-1.43E-04	2.25E-04	-6.97E-05	1.75E-04	0.262
1	SEC	$^{239/240}$Pu	2.54E-04	1.76E-04	-4.94E-05	2.29E-04	0.981
1	SEC	^{241}Am	1.39E-04	4.84E-04	-2.48E-04	3.76E-04	0.493
1	SEC	^{40}K	-4.22E-01	3.29E+00	5.22E-01	3.15E+00	0.200
1	SEC	^{60}Co	4.29E-01	3.18E-01	1.60E-01	3.29E-01	0.516
1	SEC	^{137}Cs	-3.28E-01	3.21E-01	4.37E-01	2.80E-01	1.599
1	SEC	^{90}Sr	9.70E-03	1.13E-02	1.10E-02	1.10E-02	0.062

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]
2	CBD	$^{233/234}$U	3.44E-03	1.40E-03	2.51E-03	1.20E-03	0.506
2	CBD	^{235}U	-2.33E-04	3.64E-04	1.63E-04	2.54E-04	0.893
2	CBD	^{238}U	4.99E-03	1.30E-03	3.52E-03	1.08E-03	0.873
2	CBD	^{238}Pu	-1.84E-04	2.25E-04	-1.18E-04	1.75E-04	0.232
2	CBD	$^{239/240}$Pu	-1.40E-04	1.76E-04	-3.73E-05	2.29E-04	0.356
2	CBD	^{241}Am	4.42E-04	4.84E-04	5.37E-05	3.76E-04	0.634
2	CBD	^{40}K	8.02E+00	3.29E+00	-3.41E+00	3.15E+00	2.513
2	CBD	^{60}Co	4.53E-02	3.18E-01	-4.80E-02	3.29E-01	0.204
2	CBD	^{137}Cs	-6.01E-02	3.21E-01	-6.52E-02	2.80E-01	0.012
2	CBD	^{90}Sr	-1.13E-02	1.13E-02	-1.93E-02	1.10E-02	0.508

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]
3	SMR	$^{233/234}$U	2.48E-03	2.24E-03	1.76E-03	2.24E-03	0.228
3	SMR	^{235}U	-5.48E-04	4.69E-04	-3.42E-04	5.00E-04	0.300
3	SMR	^{238}U	2.38E-03	2.08E-03	4.18E-03	2.19E-03	0.597
3	SMR	^{238}Pu	-1.14E-04	2.63E-04	-1.62E-04	1.80E-04	0.151
3	SMR	$^{239/240}$Pu	3.07E-04	2.76E-04	-1.48E-04	2.13E-04	1.306
3	SMR	^{241}Am	4.27E-05	4.19E-04	4.93E-05	6.00E-04	0.009
3	SMR	^{40}K	9.50E-01	3.91E+00	3.67E+00	4.09E+00	0.696
3	SMR	^{60}Co	3.77E-01	3.88E-01	9.27E-01	4.02E-01	0.986
3	SMR	^{137}Cs	-1.73E-02	3.89E-01	-3.65E-01	4.20E-01	0.607
3	SMR	^{90}Sr	2.47E-02	1.52E-02	3.64E-04	1.15E-02	1.282

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]
4	WFF	$^{233/234}$U	2.14E-03	1.78E-03	2.29E-03	1.73E-03	0.060
4	WFF	^{235}U	6.92E-04	4.75E-04	-9.64E-05	3.73E-04	1.305
4	WFF	^{238}U	4.19E-03	1.62E-03	2.72E-03	1.51E-03	0.665
4	WFF	^{238}Pu	-1.09E-04	2.98E-04	-4.06E-04	4.00E-04	0.596
4	WFF	$^{239/240}$Pu	-4.56E-04	3.54E-04	-4.07E-04	3.96E-04	0.092
4	WFF	^{241}Am	5.71E-04	5.45E-04	-7.77E-04	4.82E-04	1.853
4	WFF	^{40}K	5.20E+00	3.28E+00	1.82E+00	4.67E+00	0.593
4	WFF	^{60}Co	5.71E-02	3.29E-01	5.25E-01	4.63E-01	0.825
4	WFF	^{137}Cs	1.43E-01	3.54E-01	2.79E-01	4.88E-01	0.226
4	WFF	^{90}Sr	-3.47E-03	1.25E-02	-2.39E-03	1.22E-02	0.062

(a) Radionuclide activity
(b) Total Propagated Uncertainty.
(c) Relative error ratio

There is no firmly established QA objective for the precision of field duplicates, since the composition of field samples could be slightly different. One source (*Rocky Flats Annual Report of Site Surveillance and Maintenance Activities—CY 2008*, Doc. No. S05247, U.S. Department of Energy, April 2009) suggested that 85 percent of field duplicates should yield RERs less than 1.96. This objective was readily met for the air particulate samples discussed above with only one RER >1.96 (CBD, ^{40}K, second quarter). Field duplicate RERs less than 2 indicate good precision for the combined sampling and laboratory analysis procedures.

The laboratory generates and analyzes lab duplicate samples from a single field sample for matrices other than air particulate samples where enough of the sample is available for an additional sample analysis. In the case of laboratory duplicates for the WIPP environmental analysis program, the QA objective for laboratory precision is a RER of less than 2. The laboratory generated precision data for all the radionuclides in a sample whether the radionuclides were detected or not, based on the activities compared to the 1 σ TPUs and MDCs measured in the samples. The laboratory duplicate sample RERs are not provided in the ASER, but greater than 99 percent of the laboratory RERs from analysis of WIPP environmental samples during 2014 were less than 2.

Event Evaluation Samples

Possible presentation formats for the event evaluation samples including by radionuclide, by sampling date, and by sampling location. The sample collection date has been used as the primary differentiator for presenting the data since it most readily conveys results relative to the radiation event.

DOE/WIPP-15-3547 presents the analysis results for all the individual event evaluation low-volume air particulate filters that were analyzed following the radiation release event. The data are reported in units of Bq/sample. Some of these samples were analyzed for all the regular target radionuclides, but most of the samples were analyzed for the three radionuclides of interest following the release event: ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. WIPP

Laboratories were originally requested to report all radionuclide data following the release event in units of disintegrations per minute. For consistency with previous ASERs, all the disintegrations per minute results since the release event have been divided by 60 to convert the data to Bqs.

DOE/WIPP-15-3547 includes a map of the sampling locations and a section titled Additional Air Monitoring Stations and Network Filter Exchange Frequency, Rev. 1, describing the locations and dates of activation. Samples still being taken at these locations are generally archived rather than analyzed, unless some activity at the WIPP site (e.g., filter change outs) is performed that could potentially release radionuclides into the atmosphere.

The data provided in DOE/WIPP-15-3547 show the following detections:

- The February 15 samples from WFF showed detection of $^{239/240}$Pu (6.12E-02 Bq/sample) and ^{241}Am (8.13E-01 Bq/sample, alpha) and 7.18E-01 Bq/sample (gamma spectrometry)
- The February 17 samples from WEE showed detection of ^{241}Am (9.55E-03 Bq/sample)
- The February 17 sample from WSS showed detection of ^{241}Am (2.35E-03 Bq/sample)
- The February 18 sample from SMR showed detection of ^{241}Am (4.05E-03 Bq/sample)
- The February 18 sample from WFF showed detection of ^{241}Am (4.48E-03 Bq/sample)
- The March 18 sample from WFF showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from WEE showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from WSS showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from CBD showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from MTB showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from MLR showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from SLT showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from SMR showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from SEC (and duplicate) showed detection of $^{233/234}$U and ^{238}U
- The March 18 sample from STB showed detection of $^{233/234}$U, ^{238}U, and ^{40}K

Some highlights from the event evaluation data include:

- Pu-239/240 and ^{241}Am were detected at WFF on February 15, 2014, the day after the radiation release on February 14, 2014. Pu-239/240 was not detected in any other event evaluation samples.
- Am-241 was detected in the air particulate samples collected on February 17, 2014, at WEE and WSS.
- Am-241 was detected in the air particulate filters from WFF and SMR on February 18, 2014.
- Both $^{233/234}$U and ^{238}U were detected in the air particulate filters from all locations on March 18, 2014. The activities of the samples were all greater than the activities in the air particulate filter blank. No event evaluation samples were analyzed for the uranium isotopes after March 18, 2014. The concentrations of

uranium that were higher than usual were likely due to recent high winds and a significant particulate loading on the filters.

- Am-241 was detected in a sample collected at SLT on October 22, 2014. This detection was not unexpected since the WIPP site 860-A fan, which was in operation during the radiation release event, was re-started.

DOE/WIPP-15-3547 includes the sampling details of the event evaluation samples that contained detectable concentrations of radionuclides at concentrations above the 99 percent confidence interval concentrations from the baseline, as follows:

- Pu-239/240 at WFF on February 15: 1.19E-03 Bq/m^3; 99 percent confidence interval of the baseline: 8.00E-06 Bq/m^3
- Am-241 at WFF on February 15: 1.58E-02 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 5.30E-05 Bq/m^3
- U-233/234 at MET on March 18; 9.48E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 7.90E-06 Bq/m^3
- U-238 at MET on March 18; 7.96E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 5.90E-06 Bq/m^3
- U-233/234 at STB on March 18; 8.99E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 7.90E-06 Bq/m^3
- U-238 at STB on March 18; 7.62E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 5.90E-06 Bq/m^3
- U-233/234 at SLT on March 18; 9.60E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 7.90E-06 Bq/m^3
- U-238 at SLT on March 18; 8.79E-06 Bq/m^3; 99 percent confidence interval range of the baseline concentration: 5.90E-06 Bq/m^3

The other ^{241}Am detections were below the 99 percent confidence interval range of the baseline concentration as shown below:

- WEE on February 17: 9.55E-03 Bq/sample (4.57E-05 Bq/m^3)
- WSS on February 17: 2.35E-03 Bq/sample (1.13E-05 Bq/m^3)
- WFF on February 18: 4.48E-03 Bq/sample (1.85E-05 Bq/m^3)
- SMR on February 18: 4.05E-03 Bq/sample (1.49E-05 Bq/m^3)
- SLT on October 22: 1.37E-03 Bq/sample (8.38E-06 Bq/m^3)

4.3 Groundwater

4.3.1 Sample Collection

Groundwater samples were collected once in 2014 (Round 36) from six different detection monitoring wells on the WIPP site, as shown in Figure 6.3. The wells were completed in the Culebra, which is a water-bearing member of the Rustler formation. The groundwater from the detection monitoring wells was collected from depths ranging from 180 to 270 m (591 to 886 ft) from the six wells (WQSP-1 to WQSP-6). Each well was purged, and the field parameters, including pH (measure of the acidity or alkalinity of a solution), conductivity, and temperature were measured in an on-site mobile laboratory, in a continuous flow-cell sampling system. Specific gravity was also measured using a classical hydrometer technique. Field parameters were measured until individual values for each parameter were within 5 percent for three consecutive measurements, or until no more than three well bore volumes had been purged, whichever occurred first. At this point, the detection monitoring well was considered stable (i.e., the sampled water was representative of the undisturbed groundwater found in the formation) and was analyzed for hazardous constituents (volatile and semivolatile organics and metals), general chemistry parameters, and radionuclides.

Approximately 23 liters (L) of groundwater were collected from a continuous sample stream during each of the six sampling episodes. Each chemical or radiological profile required a primary sample and a duplicate sample collected for analysis. Approximately 8 L of water from each well was sent to the laboratory for measurement of the target radionuclides. The remaining sample portions (15 L each) were used for the non-radiological analyses or were placed in storage as backup samples. The radionuclide samples were filtered during collection and acidified to pH less than or equal to 2 with concentrated nitric acid.

4.3.2 Sample Preparation

The acidified groundwater sample containers were shaken to distribute any suspended material evenly, and sample aliquots were measured into glass beakers. The first 0.5-L portion was used directly for gamma spectroscopy analysis, and the second 0.5-L portion was used for uranium and TRU target isotopes and ^{90}Sr. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) were added to the second portion, and the samples were digested using concentrated nitric acid and hydrofluoric acid. The samples were then heated to dryness and wet-ashed using concentrated nitric acid and hydrogen peroxide. Finally, the samples were heated to dryness, taken up in nitric acid solution, and processed to separate the various isotopes.

4.3.3 Determination of Individual Radionuclides

The first portion of the water sample was used directly for the measurement of the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs by gamma spectroscopy. The second 0.5-L portion of the water sample was used for the sequential separation of the uranium isotopes, the transuranics, and ^{90}Sr. The digested samples described in Section 4.3.2 were prepared for counting by co-precipitating the target isotopes and

corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides as described in Section 4.2.3, and microprecipitating the separated radionuclides onto planchets for counting the uranium/transuranic isotopes by alpha spectroscopy and ^{90}Sr by gas proportional counting.

4.3.4 Results and Discussion

Isotopes of naturally occurring uranium ($^{233/234}$U, ^{235}U, and ^{238}U) were detected in all the groundwater well samples in 2014, as shown by the data in Table 4.12. The sample collection dates are also shown in the table. The concentrations reported in Table 4.12 are from the primary samples collected from each WQSP well. A duplicate sample from each well was analyzed during each sampling episode. The duplicate sample activities and corresponding 2 σ TPUs for each radionuclide are given in Table 4.13, which shows the precision of the analysis of the primary and duplicate samples, as discussed in detail below.

The 2014 uranium groundwater concentrations in the detection monitoring wells were compared with the concentrations from the same locations in 2013 using ANOVA. The ANOVA calculations were performed using the Round 36 average uranium sample concentrations from 2014 and the average uranium concentrations from Round 35 in 2013.

The concentrations of the uranium isotopes measured in 2014 did not vary significantly from the concentrations measured in the same wells in 2013, as demonstrated by the combined ANOVA results of the wells, with all the *p* values well above the significance level of 0.05 (ANOVA $^{233/234}$U, p = 0.876; ANOVA ^{235}U, p = 0.0.642; and ANOVA ^{238}U, p = 0.985).

The average concentrations of the uranium isotopes measured in the groundwater samples in 2014 were also compared to the 2013 concentrations by location. There was significant variation by location between the wells sampled in 2013 and 2014, as demonstrated by the ANOVA results (ANOVA $^{233/234}$U, p = 5.43E-06; ANOVA ^{235}U, p = 6.75E-04; and ANOVA ^{238}U, p = 3.67E-05). The large differences in uranium isotope concentrations at the different locations are likely due to the differences in the abundance of these naturally occurring isotopes in the sedimentary rocks deposited in the area and the associated variable dissolution of the uranium isotopes into the groundwater.

Table 4.12 – 2014 Radionuclide Concentrations in Primary Groundwater from Detection Monitoring Program Wells at the WIPP Site Units are in Bq/L

Location	Round	Date	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
			$^{233/234}$U				^{235}U				^{238}U			
WQSP-1	36	5/28/14	1.21E+00	1.77E-01	8.03E-04	+	1.60E-02	3.62E-03	5.63E-04	+	2.00E-01	3.02E-02	7.92E-04	+
WQSP-2	36	6/10/14	1.22E+00	2.20E-01	8.83E-04	+	1.09E-02	3.23E-03	6.85E-04	+	1.90E-01	3.53E-02	8.55E-04	+
WQSP-3	36	6/25/14	2.28E-01	4.08E-02	9.95E-04	+	2.83E-03	1.38E-03	6.85E-04	+	3.53E-02	7.35E-03	8.37E-04	+
WQSP-4	36	4/16/14	5.40E-01	7.87E-02	8.82E-04	+	6.15E-03	2.05E-03	6.13E-04	+	9.08E-02	1.44E-02	8.37E-04	+
WQSP-5	36	4/29/14	5.82E-01	1.09E-01	8.57E-04	+	5.25E-03	2.02E-03	7.62E-04	+	8.83E-02	1.75E-02	8.90E-04	+
WQSP-6	36	5/13/14	4.23E-01	6.97E-02	8.37E-04	+	4.38E-03	1.70E-03	6.08E-04	+	5.40E-02	1.00E-02	8.57E-04	+

			^{238}Pu				$^{239/240}$Pu				^{241}Am			
WQSP-1	36	5/28/14	1.27E-04	3.63E-04	5.27E-04	U	9.70E-05	3.80E-04	7.13E-04	U	4.58E-05	3.48E-04	9.47E-04	U
WQSP-2	36	6/10/14	4.23E-05	4.10E-04	5.90E-04	U	9.32E-05	2.32E-04	5.12E-04	U	4.90E-04	5.88E-04	7.02E-04	U
WQSP-3	36	6/25/14	0.00E+00	0.00E+00	7.58E-04	U	2.90E-04	6.58E-04	1.43E-03	U	7.83E-04	7.18E-04	9.07E-04	U
WQSP-4	36	4/16/14	-3.75E-05	1.80E-04	7.63E-04	U	7.50E-05	2.85E-04	7.33E-04	U	-1.05E-04	2.53E-04	1.06E-03	U
WQSP-5	36	4/29/14	0.00E+00	3.65E-04	9.93E-04	U	-8.95E-05	2.72E-04	7.03E-04	U	4.78E-04	5.47E-04	7.98E-04	U
WQSP-6	36	5/13/14	6.48E-05	2.47E-04	6.75E-04	U	3.57E-04	4.13E-04	4.92E-04	U	8.60E-04	8.72E-04	1.11E-03	U

			^{40}K			ID Conf.[e]	Q[d]	^{60}Co			ID Conf.[e]	Q[d]	^{137}Cs			ID Conf.[e]	Q[d]
WQSP-1	36	5/28/14	1.68E+01	4.73E+00	5.20E+00	0.996	+	-1.65E-01	3.87E-01	4.08E-01	0.00	U	-6.30E-02	3.50E-01	4.07E-01	0.00	U
WQSP-2	36	6/10/14	1.66E+01	4.72E+00	5.27E+00	0.988	+	1.68E-01	4.00E-01	4.90E-01	0.00	U	-1.11E-01	3.55E-01	4.00E-01	0.00	U
WQSP-3	36	6/25/14	3.50E+01	6.90E+00	5.25E+00	0.996	+	1.75E-01	3.68E-01	4.60E-01	0.00	U	-2.55E-01	3.65E-01	3.88E-01	0.00	U
WQSP-4	36	4/16/14	2.32E+01	5.07E+00	3.93E+00	0.995	+	-1.70E-02	4.50E-01	5.00E-01	0.00	U	4.23E-02	3.92E-01	4.48E-01	0.00	U
WQSP-5	36	4/29/14	9.63E+00	3.30E+00	3.83E+00	0.950	+	-6.03E-02	3.77E-01	4.25E-01	0.00	U	1.08E-02	3.28E-01	3.73E-01	0.00	U
WQSP-6	36	5/13/14	5.02E+00	2.62E+00	3.57E+00	0.985	+	1.65E-02	3.22E-01	3.62E-01	0.00	U	1.85E-01	3.27E-01	3.92E-01	0.00	U

			^{90}Sr			Q[(d)]
WQSP-1	36	5/28/14	5.47E-03	2.20E-02	2.20E-02	U
WQSP-2	36	6/10/14	6.03E-03	1.97E-02	2.13E-02	U
WQSP-3	36	6/25/14	-1.57E-02	2.12E-02	2.13E-02	U
WQSP-4	36	4/16/14	-5.63E-03	1.59E-02	2.12E-02	U
WQSP-5	36	4/29/14	4.08E-03	1.88E-02	2.17E-02	U
WQSP-6	36	5/13/14	-2.97E-03	1.88E-02	2.17E-02	U

Notes:

See Chapter 6 for sampling locations.

(a) Radionuclide activity of the primary sample.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) ID Conf. = Identification confidence for gamma radionuclides. Value>0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

Table 4.13 - Precision Results for 2014 Field Duplicate Groundwater Sample Analyes from Round 36

		Primary Sample		Duplicate Sample			
		Bq/L					
Location	Radionuclide	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]	Q[d]
WQSP-1	$^{233/234}U$	1.21E+00	8.85E-02	1.32E+00	1.12E-01	0.773	+
	^{235}U	1.60E-02	1.81E-03	2.42E-02	2.74E-03	2.497	+
	^{238}U	2.00E-01	1.51E-02	2.27E-01	1.98E-02	1.086	+
	^{238}Pu	1.27E-04	1.82E-04	-2.42E-05	4.92E-05	0.804	U
	$^{239/240}Pu$	9.70E-05	1.90E-04	1.65E-04	1.59E-04	0.274	U
	^{241}Am	4.58E-05	1.74E-04	8.45E-05	1.44E-04	0.172	U
	^{40}K	1.68E+01	2.37E+00	1.42E+01	4.79E+00	0.487	+/U[e]
	^{60}Co	-1.65E-01	1.94E-01	4.18E-01	6.85E-01	0.819	U
	^{137}Cs	-6.30E-02	1.75E-01	-1.66E-01	6.00E-01	0.165	U
	^{90}Sr	5.47E-03	1.10E-02	-1.36E-02	1.01E-02	1.277	U
WQSP-2	$^{233/234}U$	1.22E+00	1.10E-01	1.13E+00	9.35E-02	0.623	+
	^{235}U	1.09E-02	1.62E-03	1.17E-02	1.63E-03	0.349	+
	^{238}U	1.90E-01	1.77E-02	1.82E-01	1.58E-02	0.338	+
	^{238}Pu	4.23E-05	2.05E-04	8.32E-05	1.18E-04	0.173	U
	$^{239/240}Pu$	9.32E-05	1.16E-04	-4.57E-05	6.90E-05	1.029	U
	^{241}Am	4.90E-04	2.94E-04	1.95E-04	2.13E-04	0.813	U
	^{40}K	1.66E+01	2.36E+00	1.48E+01	7.55E+00	0.228	+/U[e]
	^{60}Co	1.68E-01	2.00E-01	5.80E-01	5.75E-01	0.677	U
	^{137}Cs	-1.11E-01	1.78E-01	6.58E-01	4.94E-01	1.465	U
	^{90}Sr	6.03E-03	9.85E-03	-9.60E-03	1.12E-02	1.051	U
WQSP-3	$^{233/234}U$	2.28E-01	2.04E-02	2.97E-01	3.74E-02	1.620	+
	^{235}U	2.83E-03	6.90E-04	9.08E-03	1.77E-03	3.298	+
	^{238}U	3.53E-02	3.68E-03	4.65E-02	6.40E-03	1.518	+
	^{238}Pu	0.00E+00	0.00E+00	-9.23E-05	1.62E-04	0.572	U
	$^{239/240}Pu$	2.90E-04	3.29E-04	-3.70E-05	1.03E-04	0.949	U
	^{241}Am	7.83E-04	3.59E-04	1.83E-04	2.21E-04	1.423	U
	^{40}K	3.50E+01	3.45E+00	4.35E+01	7.05E+00	1.083	+
	^{60}Co	1.75E-01	1.84E-01	2.42E-01	7.40E-01	0.088	U
	^{137}Cs	-2.55E-01	1.83E-01	3.63E-02	5.75E-01	0.483	U
	^{90}Sr	-1.57E-02	1.06E-02	-1.15E-02	1.04E-02	0.283	U

Table 4.13, Continued

		Primary Sample		Duplicate Sample			
		Bq/L					
Location	Radionuclide	[RN](a)	1 σ TPU(b)	[RN](a)	1 σ TPU(b)	RER(c)	Q(d)
WQSP-4	$^{233/234}$U	5.40E-01	3.94E-02	5.68E-01	4.29E-02	0.481	+
	^{235}U	6.15E-03	1.03E-03	8.08E-03	1.24E-03	1.203	+
	^{238}U	9.08E-02	7.20E-03	9.57E-02	7.85E-03	0.460	+
	^{238}Pu	-3.75E-05	9.00E-05	2.25E-04	1.98E-04	1.209	U
	$^{239/240}$Pu	7.50E-05	1.43E-04	-3.02E-05	8.60E-05	0.632	U
	^{241}Am	-1.05E-04	1.27E-04	2.15E-04	2.29E-04	1.223	U
	^{40}K	2.32E+01	2.54E+00	2.58E+01	2.84E+00	0.683	+
	^{60}Co	-1.70E-02	2.25E-01	3.85E-01	1.52E-01	1.482	U
	^{137}Cs	4.23E-02	1.96E-01	-1.11E-01	1.64E-01	0.600	U
	^{90}Sr	-5.63E-03	7.95E-03	3.37E-03	1.64E-02	0.072	U
WQSP-5	$^{233/234}$U	5.82E-01	5.45E-02	5.40E-01	4.44E-02	0.597	+
	^{235}U	5.25E-03	1.01E-03	6.08E-03	1.06E-03	0.567	+
	^{238}U	8.83E-02	8.75E-03	7.85E-02	7.00E-03	0.875	+
	^{238}Pu	0.00E+00	1.83E-04	-5.22E-05	1.03E-04	0.249	U
	$^{239/240}$Pu	-8.95E-05	1.36E-04	3.47E-05	1.56E-04	0.600	U
	^{241}Am	4.78E-04	2.74E-04	4.70E-04	2.76E-04	0.021	U
	^{40}K	9.63E+00	1.65E+00	1.31E+01	1.83E+00	1.410	+
	^{60}Co	-6.03E-02	1.89E-01	7.23E-02	1.89E-01	0.497	U
	^{137}Cs	1.08E-02	1.64E-01	-5.83E-02	1.50E-01	0.311	U
	^{90}Sr	4.08E-03	9.40E-03	2.67E-03	1.02E-02	0.102	U
WQSP-6	$^{233/234}$U	4.23E-01	3.49E-02	3.60E-01	3.88E-02	0.279	+
	^{235}U	4.38E-03	8.50E-04	3.92E-03	7.40E-04	0.408	+
	^{238}U	5.40E-02	5.00E-03	4.85E-02	3.91E-03	0.867	+
	^{238}Pu	6.48E-05	1.24E-04	-7.33E-05	2.24E-04	0.540	U
	$^{239/240}$Pu	3.57E-04	2.07E-04	5.50E-05	1.53E-04	1.176	U
	^{241}Am	8.60E-04	4.36E-04	4.90E-04	2.74E-04	0.719	U
	^{40}K	5.02E+00	1.31E+00	5.17E+00	1.42E+00	0.078	+
	^{60}Co	1.65E-02	1.61E-01	1.49E-01	1.94E-01	0.526	U
	^{137}Cs	1.85E-01	1.64E-01	-1.05E-01	2.03E-01	1.114	U
	^{90}Sr	-2.97E-03	9.40E-03	-6.53E-05	7.85E-03	0.237	U

Notes:

See Chapter 6 for sampling locations.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected

(e) ^{40}K detected in the primary sample but not the duplicate sample.

Concentrations of uranium isotopes in the primary groundwater samples were also

compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (baseline values: $^{233/234}$U = 1.30E+00 Bq/L, ^{235}U = 3.10E–02 Bq/L, and ^{238}U = 3.20E–01 Bq/L). The highest Round 36 concentrations of $^{233/234}$U of 1.32E+00 Bq/L in the duplicate sample at WQSP-1 was slightly higher than the 99 percent confidence interval range of the baseline concentration of 1.30E+00 Bq/L. The highest concentration of ^{235}U of 2.42E-02 Bq/L in the duplicate sample at WQSP-1 was a little lower than the 99 percent confidence interval range of the baseline concentration of 3.10E-02 Bq/L. The highest concentration of ^{238}U of 2.27E-01 Bq/L in the duplicate sample at WQSP-1 was also lower than the 99 percent confidence interval range of the baseline concentration of 3.20E-01 Bq/L. The other individual and average $^{233/234}$U, ^{235}U, and ^{238}U concentrations were well within the 99 percent confidence interval ranges of the baseline concentrations (DOE/WIPP–98–2285).

The groundwater samples were also analyzed for TRU alpha spectroscopy radionuclides: ^{238}Pu, $^{239/240}$Pu, and ^{241}Am (Table 4.12). These isotopes, which are related to WIPP waste disposal operations, were not detected in the groundwater samples, so no ANOVA comparisons between years or among locations could be performed.

Table 4.12 also shows the concentration of the gamma radionuclides and ^{90}Sr. The identification confidences for the gamma analyses have been included. The potassium isotope ^{40}K was detected in the primary samples of all six wells in 2014. The radionuclide was not detected in the duplicate sample of WQSP-2, and the identification confidence was 0.873 in the duplicate sample from WQSP-1. Since the identification confidence was close to the 0.90 value for confirmation, the activity of the duplicate WQSP-1 sample was averaged with the primary sample and the sample was used for the ANOVA calculation. However, since ^{40}K was not detected in the duplicate sample of WQSP-2 in 2014 and the WQSP-5 and WQSP-6 samples in 2013, only three common locations were used for the ANOVA calculation (WQSP-1, WQSP-3, and WQSP-4).

The 2014 concentrations of ^{40}K in the primary groundwater samples did not vary significantly from the 2013 concentrations (ANOVA ^{40}K, p = 0.914). However, ^{40}K concentrations did vary significantly by location from well to well (ANOVA ^{40}K, p = 1.08E-03). Some differences in ^{40}K concentrations at the various wells (locations) would be expected due to differences in the abundance of this naturally occurring isotope in the sedimentary minerals deposited at various locations in the area and the associated variable dissolution of the isotope by groundwater.

The measured concentrations of ^{40}K in the primary groundwater samples in 2014 were all within the 99 percent confidence interval range of the baseline concentrations (baseline concentration: 6.30E+01 Bq/L). The highest concentration measured in 2014 was 4.35E+01 Bq/L (the concentration in WQSP-3 primary sample in 2013 was 4.32E+01 Bq/L).

The isotopes ^{137}Cs and ^{60}Co were not detected in any of the 2014 groundwater samples, and no ANOVA comparisons were performed.

The beta emitter, ^{90}Sr, was not detected in any of the groundwater samples, thus no ANOVA comparisons between years or among locations could be performed.

The precision data for the radionuclides in the duplicate groundwater samples are reported in Table 4.13. Precision data for radionuclides in groundwater (primary and duplicate samples) as well as in duplicate surface water, sediment, soil, and biota samples, are reported for all radionuclides whether or not they were detected. An associated qualifier column indicates whether the radionuclide was detected.

The Round 36 RERs in Table 4.13 show that the RERs were less than 2, except for ^{235}U in the WQSP-1 duplicate samples where the RER was 2.50, and in the WQSP-3 duplicate samples with a RER of 3.30.

The RER precision data indicate good reproducibility for the combined sampling and analysis procedures for the primary and duplicate groundwater samples.

4.4 Surface Water

4.4.1 Sample Collection

The surface water results are divided into the routine regional and local surface water sampling data and discussion as regularly reported in the ASER and the surface water SOO that were collected following the radiation release event. The samples were analyzed for the radionuclides of interest, including ^{238}Pu, $^{239/240}Pu$, and ^{241}Am by alpha spectroscopy. These samples were specifically obtained to evaluate the impact of the radiological release on the surface water within the facility. None of the surface water bodies sampled represent either human or ecological pathways.

Most of the data were initially reported as disintegrations per minute per liter at the request of the “WIPP Response Team” following the radiation release event. The units have been converted to Bq/L so that the units are consistent with previous ASERs.

The *WIPP Environmental Monitoring Plan* includes routine regional and local surface water and sediment sampling that extends as far north as Artesia, NM, on the upper Pecos River, to as far south as Pierce Canyon on the lower Pecos River. Figure 4.2 (see Appendix C for sampling location codes) shows the locations where samples are collected annually and reported in the ASER. If a particular surface water collection location was dry, only a sediment sample was collected. Sediment sample analysis results are discussed in Section 4.5.

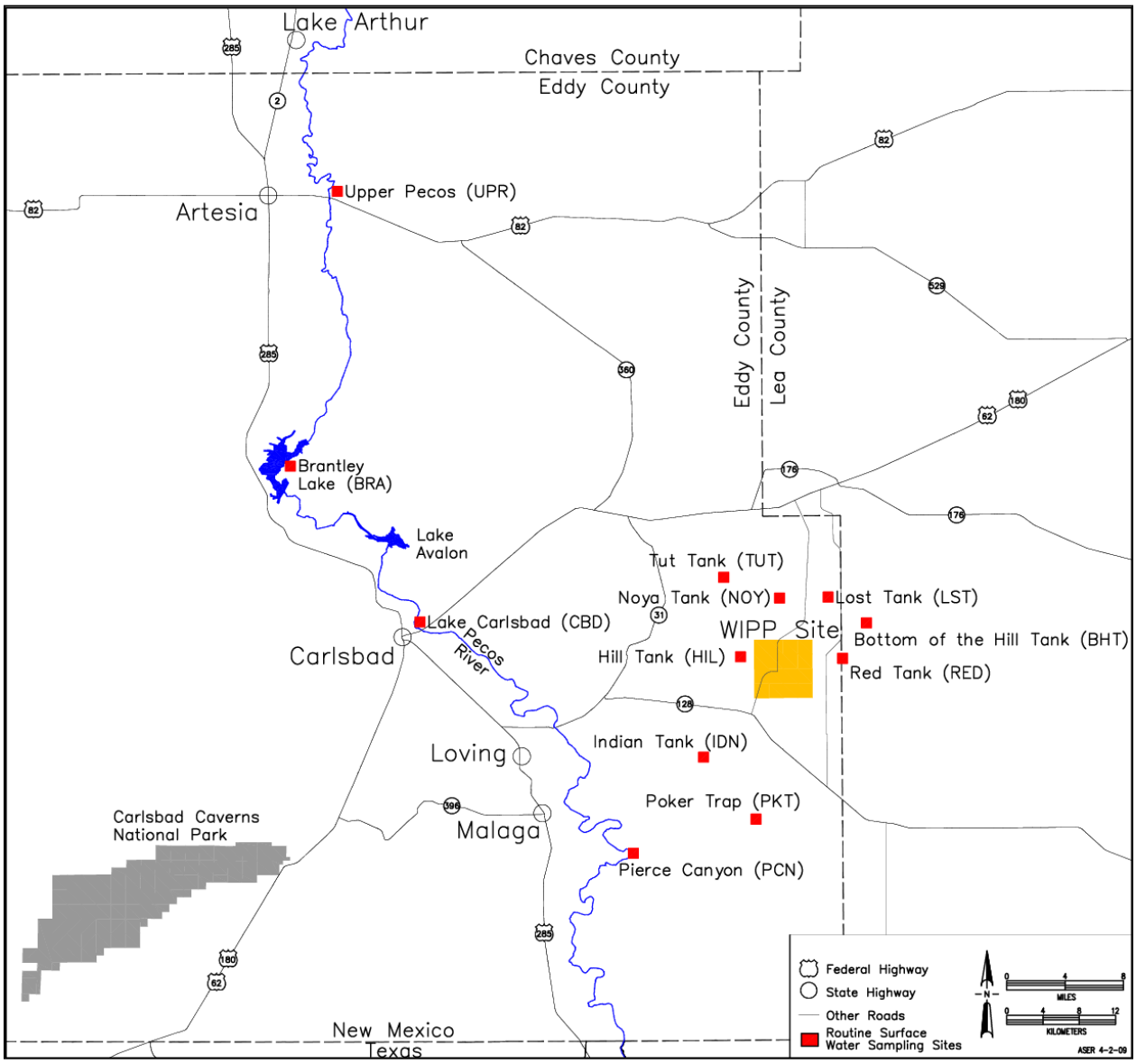


Figure 4.2 – Routine Surface Water Sampling Locations

Routine surface water and sediment sampling is normally performed in late summer of every year. At times, the cattle tanks (earthen ponds) are dry and only sediment samples can be obtained. Because of the radiation release event, the surface water and sediment sampling schedule was accelerated. Routine surface water sampling was performed March 12–16, 2014. The locations marked on Figure 4.2 were sampled for surface waters and for sediments. This sampling resulted in 17 surface water samples, including blanks and duplicate samples. Some of the earthen tanks were dry in March, and samples were taken later in the year.

As a result of the radiological release event, seven non-routine surface water samples, including a field blank, were collected on February 19, 2014, from six surface water

catchment basins within the WIPP facility. These locations included Evaporation Basin A, Salt Pile Evaporation Pond, Salt Storage Extension Basin I, Salt Storage Extension Basin II, Storm Water Infiltration Control Pond 1, and Storm Water Infiltration Control Pond 2. The sample locations are shown on the map at the beginning of DOE/WIPP-15-3547. These samples were analyzed for the three radionuclides of interest; ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. The data are also presented in DOE/WIPP-15-3547.

On March 2, 2014, two composite samples were collected from pooled water resulting from a minor rain event. These surface pools accumulated at Buildings 481, 489, 451 (roof top), and Substation No. 3 on the WIPP site. The radionuclide analysis data for these samples is presented in DOE/WIPP-15-3547and shows that the samples tested positive for $^{239/240}$Pu and ^{241}Am; however, the highest result was only about 3 percent of the EPA drinking water standard for alpha radioactivity.

On March 16, 2014, three composite samples were collected from sources resulting from a minor rain event. The three sample groups were defined as North Composite, Site Composite, and South Composite. DOE/WIPP-15-3547 contains a map showing the composite sample locations for each group along with the data for the samples.

Water from each sampling location was used to rinse 3.78-L (1-gallon) polyethylene containers at least three times prior to taking the sample. Approximately 1 gallon of water was collected from each location. Immediately after collection, the samples were acidified to pH ≤ 2 with concentrated nitric acid. Later, the samples were transferred to the WIPP Laboratories for analysis. Chain of custody was maintained throughout the process.

4.4.2 Sample Preparation

Surface water sample containers were shaken to distribute suspended material evenly, and sample aliquots were measured into glass beakers. One 0.5-L portion was used for gamma spectroscopy, and another 0.5-L portion was used for sequential analysis of the uranium/transuranic isotopes and ^{90}Sr. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) were added to the second sample portion, and the samples were then digested using concentrated nitric acid and hydrofluoric acid. The samples were heated to dryness and wet-ashed using concentrated nitric acid and hydrogen peroxide. Finally, the samples were heated to dryness, taken up in nitric acid solution, and processed to separate the various isotopes.

4.4.3 Determination of Individual Radionuclides

A 0.5-L portion of the acidified water sample was used directly for the gamma spectroscopy measurement of the gamma-emitting radionuclides ^{40}K, ^{60}Co, and ^{137}Cs. The other 0.5-L portion of the water was prepared by co-precipitating the target isotopes and corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides as described in Section 4.2.3, and microprecipitating the separated radionuclides onto planchets for counting.

The uranium isotopes and transuranics were counted using alpha spectroscopy, and ^{90}Sr was beta counted using a gas proportional detector.

4.4.4 Results and Discussion

This section is separated into the routine surface water samples typically reported in the ASER and the event evaluation samples consisting of the SOO that were collected following rain events on the WIPP site. The routine surface water sample analysis results are discussed immediately below and the analysis results for the surface water SOO are presented in DOE/WIPP-15-3547 and discussed in a separate section below.

Routine Surface Water Samples

The analysis results for the uranium isotopes in the routine surface water samples are shown in Table 4.14. Uranium isotopes were detected in most of the surface water samples, which included 14 separate samples, two sets of duplicate samples, and a distilled water field blank (COW), which was submitted to the laboratory as a "blind" quality control (QC) sample. The uranium isotope analyses resulted in detection of $^{233/234}$U in all the surface water samples (not including the COW field blank), detection of ^{235}U in TUT, PCN, CBD and its duplicate, BRA, and UPR; and detection of ^{238}U in all the samples except IDN and the COW field blank.

The concentrations of the uranium isotopes were compared between 2014 and 2013 and also between sampling locations using ANOVA for those locations where the uranium isotopes were detected both years. The average concentrations were used for detections at HIL and CBD in 2014 and CBD in 2013. In 2014 and 2013, $^{233/234}$U was detected in 13 common locations, ^{235}U was detected in only four common locations, and ^{238}U was detected in 12 common locations.

There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2014 and 2013 (ANOVA $^{233/234}$U, p = 0.614; ANOVA ^{235}U, p = 0.972; and ANOVA ^{238}U, p = 0.664). However, there were only four common locations for ^{235}U, and they were all in the Pecos River and associated bodies of water.

Except for the very limited number of common locations for ^{235}U, there was significant variation in the concentration of the uranium isotopes by location compared to 2013 with ANOVA $^{233/234}$U, p = 4.63E-05; ANOVA ^{235}U, p = 0.146; and ANOVA ^{238}U, p = 3.27E-05. This is a significant increase in variation for $^{233/234}$U and ^{238}U from the values reported in the 2013 ASER comparing 2012 and 2013. The reason for the increase in variability by location is not known, but the concentrations of the uranium isotopes varied significantly at the various locations.

Table 4.14 – 2014 Uranium Isotope Concentrations in Surface Waters Taken Near WIPP Site

Location	Date	$^{233/234}U$				^{235}U				^{238}U			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	8/14/2014	2.35E-02	7.35E-03	1.10E-03	+	8.05E-04	9.62E-04	1.29E-03	U	1.54E-02	5.22E-03	1.14E-03	+
NOY	8/14/2014	5.52E-03	2.30E-03	1.07E-03	+	-5.80E-05	2.17E-04	9.32E-04	U	2.53E-03	1.41E-03	8.75E-04	+
HIL	3/12/2014	6.98E-03	2.35E-03	8.80E-04	+	1.53E-04	3.43E-04	6.48E-04	U	6.55E-03	2.25E-03	9.17E-04	+
HIL Dup	3/12/2014	6.07E-03	2.22E-03	1.00E-03	+	1.46E-05	4.75E-04	1.61E-03	U	3.60E-03	1.64E-03	1.15E-03	+
TUT	3/13/2014	2.20E-02	5.12E-03	8.47E-04	+	1.35E-03	9.63E-04	5.72E-04	+	1.66E-02	4.13E-03	9.42E-04	+
PKT	9/11/2014	1.31E-03	1.00E-03	1.12E-03	+	-1.15E-04	3.05E-04	9.85E-04	U	9.77E-04	8.57E-04	8.47E-04	+
FWT	3/12/2014	4.82E-02	1.18E-02	9.25E-04	+	5.78E-04	6.93E-04	7.57E-04	U	1.98E-02	5.53E-03	9.50E-04	+
COW (e)	3/14/2014	5.02E-04	6.55E-04	9.92E-04	U	-3.75E-05	1.80E-04	9.20E-04	U	6.98E-04	7.45E-04	1.00E-03	U
IDN	8/18/2014	3.32E-03	1.88E-03	1.32E-03	+	1.88E-04	5.52E-04	1.09E-03	U	3.13E-03	1.98E-03	3.33E-03	U
PCN	3/13/2014	1.95E-01	3.30E-02	8.08E-04	+	5.17E-03	1.90E-03	6.53E-04	+	9.55E-02	1.68E-02	7.73E-04	+
SWL	4/16/2014	2.27E-02	5.07E-03	9.97E-04	+	2.63E-04	4.65E-04	7.63E-04	U	9.83E-03	2.75E-03	9.10E-04	+
CBD	3/13/2014	1.51E-01	2.38E-02	8.55E-04	+	2.97E-03	1.37E-03	6.48E-04	+	6.60E-02	1.12E-02	7.70E-04	+
CBD Dup	3/13/2014	1.62E-01	3.57E-02	8.52E-04	+	4.78E-03	2.00E-03	6.23E-04	+	7.37E-02	1.68E-02	7.82E-04	+
BRA	3/14/2014	1.16E-01	1.85E-02	1.15E-03	+	1.48E-03	9.48E-04	7.03E-04	+	5.67E-02	9.73E-03	7.55E-04	+
UPR	3/14/2014	1.88E-01	2.77E-02	8.15E-04	+	3.67E-03	1.48E-03	6.65E-04	+	8.08E-02	1.27E-02	6.98E-04	+
LST	9/11/2014	6.50E-03	2.93E-03	1.27E-03	+	-9.32E-05	3.12E-04	1.23E-03	U	6.48E-03	2.92E-03	1.01E-03	+
BHT	9/15/2014	2.77E-03	2.02E-03	1.46E-03	+	2.70E-04	7.07E-04	1.38E-03	U	2.42E-03	1.92E-03	1.73E-03	+

Notes:

See Appendix C for sampling location codes. Units are Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(e) Blind field blank consisting of deionized water.

The 2014 uranium isotope surface water concentrations were also compared with the 99 percent confidence interval range of the baseline concentrations measured between 1985 and 1989 (DOE/WIPP–92–037). The concentrations detected for $^{233/234}$U, ^{235}U, and ^{238}U in the Pecos River and associated bodies of water, which include locations PCN, CBD, BRA, and UPR, were compared with the 99 percent confidence interval ranges of the measured baseline concentrations (baseline levels: $^{233/234}$U = 3.30E–01 Bq/L, ^{235}U = 1.40E–02 Bq/L, and ^{238}U = 1.10E–01 Bq/L). The highest concentrations detected were 1.95E-01 Bq/L of $^{233/234}$U at PCN; 5.17E-03 Bq/L of ^{235}U at PCN; and 9.55E-02 Bq/L of ^{238}U at PCN. Thus, none of the measured 2014 concentrations were higher than the 99 percent confidence interval concentrations from the baseline.

The 99 percent confidence interval ranges of the baseline concentrations for the tank and tank-like structures (RED, NOY, HIL, TUT, FWT, PKT, IDN, BHT, and LST) are $^{233/234}$U = 1.07E-01 Bq/L, ^{235}U = 5.59E-03 Bq/L, and ^{238}U = 1.02E-01 Bq/L. The highest concentrations measured in 2014 include 4.82 E-02 Bq/L $^{233/234}$U at FWT; detection of ^{235}U in one tank and tank-like structure, TUT, at 1.35E-03 Bq/L; and 1.98E-02 Bq/L ^{238}U at FWT. Thus, none of the measured 2014 concentrations were higher than the 99 percent confidence interval concentrations from the baseline. Location IDN contained the highest concentrations of uranium isotopes in tanks and tank-like structures in 2013, but IDN was the only location where ^{238}U was not detected in 2014. The reason is likely attributable to more precipitation in 2014 and a dilution of the uranium isotopes in the IDN sample.

In 2012, the highest concentrations of the uranium isotopes were detected in the sewage lagoon sample, which is not included in the Pecos River and associated bodies of water or the tanks and tank-like structures. There are no baseline concentrations for the uranium isotopes in the sewage lagoon. However, the SWL uranium isotope concentrations were much lower in 2013 and again in 2014, and ^{235}U was not detected in the SWL sample in 2013 or 2014.

The surface water samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, as shown in Table 4.15. None of these radionuclides were detected in the surface water samples in 2014. Thus, no ANOVA comparisons between years and among locations could be performed.

The analysis data for the gamma isotopes and ^{90}Sr are presented in Table 4.11. A column has been added for the gamma isotopes to show the identification confidence. An identification confidence greater than or equal to 0.90, in addition to sample activity greater than the total propagated uncertainty and MDC, are required fordetection.

As shown in Table 4.16, ^{40}K was the only gamma radionuclide detected, and it was only detected in the SWL sample in 2014. The identification confidence was 0.987 in the SWL sample. SWL was the only location where ^{40}K was detected in 2014 and 2013; therefore, there were not enough data to perform ANOVA comparisons.

Table 4.15 – 2014 Plutonium Isotope and Americium Concentrations in Surface Waters Taken Near the WIPP Site

Location	Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	8/14/2014	-6.97E-05	1.87E-04	7.70E-04	U	1.88E-04	4.03E-04	7.78E-04	U	7.83E-04	8.27E-04	1.23E-03	U
NOY	8/14/2014	-7.77E-05	1.95E-04	8.88E-04	U	4.95E-05	3.17E-04	7.82E-04	U	7.02E-04	7.85E-04	9.72E-04	U
HIL	3/12/2014	-5.32E-05	1.54E-04	5.88E-04	U	1.51E-04	3.72E-04	8.32E-04	U	2.05E-04	4.38E-04	1.04E-03	U
HIL Dup	3/12/2014	-3.80E-05	1.29E-04	6.20E-04	U	-7.58E-05	1.82E-04	8.30E-04	U	3.50E-04	4.22E-04	7.55E-04	U
TUT	3/13/2014	-1.62E-04	2.85E-04	9.22E-04	U	1.31E-04	4.45E-04	9.87E-04	U	2.40E-04	3.77E-04	7.92E-04	U
PKT	9/11/2014	-1.59E-05	5.07E-04	1.18E-03	U	-3.97E-05	5.17E-04	1.27E-03	U	-2.88E-04	3.97E-04	9.82E-04	U
FWT	3/12/2014	-1.95E-05	9.33E-05	5.63E-04	U	-3.88E-05	1.32E-04	8.70E-04	U	6.25E-05	3.30E-04	8.97E-04	U
COW [(e)]	3/14/2014	2.17E-04	3.30E-04	5.48E-04	U	7.22E-05	2.65E-04	8.13E-04	U	1.01E-04	4.62E-04	1.02E-03	U
IDN	8/18/2014	-7.57E-05	1.73E-04	7.63E-04	U	-3.78E-05	1.23E-04	5.95E-04	U	-1.77E-04	4.98E-04	1.02E-03	U
PCN	3/13/2014	-8.30E-05	2.07E-04	7.57E-04	U	3.52E-04	4.87E-04	9.08E-04	U	1.77E-04	3.78E-04	7.78E-04	U
SWL	4/16/2014	3.92E-04	6.35E-04	1.10E-03	U	-4.37E-05	1.54E-04	7.20E-04	U	5.55E-04	7.30E-04	1.23E-03	U
CBD	3/13/2014	-7.48E-05	1.77E-04	6.22E-04	U	1.24E-04	3.57E-04	8.88E-04	U	2.03E-04	4.08E-04	8.83E-04	U
CBD Dup	3/13/2014	4.70E-04	5.35E-04	7.72E-04	U	2.90E-04	4.95E-04	9.60E-04	U	6.97E-04	6.78E-04	1.06E-03	U
BRA	3/14/2014	-9.17E-05	2.05E-04	8.68E-04	U	9.17E-05	2.60E-04	8.40E-04	U	5.67E-04	5.58E-04	8.65E-04	U
UPR	3/14/2014	-7.70E-05	1.82E-04	6.37E-04	U	-3.42E-05	1.21E-04	8.17E-04	U	5.35E-05	3.47E-04	9.10E-04	U
LST	9/11/2014	-3.60E-05	3.43E-04	8.93E-04	U	1.97E-04	3.42E-04	5.87E-04	U	-1.25E-04	5.00E-04	1.19E-03	U
BHT	9/15/2014	-5.73E-05	1.59E-04	7.98E-04	U	-4.58E-05	1.42E-04	5.98E-04	U	3.03E-04	5.53E-04	1.08E-03	U

Notes:

See Appendix C for sampling location codes. Units are Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(e) Blind field blank consisting of deionized water.

Table 4.16 – 2014 Gamma Radionuclides ^{90}Sr Concentrations in Standard Surface Water Samples Taken Near the WIPP Site

Location	Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]
RED	8/14/2014	5.35E+00	4.40E+00	5.73E+00	0	U	1.25E-01	4.12E-01	4.88E-01	0	U
NOY	8/14/2014	1.06E+01	3.45E+00	5.60E+00	0	U	-1.13E-01	3.68E-01	3.85E-01	0	U
HIL	3/12/2014	6.12E+00	3.43E+00	4.97E+00	0	U	-6.40E-02	3.55E-01	3.98E-01	0	U
HIL Dup	3/12/2014	-9.92E+00	1.66E+01	1.57E+01	0	U	3.98E-01	1.45E+00	1.80E+00	0	U
TUT	3/13/2014	5.90E+00	3.52E+00	4.98E+00	0	U	-1.27E-03	3.80E-01	4.32E-01	0	U
PKT	9/11/2014	2.75E+00	3.98E+00	4.92E+00	0	U	1.01E-02	3.80E-01	4.35E-01	0	U
FWT	3/12/2014	2.50E+00	3.15E+00	4.18E+00	0	U	-8.30E-02	3.23E-01	3.58E-01	0	U
COW (f)	3/14/2014	3.38E+00	4.45E+00	5.50E+00	0	U	-1.15E-01	4.53E-01	4.83E-01	0	U
IDN	8/18/2014	-4.13E+00	1.54E+01	1.66E+01	0	U	-3.73E-01	1.35E+00	1.48E+00	0	U
PCN	3/13/2014	1.53E+01	1.37E+01	1.97E+01	0	U	5.83E-01	1.25E+00	1.63E+00	0	U
SWL	4/16/2014	1.44E+01	4.18E+00	4.55E+00	0.987	+	-5.57E-02	3.30E-01	3.70E-01	0	U
CBD	3/13/2014	4.73E+00	3.22E+00	4.57E+00	0	U	2.17E-01	3.37E-01	4.30E-01	0	U
CBD Dup	3/13/2014	2.88E+00	4.20E+00	5.13E+00	0	U	6.12E-02	4.20E-01	4.82E-01	0	U
BRA	3/14/2014	6.93E+00	3.58E+00	5.27E+00	0	U	1.45E-01	3.32E-01	4.00E-01	0	U
UPR	3/14/2014	1.05E+01	1.35E+01	1.87E+01	0	U	7.68E-01	1.27E+00	1.70E+00	0	U
LST	9/11/2014	2.97E+00	5.28E+00	6.52E+00	0	U	2.28E-01	4.60E-01	5.73E-01	0	U
BHT	9/15/2014	5.12E+00	4.02E+00	5.30E+00	0	U	2.23E-01	3.38E-01	4.38E-01	0	U

Location	Date	^{137}Cs					^{90}Sr			
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
RED	8/14/2014	6.30E-02	3.77E-01	4.38E-01	0	U	-1.75E-02	3.38E-02	2.38E-02	U
NOY	8/14/2014	1.82E-01	2.68E-01	3.48E-01	0	U	-1.95E-02	3.12E-02	2.37E-02	U
HIL	3/12/2014	-2.60E-01	3.47E-01	3.65E-01	0	U	-1.73E-03	2.45E-02	3.52E-02	U
HIL Dup	3/12/2014	-4.90E-02	1.07E+00	1.28E+00	0	U	3.77E-03	2.78E-02	3.57E-02	U
TUT	3/13/2014	2.62E-01	2.87E-01	3.73E-01	0	U	-6.75E-03	2.35E-02	3.52E-02	U
PKT	9/11/2014	-2.23E-01	4.00E-01	4.22E-01	0	U	2.55E-02	4.10E-02	2.55E-02	U
FWT	3/12/2014	-2.12E-02	3.15E-01	3.53E-01	0	U	-1.01E-03	2.27E-02	3.50E-02	U
COW (f)	3/14/2014	-4.20E-03	3.82E-01	4.35E-01	0	U	1.54E-02	2.28E-02	3.50E-02	U
IDN	8/18/2014	-3.67E-02	1.11E+00	1.32E+00	0	U	-5.60E-03	3.10E-02	2.35E-02	U
PCN	3/13/2014	1.10E-01	1.12E+00	1.37E+00	0	U	7.40E-03	2.55E-02	3.55E-02	U
SWL	4/16/2014	4.83E-02	3.08E-01	3.55E-01	0	U	-4.33E-02	3.67E-02	3.72E-02	U
CBD	3/13/2014	3.12E-01	3.25E-01	4.02E-01	0	U	-2.27E-03	2.70E-02	3.57E-02	U
CBD Dup	3/13/2014	2.02E-01	3.88E-01	4.62E-01	0	U	-2.52E-03	2.57E-02	3.53E-02	U
BRA	3/14/2014	-7.20E-03	3.03E-01	3.63E-01	0	U	-7.02E-04	2.72E-02	3.55E-02	U
UPR	3/14/2014	5.88E-01	1.07E+00	1.40E+00	0	U	8.18E-03	2.65E-02	3.55E-02	U
LST	9/11/2014	-1.73E-01	5.08E-01	5.40E-01	0	U	4.35E-02	4.43E-02	2.58E-02	U
BHT	9/15/2014	-2.48E-01	3.37E-01	3.60E-01	0	U	1.26E-02	3.70E-02	2.50E-02	U

Notes:

See Appendix C for sampling location codes. Units are Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

(f) Blind field blank consisting of deionized water.

Comparison of the detected ^{40}K concentrations with the 99 percent confidence interval range of the baseline concentration data (7.60E+01 Bq/L) shows that the single 2014 detection ^{40}K concentration of 1.44 E+01 Bq/L was lower than the 99 percent confidence interval range of the baseline concentration (DOE/WIPP–92–037). It is expected that ^{40}K would be detected in the sewage lagoon sample since sewage contains significant potassium from human excretions, and ^{40}K makes up 0.012 percent of all naturally occurring potassium.

The reproducibility of the sampling and analysis procedures was assessed by collecting and analyzing duplicate field samples from locations HIL and CBD. The RERs were calculated for all the target radionuclides in the primary and duplicate samples. The RERs for the analysis results are presented in Table 4.17.

The RERs for all radionuclides analyzed in the samples including the detected $^{233/234}$U, ^{235}U, and ^{238}U were all less than 2 except for the RER of 2.12 for ^{238}U in the Hill Tank duplicates. The analysis data demonstrate good reproducibility for the combined sampling and analysis procedures.

Surface Water Samples of Opportunity

The sampling information and analysis results for the surface water SOO are presented in DOE/WIPP-15-3547. The information includes the collection date, the sample location, the activity as Bq/L, 2 σ TPU, the MDC, the identification confidence for the gamma radionuclides, and the detection qualifier (U or +).

Surface water samples were collected on one day in February; three days in March; one day in April; one day in May; one day in June; six days in July; three days in August; two days in September; and one day in October, 2014.

The Seven samples collected at various surface water locations around the WIPP site on February 19, 2014, were analyzed for all the target radionuclides. As shown in DOE/WIPP-15-3547, four samples contained all three uranium isotopes; three samples contained $^{233/234}$U and ^{238}U; and three samples contained ^{40}K. However, none of the samples contained the radioisotopes associated with the radiation release event (^{238}Pu, $^{239/240}$Pu, and ^{241}Am).

A total of 91 SOOs associated with rain events were analyzed for the three target radionuclides associated with the radiation release event. Pu-239/240 was detected in one SOO, building run-off, collected on March 2, 2014 (1.25E-03 Bq/L). Am-241 was detected in four SOO samples including two building run-off samples collected on March 2, 2014 (1.62E-02 Bq/L, 6.55E-03 Bq/L), and two rainwater samples collected on March 26, 2014, taken inside the property protection area (2.66E-03 Bq/L, 1.51E-03 Bq/L).

None of the three radionuclides of interest were detected in any surface water samples collected after March 26, 2014.

Table 4.17 -Precision Results for 2014 Duplicate Surface Water Samples

Location	Radionuclide	Primary Sample		Duplicate Sample			
		[RN](a)	1 σ TPU[b]	[RN](a)	1 σ TPU[b]	RER(c)	Q(d)
HIL and HIL Dup	$^{233/234}$U	6.98E-03	1.18E-03	6.07E-03	1.11E-03	0.56298	+
	^{235}U	1.53E-04	1.72E-04	1.46E-05	2.38E-04	0.472	U
	^{238}U	6.55E-03	1.13E-03	3.60E-03	8.20E-04	2.119	+
	^{238}Pu	-5.32E-05	7.70E-05	-3.80E-05	6.45E-05	0.90796	U
	$^{239/240}$Pu	1.51E-04	1.86E-04	-7.58E-05	9.10E-05	1.095	U
	^{241}Am	2.05E-04	2.19E-04	3.50E-04	2.11E-04	0.477	U
	^{40}K	6.12E+00	1.72E+00	-9.92E+00	8.30E+00	1.893	U
	^{60}Co	-6.40E-02	1.78E-01	3.98E-01	7.25E-01	0.61896	U
	^{137}Cs	-2.60E-01	1.74E-01	-4.90E-02	5.35E-01	0.375	U
	^{90}Sr	-1.73E-03	1.23E-02	3.77E-03	1.39E-02	0.297	U
CBD and CBD Dup	$^{233/234}$U	1.51E-01	1.19E-02	1.62E-01	1.79E-02	0.513	+
	^{235}U	2.97E-03	6.85E-04	4.78E-03	1.00E-03	1.493	+
	^{238}U	6.60E-02	5.60E-03	7.37E-02	8.40E-03	0.763	+
	^{238}Pu	-7.48E-05	8.85E-05	4.70E-04	2.68E-04	1.934	U
	$^{239/240}$Pu	1.24E-04	1.79E-04	2.90E-04	2.48E-04	0.544	U
	^{241}Am	2.03E-04	2.04E-04	6.97E-04	3.39E-04	1.249	U
	^{40}K	4.73E+00	1.61E+00	2.88E+00	2.11E+00	0.698	U
	^{60}Co	2.17E-01	1.69E-01	6.12E-02	2.10E-01	0.579	U
	^{137}Cs	3.12E-01	1.63E-01	2.02E-01	1.94E-01	0.435	U
	^{90}Sr	-2.27E-03	1.35E-02	-2.52E-03	1.29E-02	0.013	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/L.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Relative error ratio.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

4.5 Sediments

4.5.1 Sample Collection

Sediment samples were collected from 12 locations around the WIPP site (Figure 4.3); duplicate samples were collected from two sites (14 samples total). A sample was taken from the BHT location in 2014 after being declared inaccessible by the owner in 2013. See Figure 4.3 for sediment sample locations and Appendix C for location codes. The sites included all the same sites as for 2014 surface water, except for locations FWT and SWL. The samples were collected in 1-L plastic containers from the top 15 cm (6 in.) of sediment of the water bodies and transferred to WIPP Laboratories for determination of individual radionuclides. No sediment SOO samples were collected.

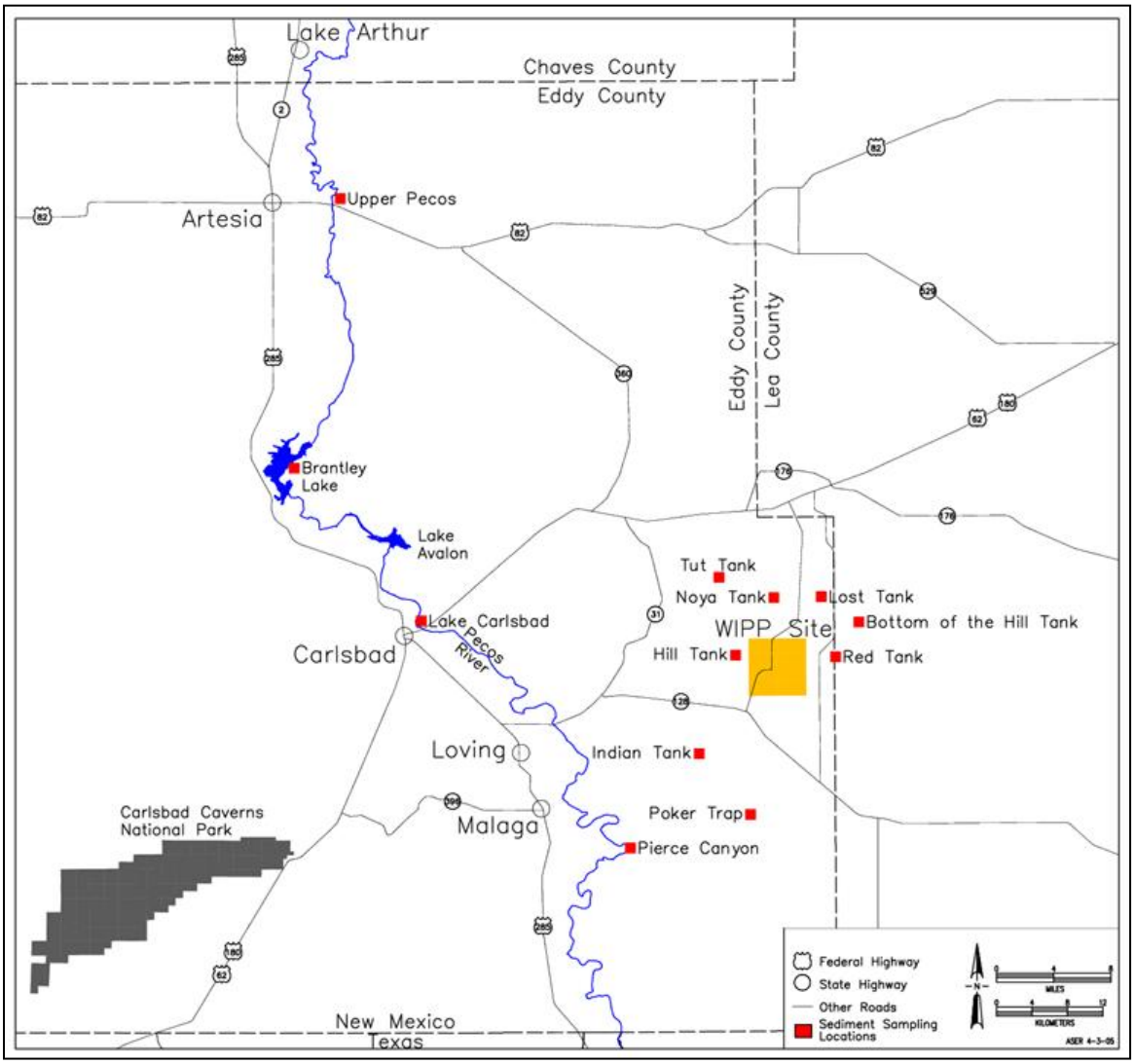


Figure 4.3 – Sediment Sampling Sites

4.5.2 Sample Preparation

Sediment samples were dried at 110°C (230°F) for several hours and homogenized by grinding into smaller particle sizes. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) were added to a 2-gram aliquot of each of the dried and homogenized sediment samples, which were subsequently dissolved by heating with a mixture of nitric, hydrochloric, and hydrofluoric acids. The sample residues were heated with nitric and boric acids to remove hydrofluoric acid. Finally, the residues were dissolved in hydrochloric acid in preparation for separation of the radionuclides.

4.5.3 Determination of Individual Radionuclides

The hydrochloric acid digestates of the sediment samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radioisotopes and ^{90}Sr by employing a series of chemical, physical, and ion exchange separations as described in Section 4.2.3, followed by mounting the sample residues on planchets for counting. The uranium/transuranic isotopes were measured by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.5.4 Results and Discussion

Table 4.18 presents the results of the uranium isotope analyses in the sediment samples. Uranium-233/234, ^{235}U, and ^{238}U were detected in the sediment samples listed.

Using ANOVA, the concentrations of the uranium isotopes were compared between 2014 and 2013 and between sampling locations. Average concentrations were used for HIL and CBD in 2014 and 2013. There were 11 common locations for $^{233/234}$U, ^{235}U, and ^{238}U, with detections in all samples in both 2014 and 2013.

The ANOVA calculations showed that the concentrations of $^{233/234}$U, ^{235}U, and ^{238}U did not vary significantly between 2014 and 2013 (ANOVA $^{233/234}$U, $p = 0.283$; ANOVA ^{235}U, $p = 0.880$; and ANOVA ^{238}U, $p = 0.389$).

The ANOVA calculations also showed that the concentrations of the three uranium isotopes did not vary significantly between sediment locations (ANOVA $^{233/234}$U, $p = 0.999$; ANOVA ^{235}U, $p = 0.273$; and ANOVA ^{238}U, $p = 0.851$). The p values for the variation by year and the variation by location were all well above the significance value of 0.05.

The ongoing drought in recent years may limit significant changes in the composition of the sediments since they are less affected by the washing away and redeposition of sedimentary particles. The year 2014 was wetter after the sediment sampling, and it will be interesting to see if the p values are lower in 2015 due to the effect of water on the sediment composition.

The concentrations of all three uranium isotopes fell within the 99 percent confidence interval ranges of the baseline data ($^{233/234}$U: 1.10E–01 becquerels per gram [Bq/g]; ^{235}U: 3.20E–03 Bq/g; ^{238}U: 5.00E–02 Bq/g).

Sediment samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, by alpha spectroscopy, with the results reported in Table 4.19. There were no detections of any of the three radionuclides in 2014, and no ANOVA calculations could be performed.

The sediment analysis results for the gamma radionuclides and ^{90}Sr are shown in Table 4.20. The gamma radionuclide ^{40}K was detected in all the sediment samples and ^{137}Cs was detected in RED, HIL, the HIL duplicate, TUT, PKT, IDN, PCN, the CBD duplicate, LST, and BHT. Cesium-137 was detected in 10 locations in 2014, while it was detected in only six locations in 2013 with the four additional locations being NOY, PCN, CBD, and BHT (BHT not sampled in 2013). Cobalt-60 and ^{90}Sr were not detected in any of the sediment samples.

Table 4.18 – 2014 Uranium Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Date	$^{233/234}U$				^{235}U				^{238}U			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	3/12/2014	2.18E-02	5.93E-03	5.95E-04	+	8.10E-04	4.87E-04	3.37E-04	+	2.05E-02	5.58E-03	5.92E-04	+
NOY	3/12/2014	2.10E-02	3.87E-03	5.28E-04	+	8.78E-04	3.97E-04	2.37E-04	+	2.37E-02	4.32E-03	5.33E-04	+
HIL	3/12/2014	1.82E-02	3.77E-03	5.43E-04	+	6.40E-04	3.55E-04	2.70E-04	+	1.85E-02	3.80E-03	5.40E-04	+
HIL Dup	3/12/2014	2.18E-02	4.72E-03	5.35E-04	+	1.07E-03	4.72E-04	2.45E-04	+	2.42E-02	5.18E-03	5.45E-04	+
TUT	3/13/2014	1.87E-02	4.23E-03	5.50E-04	+	9.03E-04	4.57E-04	2.58E-04	+	2.28E-02	5.08E-03	5.68E-04	+
PKT	3/13/2014	2.90E-02	8.75E-03	6.07E-04	+	8.83E-04	5.61E-04	3.99E-04	+	3.03E-02	9.14E-03	6.18E-04	+
IDN	3/13/2014	2.80E-02	6.88E-03	5.63E-04	+	1.22E-03	5.95E-04	3.46E-04	+	2.95E-02	7.24E-03	5.85E-04	+
PCN	3/13/2014	2.38E-02	4.65E-03	5.13E-04	+	1.07E-03	4.51E-04	2.61E-04	+	1.97E-02	3.91E-03	5.50E-04	+
CBD	3/13/2014	2.79E-02	4.97E-03	5.12E-04	+	1.26E-03	4.88E-04	2.64E-04	+	2.03E-02	3.71E-03	5.49E-04	+
CBD Dup	3/13/2014	2.62E-02	4.45E-03	5.11E-04	+	6.76E-04	3.39E-04	2.75E-04	+	1.72E-02	3.03E-03	5.44E-04	+
BRA	3/14/2014	1.62E-02	3.02E-03	5.17E-04	+	8.80E-04	4.02E-04	2.69E-04	+	1.53E-02	2.88E-03	5.51E-04	+
UPR	3/14/2014	1.30E-02	2.60E-03	5.14E-04	+	5.52E-04	3.15E-04	2.81E-04	+	1.31E-02	2.61E-03	5.49E-04	+
LST	3/12/2014	1.93E-02	3.70E-03	5.30E-04	+	7.25E-04	3.63E-04	3.78E-04	+	2.08E-02	3.97E-03	5.47E-04	+
BHT	3/12/2014	2.07E-02	5.90E-03	5.93E-04	+	2.63E-03	1.08E-03	3.33E-04	+	2.03E-02	5.83E-03	6.15E-04	+

Notes:

See Appendix C for sampling location codes. Units are in Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

Table 4.19 – 2014 Plutonium and Americium Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
RED	3/12/2014	2.22E-05	1.06E-04	4.03E-04	U	1.25E-04	1.54E-04	5.60E-04	U	2.15E-04	1.90E-04	5.52E-04	U
NOY	3/12/2014	-2.92E-05	7.23E-05	4.05E-04	U	2.93E-05	1.07E-04	5.67E-04	U	1.85E-04	1.51E-04	5.30E-04	U
HIL	3/12/2014	-3.90E-05	7.63E-05	3.97E-04	U	2.20E-04	1.93E-04	5.50E-04	U	3.00E-04	2.43E-04	5.72E-04	U
HIL Dup	3/12/2014	2.42E-05	6.15E-05	3.40E-04	U	2.20E-04	1.65E-04	5.20E-04	U	6.07E-05	8.97E-05	5.32E-04	U
TUT	3/13/2014	7.37E-05	1.85E-04	5.05E-04	U	1.06E-04	2.28E-04	6.10E-04	U	1.78E-04	2.00E-04	5.67E-04	U
PKT	3/13/2014	-6.42E-05	2.13E-04	5.43E-04	U	4.62E-04	2.95E-04	5.83E-04	U	1.97E-04	1.94E-04	5.63E-04	U
IDN	3/13/2014	1.64E-04	1.55E-04	2.93E-04	U	2.12E-04	1.88E-04	5.67E-04	U	3.88E-04	2.73E-04	5.64E-04	U
PCN	3/13/2014	6.33E-05	9.90E-05	2.83E-04	U	4.28E-05	8.03E-05	5.38E-04	U	4.27E-05	8.55E-05	5.21E-04	U
CBD	3/13/2014	-9.93E-06	3.13E-05	2.72E-04	U	6.17E-05	9.63E-05	5.45E-04	U	6.13E-05	1.00E-04	5.18E-04	U
CBD Dup	3/13/2014	-8.67E-06	3.07E-05	2.75E-04	U	-2.17E-05	4.85E-05	5.45E-04	U	-7.66E-05	1.56E-04	7.37E-04	U
BRA	3/14/2014	1.07E-04	1.29E-04	3.12E-04	U	1.90E-05	7.13E-05	5.53E-04	U	5.60E-05	1.00E-04	5.21E-04	U
UPR	3/14/2014	-1.05E-05	3.32E-05	2.77E-04	U	1.68E-05	6.28E-05	5.42E-04	U	1.43E-05	6.19E-05	5.20E-04	U
LST	3/12/2014	7.40E-05	1.42E-04	3.70E-04	U	2.03E-04	1.62E-04	5.22E-04	U	1.16E-04	1.42E-04	5.53E-04	U
BHT	3/12/2014	6.72E-05	1.21E-04	3.60E-04	U	2.85E-04	2.03E-04	5.32E-04	U	2.60E-04	1.97E-04	5.42E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

Table 4.20 – 2014 Gammas and ^{90}Sr Concentrations in Sediment Samples Taken Near the WIPP Site

Location	Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]
RED	3/12/2014	6.80E-01	9.85E-02	1.78E-02	0.921	+	9.52E-04	2.32E-03	2.75E-03	0	U
NOY	3/12/2014	1.10E+00	1.55E-01	1.56E-02	0.920	+	-1.77E-03	2.12E-03	2.05E-03	0	U
HIL	3/12/2014	1.15E+00	1.57E-01	1.80E-02	0.922	+	3.22E-04	1.97E-03	2.27E-03	0	U
HIL Dup	3/12/2014	1.20E+00	1.68E-01	2.17E-02	0.928	+	-1.12E-03	2.72E-03	2.93E-03	0	U
TUT	3/13/2014	9.12E-01	1.25E-01	1.45E-02	0.925	+	-3.02E-04	1.56E-03	1.73E-03	0	U
PKT	3/13/2014	1.07E+00	1.59E-01	1.97E-02	0.993	+	1.57E-03	2.37E-03	2.87E-03	0	U
IDN	3/13/2014	8.42E-01	1.24E-01	1.57E-02	0.992	+	-8.22E-04	1.92E-03	1.98E-03	0	U
PCN	3/13/2014	2.97E-01	4.48E-02	7.90E-03	0.999	+	2.02E-04	7.67E-04	9.05E-04	0	U
CBD	3/13/2014	2.52E-01	3.75E-02	1.12E-02	0.916	+	-5.05E-05	1.08E-03	1.23E-03	0	U
CBD Dup	3/13/2014	2.65E-01	3.88E-02	9.13E-03	0.953	+	3.97E-04	9.43E-04	1.09E-03	0	U
BRA	3/14/2014	3.17E-01	4.72E-02	1.01E-02	0.943	+	2.22E-04	1.26E-03	1.47E-03	0	U
UPR	3/14/2014	5.30E-01	7.32E-02	7.57E-03	0.998	+	5.40E-04	8.45E-04	1.04E-03	0	U
LST	3/12/2014	8.27E-01	1.14E-01	1.34E-02	0.993	+	9.72E-04	1.43E-03	1.73E-03	0	U
BHT	3/12/2014	8.18E-01	1.13E-01	1.35E-02	0.995	+	-1.53E-04	1.55E-03	1.73E-03	0	U

Location	Date	^{137}Cs					^{90}Sr			
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]
RED	3/12/2014	3.93E-03	1.50E-03	2.02E-03	0.986	+	-1.48E-04	7.10E-03	3.42E-02	U
NOY	3/12/2014	8.80E-04	8.55E-04	1.35E-03	0.995	U	8.22E-04	7.18E-03	3.42E-02	U
HIL	3/12/2014	4.62E-03	1.37E-03	1.68E-03	0.988	+	1.43E-03	7.23E-03	3.42E-02	U
HIL Dup	3/12/2014	5.17E-03	1.77E-03	2.28E-03	0.996	+	-3.63E-03	6.78E-03	3.42E-02	U
TUT	3/13/2014	1.57E-03	9.92E-04	1.51E-03	0.997	+	3.43E-03	6.82E-03	3.42E-02	U
PKT	3/13/2014	1.31E-02	2.53E-03	1.92E-03	0.999	+	-2.87E-05	5.40E-03	3.35E-02	U
IDN	3/13/2014	6.32E-03	1.56E-03	1.63E-03	1.000	+	3.90E-04	6.72E-03	3.37E-02	U
PCN	3/13/2014	9.95E-04	5.02E-04	7.05E-04	0.998	+	-1.88E-05	5.47E-03	3.35E-02	U
CBD	3/13/2014	9.65E-04	5.80E-04	8.57E-04	0.982	+	6.10E-04	5.17E-03	3.35E-02	U
CBD Dup	3/13/2014	1.18E-03	4.23E-04	7.65E-04	0.980	+	1.48E-03	5.28E-03	3.35E-02	U
BRA	3/14/2014	7.05E-04	1.10E-03	1.36E-03	0.000	U	-2.47E-03	5.67E-03	3.35E-02	U
UPR	3/14/2014	6.13E-04	8.87E-04	1.03E-03	0.000	U	9.47E-04	5.73E-03	3.35E-02	U
LST	3/12/2014	5.23E-03	1.04E-03	1.15E-03	0.998	+	3.58E-03	7.05E-03	3.42E-02	U
BHT	3/12/2014	8.03E-03	1.75E-03	1.88E-03	1.000	+	1.36E-03	7.33E-03	3.42E-02	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/L. HIL and CBD used for field duplicates.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected; U equals undetected.

With respect to sediment concentrations associated with tanks and tank-like structures, the concentration ^{40}K detected in the HIL duplicate sample of 1.20E+00 Bq/g was equal to the 99 percent confidence interval range of baseline concentrations (baseline 99 percent confidence interval concentration: 1.20E+00 Bq/g). The primary HIL sample concentration was just below the 99 percent confidence interval range concentration at 1.15E+00 Bq/g. These concentrations are very close to the concentrations measured in 2013.

The sediment locations associated with the Pecos River and associated bodies of water (PCN, CBD, BRA, and UPR) have a ^{40}K baseline concentration of 4.00E–01 Bq/g. One of the 2014 concentrations exceeded the 99 percent confidence interval range of the baseline concentration (UPR with 5.30E-01 Bq/g) and BRA with the next highest concentration but below the 99 percent confidence interval range at 3.17E-01 Bq/g. Potassium is ubiquitous throughout the earth's crust, with variable concentrations in rocks, soil, and water, and therefore would be expected to be present at variable concentrations in the sediment samples.

The ANOVA calculations showed that the sediment concentrations of ^{40}K did not vary significantly between years (ANOVA ^{40}K, $p = 0.323$), but it did vary significantly by location (ANOVA ^{40}K, $p = 0.0084$) with the 2014 concentrations more than double the 2013 concentrations at PKT and IDN, but the concentrations at the other locations were quite similar. When the ^{40}K ANOVA calculations are performed differentiating the tank and tank-like structures and the Pecos River and associated bodies of water, both groups (tanks and Pecos River) yielded p values greater than the 0.05 significance factor for the variation between years and between locations. The variation by year for tanks was ANOVA ^{40}K, p = 0.141 and by location ANOVA ^{40}K, p = 0.298, while the variation for the Pecos River and associated bodies of water were ANOVA ^{40}K, p = 0.807 by year and ANOVA ^{40}K, p = 0.199 by location. In comparing the ^{137}Cs 2014 data with the 2013 data, ^{137}Cs was detected in six common locations between 2014 and 2013 including RED, HIL, TUT, PKT, IDN, and LST, all of which are tanks and tank-like structures. There was no significant variation in the concentrations between 2014 and 2013 (ANOVA ^{137}Cs, $p = 0.275$) or by location (ANOVA ^{137}Cs, $p = 0.385$). In 2014 ^{137}Cs was detected in two samples associated with the Pecos River and associated bodies of water, including PCN and the CBD duplicates, after not being detected in any of the samples in 2013. As a result ANOVA calculations were not performed for Pecos River and associated samples due to lack of detections at common locations the last two years.

The measured ^{137}Cs concentrations in the sediments associated with tanks and tank-like structures (RED, NOY, HIL, TUT, PKT, IDN, LST, and BHT) were within the 99 percent confidence interval range of the baseline concentration (3.50E–02 Bq/g). The measured ^{137}Cs concentrations in Pecos River and associated bodies of water (PCN and CBD were also within the 99 percent confidence interval range of the baseline concentration (5.00E-03 Bq/g). Cesium-137 is a fission product and is consistently found in sediment because of global fallout from atmospheric nuclear

weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). Thus, it is not present in sediments in the same manner as ^{40}K, which is abundant in rocks and soils.

Because ^{90}Sr and ^{60}Co were not detected in any of the sediment samples (Table 4.20), no ANOVA comparisons among sampling locations or between years could be calculated.

Duplicate analyses were performed for the target radionuclides in sediment samples from sampling locations HIL and CBD. Precision calculations as RER were performed for all the target radionuclides, as shown in Table 4.16. The qualifier column shows which radionuclides were detected in the samples.

Table 4.21 - Precision Results for 2014 Duplicate Sediment Samples

		Primary Sample		Duplicate Sample			
Location	Radionuclide	[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]	Q[d]
HIL and HIL Dup	$^{233/234}U$	1.82E-02	1.89E-03	2.18E-02	2.36E-03	1.192	+
	^{235}U	6.40E-04	1.78E-04	1.07E-03	2.36E-04	1.456	+
	^{238}U	1.85E-02	1.90E-03	2.42E-02	2.59E-03	1.774	+
	^{238}Pu	-3.90E-05	3.82E-05	2.42E-05	3.08E-05	1.290	U
	$^{239/240}Pu$	2.20E-04	9.65E-05	2.20E-04	8.25E-05	0.000	U
	^{241}Am	3.00E-04	1.22E-04	6.07E-05	4.49E-05	1.848	U
	^{40}K	1.15E+00	7.85E-02	1.20E+00	8.40E-02	0.435	+
	^{60}Co	3.22E-04	9.85E-04	-1.12E-03	1.36E-03	0.859	U
	^{137}Cs	4.62E-03	6.85E-04	5.17E-03	8.85E-04	0.491	+
	^{90}Sr	1.43E-03	3.62E-03	-3.63E-03	3.39E-03	1.021	U
CBD and CBD Dup	$^{233/234}U$	2.79E-02	2.49E-03	2.62E-02	2.23E-03	0.510	+
	^{235}U	1.26E-03	2.44E-04	6.76E-04	1.70E-04	1.966	+
	^{238}U	1.97E-02	1.86E-03	2.03E-02	1.86E-03	1.182	+
	^{238}Pu	-9.93E-06	1.57E-05	-8.67E-06	1.54E-05	0.057	U
	$^{239/240}Pu$	6.17E-05	4.82E-05	-2.17E-05	2.43E-05	1.547	U
	^{241}Am	6.13E-05	5.00E-05	-7.66E-05	7.80E-05	1.488	U
	^{40}K	2.52E-01	1.88E-02	2.65E-01	1.94E-02	0.482	+
	^{60}Co	-5.05E-05	5.40E-04	3.97E-04	4.72E-04	0.624	U
	^{137}Cs	9.65E-04	2.90E-04	1.18E-03	2.12E-04	0.599	+
	^{90}Sr	6.10E-04	2.59E-03	1.48E-03	2.64E-03	0.235	U

Notes:
See Appendix C for sampling location codes. Units are in Bq/L.
(a) Radionuclide concentration.
(b) Total propagated uncertainty.
(c) Relative error ratio.
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

All of the RERs in Table 4.21 were less than 2 with one value slightly greater than 1.96. The precision met the objective for the combined sampling and analysis procedures.

4.6 Soil Samples

4.6.1 Sample Collection

Regular soil samples were collected from the six locations where the low-volume air samplers are stationed around the WIPP site: WFF, WEE, WSS, MLR, SEC, and SMR (Figure 4.4). Samples were collected from each location in three incremental profiles: surface (shallow) soil (0–2 cm [0–0.8 in.]), intermediate soil (2–5 cm [0.8–2 in.]), and deep soil (5–10 cm [2–4 in.]). Measurements of radionuclides in depth profiles may provide information about their vertical movements in the soil systems.

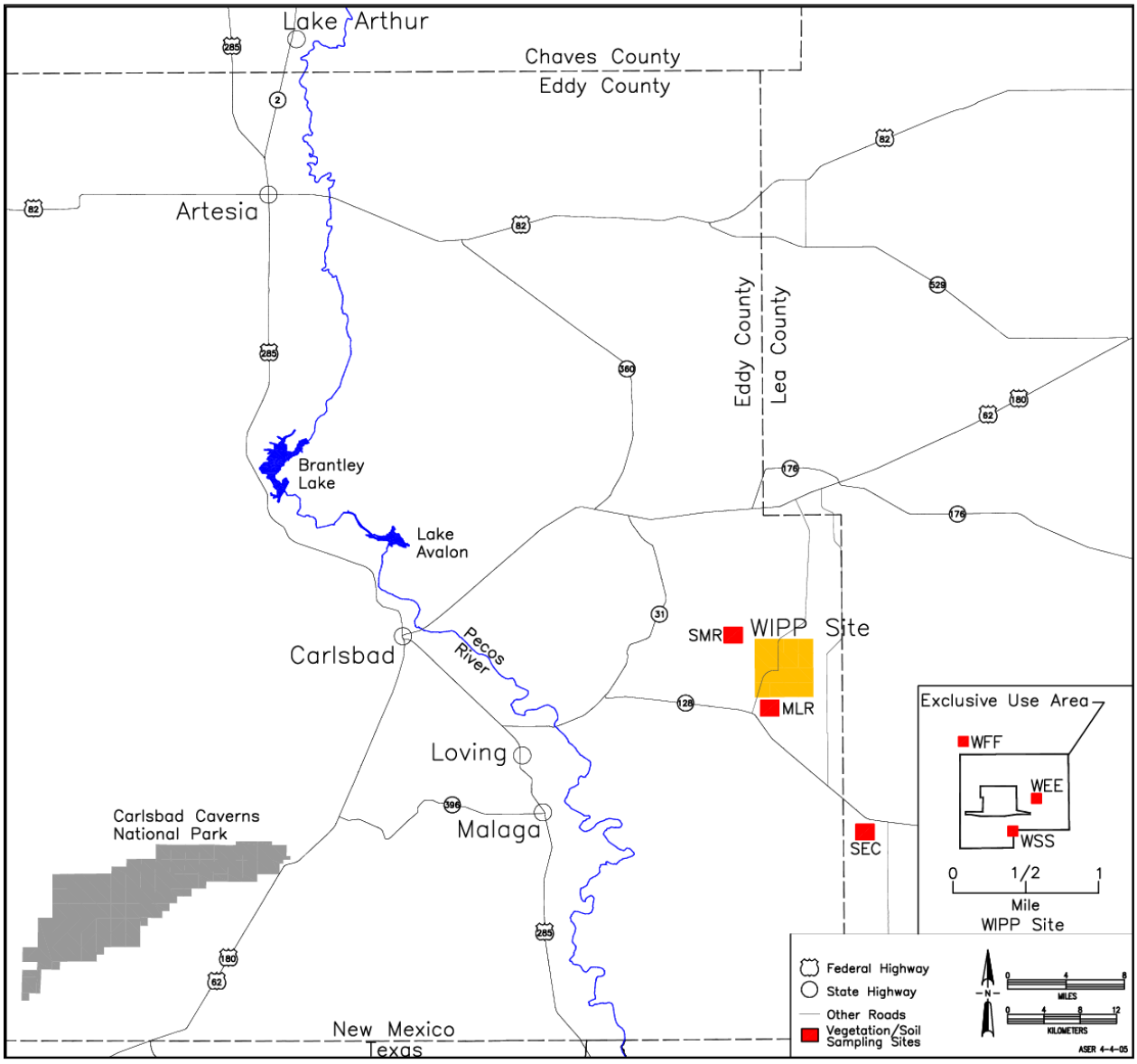


Figure 4.4 – Routine Soil and Vegetation Sampling Areas

Soil sample locations are divided into three geographic groups.

- The WIPP site group covers the smallest area with locations within one km of the WHB and exhaust shaft and includes WFF, WEE, and WSS.
- The five-mile ring has a radius of approximately 8 km (5 mi) from the center of the WIPP facility and includes MLR and SMR.
- The outer sites group, including SEC, represents a variety of habitats, soil types and land uses and ranges from Artesia and Loving on the west to Hobbs and Jal on the east and includes the Gnome site, a potash mine, and an oil and gas production area covering a total area of 10,000 km^2.

Samples were collected from locations WFF, WEE, and WSS on February 13, 2014, and February 14, 2014, just before the release event on February 14, 2014. Samples from MLR, SEC, and SMR had not yet been collected. On February 17, 2014, the routine annual sampling of the six sites was restarted and continued on February 20, 2014, with samples taken at all six locations. A separate set of duplicate samples was taken from the 0–2 cm depth from location MLR on May 15, 2014, to obtain follow-up samples because of the detection of $^{239/240}Pu$ at the 0–2 cm depth in the February samples.

In addition, 36 soil SOO from 33 locations, including three duplicate samples, were collected at the 0–2 cm depth from various locations on March 19, 20, and 21, 2014; and June 13, 2014. All the samples were designated by global positioning system (GPS) locations except for the sample collected at the H-7 well pad on June 13, 2014. DOE/WIPP-15-3547 contains a document titled “Soil Sampling Plan for Additional Samples.” This document describes the strategy that was used to select locations for the additional soil samples and contains a table of the GPS location number along with the approximate GPS coordinates for each sampling location. The soil SOO were analyzed for the three radionuclides of interest following the radiation release event including ^{238}Pu, $^{239/240}Pu$, and ^{241}Am.

4.6.2 Sample Preparation

Soil samples were dried at 110°C (230°F) for several hours and homogenized by grinding to small particles. Tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) were added to a 2-gram aliquot of each of the dried and homogenized soil samples, which were subsequently dissolved by heating with a mixture of nitric, hydrochloric, and hydrofluoric acids. The sample residues were heated with nitric and boric acids to remove hydrofluoric acid. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

4.6.3 Determination of Individual Radionuclides

The nitric acid digestates of the soil samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radioisotopes and ^{90}Sr by employing a series of chemical, physical, and ion exchange separations as described in Section 4.2.3, then mounting the sample residues on a planchet for counting. The uranium/transuranic isotopes were measured by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.6.4 Results and Discussion

The data and discussion is separated into the routine soil samples typically reported in the ASER, and the event evaluation samples consisting of the SOO that were collected on the four sampling dates discussed above. The routine soil sample analysis results are discussed immediately below, followed by discussion of the analysis results for the soil SOO, which are also presented in DOE/WIPP-15-3547.

Routine Soil Samples

The data from the samples taken at locations WFF, WEE, and WSS before the event on February 13 and February 14, 2014, are shown in Table 4.22 (uranium, plutonium, and americium) and Table 4.23 (gammas and ^{90}Sr). No samples were collected in duplicate because the duplicate sample location was expected to be SEC. The data from all the soil samples collected on February 17, February 20, and May 15, 2014, are presented in Table 4.24 through Table 4.26. Duplicate samples were collected at locations WFF and SEC. Table 4.25 also contains the plutonium and americium data for the follow-up samples collected on May 15, 2014.

The data for the first three soil samples in Tables 4.22 and 4.23 show that $^{233/234}$U, ^{238}U, ^{40}K and ^{137}Cs were detected in all three samples at all three depths. The ^{235}U was detected in seven of the nine samples but not at the 0–2 cm depth in WFF and the 2–5 cm depth of WSS. The other radionuclides including ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{60}Co and ^{90}Sr were not detected at any depth in any of the samples.

Table 4.24 presents the uranium isotope analysis data for the complete set of 2014 soil samples including the two sets of duplicate samples collected at WFF and SEC. As shown in the table, $^{233/234}$U and ^{238}U were detected in all soil samples, and ^{235}U was detected in 16 out of 24 soil samples. The ^{235}U was present at relatively low concentrations compared to $^{233/234}$U and ^{238}U, and the duplicate sample detections for ^{235}U did not always match the primary sample detections.

In comparing the 2014 and 2013 uranium data, the average of the primary and duplicate samples was used for the WFF and SEC locations in 2014 and the WEE location in 2013. All locations and all depths were common for $^{233/234}$U and ^{238}U in 2014 and 2013. However, for ^{235}U, there were variable detections both years and occasions when the

radionuclide was detected in one of the WFF and SEC duplicates but not the other in 2014, and in one of the WEE duplicates but not the other in 2013.

Table 4.22 – 2014 Uranium, Plutonium, and Americium Concentrations in Soil Samples Taken near the WIPP Site just Prior to Release Event

Location	Depth (cm)	Date	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)
			$^{233/234}$U				^{235}U				^{238}U			
WFF	0–2	2/13/2014	5.88E-03	1.27E-03	3.93E-04	+	1.83E-04	1.72E-04	2.32E-04	U	5.48E-03	1.20E-03	4.10E-04	+
WFF	2–5	2/13/2014	5.68E-03	1.59E-03	4.25E-04	+	3.42E-04	2.70E-04	2.63E-04	+	5.25E-03	1.49E-03	4.53E-04	+
WFF	5–10	2/13/2014	4.85E-03	1.15E-03	4.07E-04	+	4.25E-04	2.83E-04	3.90E-04	+	6.03E-03	1.36E-03	4.43E-04	+
WEE	0–2	2/13/2014	6.65E-03	1.51E-03	4.03E-04	+	4.28E-04	2.77E-04	2.35E-04	+	7.22E-03	1.61E-03	4.33E-04	+
WEE	2–5	2/13/2014	6.27E-03	1.48E-03	4.05E-04	+	2.78E-04	2.28E-04	2.52E-04	+	6.85E-03	1.59E-03	4.23E-04	+
WEE	5–10	2/13/2014	7.40E-03	1.57E-03	3.98E-04	+	5.57E-04	3.17E-04	2.48E-04	+	6.87E-03	1.48E-03	4.22E-04	+
WSS	0–2	2/14/2014	7.23E-03	1.75E-03	3.93E-04	+	4.13E-04	2.62E-04	2.28E-04	+	8.07E-03	1.93E-03	4.10E-04	+
WSS	2–5	2/14/2014	7.10E-03	1.44E-03	4.47E-04	+	1.68E-04	1.72E-04	2.47E-04	U	7.15E-03	1.45E-03	4.12E-04	+
WSS	5–10	2/14/2014	8.03E-03	1.88E-03	4.25E-04	+	3.05E-04	2.52E-04	2.82E-04	+	7.45E-03	1.77E-03	4.28E-04	+
			^{238}Pu				$^{239/240}$Pu				^{241}Am			
WFF	0–2	2/13/2014	-2.95E-05	1.30E-04	4.22E-04	U	1.05E-04	1.22E-04	3.10E-04	U	1.46E-04	1.87E-04	6.48E-04	U
WFF	2–5	2/13/2014	-5.15E-05	8.13E-05	4.52E-04	U	5.45E-05	1.00E-04	3.27E-04	U	2.85E-04	2.57E-04	6.43E-04	U
WFF	5–10	2/13/2014	-2.22E-05	8.92E-05	4.22E-04	U	7.38E-05	9.62E-05	3.02E-04	U	1.29E-04	2.02E-04	6.43E-04	U
WEE	0–2	2/13/2014	-3.12E-05	6.10E-05	4.13E-04	U	8.20E-05	1.12E-04	3.13E-04	U	-8.60E-06	1.49E-04	6.77E-04	U
WEE	2–5	2/13/2014	2.37E-05	1.11E-04	4.32E-04	U	8.38E-05	1.13E-04	3.18E-04	U	7.88E-05	1.52E-04	6.42E-04	U
WEE	5–10	2/13/2014	-1.51E-05	4.40E-05	4.17E-04	U	1.93E-04	1.62E-04	3.18E-04	U	1.07E-04	1.80E-04	6.73E-04	U
WSS	0–2	2/14/2014	3.22E-05	9.77E-05	4.05E-04	U	1.48E-04	1.51E-04	3.22E-04	U	4.38E-05	1.07E-04	6.43E-04	U
WSS	2–5	2/14/2014	-1.16E-05	3.65E-05	3.97E-04	U	1.11E-04	1.22E-04	3.07E-04	U	4.87E-05	9.55E-05	6.32E-04	U
WSS	5–10	2/14/2014	0.00E+00	9.27E-05	4.27E-04	U	1.55E-04	1.52E-04	3.27E-04	U	1.56E-04	2.40E-04	6.87E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.23 – 2014 Gamma Radionuclide and 90Sr Concentrations in Soil Samples Taken Near the WIPP Site just Prior to the Release Event

Location	Depth (cm)	Sampling Date	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf. [e]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf.	Q[d]
			^{40}K					^{60}Co				
WFF	0–2	2/13/2014	3.03E-03	4.75E-04	1.21E-04	1.000	+	8.18E-06	1.15E-05	1.42E-05	0.00	U
WFF	2–5	2/13/2014	3.35E-03	5.53E-04	1.54E-04	1.000	+	-2.12E-06	1.75E-05	1.97E-05	0.00	U
WFF	5–10	2/13/2014	3.48E-03	5.38E-04	1.31E-04	1.000	+	5.48E-06	1.25E-05	1.47E-05	0.00	U
WEE	0–2	2/13/2014	3.80E-03	5.83E-04	1.26E-04	1.000	+	1.20E-05	1.11E-05	1.40E-05	0.00	U
WEE	2–5	2/13/2014	3.78E-03	5.83E-04	1.26E-04	1.000	+	-1.49E-06	1.10E-05	1.24E-05	0.00	U
WEE	5–10	2/13/2014	3.97E-03	6.42E-04	1.43E-04	1.000	+	2.25E-06	1.80E-05	2.10E-05	0.00	U
WSS	0–2	2/14/2014	3.53E-03	5.78E-04	1.70E-04	1.000	+	-1.70E-06	1.65E-05	1.85E-05	0.00	U
WSS	2–5	2/14/2014	3.78E-03	5.82E-04	1.27E-04	1.000	+	5.22E-06	1.36E-05	1.57E-05	0.00	U
WSS	5–10	2/14/2014	3.70E-03	5.70E-04	1.22E-04	1.000	+	8.63E-06	1.36E-05	1.61E-05	0.00	U
Location	**Depth (cm)**	**Sampling Date**	**[RN][a]**	**2 σ TPU[b]**	**MDC[c]**	**ID Conf.**	**Q[d]**	**[RN][a]**	**2 σ TPU[b]**	**MDC[c]**	**Q[d]**	
			^{137}Cs					^{90}Sr				
WFF	0–2	2/13/2014	2.63E-05	8.70E-06	1.04E-05	0.999	+	-6.40E-04	5.60E-03	3.63E-02	U	
WFF	2–5	2/13/2014	2.18E-05	1.19E-05	1.70E-05	0.999	+	1.15E-03	5.35E-03	3.62E-02	U	
WFF	5–10	2/13/2014	2.50E-05	9.50E-06	1.23E-05	1.000	+	-5.80E-04	5.83E-03	3.63E-02	U	
WEE	0–2	2/13/2014	3.82E-05	1.06E-05	1.15E-05	0.999	+	-1.92E-03	5.38E-03	3.62E-02	U	
WEE	2–5	2/13/2014	4.50E-05	1.09E-05	1.04E-05	1.000	+	-1.42E-03	5.25E-03	3.62E-02	U	
WEE	5–10	2/13/2014	3.73E-05	1.21E-05	1.37E-05	1.000	+	-1.73E-03	5.58E-03	3.63E-02	U	
WSS	0–2	2/14/2014	3.32E-05	1.18E-05	1.44E-05	1.000	+	2.40E-04	5.23E-03	3.62E-02	U	
WSS	2–5	2/14/2014	3.45E-05	1.01E-05	1.13E-05	0.999	+	-2.97E-03	5.52E-03	3.62E-02	U	
WSS	5–10	2/14/2014	1.78E-05	7.85E-06	1.05E-05	1.000	+	-1.90E-03	5.35E-03	3.62E-02	U	

Notes:

See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

Table 4.24 – 2014 Uranium Concentrations in Soil Samples Taken Near the WIPP Site

			$^{233/234}$U				^{235}U				^{238}U			
Location	**Depth (cm)**	**Date**	**[RN](a)**	**2 σ TPU(b)**	**MDC(c)**	**Q(d)**	**[RN](a)**	**2 σ TPU(b)**	**MDC(c)**	**Q(d)**	**[RN](a)**	**2 σ TPU(b)**	**MDC(c)**	**Q(d)**
WFF	0–2	2/17/2014	5.80E-03	1.39E-03	5.03E-04	+	2.18E-04	2.17E-04	5.08E-04	U	5.73E-03	1.38E-03	4.72E-04	+
WFF	2–5	2/17/2014	6.57E-03	1.51E-03	5.12E-04	+	2.17E-04	1.98E-04	2.40E-04	U	7.43E-03	1.68E-03	4.77E-04	+
WFF	5–10	2/17/2014	5.62E-03	1.26E-03	4.93E-04	+	1.46E-04	1.53E-04	2.25E-04	U	5.18E-03	1.19E-03	4.65E-04	+
WFF Dup	0–2	2/17/2014	5.25E-03	1.20E-03	5.05E-04	+	2.32E-04	2.02E-04	2.48E-04	U	5.48E-03	1.24E-03	4.72E-04	+
WFF Dup	2–5	2/17/2014	7.15E-03	1.65E-03	5.13E-04	+	3.82E-04	2.62E-04	2.35E-04	+	6.68E-03	1.56E-03	4.77E-04	+
WFF Dup	5–10	2/17/2014	5.83E-03	1.29E-03	5.00E-04	+	2.27E-04	1.93E-04	2.28E-04	U	6.67E-03	1.43E-03	4.65E-04	+
WEE	0–2	2/17/2014	6.92E-03	1.55E-03	4.80E-04	+	3.80E-04	2.48E-04	2.18E-04	+	6.23E-03	1.42E-03	4.53E-04	+
WEE	2–5	2/17/2014	6.30E-03	1.50E-03	4.97E-04	+	2.47E-04	2.33E-04	4.08E-04	U	7.35E-03	1.70E-03	4.83E-04	+
WEE	5–10	2/17/2014	5.95E-03	1.23E-03	4.73E-04	+	2.93E-04	2.08E-04	2.07E-04	+	6.87E-03	1.38E-03	4.48E-04	+
WSS	0–2	2/17/2014	8.75E-03	1.93E-03	4.88E-04	+	4.37E-04	2.83E-04	2.38E-04	+	9.02E-03	1.98E-03	4.53E-04	+
WSS	2–5	2/17/2014	6.83E-03	1.55E-03	4.90E-04	+	2.88E-04	2.37E-04	2.47E-04	+	7.15E-03	1.60E-03	4.60E-04	+
WSS	5–10	2/17/2014	7.52E-03	1.95E-03	4.90E-04	+	2.50E-04	2.12E-04	2.30E-04	+	7.77E-03	2.00E-03	4.53E-04	+
MLR	0–2	2/20/2014	1.51E-02	4.27E-03	6.25E-04	+	5.20E-04	3.83E-04	3.33E-04	+	1.48E-02	4.18E-03	5.92E-04	+
MLR	2–5	2/20/2014	1.44E-02	3.92E-03	6.08E-04	+	9.55E-04	5.32E-04	3.07E-04	+	1.54E-02	4.15E-03	5.97E-04	+
MLR	5–10	2/20/2014	1.20E-02	2.68E-03	5.75E-04	+	3.27E-04	2.53E-04	2.48E-04	+	1.30E-02	2.87E-03	5.48E-04	+
SEC	0–2	2/20/2014	1.21E-02	3.58E-03	6.23E-04	+	6.00E-04	4.22E-04	3.38E-04	+	1.04E-02	3.12E-03	5.82E-04	+
SEC	2–5	2/20/2014	9.45E-03	2.33E-03	5.72E-04	+	8.18E-04	4.18E-04	2.45E-04	+	1.01E-02	2.47E-03	5.52E-04	+
SEC	5–10	2/20/2014	8.93E-03	2.28E-03	5.87E-04	+	2.47E-04	2.55E-04	4.65E-04	U	9.95E-03	2.50E-03	5.82E-04	+
SEC Dup	0–2	2/20/2014	8.97E-03	2.23E-03	5.78E-04	+	2.33E-04	2.32E-04	2.90E-04	U	9.43E-03	2.33E-03	5.50E-04	+

Location	Depth (cm)	Date	$^{233/234}$U				^{235}U				^{238}U			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
SEC Dup	2–5	2/20/2014	8.55E-03	2.35E-03	5.77E-04	+	3.77E-04	2.98E-04	2.72E-04	+	9.27E-03	2.52E-03	5.67E-04	+
SEC Dup	5–10	2/20/2014	1.10E-02	3.13E-03	5.95E-04	+	5.52E-04	3.95E-04	3.07E-04	+	1.16E-02	3.28E-03	5.83E-04	+
SMR	0–2	2/20/2014	1.77E-02	5.47E-03	6.27E-04	+	5.48E-04	4.37E-04	3.88E-04	+	1.78E-02	5.48E-03	6.03E-04	+
SMR	2–5	2/20/2014	1.64E-02	4.37E-03	6.00E-04	+	8.03E-04	4.80E-04	3.32E-04	+	1.72E-02	4.55E-03	5.70E-04	+
SMR	5–10	2/20/2014	1.85E-02	4.22E-03	5.53E-04	+	6.02E-04	3.70E-04	4.43E-04	+	1.78E-02	4.08E-03	5.78E-04	+

Notes:

See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.25 – 2014 Plutonium Isotope and Americium Concentrations in Soil Samples Taken Near the WIPP Site

Location	Depth (cm)	Date	^{238}Pu				$^{239/240}$Pu				^{241}Am			
			[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	0–2	2/17/2014	-6.33E-06	1.03E-04	4.37E-04	U	9.12E-05	1.30E-04	3.25E-04	U	8.30E-05	1.34E-04	6.03E-04	U
WFF	2–5	2/17/2014	1.92E-05	6.20E-05	3.40E-04	U	6.38E-06	7.20E-05	3.33E-04	U	7.88E-05	9.52E-05	5.03E-04	U
WFF	5–10	2/17/2014	2.08E-05	5.87E-05	3.38E-04	U	5.80E-05	1.04E-04	3.33E-04	U	1.12E-04	1.17E-04	5.08E-04	U
WFF Dup	0–2	2/17/2014	5.92E-05	1.02E-04	4.03E-04	U	-2.22E-05	5.42E-05	3.28E-04	U	7.20E-05	9.65E-05	5.70E-04	U
WFF Dup	2–5	2/17/2014	-1.03E-05	3.23E-05	3.40E-04	U	-1.03E-05	3.23E-05	3.28E-04	U	7.07E-05	1.02E-04	5.08E-04	U
WFF Dup	5–10	2/17/2014	1.88E-05	6.08E-05	3.42E-04	U	7.30E-05	9.68E-05	3.30E-04	U	1.47E-04	1.44E-04	5.20E-04	U
WEE	0–2	2/17/2014	-1.29E-05	3.58E-05	3.90E-04	U	1.70E-04	1.38E-04	3.00E-04	U	2.03E-05	5.93E-05	5.68E-04	U
WEE	2–5	2/17/2014	0.00E+00	1.26E-04	3.68E-04	U	1.43E-05	6.18E-05	3.25E-04	U	1.54E-04	1.26E-04	4.95E-04	U
WEE	5–10	2/17/2014	-1.47E-05	8.40E-05	3.80E-04	U	1.78E-04	1.43E-04	3.30E-04	U	1.60E-05	9.05E-05	5.03E-04	U
WSS	0–2	2/17/2014	6.55E-05	1.58E-04	4.93E-04	U	2.37E-04	2.22E-04	3.63E-04	U	2.08E-05	7.10E-05	5.80E-04	U
WSS	2–5	2/17/2014	0.00E+00	7.38E-05	3.57E-04	U	4.35E-05	8.02E-05	3.27E-04	U	1.21E-04	1.30E-04	5.13E-04	U
WSS	5–10	2/17/2014	2.00E-05	9.40E-05	3.70E-04	U	9.75E-05	1.09E-04	3.30E-04	U	1.34E-04	1.52E-04	5.17E-04	U
MLR	0–2	2/20/2014	1.85E-05	7.38E-05	4.18E-04	U	5.57E-04	2.80E-04	3.12E-04	+	2.32E-04	1.58E-04	5.67E-04	U
MLR	2–5	2/20/2014	2.08E-05	7.05E-05	2.93E-04	U	1.04E-04	1.32E-04	5.53E-04	U	8.00E-05	1.20E-04	5.03E-04	U
MLR	5–10	2/20/2014	-1.33E-05	3.83E-05	2.82E-04	U	9.52E-05	1.23E-04	5.45E-04	U	8.50E-05	1.03E-04	4.78E-04	U
MLR	0–2	5/15/2014	4.23E-05	7.60E-05	3.98E-04	U	1.68E-04	1.35E-04	2.43E-04	U	1.58E-04	1.90E-04	4.97E-04	U

MLR	0–2	5/15/2014	5.70E-05	1.03E-04	4.25E-04	U	3.97E-04	2.38E-04	2.73E-04	+	6.80E-05	2.12E-04	5.12E-04	U
SEC	0–2	2/20/2014	-2.48E-05	5.98E-05	4.42E-04	U	7.45E-05	1.46E-04	3.28E-04	U	1.06E-04	1.14E-04	5.73E-04	U
SEC	2–5	2/20/2014	4.65E-05	8.72E-05	2.85E-04	U	2.98E-04	1.93E-04	5.55E-04	U	1.25E-04	1.30E-04	4.77E-04	U
SEC	5–10	2/20/2014	1.70E-05	5.48E-05	2.68E-04	U	2.02E-04	1.51E-04	5.33E-04	U	9.53E-05	1.12E-04	4.77E-04	U
SEC Dup	0–2	2/20/2014	1.10E-05	8.32E-05	4.22E-04	U	2.30E-04	1.97E-04	3.15E-04	U	1.65E-04	1.42E-04	5.73E-04	U
SEC Dup	2–5	2/20/2014	2.32E-05	6.55E-05	2.80E-04	U	1.55E-04	1.55E-04	5.53E-04	U	1.58E-04	1.53E-04	4.87E-04	U
SEC Dup	5–10	2/20/2014	1.38E-05	7.28E-05	3.08E-04	U	1.68E-04	1.48E-04	5.50E-04	U	4.98E-05	9.23E-05	4.82E-04	U
SMR	0–2	2/20/2014	1.11E-05	8.40E-05	4.23E-04	U	1.41E-04	1.58E-04	3.17E-04	U	4.63E-05	8.92E-05	5.77E-04	U
SMR	2–5	2/20/2014	-9.22E-06	3.25E-05	2.85E-04	U	2.07E-05	6.70E-05	5.50E-04	U	5.42E-05	8.00E-05	4.75E-04	U
SMR	5–10	2/20/2014	-7.20E-06	2.93E-05	2.83E-04	U	4.80E-05	9.60E-05	5.53E-04	U	5.68E-05	1.31E-04	5.03E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.26 – 2014 Gamma Radionuclide and ^{90}Sr Concentrations in Soil Samples Taken Near the WIPP Site

			^{40}K					^{60}Co					^{137}Cs					^{90}Sr			
Location	Depth (cm)	Sampling Date	[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf.	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf (e)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf.	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)
WFF	0–2	2/17/2014	1.82E-01	2.87E-02	7.82E-03	0.999	+	5.92E-04	6.15E-04	7.95E-04	0.00	U	1.10E-03	4.67E-04	6.18E-04	1.000	+	-1.32E-03	8.08E-03	3.63E-02	U
WFF	2–5	2/17/2014	2.02E-01	3.13E-02	5.95E-03	1.000	+	6.25E-05	6.40E-04	7.48E-04	0.00	U	1.67E-03	5.38E-04	6.37E-04	0.999	+	7.13E-03	8.28E-03	3.63E-02	U
WFF	5–10	2/17/2014	1.92E-01	3.17E-02	8.95E-03	1.000	+	-1.49E-04	9.93E-04	1.12E-03	0.00	U	1.10E-03	5.83E-04	8.13E-04	1.000	+	1.32E-03	8.45E-03	3.63E-02	U
WFF Dup	0–2	2/17/2014	1.83E-01	2.88E-02	6.85E-03	1.000	+	-3.57E-04	8.40E-04	8.60E-04	0.00	U	1.12E-03	4.32E-04	5.37E-04	1.000	+	1.15E-02	8.72E-03	3.63E-02	U
WFF Dup	2–5	2/17/2014	2.03E-01	3.37E-02	9.32E-03	0.999	+	1.48E-04	1.07E-03	1.26E-03	0.00	U	2.00E-03	6.67E-04	7.63E-04	0.999	+	-2.43E-04	8.50E-03	3.65E-02	U
WFF Dup	5–10	2/17/2014	1.90E-01	2.95E-02	6.58E-03	0.999	+	3.02E-05	6.77E-04	7.80E-04	0.00	U	1.18E-03	4.70E-04	6.03E-04	1.000	+	4.32E-03	8.00E-03	3.63E-02	U
WEE	0–2	2/17/2014	2.38E-01	3.65E-02	7.95E-03	1.000	+	-2.47E-04	8.78E-04	9.35E-04	0.00	U	2.42E-03	6.75E-04	7.48E-04	0.999	+	9.42E-04	7.82E-03	3.67E-02	U
WEE	2–5	2/17/2014	2.48E-01	3.82E-02	7.78E-03	0.999	+	3.13E-04	7.20E-04	8.58E-04	0.00	U	2.57E-03	7.08E-04	7.82E-04	0.999	+	5.23E-03	7.62E-03	3.65E-02	U
WEE	5–10	2/17/2014	2.30E-01	3.73E-02	9.17E-03	1.000	+	8.25E-04	9.75E-04	1.28E-03	0.00	U	2.32E-03	7.58E-04	8.82E-04	1.000	+	1.12E-02	8.45E-03	3.67E-02	U
WSS	0–2	2/17/2014	2.20E-01	3.38E-02	7.35E-03	1.000	+	3.02E-04	6.22E-04	7.63E-04	0.00	U	1.98E-03	5.55E-04	5.90E-04	1.000	+	5.20E-03	8.40E-03	3.67E-02	U
WSS	2–5	2/17/2014	2.42E-01	3.68E-02	6.85E-03	1.000	+	-2.90E-04	8.67E-04	9.13E-04	0.00	U	2.42E-03	6.15E-04	6.02E-04	1.000	+	2.20E-03	7.43E-03	3.67E-02	U

WSS	5–10	2/17/2014	2.22E-01	3.43E-02	7.77E-03	1.000	+	-4.32E-04	7.58E-04	7.67E-04	0.00	U	2.95E-03	6.70E-04	5.80E-04	1.000	+	-1.09E-03	7.88E-03	3.67E-02	U
MLR	0–2	2/20/2014	4.28E-01	6.60E-02	1.39E-02	0.999	+	-1.03E-03	1.60E-03	1.61E-03	0.00	U	1.10E-02	2.00E-03	1.37E-03	1.000	+	9.45E-04	7.17E-03	3.63E-02	U
MLR	2–5	2/20/2014	4.33E-01	6.10E-02	1.18E-02	0.994	+	-3.45E-04	1.12E-03	1.23E-03	0.00	U	5.28E-03	1.14E-03	1.15E-03	0.996	+	-4.62E-03	6.68E-03	3.62E-02	U
MLR	5–10	2/20/2014	4.22E-01	6.18E-02	1.38E-02	0.998	+	1.57E-03	1.31E-03	1.73E-03	0.00	U	8.17E-04	7.97E-04	1.26E-03	0.995	U	-8.75E-04	6.75E-03	3.62E-02	U
SEC	0–2	2/20/2014	2.62E-01	3.77E-02	7.35E-03	1.000	+	3.77E-04	7.10E-04	8.73E-04	0.00	U	4.18E-03	8.53E-04	7.80E-04	0.999	+	-2.50E-03	6.90E-03	3.62E-02	U
SEC	2–5	2/20/2014	2.48E-01	3.60E-02	8.28E-03	0.986	+	-5.00E-04	8.68E-04	9.07E-04	0.00	U	4.30E-03	8.62E-04	7.53E-04	1.000	+	-1.45E-03	6.97E-03	3.62E-02	U
SEC	5–10	2/20/2014	2.68E-01	4.10E-02	1.14E-02	0.996	+	4.78E-04	1.09E-03	1.34E-03	0.00	U	2.58E-03	8.55E-04	1.07E-03	1.000	+	-2.88E-03	6.87E-03	3.62E-02	U
SEC Dup	0–2	2/20/2014	2.45E-01	3.53E-02	8.35E-03	0.987	+	3.00E-04	7.58E-04	9.13E-04	0.00	U	4.22E-03	8.40E-04	7.30E-04	0.993	+	5.52E-04	7.28E-03	3.53E-02	U
SEC Dup	2–5	2/20/2014	2.55E-01	3.87E-02	9.72E-03	0.998	+	-4.35E-04	1.17E-03	1.26E-03	0.00	U	4.62E-03	1.06E-03	1.07E-03	1.000	+	-3.95E-03	7.00E-03	3.53E-02	U
SEC Dup	5–10	2/20/2014	2.73E-01	3.93E-02	8.10E-03	1.000	+	-5.75E-04	8.07E-04	8.15E-04	0.00	U	2.53E-03	6.45E-04	7.00E-04	1.000	+	-2.95E-03	6.83E-03	3.53E-02	U
SMR	0–2	2/20/2014	8.98E-01	1.26E-01	1.24E-02	0.998	+	6.98E-04	1.34E-03	1.54E-03	0.00	U	7.48E-04	5.48E-04	8.37E-04	0.998	U	-4.18E-03	7.03E-03	3.53E-02	U
SMR	2–5	2/20/2014	8.38E-01	1.17E-01	1.29E-02	0.984	+	-1.15E-03	1.92E-03	2.00E-03	0.00	U	2.08E-03	8.93E-04	1.23E-03	1.000	+	-4.23E-04	6.70E-03	3.53E-02	U
SMR	5–10	2/20/2014	9.00E-01	1.23E-01	9.90E-03	0.998	+	-8.50E-05	1.16E-03	1.31E-03	0.00	U	5.70E-04	1.13E-03	1.29E-03	0.00	U	-1.48E-05	6.57E-03	3.53E-02	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected if the sample activity is greater than 2 σ TPU and MDC.

(e) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

Using ANOVA, the concentrations of the uranium isotopes were compared between 2014 and 2013 and between sampling locations using all three sample depths in the calculation. Average concentrations were used for WFF and SEC in 2014 and for WEE in 2013. There were 18 common locations for $^{233/234}$U and ^{238}U, and 9 of 18 possible common locations for ^{235}U between 2014 and 2013.

The ANOVA calculations showed that the concentrations of $^{233/234}$U, ^{235}U, and ^{238}U did not vary significantly between 2014 and 2013 (ANOVA $^{233/234}$U, p = 0.869; ANOVA ^{235}U, p = 0.200; and ANOVA ^{238}U, p = 0.742).

As in 2013, the 2014 ANOVA calculations showed significant variation by location for $^{233/234}$U (ANOVA $^{233/234}$U, p = 3.83E-11) and for ^{238}U (ANOVA ^{238}U, p = 2.18E-13), but less variation by location for ^{235}U at only nine common locations (ANOVA ^{235}U, p = 0.208), which is well above the 0.05 significance factor.

There are three soil baseline concentrations for the three uranium isotopes based on location. The WIPP site group of baseline concentrations is for locations WFF, WEE, and WSS; the five-mile ring sites include SMR and MLR; and the outer sites include SEC.

The highest concentrations of $^{233/234}$U measured in 2014 was 1.85E-02 Bq/g at the 5-10 cm depth from location SMR. This concentration fell within the 99 percent confidence interval baseline concentration of 2.20E−02 Bq/g for SMR and MLR. The highest ^{235}U concentration of 9.55E-04 Bq/g at the 2-5 cm depth at location MLR was lower than the 99 percent confidence interval concentration of 1.70E–03 Bq/g for SMR and MLR. The highest ^{238}U concentration of 1.78E–02 Bq/g in both the 0-2 cm depth sample and 5-10 cm depth sample from SMR was higher than the 99 percent confidence interval range of the baseline concentration for ^{238}U of 1.30E–02 Bq/g (DOE/WIPP–92–037). The concentration of 1.72E-02 Bq/g at the 2-5 cm depth was also higher than the 99 percent confidence interval range of the baseline concentration. The 1.78 E-02 Bq/g concentrations in the two samples were identical to the concentration measured at the 5-10 cm depth in 2013.

The measured concentration of 8.75 Bq/g in the 0-2 cm depth at WSS was also higher than the 99 percent confidence interval range of the baseline concentration of 8.60E-03 Bq/g. Other measured 2014 concentrations of the uranium isotopes were within the 99 percent confidence interval range of the baseline concentration. The detected uranium concentrations in soil follow a pattern of variability consistent with the distribution of natural uranium.

Table 4.25 presents the analysis data for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am. Pu-239/240 was detected in the sample at the 0-2 cm depth from MLR, just as it was in 2013. Two more samples were collected from the same location on May 15, 2014. Pu-239/240 was detected in one of the samples but not the other. The detected concentrations of 5.57E-04 Bq/g on February 20, 2014, and 3.97E-04 Bq/g on May 15, 2014, were lower than the 99 percent confidence interval of the baseline soil concentration of 1.90E-03

Bq/g. The concentration measured in 2013 was 3.78 E-04 Bq/g. No ANOVA calculations could be performed on the limited amount of data. The $^{239/240}$Pu detection was not related to the release event because no ^{241}Am was detected in the sample, and the $^{239/240}$Pu concentration was similar to concentrations measured in the past.

Table 4.26 presents the 2014 soil sample analysis data for the gamma radionuclides and ^{90}Sr. The sample data in Table 4.26 show that ^{40}K was detected in all the samples, ^{137}Cs was detected in all but three of the samples (MLR at 5-10 cm and SMR at 0-2 cm and 5-10 cm), and ^{60}Co and ^{90}Sr were not detected in any of the samples. In 2013, the only sample in which ^{137}Cs was not detected was SMR at the 0-2 cm depth.

There were 18 common locations where ^{40}K was detected between 2014 and 2013 for ANOVA comparisons. The average concentrations were used for the duplicate samples at WEE in 2013 and WFF and SEC in 2014.

There was no significant variation in the ^{40}K concentrations between 2014 and 2013 (ANOVA ^{40}K, p = 0.647). There was significant variation in the concentrations between locations, including the various soil depths (ANOVA ^{40}K, p = 4.26E-13). This great variation appears to be due to the fact that a higher concentration was measured in all samples at all depths in 2014. The concentrations were generally only a few percent higher at each location at each depth in 2014, but this consistent difference in concentration in one direction for each sample highly exaggerates the ANOVA calculation.

Potassium-40 is a naturally occurring gamma-emitting radionuclide that is ubiquitous in soils with various concentrations, depending on weathering of various rock and mineral sources. It is not known why all concentrations would shift slightly higher in one year.

The highest ^{40}K concentration of 9.00E-01 Bq/g occurred at the 5-10 cm depth at location SMR. All three depths of MLR samples and all three depths of samples from SMR yielded concentrations higher than the 99 percent confidence interval range of baseline concentrations of 3.40E–01 Bq/g (DOE/WIPP–92–037). Like the uranium isotopes, ^{40}K has a 99 percent confidence interval range of baseline concentration that varies by location from the WIPP site with values of 2.80E-01 Bq/g for WFF, WEE, and WSS; 3.40E-01 Bq/g for SMR and MLR; and 7.80E-01 Bq/g for SEC. As with the uranium isotopes, the baseline concentrations are higher at greater distances from the WIPP site.

Statistical analyses for ^{137}Cs were performed for 15 common locations using the average concentrations for the 2013 WEE duplicate samples and the average concentrations for the 2014 WFF and SEC samples. The three samples in which ^{137}Cs was not detected in 2014 were the deep sample from MLR and the shallow and deep samples from SMR. The ANOVA calculations showed no significant difference between the concentrations in 2014 and 2013 (ANOVA ^{137}Cs, p = 0.449). However, there was a significant difference in the concentrations between the sampling locations (ANOVA

^{137}Cs, p = 4.86E-06). Eleven ^{137}Cs concentrations were higher and four concentrations were lower in 2014 compared to 2013.

The ^{137}Cs 99 percent confidence interval range of baseline concentrations were determined according to distance from the WIPP site. The values were 2.40 Bq/g both for the locations near the WIPP site (WFF, WEE, WSS) and within the five-mile ring sites (SMR, MLR), and 4.00E-02 Bq/g for outer sites (SEC). As shown in Table 4.26, the WEE samples at 0-2 cm depth and 2-5 cm depth were higher than 2.40 Bq/g, as were the samples from WSS at 2-5 cm and 5-10 cm. The SEC outer samples at 0-2 cm and 2-5 cm were both higher than 4.00 Bq/g. The samples from MLR showed the most pronounced decrease in ^{137}Cs concentration with depth with concentrations of 1.10E-02 Bq/g at 0-2 cm; 5.28E-03 Bq/g at 2-5 cm; and not detected at 5-10 cm. Cesium-137 is a fission product and is ubiquitous in soils because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000).

Since ^{90}Sr and ^{60}Co were not detected at any sampling locations (Table 4.26), there were insufficient data to permit any kind of variance analysis between years or among sampling locations.

The duplicate samples from WFF were selected to perform precision calculations for all the target radionuclides. The calculated RERs for the WFF samples at all three depths are presented in Table 4.27. The qualifier column shows whether the radionuclide was detected in the samples.

The 30 RER calculations for soil samples in Table 4.27 show that all RERs were less than 2, except for the non-detected ^{90}Sr at the 0-2 cm depth with a value of 2.16. The data in Table 4.27 show good precision for the combined field sampling and laboratory analysis procedures.

Soil Samples of Opportunity

The analysis results for the SOO are presented in DOE/WIPP-15-3547. The information includes the “Soil Sampling Plan for additional Samples,” the GPS coordinates of the sampling locations, a map showing the soil sample locations and a table showing the collection date, the sample location, the sample depth, the activity as Bq/g, the 2 σ TPU, the MDC, and the detection qualifier (U or +).

None of the three radionuclides of interest were detected in any of the 36 soil SOOs.

Table 4.27 - Precision Analysis Results for 2014 Duplicate Soil Samples

Location	Depth (cm)	Radionuclide	Primary Sample [RN][a]	Primary Sample 1 σ TPU[b]	Duplicate Sample [RN][a]	Duplicate Sample 1 σ TPU[b]	RER[c]	Q[d]
WFF	0-2	$^{233/234}$U	5.80E-03	6.95E-04	5.25E-03	6.00E-04	0.599	+
WFF	2-5	$^{233/234}$U	6.57E-03	7.55E-04	7.15E-03	8.25E-04	0.519	+
WFF	5-10	$^{233/234}$U	5.62E-03	6.30E-04	5.83E-03	6.45E-04	0.233	+
WFF	0-2	^{235}U	2.18E-04	1.09E-04	2.32E-04	1.01E-04	0.094	U
WFF	2-5	^{235}U	2.17E-04	9.90E-05	3.82E-04	1.31E-04	1.005	+
WFF	5-10	^{235}U	1.46E-04	7.65E-05	2.27E-04	9.65E-05	0.658	U/+[e]
WFF	0-2	^{238}U	5.73E-03	6.90E-04	5.48E-03	6.20E-04	0.270	+
WFF	2-5	^{238}U	7.43E-03	8.40E-04	6.68E-03	7.80E-04	0.654	+
WFF	5-10	^{238}U	5.18E-03	5.95E-04	6.67E-03	7.15E-04	1.602	+
WFF	0-2	^{238}Pu	-6.33E-06	5.15E-05	5.92E-05	5.10E-05	0.904	U
WFF	2-5	^{238}Pu	1.92E-05	3.10E-05	-1.03E-05	1.62E-05	0.844	U
WFF	5-10	^{238}Pu	2.08E-05	2.94E-05	1.88E-05	3.04E-05	0.047	U
WFF	0-2	$^{239/240}$Pu	9.12E-05	6.50E-05	-2.22E-05	2.71E-05	1.610	U
WFF	2-5	$^{239/240}$Pu	6.38E-06	3.60E-05	-1.03E-05	1.62E-05	0.423	U
WFF	5-10	$^{239/240}$Pu	5.80E-05	5.20E-05	7.30E-05	4.84E-05	0.211	U
WFF	0-2	^{241}Am	8.30E-05	6.70E-05	7.20E-05	4.83E-05	0.133	U
WFF	2-5	^{241}Am	7.88E-05	4.76E-05	7.07E-05	5.10E-05	0.116	U
WFF	5-10	^{241}Am	1.12E-04	5.85E-05	1.47E-04	7.20E-05	0.377	U
WFF	0-2	^{40}K	1.82E-01	1.44E-02	1.83E-01	1.44E-02	0.049	+
WFF	2-5	^{40}K	2.02E-01	1.57E-02	2.03E-01	1.69E-02	0.043	+
WFF	5-10	^{40}K	1.92E-01	1.59E-02	1.90E-01	1.48E-02	0.092	+
WFF	0-2	^{60}Co	5.92E-04	3.08E-04	-3.57E-04	4.20E-04	1.823	U
WFF	2-5	^{60}Co	6.25E-05	3.20E-04	1.48E-04	5.35E-04	0.137	U
WFF	5-10	^{60}Co	-1.49E-04	4.97E-04	3.02E-05	3.39E-04	0.298	U
WFF	0-2	^{137}Cs	1.10E-03	2.34E-04	1.12E-03	2.16E-04	0.063	+
WFF	2-5	^{137}Cs	1.67E-03	2.69E-04	2.00E-03	3.34E-04	0.770	+
WFF	5-10	^{137}Cs	1.10E-03	2.92E-04	1.18E-03	2.35E-04	0.214	+
WFF	0-2	^{90}Sr	-1.32E-03	4.04E-03	1.15E-02	4.36E-03	2.157	U
WFF	2-5	^{90}Sr	7.13E-03	4.14E-03	-2.43E-04	4.25E-03	1.243	U
WFF	5-10	^{90}Sr	1.32E-03	4.23E-03	4.32E-03	4.00E-03	0.516	U

Notes:
See Appendix C for sampling location codes. Units are in Bq/g.

(a) Radionuclide concentration.
(b) Total propagated uncertainty.
(c) Relative error ratio.
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.
(e) ^{235}U detected in the duplicate sample but not the primary sample.

4.7 Biota

4.7.1 Sample Collection

Rangeland vegetation samples were collected from the same six locations as the soil samples (Figure 4.4). Fauna (animal) samples were also collected when available. All biota samples were analyzed for the target radionuclides.

In addition, 31 vegetation SOOs from 28 locations, including three duplicate samples, were collected from various locations around the WIPP site on March 19, 20, and 21, 2014. The sample locations were designated by GPS locations. DOE/WIPP-15-3547 contains a document titled "Vegetation Sampling Plan for Additional Samples." This document describes the strategy used to select locations for the additional vegetation samples and contains a table of the GPS location number and the approximate GPS coordinates for each sampling location. The samples were analyzed by alpha spectroscopy for the three radionuclides of interest following the radiation release event including ^{238}Pu, $^{239/240}$Pu, and ^{241}Am.

4.7.2 Sample Preparation

4.7.2.1 Vegetation

The vegetation samples were chopped into 2.5- to 5-cm (1- to 2-in.) pieces, mixed together well, and air dried at room temperature. Weighed aliquots were spiked with tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) and heated in a muffle furnace to burn off organic matter.

The samples were digested with concentrated nitric acid, hydrochloric acid, hydrofluoric acid, and hydrogen peroxide. The samples were dried and heated in a muffle furnace. The remaining residue was repetitively wet-ashed with concentrated acids until only a white or pale yellow residue remained. The residue was dissolved in nitric acid for processing the individual radionuclides.

4.7.2.2 Fauna (Animals)

The animal tissue samples were spiked with tracers (^{232}U, ^{243}Am, and ^{242}Pu) and carriers (strontium nitrate and barium nitrate) and dried in a muffle furnace. The samples were then digested with concentrated acids and hydrogen peroxide in the same manner as the vegetation samples, and the residue was then dissolved in nitric acid for processing the individual radionuclides.

4.7.3 Determination of Individual Radionuclides

The nitric acid digestates of the biota samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for ^{40}K, ^{60}Co, and ^{137}Cs. The other fraction was analyzed sequentially for the uranium/transuranic radionuclides and ^{90}Sr by employing a

series of chemical, physical, and ion exchange separations as described in Section 4.2.3, then mounting the sample residues on a planchet for counting. The uranium/transuranics were counted by alpha spectroscopy and the ^{90}Sr by gas proportional counting.

4.7.4 Results and Discussion

The data and discussion are separated into the routine vegetation samples typically reported in the ASER and the event evaluation samples consisting of the SOO that were collected on the three March sampling dates discussed above. The routine vegetation sample analysis results are discussed immediately below and the analysis results for the vegetation SOO are presented in DOE/WIPP-15-3547 and discussed in a separate section below.

4.7.4.1 Vegetation

Routine Vegetation Samples

Table 4.28 presents the analysis results for the uranium, plutonium, and americium target radionuclides in the vegetation samples from six locations. More samples were analyzed for the plutonium isotopes and americium than for the uranium isotopes due to the collection of vegetation samples at all six locations following the radiation release event that were only analyzed for plutonium isotopes and americium. Duplicate samples were taken at WFF following the release event and duplicate samples were taken at WEE during the regular vegetation sampling in July and August, 2014.

Table 4.29 presents the analysis results for the gamma radionuclides and ^{90}Sr during the regular vegetation sampling in July and August, 2014.

Table 4.28 shows that no plutonium isotopes or americium were detected in any of the vegetation samples either just after the release event or later in the summer. There were three detections of $^{233/234}$U and four detections of ^{238}U. Both isotopes were detected in the WEE duplicate sample, but not the WEE primary sample. Both isotopes were detected in the vegetation samples from MLR and SMR, and ^{238}U was detected in the sample collected at location WSS.

The three measured detections of $^{233/234}$U shown in Table 4.28 were higher than the mean baseline concentration from all locations of 6.00E-05 Bq/g. Three of the four ^{238}U detections in Table 4.28 were higher than the mean baseline concentration from all locations of 6.90E-04 Bq/g. The only ^{238}U concentration that was lower than the baseline mean concentration was 4.53E-04 Bq/g in the sample from location WSS.

A comparison of the vegetation data from 2013 and 2014 shows that for $^{233/234}$U, the only common location was SMR, and thus, there were not enough data to perform ANOVA calculations. Two common locations had detections of ^{238}U between 2013 and 2014, including MLR and SMR. The ANOVA calculation is able to be performed with just two common locations. There was some variation in the concentrations of ^{238}U

between years, with the *p* value at the significance factor of 0.05 (ANOVA ^{238}U, p = 0.053). There was no significant variation in the ^{238}U vegetation concentrations between locations (ANOVA ^{238}U, p = 0.718).

Table 4.28 – 2014 Uranium Plutonium and Americium Radionuclide Concentrations in Vegetation Samples Taken Near the WIPP Site
Units are in Bq/g

Location	Date	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
		$^{233/234}$U				^{235}U				^{238}U			
WFF	7/10/2014	5.03E-04	2.28E-04	6.02E-04	U	-8.12E-06	2.67E-05	2.75E-04	U	3.50E-04	1.85E-04	4.75E-04	U
WEE	7/10/2014	1.72E-04	9.83E-05	5.87E-04	U	-5.60E-06	1.83E-05	2.55E-04	U	3.65E-04	1.46E-04	4.58E-04	U
WEE Dup	7/10/2014	1.65E-03	3.95E-04	5.85E-04	+	8.67E-05	7.87E-05	2.55E-04	U	1.43E-03	3.55E-04	4.58E-04	+
WSS	8/7/2014	3.88E-04	1.60E-04	5.57E-04	U	2.58E-05	5.35E-05	2.70E-04	U	4.53E-04	1.77E-04	4.42E-04	+
MLR	8/7/2014	9.97E-04	3.33E-04	5.67E-04	+	8.12E-05	9.78E-05	2.88E-04	U	8.98E-04	3.08E-04	4.50E-04	+
SEC	8/7/2014	3.75E-04	1.75E-04	5.63E-04	U	1.44E-05	4.37E-05	2.72E-04	U	3.88E-04	1.78E-04	4.48E-04	U
SMR	7/11/2014	1.13E-03	3.30E-04	5.92E-04	+	6.42E-05	7.10E-05	2.58E-04	U	1.22E-03	3.47E-04	4.63E-04	+
		^{238}Pu				$^{239/240}$Pu				^{241}Am			
WFF	2/21/2014	1.24E-06	3.37E-05	3.57E-04	U	7.97E-07	3.40E-05	2.38E-04	U	3.05E-05	9.85E-05	5.60E-04	U
WFF Dup	2/21/2014	-4.38E-06	1.38E-05	3.52E-04	U	1.95E-05	3.37E-05	2.32E-04	U	2.27E-05	9.30E-05	5.60E-04	U
WFF	7/10/2014	-1.58E-05	4.72E-05	2.82E-04	U	6.43E-06	3.27E-05	2.72E-04	U	4.23E-05	6.05E-05	4.68E-04	U
WEE	2/21/2014	1.01E-05	3.42E-05	3.50E-04	U	-3.67E-06	1.19E-05	2.28E-04	U	6.87E-05	8.73E-05	5.57E-04	U
WEE	7/10/2014	-1.15E-05	2.33E-05	2.68E-04	U	1.87E-05	3.77E-05	2.65E-04	U	3.30E-05	6.52E-05	4.63E-04	U
WEE Dup	7/10/2014	0.00E+00	3.48E-05	2.68E-04	U	-6.97E-07	3.53E-05	2.65E-04	U	2.25E-05	4.85E-05	4.57E-04	U
WSS	2/22/2014	-1.92E-06	8.78E-06	3.48E-04	U	5.73E-06	2.48E-05	2.30E-04	U	-9.30E-06	5.02E-05	5.57E-04	U
WSS	8/7/2014	-2.98E-05	3.58E-05	2.68E-04	U	1.72E-06	2.98E-05	2.62E-04	U	7.73E-06	5.05E-05	5.12E-04	U
MLR	2/22/2014	-8.75E-06	3.90E-05	3.57E-04	U	-3.28E-06	1.23E-05	2.33E-04	U	7.83E-05	7.05E-05	5.55E-04	U
MLR	8/7/2014	-3.85E-06	1.40E-05	2.72E-04	U	4.87E-05	5.45E-05	2.67E-04	U	9.73E-05	8.73E-05	5.23E-04	U
SEC	2/22/2014	1.07E-05	2.10E-05	3.48E-04	U	8.77E-06	2.28E-05	2.30E-04	U	4.57E-06	7.87E-05	5.63E-04	U
SEC	8/7/2014	2.05E-05	5.97E-05	2.72E-04	U	-9.33E-07	6.60E-06	2.62E-04	U	5.63E-05	7.82E-05	5.20E-04	U
SMR	2/22/2014	2.23E-06	3.55E-05	3.62E-04	U	1.11E-05	4.67E-05	2.40E-04	U	4.82E-05	7.33E-05	5.60E-04	U
SMR	7/11/2014	-1.93E-06	9.25E-06	2.63E-04	U	1.68E-05	3.62E-05	2.63E-04	U	5.88E-05	5.40E-05	4.55E-04	U

Notes:
See Appendix C for sampling location codes.
(a) Radionuclide concentration.
(b) Total propagated uncertainty.
(c) Minimum detectable concentration.
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.29 – 2014 Gamma and ^{90}Sr Radionuclide Concentrations in Vegetation Samples Taken Near the WIPP Site
Units are in Bq/g

Location	Date	^{40}K					^{60}Co				
		[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf(d)	Q(e)	[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf(d)	Q(e)
WFF	7/10/2014	5.22E-01	1.01E-01	5.75E-02	0.875	U	8.95E-04	5.90E-03	7.05E-03	0.00	U
WEE	7/10/2014	5.45E-01	1.34E-01	1.25E-01	0.925	+	2.95E-03	9.02E-03	1.12E-02	0.00	U
WEE Dup	7/10/2014	6.78E-01	1.63E-01	2.60E-01	0.00	U	4.85E-03	9.08E-03	1.22E-02	0.00	U
WSS	8/7/2014	9.88E-03	2.15E-03	1.65E-03	0.998	+	2.67E-05	1.39E-04	1.64E-04	0.00	U
MLR	8/7/2014	1.12E-02	2.52E-03	3.82E-03	0.00	U	-5.03E-05	1.61E-04	1.75E-04	0.00	U
SEC	8/7/2014	1.41E-02	2.42E-03	1.10E-03	0.997	+	1.33E-05	1.02E-04	1.17E-04	0.00	U
SMR	7/11/2014	1.02E+00	1.78E-01	8.63E-02	0.972	+	6.62E-03	7.97E-03	1.01E-02	0.00	U

Location	Date	^{137}Cs					^{90}Sr			
		[RN](a)	2 σ TPU(b)	MDC(c)	ID Conf(d)	Q(e)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(e)
WFF	7/10/2014	-8.32E-04	5.92E-03	6.55E-03	0.00	U	3.95E-03	3.17E-03	1.87E-02	U
WEE	7/10/2014	5.92E-03	8.35E-03	1.08E-02	0.00	U	2.00E-05	3.08E-03	1.87E-02	U
WEE Dup	7/10/2014	-2.47E-05	7.72E-03	9.40E-03	0.00	U	2.63E-04	2.98E-03	1.87E-02	U
WSS	8/7/2014	8.97E-05	1.19E-04	1.55E-04	0.00	U	3.02E-06	4.65E-05	3.20E-04	U
MLR	8/7/2014	7.45E-05	9.90E-05	1.33E-04	0.00	U	-6.52E-06	4.92E-05	3.20E-04	U
SEC	8/7/2014	1.61E-06	1.02E-04	1.16E-04	0.00	U	-1.28E-06	5.47E-05	3.22E-04	U
SMR	7/11/2014	7.62E-04	7.75E-03	8.93E-03	0.00	U	3.37E-03	3.07E-03	1.87E-02	U

Notes:

See Appendix C for sampling location codes.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.29 shows that ^{40}K was detected in four of the seven vegetation samples in 2014 (including one of the WEE duplicate samples). In the three samples where it was not detected, the ^{40}K activity of the sample was greater than the TPU and the MDC, but the identification confidence from the gamma analysis software was less than 0.90. All the measured concentrations of ^{40}K were less than the average baseline concentration of 3.20E+00 Bq/g.

The ANOVA calculations used the activity for the primary WEE sample instead of the average, since ^{40}K was not detected in the duplicate sample. The activity for MLR was not used, so there were just four common locations between 2013 and 2014. The ANOVA calculations showed no significant statistical difference in ^{40}K vegetation concentrations between 2014 and 2013 (ANOVA ^{40}K, p = 0.247). There was more variation in the concentrations of ^{40}K between locations, but the p value was higher than the significance factor of 0.05 (ANOVA ^{40}K, p = 0.142). The natural variability of the concentration of this naturally occurring radionuclide in the soil would be expected to yield some variation in the vegetation concentrations between locations.

Since there were no detections of ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{60}Co, ^{137}Cs, and ^{90}Sr in any of the vegetation samples, no ANOVA statistical comparisons between years or locations could be performed. Table 4.30 shows the precision analysis results for all the target radionuclides in the duplicate samples from location WEE. Three of the RERs, all for uranium isotopes, were greater than 2. The reason for the poorer precision for the uranium isotopes is not known; it could be due to the analysis steps since the precision of the other radionuclides was much better in the duplicate vegetation samples. However, the poorer precision could be due to the need to collect separate plants to yield enough mass for the primary and duplicate vegetation samples, and the uranium uptake could be different in the various plants due to the nature of the plants or the distribution of uranium isotopes in the root zone.

Table 4.30 - 2014 Precision Analysis Results for Duplicate Vegetation Samples

Location	Isotope	Sample		Duplicate			
		[RN][a]	1 σ TPU[b]	[RN][a]	1 σ TPU[b]	RER[c]	Q[d]
WEE and Dup	$^{233/234}$U	1.72E-04	4.92E-05	1.65E-03	1.98E-04	7.262	U/+[e]
	^{235}U	-5.60E-06	9.15E-06	8.67E-05	3.94E-05	2.285	U
	^{238}U	3.65E-04	7.30E-05	1.43E-03	1.78E-04	5.549	U/+[e]
	^{238}Pu	-1.15E-05	1.17E-05	0.00E+00	1.74E-05	0.549	U
	$^{239/240}$Pu	1.87E-05	1.89E-05	-6.97E-07	1.77E-05	0.751	U
	^{241}Am	3.30E-05	3.26E-05	2.25E-05	2.43E-05	0.258	U
	^{40}K	5.45E-01	6.70E-02	6.78E-01	8.15E-02	1.261	+/U[f]
	^{60}Co	2.95E-03	4.51E-03	4.85E-03	4.54E-03	0.297	U
	^{137}Cs	5.92E-03	4.18E-03	-2.47E-05	3.86E-03	1.046	U
	^{90}Sr	2.00E-05	1.54E-03	2.63E-04	1.49E-03	0.113	U

Notes:
See Appendix C for sampling location codes. Units are in Bq/g.
(a) Radionuclide concentration.
(b) Total propogated uncertainty.
(c) Relative error ratio.
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.
(e) Detected in the duplicate sample but not the primary sample.
(f) Detected in the primary sample but not the duplicate sample.

4.7.4.2 Fauna (Animals)

The fauna analysis results for radionuclides are presented in Table 4.31 for the uranium isotopes, plutonium isotopes, and americium and in Table 4.32 for the gamma radionuclides and ^{90}Sr. The fauna samples that were analyzed included a quail composite sample (four quail), a deer, three rabbits, and three fish composite samples (two PCN fish, two CBD fish, five BRA fish). The deer sample was analyzed in duplicate. The only radionuclide detected in any of the animal samples was ^{40}K, which was detected in all the samples. The data for all three uranium isotopes for a rabbit from the WIPP site parking lot showed a qualifier of "UJ," indicating that the radionuclide activity was less than the TPU and the MDC, but that a quality deficiency affected the data, making the data more uncertain.

Statistical ANOVA comparisons could not be performed due to the mobile nature of the fauna samples. The detected ^{40}K concentrations were within the average baseline analysis results, including 4.1E–01Bq/g for quail (dry), 3.9E-01 Bq/g for rabbit (dry), and 6.1E–01Bq/g for fish (dry) (DOE/WIPP–92–037). An average baseline concentration was not available for deer.

These results can only be used as a gross indication of uptake by the animals, since there were too few samples to provide a detailed statistical analysis. Within this limitation, the data suggest that no animal uptake of radionuclides from the WIPP facility has occurred.

Precision data for animal samples were generally limited to laboratory duplicates from the same sample since duplicate animal samples were not collected. The laboratory duplicate analysis data on the deer, rabbit, and three fish showed that the RERs were less than 2. However, a duplicate field sample was taken from the single deer SOO. The precision data for the analysis of the duplicate deer samples are shown in Table 4.33. All the RERs were less than 2 except for ^{238}U at 2.23. The data demonstrate generally good precision for the combined sampling and analysis procedures.

Table 4.31 – 2014 Uranium, Plutonium, and Americium Radionuclide Concentrations in Fauna Samples Taken Near the WIPP Site

(Location)	Date	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)	[RN](a)	2 σ TPU(b)	MDC(c)	Q(d)
		$^{233/234}$U				^{235}U				^{238}U			
Quail (WEE)	3/25/2014	1.95E-04	5.75E-05	5.15E-04	U	7.67E-06	5.32E-06	1.18E-04	U	2.12E-04	6.20E-05	4.57E-04	U
Deer (SOO)	6/5/2014	9.43E-07	1.04E-06	5.12E-04	U	-6.00E-08	2.68E-07	1.50E-04	U	1.93E-07	5.48E-07	4.70E-04	U
Rabbit (SOO)	5/15/2014	8.40E-05	1.97E-05	4.98E-04	U	5.90E-06	4.18E-06	1.26E-04	U	7.82E-05	1.85E-05	5.02E-04	U
Rabbit (SOO)	7/29/2014	4.17E-05	1.16E-05	5.02E-04	U	2.52E-06	2.48E-06	2.12E-04	U	3.93E-05	1.12E-05	4.32E-04	U
Rabbit (SOO)	8/14/2014	1.27E-05	4.87E-06	5.75E-04	UJ(e)	-2.37E-07	6.53E-07	2.32E-04	UJ	8.60E-06	3.85E-06	3.15E-04	UJ
Fish (PCN)	9/4/2014	3.62E-04	6.02E-05	6.03E-04	U	9.60E-06	4.13E-06	2.35E-04	U	1.70E-04	3.02E-05	3.40E-04	U
Fish (CBD)	10/31/2014	3.02E-04	5.29E-05	5.71E-04	U	8.38E-06	4.92E-06	1.88E-04	U	1.75E-04	3.31E-05	3.61E-04	U
Fish (BRA)	10/17/2014	3.17E-04	6.47E-05	5.37E-04	U	1.50E-05	6.40E-06	1.83E-04	U	2.22E-04	4.67E-05	3.45E-04	U
		^{238}Pu				$^{239/240}$Pu				^{241}Am			
Quail (WEE)	3/25/2014	2.77E-07	1.43E-06	2.80E-04	U	1.19E-05	4.35E-06	1.44E-04	U	8.12E-06	5.07E-06	4.02E-04	U
Deer (SOO)	6/5/2014	-2.15E-07	4.58E-07	2.32E-04	U	-2.83E-07	5.25E-07	2.03E-04	U	9.03E-07	1.25E-06	3.35E-04	U
Rabbit (SOO)	5/15/2014	-6.17E-07	1.09E-06	3.13E-04	U	1.35E-06	1.78E-06	1.54E-04	U	2.50E-06	3.97E-06	3.82E-04	U
Rabbit (SOO)	7/29/2014	3.80E-07	1.75E-06	2.43E-04	U	1.67E-06	2.77E-06	2.33E-04	U	3.52E-06	3.50E-06	4.22E-04	U
Rabbit (SOO)	8/14/2014	8.05E-07	1.95E-06	2.67E-04	U	9.27E-07	1.88E-06	2.13E-04	U	1.57E-06	2.53E-06	4.87E-04	U
Fish (PCN)	9/4/2014	8.32E-07	1.34E-06	4.33E-04	U	1.09E-07	9.10E-07	2.10E-04	U	3.07E-07	1.11E-06	4.20E-04	U
Fish (CBD)	10/31/2014	0.00E+00	1.49E-06	2.11E-04	U	2.78E-06	2.74E-06	2.60E-04	U	-1.16E-07	3.89E-06	8.09E-04	U
Fish (BRA)	10/17/2014	2.92E-07	2.10E-06	2.22E-04	U	-1.54E-07	5.22E-07	4.20E-04	U	4.85E-07	1.90E-06	4.08E-04	U

Notes:

See Appendix C for sampling location codes. Units are in Bq/g wet mass.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) UJ nuclide not detected above the reported MDC or 2 σ counting uncertainty and a quality deficiency affects the data, making the reported data more uncertain.

Table 4.32 – 2014 Gamma and ^{90}Sr Radionuclide Concentrations in Fauna Samples Taken Near the WIPP Site

Location	Date	^{40}K					^{60}Co				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]
Quail (WEE)	3/25/2014	1.45E-01	2.58E-02	2.25E-02	0.993	+	-2.42E-04	2.53E-03	2.75E-03	0.00	U
Deer (SOO)	6/5/2014	1.47E-01	2.37E-02	1.82E-02	0.997	+	-3.20E-04	1.59E-03	1.77E-03	0.00	U
Rabbit (SOO)	5/15/2014	1.40E-01	3.00E-02	2.85E-02	0.999	+	9.65E-04	3.53E-03	3.92E-03	0.00	U
Rabbit (SOO)	7/29/2014	8.03E-02	1.98E-02	2.22E-02	1.00	+	1.88E-04	2.50E-03	2.77E-03	0.00	U
Rabbit (SOO)	8/14/2014	1.11E-01	2.30E-02	2.33E-02	0.993	+	2.97E-03	2.68E-03	3.15E-03	0.00	U
Fish (PCN)	9/4/2014	7.53E-02	1.73E-02	1.98E-02	1.00	+	-2.98E-04	1.82E-03	2.03E-03	0.00	U
Fish (CBD)	10/31/2014	8.14E-02	3.32E-02	4.15E-02	0.993	+	-5.12E-03	5.42E-03	5.16E-03	0.00	U
Fish (BRA)	10/17/2014	1.15E-01	2.17E-02	2.00E-02	0.995	+	1.43E-03	2.45E-03	2.80E-03	0.00	U
Location	Date	^{137}Cs					^{90}Sr				
		[RN][a]	2 σ TPU[b]	MDC[c]	ID Conf[d]	Q[e]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[e]	
Quail (WEE)	3/25/2014	-6.65E-05	2.50E-03	2.78E-03	0.00	U	1.21E-04	7.22E-05	3.50E-02	U	
Deer (SOO)	6/5/2014	6.12E-04	1.51E-03	1.80E-03	0.00	U	-1.48E-05	5.68E-05	1.97E-02	U	
Rabbit (SOO)	5/15/2014	7.05E-04	3.83E-03	4.30E-03	0.00	U	3.35E-04	1.44E-04	2.00E-02	U	
Rabbit (SOO)	7/29/2014	-1.26E-04	2.70E-03	3.00E-03	0.00	U	6.62E-04	1.73E-04	1.92E-02	U	
Rabbit (SOO)	8/14/2014	-7.28E-04	2.57E-03	2.82E-03	0.00	U	1.13E-04	1.10E-04	2.22E-02	U	
Fish (PCN)	9/4/2014	1.06E-06	1.72E-03	2.02E-03	0.00	U	4.52E-05	1.08E-04	2.43E-02	U	
Fish (CBD)	10/31/2014	-3.62E-03	5.99E-03	6.23E-03	0.00	U	4.07E-05	1.38E-04	2.05E-02	U	
Fish (BRA)	10/17/2014	1.98E-03	2.50E-03	2.87E-03	0.00	U	-7.13E-06	8.75E-05	2.20E-02	U	

Notes:

See Appendix C for sampling location codes. Units are in Bq/g wet weight.

(a) Radionuclide concentration.

(b) Total propagated uncertainty.

(c) Minimum detectable concentration.

(d) ID Conf. = Identification confidence for gamma radionuclides. Value >0.90 implies detection if the sample activity is greater than 2 σ TPU and MDC.

(e) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

Table 4.33 - 2014 Precision Analysis Results for Duplicate Fauna (Deer) Samples

Type	Isotope	Sample		Duplicate			
		[RN](a)	1 σ TPU(b)	[RN](a)	1 σ TPU(b)	RER(c)	Q(d)
Deer and Dup	$^{233/234}U$	9.43E-07	5.20E-07	1.97E-06	6.90E-07	1.189	U
	^{235}U	-6.00E-08	1.34E-07	-2.13E-08	7.55E-08	0.252	U
	^{238}U	1.93E-07	2.74E-07	1.87E-06	7.00E-07	2.231	U
	^{238}Pu	-2.15E-07	2.29E-07	-5.27E-07	3.33E-07	0.773	U
	$^{239/240}Pu$	-2.83E-07	2.63E-07	-1.75E-07	1.92E-07	0.332	U
	^{241}Am	9.03E-07	6.25E-07	2.70E-06	9.15E-07	1.622	U
	^{40}K	1.47E-01	1.19E-02	1.34E-01	1.12E-02	0.799	U
	^{60}Co	-3.20E-04	7.95E-04	1.33E-03	7.40E-04	1.519	U
	^{137}Cs	6.12E-04	7.55E-04	1.09E-03	8.05E-04	0.433	U
	^{90}Sr	-1.48E-05	2.84E-05	7.42E-06	2.64E-05	0.573	U

Notes:
Units are in Bq/g.
(a) Radionuclide concentration.
(b) Total propagated uncertainty.
(c) Relative error ratio.
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected U equals undetected.

4.8 Potential Dose from WIPP Operations

4.8.1 Dose Limits

Compliance with the environmental radiation dose standards is determined by comparing annual radiation doses to the dose standards, discussed in the introduction to this chapter.

Compliance with the environmental radiation dose standards is determined by monitoring, extracting, and calculating the EDE. The EDE is the weighted sum of the doses to the individual organs of the body. The dose to each organ is weighted according to the risk that dose represents. These organ doses are then added together, and the total is the EDE. Calculating the EDE to members of the public requires the use of CAP88–PC or other EPA-approved computer models and procedures. The WIPP

effluent monitoring program generally uses CAP88–PC, which is a set of computer programs, datasets, and associated utility programs for estimating dose and risk from radionuclide air emissions. CAP88–PC uses a Gaussian Plume dispersion model, which calculates deposition rates, concentrations in food, and intake rates for people. CAP88–PC estimates dose and risk to individuals and populations from multiple pathways. Dose and risk are calculated for ingestion, inhalation, ground-level air immersion, and ground-surface irradiation exposure pathways.

The *Safe Drinking Water Act* (40 CFR §141.66, "Maximum Contaminant Levels for Radionuclides") states that average annual concentrations for beta- and gamma-emitting human-made radionuclides in drinking water shall not result in an annual dose equivalent greater than 0.04 millisievert (mSv) (4 mrem). It is important to note that these dose equivalent limits are set for radionuclides released to the environment from DOE operations. They do not include, but rather are limits in addition to, doses from natural background radiation or from medical procedures.

4.8.2 Background Radiation

There are several sources of natural radiation: cosmic and cosmogenic radiation (from outer space and the earth's atmosphere), terrestrial radiation (from the earth's crust), and internal radiation (naturally occurring radiation in our bodies, such as ^{40}K). The most common sources of terrestrial radiation are uranium and thorium, and their decay products. Another source of terrestrial radiation is ^{40}K. Radon gas, a decay product of uranium, is a widely known naturally occurring terrestrial radionuclide. In addition to natural radioactivity, small amounts of radioactivity are present in the environment from aboveground nuclear weapons tests and the 1986 Chernobyl nuclear accident. Together, these sources of radiation are called background radiation.

Naturally occurring radiation in the environment can deliver both internal and external doses. Internal dose is received as a result of the intake of radionuclides through ingestion (consuming food or drink containing radionuclides) and inhalation (breathing radioactive particulates). External dose can occur from immersion in contaminated air or deposition of contaminants on surfaces. The average annual dose received by a member of the public from naturally occurring radionuclides is approximately 3 mSv (300 mrem).

4.8.3 Dose from Air Emissions

The standard 40 CFR Part 191, Subpart A, limits radiation doses to members of the public and the general environment from all sources (i.e., air, soil, water). The DOE has identified air emissions as the major pathway of concern for the WIPP facility during operations.

Compliance with Subpart A (40 CFR §191.03[b]) and the NESHAP standard (40 CFR §61.92) is determined by comparing annual radiation doses to the MEI to the regulatory standards. As recommended by the EPA, the DOE uses computer modeling to calculate radiation doses for compliance with the Subpart A and NESHAP standards.

Compliance procedures for DOE facilities (40 CFR §61.93[a]) require the use of CAP88–PC or AIRDOS–PC computer programs, or equivalent, to calculate dose to members of the public.

Source term input for CAP88–PC was determined by radiochemical analyses of particulate samples taken from fixed air sampling filters at Stations A, B, and C. Air filter samples were analyzed for ^{241}Am, $^{239/240}$Pu, ^{238}Pu, ^{90}Sr, $^{233/234}$U, ^{238}U, and ^{137}Cs because these radionuclides constitute over 98 percent of the dose potential from contact-handled and remote-handled TRU waste. A conservative dataset using the higher value of either the measured radionuclide activity or 2 σ TPU was used as input to the CAP88–PC computer program to calculate the EDEs to members of the public. See Section 4.1.4 for more information on the results and discussion of the effluent monitoring data.

CAP88–PC dose calculations are based on the assumption that exposed persons remain at home during the entire year and all vegetables, milk, and meat consumed are home-produced. Thus, this dose calculation is a maximum potential dose, which encompasses dose from inhalation, submersion, deposition, and ingestion of radionuclides emitted via the air pathway from the WIPP facility.

4.8.4 Total Potential Dose from WIPP Operations

Specific environmental radiation standards in 40 CFR Part 191, Subpart A state that the combined annual dose equivalent to any member of the public in the general environment resulting from the discharges of radioactive material and direct radiation from management and storage shall not exceed 0.25 mSv (25 mrem) to the whole body and 0.75 mSv (75 mrem) to any critical organ. The following sections discuss the potential dose equivalent through other pathways and the total potential dose equivalent a member of the public may have received from the WIPP facility during 2014. Section 4.8.4.3 discusses the potential dose equivalent received from radionuclides released to the air from the WIPP facility.

4.8.4.1 Potential Dose from Water Ingestion Pathway

The potential dose to individuals from the ingestion of WIPP facility-related radionuclides transported in water is determined to be zero for several reasons. Drinking water for communities near the WIPP facility comes from groundwater sources that are too remote to be affected by WIPP facility contaminants, based on current radionuclide transport scenarios summarized in *Title 40 CFR Part 191 Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE/CAO–96–2184). Water from the Culebra is naturally not potable due to high levels of TDS.

4.8.4.2 Potential Dose from Wild Game Ingestion

Game animals sampled during 2014 were deer, rabbit, fish, and quail. The only radionuclides detected in any of the animal samples were ^{40}K, which was detected in all

the samples. Therefore, no dose from WIPP facility-related radionuclides could have been received by any individual from this pathway during 2014.

4.8.4.3 Total Potential Dose from All Pathways

The only credible pathway from the WIPP facility to humans is through air emissions; therefore, this is the only pathway for which a dose is calculated. The total radiological dose and atmospheric release at the WIPP facility in 2014 is summarized in Table 4.34 for the standards in both 40 CFR §61.92 and 40 CFR §191.03(b).

Table 4.34 – WIPP Radiological Dose and Releases[a] During 2014

^{238}Pu	$^{239/240}$Pu	^{241}Am	^{90}Sr	$^{233/234}$U	^{238}U	^{137}Cs
4.835E-06 Ci	9.431E-05 Ci	1.670E-03 Ci	1.760E-06 Ci	7.124E-08 Ci	3.704E-08 Ci	2.333E-05 Ci
1.789E+05 Bq	3.490E+06 Bq	6.179E+07 Bq	6.513E+04 Bq	2.636E+03 Bq	1.370E+03 Bq	8.632E+05 Bq

WIPP Radiological Dose Reporting Table for 2014							
	EDE to the MEI at 7,500 m WNW		Percent of EPA 10 mrem/year limit to member of the public	Estimated population dose within 50 mi		Population within 50 miles[b]	Estimated natural radiation population dose[c]
Pathway	(mrem/year)	(mSv/year)		(person-rem/year)	(person-Sv/year)		(person-rem)
Air	5.86E-03	5.86E-05	5.86E-02	7.99E-03	7.99E-05	92,599	27,780
Water	N/A[(d)]	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A	N/A

WIPP Radiological Dose Reporting Table for 2014						
	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 650 m WNW		Percent of EPA 25 mrem/year whole body limit	Dose equivalent to the critical organ of the receptor who resides year-round at WIPP fence line 650 m WNW		Percent of EPA 75-mrem/year critical organ limit
Pathway	(mrem/year)	(mSv/year)		(mrem/year)	(mSv/year)	
Air	2.38E-01	2.38E-03	9.6E-01	4.80E-01	4.80E-03	6.4E-01
Water	N/A	N/A	N/A	N/A	N/A	N/A
Other Pathways	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

(a) Total releases from combination of Stations A, B, and C. Values are calculated from detected activities plus 2 σ TPU or the central value, whichever is greater, and multiplied by the ratio of sample flow to stack flow volumes.

(b) Source: United States Census Bureau (2010 Census Data).

(c) Estimated natural radiation population dose = (population within 50 mi) × (300 mrem/year).

(d) Not applicable at the WIPP facility.

In compliance with 40 CFR Part 191, Subpart A, the receptor selected is assumed to reside year-round at the exclusive use area fence line in the west-northwest sector. For 2014, the dose to this receptor was estimated to be 2.38E-03mSv (2.38E-01 mrem) per year for the whole body and 4.80E-03 mSv (4.80E-01 mrem) per year to the critical organ. These values are in compliance with the requirements specified in 40 CFR §191.03(b).

For the NESHAP standard (40 CFR §61.92), the EDE potentially received by the MEI in 2014 assumed to be residing 7.5 km (4.66 mi) west-northwest of the WIPP facility is calculated to be 5.86E-05 mSv (5.86E-03 mrem) per year for the whole body. This value is in compliance with 40 CFR §61.92 requirements.

As required by DOE Order 458.1, the collective dose to the public within 80 km (50 mi) of the WIPP facility has been evaluated and is 7.99E-05 person-sieverts (Sv) per year (person-Sv/year) (7.99E-03 person-rem/year) in 2014.

4.8.5 Dose to Nonhuman Biota

Dose limits for populations of aquatic and terrestrial organisms are discussed in National Council on Radiation Protection and Measurements Report No. 109, *Effects of Ionizing Radiation on Aquatic Organisms* (1991), and the International Atomic Energy Agency Technical Report Series No. 332, *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards*. Those dose limits are:

- Aquatic animals—10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial plants—10 milligrays per day (1 radiation absorbed dose per day)
- Terrestrial animals—1 milligrays per day (0.1 radiation absorbed dose per day)

The DOE has considered establishing these dose standards for aquatic and terrestrial biota in proposed rule 10 CFR Part 834, “Radiation Protection of the Public and the Environment,” but has delayed finalizing this rule until guidance for demonstrating compliance is developed. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE–STD–1153–2002) was developed to meet this need.

The DOE requires reporting of radiation doses to nonhuman biota in the ASER using DOE–STD–1153–2002, which requires an initial general screening using conservative assumptions. In the initial screen, biota concentration guides are derived using

conservative assumptions for a variety of generic organisms. Maximum concentrations of radionuclides detected in soil, sediment, and water during environmental monitoring are divided by the biota concentration guides, and the results are summed for each organism. If the sum of these fractions is less than 1.0, the site is deemed to have passed the screen, and no further action is required. This screening evaluation is intended to provide a very conservative evaluation of the site in relation to the recommended limits. This guidance was used to screen radionuclide concentrations observed around WIPP during 2014 using the maximum radionuclide concentrations listed in Table 4.35, and the sum of fractions was less than 1.0 for all media. The element ^{40}K is not included in Table 4.35 because it is a natural component of the earth's crust and is not part of WIPP-related radionuclides.

Table 4.35 – 2014 General Screening Results for Potential Radiation Dose to Nonhuman Biota from Radionuclide Table Concentrations in Surface Water (Bq/L), Sediment (Bq/g), and Soil (Bq/g) near the WIPP Site

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[(a)]	Concentration/BCG
Aquatic System Evaluation					
Sediment (Bq/g)	$^{233/234}U$	2.90E-02	PKT	2.00E+02	1.45E-04
	^{235}U	2.63E-03	BHT	1.00E+02	2.63E-05
	^{238}U	3.03E-02	PKT	9.00E+01	3.37E-04
	^{238}Pu	ND[(c)]		2.00E+02	NA[(d)]
	$^{239/240}Pu$	ND[(c)]		2.00E+02	NA[(d)]
	^{241}Am	ND[(c)]		2.00E+02	NA[(d)]
	^{60}Co	ND[(c)]		5.00E+01	NA[(d)]
	^{137}Cs	1.31E-02	PKT	1.00E+02	1.31E-04
	^{90}Sr	ND[(c)]		2.00E+01	NA[(d)]
Surface Water[(b)] (Bq/L)	$^{233/234}U$	1.95E-01	PCN	7.00E+00	2.79E-02
	^{235}U	5.17E-03	PCN	8.00E+00	6.46E-04
	^{238}U	9.55E-02	PCN	8.00E+00	1.19E-02
	^{238}Pu	ND[(c)]		7.00E+00	NA[(d)]
	$^{239/240}Pu$	ND[(c)]		7.00E+00	NA[(d)]
	^{241}Am	ND[(c)]		2.00E+01	NA[(d)]
	^{60}Co	ND[(c)]		1.00E+02	NA[(d)]
	^{137}Cs	ND[(c)]		2.00E+00	NA[(d)]
	^{90}Sr	ND[(c)]		1.00E+01	NA[(d)]
Sum of Fractions					4.11E-02
Terrestrial System Evaluation					
Soil (Bq/g)	$^{233/234}U$	1.85E-02	SMR (5-10)	2.00E+02	9.25E-05
	^{235}U	9.55E-04	MLR (2-5)	1.00E+02	9.55E-06

Medium	Radionuclide	Maximum Detected Concentration	Location	BCG[(a)]	Concentration/BCG
	^{238}U	1.78E-02	SMR (0-2, 5-10)	6.00E+01	2.97E-04
	^{238}Pu	ND[(c)]		2.00E+02	NA[(d)]
	$^{239/240}Pu$	5.57E-04	MLR (0-2)	2.00E+02	2.79E-06
	^{241}Am	ND[(c)]		1.00E+02	NA[(d)]
	^{60}Co	ND[(c)]		3.00E+01	NA[(d)]
	^{137}Cs	1.10E-02	MLR (0-2)	8.00E-01	1.38E-02
	^{90}Sr	ND[(c)]		8.00E-01	NA[(d)]
Surface Water (Bq/L)	$^{233/234}U$	1.95E-01	PCN	7.00E+00	2.79E-02
	^{235}U	5.17E-03	PCN	8.00E+00	6.46E-04
	^{238}U	9.55E-02	PCN	8.00E+00	1.19E-02
	^{238}Pu	ND[(c)]		7.00E+00	NA[(d)]
	$^{239/240}Pu$	ND[(c)]		7.00E+00	NA[(d)]
	^{241}Am	ND[(c)]		2.00E+01	NA[(d)]
	^{60}Co	ND[(c)]		1.00E+02	NA[(d)]
	^{137}Cs	ND[(c)]		2.00E+04	NA[(d)]
	^{90}Sr	ND[(c)]		2.00E+04	NA[(d)]
Sum of Fractions					5.46E-02

Notes:

Maximum detected concentrations were compared with biota concentration guide (BCG) values to assess potential dose to biota. As long as the sum of the ratios between detected maximum concentrations and the associated BCG is below 1.0, no adverse effects on plant or animal populations are expected (DOE-STD-1153-2002).

(a) The radionuclide concentration in the medium that would produce a radiation dose in the organism equal to the dose limit under the conservative assumptions in the model.

(b) Sediment and surface water sample were assumed to be co-located.

(c) Not detected in any of the sampling locations for a given sample matrix.

(d) Not available for calculation.

4.8.6 Release of Property Containing Residual Radioactive Material

No radiologically contaminated materials or property were released from the WIPP facility in 2014.

4.9 Radiological Program Conclusions

4.9.1 Effluent Monitoring

For 2014, the calculated EDE to the receptor (hypothetical MEI) who resides year-round at the fence line is 2.38E-03 mSv (2.38E-01 mrem) per year for the whole body and 4.80E-03 mSv (4.80E-01 mrem) per year for the critical organ. For the WIPP effluent monitoring program, Figure 4.5 and Table 4.36 show the dose to the whole body for the

hypothetical MEI for CY 2002 to CY 2014. Figure 4.6 and Table 4.37 show the dose to the critical organ for the hypothetical MEI for CY 2002 to CY 2014. These dose equivalent values are below 25 mrem to the whole body and 75 mrem to any critical organ, in accordance with the provisions of 40 CFR §191.03(b).

In CY 2014, the dose was estimated to be considerably more than for the previous year, as would be expected given the February 2014 radiological release event. Notwithstanding the increase, all calculated dose estimates were well within the limit of 10 mrem EDE to the MEI.

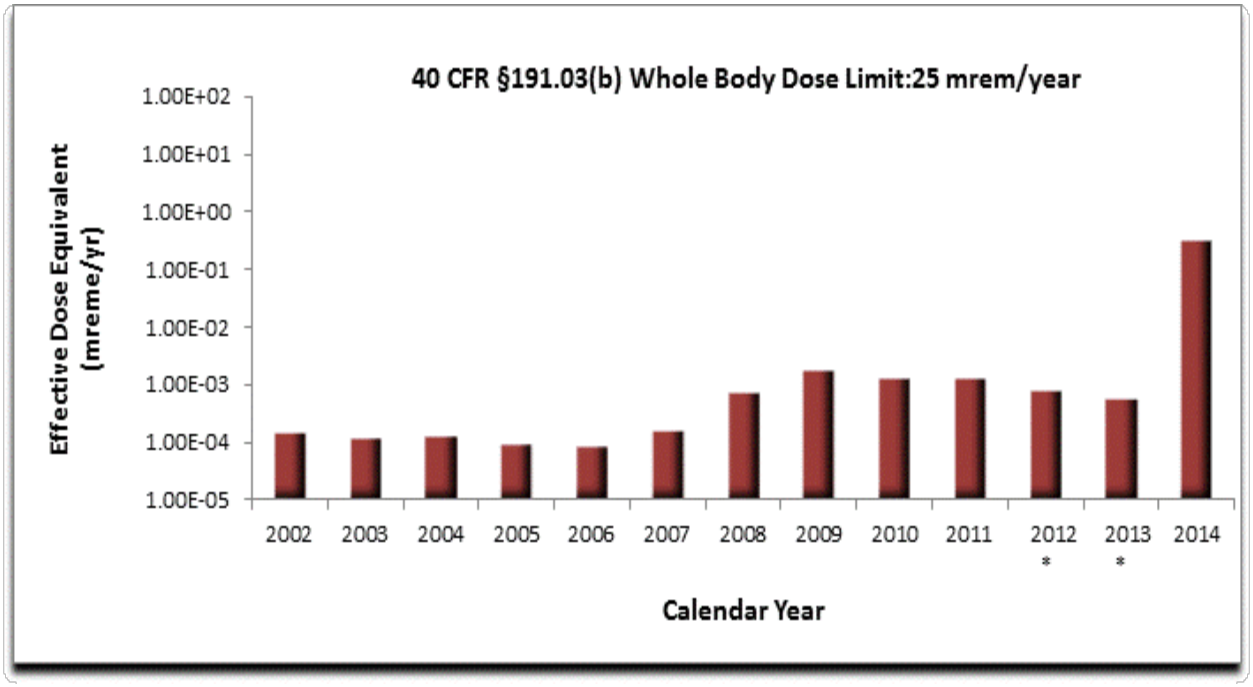


Figure 4.5 – Dose to the Whole Body for the Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.36 – Comparison of Dose to the Whole Body to EPA Standard of 25 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	1.51E–04	0.00060
2003	1.15E–04	0.00046
2004	1.27E–04	0.00051
2005	8.86E–05	0.00035
2006	8.16E–05	0.00033
2007	1.52E–04	0.00061
2008	7.14E–04	0.00290
2009	1.71E–03	0.00684

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2010	1.31E–03	0.00524
2011	1.29E–03	0.00516
2012*	7.55E-04	0.00302
2013*	5.25E-04	0.00210
2014	2.38E-01	0.95200
40 CFR §191.03(b) Whole Body Limit	**25**	

*Station C bias-corrected.

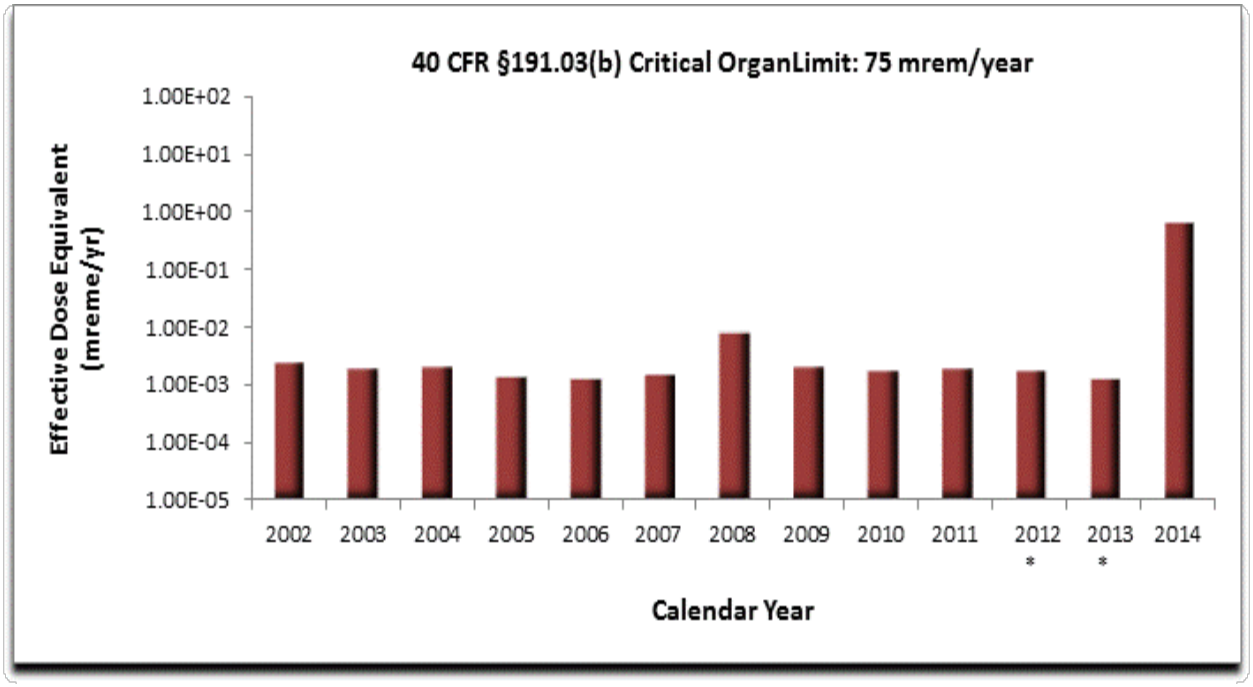


Figure 4.6 – Dose to the Critical Organ for Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.37 – Comparison of Dose to the Critical Organ to EPA Standard of 75 mrem/year per 40 CFR §191.03(b)

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	2.46E–03	0.0033
2003	1.85E–03	0.0025
2004	2.11E–03	0.0028
2005	1.41E–03	0.0019
2006	1.30E–03	0.0017
2007	1.46E–03	0.0019
2008	7.81E–03	0.0014
2009	2.10E–03	0.0028

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2010	1.73E–03	0.0023
2011	1.86E–03	0.0025
2012*	1.75E-03	0.0023
2013*	1.31E-03	0.0017
2014	4.80E-01	0.6400
40 CFR §191.03(b) Critical Organ Limit	**75**	

*Station C bias-corrected.

For 2014, the calculated EDE to the MEI from normal operations conducted at the WIPP facility is 5.86E-05 mSv (5.86E-03 mrem). For the WIPP effluent monitoring program, Figure 4.7 and Table 4.38 show the EDE to the MEI for CY 2002 to CY 2014. These EDE values are more than three orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

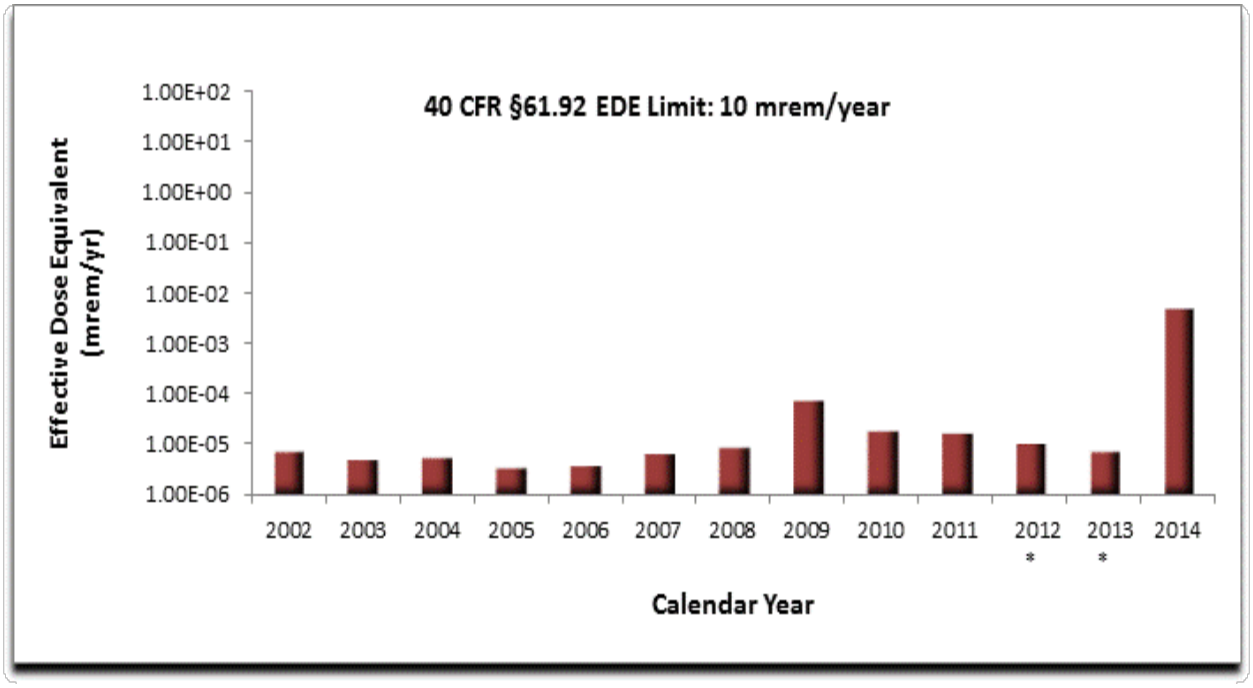


Figure 4.7 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual

Table 4.38 – Comparison of EDEs to EPA Standard of 10 mrem/year per 40 CFR §61.92

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2002	7.61E–06	0.000076
2003	5.43E–06	0.000054
2004	5.69E–06	0.000057
2005	3.85E–06	0.000039
2006	3.93E–06	0.000039

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2007	7.01E–06	0.000070
2008	9.05E–06	0.000091
2009	7.80E–05	0.000780
2010	1.91E–05	0.000191
2011	1.75E–05	0.000175
2012*	1.06E-05	0.000106
2013*	7.39E-06	0.000074
2014	5.86E-03	0.058600
NESHAP Limit	**10**	

*Station C bias-corrected.

4.9.2 Environmental Monitoring

Radionuclide concentrations observed in environmental monitoring samples were extremely small and comparable to radiological baseline levelsexcept for the air particulate sample collected immediated after the radiation release event on Feb. 14, 2014. Appendix H contains graphs comparing detected radionuclide concentrations to their respective baseline values.

The Event Evaluation air filter samples with concentrations higher than the baseline included the following:

- The March 18 MET concentration of $^{233/234}$U of 9.48E-06 Bq/m^3 was higher than the baseline concentration of 7.90E-06 Bq/m^3
- The March 18 SLT concentration of $^{233/234}$U of 9.60E-06 Bq/m^3 was higher than the baseline concentration of 7.90E-06 Bq/m^3
- The March 18 STB concentration of $^{233/234}$U of 8.99E-06 Bq/m^3 was higher than the baseline concentration of 7.90E-06 Bq/m^3
- The March 18 SLT concentration of ^{238}U of 8.79E-06 Bq/m^3 was higher than the baseline concentration of 5.90E-06 Bq/m^3
- The March 18 MET concentration of ^{238}U of 7.96E-06 Bq/m^3 was higher than the baseline concentration of 5.90E-06 Bq/m^3
- The March 18 STB concentration of ^{238}U of 7.62E-06 Bq/m^3 was higher than the baseline concentration of 5.90E-06 Bq/m^3
- The February 15 WFF concentration of $^{239/240}$Pu of 1.19E-03 Bq/m^3 was higher than the baseline concentration of 8.00E-06 Bq/m^3

- The February 15 WFF concentration of ^{241}Am at 1.58E-02 Bq/m^3 was higher than the baseline concentration of 5.30E-05 Bq/m^3

- The March 18 STB concentration of ^{40}K at 1.08E-03 Bq/m^3 was higher than the baseline concentration of 3.20E-04 Bq/m^3.

Other environmental samples that contained highest concentrations of radioncuclides that were higher (or equal) to the baseline concentrations included the following:

- The WQSP-1 groundwater concentration of $^{233/234}$U at 1.32E+00 Bq/L was slightly higher than the baseline concentration of 1.30E+00 Bq/L

- The sediment HIL tank duplicate concentration (tanks and tank-like structures) of ^{40}K at 1.20E+00 Bq/g was equivalent to the baseline concentration.

- The sediment UPR concentration (Pecos River Valley and associated bodies of water) of ^{40}K at 5.30E-01 Bq/g was higher than the baseline concentration of 5.00E-01 Bq/g.

- The soil SMR ^{238}U concentrations at 0 – 2 cm and 5 - 10 cm of 1.78E-02 Bq/g were higher than the baseline concentration of 1.30E-02 Bq/g.

- The soil SMR ^{40}K concentration at 5-10 cm of 9.00E-01 Bq/g was higher than the baseline concentration of 3.40E-01 Bq/g.

- The WEE duplicate vegetation sample concentration of $^{233/234}$U at 1.65E-03 Bq/g was higher than the baseline concentration of 6.00E-05 Bq/g.

- The WEE duplicate vegetation sample concentration of ^{238}U at 1.43 Bq/g was higher than the baseline concentration of 6.90E-04 Bq/g.

A few other soil and vegetation samples contained concentrations of uranium isotopes and ^{40}K that were slightly higher than the baseline concentrations but were not the highest concentrations and thus were not included in Appendix H and are not listed above. The higher concentrations are most likely due to natural spatial variability, and they are so far below the regulatory limit as to be nonimpactive.

CHAPTER 5 – ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

Non-radiological programs at the WIPP facility include land management, meteorological monitoring, VOC monitoring, hydrogen and methane monitoring, seismic monitoring, certain aspects of liquid effluent, as well as surface water and groundwater monitoring. The monitoring is performed to comply with the Permit requirements and provisions of the WIPP authorization documents. Radiological and non-radiological groundwater monitoring is discussed in Chapters 4 and 6, respectively.

5.1 Principal Functions of Non-radiological Sampling

The principal functions of the non-radiological environmental surveillance program are to:

- Provide continued protection to human health and the environment.
- Assess the impacts of WIPP facility operations on the surrounding ecosystem.
- Monitor ecological conditions in the Los Medaños region.
- Provide environmental data that have not or will not be acquired by other programs, but are important to WIPP mission.
- Comply with applicable commitments (e.g., DOE/BLM Memorandum of Understanding and interagency agreements).

5.2 Land Management Plan

The DOE developed a LMP as required by the WIPP LWA to identify resource values, promote multiple-use management, and identify long-term goals for the management of WIPP lands. The LMP was developed in consultation with the BLM and the State of New Mexico.

The LMP sets forth cooperative arrangements and protocols for addressing WIPP-related land management actions. This LMP is reviewed biennially to assess the adequacy and effectiveness of the document, or as may be necessary to address emerging issues affecting WIPP lands. Affected agencies, groups, and/or individuals may be involved in the review process.

5.2.1 Land Use Requests

Parties who wish to conduct activities that may impact lands under the jurisdiction of the DOE but outside the property protection area are required by the LMP to prepare a land use request. A land use request consists of a narrative description of the project, a completed environmental review, and a map depicting the location of the proposed activity. This documentation is used to determine if applicable regulatory requirements have been met prior to the approval of a proposed project. A land use request is

submitted to the Land Use Coordinator by organizations wishing to complete construction on rights-of-way, pipeline easements, or similar actions within the WIPP LWA, or on lands used in the operation of the WIPP facility, under the jurisdiction of the DOE. In 2014, seven land use requests were submitted to and approved by the Land Use Coordinator.

5.2.2 Wildlife Population Monitoring

In 1995, the U.S. Fish and Wildlife Service provided an updated list of threatened and endangered species for Eddy and Lea Counties, New Mexico. Included were 18 species that may be present on DOE lands. A comprehensive evaluation in support of the Supplemental Environmental Impact Statement II (SEIS-II) (*Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement*, DOE/EIS 0026–S–2) was conducted in 1996 to determine the presence or absence of threatened or endangered species in the vicinity of the WIPP site and the effect of WIPP facility operations on these species. Results indicated that activities associated with the operation of the WIPP facility have no negative impact on wildlife species.

Employees of the WIPP facility continue to consider resident species when planning activities that may impact their habitat, in accordance with the DOE/BLM Memorandum of Understanding, the Joint Powers Agreement with the State of New Mexico (Appendices C and G of the LMP, respectively), and 50 CFR Part 17, “Endangered and Threatened Wildlife and Plants.”

5.2.3 Reclamation of Disturbed Lands

Reclamation serves to mitigate the effects of WIPP-related activities on affected plant and animal communities. The objective of the reclamation program is to restore lands used in the operation of the WIPP facility that are no longer needed for those activities. Reclamation is intended to reduce soil erosion, increase the rate of plant colonization and succession, and provide habitat for wildlife in disturbed areas.

The DOE follows a reclamation program and a long-range reclamation plan in accordance with the LMP and specified permit conditions. As locations are identified for reclamation, WIPP personnel reclaim these areas by using the best acceptable reclamation practices. Seed mixes used reflect those species indigenous to the area, with priority given to those plant species that are conducive to soil stabilization, wildlife, and livestock needs.

5.2.4 Oil and Gas Surveillance

Oil and gas activities within 1.6 km (1 mi) of the WIPP site boundary are routinely monitored in accordance with the LMP to identify new activities associated with oil and gas exploration and production, including the following:

- Survey staking
- Surface geophysical exploration

- Drilling
- Pipeline construction
- Work-overs
- Changes in well status
- Anomalous occurrences (e.g., leaks, spills, accidents)

During 2014, WIPP surveillance teams conducted monthly surveillances and field inspections.

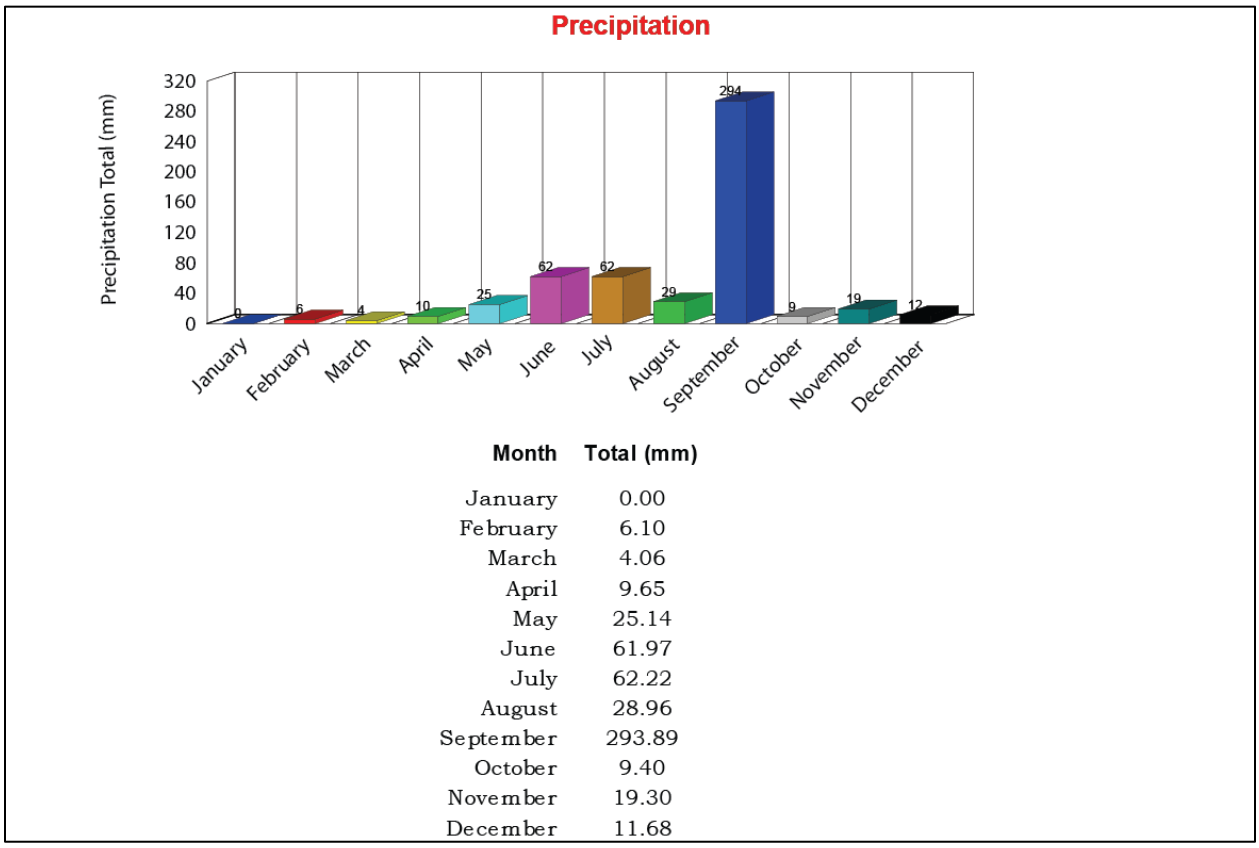
Proposed new well locations staked within 1.6 km (1 mi) of the WIPP site boundary are field-verified. This ensures that the proposed location is of sufficient distance from the WIPP site boundary to protect the WIPP withdrawal from potential surface and subsurface trespass. Two new wells were drilled and completed in 2014 within 1.6 km (1 mi) of the WIPP site boundary. If a well is within 100 m (330 ft) of the WIPP site boundary, the driller is required to submit daily deviation surveys to the WIPP Land Use Coordinator to assess the horizontal drift of the well bore during drilling. None of these wells deviated inside of the WIPP site boundary.

5.3 Meteorological Monitoring

The WIPP facility meteorological station is located 600 m (1,969 ft) northeast of the WHB. The main function of the station is to provide data for atmospheric dispersion modeling. The station records measures every 15 minutes of wind speed, wind direction, and temperature at elevations of 2, 10, and 50 m (6.6, 33, and 164 ft). The station also records ground-level measurements of barometric pressure, relative humidity, precipitation, and solar radiation.

5.3.1 Weather Data

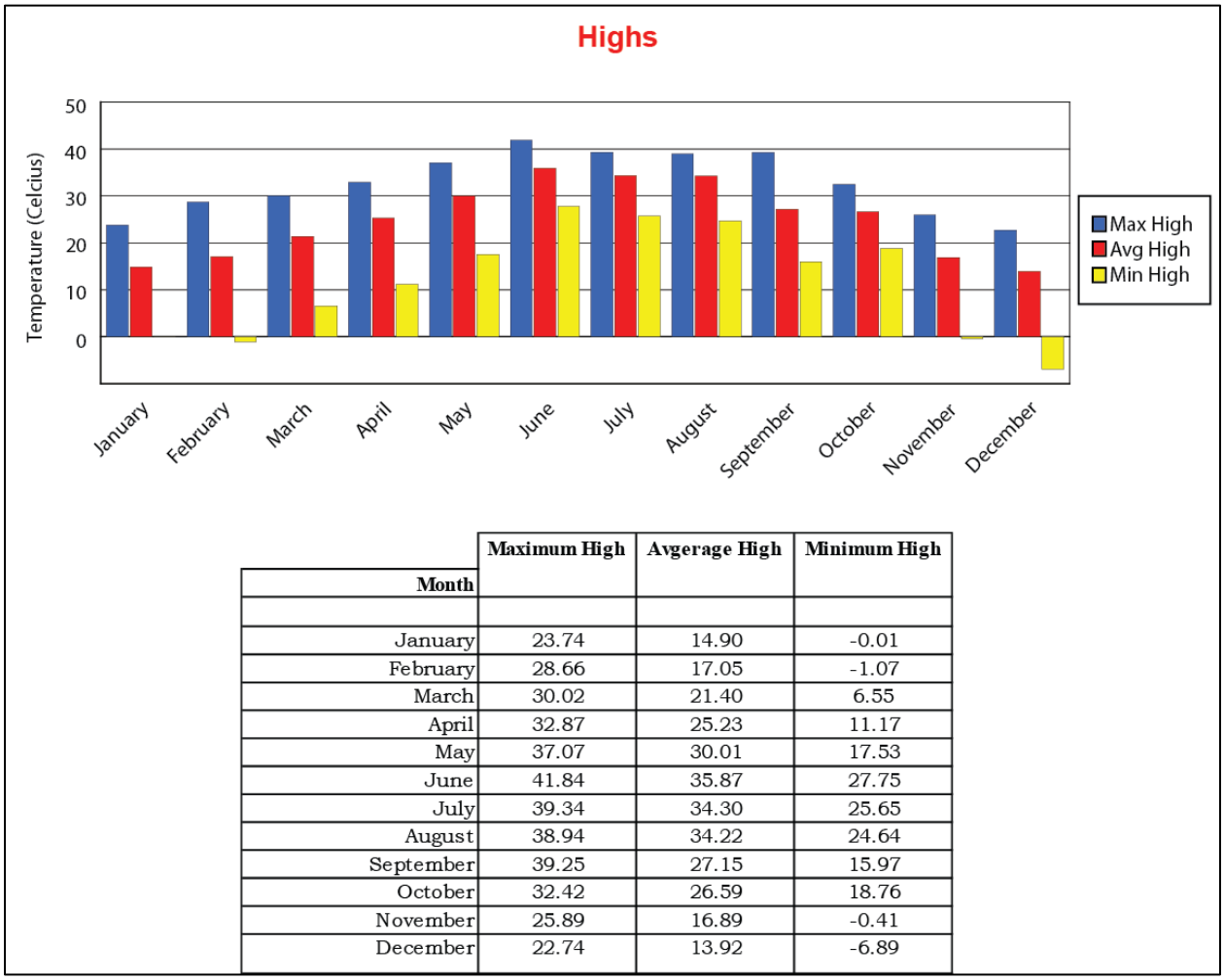
Precipitation at the WIPP site for 2014 was 548.64 millimeter (21.6 in.) compared to 263.4 mm (10.37 in.) for 2013. The average yearly rainfall recorded at the meteorological tower since 1970 is (13.55 in). Figure 5.1 displays the monthly precipitation at the WIPP site.



Month	Total (mm)
January	0.00
February	6.10
March	4.06
April	9.65
May	25.14
June	61.97
July	62.22
August	28.96
September	293.89
October	9.40
November	19.30
December	11.68

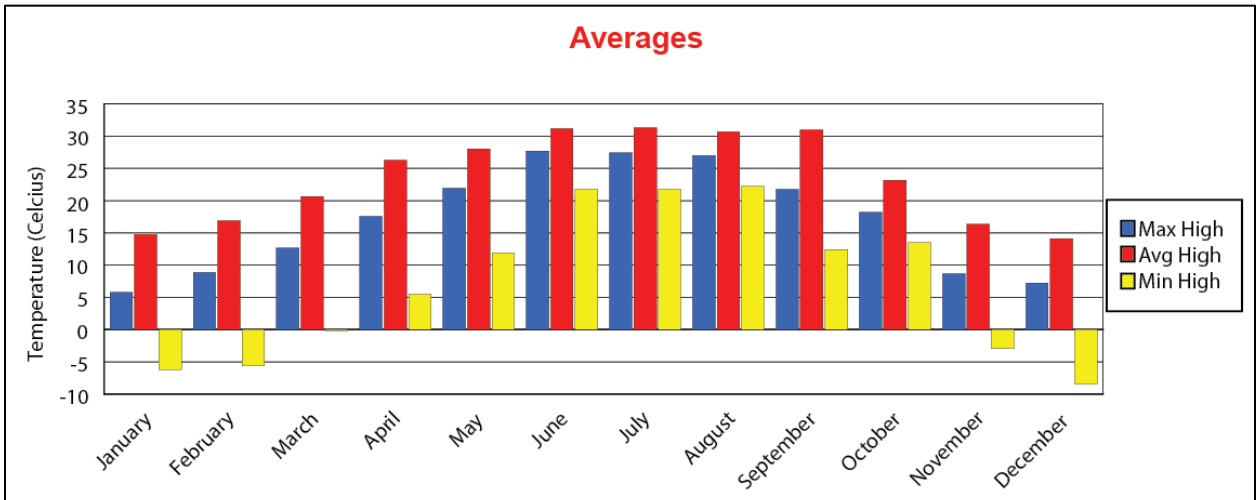
Figure 5.1 – WIPP Site Precipitation Report for 2014

The maximum recorded surface temperature (2-m level) at the WIPP site in 2014 was 41.84°C (106.66°F) in June, whereas the lowest surface temperature recorded was −13.27°C (8.114°F) in January. Monthly temperatures are illustrated in Figures 5.2, 5.3, and 5.4. The mean temperature at the WIPP site in 2014 was 17.06°C (62.708°F), which is 0.05 °C cooler than the 2013 average of 17.11 °C (62.80 °F). The average monthly temperatures for the WIPP area ranged from 27.71°C (81.88°F) during June to 5.75°C (42.35°F) in January (Figure 5.3).



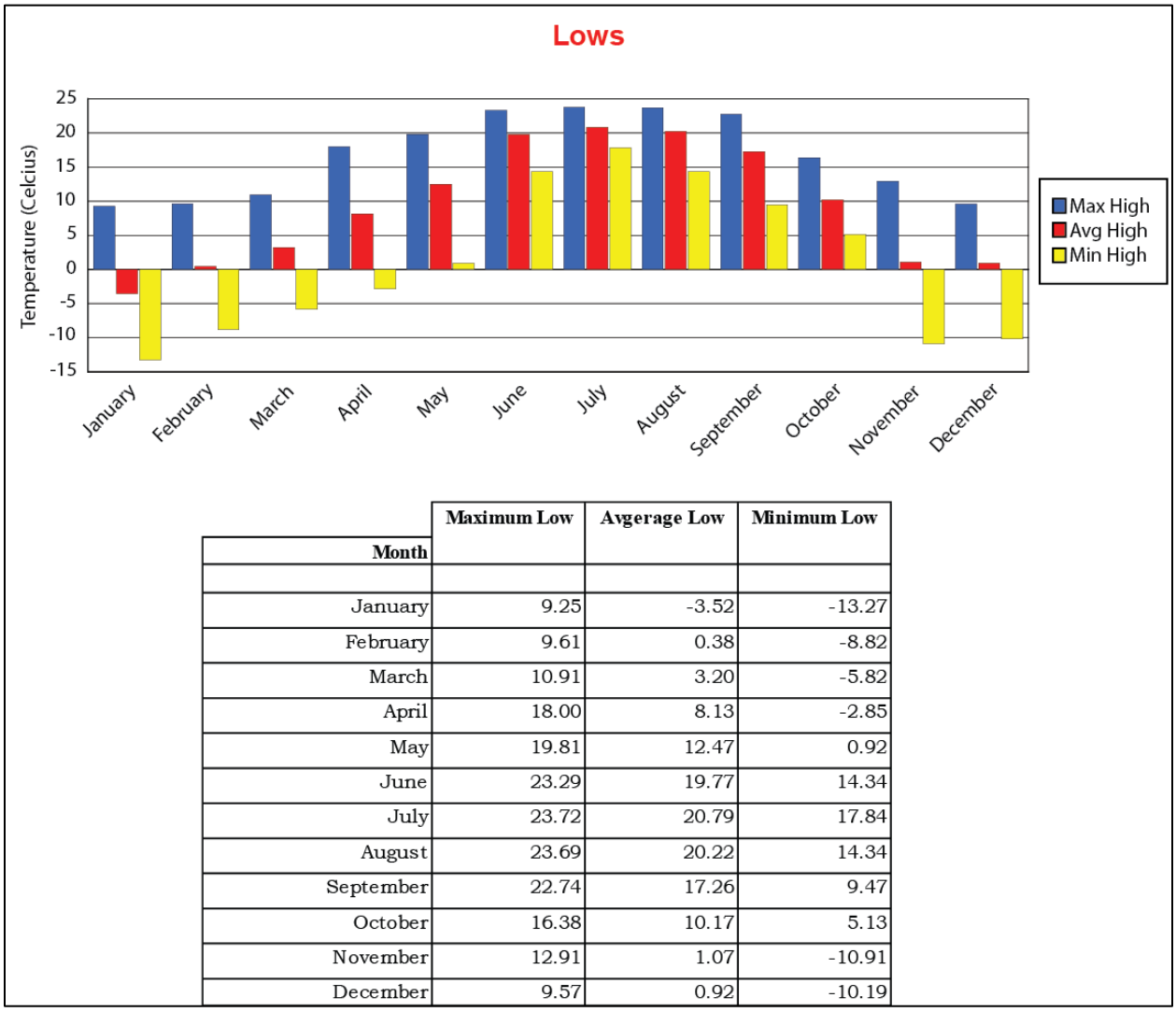
Month	Maximum High	Avgerage High	Minimum High
January	23.74	14.90	-0.01
February	28.66	17.05	-1.07
March	30.02	21.40	6.55
April	32.87	25.23	11.17
May	37.07	30.01	17.53
June	41.84	35.87	27.75
July	39.34	34.30	25.65
August	38.94	34.22	24.64
September	39.25	27.15	15.97
October	32.42	26.59	18.76
November	25.89	16.89	-0.41
December	22.74	13.92	-6.89

Figure 5.2 – WIPP Site High Temperatures for 2014



Month	Maximum Average	Avgerage Average	Minimum Average
January	14.75	5.75	-6.18
February	16.85	8.88	-5.57
March	20.66	12.67	-0.14
April	26.27	17.57	5.48
May	28.04	21.94	11.87
June	31.22	27.71	21.80
July	31.33	27.42	21.78
August	30.67	27.02	22.24
September	30.98	21.76	12.45
October	23.17	18.20	13.51
November	16.33	8.65	-2.93
December	14.10	7.20	-8.41

Figure 5.3 – WIPP Site Average Temperatures for 2014

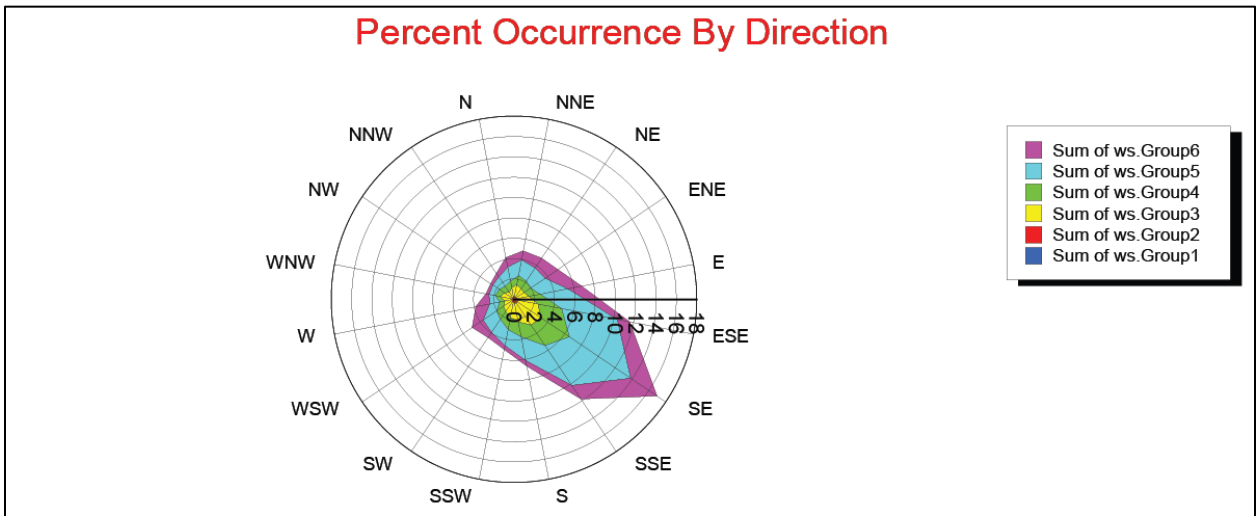


Month	Maximum Low	Avgerage Low	Minimum Low
January	9.25	-3.52	-13.27
February	9.61	0.38	-8.82
March	10.91	3.20	-5.82
April	18.00	8.13	-2.85
May	19.81	12.47	0.92
June	23.29	19.77	14.34
July	23.72	20.79	17.84
August	23.69	20.22	14.34
September	22.74	17.26	9.47
October	16.38	10.17	5.13
November	12.91	1.07	-10.91
December	9.57	0.92	-10.19

Figure 5.4 – WIPP Site Low Temperatures for 2014

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2014, winds of 3.71 to 6.30 m per second (8.30 to 14.09 mi per hour) were the most prevalent, occurring approximately 37 percent of the time (measured at the 10-m level). There were no tornadoes at the WIPP site in 2014. Figure 5.5 displays the annual wind data at WIPP for 2014.



Wind Direction	Wind Speeds in meters per second 0.0 - 0.50	0.51 - 1.40	1.41 - 2.80	2.81 - 3.70	3.71 - 6.30	>6.30	Total Percent Occurrence by Direction
E	0.01	0.37	1.15	1.13	2.77	1.38	6.80
ENE	0.01	0.27	0.91	0.80	1.71	1.50	5.20
NE	0.01	0.27	1.00	0.91	1.56	1.14	4.88
NNE	0.02	0.27	1.20	0.90	1.58	0.88	4.83
N	0.01	0.25	0.90	0.67	1.40	0.95	4.17
NNW	0.02	0.17	0.68	0.68	1.12	0.42	3.09
NW	0.02	0.18	0.93	0.64	0.74	0.24	2.75
WNW	0.03	0.23	1.12	0.50	0.63	0.29	2.80
W	0.01	0.22	0.71	0.51	1.02	1.36	3.82
WSW	0.02	0.23	1.01	0.81	1.61	1.30	4.97
SW	0.02	0.30	1.19	0.87	1.58	0.59	4.54
SSW	0.02	0.31	1.50	1.24	1.59	0.38	5.03
S	0.02	0.37	1.88	1.52	2.36	0.53	6.68
SSE	0.02	0.42	2.62	2.44	4.72	1.61	11.82
SE	0.01	0.41	2.78	3.41	7.28	3.12	16.99
ESE	0.02	0.41	2.00	2.37	5.57	1.25	11.62
	0.27%	4.66%	21.54%	19.37%	37.24%	16.92%	100.00%

Figure 5.5 – WIPP Site Wind Speed (at 10-Meter Level) Report for 2014

5.4 Volatile Organic Compound Monitoring

The purpose of the VOC monitoring program is to demonstrate compliance with the limits specified in the WIPP Permit Part 4, in order to provide continued protection of human health and the environment.

WIPP VOC monitoring, as required by Permit Part 4 and Attachment N, has not been conducted since early February 2014 due to the occurrence of two separate events in the underground facility, a fire on February 5 and a breach of a waste container that resulted in the release of radioactive material on February 14. Underground VOC monitoring has not been possible since then due to the ongoing re-entry and recovery operations and the risk of exposure to sampling personnel from radiological contamination. The last VOC monitoring program samples collected were on February 4, 2014. This chapter describes requirements for underground VOC monitoring as well as additional sampling activities that have been performed on the surface since the two February events.

The nine target VOCs selected for monitoring were determined to represent approximately 99 percent of the risk due to air emissions. Starting with samples collected on or after May 12, 2014, trichloroethylene was a target analyte in compliance with the NMED AO dated May 12, 2014. A concentration of concern has yet to be established for this compound. A summary of the target VOC results from samples collected between January 1 and February 4, 2014, and the limits prescribed by Part 4 of the Permit are shown later in Tables 5.1 through 5.3.

Repository VOC monitoring was implemented in November 1999 and disposal room VOC monitoring was implemented in November 2006. The requirements for disposal room VOC monitoring include the addition of sampling locations within active underground hazardous waste disposal units. As seen in Figure 5.6, two sampling locations are required for each filled disposal room, one at the exhaust side of the room and one at the inlet side of the room. In addition, each room actively receiving waste is required to be sampled at the exhaust side of the room. For 2014, sampling occurred in active and filled rooms of Panel 6 and the active room (Room 7) of Panel 7 at a frequency of once every two weeks between February 1, 2013 and January 4, 2014. In April 2008, new Permit conditions (for Panels 3 through 8) were implemented for ongoing disposal room VOC monitoring in filled panels (panels in which waste emplacement is complete). This included continued monthly VOC monitoring in Room 1 of a filled panel unless an explosion-isolation wall is installed. For 2014, ongoing disposal room VOC monitoring was conducted in Panels 3 and 4 between January 1 and February 4, 2014.

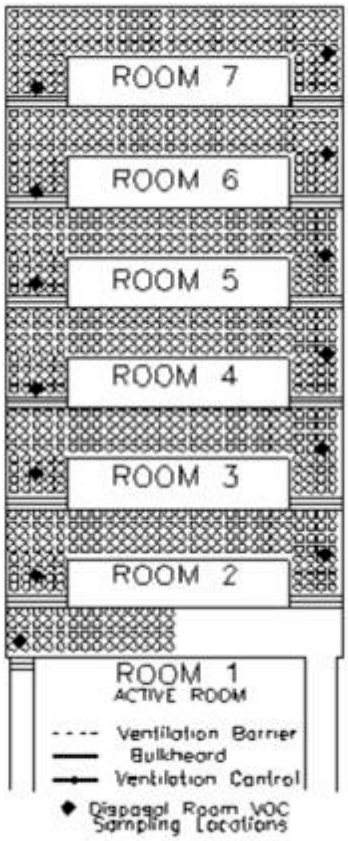


Figure 5.6 – Disposal Room Volatile Organic Compound Monitoring

Repository VOC monitoring is performed twice per week at two ambient air monitoring stations: Station VOC-A, sample inlet located downstream from hazardous waste disposal unit Panel 1 in the E300 drift; and Station VOC-B, sample inlet located upstream from the active panel(s). As waste is emplaced in new panels, Station VOC-B will be relocated to ensure that it samples underground air before it passes the waste panels. The location of Station VOC-A is not anticipated to change. As stated previously, this underground monitoring has not been performed since the two events in February 2014.

Target compounds found at Station VOC-B are considered to be non-waste-emplacement-related. The VOCs collected at this location are entering the mine through the Air Intake Shaft and may include VOCs from facility operations upstream of the waste panels. As prescribed by the Permit, target VOC concentrations are normalized and differences calculated between the two stations represent VOC contributions from the waste panels (i.e., underground hazardous waste disposal unit emissions). The normalized emission concentrations for a sample event and the running annual averages of emission concentrations must be less than the concentrations of concern listed in the Permit (Table 5.1).

Table 5.1 – Summary of Repository VOC Monitoring Results

Target Compound	Running Annual Average Maximum Value (ppbv)	Emission Concentration Maximum Value (ppbv)	Concentration of Concern (ppbv)
Carbon tetrachloride	382	825	960
Chlorobenzene	0	0	220
Chloroform	34.1	73.2	180
1,1-Dichloroethylene	0	0	100
1,2-Dichloroethane	0	0	45
Methylene chloride	4.65	9.66	1,930
1,1,2,2-Tetrachloroethane	0	0	50
Toluene	0	0	190
1,1,1-Trichloroethane	54.4	105	590
Trichloroethylene	131	341	N/A

Notes:
N/A = not applicable.
ppbv = parts per billion by volume.

The basis for the VOC sampling reported in this section is the guidance included in Compendium Method TO–15, *Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS)* (EPA, 1999). The samples were analyzed using gas chromatography/mass spectrometry under an established QA/QC program. Laboratory analytical procedures were developed based on the concepts contained in both TO–15 and *Contract Laboratory Program Volatile Organics Analysis of Ambient Air in Canisters* (EPA, 1994).

For repository VOC monitoring in 2014, only 18 samples were collected due to the 2014 February events. The running annual average and emission concentration maximum values for 2014 are found in Table 5.1.

A summary of disposal room VOC monitoring results for Panels 6 and 7 are shown in Table 5.2. Four of the nine target compounds were detected above the method reporting limit (MRL). During 2014, none of the samples exceeded the 50 or 95 percent action level.

Ongoing disposal room VOC monitoring was conducted in Panels 3 and 4 from January 1, 2014, to February 3, 2014. None of the samples yielded concentrations exceeding the action levels. Ongoing disposal room VOC monitoring results are listed in Table 5.3.

Table 5.2 – Summary of Disposal Room VOC Monitoring Results

Target Compound	Maximum Detected Value (ppmv)	50% Action Level (ppmv)	95% Action Level (ppmv)	Room-based Limit (ppmv)
Panel 6				
Carbon tetrachloride	2,440	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	140.5	4,965	9,433	9,930
1,1-Dichloroethylene	<1	2,745	5,215	5,490
1,2-Dichloroethane	<1	1,200	2,280	2,400
Methylene chloride	16.53 J	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<1	1,480	2,812	2,960
Toluene	2.76 J	5,500	10,450	11,000
1,1,1-Trichloroethane	5.97	16,850	32,015	33,700
Trichloroethylene	1,883	N/A	N/A	N/A
Panel 7				
Carbon tetrachloride	<1	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	<1	4,965	9,433	9,930
1,1-Dichloroethylene	<MDL	2,745	5,215	5,490
1,2-Dichloroethane	<MDL	1,200	2,280	2,400
Methylene chloride	<1	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<MDL	1,480	2,812	2,960
Toluene	<1	5,500	10,450	11,000
1,1,1-Trichloroethane	<1	16,850	32,015	33,700
Trichloroethylene	<1	N/A	N/A	N/A

Notes:
J = estimated concentration, below MRLs, but above MDL.
MDL = method detection limit.
N/A = not applicable.
ppmv = parts per million by volume.

Table 5.3 – Summary of Ongoing Disposal Room VOC Monitoring Results

Target Compound	Maximum Detected Value (ppmv)	50% Action Level (ppmv)	95% Action Level (ppmv)	Room-based Limit (ppmv)
Panel 3				
Carbon tetrachloride	4.2	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	<1	4,965	9,433	9,930
1,1-Dichloroethylene	<1	2,745	5,215	5,490
1,2-Dichloroethane	<1	1,200	2,280	2,400
Methylene chloride	<1	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<MDL	1,480	2,812	2,960
Toluene	<1	5,500	10,450	11,000
1,1,1-Trichloroethane	2.8	16,850	32,015	33,700
Trichloroethylene	<1	N/A	N/A	N/A
Panel 4				
Carbon tetrachloride	365.8	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	18.98	4,965	9,433	9,930
1,1-Dichloroethylene	<MDL	2,745	5,215	5,490
1,2-Dichloroethane	<MDL	1,200	2,280	2,400
Methylene chloride	9.74	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<MDL	1,480	2,812	2,960
Toluene	<1	5,500	10,450	11,000
1,1,1-Trichloroethane	65.44	16,850	32,015	33,700
Trichloroethylene	94.71	N/A	N/A	N/A

Notes:
MDL = method detection limit.
N/A = not applicable.
ppmv = parts per million by volume.

5.5 Hydrogen and Methane Monitoring

Monitoring for hydrogen and methane in “filled” panels until final panel closure, unless an explosion-isolation wall is installed, was implemented in April 2008 (for Panels 3 through 8). Hydrogen and methane sampling locations include two locations in each room (exhaust and inlet) and four additional locations installed near the back (roof) of the bulkheads located in the panel access drifts. Monitoring is performed monthly at locations with working sample lines. Hydrogen and methane monitoring was conducted in Panels 3 and 4 between January 1, 2014, and February 3, 2014.

Hydrogen and methane samples are analyzed using gas chromatography with thermal conductivity detection under an established QA/QC program. Specialized laboratory analytical procedures were developed based on standard laboratory techniques and approved through established QA processes.

For samples collected between January 1 and February 3, 2014, the maximum detected value for hydrogen, 179 parts per million by volume, was considerably lower than the action levels as shown in Table 5.4. None of the samples contained detectable levels of methane.

Table 5.4 – Summary of Hydrogen and Methane Monitoring Results

Target Compound	Maximum Detected Value (ppmv)	Action Level 1 (ppmv)	Action Level 2 (ppmv)
Panel 3			
Hydrogen	<MDL	4,000	8,000
Methane	<MDL	5,000	10,000
Panel 4			
Hydrogen	179	4,000	8,000
Methane	<MDL	5,000	10,000

Notes:
MDL = method detection limit.
ppmv = parts per million by volume.

5.6 Additional Surface VOC Monitoring

After the February fire event, VOC sampling activities began at surface locations with the first post-event sample collected on February 12, 2014. These samples were intended to allow for determination of compliance with environmental performance standards associated with the Repository VOC sampling program. During the collection of surface samples, multiple sample locations were tested. Surface VOC sampling continued throughout 2014.

Sampling is performed using a commercially available portable passive air sampling kit. Each sample is set to collect as a 24-hour time-integrated sample consistent with EPA Compendium Method TO-15. Surface VOC monitoring data were reported in the Semi-annual VOC, Hydrogen, and Methane Data Summary Reports. Summary results for the period July 1, 2014, through December 31, 2014, are included in Table 5.5.

Table 5.5 – Summary of Surface VOC Monitoring Results for Reporting Period July 1, 2014 through December 1, 2014

Target Compound	Max. Value (pptv)	Location	Sampling Date
Carbon Tetrachloride	720	Building 489 North Air Intake	10/9/2014
Chlorobenzene	160 J	Southeast Fenceline	7/23/2014
Chloroform	55.77 J	Building 489 Air Intake	12/4/2014
1,1-Dichloroethylene	N/A	N/A	N/A
1,2-Dichloroethane	54.99 J	Building 489 Air Intake	12/4/2014
Methylene Chloride	140 J	Building 489 North Air Intake	12/22/2014
1,1,2,2-Tetrachloroethane	N/A	N/A	N/A
Toluene	870	Building 489 Air Intake	12/4/2014
1,1,1-Trichloroethane	107.7 J	Building 489 Air Intake	12/4/2014
Trichloroethylene	220 J	Building 489 North Air Intake	10/9/2014

Notes:
J = estimated concentration, below MLRs, but above MDL
pptv = parts per trillion by volume
N/A = not applicable.

5.7 Seismic Activity

Currently, seismicity within 300 km (186 mi) of the WIPP site is being monitored by the New Mexico Institute of Mining and Technology using data from a nine-station network approximately centered on the site (Figure 5.7). Station signals are transmitted to the New Mexico Institute of Mining and Technology Seismological Observatory in Socorro, New Mexico. When appropriate, readings from the WIPP network stations are combined with readings from an additional New Mexico Institute of Mining and Technology network in the central Rio Grande Rift. Occasionally, data are also exchanged with the University of Texas at El Paso and Texas Tech University in Lubbock, both of which operate monitoring stations in west Texas.

The mean operational efficiency of the WIPP seismic monitoring stations during 2014 was approximately 73.3 percent. The reduction in network availability is primarily due to seismic and communication equipment downtime. Upgrades to both the seismic monitoring and communication equipment are planned for the latter part of 2015. From January 1 through December 31, 2014, locations for 34 seismic events were recorded within 300 km (186 mi) of the WIPP site. Recorded data included origin times, epicenter coordinates, and magnitudes. The strongest recorded event (magnitude 2.2) occurred on December 25, 2014, and was approximately 286 km (177 mi) northeast of the site. The closest earthquake to the site was approximately 47 km (29 mi) west and had a magnitude of 0.3.

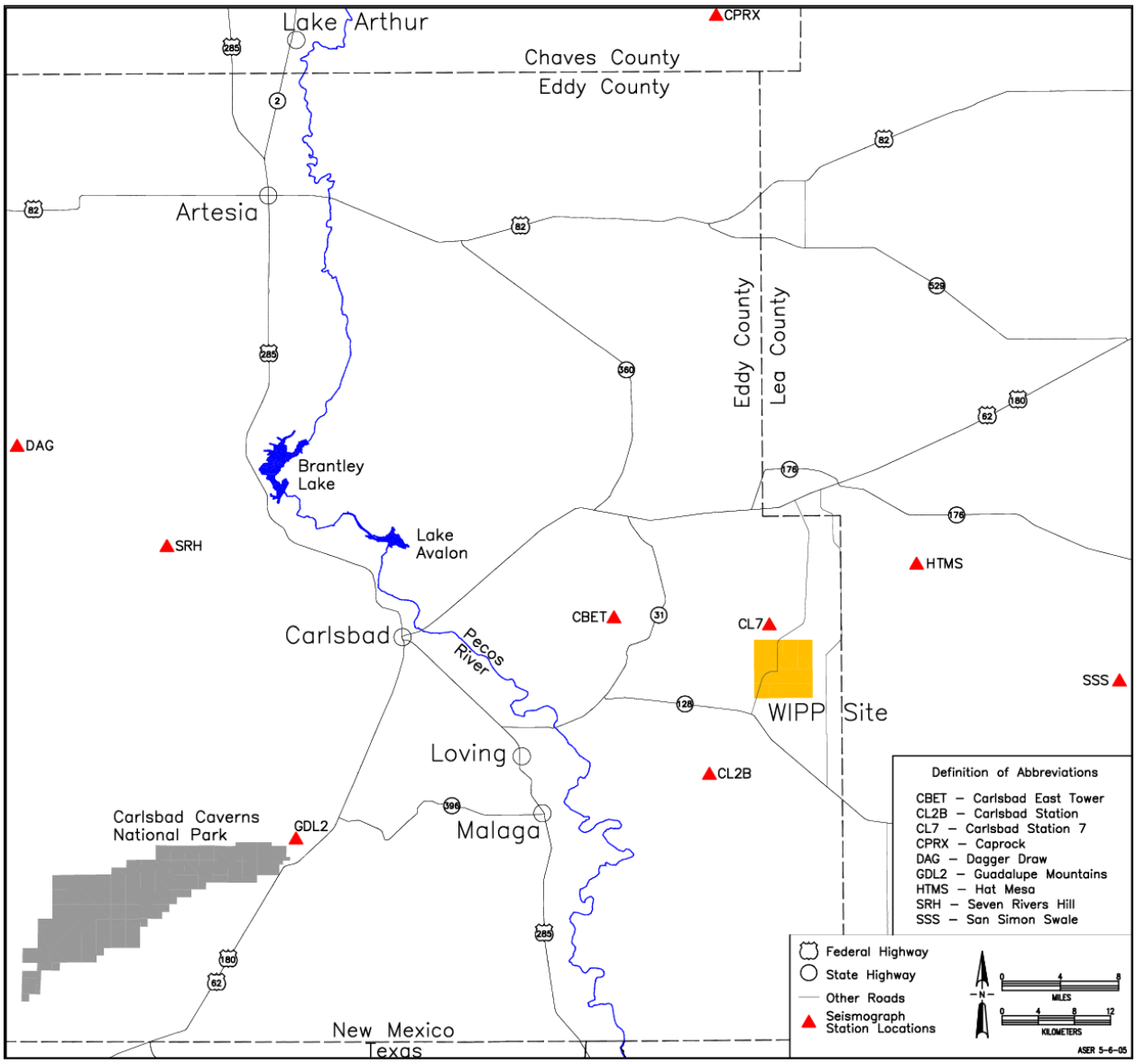


Figure 5.7 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.8 Liquid Effluent Monitoring

The NMED Ground and Surface Water Protection regulations set forth in 20.6.2 NMAC regulate discharges that could impact surface water or groundwater. DOE compliance with these regulations is discussed in Chapter 2. The DP was renewed on July 29, 2014. A renewal is necessary every five years. No modification occurred during this renewal process. The names of the ponds were changed to reflect a more orderly nomenclature. However, the water collection processes remained the same as the last DP modification. Analytical data from the discharge monitoring reports are summarized in Table 5.6 and Table 5.7.

Table 5.6 – Sewage Lagoon and H–19 Analytical Results for Spring 2014

Analyte	Influent Pond 2A[(a)]	Evaporation Pond B	Evaporation Pond C	H–19 Evaporation Pond
Nitrate (mg/L)	ND	N/A	N/A	N/A
TKN (mg/L)	112	N/A	N/A	N/A
TDS (mg/L)	589 [(a)]	NS	NS	NS
Sulfate (mg/L)	49.0 [(a)]	NS	NS	NS
Chloride (mg/L)	94.8 [(a)]	NS	NS	NS

Notes:
mg/L = milligrams per liter.
N/A = not applicable.
ND = non-detect.
NS = not sampled.
TKN = total Kjeldahl nitrogen.
[(a)] = average of duplicate samples.

Table 5.7 – Sewage Lagoon, H-19, and Infiltration Control Pond Analytical Results for Fall 2014

Location	Nitrate (mg/L)	TKN (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Influent Pond 2A	ND	48.2	670[(a)]	53.6[(a)]	104[(a)]
Evaporation Pond B	N/A	N/A	50,600	883	33,500
Evaporation Pond C	N/A	N/A	272	4.0 J	121
H-19 Evaporation Pond	N/A	N/A	64,500[(a)]	49.5[(a)]	33,200[(a)]
Salt Pile Evaporation Pond	N/A	N/A	6,330[(a)]	49.3[(a)]	3,770[(a)]
Salt Storage Extension Evaporation Basin I	N/A	N/A	271,000	12,900	170,000
Salt Storage Extension Evaporation Basin II	N/A	N/A	122,000	6,360	81,200
Pond 1	N/A	N/A	421[(a)]	19.5[(a)]	186[(a)]
Pond 2	N/A	N/A	480	13.6	230
Pond A	N/A	N/A	172	7.67	71.6

Notes:
(a) – average of duplicate samples.
J – estimated concentration between method detection limit and reporting limit.
mg/L = milligrams per liter.
N/A – not applicable.
ND – non-detect.
TKN –total Kjeldahl nitrogen (as N).
Influent Pond 2A = Settling Lagoon 2.
Evaporation Pond B = Effluent Lagoon B.
Evaporation Pond C = Effluent Lagoon C.
Salt Pile Evaporation Pond = Salt Storage Pond 1.
Salt Storage Extension Evaporation Basin I = Salt Storage Pond 2.
Salt Storage Extension Evaporation Basin II = Salt Storage Pond 3.
Pond 1 = Storm Water Pond 1; Pond 2 = Storm Water Pond 2; Pond A = Storm Water Pond 3.

CHAPTER 6 – SITE HYDROLOGY, GROUNDWATER MONITORING, AND PUBLIC DRINKING WATER PROTECTION

Current groundwater monitoring activities for the WIPP facility are outlined in the *WIPP Groundwater Monitoring Program Plan* (WP 02–1). In addition, the WIPP facility has detailed procedures for performing specific activities, such as pumping system installations, field monitoring analyses and documentation, and QA records management. Groundwater monitoring activities are also included in the *Waste Isolation Pilot Plant Environmental Monitoring Plan* (DOE/WIPP–99–2194).

6.1 Site Hydrology

The hydrology at and surrounding the WIPP site has been studied extensively over the past 40 years. A summary of the hydrology in this area is contained in the following sections. Figure 6.1 shows a generalized schematic of the stratigraphy at the site. Details for hydrology and stratigraphy can be found in Mercer 1983, Beauheim 1986, Beauheim 1987, and Beauheaim and Ruskauff 1998.

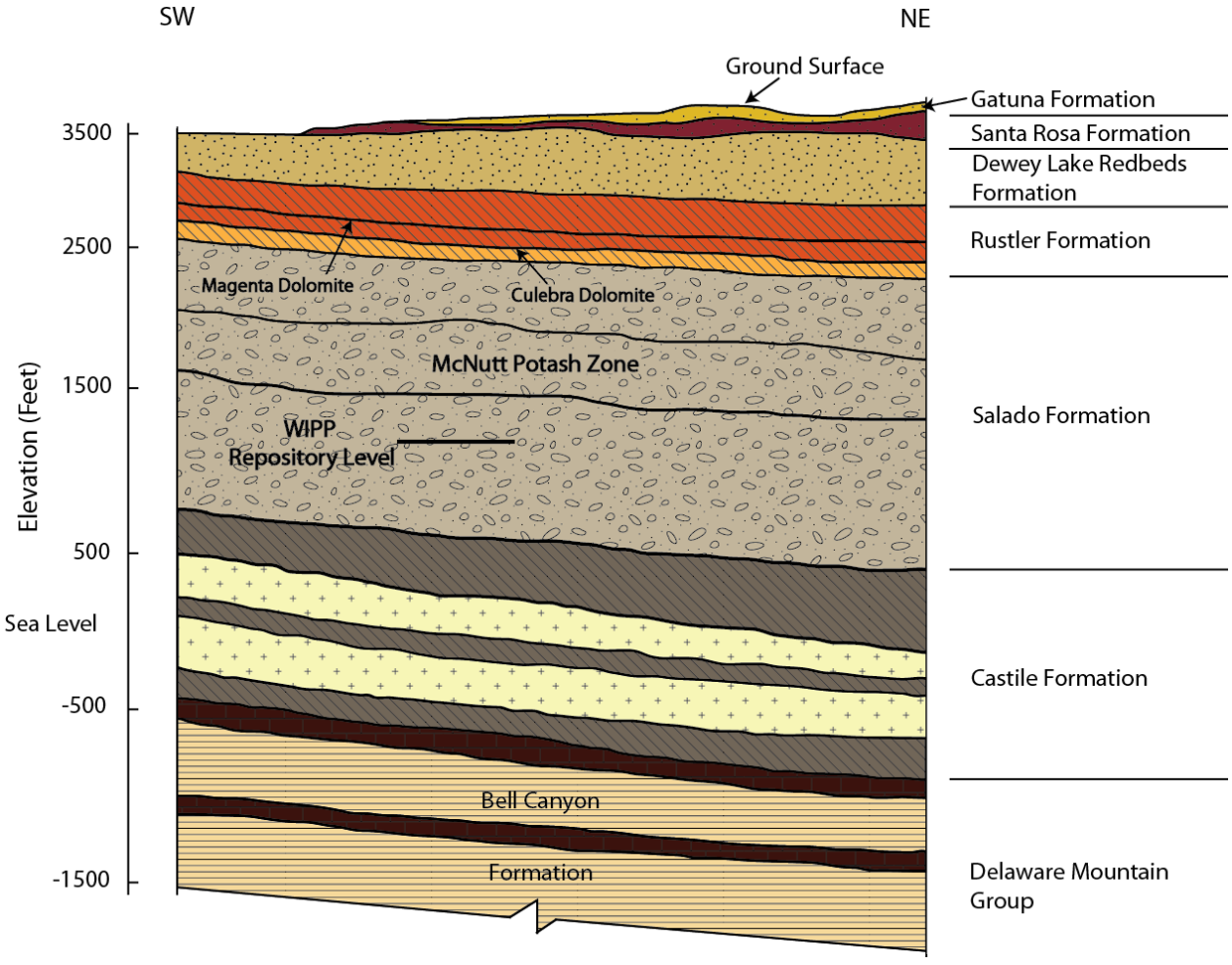


Figure 6.1 – WIPP Stratigraphy

6.1.1 Surface Hydrology

Surface water is absent from the WIPP site. The nearest significant surface water body, Laguna Grande de la Sal, is 13 km (8 mi) west-southwest of the center of the WIPP site in Nash Draw, where shallow brine ponds occur. Small, manmade livestock watering holes (tanks) occur several kilometers from the WIPP site, but are not hydrologically connected to the formations overlying the WIPP repository.

6.1.2 Subsurface Hydrology

Several water-bearing zones have been identified and extensively studied at and near the WIPP site. Limited amounts of potable water are found in the middle Dewey Lake Redbeds Formation (Dewey Lake) and the overlying Triassic Dockum group in the southern part of the WIPP LWA. Two water-bearing units, the Culebra Dolomite (Culebra) and the Magenta Dolomite (Magenta), occur in the Rustler Formation (Rustler) and produce brackish to saline water at and in the vicinity of the WIPP site. Another very low transmissivity, saline water-bearing zone occurs at the Rustler and Salado Formation (Salado) contact.

6.1.2.1 Hydrology of the Castile Formation

The Castile Formation (Castile) is composed of a sequence of three thick anhydrite beds separated by two thick halite beds. This formation acts as an aquitard, separating the Salado from the underlying water-bearing sandstones of the Bell Canyon Formation (Bell Canyon). In the halite zones, the occurrence of circulating groundwater is restricted because halite at these depths does not readily maintain secondary porosity, open fractures, or solution channels.

No regional groundwater flow system has been found in the Castile in the vicinity of the WIPP site. The only significant water present in the formation occurs in isolated brine reservoirs in fractured anhydrite. Wells have encountered pressurized brine reservoirs in the upper anhydrite unit of the Castile in the vicinity of the WIPP site. Two such encounters were made by boreholes drilled for the WIPP project: ERDA 6, northeast of the WIPP site, encountered a pressurized brine reservoir in 1975; and borehole WIPP–12, 1 mi north of the center of the WIPP site, encountered a brine reservoir in 1981. Both encounters were hydrologically and chemically tested in 1981 and determined to be unconnected (Popielak et al., 1983).

6.1.2.2 Hydrology of the Salado Formation

The massive halite beds within the Salado host the WIPP repository horizon. The Salado represents a regional aquiclude due to the hydraulic properties of the bedded halite that forms most of the formation. In the halites, the presence of circulating groundwater is restricted because halites do not readily maintain primary porosity, solution channels, or open fractures.

The results of permeability testing, both within the facility and from the surface, provide interpreted Darcy permeabilities that range from less than 1E-23 to 3E-16 square meters (m^2), with the more pure (less argillaceous) halites having the lower permeability. Anhydrite interbeds typically have permeabilities ranging from 2E-20 to 9E-18 m^2 (Beauheim and Roberts, 2002). The only significant variation to these extremely low permeabilities occurs in the immediate vicinity of the underground workings (Stormont et al., 1991). This increase is believed to be a result of near-field fracturing due to the excavation.

Small quantities of brine have been observed to collect in boreholes drilled into Marker Bed 139 a few feet below the floor of the WIPP underground repository rooms, and have been observed to seep out of the excavated walls. The long-term performance assessment for the WIPP disposal system assumes that small quantities of brine will be present in the WIPP repository.

6.1.2.3 Hydrology of the Rustler-Salado Contact

In Nash Draw and areas immediately west of the site, the Rustler-Salado contact exists as a dissolution residue capable of transmitting water. Eastward from Nash Draw toward the WlPP site, the amount of dissolution decreases and the transmissivity of this interval decreases (Mercer, 1983). Small quantities of brine were found in the test holes in this zone at the WIPP site (Mercer and Orr, 1977).

6.1.2.4 Hydrology of the Culebra Member

The Culebra is the most transmissive hydrologic unit in the WIPP site area and is considered the most significant potential hydrologic pathway for a radiologic release to the accessible environment.

Tests show that the Culebra is a fractured, heterogeneous system approximately 25 ft thick, with varying local anisotropic characteristics (Mercer and Orr, 1977; Mercer, 1983; Beauheim, 1986, 1987; Beauheim and Ruskauff, 1998). Calculated transmissivities for the Culebra within the WIPP site boundary have a wide range, with values between 1.2E–08 square meters per day (m^2/d) to approximately 112 m^2/d (1.29E–07 square feet per day [ft^2/d] to 1.20E03 ft^2/d). The majority of the values are less than 9.3E–02 m^2/d (1 ft^2/d) (DOE/WIPP–09–3424, *Compliance Recertification Application, Appendix HYDRO*, 2009). Transmissivities generally decrease from west to east across the site area, with a relatively high transmissivity zone trending southeast from the center of the WIPP site to the site boundary. The regional flow direction of groundwater in the Culebra is generally south.

6.1.2.5 Hydrology of the Magenta Member

The Magenta is situated above the Culebra and, although it is not the water-bearing zone of interest for monitoring of a facility release, it is of interest in understanding water-level changes that occur in the Culebra. The Magenta has been tested in 18 cased and open holes at and around the WIPP site. Magenta transmissivities within the

WIPP site range from 2.0E–04 to 3.5E–02 m^2/d (2.1E–03 to 3.8E–01 ft^2/d) (Beauheim et al., 1991; Beauheim and Ruskauff, 1998; Bowman and Roberts, 2009).

6.1.2.6 Hydrology of the Dewey Lake Redbeds Formation

The Dewey Lake at the WIPP site is approximately 152 m (500 ft) thick and consists of alternating thin beds of siltstone and fine-grained sandstone. The upper Dewey Lake consists of a thick, generally unsaturated section. The middle Dewey Lake is the interval immediately above a cementation change, from carbonate (above) to sulfate (below), where saturated conditions and a natural water table have been identified in limited areas. An anthropogenic saturated zone has been observed in the overlying Santa Rosa Formation (Santa Rosa) and in the upper part of the Dewey Lake since 1995. This is described in Section 6.6. The lower Dewey Lake is below the sulfate cementation change, with much lower permeabilities.

WIPP monitoring well WQSP–6A (Figure 6.2) intersects natural water in the Dewey Lake. At this location, the saturated horizon is within the middle portion of the formation. The saturated zone at well WQSP–6A is both vertically and laterally distinct from the water at C–2811 (see Section 6.6 for a full discussion of SSW). Well C–2811 is located approximately 1.61 km (1 mi) to the northeast of WQSP–6A on the C–2737 well pad (Figure 6.2). Approximately 1.61 km (1 mi) south of the WIPP site, domestic and stock supply wells produce water from the middle Dewey Lake.

6.1.2.7 Hydrology of the Santa Rosa and Gatuña Formations

Within the WIPP site boundary, the Santa Rosa is relatively thin to absent. At the Air Intake Shaft, 0.6 m (2 ft) of rock is classified as the Santa Rosa. The Santa Rosa is a maximum of 78 m (256 ft) thick in exploratory potash holes drilled for the WIPP project, east of the site boundary. The Santa Rosa is thicker to the east. The geologic data from site characterization studies have been incorporated with data from drilling to investigate SSW for the purpose of mapping Santa Rosa structure and thickness in the vicinity of the WIPP surface structures. These results are consistent with the broader regional distribution of the Santa Rosa (*WIPP Compliance Recertification Application*, DOE/WIPP–04–3231).

Water in the Santa Rosa has been found in the center part of the WIPP site since 1995. Because no water was found in this zone during the mapping of the shafts in 1980s, the water is deemed to be caused by human activity (Daniel B. Stephens & Associates, Inc., 2003). To assess the quantity and quality of this water, piezometers PZ–1 to PZ-12 were installed in the area between the WIPP shafts. Also, wells C–2505, C–2506, and C–2507 were drilled and tested in 1996 and 1997 (*Exhaust Shaft Hydraulic Assessment Data Report*, DOE/WIPP–97–2219). These wells are shown in Figure 6.6. During October 2007, three additional piezometers (PZ–13, PZ–14, and PZ–15) were installed around the Site and Preliminary Design Validation tailings pile to evaluate the nature and extent of SSW around this area.

The Gatuña Formation (Gatuña) unconformably overlies the Santa Rosa at the WIPP site, ranging in thickness from approximately 6 to 9 m (20 to 30 ft). The Gatuña consists of silt, sand, and clay, with deposits formed in localized depressions during the Pleistocene period.

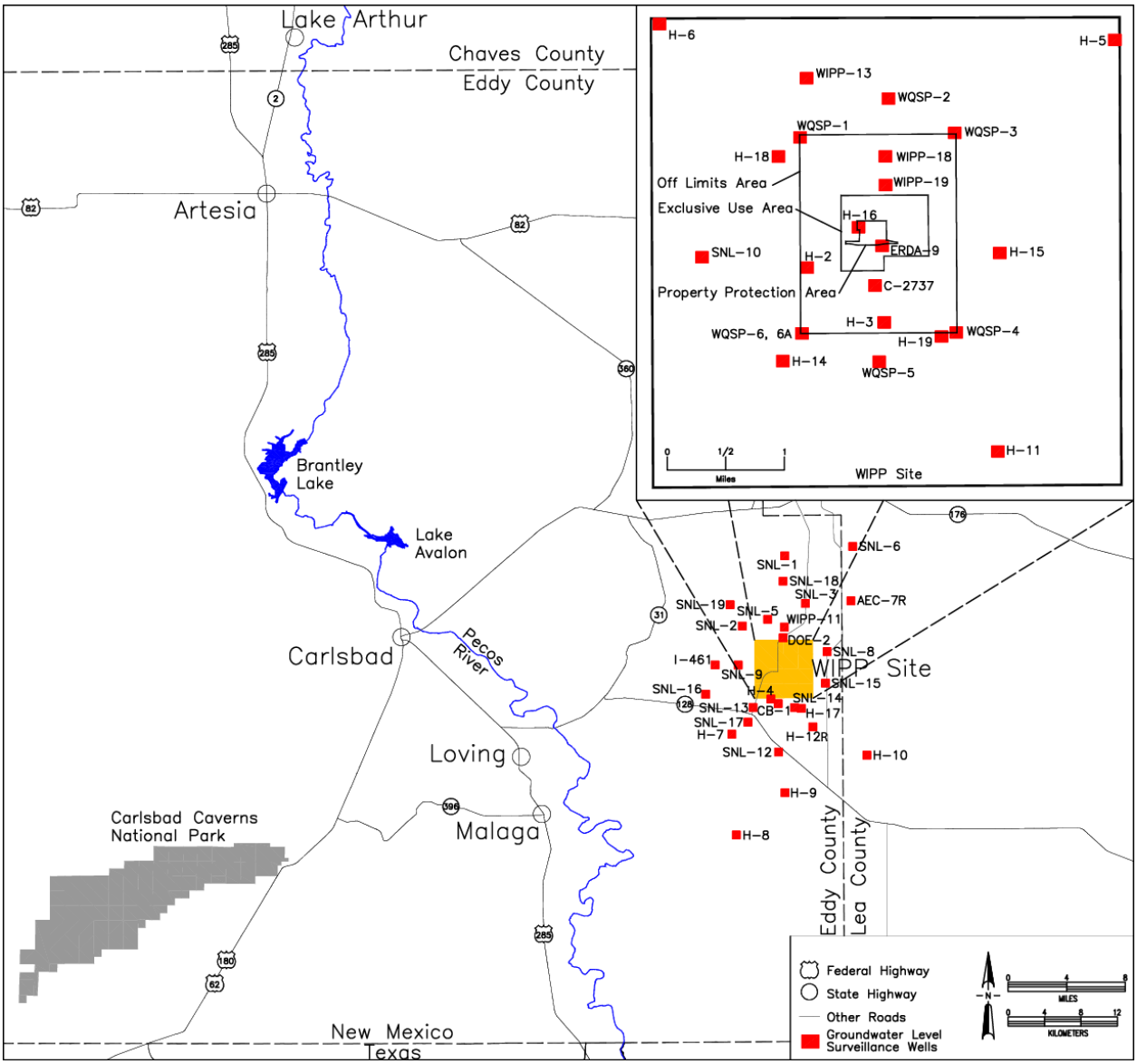


Figure 6.2 – Groundwater Level Surveillance Wells (Inset Represents the Groundwater Surveillance Wells in the WIPP Land Withdrawal Area)

The Gatuña is water bearing in some areas, with saturation occurring in discontinuous perched zones. However, because of its erratic distribution, the Gatuña has no known continuous saturation zone. Drilling at the WIPP site, including 30 exploration borings drilled between 1978 and 1979, did not identify saturated zones in the Gatuña (Daniel B. Stephens & Associates, Inc., 2003).

6.2 Groundwater Monitoring

6.2.1 Program Objectives

The objectives of the groundwater monitoring program are to:

- Monitor the physical and chemical characteristics of groundwater.
- Maintain surveillance of groundwater levels surrounding the WIPP facility throughout the operational lifetime of the facility.
- Document and identify effects, if any, of WIPP operations on groundwater parameters throughout the operational lifetime (including closure) and post-closure of the facility.

Data obtained through the WIPP groundwater monitoring program support two major regulatory programs: (1) the Resource Conservation and Recovery Act DMP supporting the Permit in compliance with 20.4.1.500 NMAC (incorporating 40 CFR Part 264, Subpart F, "Releases From Solid Waste Management Units," and 40 CFR Part 264 Subpart X, "Miscellaneous Units"), and (2) performance assessment supporting the *Compliance Certification Application for the Waste Isolation Pilot Plant* (DOE/CAO–96–2184) and five-year recertification applications.

Baseline water chemistry data were collected from 1995 through 1997 and reported in the *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report* (DOE/WIPP–98–2285). The baseline data were expanded in 2000 to include ten rounds of sampling instead of five. The data were published in Addendum 1, *Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Update Report* (IT Corporation, 2000). These baseline data are compared to water quality data collected annually.

6.2.2 Summary of 2014 Activities

Routine Culebra groundwater monitoring activities include groundwater quality sampling, groundwater level monitoring, and the fluid density survey, as described in this section. These programs are required by the Permit. Activities supported during 2014 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4). Table 6.1 presents a summary of WIPP groundwater monitoring activities in 2014.

Wells are classified as environmental surveillance wells. The WIPP facility does not have wells required for remediation, waste management, or other requirements. Appendix F, Table F.3, lists active groundwater monitoring wells used by the DOE for the WIPP facility at the end of 2014.

Radiological data for 2014 from the DMP are summarized in Chapter 4. The remaining data from the DMP are contained in this chapter.

Table 6.1 – Summary of 2013 DOE WIPP Groundwater Monitoring Program

Number of Active Wells	84
Number of Physical Samples Collected	250[a]
Number of Water Level Measurements	778
Total Number of Individual Analysis	1,206[b]

Notes:

(a) Includes primary, duplicate, and blank samples taken from six wells in 2014.

(b) Includes primary, duplicate, and QA (blanks) sample analyses.

Regular monthly groundwater level data were gathered from 58 wells across the WIPP region (Figure 6.2), one of which is equipped with a production-injection packer to allow groundwater level surveillance of more than one hydrologic zone in the same well. The six redundant wells on the H–19 pad, the 19 shallow water wells, and H–03D, which was dry (for Santa Rosa/Dewey Lake contact listed in Appendix F, Table F.3), were measured quarterly. Table F.4 shows the water level data. Water level data were not taken where access was unavailable, or in certain wells when testing equipment was present.

6.2.3 Groundwater Quality Sampling

The Permit requires groundwater quality sampling once a year, from March through May (Round 36 for 2014). Sampling for groundwater quality was performed at six well sites (Figure 6.3). Field analyses for pH, specific gravity, specific conductance, and temperature were performed during the sampling to determine when the well had stabilized for final sampling.

Primary and duplicate samples for groundwater quality were taken from each of the six wells completed in the Culebra (WQSP–1 through WQSP–6), for a total of 250 samples analyzed per sampling round.

Wells WQSP–1, WQSP–2, and WQSP–3 are upgradient of the WIPP shafts. The locations of the wells were selected to be representative of the groundwater moving downgradient onto the WIPP site. Wells WQSP–4, WQSP–5, and WQSP–6 are downgradient of the WIPP shafts. WQSP–4 was also specifically located to monitor a zone of higher transmissivity.

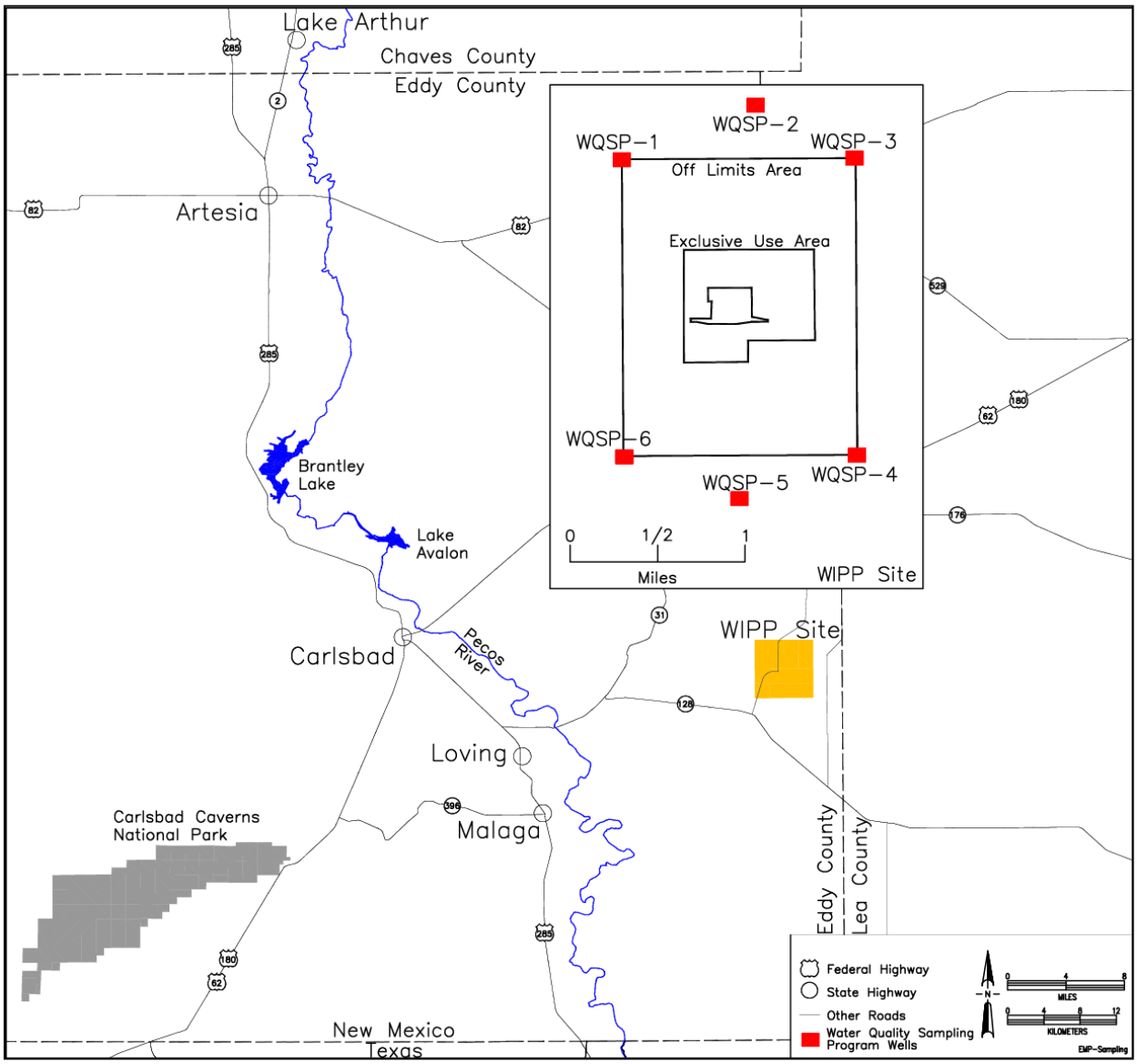


Figure 6.3 – Detection Monitoring Program Wells

The difference between the depth of the WIPP repository and the depth of the detection monitoring wells completed in the Culebra varies from 387 m to 587 m (1,270 ft to 1,926 ft). The DOE does not anticipate finding WIPP related contamination in the groundwater because a release from the repository to the Culebra is highly unlikely. In order for contaminated liquid to move from the repository to the Culebra, three conditions would have to be met. First, sufficient brine would have to accumulate in the waste disposal areas to leach contaminants from the disposed waste. Second, sufficient pressure would have to build up in the disposal area to overcome the hydrostatic head between the repository and the Culebra. Third, a pathway would have to exist and remain open for contaminated brine to flow from the repository to the Culebra. Since the times required for the brine accumulation and repository

pressurization are on the order of thousands of years, and current plans call for the sealing of the shafts and boreholes that could potentially become such pathways upon closure of the facility, WIPP-related contamination of the groundwater is highly unlikely.

Table 6.2 lists the analytical parameters and hazardous constituents included in the 2014 groundwater sampling program.

Table 6.2 – Permit Required Indicator Parameters and Hazardous Constituents List

Hazardous Constituents: Volatile and Semivolatile Organic Compounds	Indicator Parameters: General Chemistry and Major Cations/Anions	Hazardous Constituents Total Trace Metals
VOCs: Isobutanol Carbon tetrachloride Chlorobenzene Chloroform 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethylene Trans-1,2-Dichloroethylene Methyl ethyl ketone Methylene chloride 1,1,2,2-Tetrachloroethane Tetrachloroethylene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Toluene Trichloroethylene Trichlorofluoromethane Vinyl chloride Xylenes **SVOCs:** 1,2-Dichlorobenzene 1,4-Dichlorobenzene 2,4-Dinitrophenol 2,4-Dinitrotoluene Hexachlorobenzene Hexachloroethane Cresols (2-, 3-, & 4-Methylphenols) Nitrobenzene Pentachlorophenol Pyridine	**General Chemistry:** Density (measured as specific gravity) pH Specific conductance TOC (total organic carbon) TDS TSS **Major Cations:** Calcium (Ca^{++}) Magnesium (Mg^{++}) Potassium (K^{+}) **Major Anions:** Chloride (Cl^{-})	**Trace Metals:** Antimony (Sb) Arsenic (As) Barium (Ba) Beryllium (Be) Cadmium (Cd) Chromium (Cr) Lead (Pb) Mercury (Hg) Nickel (Ni) Selenium (Se) Silver (Ag) Thallium (Tl) Vanadium (V)

Notes:
pH = hydrogen ion potential (measure of alkalinity or acidity).
VOC = Volatile Organic Compound
SVOC = semivolatile organic compound.
Alkalinity, sodium, and sulfate are parameters for additional analysis.

6.2.4 Evaluation of Culebra Groundwater Quality

The quality of the Culebra groundwater sampled at the WIPP site is naturally poor and not suitable for human consumption or for agricultural purposes, because the TDS concentrations are generally above 10,000 mg/L. In 2014, TDS concentrations in the Culebra (as measured in detection monitoring wells) varied from a low of 16,000 mg/L (WQSP–6) to a high of 206,000 mg/L (WQSP–3). The groundwater of the Culebra is considered to be Class III water (nonpotable) by EPA guidelines.

For comparison, water quality measurements performed in the Dewey Lake indicate the water is considerably better quality than in the Culebra. In 2014, the TDS concentrations (see Table 6.6 later in this chapter) in water from well WQSP–6A, obtained from the Dewey Lake, averaged 3,430 mg/L. This water is suitable for livestock consumption and is classified as Class II water by EPA guidelines. Saturation of the Dewey Lake in the area of the WIPP facility is discontinuous. In addition to this naturally occurring groundwater, anthropogenic SSW has been encountered in the upper Dewey Lake at the Santa Rosa contact (see Section 6.6).

Because of the highly variable TDS concentrations within the Culebra, baseline groundwater quality was defined for each individual well. The 2014 analytical results showing the concentrations of detectable constituents are displayed as time trend plots compared to the baseline concentrations (Appendix E). The analytical results for each parameter or constituent for the sampling in 2014 (Round 35) are summarized in Appendix F, Tables F.1 through F.2. The tables in Appendix F display either the 95th upper tolerance limit value (UTLV) or the 95th percentile value (as calculated for the background sampling rounds) for each parameter, depending on the type of distribution exhibited by the particular parameter or constituent. Both values represent the concentrations below which 95 percent of the concentrations in a population are expected to occur. The UTLVs were calculated for data that exhibited a normal or a lognormal distribution. The 95th percentile was applied to data that were considered nonparametric (i.e., having neither a normal nor a lognormal distribution with 16–95 percent non-detects). Due to the large number of nondetectable concentrations of organic compounds, the limits for organic compounds were considered nonparametric and based on the contract-required MRL for the contract laboratory. These values were recomputed after the baseline sampling was completed in 2000 and were applied to sampling Round 36 to evaluate potential contamination of the local groundwater. None of the constituents of interest (organics and trace metals) exceeded the baseline concentrations.

The indicator parameter concentrations in Round 36, including those of the major cations, were all below the concentrations from the baseline studies with the following exceptions:

- WQSP–1: The concentrations of total suspended solids (TSS) in the primary and duplicate groundwater samples were 61 mg/L and 40 mg/L, respectively, which are higher than the 95th percentile concentration of 33.3 mg/L.
- WQSP–3: The TSS concentrations of 130 mg/L in the primary groundwater sample and 187 mg/L in the duplicate sample were higher than the 95th percentile concentration of 107 mg/L.
- WQSP–4: The TSS concentrations of 98 mg/L in the primary and 94 mg/L in the duplicate groundwater sample were higher than the 95th percentile concentration of 57.0 mg/L.
- WQSP–5: The TSS concentrations in the primary and duplicate groundwater samples were 24 mg/L and 29 mg/L respectively, which are higher than the 95th percentile concentration of <10 mg/L.

The Round 36 VOC concentrations reported for man-made organic compounds were less than the Permit background values and less than the MRL in all groundwater samples. Water quality data for Round 36 can be found in the *Annual Culebra Groundwater* Report (U.S. Department of Energy, November 2014).

6.2.5. Groundwater Level Surveillance

Wells were used to perform surveillance of the groundwater surface elevation of five water-bearing zones in the vicinity of the WIPP facility:

- SSW (Santa Rosa/Dewey Lake contact)
- Dewey Lake
- Magenta
- Culebra
- Bell Canyon

During 2014, water levels in 49 Culebra wells were measured (including the Culebra zone of a dual completion well) and 13 wells in the Magenta (including the Magenta zone of a dual completion well). One Dewey Lake well and two Bell Canyon wells were measured. Nineteen wells in the SSW zone of the Santa Rosa/Dewey Lake contact were measured. Groundwater level measurements were taken monthly in at least one accessible well bore at each well site for each available formation (Figure 6.2). Water levels in redundant well bores (well bores located on well pads with multiple wells completed in the same formation) were measured on a quarterly basis (Appendix F, Table F.4). Water levels at SSW wells and piezometers were also measured on a quarterly basis.

A breakdown of the groundwater zones intercepted by each well measured at least once in 2014 is given in Appendix F, Table F.3. Note that one existing well (Culebra/Magenta C–2737) is completed at multiple depths by using a production-injection packer.

Water elevation trend analysis was performed for 49 wells completed or isolated in the Culebra, which showed only 16 naturally changing wells. The subset of wells analyzed were those that had a sufficient period of record to analyze through CY 2014 (Appendix F, Table F.3). Additional filtering of the water level data could not be performed to remove wells affected by un-natural fluctuations for 2014 due to the vast majority of wells being impacted by pumping at Mills Ranch. If the pumping-impacted well data were removed, there would not have been enough data points for mapping. The wells affected by Mills Ranch pumping were used in the analysis with lower weights to improve fit. Excluded from trend analysis were SNL–6 and SNL–15, which were both in long-term water level recovery. Because they were only measured quarterly, the redundant H–19 wells were also excluded.

The dominant trend through 2014 on naturally occurring changes was a general increasing freshwater equivalent level in the Culebra monitoring wells at the WIPP site. This can be attributed to the rain event that occurred in September resulting in 291.59 mm (11.48 in) for the month (see Chapter 5). Water level rose in 14 of the 16 naturally occurring water level changes, which averaged 1.38 ft.

The Permit requires that the NMED be notified if a cumulative groundwater surface elevation change of more than 2 ft is detected in wells WQSP–1 to WQSP–6 over the course of one year that is not attributable to site tests or natural stabilization of the site hydrologic system. In 2014 WQSP-3, 4, 5 and 6 all experienced water level decreases greater than two feet due to the pumping associated with Mills Ranch. The Mills Ranch pumping is associated with oil field activities. Hydrographs for all Culebra groundwater wells are included in the *Annual Culebra Groundwater Report* (U.S. Department of Energy, November 2014).

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for January 2014 were used to calibrate a groundwater flow model, which was used by Sandia National Laboratories (SNL) to compute a potentiometric surface using SNL procedure SP 9–9. This month was judged to have the most number of Culebra water levels available, few wells affected by pumping events, and all wells in quasi-steady state, with few individual wells contrary to the general water-level trend. Table 6.3 shows the water-level data set. Wells SNL–6 and SNL–15 were not included in the mapping because the elevations do not represent static conditions. These wells are located in the low transmissivity zone of the Culebra and after drilling and testing, are still in recovery to reach equilibrium. Adjusted freshwater heads are typically accurate to ±1.5 ft, given the density measurement error. Density measurement error is less than 0.019 specific gravity units (WP 02–1).

Table 6.3 – Water Level Elevations for the 2013 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Date of Measurement	Adjusted Freshwater Head (ft, amsl)	Density (g/cm^3)*	Notes
C-2737‡	01/09/14	917.48	1.023	
ERDA-9	01/09/14	922.27	1.071	
H-02b2	01/09/14	927.54	1.013	
H-03b2‡	01/08/14	913.33	1.032	
H-04bR‡	01/08/14	901.07	1.017	
H-05b	01/09/14	939.13	1.092	
H-06bR	01/08/14	935.67	1.039	
H-07b1	01/07/14	913.37	1.007	
H-09bR‡	01/07/14	905.87	1.001	
H-10c	01/07/14	924.45	1.095	
H-11b4R‡	01/09/14	906.64	1.076	
H-12	01/07/14	914.04	1.108	
H-15R‡	01/08/14	914.32	1.118	
H-16	01/08/14	927.30	1.036	
H-17‡	01/09/14	907.35	1.133	
H-19b0‡	01/07/14	913.20	1.066	
IMC-461	01/07/14	927.82	1.000	
SNL-01	01/07/14	938.23	1.030	
SNL-02	01/07/14	935.94	1.009	
SNL-03	01/08/14	937.94	1.028	
SNL-05	01/07/14	936.12	1.009	
SNL-06	01/09/14	994.50	1.243	Excluded from Mapping
SNL-08	01/09/14	931.01	1.095	
SNL-09	01/08/14	930.36	1.018	
SNL-10	01/08/14	930.03	1.010	
SNL-12‡	01/07/14	903.12	1.006	
SNL-13	01/08/14	913.96	1.017	
SNL-14‡	01/08/14	904.54	1.046	
SNL-15	01/09/14	925.24	1.229	Excluded from mapping.
SNL-16	01/07/14	917.49	1.008	
SNL-17‡	01/07/14	912.09	1.005	

Table 6.3 – Water Level Elevations for the 2013 Potentiometric Surface Calibration, Culebra Hydraulic Unit

Well ID	Date of Measurement	Adjusted Freshwater Head (ft, amsl)	Density (g/cm^3)*	Notes
SNL-18	01/07/14	936.39	1.009	
SNL-19	01/07/14	935.94	1.007	
WIPP-11	01/08/14	938.60	1.038	
WIPP-13	01/08/14	937.25	1.040	
WIPP-19	01/09/14	933.02	1.052	
WQSP-1	01/08/14	936.82	1.049	
WQSP-2	01/09/14	939.01	1.047	
WQSP-3	01/07/14	936.46	1.148	
WQSP-4	01/07/14	913.50	1.076	
WQSP-5	01/08/14	914.49	1.027	

Notes:

amsl = above mean sea level.

cc = cubic centimeter.

ID = identification.

‡ = significantly influenced by Mills Ranch Pumping

* = 2013 conversion to specific gravity at 70˚F.

Modeled freshwater head contours for January 2014 for the model domain are shown in Figure 6.5. These contours were generated using the results of the Culebra MODFLOW 2K (Harbaugh et al., 2000) run using ensemble average distributed aquifer parameters from the SNL Culebra flow model, which was calibrated as part of the performance assessment baseline calculation for the 2009 *Compliance Recertification Application Performance Assessment Baseline Calculation* (Clayton et al., 2009). Because that model was calibrated to both a snapshot of assumed steady-state water levels (May 2007) and to transient multi-well responses observed during large-scale pumping tests throughout the domain, the boundary conditions were adjusted to improve the match between the model and the observed January 2014 Culebra freshwater heads presented in this report (see Section 6.2.6). The portion of the flow domain of interest to the site is extracted as shown in Figure 6.6. The freshwater head values for January 2014 were computed using 2013 densities.

The scatter plot in Figure 6.4 shows measured and modeled freshwater heads at the observation locations used in the PEST calibration. The observations are divided into three groups, based on proximity to the WIPP site. Wells within the LWB are represented by red crosses, wells outside but within 3 km of the LWB are represented with green '×'s, and other wells within the MODFLOW model domain but distant from the WIPP site are indicated with blue stars. AEC-7 was given a low weight (0.01), to prevent its large residual from dominating the optimization. Additional observations

representing the average heads north of the LWB and south of the Land Withdrawal Boundary (LWB) were used to help prevent over-smoothing of the estimated results across the LWB.

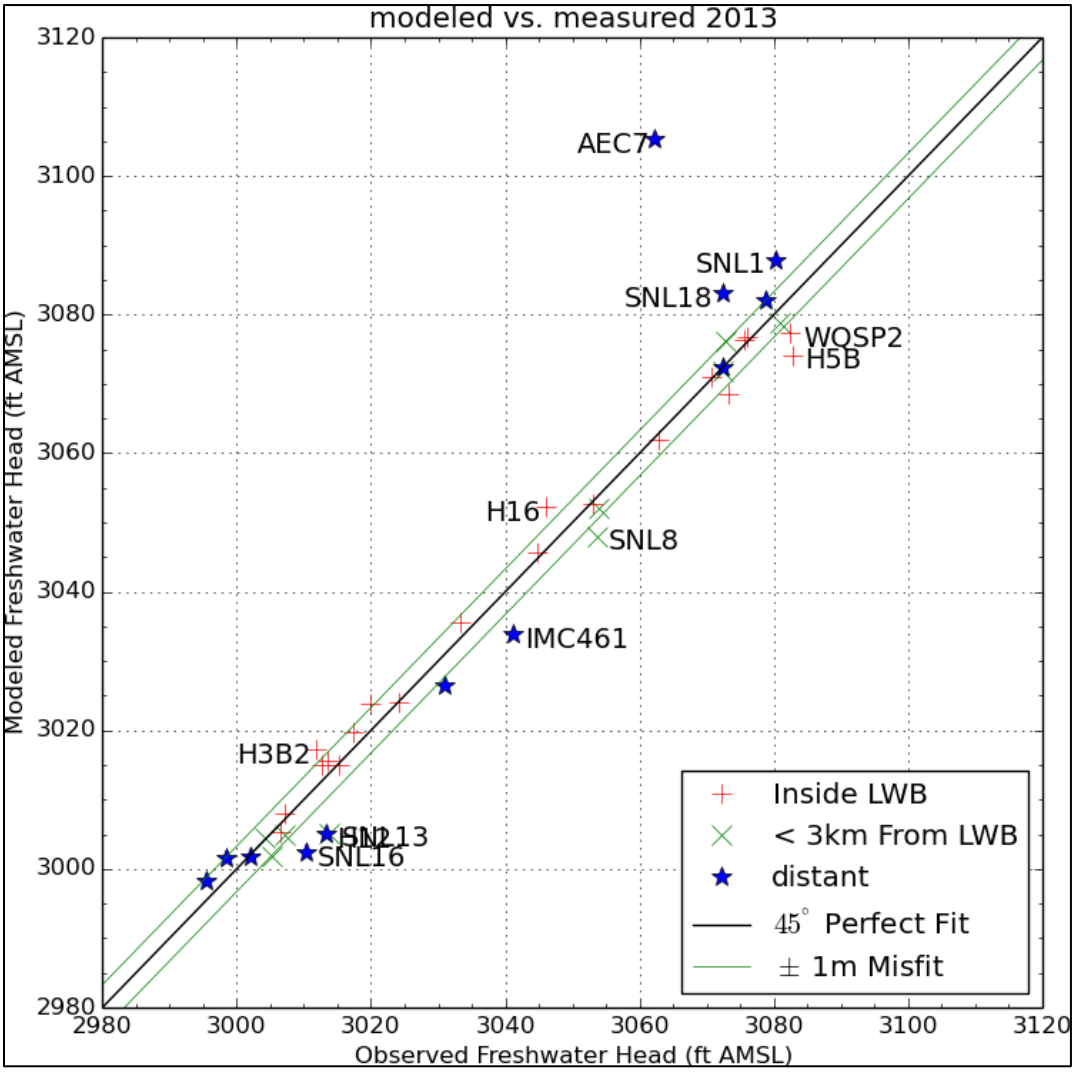


Figure 6.4 – Measured Versus Modeled Scatter Plot for Parameter Estimation Tool-Calibrated MODFLOW 2000 Generated Heads and February 2013 Freshwater Heads

The base transmissivity fields and the 100 calibrated model realizations derived from them for the performance assessment baseline calculation embody the hydrologic and geologic understanding of the Culebra behavior in the vicinity of the WIPP site (Kuhlman, 2012). Using the ensemble average of these 100 realizations, therefore, captures the mean flow behavior of the system and allows straightforward contouring of results from a single-flow model.

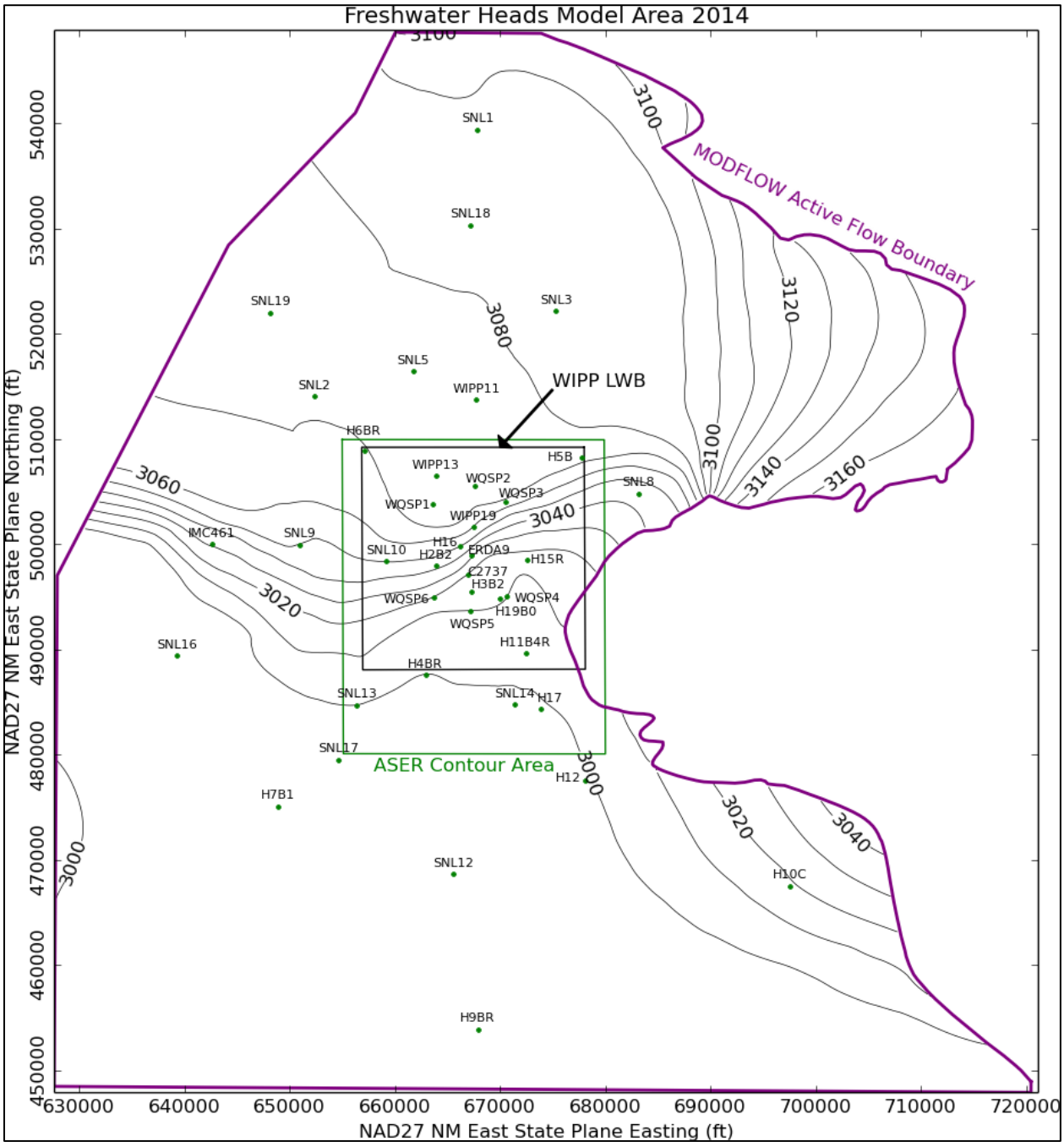


Figure 6.5 – Model-Generated February 2014 Freshwater Head Contours in the Model Domain (Contour in Feet Above Mean Sea Level)

The illustrated particle in Figure 6.6 (heavy blue line) shows the DTRKMF-predicted path a water particle would take through the Culebra from the coordinates corresponding to the WIPP waste handling shaft to the land withdrawal boundary (a computed path length of 4.092 km). Assuming a thickness of 4 m for the transmissive portion of the Culebra and a constant porosity of 16 percent, the travel time to the WIPP land withdrawal boundary is 5,829 years (output from DTRKMF is adjusted from a

7.75-m Culebra thickness), for an average velocity of 0.70 m per year. Since the flow model has the ensemble hydraulic conductivity and anisotropy fields as inputs, the freshwater head contours and particle tracks take into account the variability of known aquifer conditions across the site.

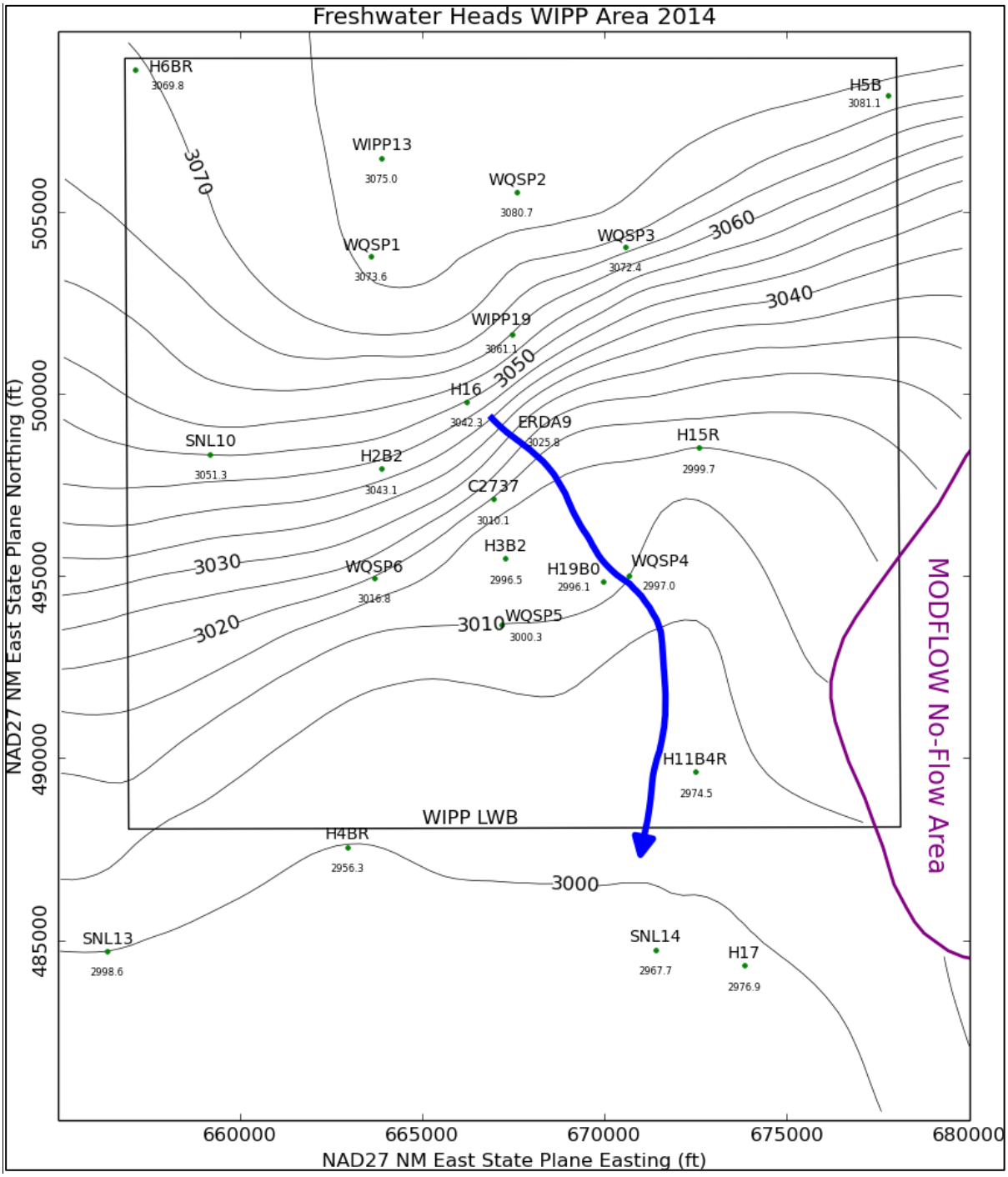


Figure 6.6 – Model-Generated February 2014 Freshwater Head Contours (5-foot Contour Interval) in the WIPP Vicinity with Water Particle Track (Dark Blue) from Waste-Handling Shaft to WIPP Land Withdrawal Boundary (Contour in Feet Above Mean Sea Level)

Figure 6.7 is a contour plot comparing freshwater heads in the WIPP area from 2013 to 2014. This map was created through splined linear interpolation (triangulation) of the heads only to show a relative comparison of head change between the years. Linear interpolation does not take into account any modeling or hydrogeologic parameters as in the previously presented model of potentiometric surface. This figure only shows relative difference between the two years. The effect of a pumping well in the Culebra at the ranch to the south can be seen on this figure by the apparent cone of depression developed to the south of the WIPP LWB and a relative difference between the years at well H-4bR of 50 feet.

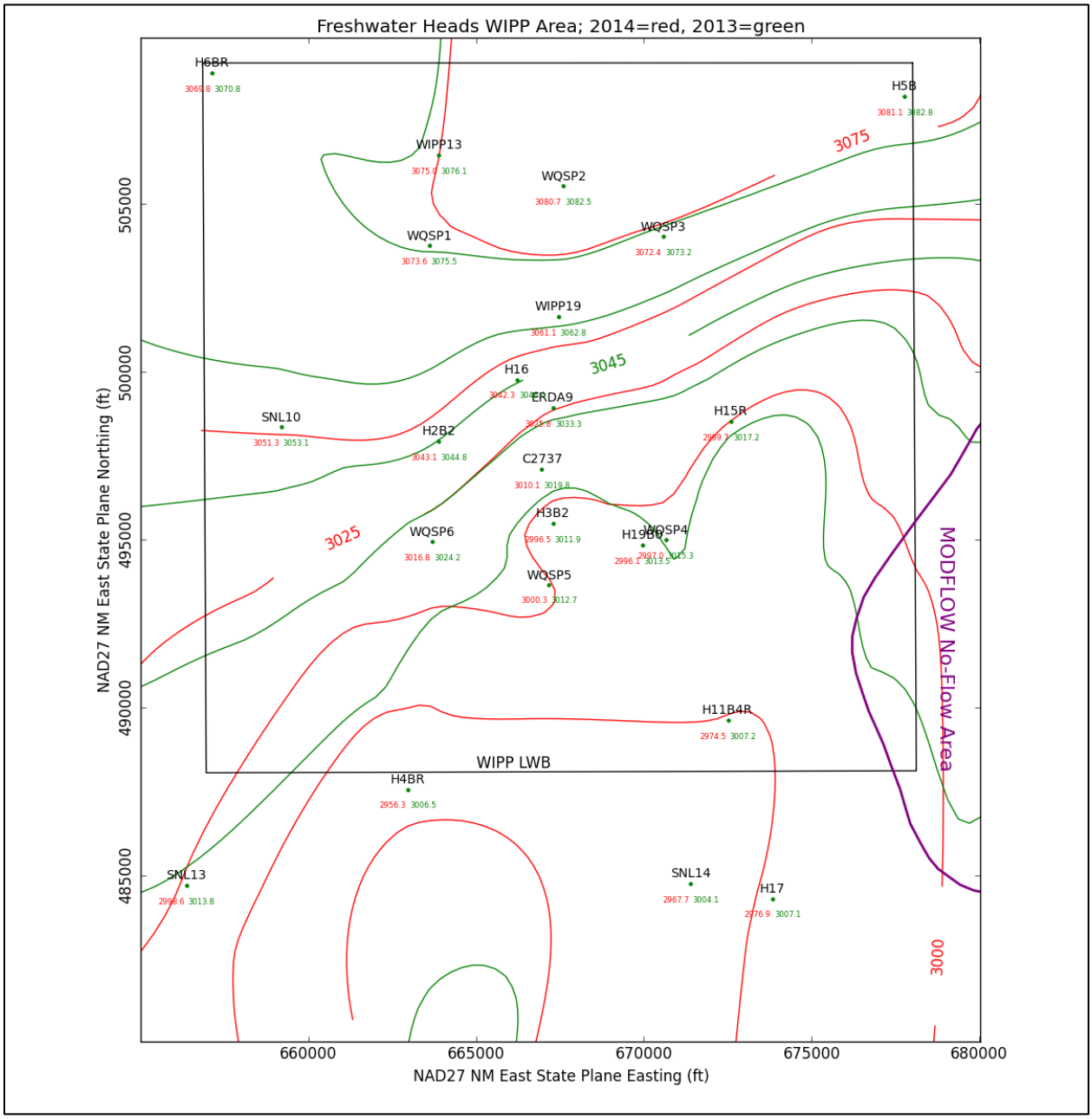


Figure 6.7 - Linearly Interpolated (triangulation) of Culebra Freshwater Heads Comparing 2013 (green contours) to 2014 (red contours). Contour interval = 20 feet

6.2.6 Fluid Density Surveys

At the WIPP site, variable TDS concentrations result in variability in groundwater density (WP 02–1). WIPP personnel measure the density of well-bore fluids in water-level monitoring wells to adjust water levels to their equivalent freshwater head values. This

allows more accurate determination of relative heads between wells. In 2014, densities were derived from 37 wells containing pressure transducers installed by SNL (Table 6.4), six wells from hydrometers as part of the DMP sampling program, and six from the redundant H–19 wells. This approach employed several calibrated pressure-measuring transducers dedicated to given wells during the year. For the DMP wells, field hydrometer measurements are always used. For comparison, 2013 and 2014 density data are shown. Year-to-year density differences are within the error as described in WP 02-1.

Table 6.4 – Fluid Density Survey for 2014

Well	2012 Fluid Density Survey Result	2012 Conversion to Specific Gravity at 70°F	2013 Fluid Density Survey Result	2013 Conversion to Specific Gravity at 70°F	2014 Fluid Density Survey Result	2014 Conversion to Specific Gravity at 70°F	Notes for 2012-2014 Fluid Density Survey
	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	
AEC-7	1.065	1.067	1.066	1.068	NA	NA	AEC-7 was plugged in 2013.
AEC-7R	NA	NA	NA	NA	1.071	1.073	AEC-7R was drilled in 2013.
C-2737	1.021	1.023	1.021	1.023	1.022	1.025	
ERDA-9	1.071	1.073	1.069	1.071	1.070	1.072	
H-02b2	1.010	1.012	1.011	1.013	1.010	1.012	
H-03b2	1.034	1.036	1.030	1.032	1.025	1.027	
H-04bR	1.015	1.017	1.015	1.017	1.025	1.027	
H-05b	1.093	1.095	1.090	1.092	1.087	1.089	
H-06bR	1.036	1.038	1.037	1.039	1.036	1.038	
H-07b1	1.005	1.007	1.005	1.007	1.007	1.009	
H-9bR	1.000*	1.000*	0.999	1.001	1.004	1.006	* Rounded up to 1.000 for 2012.
H-10c	1.092	1.094	1.093	1.095	1.096	1.098	
H-11b4R	1.074	1.076	1.074	1.076	1.077	1.079	
H-12	1.111	1.113	1.106	1.108	NA	NA	Plugged in 2014.
H-12R	NA	NA	NA	NA	1.040	1.042	Drilled in 2014. Still under development so density is unreliable.
H-15R	1.116	1.118	1.116	1.118	1.118	1.120	
H-16	1.035	1.037	1.034	1.036	1.035	1.037	
H-17	1.131	1.133	1.131	1.133	1.134	1.136	
H-19b0	1.064	1.066	1.064	1.066	1.067	1.069	
H-19b2	1.060	1.062	1.066	1.068	1.070	1.072	

Table 6.4 – Fluid Density Survey for 2014

Well	2012 Fluid Density Survey Result Density (g/ cm^3)	2012 Conversion to Specific Gravity at 70°F Density (g/ cm^3)	2013 Fluid Density Survey Result Density (g/ cm^3)	2013 Conversion to Specific Gravity at 70°F Density (g/ cm^3)	2014 Fluid Density Survey Result Density (g/ cm^3)	2014 Conversion to Specific Gravity at 70°F Density (g/ cm^3)	Notes for 2012-2014 Fluid Density Survey
H-19b3	1.064	1.066	1.064	1.066	1.073	1.075	
H-19b4	1.065	1.067	1.064	1.066	1.069	1.071	
H-19b5	1.067	1.069	1.067	1.069	1.072	1.074	
H-19b6	1.068	1.070	1.068	1.070	1.073	1.075	
H-19b7	1.070	1.072	1.068	1.070	1.073	1.075	
I-461	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*	* Rounded up to 1.000 for 2012–2014.
SNL-01	1.027	1.029	1.028	1.030	1.030	1.032	
SNL-02	1.007	1.009	1.007	1.009	1.010	1.012	
SNL-03	1.026	1.028	1.026	1.028	1.027	1.029	
SNL-05	1.007	1.009	1.007	1.009	1.008	1.010	
SNL-06	1.241	1.243	1.241	1.243	1.246	1.248	
SNL-08	1.092	1.094	1.093	1.095	1.095	1.097	
SNL-09	1.016	1.018	1.016	1.018	1.018	1.020	
SNL-10	1.007	1.009	1.008	1.010	1.010	1.012	
SNL-12	1.004	1.006	1.004	1.006	1.007	1.009	
SNL-13	1.016	1.018	1.015	1.017	1.022	1.024	
SNL-14	1.044	1.046	1.044	1.046	1.046	1.048	
SNL-15	1.227	1.229	1.227	1.229	1.230	1.232	
SNL-16	1.007	1.009	1.006	1.008	1.012	1.014	
SNL-17	1.003	1.005	1.003	1.005	1.007	1.009	
SNL-18	1.003	1.005	1.007	1.009	1.009	1.011	
SNL-19	1.005	1.007	1.005	1.007	1.006	1.008	
WIPP-11	1.036	1.038	1.036	1.038	1.038	1.040	
WIPP-13	1.039	1.041	1.038	1.040	1.037	1.039	
WIPP-19	1.050	1.052	1.050	1.052	1.053	1.055	
WQSP-1	1.049	1.051	1.047	1.049	1.048	1.050	Average Round 36, field hydrometer.
WQSP-2	1.046	1.048	1.045	1.047	1.045	1.047	Average Round 36, field hydrometer.
WQSP-3	1.145	1.147	1.146	1.148	1.144	1.146	Average Round 36, field hydrometer.

Table 6.4 – Fluid Density Survey for 2014

Well	2012 Fluid Density Survey Result	2012 Conversion to Specific Gravity at 70°F	2013 Fluid Density Survey Result	2013 Conversion to Specific Gravity at 70°F	2014 Fluid Density Survey Result	2014 Conversion to Specific Gravity at 70°F	Notes for 2012-2014 Fluid Density Survey
	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	Density (g/ cm^3)	
WQSP-4	1.075	1.077	1.074	1.076	1.074	1.076	Average Round 36, field hydrometer.
WQSP-5	1.025	1.027	1.025	1.027	1.025	1.027	Average Round 36, field hydrometer.
WQSP-6	1.013	1.015	1.013	1.015	1.015	1.017	Average Round 36, field hydrometer.

Notes:
NA = no available measurement.

6.3 Drilling Activities

Well H-12 was plugged and abandoned due to its deteriorating condition and replaced by H-12R in September 2014. The total depth of the drill hole was 263.65 m (865 ft) below ground surface with the screened interval in the Culebra at 257.86 – 250.55 m (846-822 ft) below ground surface.

6.4 Hydraulic Testing and Other Water Quality Sampling

In addition to the chemical testing in the six DMP wells as required by the Permit, WIPP personnel conducted basic water chemistry tests in two other wells as listed in Table 6.5.

Table 6.5 – 2013 Well Testing Activities

Well Location	Dates	Activity
AEC-7R, Culebra	January through December 2014	SNL development and pumping test
H-12R, Culebra	September through December	SNL development and pumping test

6.5 Well Maintenance

No well maintenance occurred in 2014.

6.6 Shallow Subsurface Water Monitoring Program

Shallow subsurface water occurs beneath the WIPP site at a depth of 12 - 21 m (39 - 69 ft) below ground level at the contact between the Santa Rosa and the Dewey Lake (Figure 6.7). Water yields are generally less than 1 gallon per minute in monitoring

wells and piezometers, and the water contains varying concentrations of TDS (910 mg/L to 274,000 mg/L) and chloride (167 mg/L to 179,000 mg/L). To the south, yields are greater and TDS and chloride concentrations lower. The origin of the high TDS and chlorides in this water is believed to be primarily from anthropogenic sources, with some contribution from natural sources. The SSW occurs not only under the WIPP site surface facilities but also to the south, as indicated by shallow water in drill hole C-2811, about one-half mile south of the WIPP property protection fence.

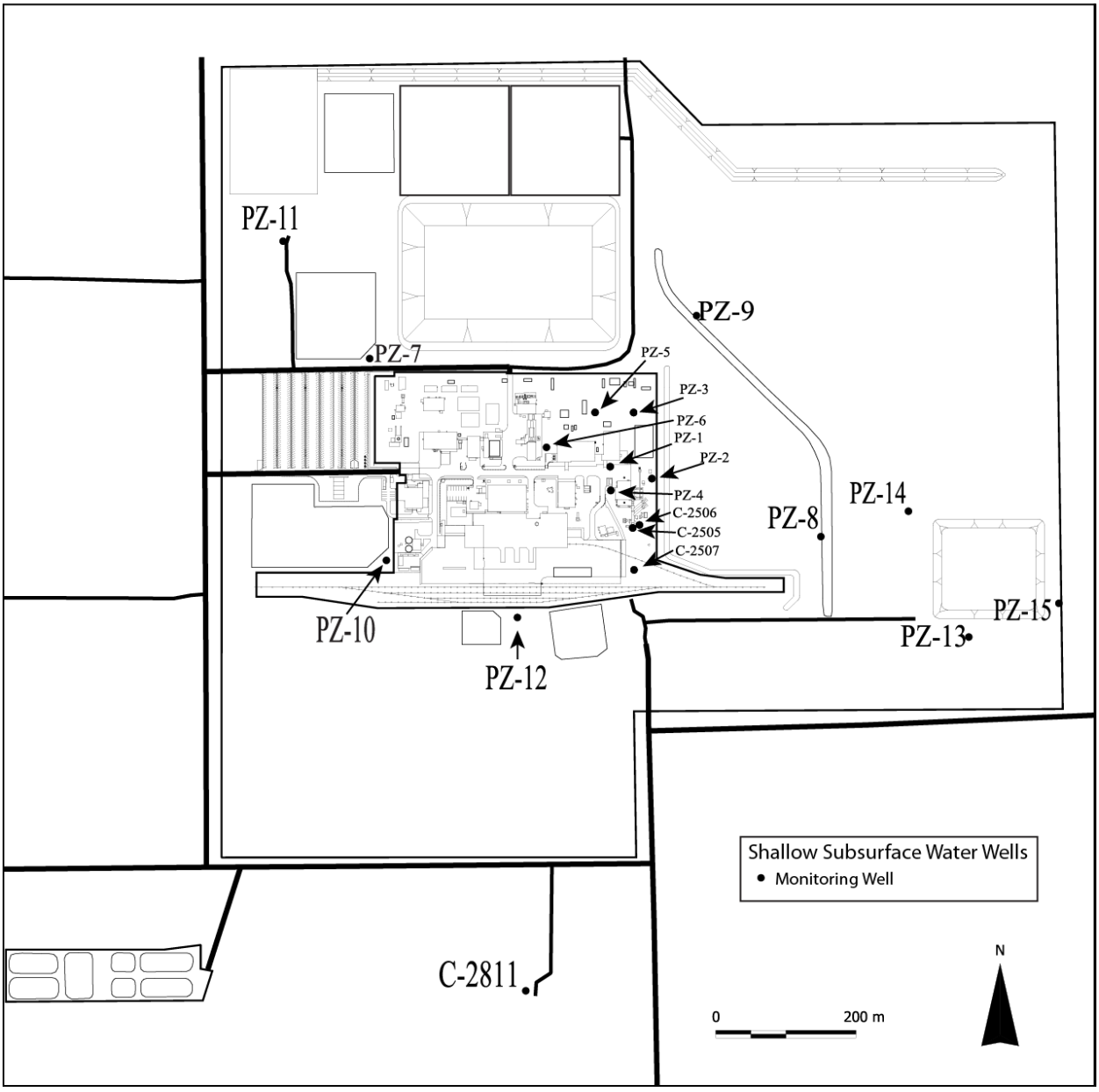


Figure 6.7 – Location of Shallow Subsurface Water Wells (Piezometers PZ–1 through PZ–15, C-2811, C–2505, C–2506, and C–2507)

In order to investigate the SSW, 15 piezometers (PZ–1 to PZ–15) and four wells (C-2505, C–2506, C–2507, and C–2811) were drilled as part of a monitoring program to measure spatial and temporal changes in SSW levels and water quality. Monitoring activities during 2014 included SSW level surveillance at these 19 locations.

In addition, drilling in 2007 around the site and preliminary design validation salt pile tailings revealed shallow water in three piezometers (PZ–13, PZ–14, and PZ–15, shown in Figure 6.7). Natural shallow groundwater occurs in the middle part of the Dewey Lake at the southern portion of the WIPP site (WQSP–6A; see Figure 6.2) and to the south of the WIPP site (J. C. Mills Ranch). To date, there is no indication that the anthropogenic SSW has affected the naturally occurring groundwater in the Dewey Lake.

6.6.1 Shallow Subsurface Water Quality Sampling

The DP-831, as modified, requires 11 SSW wells (C–2507, C–2811, PZ–1, PZ–5, PZ–6, PZ–7, PZ–9, PZ–10, PZ–11, PZ–12 and PZ–13) and WQSP-6A to be sampled on a semiannual basis. These wells were sampled in May and October 2014, and the parameters shown in Table 6.6 were analyzed.

6.6.2 Shallow Subsurface Water Level Surveillance

A water budget analysis in 2003 (Daniel B. Stephens & Associates, Inc., 2003) indicated that seepage from five primary sources (salt pile and four surface water detention basins) provided sufficient recharge to account for the observed SSW saturated lens, and that the lens was expected to spread.

The potential extent for long-term SSW migration was examined by expanding the saturated flow model domain to include the 16-mi^2 WIPP LWA. The long-term migration model simulations indicated the engineered seepage controls now in place will substantially reduce the extent of migration.

Nineteen wells were used for surveillance of the SSW-bearing horizon in the Santa Rosa and the upper portion of the Dewey Lake. Water levels were measured quarterly at all the piezometers and wells shown in Figure 6.7.

The potentiometric surface for the SSW using December 2014 data is presented in Figure 6.8. The contours were generated using *SURFER*, Version 11, surface mapping software by Golden Software. Sixteen data points were used in the contour development, whereas the contours around the site and preliminary design validation salt pile were estimated by hand.

Table 6.6 – 2014 DP-831 Groundwater Quality Sampling Results

Shallow Subsurface Water Quality Sampling Results							
Monitoring Site	Sample Date	Nitrate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Nitrate (mg/L)	TKN (mg/L)
PZ-1	5/13/2014	NA	2,010	44,000	76,000	NA	NA
PZ-1	10/14/2014	NA	2,090	46,700	84,800	NA	NA
PZ-5	5/13/2014	NA	1,180	9,080	18,100	NA	NA
PZ-5	10/14/2014	NA	1,250	13,300	26,500	NA	NA
PZ-6	5/13/2014	NA	2,040	46,600	80,800	NA	NA
PZ-6	10/14/2014	NA	2,160	49,800	80,400	NA	NA
PZ-7	5/13/2014	NA	2,650	35,400	114,000	NA	NA
PZ-7	10/13/2014	NA	3,530	74,500	136,000	NA	NA
PZ-9	5/13/2014	NA	4,730	83,600	161,000	NA	NA
PZ-9	10/14/2014	NA	5,150	98,600	172,000	NA	NA
PZ-10	5/12/2014	NA	471	407	1,840	NA	NA
PZ-10	10/13/2014	NA	178	167	910	NA	NA
PZ-11	5/12/2014	NA	2,260	45,000	102,000	NA	NA
PZ-11	10/13/2014	NA	2,740	68,800	123,000	NA	NA
PZ-12	5/12/2014	NA	374	2,490	5,640	NA	NA
PZ-12	10/13/2014	NA	409	2,440	6,100	NA	NA
PZ-13	5/13/2014	NA	2,900	104,000	265,000	NA	NA
PZ-13	10/14/2014	NA	3,100	179,000	274,000	NA	NA
C-2811	5/13/2014	NA	297	865	2,250	NA	NA
C-2811	10/14/2014	NA	277	827	2,580	NA	NA
C-2507	5/13/2014	NA	643	2,770	7,590	NA	NA
C-2507	10/14/2014	NA	693	3,830	9,180	NA	NA
WQSP-6A	5/14/2014	5.4	1,870	342	3,500	5.4	<1.0
WQSP-6A	10/15/2014	5.38	2,000	285	3,360	5.38	<1.0
NA: Not Analyzed, parameter not required, per permit conditions.							

Groundwater elevation measurements in the SSW indicate that flow is to the east and south away from a potentiometric high located near PZ–7 adjacent to the Salt Pile Evaporation Pond (Figure 6.8). At this time, it appears that the water identified in PZ–13 and PZ–14 is separate and distinct from the SSW in the other wells at the WIPP facilities area (DOE/WIPP-08-3375, *Basic Data Report for Piezometers PZ–13, PZ–14, PZ–15 and SSW)*. PZ–13 and PZ–14 were completed at the contact of the Santa Rosa and Dewey Lake. PZ–15 was completed at a shallower level in the Gatuña, where it appears rainwater has accumulated from a localized recharge source. Geochemically, the piezometer wells around the site and preliminary design validation salt pile are distinct from the SSW wells located in the WIPP facilities area. Because of the recharge influence from a localized depression near PZ–15, this is geochemically distinct from the areas around the site and preliminary design validation salt pile and the WIPP facilities.

In 2004, storm water evaporation ponds were lined with high-density polyethylene in accordance with DP–831 requirements. Since the installation of the liners, there has been a decrease in SSW elevations, which indicates that the liners have reduced the potential for groundwater to be impacted.

6.7 Public Drinking Water Protection

The water wells nearest the WIPP site that use the natural shallow groundwater for domestic use are the Barn Well and Ranch Well located on the J. C. Mills Ranch. These wells are located approximately 3 mi south-southwest of the WIPP surface facilities and about 1.75 mi south of WQSP–6A (Figure 6.2). These wells are used for livestock and industrial purposes. TDS in the Barn Well have ranged from 630 to 720 mg/L, and TDS concentrations in the Ranch Well have ranged from 2,800 to 3,300 mg/L (DOE/CAO–96–2184).

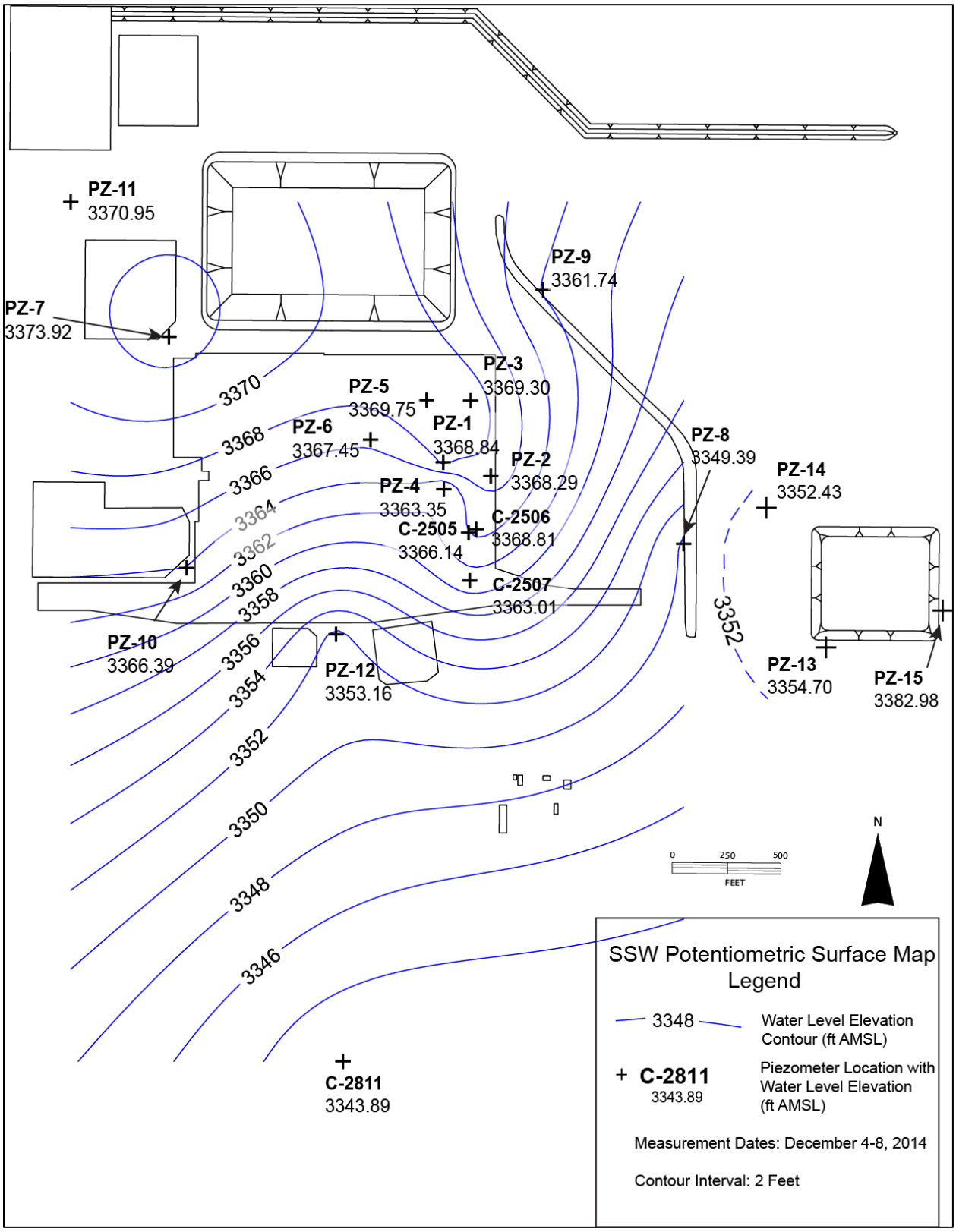


Figure 6.8 – Shallow Subsurface Water Potentiometric Surface

CHAPTER 7 – QUALITY ASSURANCE

The fundamental objective of the environmental QA program is to obtain accurate and precise analytical data that are technically and legally defensible. Quality data are generated through a series of activities that plan, implement, review, assess, and correct as necessary. Samples are collected and analyzed in sample delivery groups along with the requisite QA samples using standardized and proven analytical methods. The sample analysis results and associated QC data are reviewed, verified, validated, and incorporated into succinct and informative reports, which present the data and describe how well the lab met its QA objectives.

During 2014, WIPP Laboratories performed the radiological analyses of environmental samples from the WIPP site. The Organic Chemistry Laboratory at the Carlsbad Environmental Monitoring and Research Center (CEMRC) in Carlsbad, New Mexico, performed the non-radiological VOC analyses, and Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, New Mexico, performed the non-radiological groundwater analyses. In addition, HEAL subcontracted groundwater analyses to Anatek Laboratories to perform trace metal analyses. The subcontracted laboratories have documented QA programs, including an established QA plan, and laboratory-specific standard operating procedures (SOPs) based on published standard analytical methods. Anatek Laboratories is a subcontract laboratory used to measure trace concentrations of metals by EPA Method 6020 (for inductively coupled plasma emission spectroscopy/mass spectrometry) and is accredited by The NELAC Institute. All reports from Anatek Laboratories are received by HEAL and reviewed before they are included in WIPP reports.

All the laboratories, except CEMRC, demonstrated the quality of their analytical data through participation in reputable, inter-laboratory comparison programs such as the National Institute of Standards and Technology Radiochemistry Intercomparison Program (NRIP), Mixed Analyte Performance Evaluation Program (MAPEP), and National Environmental Laboratory Accreditation Conference (NELAC) proficiency testing studies. Laboratories used by the WIPP program are also required to meet the applicable requirements of the CBFO *Quality Assurance Program Document* (DOE/CBFO–94–1012), as flowed down through the NWP, *Quality Assurance Program Description* (WP 13–1). The Organic Chemistry Laboratory at CEMRC was not required to participate in inter-comparison programs during 2014.

The WIPP sampling program and the subcontracted analytical laboratories operate in accordance with QA plans and QA project plans that incorporate QA requirements from the MOC *Quality Assurance Program Description*. These plans address the following elements:

- Management and organization
- Quality system and description
- Personnel qualification and training

- Procurement of products and services including supplier-related noncomformances
- Documents and records
- Computer hardware and software
- Planning
- Management of work processes (SOPs)
- Assessment and response
- Quality improvement including the reporting of non-administrative nonconformances

To ensure that the quality of systems, processes, and deliverables are maintained or improved, three layers of assessments and audits are performed:

- DOE/CBFO performs assessments and audits of the MOC QA program.
- MOC performs internal assessments and audits of its own QA program.
- MOC performs assessments and audits of subcontractor QA programs as applied to MOC contract work.

The QA objectives for the sampling and analysis program are completeness, precision, accuracy, comparability, and representativeness. Each laboratory processes QA/QC data independently according to laboratory SOPs and SOWs. Sections 7.1, 7.2, and 7.3 discuss the QC results for the WIPP Laboratories, CEMRC, and HEAL, in terms of how well they met the QA objectives.

7.1 WIPP Laboratories

Samples for analysis of radionuclides were collected using approved WIPP procedures. The procedures are based on generally accepted methodologies for environmental sampling, ensuring that the samples were representative of the media sampled. The samples were analyzed for natural radioactivity, fallout radioactivity from nuclear weapons tests, and radionuclides contained in the TRU waste disposed at the WIPP facility. The reported concentrations at various locations in 2014 were generally representative of the baseline concentrations for the radionuclides of interest except for the detections of $^{239/240}$Pu and ^{241}Am immediately following the radiation release event.

7.1.1 Completeness

The SOW for analyses performed by WIPP Laboratories states that “analytical completeness, as measured by the amount of valid data collected versus the amount of data expected or needed, shall be greater than 90 percent for the MOC sampling programs.” For radiological sampling and analysis programs, this contract requirement translates into the following quantitative definition of completeness.

Completeness is expressed as the number of samples analyzed with valid results as a percentage of the total number of samples submitted for analysis, or

$$\%C = \frac{V}{n} \times 100$$

Where:

%C = percent completeness

V = number of samples with valid results

n = number of samples submitted for analysis

Samples and measurements for all environmental media (air particulate composites, groundwater, surface water, soil, sediment, plant, and animal) were 100 percent complete for 2014.

7.1.2 Precision

The SOW states that analytical precision (as evaluated through replicate measurements) will meet control criteria or guidelines established in the industry-standard methods used for sample analysis. To ensure overall quality of analysis of environmental samples, precision was evaluated for sample collection and sample analysis procedures combined, as well as the sample analysis procedures alone. At least one pair of field duplicates was collected and analyzed for each matrix type. (Field duplicates would not necessarily apply to all sample types, such as small animals.) The precision of laboratory duplicates was reported by WIPP Laboratories and reviewed by the data validator, and the precision of field duplicates was calculated and reviewed by the data validator.

The measure of precision for radionuclide sample analyses is the RER, which is expressed as:

$$RER = \frac{(Activity)pri - (Activity)dup}{\sqrt{(1\sigma TPU)^2 pri + (1\sigma TPU)^2 dup}}$$

Where:

RER = relative error ratio

(Activity)pri = activity of the primary sample

(Activity)dup = activity of the duplicate sample

1 σ TPU = total propagated uncertainty at the 1 σ level

In order to generate analysis precision data, the laboratory performed duplicate analyses on separate portions of the same homogenized sample (laboratory duplicate). At least one sample was taken from each batch for each type of sample matrix to analyze as a laboratory duplicate except for air filter composite samples, where only one sample is available. However, a field duplicate was taken from a different location each quarter. The duplicate analyses of separate aliquots of the same sample evaluated the precision of sub-sampling in the laboratory, the heterogeneity of the

media sampled, and the precision of the analytical method. These laboratory precision data, as RERs, are reviewed and evaluated during verification and validation of the data, but are not included in this ASER. The verification and validation review showed that every RER met the WIPP QA objective of less than two for the sample batches analyzed in 2014, demonstrating good precision for the analysis procedures. Note that the WIPP precision requirement of the RER was formerly less than 1, but was changed to less than 2 in 2014 to match the WIPP Laboratories precision objective for other clients. However, this has not resulted in the lab reporting any poorer precision results in 2014.

The RERs for field duplicate samples were calculated by the data reviewer as an indicator of the overall precision, reflecting the combination of both sample collection and laboratory analysis. Duplicate samples were collected at the same time, same place, and under similar conditions as the primary samples. In the case of fauna (animals), field duplicates (separate animals) cannot be collected. In one case duplicate field samples were taken from a single deer SOO and analyzed as a measure of combined sampling and analysis precision.

The WIPP Environmental Monitoring Program has not defined a QA objective for the precision of the analysis results for field duplicate samples. Nonetheless, precision for field duplicate measurements is tracked. For the purposes of this report, precision data are evaluated using the guidance for a similar monitoring project as cited in the reference document *Rocky Flats Annual Report of Site Surveillance and Maintenance Activities-CY 2008* (Doc. No. S05247, U.S. Department of Energy, April 2009). This source suggests that 85 percent of field duplicates should yield RERs less than 1.96. Thus, 15 percent of the precision values would be allowed to be greater than 1.96. Even so, the following summary of the field duplicate samples with precision RERs greater than 2 was compiled from the data in Tables 4.11, 4.13, 4.17, 4.21, 4.27, 4.30, and 4.33 (see Appendix C for location codes): Duplicate analysis results for the target radionuclides are considered, not just those results where the analyte was detected.

- ^{40}K yielded a RER of 2.51 in the duplicate air filter second quarter samples from location CBD (^{40}K was not detected in the samples).
- ^{235}U yielded a RER of 2.50 in the duplicate groundwater samples collected from WQSP-1 and a RER of 3.30 in the duplicate groundwater samples from WQSP-3 during Round 36 (^{235}U was detected in the samples).
- ^{238}U yielded a RER of 2.12in the duplicate surface water samples collected at location HIL (^{238}U was detected in the samples).
- ^{90}Sr yielded a RER of 2.16 in the duplicate soil samples taken at the 0–2 cm depth at location WFF (^{90}Sr was not detected in the samples).
- $^{233/234}$U yielded a RER of 7.26 in the duplicate vegetation samples collected from location WEE ($^{233/234}$U was detected in one of the duplicate samples but not the other).

- ^{235}U yielded a RER of 2.28 in the duplicate vegetation samples collected from location WEE (^{235}U was not detected in the samples).
- ^{238}U yielded a RER of 5.55 in the duplicate vegetation samples collected from location WEE (^{238}U was detected in one of the duplicate samples but not the other).
- ^{238}U yielded a RER of 2.23 in the duplicate deer SOO (^{238}U was not detected in the samples).

The analysis results listed above represent a very small fraction of the total number of RER values calculated for the analysis of duplicate field samples. One additional sample contained a RER greater than 1.96 (^{235}U in the sediment duplicates from location CBD). The highest RERs were for vegetation samples where multiple plants were harvested to produce the duplicate samples. Separate plants likely contain different amounts of radionuclides, and in both cases the target uranium isotope was detected in one of the duplicate samples but not the other.

In summary, the precision of the combined sampling and analysis procedures was good based on the RERs meeting the precision objective of less than two (2).

7.1.3 Accuracy

The accuracy of the radiochemical analyses was checked by analyzing initial and continuing calibration standards, reagent method blanks, matrix filter blanks in the case of air filter composite samples, some aqueous field blanks, and reagent laboratory control samples (RLCSs), which are spiked method blanks as specified in the published industry-standard analytical methods and in the corresponding lab SOPs. Samples for alpha spectrometry analysis are spiked with tracers, samples for ^{90}Sr analysis are spiked with a carrier, and air filter samples for gamma analysis are spiked with a ^{22}Na tracer. The percent recovery of the tracers and carriers are reported as a measure of accuracy, and the analysis results are corrected for the percent recoveries to improve the accuracy of the analyses. The tracer recoveries need to meet certain recovery objectives for the sample data to be acceptable, i.e., tracer recovery of 30% - 110% and carrier recovery 40% - 110%. If the recoveries are outside this range, the samples are reprocessed until the recovery objective is met.

The daily calibration standards were used to confirm that the response in the daily standard closely matched the corresponding response during the initial calibration. Instrument accuracy was ensured by using National Institute of Standards and Technology-traceable radiochemistry standards for instrument calibration. The reagent method blanks were used to confirm that the accuracy of the radiological sample analysis was not adversely affected by the presence of any of the target radionuclides as background contaminants that may have been introduced during sample preparation and analysis. The filter matrix blank sample was an unused clean particulate filter that was not used for sampling but was analyzed to correct for any particulate filter background. The RLCSs were analyzed to check that the analytical method was in

control by measuring the percent recoveries of the target analytes spiked into clean water. Duplicate RLCS samples were prepared and analyzed for some of the radiochemical batches.

The radiochemical SOW requires the measured accuracy to meet control criteria or guidelines established in the industry-standard methods used for sample analysis. However, the SOW does not require the analysis of matrix spike and matrix spike duplicate samples as a measure of accuracy and precision.

National Institute of Standards and Technology-traceable standards were spiked into clean water or a clean solid matrix to prepare RLCS samples. Analysis of RLCSs containing the radionuclides of interest was performed on a minimum 10 percent basis (1 per batch of 10 or fewer samples). The QA objective for the analysis results was for the measured concentration to be within ±20 percent of the known expected concentration. If this criterion was not met, the entire sample batch was re-analyzed. RLCS results for each radionuclide were tracked on a running basis using control charts. The data validator checked that all the control chart points matched those reported by the laboratory. The review showed that the radiological RLCS results fell within the established recovery range, indicating good accuracy.

Accuracy was also ensured through the participation of WIPP Laboratories in the DOE MAPEP, the DOE Laboratory Accreditation Program, and the NRIP interlaboratory comparison program (through National Institute of Standards and Technology), as discussed in more detail in Section 7.1.4. Under these programs, WIPP Laboratories analyzed blind performance evaluation samples, and the analysis results were compared with the official results measured by the DOE Laboratory Accreditation Program, MAPEP, and NRIP laboratories.

Performance was established by percent bias, calculated as:

$$\%Bias = \frac{(A_m - A_k)}{A_k} \times 100$$

Where:

% Bias = *percent bias*

A_m = *measured sample activity*

A_k = *known sample activity*

The DOE Laboratory Accreditation Program and NRIP primarily include the analyses of bioassay samples (urine and feces). Bioassay samples are not analyzed as part of the WIPP environmental program, and NRIP and DOE Laboratory Accreditation Program performance evaluation bioassay analysis results are not specifically discussed in this report. The NRIP bioassay samples are part of an emergency preparedness exercise where the accuracy has a relatively wide acceptance range, but a fast turnaround time for reporting the results is very important.

WIPP Laboratories analyzed eight MAPEP environmental samples consisting of two each of soil, water, air filter, and vegetation samples. The analysis results are presented in Section 7.1.4. Based on the number of acceptable (A) ratings earned by WIPP Laboratories for the analysis of performance evaluation samples, the laboratory provided accurate and reliable radionuclide analysis data for the WIPP environmental samples.

7.1.4 Comparability

The mission of WIPP Laboratories is to produce high-quality and defensible analytical data in support of the WIPP operations. The SOW requires WIPP Laboratories to ensure consistency through the use of standard analytical methods coupled with specific procedures that govern the handling of samples and the reporting of analytical results.

A key element in the WIPP Laboratories QA program is analysis of performance evaluation samples distributed as part of inter-laboratory comparison programs by reputable agencies. The DOE Laboratory Accreditation Program, MAPEP, and NRIP involve preparing QC samples containing various alpha-, beta-, and gamma-emitting radionuclides in synthetic urine, synthetic feces, air filter, water, soil, and vegetation media, and distributing the samples to the participating laboratories.

The programs are inter-laboratory comparisons in that the analysis results generated by the laboratory participants are compared with the analysis results experimentally measured by the administering agencies. The programs assess each laboratory's analysis results as acceptable (passing) or not acceptable (failing), based on the accuracy of the analyses. A warning may be issued for a result near the borderline of acceptability.

Table 7.1 presents the analysis results for the first set of MAPEP soil, water, air filter, and vegetation performance evaluation samples (Series 29) analyzed in 2014. The acceptable range for the MAPEP samples is a bias less than or equal to ±20 percent; the acceptable range with a warning is a bias greater than ±20 percent but less than ±30 percent, and the not acceptable (N) results are those with a bias greater than ±30 percent.

The WIPP Laboratories analysis results for the soil, water, and vegetation samples showed that the results were acceptable for the target radionuclides, which included the WIPP target radionuclides $^{233/234}$U, ^{238}U, ^{238}Pu, $^{239/240}$Pu, ^{241}Am, ^{40}K, ^{60}Co, ^{137}Cs, and ^{90}Sr. Results for the other WIPP radionuclide, ^{235}U, were not requested.

The WIPP Laboratories analysis results were also acceptable for the radiological air filter samples. The lab also reported gross alpha/beta results for air filter sample MAPEP–13–GrF29 (not shown). Gross alpha/beta results are not reported in the ASER, but the weekly low-volume air particulate filter samples are analyzed by gross alpha/beta before they are combined on a quarterly basis and analyzed as the quarterly air filter composite samples reported in the ASER. The gross alpha acceptable range is

±70 percent, and the gross beta acceptance range is ±50 percent. The WIPP Laboratories analysis results were slightly lower than the low end of the alpha acceptable range.

Table 7.2 presents the results for the second set of MAPEP soil, water, air filter, and vegetation performance evaluation samples (MAPEP–14, Series 30) analyzed in 2014. The data in Table 7.2 show that the WIPP Laboratories results for the MAPEP Series 30 samples were acceptable for the target radionuclides in the soil, air filters, water, and vegetation samples with three exceptions. The results for $^{233/234}$U and ^{238}U were unacceptably low in the soil samples and ^{40}K was reported in the water sample without being present (false positive). The gross alpha results for the MAPEP-14-GrF30 (not shown) were again unacceptably low, with a bias of -75.6.

Table 7.1 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2014, First Set (Series 29)

Analyte	MATRIX: Soil (Bq/kg) MAPEP–13–MaS27				MATRIX: Water (Bq/L) MAPEP–13–MaW29			
	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias
^{241}Am	0.558	NR	NA	NA	0.00647	NR	A	NA
^{60}Co	435	451	A	-3.55	22.8	23.58	A	-3.31
^{137}Cs	964	977	A	-1.33	31.7	31.6	A	0.32
^{238}Pu	61.4	61.5	A	-0.16	1.14	1.216	A	-6.25
$^{239/240}$Pu	0.409	0.36	A	13.6	0.9021.51	0.996	A	-9.44
^{90}Sr	420	460	A	-8.70	6.32	7.22	A	-12.5
$^{233/234}$U	27.2	30.0	A	4.57	0.0735	0.070	A	5.00
^{238}U	30.1	34.0	A	-11.5	0.0276	0.034	A	-18.8
^{40}K	642	633	A	1.42	8.54	NR[d]	A	NA
Analyte	**MATRIX: Air Filter (Bq/Filter) MAPEP–13–RdF29**				**MATRIX: Vegetation (Bq/Sample) MAPEP–13–RdV29**			
	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias
^{241}Am	0.000587	NR	A	NA	0.182	0.193	A	-5.70
^{60}Co	2.18	2.3	A	-5.22	0.0197	NR	A	[e]
^{137}Cs	2.74	2.7	A	1.48	7.72	6.60	A	16.9
^{238}Pu	0.122	0.124	A	-1.61	0.00153	0.0011	A	[e]
$^{239/240}$Pu	0.0879	0.092	A	-4.46	0.177	0.171	A	-0.11
^{90}Sr	1.77	1.81	A	-2.26	2.28	2.32	A	-1.72
$^{233/234}$U	0.0333	0.0292	A	14.0	0.0482	0.0466	A	3.43
^{238}U	0.207	0.205	A	0.98	0.322	0.324	A	-0.62
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

Notes:

(a) Activity.

(b) MAPEP = Mixed Analyte Performance Evaluation Program.

(c) E = evaluation rating (A = acceptable, W = acceptable with warning, N = not acceptable).

(d) False positive test.

(e) Sensitivity evaluation.

Bq/kg = becquerels per kilogram.

NA = not applicable.

NR = not reported by MAPEP.

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2014 Second Set (Series 30)

Analyte	MATRIX: Soil (Bq/g) MAPEP–14-MaS30				MATRIX: Water (Bq/L) MAPEP–14–MaW30			
	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias	Reported [RN][a]	MAPEP[b] [RN][a]	E[c]	% Bias
^{241}Am	62.8	68.0	A	-7.65	0.753	0.720	A	4.58
^{60}Co	1.19	1.22	A	-2.46	14.7	16.0	A	-8.12
^{137}Cs	1250	1238	A	0.97	26.5	28.9	A	-8.30
^{238}Pu	83.4	96	A	-13.1	0.846	0.828	A	2.17
$^{239/240}$Pu	66.1	76.8	A	-13.9	0.667	0.676	A	-1.33
^{90}Sr	1.79	NR	A	(d)	8.22	8.51	A	-3.41
$^{233/234}$U	32.0	81	N	-60.5	0.234	0.225	A	4.00
^{238}U	36.3	83	N	-56.3	1.37	1.45	A	-5.52
^{40}K	649	622	A	4.34	3.18	NR	N	(d)
	MATRIX: Air Filter (Bq/filter) MAPEP–14–RdF30				**MATRIX: Vegetation (Bq/Sample) MAPEP–14–RdV30**			
[RN]	Reported Value	MAPEP Value	E[c]	% Bias	Reported Value	MAPEP Value	E[c]	% Bias
^{241}Am	0.0905	0.090	A	0.56	0.115	0.108	A	6.48
^{60}Co	1.47	1.39	A	5.76	7.36	6.93	A	6.20
^{137}Cs	1.86	1.76	A	5.68	5.06	4.74	A	6.75
^{238}Pu	0.000826	0.00090	A, (e)	-8.22	0.12	0.12	A	-0.83
$^{239/240}$Pu	0.0774	0.0772	A	0.26	0.15	0.154	A	-2.60
^{90}Sr	1.11	1.18	A	-5.93	1.47	1.46	A	0.68
$^{233/234}$U	0.0198	0.0195	A	1.54	0.0291	0.0253	A	15.0
^{238}U	0.124	0.129	A	-3.88	0.160	0.165	A	-3.03
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

Notes:

(a) Activity.

(b) MAPEP = Mixed Analyte Performance Evaluation Program.

(c) E = evaluation rating (A = acceptable, W = acceptable with warning, N = not acceptable).

(d) False positive test.

(e) Sensitivity evaluation.

NA = not applicable.

NR = not reported.

7.1.5 Representativeness

Representativeness is the extent to which measurements actually represent the true environmental condition or population at the time a sample was collected. The primary

objective of the Environmental Monitoring Program is to protect the health and safety of the population surrounding the WIPP facility. According to the SOW, analytical representativeness is ensured through the use of technically sound and accepted approaches for environmental investigations, including industry-standard procedures for sample collection and monitoring for potential sample cross-contamination through the analysis of field blank samples and laboratory method blank samples. These conditions were satisfied during the sample collection and analysis practices of the WIPP Environmental Monitoring Program.

The environmental media samples (air, groundwater, surface water, soil, sediment, and biota) were collected from areas representative of potential pathways for intake of radionuclides. The samples were collected using generally accepted methodologies for environmental sampling, ensuring that they would be representative of the media sampled. Both sample collection blanks (field blanks) and laboratory method blanks were used, as appropriate, to check for cross-contamination and to ensure sample integrity.

7.2 Carlsbad Environmental Monitoring and Research Center

The Organic Chemistry Laboratory at CEMRC performed the analyses of VOC and hydrogen/methane samples collected in the WIPP underground during 2014.

7.2.1 Completeness

Completeness is defined in WP 12–VC.01, *Volatile Organic Compound Monitoring Program*, and WP 12–VC.04, *Quality Assurance Project Plan for Hydrogen and Methane Monitoring*, as being “the percentage of the ratio of the number of valid sample results received that meet other quality objectives versus the total number of samples required to be collected.” The QA objective for completeness for each monitoring program is 95 percent.

For 2014, 274 VOC samples (including field duplicates and additional surface samples) were submitted to CEMRC for analysis; 274 of these produced valid data. For surface, repository, disposal room, and ongoing disposal room VOC monitoring, the program completion percentage was 100 percent.

For 2014, 46 hydrogen and methane samples (including field duplicates) were submitted to CEMRC for analysis; 46 of these produced valid data. For hydrogen and methane monitoring, the program completion percentage was 100 percent.

7.2.2 Precision

Precision is demonstrated in both the VOC monitoring and hydrogen and methane monitoring programs by evaluating results from both laboratory duplicate analysis and field duplicate samples. The laboratory duplicate samples consist of a laboratory control sample (LCS) and a laboratory control sample duplicate (LCSD) and laboratory sample duplicates (duplicate runs of monitoring program samples). The field duplicate

is a duplicate sample that is collected in parallel with the original sample. Duplicate samples are evaluated using the relative percent difference (RPD), as defined in WP 12–VC.01 and WP 12–VC.04. The RPD is calculated using the following equation.

$$RPD = \frac{|(A - B)|}{(A + B) / 2} \times 100$$

Where:

RPD = relative percent difference

A = original sample result

B = duplicate sample result

A LCS and a LCSD were generated and evaluated for data submitted in 2014. The LCS/LCSD data generated during 2014 yielded RPDs less than or equal to 25.

Laboratory duplicate samples yielded RPDs less than or equal to 25.

Field duplicate samples were also collected and compared for precision. The acceptable range for the RPD between measured concentrations is less than or equal to ±35. For each target VOC value reported over the MRL in 2014, 26 of 27 field duplicates met the acceptance criterion. For each hydrogen and methane value reported over MRL, 3 of 3 field duplicates met the acceptance criterion.

7.2.3 Accuracy

The VOC monitoring program evaluates both quantitative and qualitative accuracy and recovery of internal standards. Qualitative evaluation consists of the evaluation of standard ion abundance for the instrument tune, which is a mass calibration check with bromofluorobenzene performed prior to analyses of calibration curves and samples.

The hydrogen and methane monitoring program evaluates quantitative accuracy. The quantitative evaluation includes performance verification for instrument calibrations and LCS recoveries.

7.2.3.1 Quantitative Accuracy

Instrument Calibrations

Instrument calibrations are required to have a relative standard deviation percentage of less than or equal to 30 percent for each analyte of the calibration. For VOCs, this is calculated by first calculating the relative response factor as indicated below.

$$\text{Relative Response Factor} = \frac{(\text{Analyte Response})(\text{Internal Standard Concentration})}{(\text{Internal Standard Response})(\text{Analyte Concentration})}$$

Relative Standard Deviation = $\frac{\text{Standard Deviation of Relative Response Factor}}{\text{Average Relative Response Factor of Analyte}} \times 100$

For hydrogen and methane, the calculations are similar except the method does not require internal standards and thus not factored into the equations.

During 2014, 100 percent of instrument calibrations met criteria of less than or equal to 30 percent.

Laboratory Control Sample Recoveries

Laboratory control sample recoveries are required to have a percent recovery of ±40 percent (60 to 140 percent recovery). Laboratory control sample recoveries are calculated as:

$$PercentRecovery = \frac{X}{T} \times 100$$

Where

X = experimentally determined value of the analyte recovered from the standard

T = true reference value of the analyte being measured

During 2014, 100 percent of the LCS recoveries met the ±40 percent criterion.

Internal Standard Area

For VOC analyses, internal standard areas are compared to a calibrated standard area to evaluate accuracy. The acceptance criterion is ±40 percent.

During 2014, 100 percent of internal standards met the ±40 percent criterion.

Sensitivity

To meet sensitivity requirements, MDL for each of the nine target compounds must be evaluated before sampling begins. The initial and annual MDL evaluation is performed in accordance with Appendix B of 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," and with Chapter 1, *Quality Control,* of EPA SW–846, *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (1996). The CEMRC met the MDL requirements for 2014 data.

7.2.3.2 Qualitative Accuracy

For VOC analyses, the standard ion abundance criterion for bromofluorobenzene is used to evaluate the performance of the analytical system in the ID of target analytes as well as unknown constituents (qualitative accuracy). This ensures that the instrumentation is functioning properly during the analysis of air samples.

During 2014, ion abundance criteria were within tolerance.

7.2.4 Comparability

There is no Permit requirement for comparability in the VOC monitoring program and the hydrogen and methane monitoring program. However, comparability is maintained through the use of consistent, approved SOPs for sample collection and analyses.

7.2.5 Representativeness

Representativeness is ensured by use of programmatic plans and procedures implementing EPA guidance designed to collect and analyze samples in a consistent manner.

7.3 Hall Environmental Analysis Laboratory

HEAL was awarded the groundwater analysis contract in February 2008 and performed the chemical analyses for the Round 36 groundwater sampling in 2014. HEAL followed Laboratory SOPs based on standard analytical methods from EPA and from *Standard Methods for the Examination of Water and Wastewater* (Eaton et al., 2005). The trace metals analysis for antimony, arsenic, selenium, and thallium by inductively coupled plasma emission spectroscopy/mass spectrometry was subcontracted to Anatek Laboratories in order to achieve the requisite detection limits.

7.3.1 Completeness

Six WQSP wells were sampled once in 2014 during the period May through June for the WIPP groundwater DMP. Sampling was delayed in 2014 due to the radiation release event in February. The completeness objective was met as analytical results were received for the samples submitted (100 percent completeness).

7.3.2 Precision

HEAL and Anatek provided precision data for the analyses of LCS/LCSD pairs, matrix spike/matrix spike duplicate (MS/MSD) pairs, and analysis of single primary groundwater samples in duplicate. LCS samples were prepared by spiking the target constituent (VOCs, SVOCs, and trace metals) and general chemistry parameter target analytes into clean water and preparing and analyzing the samples. LCS replicate (LCSR) samples were analyzed for analytical methods involving an instrumental analysis step, and simply involved the reanalysis of the LCS sample so that only the variability in the instrumental analysis step was measured. These methods included gas chromatography/mass spectrometry analyses, inductively coupled plasma emission spectroscopy analyses, and inductively coupled plasma emission spectroscopy/mass spectrometry analyses. Laboratory control sample duplicate samples were analyzed for some of the general chemistry parameters. A LCSD is a separately prepared LCS sample. MS/MSD samples were generated by spiking the target constituents and selected general chemistry indicator parameter analytes into separate portions of the

primary groundwater samples. The LCS/LCSR and MS/MSD samples generally contained all the target constituents and general chemistry parameters for precision measurement. The samples were analyzed, and the recoveries of the VOCs, SVOCs, and metals and general chemistry indicator parameters were measured and reported.

LCS/LCSR and MS/MSD analyses are not applicable for some analyses such as pH, specific gravity, TSS, and specific conductance. Precision data were generated for these types of analyses by analyzing a field sample in duplicate and calculating the associated RPD. The QA objective for the precision of the LCS/LCSR, MS/MSD, and duplicate sample concentrations is less than or equal to 20 RPD for constituents and general chemistry parameters. In addition, the data validator calculated the precision of the analysis results for each detected analyte in the primary and duplicate groundwater samples. Since the primary and duplicate groundwater samples are separate samples, there are no particular precision requirements for the analysis results. However, the duplicate samples are taken consecutively from continuously flowing water, and the composition of the samples is generally expected to be as consistent as separating a single groundwater sample into two fractions.

The duplicate groundwater precision measurements were calculated for the detectable concentrations of the major cations including calcium, magnesium, potassium, and sodium; some detected trace metals including barium, beryllium, and vanadium; and general chemistry parameters detected in the groundwater samples including chloride, TOC, specific gravity, TDS, TSS, pH, specific conductance, and alkalinity. The precision would not be expected to be as good for constituents and general chemistry parameters with low concentrations between the MDL and MRL.

Table 7.3 shows those cases where the precision objective (RPD$\leq$20) was not met for the duplicate groundwater samples, MS/MSD samples, and duplicate analysis of single samples when applicable. The LCS/LCSR and LCS/LCSD measurements met the precision objective.

The precision objective was sometimes not met during the analyses for analytes for which the analytical methods are challenged by the high-brine groundwater samples such as TSS. Other cases where the duplicate groundwater sample RPDs were >20 were for analytes, such as some trace metals, that yielded low sample concentrations between the MDL and the MRL, where the concentrations are J-flagged as estimated.

Table 7.3 includes two entries for trace metals at concentrations between the MDL and MRL; two entries for TOC with concentrations between the MDL and MRL; nine SVOC compounds that yielded higher recoveries in one of the matrix spike samples compared to the other; and two cases where the measured TSS concentration was higher in one of the groundwater duplicate samples compared to the other. TSS measurements appeared twice in the table and can be affected by how long a sample is allowed to settle before an aliquot is taken for analysis. In addition, the small particle size of the solids is close to the pore size of the filters, contributing to poorer precision.

Table 7.3 – Individual Cases Where the Groundwater Sampling Round 36 Relative Percent Differences were >20 for the Primary and Duplicate Groundwater Samples, Matrix Spike/Matrix Spike Duplicate Pairs, and Laboratory Duplicate Quality Assurance/Quality Control Samples

DMW	Parameter or Constituent	Primary Sample, Conc. (or as noted)	Duplicate Sample, Conc. (or as noted)	RPD
WQSP-1	TSS	61 mg/L	40 mg/L	42
WQSP-1	2,4-dinitrophenol	31.5 ug/L (MS)	40.0 ug/L (MSD)	24
WQSP-1	Pentachlorophenol	30.4 ug/L (MS)	50.1 ug/L (MSD)	49
WQSP-2	TOC	0.26 mg/L J	0.21 mg/L J	20
WQSP-2	2,4-dinitrophenol	21.1 ug/L (MS)	26.6 ug/L (MSD)	23
WQSP-3	TOC	0.20 mg/L J	0.17 mg/L J	21
WQSP-3	TSS	130 mg/L	187 mg/L	36
WQSP-3	Barium (Ba)	0.041 mg/L J	0.032 mg/L J	24
WQSP-3	2,4- dinitrophenol	18.9 ug/L (MS)	13.4 ug/L (MSD)	34
WQSP-3	Pentachlorophenol	29.6 ug/L (MS)	20.7 ug/L (MSD)	35
WQSP-4	TOC	0.35 mg/L J	0.25 mg/L J	32
WQSP-5	Silver (Ag)	0.011 mg/L J	0.021 mg/L J	62
WQSP-5	2,4-dinitrophenol	26.7 ug/L (MS)	34.1 ug/L (MSD)	24
WQSP-5	Pentachlorophenol	22.1 ug/L (MS)	30.5 ug/L (MSD)	29
WQSP-6	2,4-dinitrophenol	45.4 ug/L (MS)	56.0 ug/L (MSD)	21
WQSP-6	Pentachlorophenol	39.3 ug/L (MS)	60.8 ug/L (MSD)	43

Notes:
DMW = detection monitoring well.
J = estimated concentration between MDL and MRL.
MS = matrix spike.
MSD – matrix spike duplicate.
RPD = relative percent difference.
TOC = total organic carbon.
TSS = total suspended solids.

Considering the hundreds of groundwater sample data points and QA/QC sample data points that were generated during Round 36, the number of duplicate groundwater samples and QA samples that did not meet the precision QA objective was very low, at less than three percent.

7.3.3 Accuracy

The accuracy of the analyses was checked by analyzing initial calibration verification standards, continuing calibration verification standards, method blanks, LCS and LCSR/LCSD samples, and MS/MSD samples as specified in the standard methods and in the corresponding lab SOPs. The daily calibration standards were used to confirm that the response in the daily standard closely matched the corresponding response

during the initial calibration. The method blanks were used to confirm that the accuracy of the groundwater sample analyses was not adversely affected by the presence of any of the target analytes as background contaminants that may have been introduced during sample preparation and analysis. The LCS and LCSD/LCSR samples, where applicable, were analyzed to check that the analytical method was in control by measuring the percent recoveries of the target analytes spiked into clean water. MS/MSD samples were prepared and analyzed to check the effect of the groundwater sample matrix on the accuracy of the analytical measurements as percent recovery.

The objective for the percent recoveries varies with the type of analysis:

- 70–130 percent recovery for VOCs in LCS samples and MS samples.
- 90–110 percent recovery for chloride and sulfate in LCS samples.
- 80–120 percent recovery for mercury and recoverable metals in LCS samples.
- 75–125 percent recovery for mercury and recoverable metals in MS samples.
- 90–110 or 80–120 percent recovery for general chemistry parameters in LCS samples.
- 80–120 percent recovery or 75–125 percent recovery for general chemistry parameters in MS samples.
- SVOC recovery objectives vary widely according to the lab's historical control chart range. The EPA guidance for SVOC recoveries is 40–140 percent for base/neutral SVOCs and 30–130 percent for acidic SVOCs. However, HEAL's historical control chart recovery range is generally wider than the EPA guidance.

The accuracy QA objectives for the general chemistry indicator parameters are generally tighter than for the constituent organics and metals, with recoveries of 80–120 percent, and with any detected analytes in the method blanks at concentrations less than the MRL or preferably no detection at all.

Table 7.4 summarizes the QC samples for which the accuracy QA objective, as measured by percent recovery, was not met during the Round 36 sampling and analysis in 2014. None of the target analytes were detected in method blank samples as contaminants at concentrations above the MRL; thus, accuracy was not adversely affected by contamination. The recoveries of analytes that contained native sample concentrations greater than four times the matrix spike concentration, such as the major cations, chloride, and sulfate, are not included in Table 7.4 since MS/MSD recovery data are not applicable per EPA guidance for samples with high native concentrations of a given analyte.

Table 7.4 – Individual Cases where the Groundwater Sampling Round 36 Accuracy Objectives Were Not Met for 2014 QA/QC Samples

DMW	Constituent or Parameter	Sample	% Rec.	Sample	% Rec.
WQSP-1	2-butanone	LCS	163	LCSR	163
WQSP-1	Isobutyl alcohol	MS	150	MSD	140
WQSP-1	2-butanone	MS	157	MSD	161
WQSP-1	2,4-dinitrophenol	LCS	27.6	LCSR	30.4[(a)]
WQSP-2	Isobutyl alcohol	MS	137	MSD	137
WQSP-2	2-butanone	MS	138	MSD	152
WQSP-2	2,4-dinitrophenol	MS	21.1	MSD	26.6
WQSP-3	Isobutyl alcohol	LCS	197	LCSR	205
WQSP-3	2-butanone	MS	259	MSD	205
WQSP-3	Isobutyl alcohol	MS	1500[(b)]	MSD	1360[(b)]
WQSP-3	Pyridine	LCS	31.2	LCSR	32.3
WQSP-3	2,4-dinitrophenol	MS	18.9	MSD	13.4
WQSP-3	Pentachlorophenol	MS	29.6	MSD	20.7
WQSP-4	Isobutyl alcohol	MS	181	MSD	195
WQSP-4	2-butanone	MS	148	MSD	158
WQSP-4	2,4,6-tribromophenol surrogate	MS	18.3	MSD	16.3
WQSP-4	Potassium	MS	71.6	MSD	113[(a)]
WQSP-5	Isobutyl alcohol	MS	179	MSD	167
WQSP-5	2,4-dinitrophenol	MS	26.7	MSD	34.1[(a)]
WQSP-5	Pentachlorophenol	MS	22.1	MSD	30.5[(a)]
WQSP-6	2-butanone	LCS	136	LCSR	148
WQSP-6	Pyridine	LCS	39.3	LCSR	39.4

Notes:

Most of the recoveries in the table met the laboratory's historical control chart range for recovery.

(a) Accuracy objective was met

(b) The isobutyl alcohol quantitation was biased high based on the LCS/LCSR recoveries. However, the high MS/MSD recoveries were confirmed by the lab and were due to an extreme case of the salting out effect due to the high salt concentration of the WQSP-3 groundwater.

DMW = detection monitoring well.

LCS = laboratory control sample.

LCSR = laboratory control sample replicate (same sample with duplicate instrumental analysis.

MS = matrix spike.

MSD = matrix spike duplicate.

Table 7.4 lists only MS and MSD samples associated with analysis of VOCs and SVOCs except for the one recovery of potassium, which just missed the recovery objective of 75 percent. One spiked SVOC surrogate was low in both the MS and MSD sample from WQSP-4. Other surrogate recoveries met the QA objective for accuracy.

In some cases the VOC and SVOC recoveries were low and in some cases the recoveries were high. High MS and MSD recoveries for the polar VOC compounds listed are usually associated with more efficient purging of the compounds from samples with dissolved salts compared to the purging efficiency of the same polar compounds from the aqueous calibration standards. Some MS/MSD recoveries for VOCs and SVOCs in Table 7.4 were out of the range suggested by EPA guidance of 40 to 140 percent for base/neutral compounds and 30 to 130 percent for acidic compounds. However, many of the recoveries were still within the lab's historical control chart range even though they are included in Table 7.4.

Pentachlorophenol and pyridine are polar compounds that do not extract out of water into a solvent as efficiently as nonpolar compounds and can yield low recoveries. Since these compounds yielded higher recoveries in the LCS/LCSD/LCSR samples than in the MS/MSD samples, their extraction may also be adversely affected by the high-brine sample matrix. In addition, the gas chromatographic (GC) analysis of these particular polar compounds may result in sorption of the compounds onto the GC column resulting in some tailing of the peaks.

Other QA objectives for accuracy include agreement of daily calibration standard concentrations to within 20 percent difference (bias) from the initial calibration curve, and method blanks with any detected analytes at concentrations less than the MRL and preferably not detected at all.

Every calibration standard, groundwater sample, and QC sample analyzed by gas chromatography/mass spectrometry served as a surrogate spike sample in that the organic surrogate recovery compounds were spiked into the samples prior to analysis, and their recoveries were reported as a measure of the accuracy of the analyses

General Chemistry Indicator Parameters

Table 7.4 does not contain any recoveries for general chemistry indicator parameters that did not meet the recovery objectives.

Overall, the quality of the accuracy QC data was excellent, with nearly all the spiked LCS/LCSD/LCSR data and the MS/MSD data meeting the accuracy QA objectives.

7.3.4 Comparability

The Permit requires that groundwater analytical results be comparable by reporting data in consistent units and collecting and analyzing samples using consistent methodology. These comparability requirements were met through the use of consistent, approved SOPs for sample collection and analyses. The normal reporting unit for metals and general chemistry parameters was mg/L, and the normal reporting unit for organics was micrograms per liter (µg/L).

HEAL and its subcontract laboratories are certified by several states and by the National Environmental Laboratory Accreditation Program through Oregon for HEAL and Anatek.

HEAL is certified in Oregon, Utah, Texas, New Mexico, and Arizona. The labs participate in inter-laboratory evaluation programs, including on-site National Environmental Laboratory Accreditation Conference QA audits. The labs also regularly analyze performance evaluation samples provided by a National Environmental Laboratory Accreditation Conference–accredited proficiency standard vendor, such as Phenova Certified Reference Materials.

The details of HEAL's performance evaluation sample results are discussed in this section. Likewise, Anatek successfully analyzed for the four target inductively coupled plasma emission spectroscopy/mass spectrometry metals in several sets of performance evaluation samples. In 2014, HEAL analyzed five sets of performance evaluation samples, including three Phenova water pollution proficiency testing samples and two Phenova water supply proficiency testing samples. The Phenova water supply performance evaluation samples included chloride, nitrate, sulfate, trace metals, mercury, pH, TOC, regulated VOCs, and unregulated VOCs. The Phenova water supply testing performance evaluation samples included chloride, sulfate, TDS, TSS, nitrate, total Kjeldahl nitrogen, alkalinity, trace metals, mercury, specific conductance, pH, VOCs, and SVOCs (acids and base-neutrals). The performance evaluation samples covered all the WIPP target analytes except isobutyl alcohol. Most of the WIPP target analytes were included in three out of four of the sample sets. The sample sets also included a large number of analytes that are not WIPP analytes.

Table 7.5 – Performance Evaluation Sample Analysis Results for Hall Environmental Analysis Laboratory, 2014

Performance Evaluation Source	No. Results	No. Passing	Percent	Missed[(a)]	Assigned	Reported
Phenova WPPT[(b)] WP0414	308	306	99.35	None	NA	NA
Phenova WSPT[(c)] WS1014	112	112	100	None	NA	NA
Phenova WPPT[(b)] WP1014	273	273	100	None	NA	NA
Phenova WSPT[(c)] WS04141013	112	107	95.54	None	NA	NA

Notes:

(a) WIPP analytes only.

(b) WPPT = water pollution proficiency testing.

(c) WSPT = water supply proficiency testing.

The results shown in Table 7.5 show that HEAL's measurements of WIPP analytes in the performance evaluation samples were 100 percent correct.

Overall, HEAL performance evaluation sample analysis results were accurate, confirming the lab's ability to provide accurate and reliable environmental analysis results for the WIPP samples.

7.3.5 Representativeness

The groundwater DMP is designed so that representative groundwater samples are collected from specific monitoring well locations. Prior to collecting the final samples from each well, serial samples were collected and analyzed in an on-site mobile laboratory to help determine whether the water being pumped from the monitoring wells was stable and representative of the natural groundwater at each well. The parameters analyzed in the mobile laboratory included temperature, pH, specific gravity, and specific conductance. The final samples for analysis of VOCs, SVOCs, metals, and general chemistry parameters were collected only when it had been determined from the serial sampling analysis results that the water being pumped was representative of the natural groundwater at each location.

APPENDIX A – REFERENCES

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40 CFR Part 61. “National Emission Standards for Hazardous Air Pollutants.” *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

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40 CFR Part 191, Subpart B. "Environmental Standards for Disposal." *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

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40 CFR §194.21. "Inspections." *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

40 CFR Part 262. "Standards Applicable to Generators of Hazardous Waste." *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

40 CFR Part 264. "Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities." *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

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40 CFR Part 302. “Designation, Reportable Quantities, and Notification.” *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

40 CFR Part 372. “Toxic Chemical Release Reporting: Community Right-to-Know.” *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

40 CFR Part 761. “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.” *Code of Federal Regulations*. Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

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16 U.S.C. §§703, et seq. *Migratory Bird Treaty Act*. United States Code. U.S. Government Printing Office, Washington, D.C.

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42 U.S.C. §2011, et seq. *Atomic Energy Act of 1954*, as amended. United States Code. U.S. Government Printing Office, Washington, D.C.

42 U.S.C. §§4321, et seq. *National Environmental Policy Act*. United States Code. U.S. Government Printing Office, Washington, D.C.

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APPENDIX B – ENVIRONMENTAL PERMITS

Table B.1 – Major Active Environmental Permits for the Waste Isolation Pilot Plant as of December 31, 2014

Granting Agency	Type of Permit	Permit Number	Granted/ Submitted	Expiration	Current Permit Status
New Mexico Environment Department	Hazardous Waste Facility Permit	NM4890139088–TSDF	12/30/10	12/30/20	Active
New Mexico Environment Department Groundwater Quality Bureau	Discharge Permit	DP–831	7/29/14	7/29/19	Active
New Mexico Environment Department Air Quality Bureau	Operating Permit for Two Backup Diesel Generators	310–M–2	12/07/93	None	Active
New Mexico Environment Department Petroleum Storage Tank Bureau	Storage Tank Registration Certificate	Registration Number 2121 Facility Number 31539	7/1/14	6/30/15	Active
U.S. Environmental Protection Agency Region 6	Conditions of Approval for Disposal of PCB/TRU and PCB/TRU Mixed Waste at the US Department of Energy (DOE) Waste Isolation Pilot Plant (WIPP) Carlsbad, New Mexico	N/A	5/21/2013	4/30/2018	Active
U.S. Fish and Wildlife Service	Special Purpose – Relocate	MB155189–0	2/20/14	03/31/16	Active
New Mexico Department of Game and Fish	Biotic Collection Permit	Authorization # 3293	01/26/14	12/31/16	Active

N/A = not applicable

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APPENDIX C – LOCATION CODES

Table C.1 – Location Codes			
ANG	Angel Ranch	PL1	Polishing Lagoon 1(DP-831)
ART	Artesia	PL2	Polishing Lagoon 2 (DP-831)
BHT	Bottom of the Hill Tank	RED	Red Tank
BLK	Blank	SEC	Southeast Control
BRA	Brantley Lake	SL1	Settling Lagoon 1 (DP-831)
CBD	Carlsbad	SL2	Settling Lagoon 2 (DP-831)
COW	Coyote Well (deionized water blank)	SLT	Salt Hoist
COY	Coyote (surface water duplicate)	SMR	Smith Ranch
ELA	Evaporation Lagoon A (DP-831)	SOO	Sample of Opportunity*
ELB	Evaporation Lagoon B (DP-831)	SSP1	Salt Storage Pond 1(DP-831)
ELC	Evaporation Lagoon C (DP-831)	SSP2	Salt Storage Pond 2 (DP-831)
EUN	Eunice	SSP3	Salt Storage Pond 3 (DP-831)
FWT	Fresh Water Tank	STB	Southeast of Training Building
GSB	Guard and Security Building	SWL	Sewage Lagoon
HBS	Hobbs	SWP 1	Storm Water Pond 1 (DP-831)
HIL	Hill Tank	SWP 2	Storm Water Pond 2 (DP-831)
H2P	H-2 Well Pad	SWP 3	Storm Water Pond 3 (DP-831)
H19	Evaporation Pond H-19 (DP-831)	TUT	Tut Tank
IDN	Indian Tank	UPR	Upper Pecos River
LST	Lost Tank	WA1	WIPP Air Blank 1
LVG	Loving	WA2	WIPP Air Blank 2
LWE	Land Withdrawal East	WA3	WIPP Air Blank 3
MET	Meteorology Tower Building	WA4	WIPP Air Blank 4
MLR	Mills Ranch	WA5	WIPP Air Blank 5
MS5	Mosaic Shaft 5	WEE	WIPP East
NOY	Noya Tank	WFF	WIPP Far Field
PCN	Pierce Canyon	WIP	WIPP 16 Sections
PEC	Pecos River	WNN	WIPP North
PKT	Poker Trap	WSS	WIPP South
PMR	Potash Mines Road		

* A sample of opportunity is taken at a location that may present itself aside from any other named location.

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APPENDIX D – RADIOCHEMICAL EQUATIONS

DETECTION

All radionuclides with the exception of the gamma spectroscopy targets (^{137}Cs, ^{60}Co, and ^{40}K) are considered to be detected in environmental samples if the radionuclide activity or concentration is greater than the minimum detectable concentration and greater than the total propagated uncertainty at the 2 σ level. The gamma radionuclides are considered detected in environmental samples when the above criteria are met and the gamma spectroscopy software used to identify the peak generates an associated identification confidence of 90 percent or greater (identification confidence ≥0.90). If the identification confidence is ≥0.90, the radionuclide may be considered detected even if the sample activity is less than the total propagated uncertainty and/or the minimum detectable concentration.

MINIMUM DETECTABLE CONCENTRATION

The minimum detectable concentration (MDC) is the smallest amount (activity or mass) of a radionuclide in an environmental sample that will be detected with a 5 percent probability of nondetection while accepting a 5 percent probability of erroneously deciding that a positive quantity of a radionuclide is present in an appropriate blank sample. This method assures that any claimed MDC has at least a 95 percent chance of being detected. It is possible to achieve a very low level of detection by analyzing a large sample size and counting for a very long time.

The Waste Isolation Pilot Plant (WIPP) Laboratories use the following equation for calculating the MDCs for each radionuclide in various sample matrices:

$$MDC = \frac{4.66\sqrt{S}}{K\,T} + \frac{3.00}{K\,T}$$

Where:

MDC = Minimum Detectable Concentration

S = net method blank counts. When method blank counts = 0, average of the last 30 blanks analyzed are substituted

K = a correction factor that includes items such as unit conversions, sample volume/weight, decay correction, detector efficiency, chemical recovery, abundance correction, etc.

T = counting time where the background and sample counting time are identical.

For further evaluation of the MDC, refer to ANSI N13.30, *Performance Criteria for Radiobioassay*.

TOTAL PROPAGATED UNCERTAINTY

The total propagated uncertainty (TPU) is an estimate of the uncertainty in the measurement due to all sources, including counting error, measurement error, chemical recovery error, detector efficiency, randomness of radioactive decay, and any other sources of uncertainty.

The TPU for each data point must be reported at the 2 σ level (2 σ TPU). For further discussion of TPU, refer to ANSI N13.30.

RELATIVE ERROR RATIO

The relative error ratio (RER) is a method, similar to a t-test, with which to compare duplicate results (see Chapters 4 and 7, and WP 02–EM3004, *Radiological Data Verification and Validation*).

$$\mathrm{RER} = \frac{(Activity)pri - (Activity)dup}{\sqrt{(1\sigma TPU)^2 pri + (1\sigma TPU)^2 dup}}$$

Where:

RER	=	Relative Error Ration
(Activity)^{pri}	=	mean activity of the primary sample
(Activity)^{dup}	=	mean activity of the duplicate sample
1σTPU	=	total propagated uncertainty at the 1 σ level.

PERCENT BIAS

The percent bias is a measure of the accuracy of radiochemical separation methods and counting instruments, that is, a measure of how reliable the results of analyses are when compared to the actual values.

$$\%\ BIAS = \frac{(A_m - A_k)}{A_k} \times 100$$

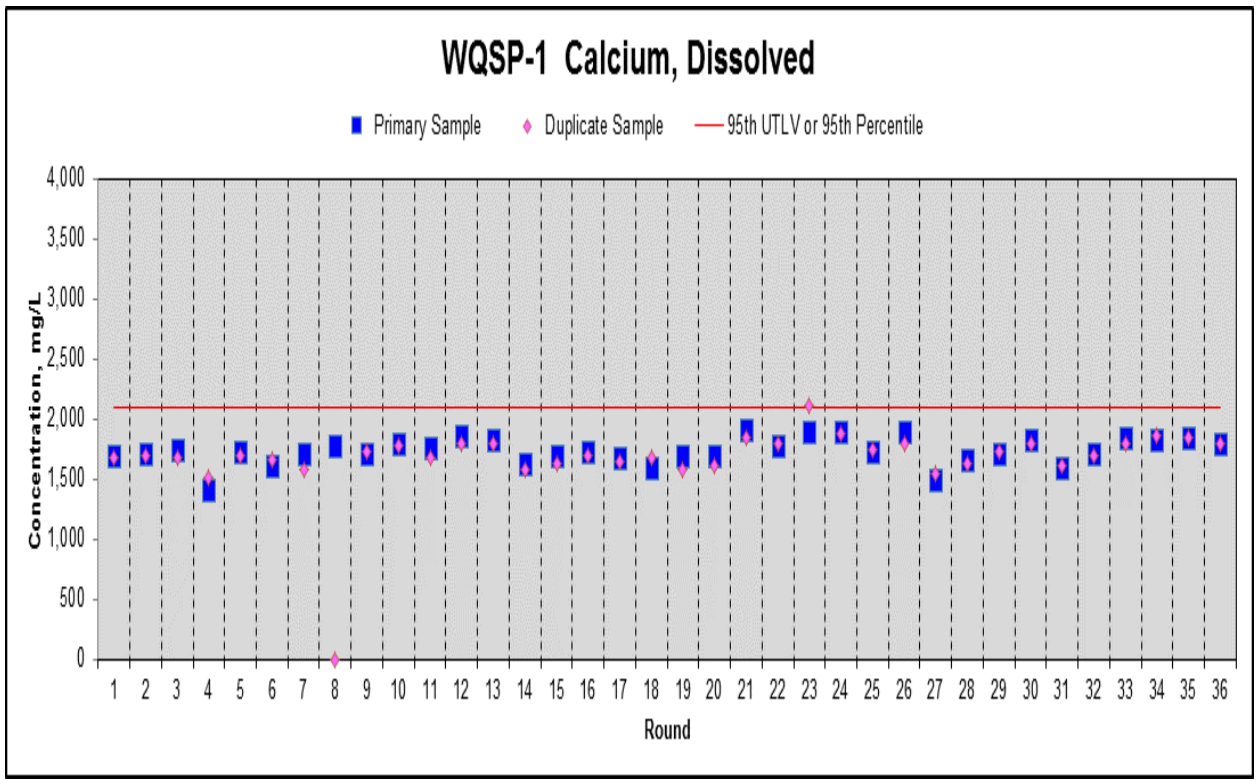
Where:

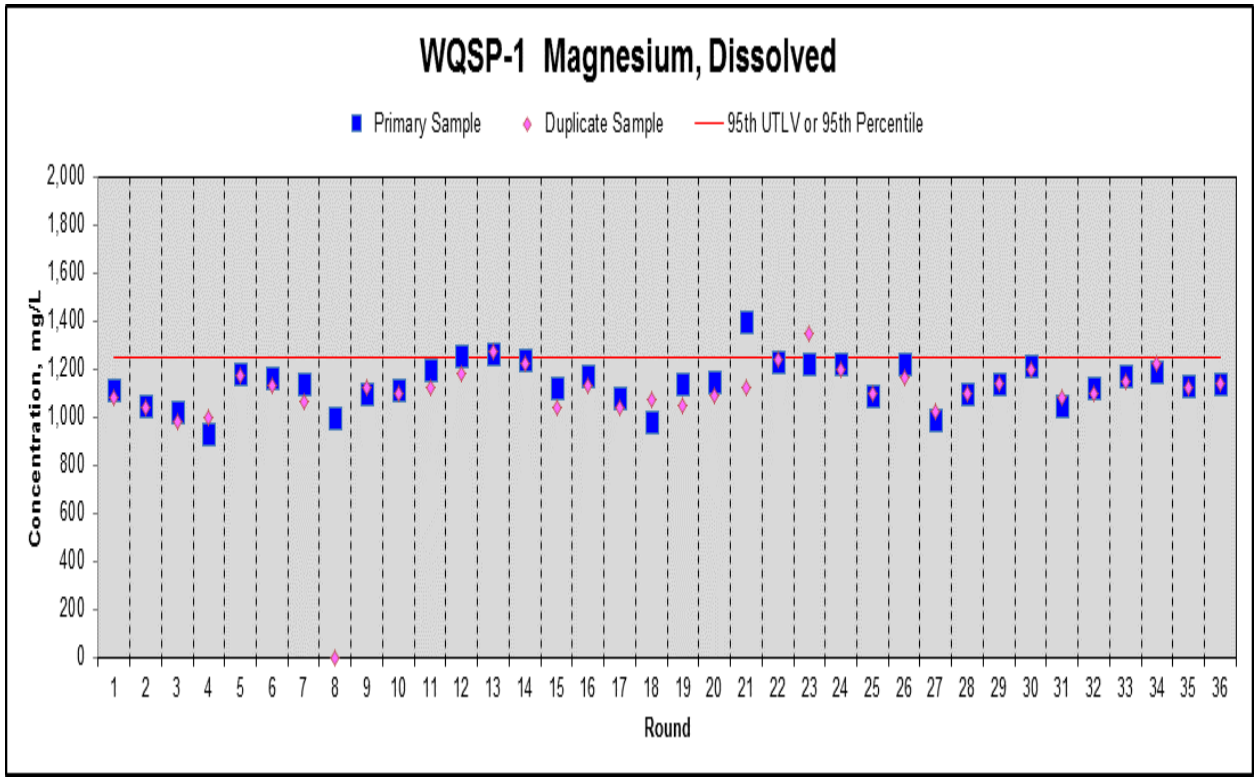
% BIAS	=	percent bias
Am	=	measured sample activity
Ak	=	known sample activity.

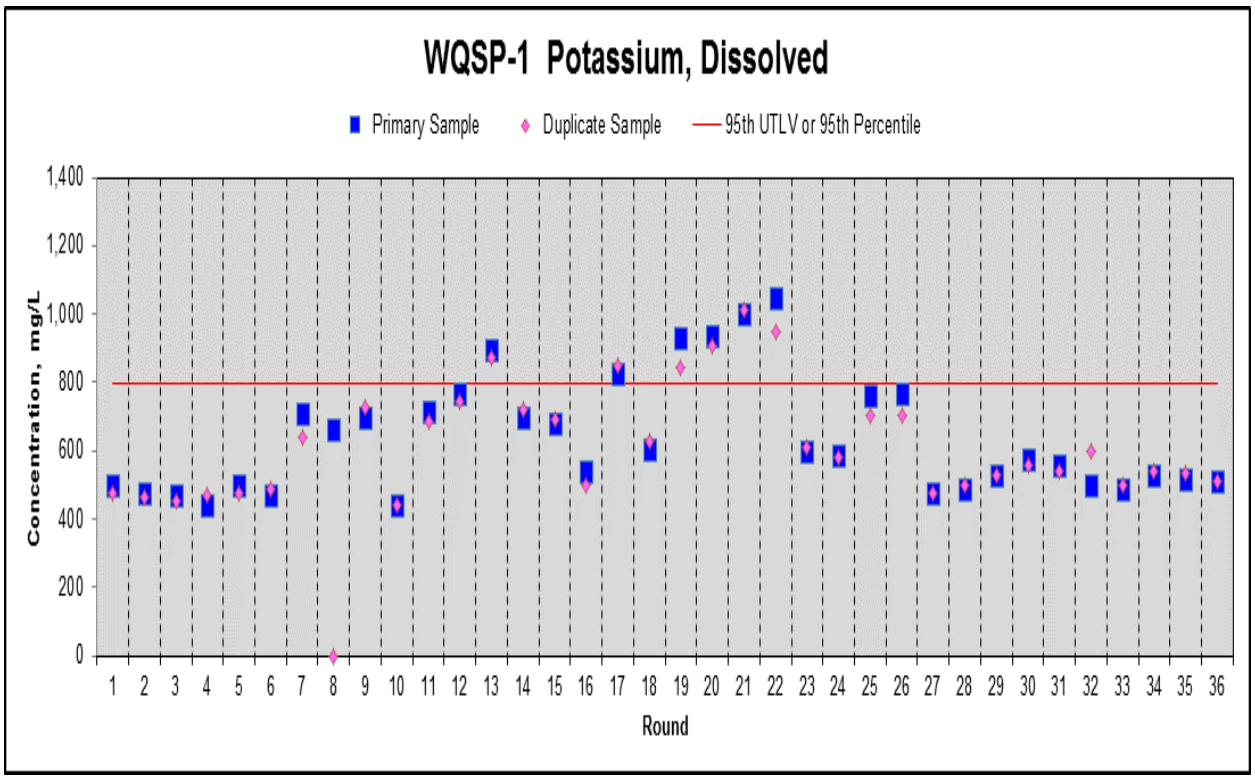
APPENDIX E – TIME TREND PLOTS FOR MAIN PARAMETERS IN GROUNDWATER

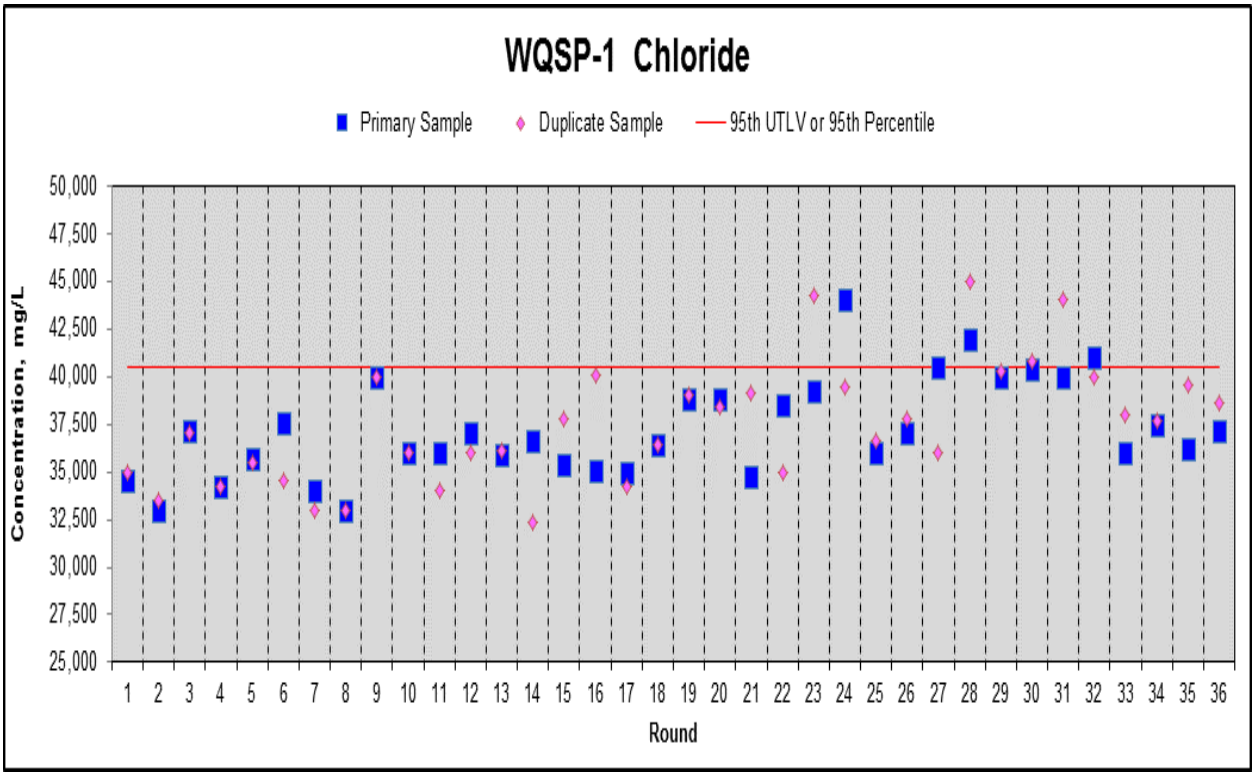
The first 10 sampling rounds were conducted from 1995 through 2000 (prior to receiving mixed waste at the Waste Isolation Pilot Plant [WIPP] site) and were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample sets are used to determine whether statistically significant changes have occurred at any well. Time trend plots are provided below for the following general chemistry indicator parameters: dissolved calcium, chloride, dissolved magnesium, pH, dissolved potassium, sulfate, and TDS. These plots show the concentrations in the primary sample and the duplicate sample for all sampling rounds.

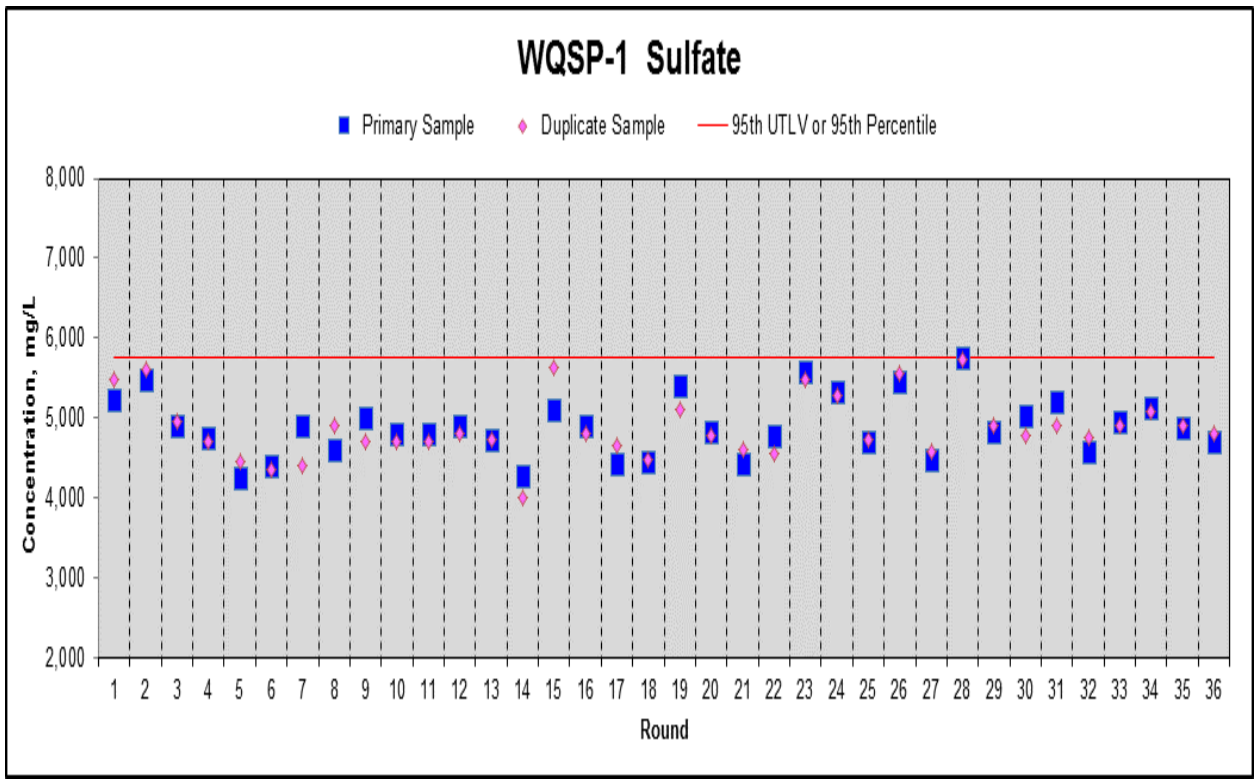
The 2014 laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. Environmental Protection Agency technical guidance. Sampling Round 36 samples were taken March through May 2014. See Appendix F for the concentrations of the target analytes in the detection monitoring wells.

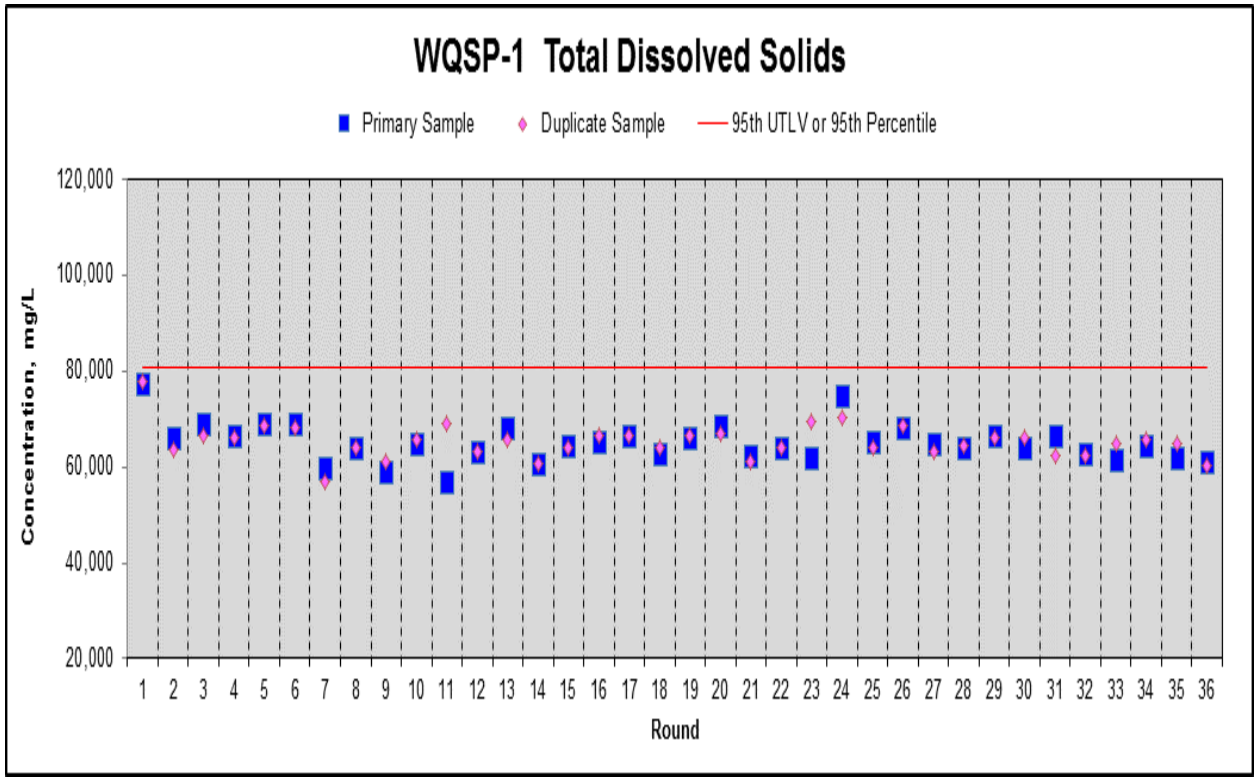

WQSP-1 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

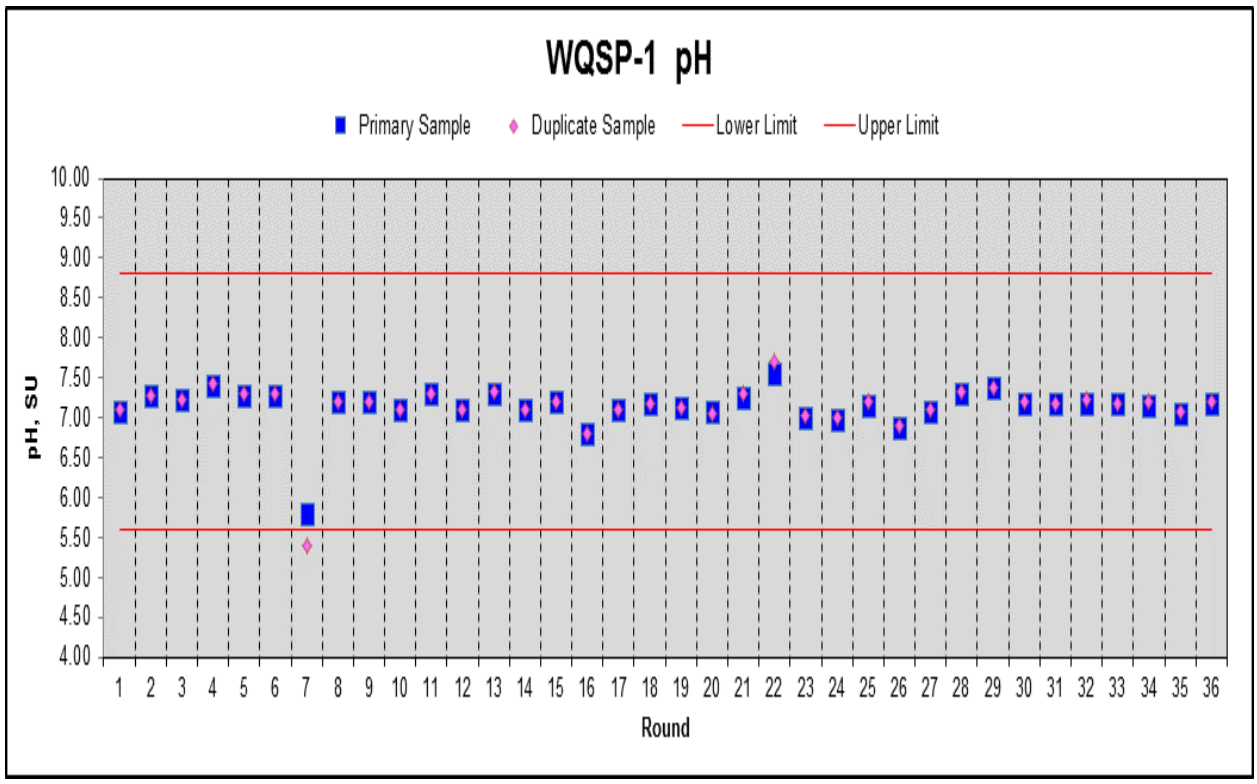

WQSP-1 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

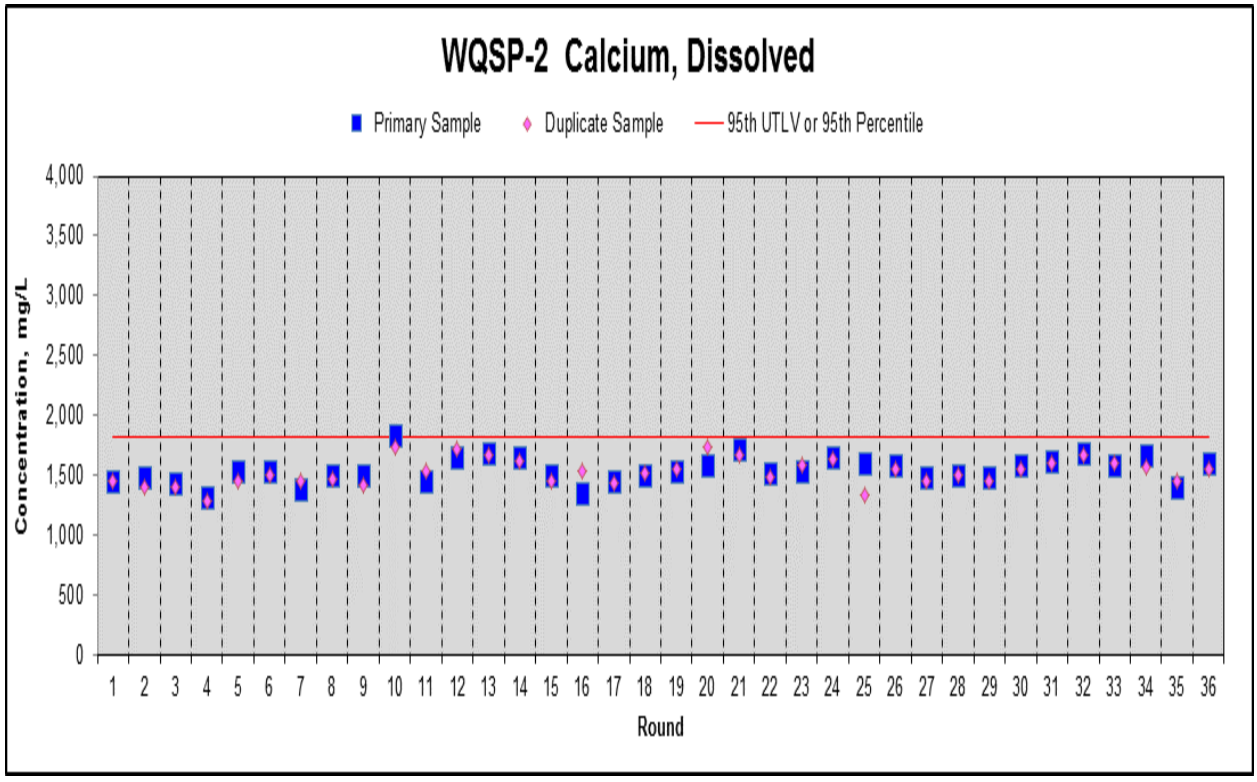

WQSP-1 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

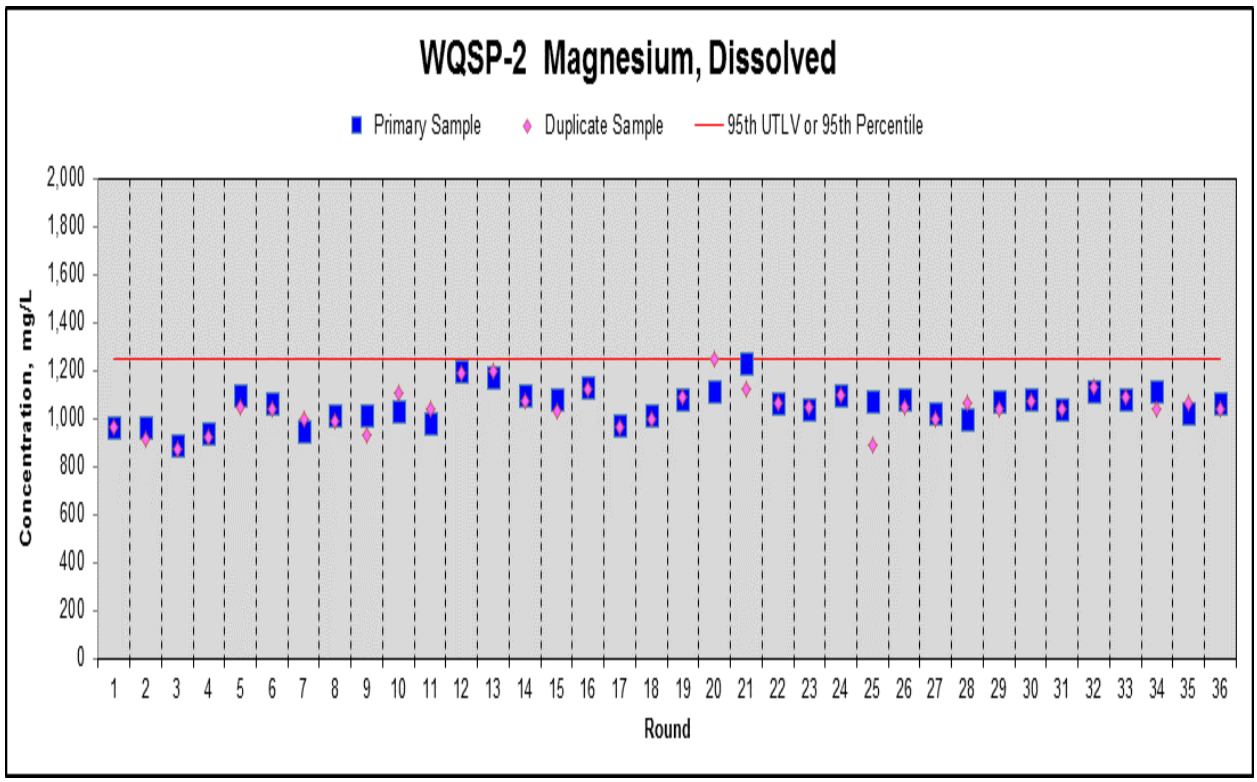

WQSP-1 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

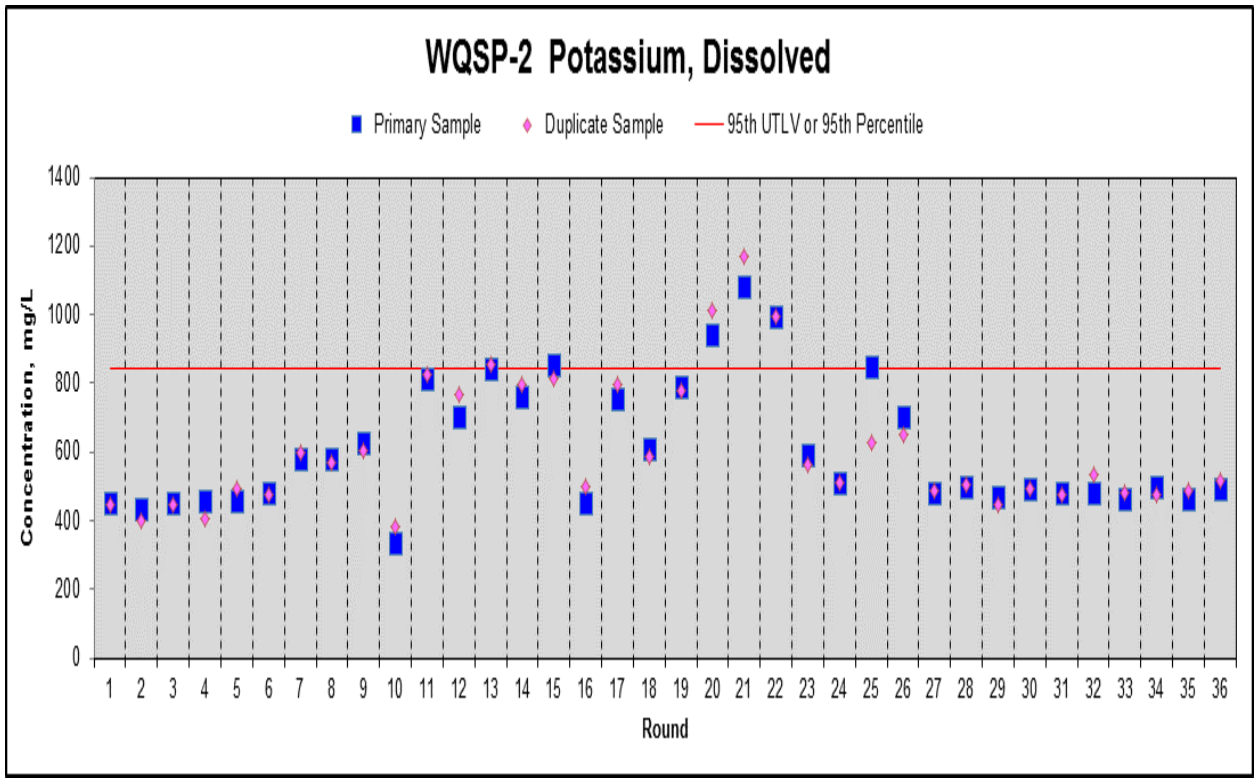

WQSP-1 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

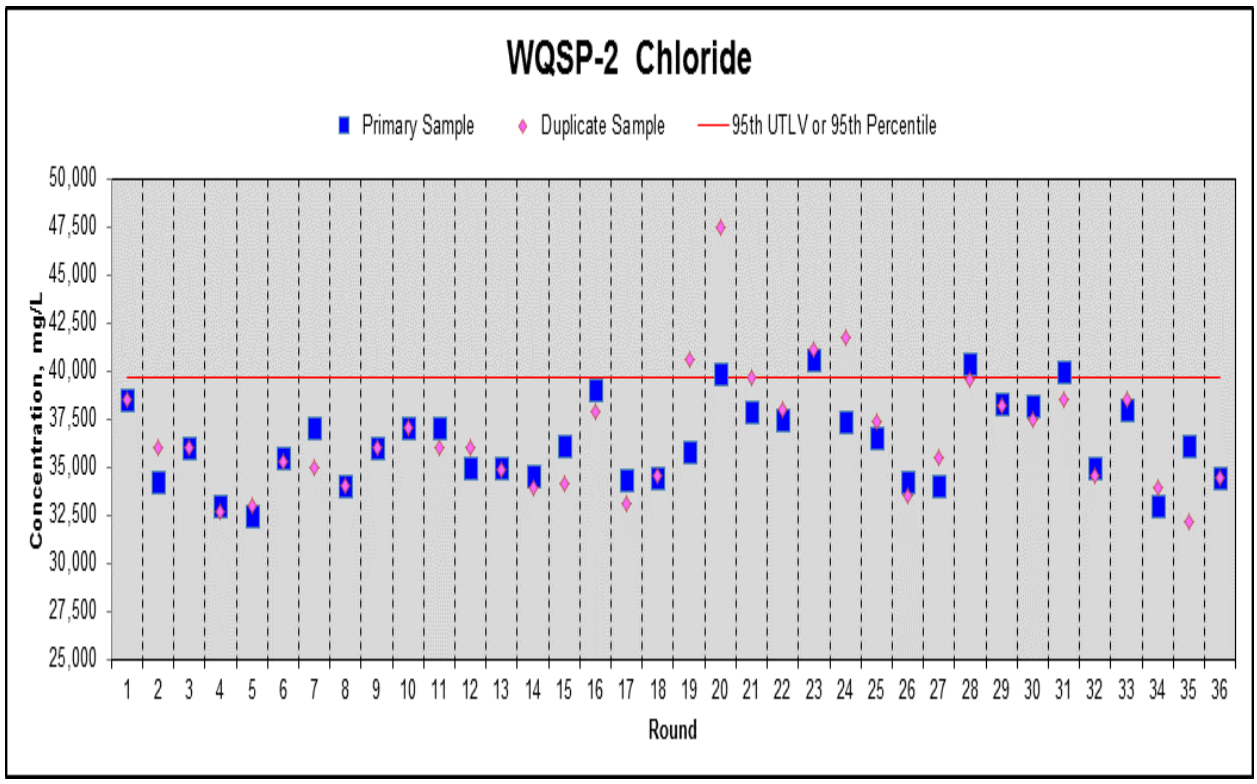

WQSP-1 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

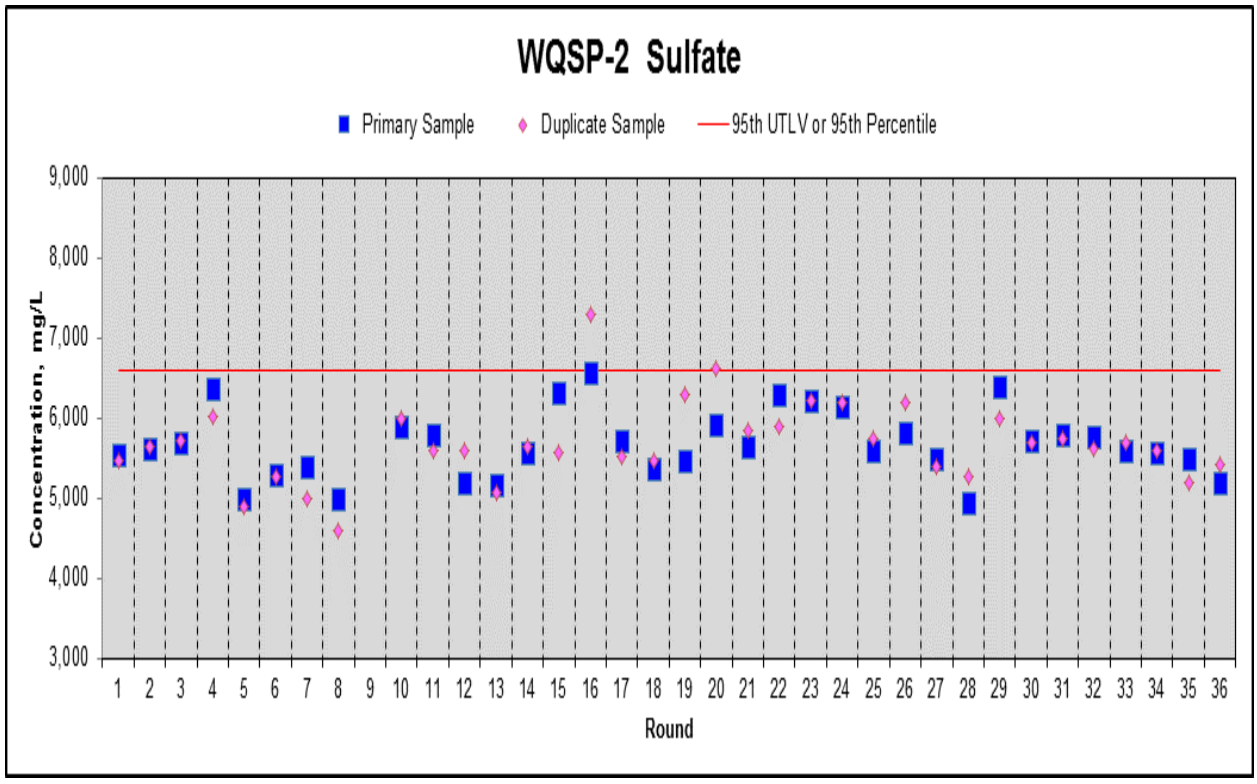

WQSP-1 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

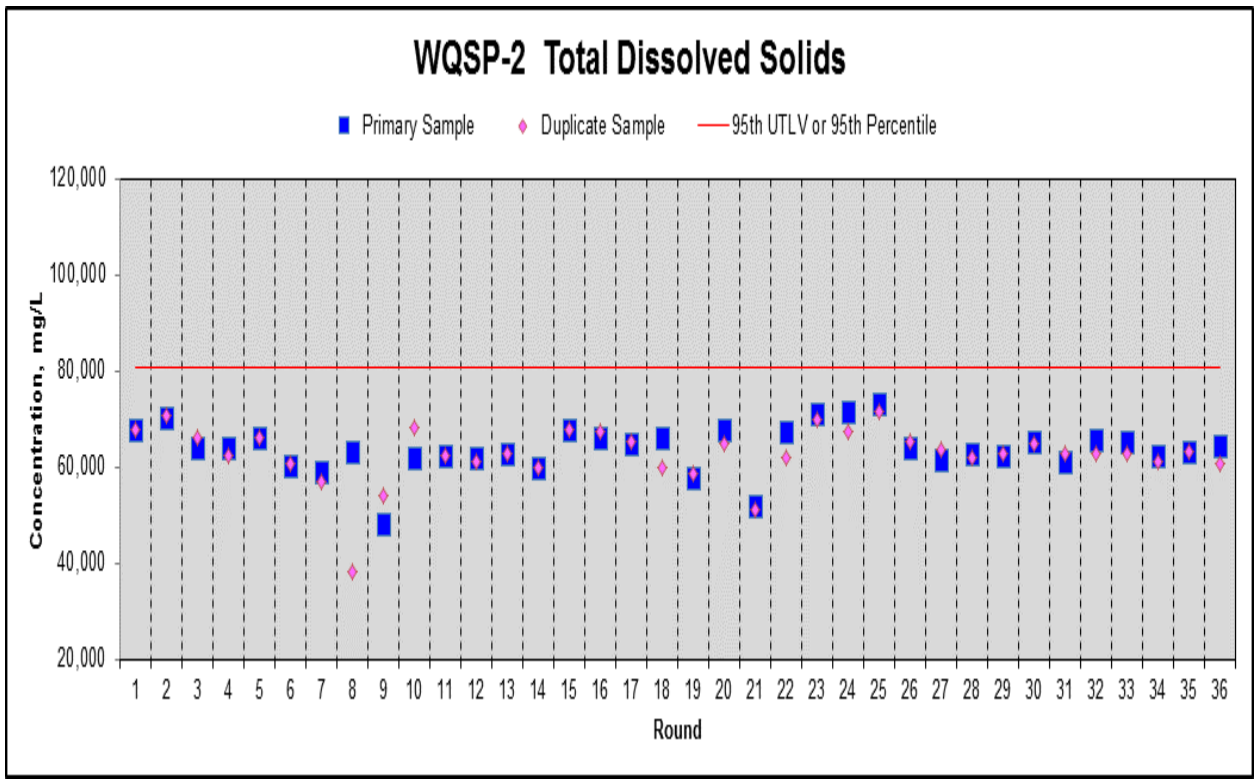

WQSP-2 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

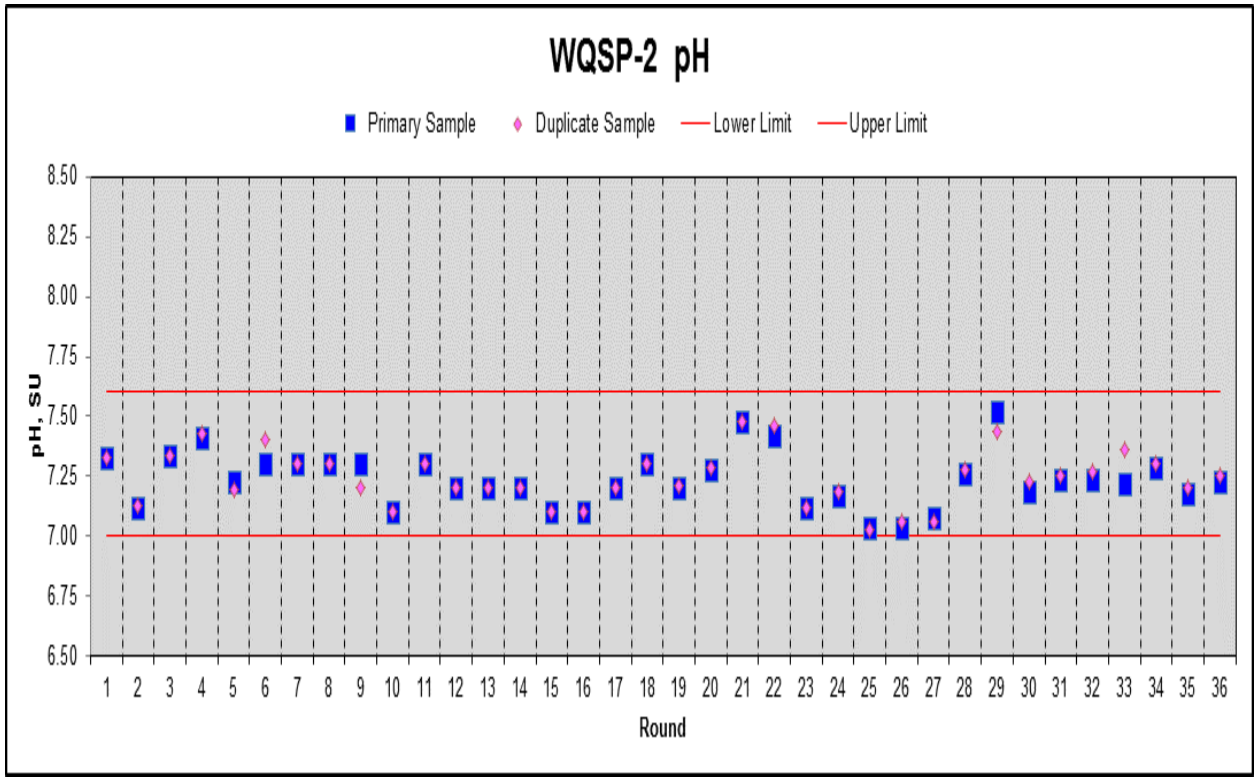

WQSP-2 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

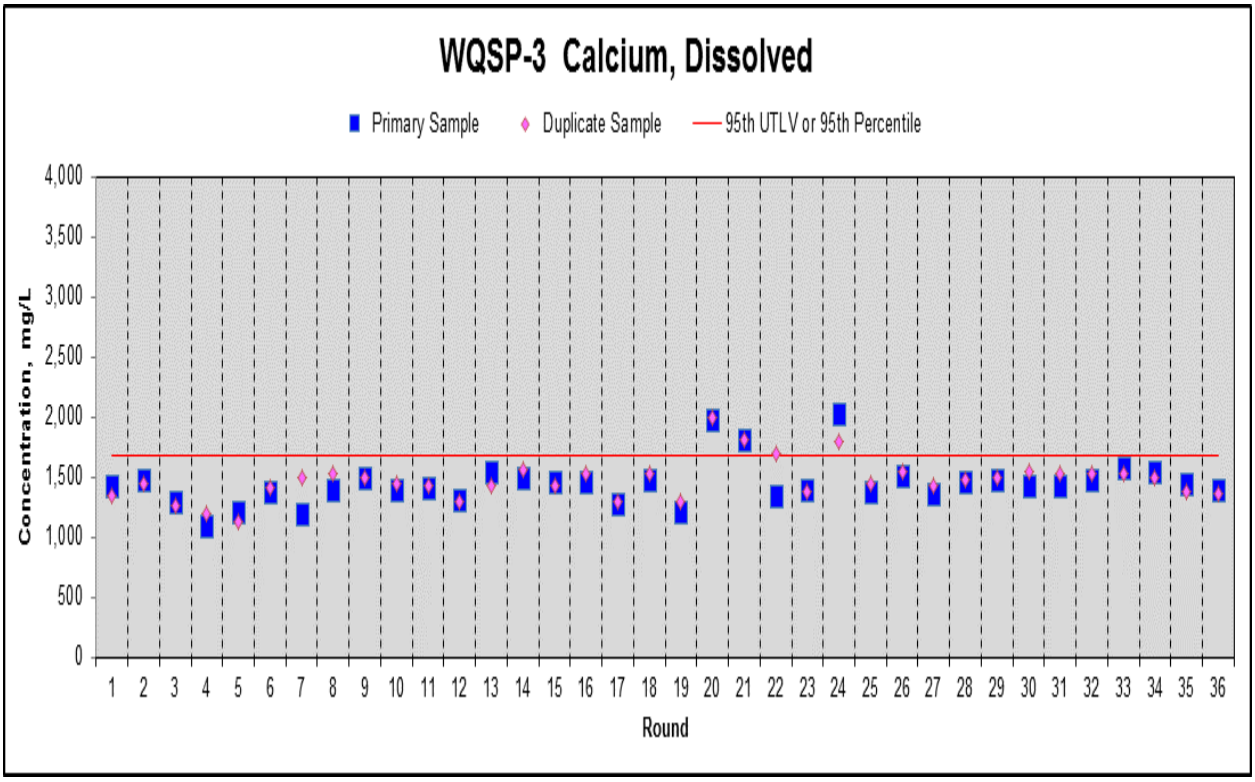

WQSP-2 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

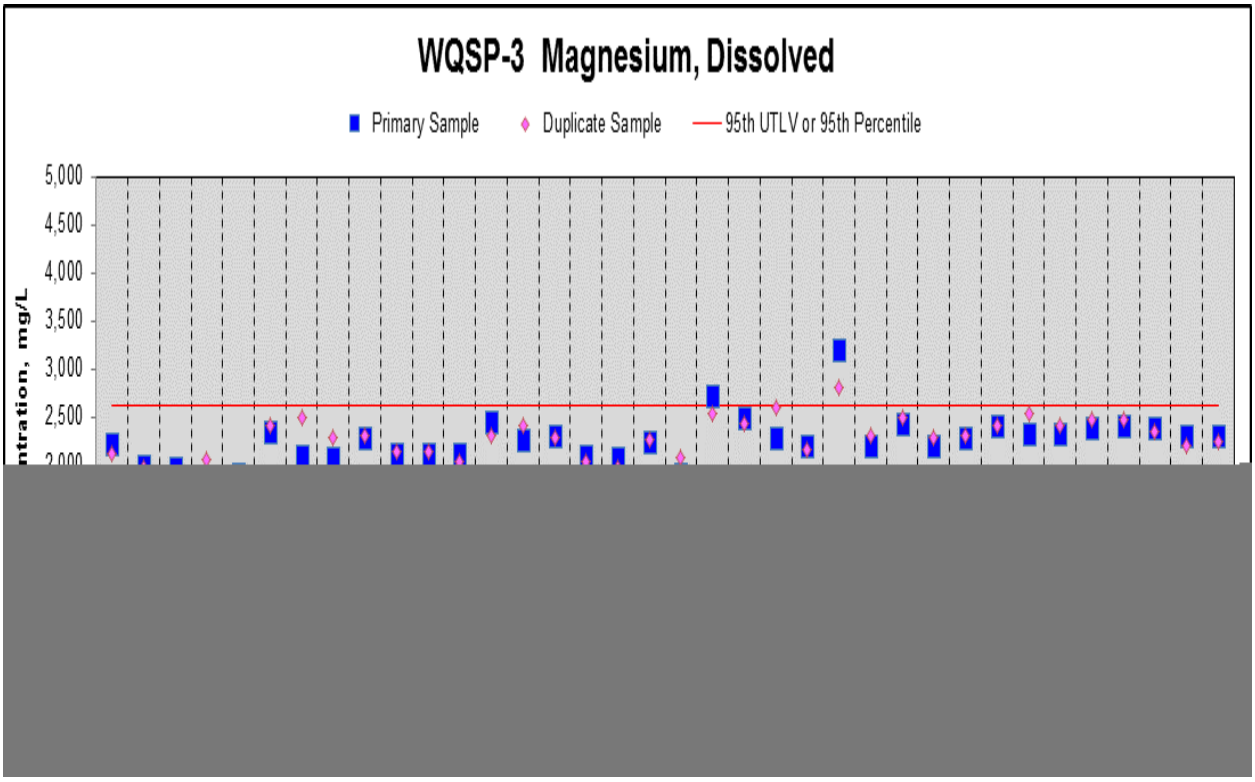

WQSP-2 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

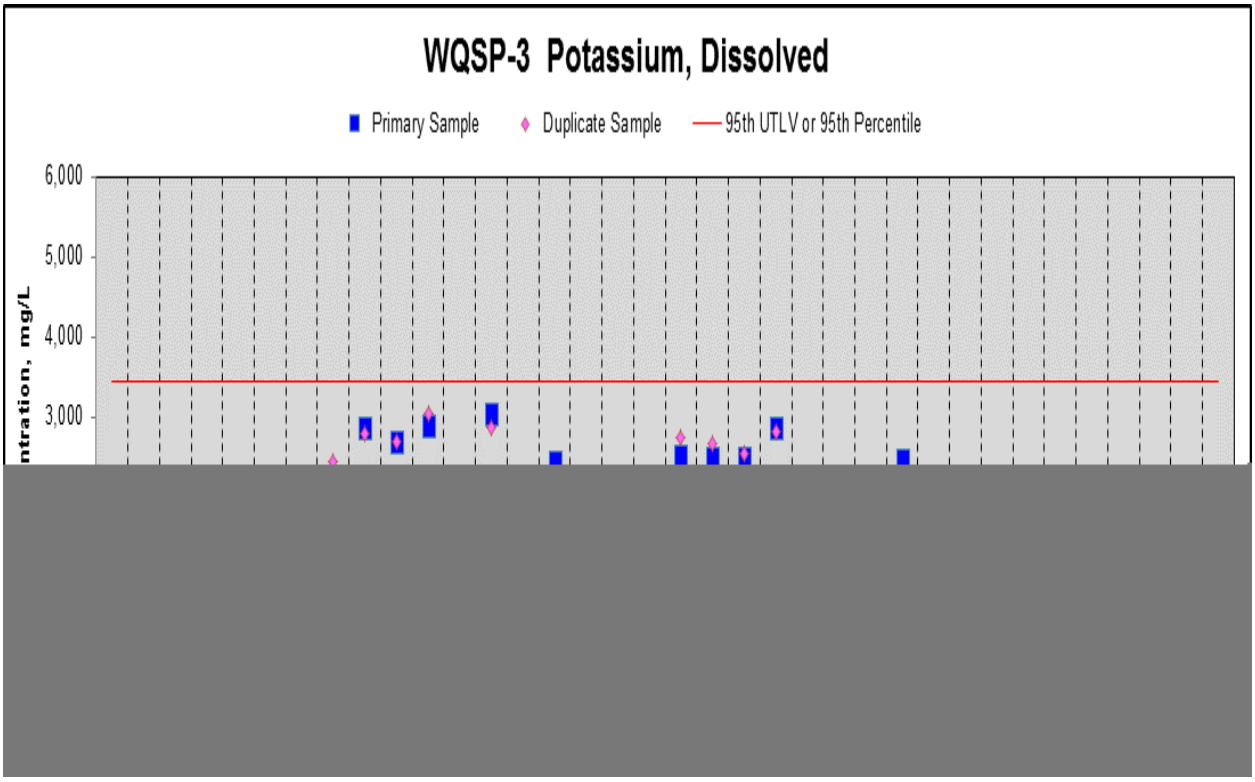

WQSP-2 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
9,000
8,000
7,000
6,000
5,000
4,000
3,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

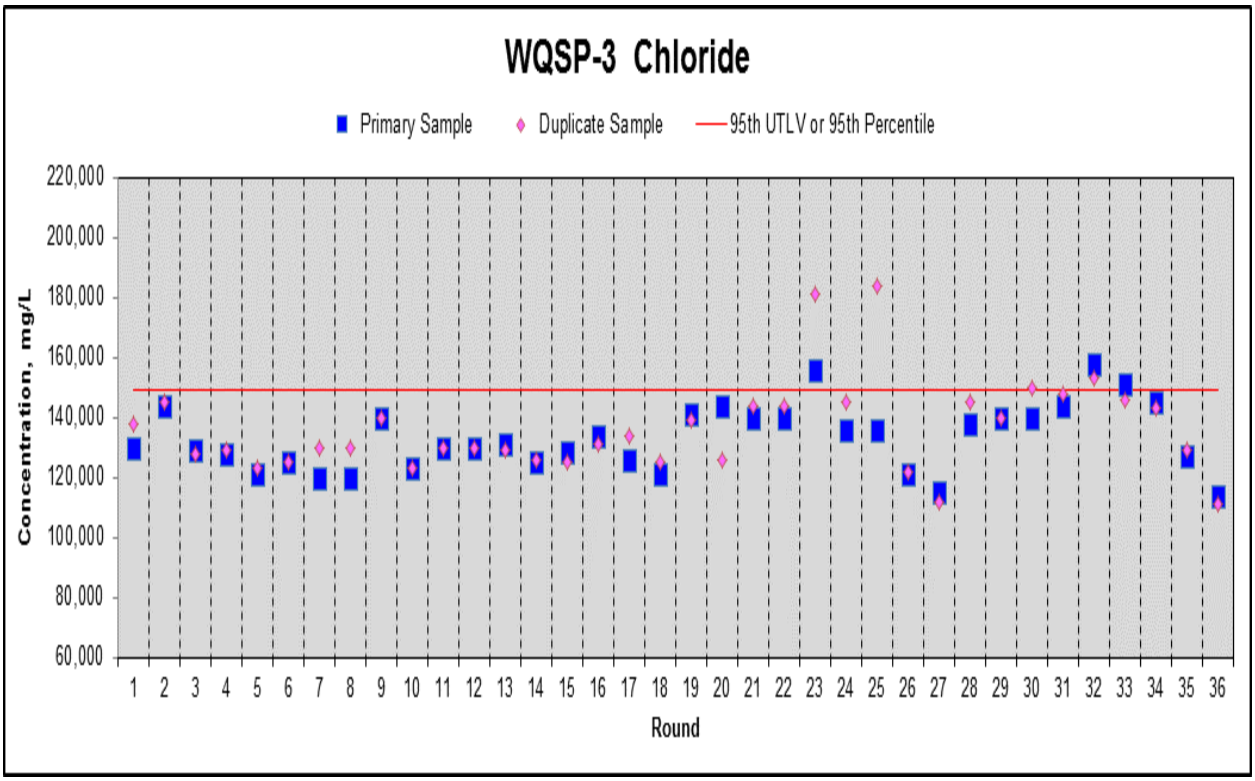

WQSP-2 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

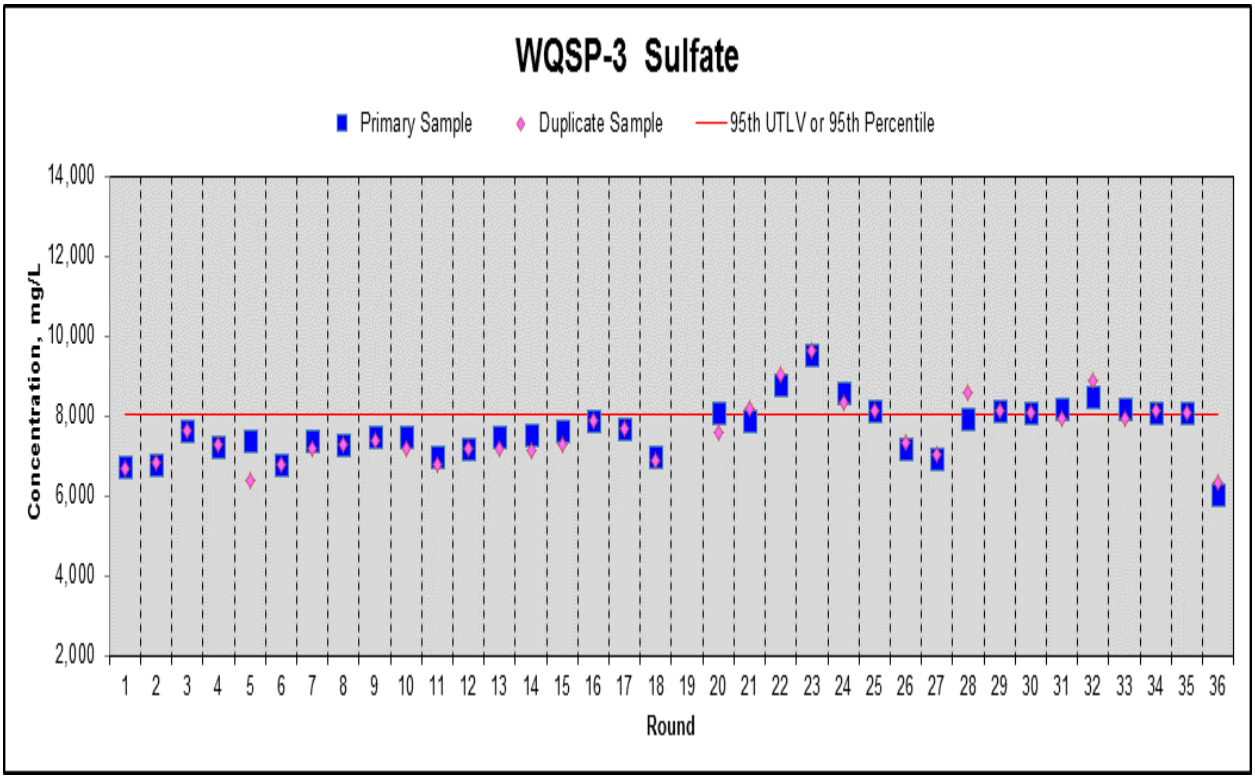

WQSP-2 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

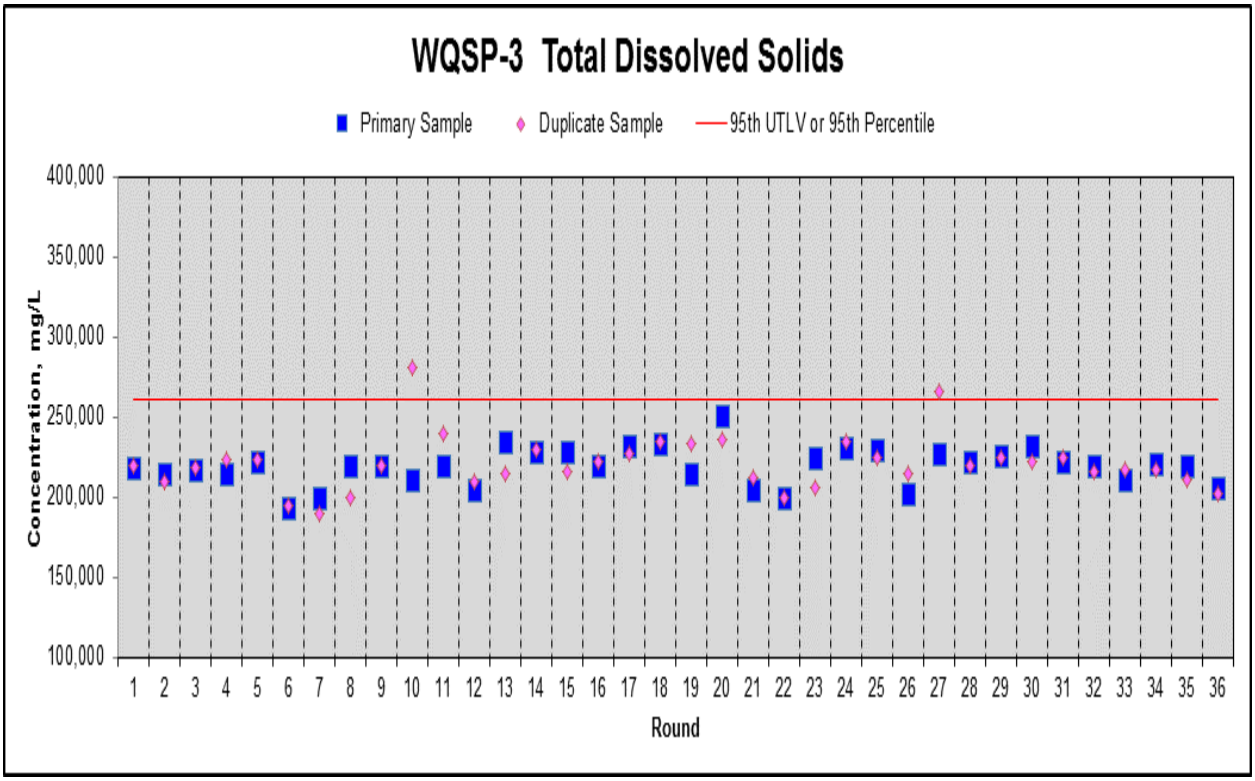

WQSP-3 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

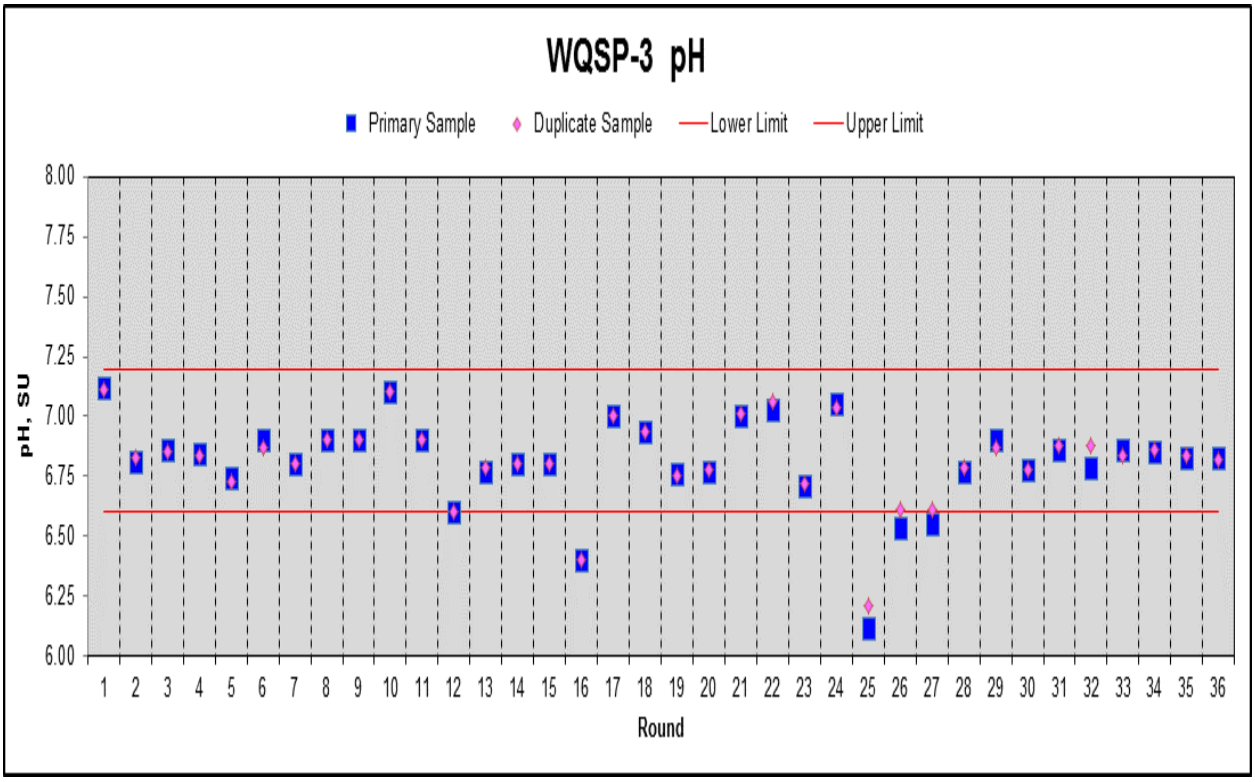

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
5,000
4,500
4,000
3,500
3,000
2,500

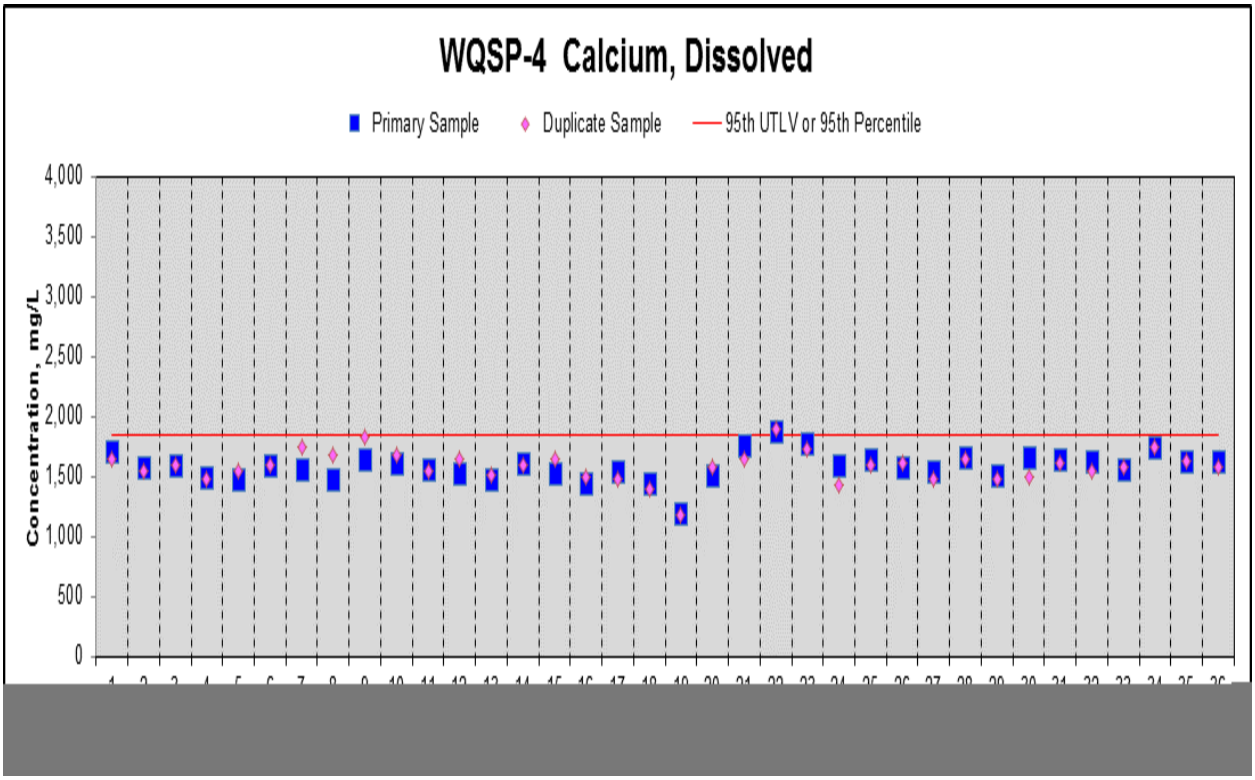

WQSP-3 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
6,000
5,000
4,000
3,000
ntration, mg/L

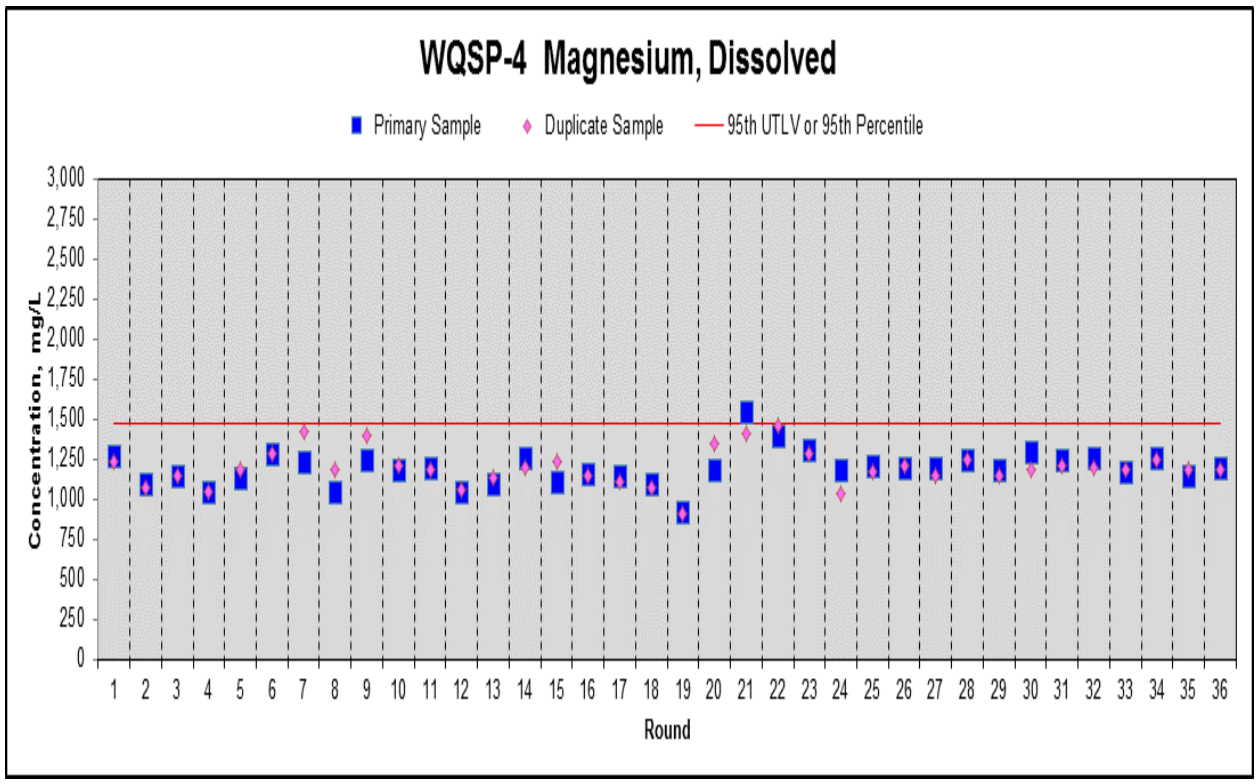

WQSP-3 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
Concentration, mg/L
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

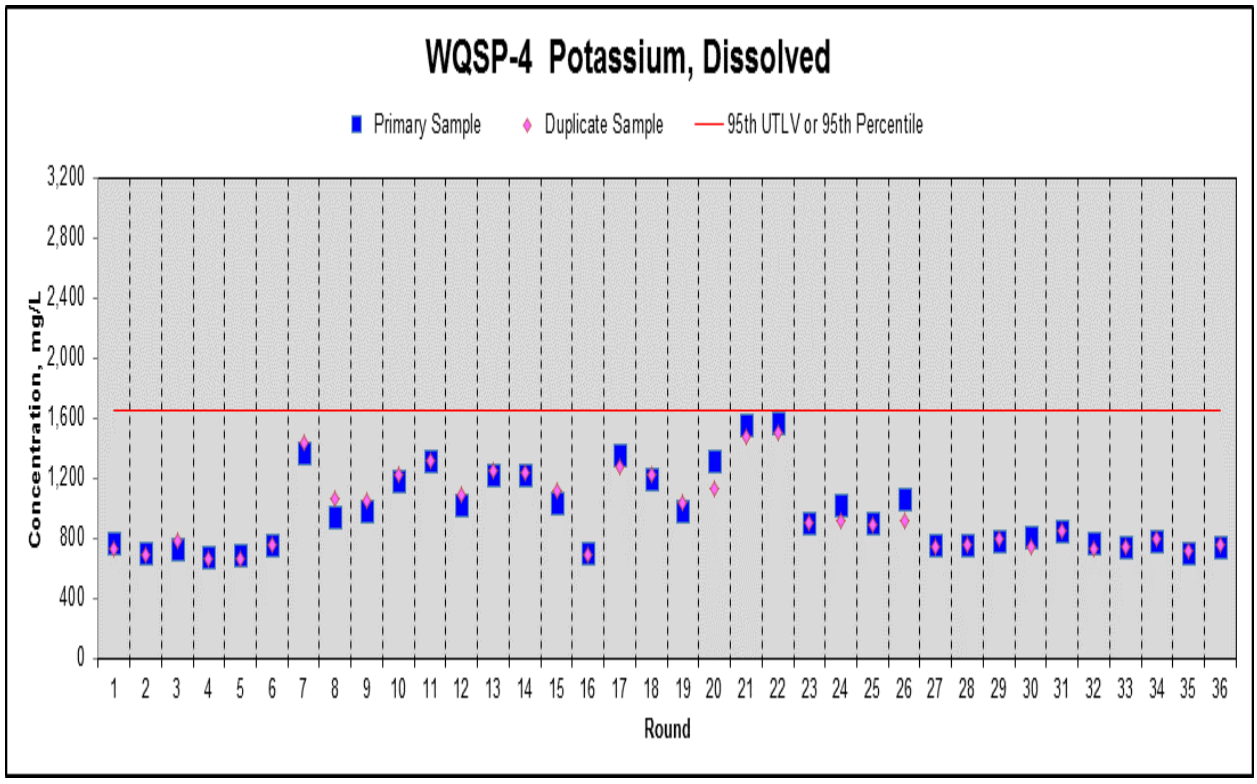

WQSP-3 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

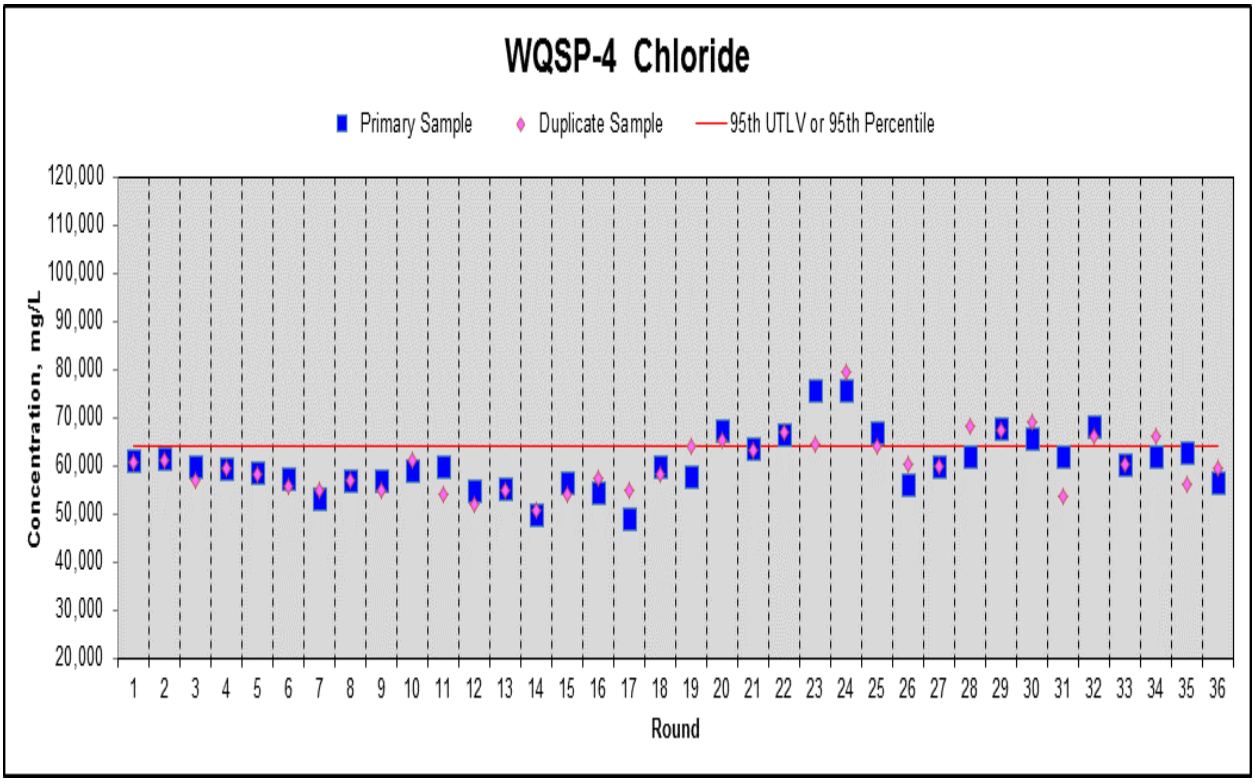

WQSP-3 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
400,000
350,000
300,000
250,000
200,000
150,000
100,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

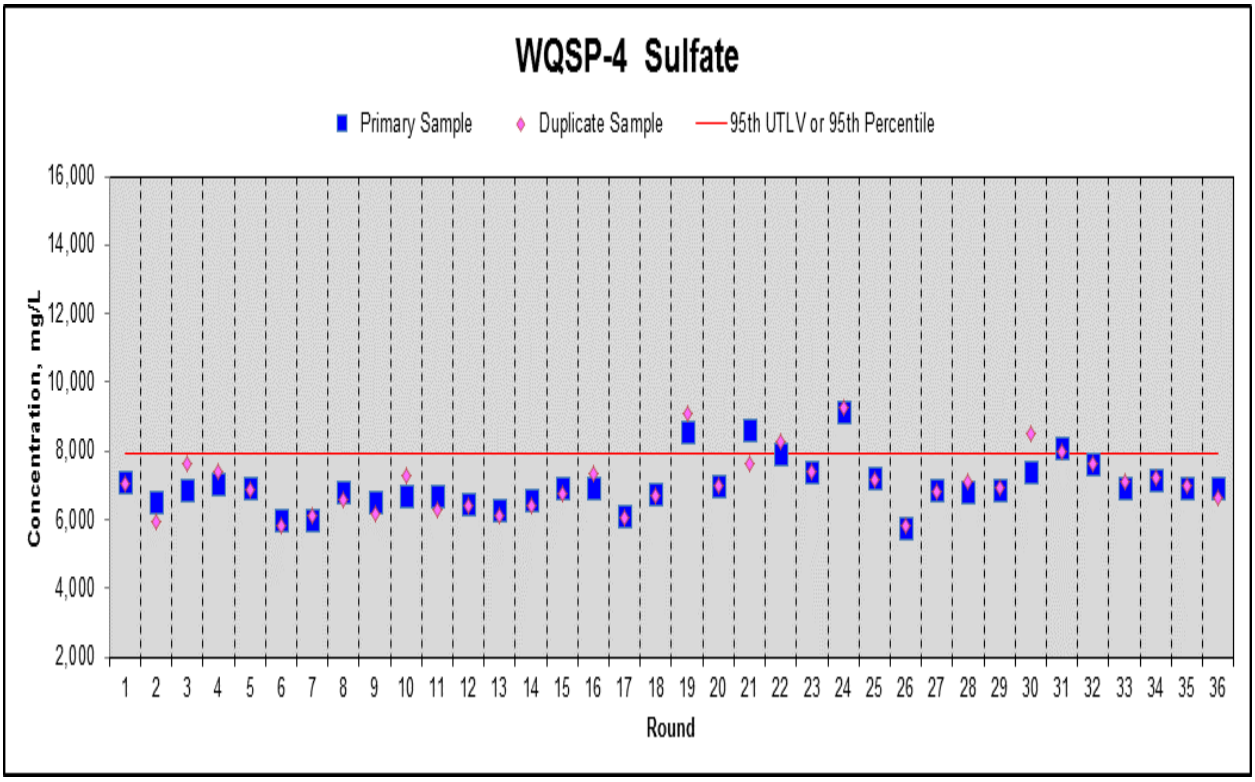

WQSP-3 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

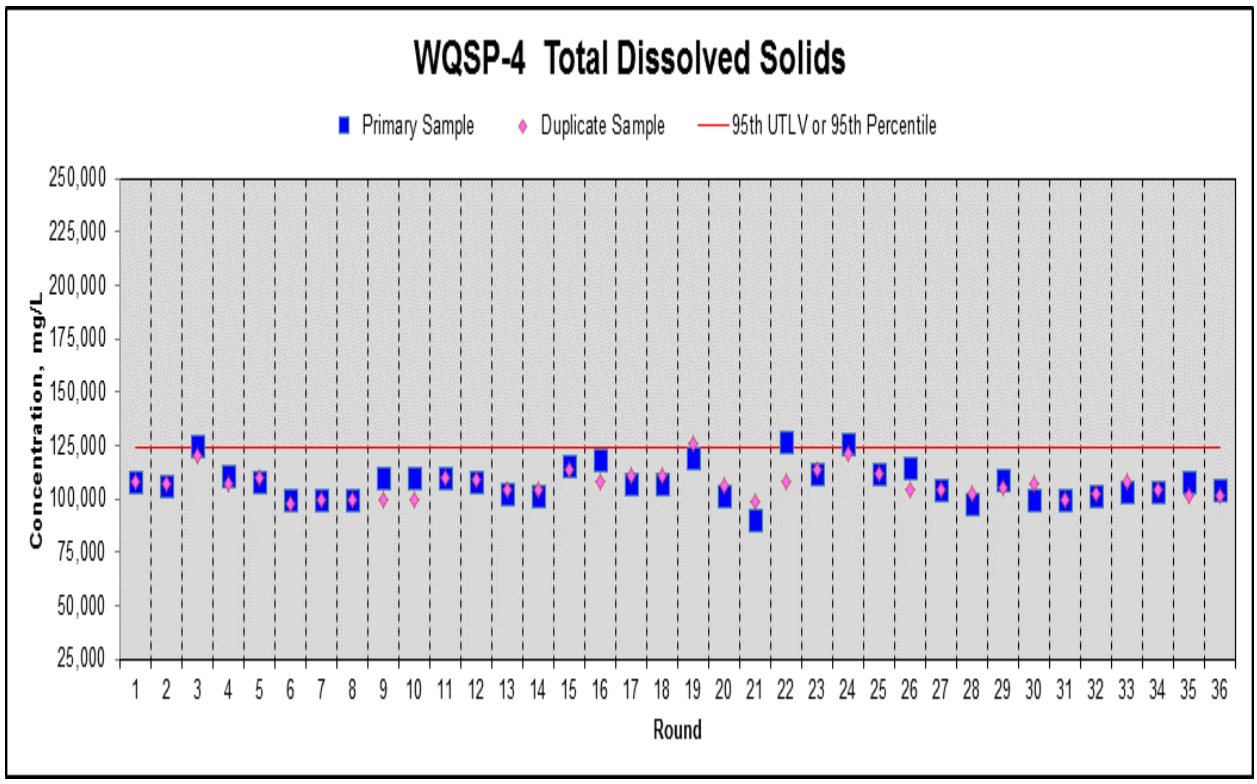

WQSP-4 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0

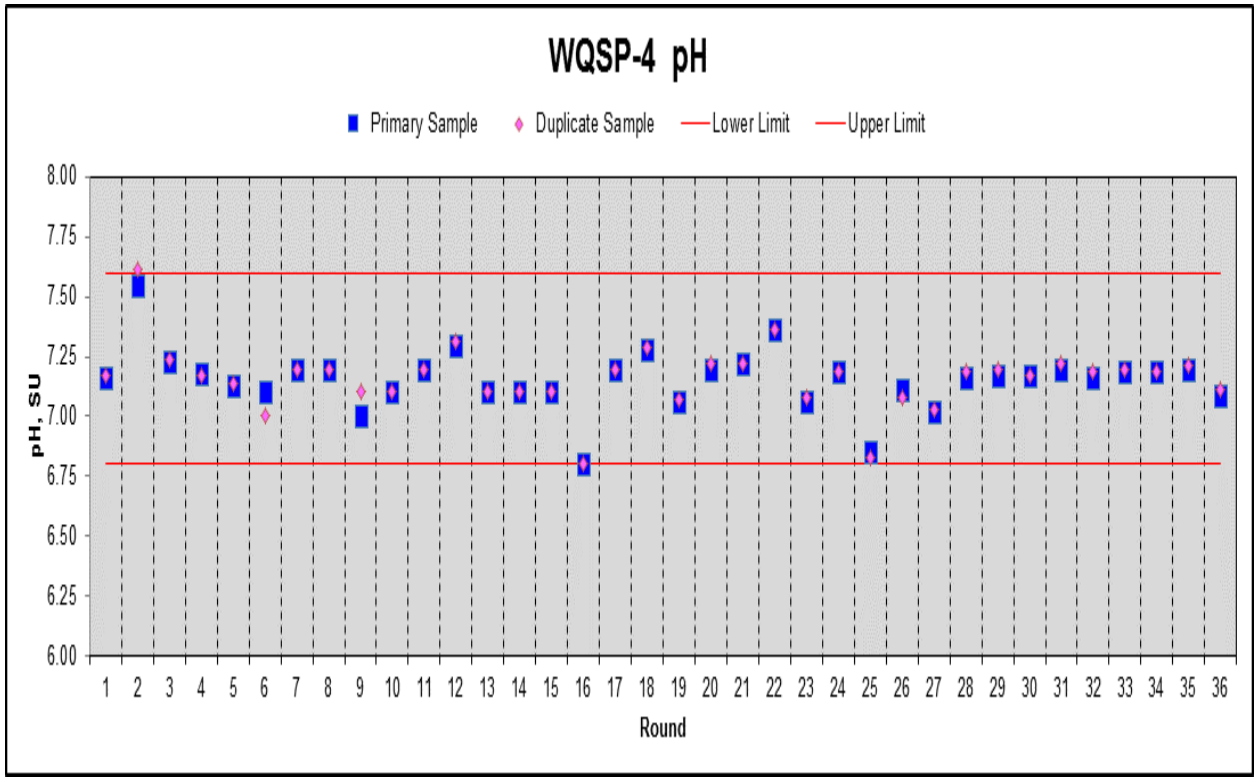

WQSP-4 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

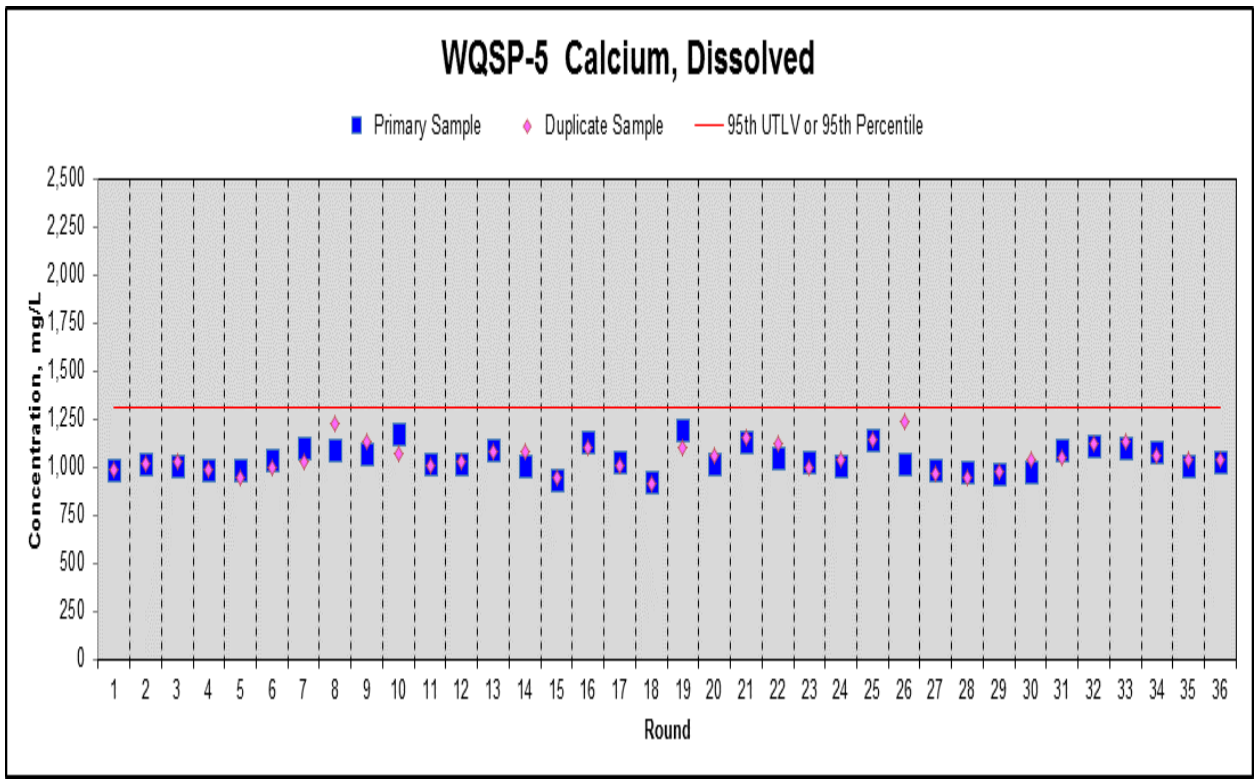

WQSP-4 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

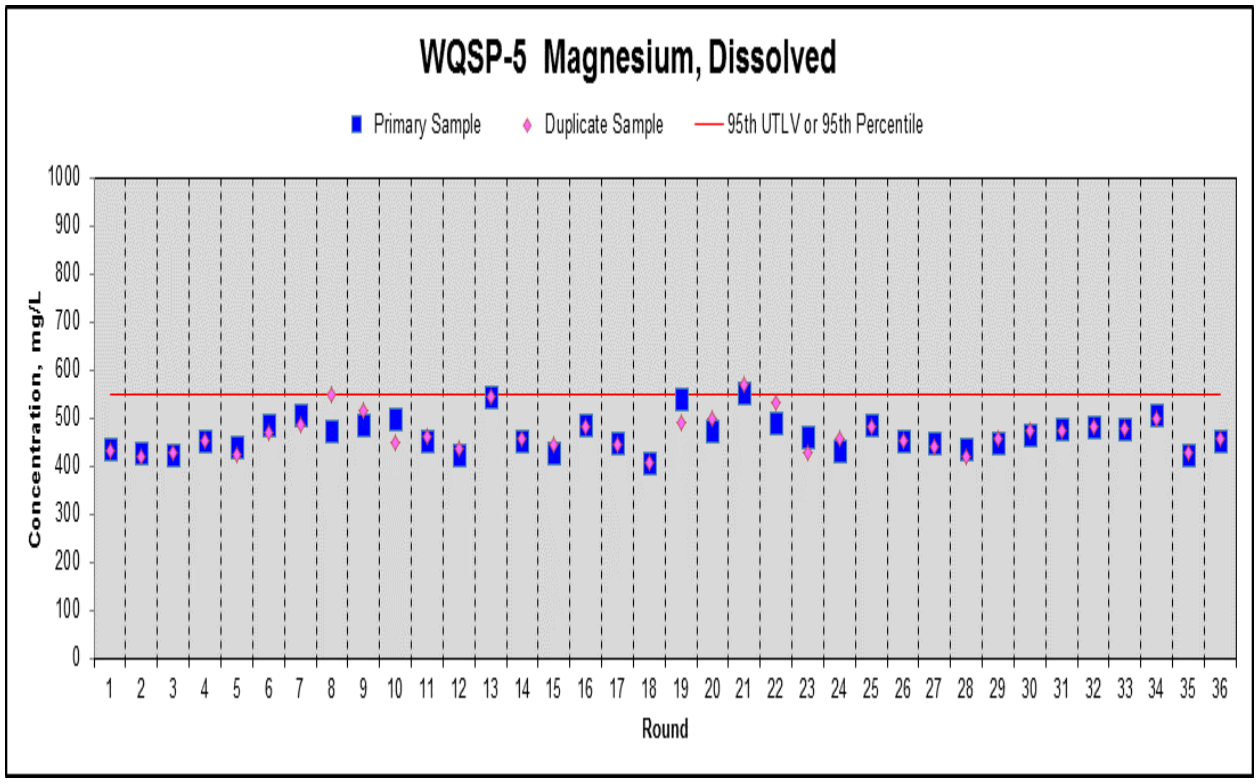

WQSP-4 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

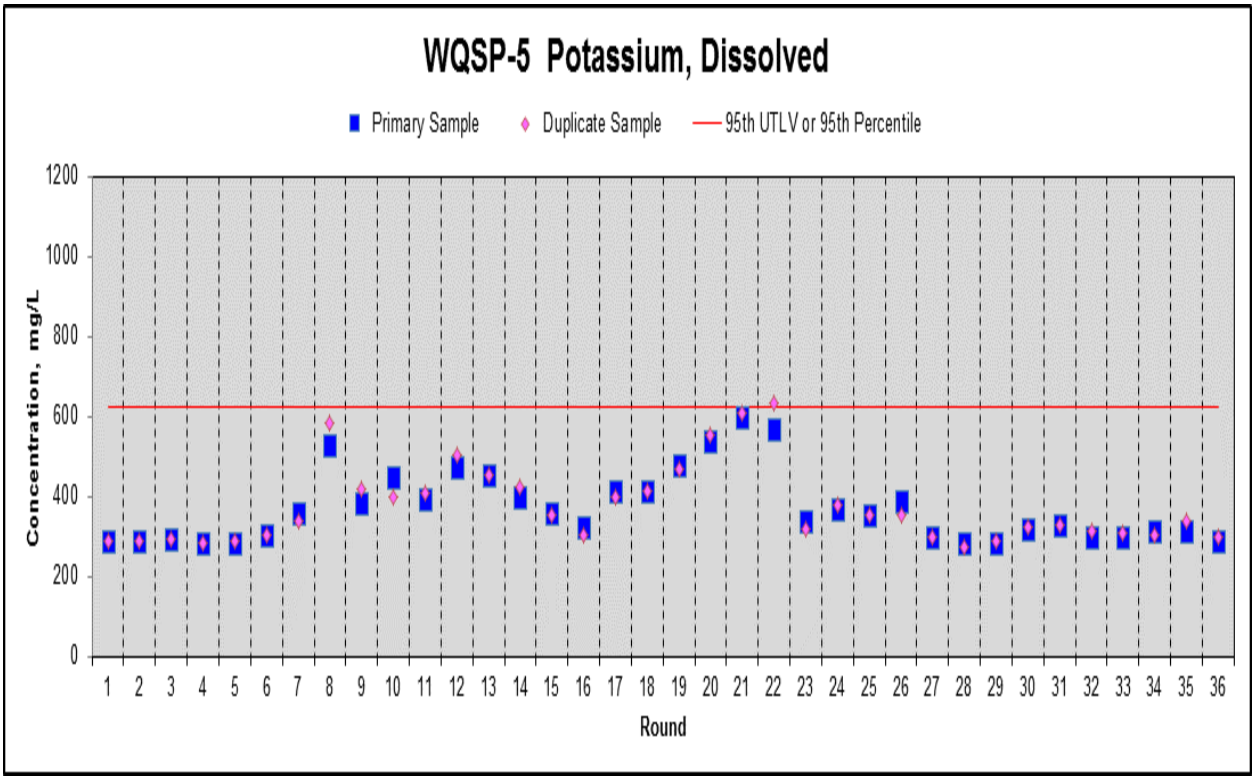

WQSP-4 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

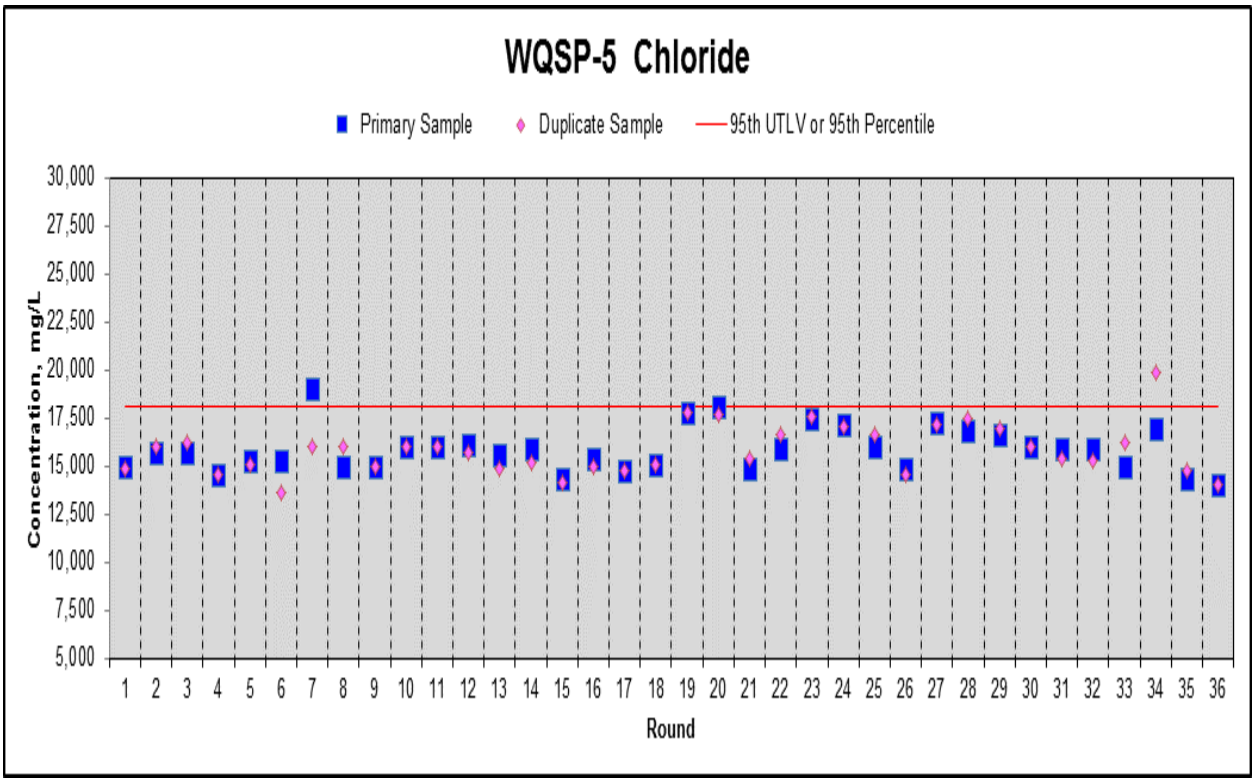

WQSP-4 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

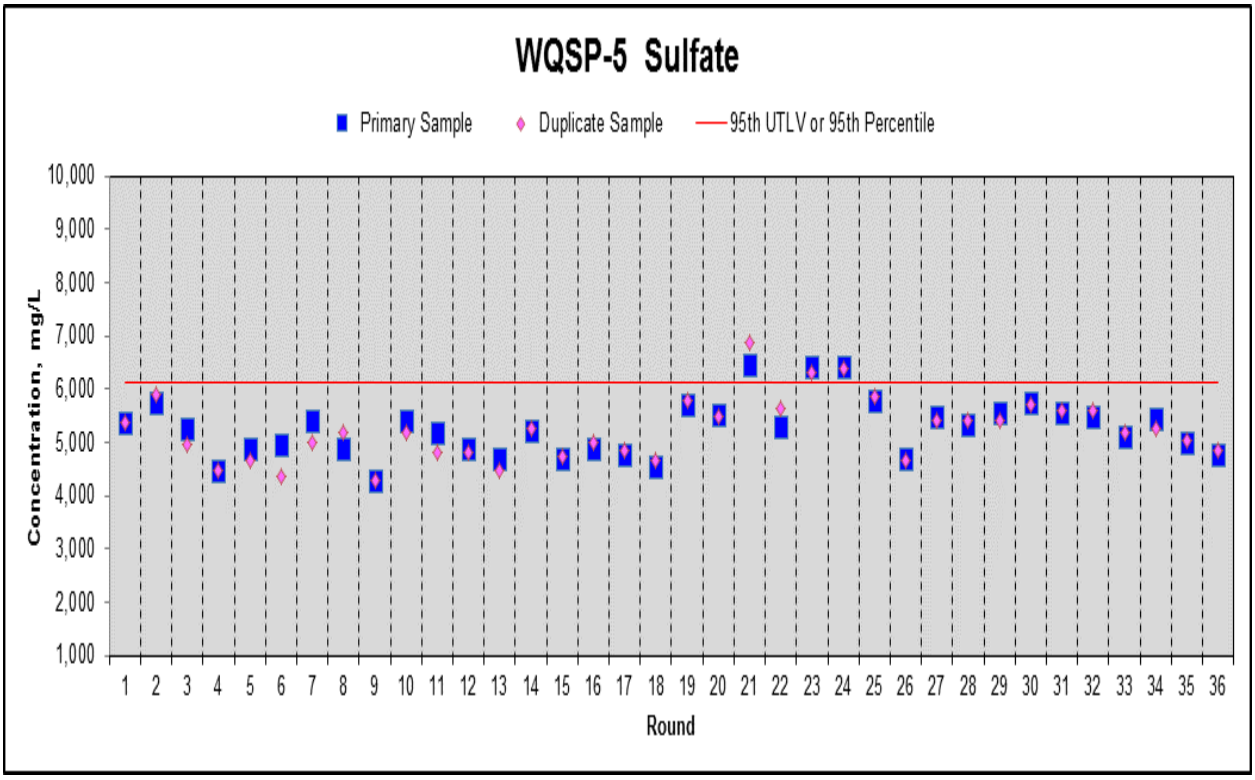

WQSP-4 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

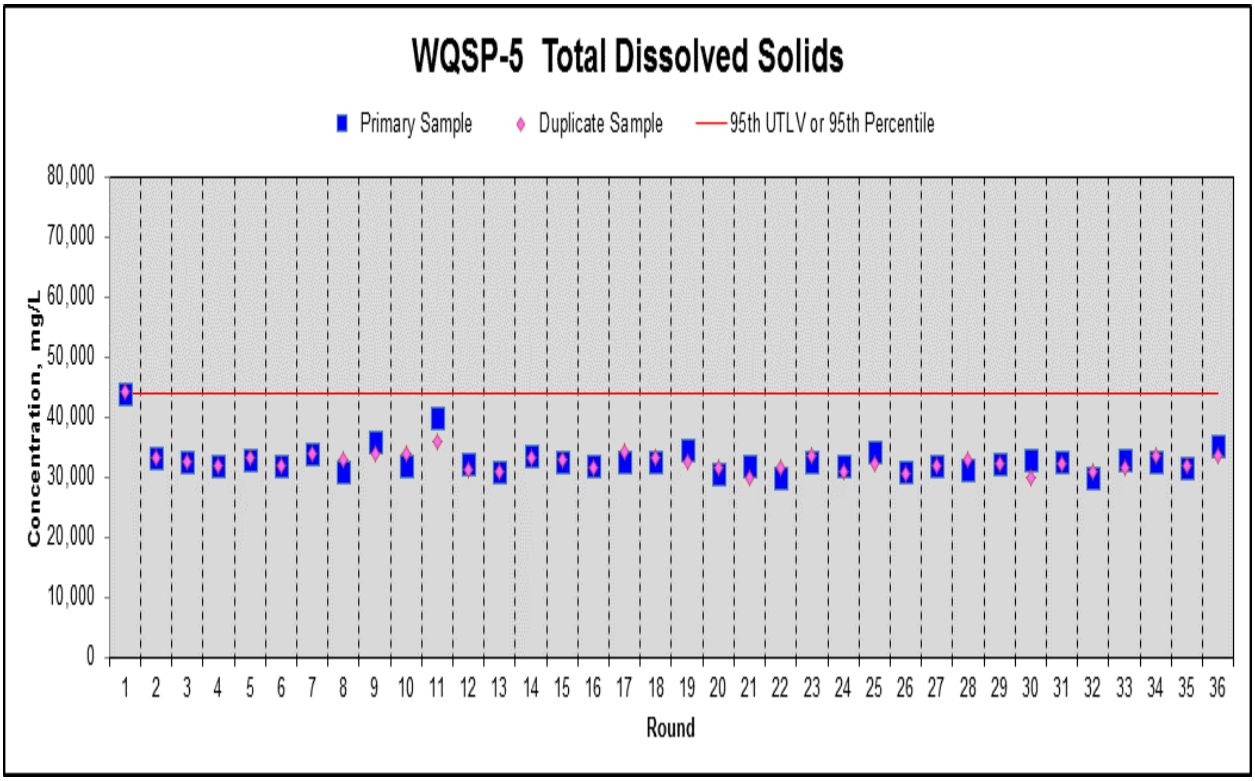

WQSP-5 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

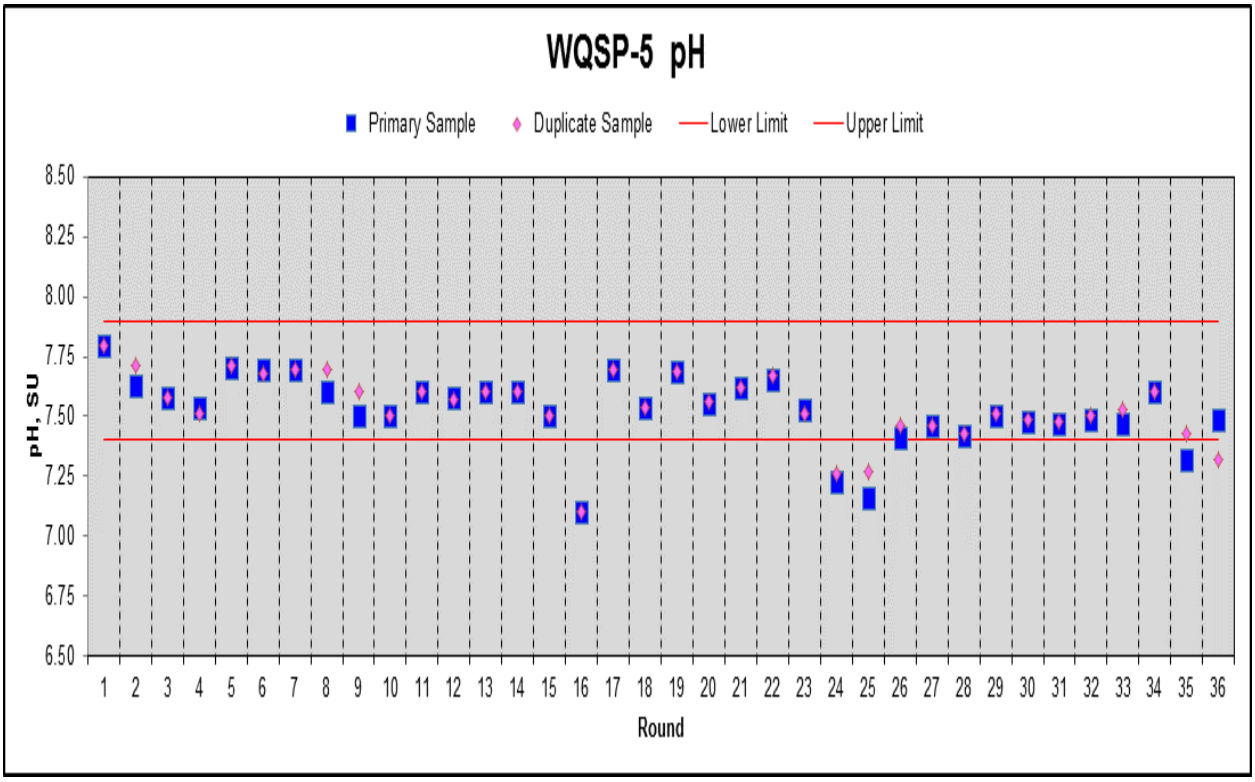

WQSP-5 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

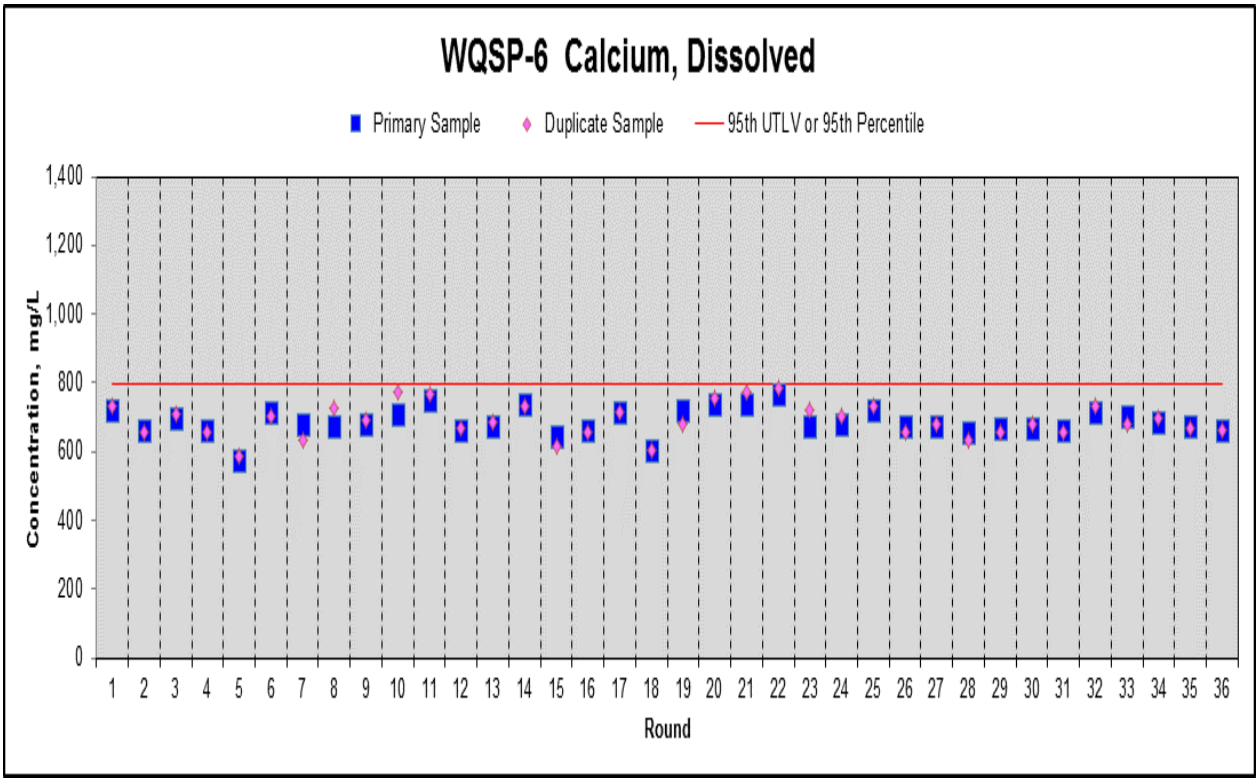

WQSP-5 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

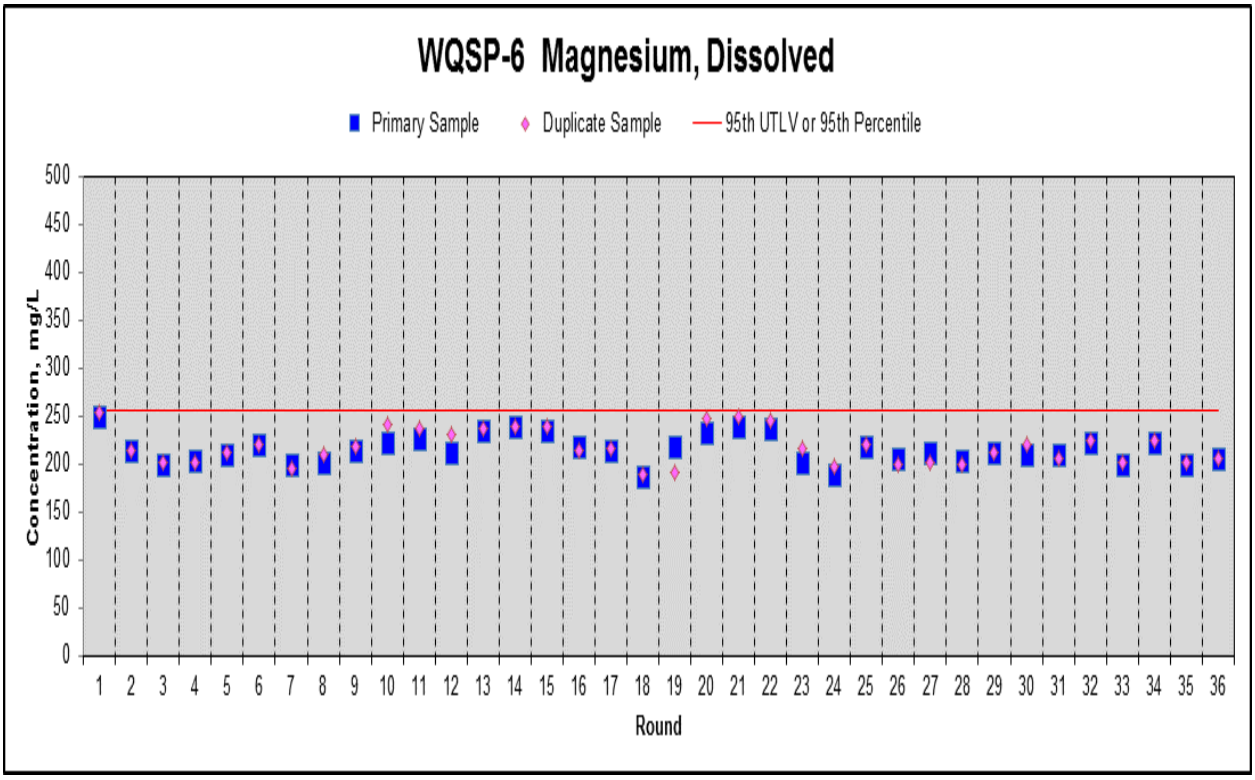

WQSP-5 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,000
27,500
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

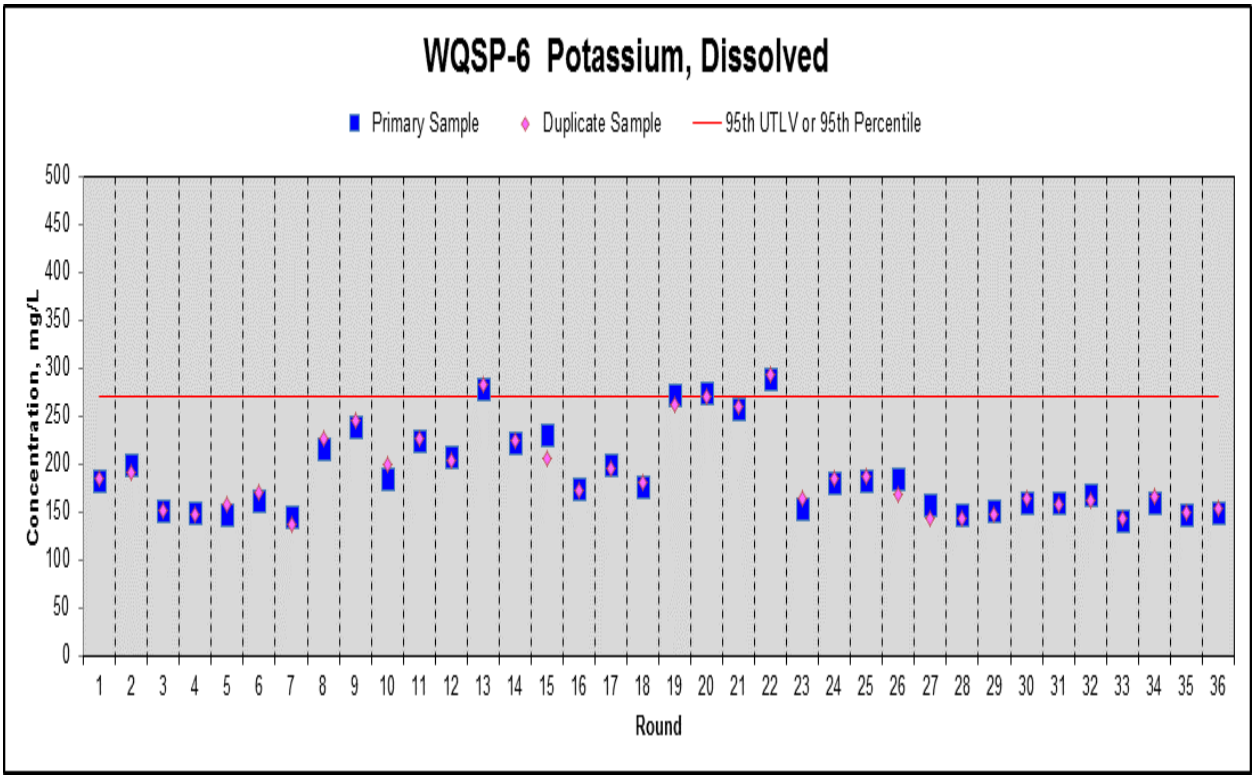

WQSP-5 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

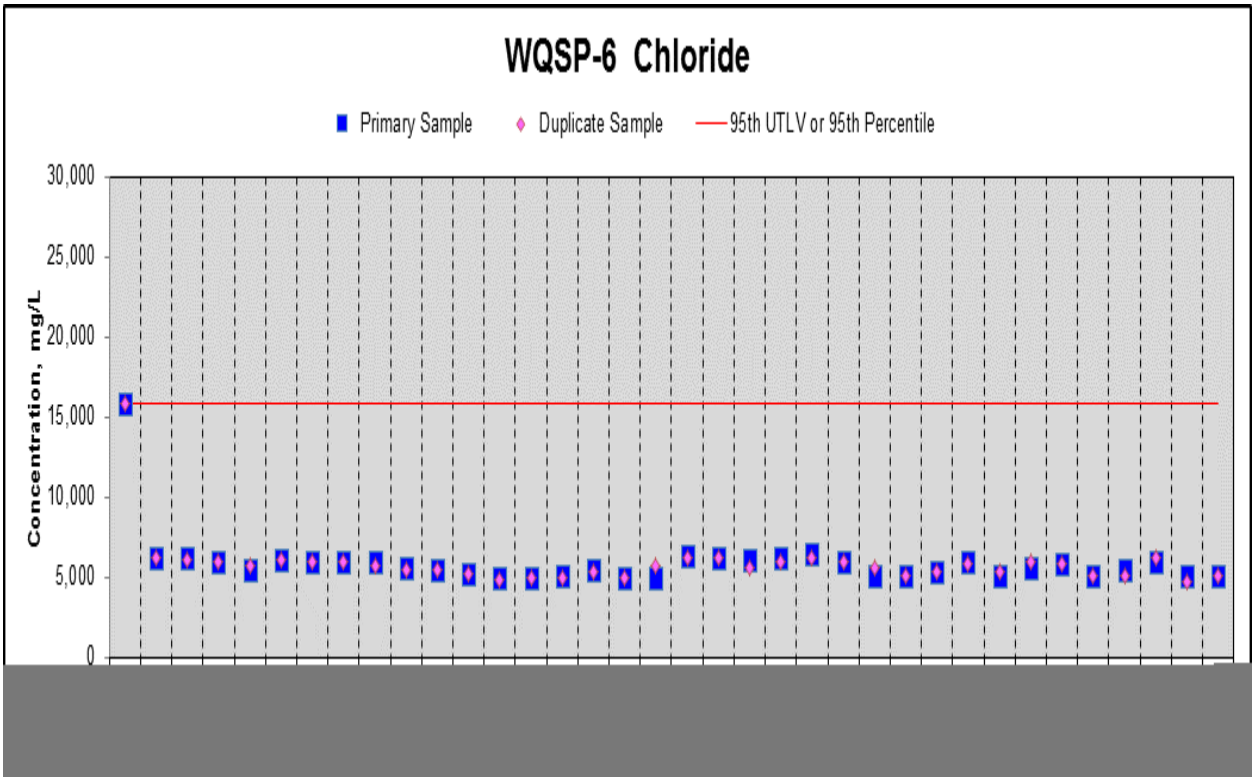

WQSP-5 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

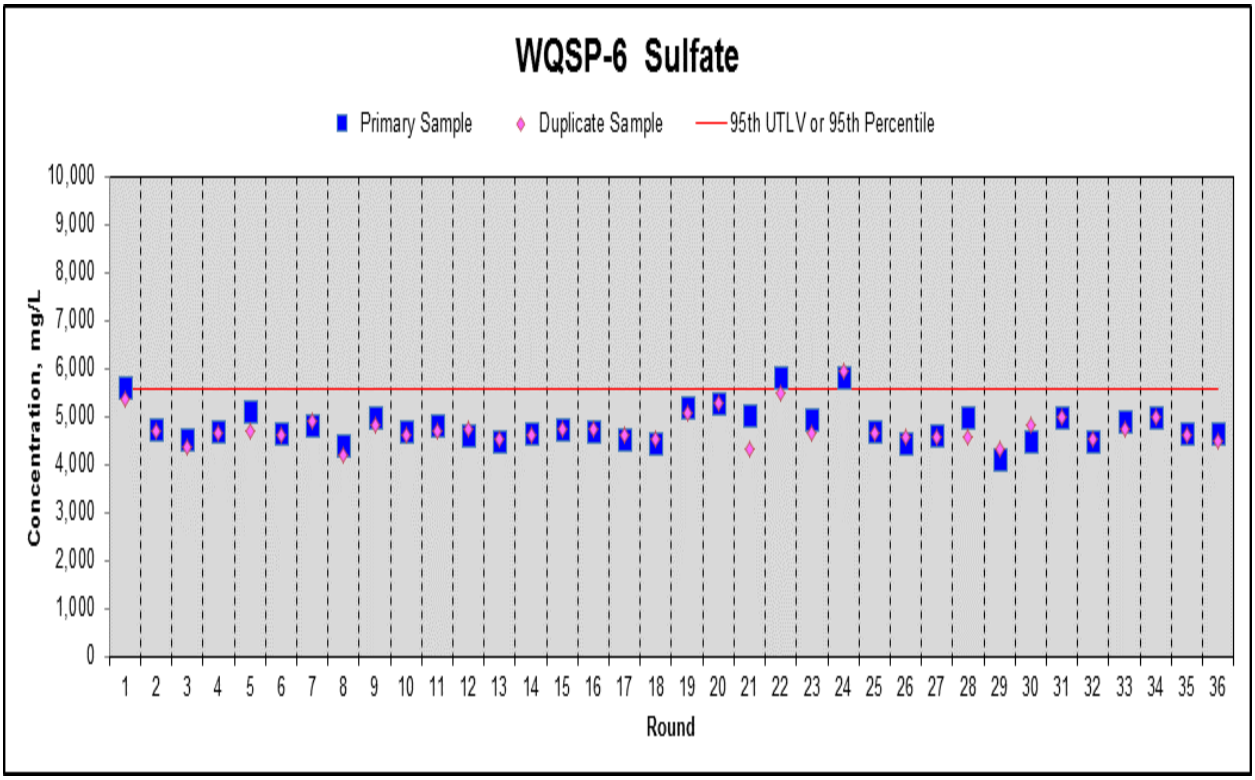

WQSP-5 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

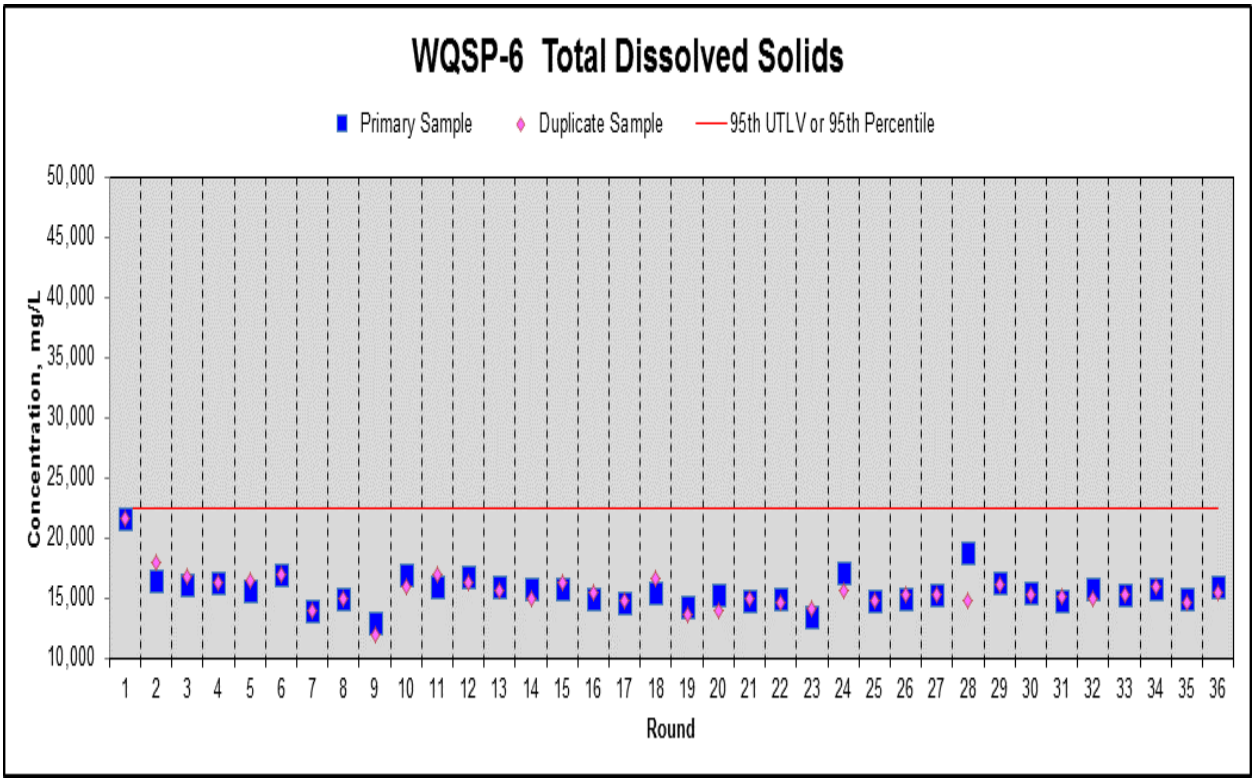

WQSP-6 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round

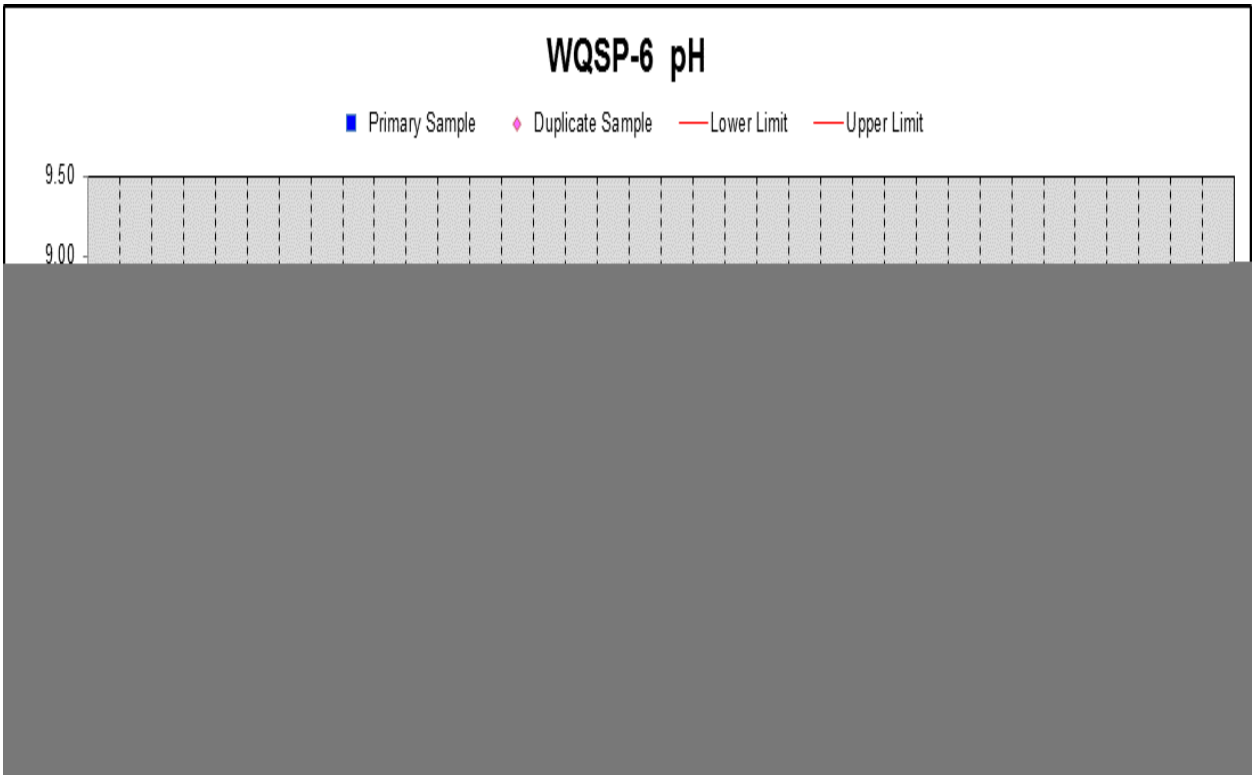

WQSP-6 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round


WQSP-6 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round


WQSP-6 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
30,000
25,000
20,000
15,000
10,000
5,000
0


WQSP-6 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round


WQSP-6 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36
Round


WQSP-6 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
9.50
9.00

APPENDIX F – GROUNDWATER DATA TABLES

Table F.1 – Volatile Organic Compound and Semivolatile Organic Compound Results for Detection Monitoring Wells in 2014 were Reported below the Method Reporting Limit for Each Parameter Shown Below.

Compound[a]	Method Reporting Limit, µg/L
Volatile Organic Compounds	
Isobutanol (isobutyl alcohol)	5.0
Carbon tetrachloride	1.0
Chlorobenzene	1.0
Chloroform	1.0
1,1-Dichloroethane	1.0
1,2-Dichloroethane	1.0
1,1-Dichloroethylene (1,1-Dichloroethene)	1.0
trans-1,2-Dichloroethylene (trans-1,2-DCE)	1.0
Methyl ethyl ketone (2-Butanone)	5.0
Methylene chloride	5.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethylene (tetrachloroethene)	1.0
1,1,1-Trichloroethane	1.0
1,1,2-Trichloroethane	1.0
Trichloroethylene (trichloroethene)	1.0
Trichlorofluoromethane	1.0
Vinyl chloride	1.0
Xylenes (xylenes, total)	1.0
Semivolatile Organic Compounds	
1,2-Dichlorobenzene	5.0
1,4-Dichlorobenzene	5.0
2,4-Dinitrophenol	5.0
2,4-Dinitrotoluene	5.0
Hexachlorobenzene	5.0
Hexachloroethane	5.0
2-Methylphenol [b]	5.0
3-Methylphenol [b]	5.0
4-Methylphenol [b]	5.0
Nitrobenzene	5.0
Pentachlorophenol	5.0
Pyridine	5.0

Notes:

a Chemical synonyms used by the current analytical laboratory, Hall Environmental Analysis Laboratory, are noted in parentheses.

b 2-, 3-, and 4-methylphenol, are listed collectively as Cresols in the Permit.

µg/L = microgram(s) per liter.

Table F.2 – WQSP-1 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-1 Culebra					
WQSP-1 General Chemistry					
Specific Gravity[b]	1.041	1.044	Normal	1.07	N/A
pH (SU)	7.19	7.21	Lognormal	5.6 – 8.8	N/A
Specific Conductance (μmhos/cm)	91,100	92,900	Lognormal	175,000	N/A
Total Dissolved Solids	61,000	60,200	Lognormal	80,700	N/A
Total Organic Carbon	0.72 J	0.66 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**61**	**40**	Nonparametric	**33.3**	N/A
WQSP-1 Total Trace Metals					
Antimony	ND (0.025)	ND (0.025)	Nonparametric	0.33	0.33
Arsenic	ND (0.025)	ND (0.025)	Nonparametric	<0.1	0.10
Barium	0.026 J	0.029 J	Nonparametric	<1.0	1.00
Beryllium	ND (0.0018)	0.0032 J	Nonparametric	<0.02	0.02
Cadmium	ND (0.0031)	ND (0.0031)	Nonparametric	<0.2	0.20
Chromium	ND (0.0084)	ND (0.0084)	Nonparametric	<0.5	0.50
Lead	ND (0.024)	ND (0.024)	Nonparametric	0.105	0.11
Mercury	ND (0.00044)	ND (0.000087)	Nonparametric	<0.002	0.002
Nickel	ND (0.0095)	ND (0.0095)	Nonparametric	0.490	0.50
Selenium	ND (0.025)	ND (0.025)	Nonparametric	0.150	0.15
Silver	ND (0.0026)	ND (0.0026)	Nonparametric	<0.5	0.50
Thallium	ND (0.025)	ND (0.025)	Nonparametric	0.98	1.00
Vanadium	ND (0.027) J	0.030 J	Nonparametric	<0.1	0.10
WQSP-1 Major Cations, Dissolved					
Calcium	1,790	1,790	Normal	2,087	N/A
Magnesium	1,140	1,140	Normal	1,247	N/A
Potassium	508	509	Lognormal	799	N/A
WQSP-1 Major Anions					
Chloride	37,200	38,600	Normal	40,472	N/A
WQSP-2 Culebra					
WQSP-2 General Chemistry					
Specific Gravity[b]	1.043	1.044	Lognormal	1.06	N/A
pH (SU)	7.23	7.25	Normal	7.0 – 7.6	N/A
Specific Conductance (μmhos/cm)	70,100	75,000	Lognormal	124,000	N/A
Total Dissolved Solids	64,500	60,800	Normal	80,500	N/A
Total Organic Carbon	0.26 J	0.21 J	Nonparametric	7.97	N/A

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
Total Suspended Solids	40	33	Nonparametric	43.0	N/A
WQSP-2 Total Trace Metals					
Antimony	ND (0.025)	ND (0.025)	Nonparametric	<0.5	0.50
Arsenic	ND (0.025)	ND (0.025)	Nonparametric	0.062	0.06
Barium	0.023 J	0.023 J	Nonparametric	<1.0	1.00
Beryllium	0.0028 J	0.0020 J	Nonparametric	<1.0	1.00
Cadmium	ND (0.0031)	ND (0.0031)	Nonparametric	<0.5	0.50
Chromium	ND (0.0084)	ND (0.0084)	Nonparametric	<0.5	0.50
Lead	ND (0.024)	ND (0.024)	Nonparametric	0.163	0.17
Mercury	ND (0.000087)	ND (0.000087)	Nonparametric	<0.002	0.002
Nickel	ND (0.0095)	ND (0.0095)	Nonparametric	0.37	0.50
Selenium	ND (0.025)	ND (0.025)	Nonparametric	0.150	0.15
Silver	ND (0.0026)	ND (0.0026)	Nonparametric	<0.5	0.50
Thallium	ND (0.025)	ND (0.025)	Nonparametric	0.980	1.00
Vanadium	0.030 J	0.029 J	Nonparametric	<0.1	0.10
WQSP-2 Major Cations, Dissolved					
Calcium	1,600	1,550	Lognormal	1,827	N/A
Magnesium	1,060	1,040	Normal	1,244	N/A
Potassium	496	518	Lognormal	845	N/A
WQSP-2 Major Anions					
Chloride	34,400	34,400	Normal	39,670	N/A
WQSP-3 Culebra					
WQSP-3 General Chemistry					
Specific Gravity[b]	1.140	1.145	Normal	1.17	N/A
pH (SU)	6.83	6.82	Lognormal	6.6 – 7.2	N/A
Specific Conductance (μmhos/cm)	358,000	352,000	Normal	517,000	N/A
Total Dissolved Solids	206,000	202,000	Lognormal	261,000	N/A
Total Organic Carbon	0.20 J	0.17 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**130**	**187**	Nonparametric	**107**	N/A
WQSP-3 Total Trace Metals					
Antimony	ND (0.025)	ND (0.025)	Nonparametric	<1.0	1.00
Arsenic	ND (0.025)	ND (0.025)	Nonparametric	<1.0	0.21
Barium	0.041 J	0.032 J	Nonparametric	<1.0	1.00
Beryllium	ND (0.0035)	0.027 J	Nonparametric	<0.1	0.10
Cadmium	ND (0.0060)	ND (0.0060)	Nonparametric	<0.5	0.50
Chromium	ND (0.017)	ND (0.017)	Nonparametric	<2.0	2.00
Lead	ND (0.048)	ND (0.048)	Nonparametric	0.8	0.80
Mercury	ND (0.000087)	ND (0.000087)	Nonparametric	<0.002	0.002

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
Nickel	ND (0.019)	ND (0.019)	Nonparametric	<5.0	5.00
Selenium	ND (0.025)	ND (0.025)	Nonparametric	<2.0	2.00
Silver	ND (0.0052)	ND (0.0052)	Nonparametric	0.31	0.31
Thallium	ND (0.025)	ND (0.025)	Nonparametric	5.8	5.80
Vanadium	ND (0.055)	0.033 J	Nonparametric	<5.0	5.00
WQSP-3 Major Cations, Dissolved					
Calcium	1,390	1,360	Normal	1,680	N/A
Magnesium	2,310	2,230	Lognormal	2,625	N/A
Potassium	1,510	1,490	Lognormal	3,438	N/A
WQSP-3 Major Anions					
Chloride	114,000	111,000	Lognormal	149,100	N/A
WQSP-4 Culebra					
WQSP-4 General Chemistry					
Specific Gravity[b]	1.070	1.066	Lognormal	1.09	N/A
pH (SU)	7.09	7.11	Lognormal	6.8 – 7.6	N/A
Specific Conductance (μmhos/cm)	162,000	161,000	Lognormal	319,800	N/A
Total Dissolved Solids	104,000	101,000	Normal	123,500	N/A
Total Organic Carbon	0.35 J	0.25 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**98**	**94**	Nonparametric	**57.0**	N/A
WQSP-4 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	<10.0	0.80
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	<0.5	0.50
Barium	0.025 J	0.027 J	Nonparametric	1.00	1.00
Beryllium	0.0039 J	ND (0.0035)	Nonparametric	0.25	0.25
Cadmium	ND (0.0063)	ND (0.0063)	Nonparametric	<0.5	0.50
Chromium	ND (0.017)	ND (0.017)	Nonparametric	<2.0	2.00
Lead	ND (0.048)	ND (0.048)	Nonparametric	0.525	0.53
Mercury	ND (0.00044)	ND (0.00044)	Nonparametric	<0.002	0.002
Nickel	0.058 J	0.050 J	Nonparametric	<5.0	5.00
Selenium	ND (0.020)	ND (0.020)	Nonparametric	2.009	2.00
Silver	ND (0.0052)	ND (0.0052)	Nonparametric	0.519	0.52
Thallium	ND (0.020)	ND (0.020)	Nonparametric	1.00	1.00
Vanadium	ND (0.055)	ND (0.055)	Nonparametric	<5.0	5.00
WQSP-4 Major Cations, Dissolved					
Calcium	1,630	1,570	Lognormal	1,834	N/A
Magnesium	1,200	1,180	Lognormal	1,472	N/A
Potassium	742	757	Lognormal	1,648	N/A
WQSP-4 Major Anions					

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
Chloride	56,300	59,400	Normal	63,960	N/A
WQSP-5 Culebra					
WQSP-5 General Chemistry					
Specific Gravity[b]	1.019	1.018	Normal	1.04	N/A
pH (SU)	7.49	**7.32**	Normal	7.4 – 7.9	N/A
Specific Conductance (μmhos/cm)	50,200	50,500	Lognormal	67,700	N/A
Total Dissolved Solids	35,100	33,400	Nonparametric	43,950	N/A
Total Organic Carbon	0.34 J	0.36 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**24**	**29**	Nonparametric	**<10**	N/A
WQSP-5 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	0.073	0.07
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	<0.5	0.50
Barium	0.018 J	0.015 J	Nonparametric	<1.0	1.00
Beryllium	ND (0.0018)	ND (0.0018)	Nonparametric	<0.02	0.02
Cadmium	ND (0.0031)	ND (0.0031)	Nonparametric	<0.05	0.05
Chromium	ND (0.0084)	ND (0.0084)	Nonparametric	<0.5	0.50
Lead	ND(0.024)	ND (0.024)	Nonparametric	<0.05	0.05
Mercury	ND (0.00044)	ND (0.00044)	Nonparametric	<0.002	0.002
Nickel	ND (0.0095)	ND (0.0095)	Nonparametric	<0.1	0.10
Selenium	ND (0.020)	ND (0.020)	Nonparametric	<0.1	0.10
Silver	ND (0.0026)	ND (0.0026)	Nonparametric	<0.5	0.50
Thallium	ND (0.020)	ND (0.020)	Nonparametric	0.209	0.21
Vanadium	ND (0.027)	ND (0.027)	Nonparametric	2.70	2.70
WQSP-5 Major Cations, Dissolved					
Calcium	1,030	1,040	Lognormal	1,303	N/A
Magnesium	454	456	Nonparametric	547	N/A
Potassium	289	299	Lognormal	622	N/A
WQSP-5 Major Anions					
Chloride	14,000	14,000	Lognormal	18,100	N/A
WQSP-6 Culebra					
WQSP-6 General Chemistry					
Specific Gravity[b]	1.009	1.008	Normal	1.02	N/A
pH (SU)	7.79	7.80	Normal	7.5 – 7.9	N/A
Specific Conductance (μmhos/cm)	20,200	19,900	Lognormal	27,660	N/A
Total Dissolved Solids	16,000	15,400	Lognormal	22,500	N/A
Total Organic Carbon	0.58 J	0.57 J	Nonparametric	10.14	N/A
Total Suspended Solids	13	12	Nonparametric	14.8	N/A

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-6 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	0.140	0.14
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	<0.5	0.50
Barium	0.0096 J	0.0092 J	Nonparametric	<1.0	1.00
Beryllium	0.00061 J	0.00054 J	Nonparametric	<0.02	0.02
Cadmium	ND (0.00063)	ND (0.00063)	Nonparametric	<0.05	0.05
Chromium	ND (0.0017)	ND (0.0017)	Nonparametric	<0.5	0.50
Lead	ND (0.0048)	ND (0.0048)	Nonparametric	0.150	0.15
Mercury	ND (0.00020)	ND (0.00020)	Nonparametric	<0.002	0.002
Nickel	ND (0.0019)	ND (0.0019)	Nonparametric	<0.5	0.50
Selenium	ND (0.020)	ND (0.020)	Nonparametric	0.10	0.10
Silver	ND (0.0052)	ND (0.0052)	Nonparametric	<0.5	0.50
Thallium	ND (0.020)	ND (0.020)	Nonparametric	0.560	0.56
Vanadium	ND (0.0055)	ND (0.0055)	Nonparametric	0.070	0.10
WQSP-6 Major Cations, Dissolved					
Calcium	665	661	Normal	796	N/A
Magnesium	205	205	Lognormal	255	N/A
Potassium	150	153	Lognormal	270	N/A
WQSP-6 Major Anions					
Chloride	5,090	5,040	Nonparametric	15,800	N/A

Notes:

Values (concentrations) in **bold** exceed, or are outside of the baseline range for the 95th upper tolerance limit value (UTLV), 95th percentile, or Permit background value. In these cases, the UTLVs are also shown in **bold** for ease of comparison.

a Baseline sample distribution type based upon Rounds 1 through 10. The 95th UTLV is used in cases where the sample distribution type is either normal or lognormal. The 95th percentile value is used in cases where the sample distribution type is nonparametric or had greater than 15 percent non-detects.

b Specific gravity is compared to density (gram per milliliter [g/mL]) as presented in the Waste Isolation Pilot Plant RCRA Background Groundwater Quality Baseline Report, Addendum 1 (DOE, 2000).

J = Estimated concentration. The concentration is between the laboratory's method detection limit and the method reporting limit/practical quantitation limit for the particular sample.

N/A = Not applicable

ND = The analytical parameter was analyzed, but not detected in the sample. The trace metals were analyzed by inductively coupled plasma spectroscopy. Antimony (Sb), arsenic (As), selenium (Se), and thallium (Tl) were analyzed by inductively coupled plasma spectroscopy/mass spectrometry. The method detection limits are shown in parentheses.

pH (SU) = Potential of hydrogen (measure of alkalinity or acidity) standard unit.

95th UTLV = Upper tolerance limit value in mg/L (coverage and tolerance coefficient value of 95 percent).

Table F.3 – WIPP Well Inventory for 2014

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2014			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
1	AEC-7R	CUL		1	CB-1(PIP)	B/C	
2	C-2505	SR/DL		2	DOE-2	B/C	
3	C-2506	SR/DL		3	AEC-7R	CUL	New well September 2013
4	C-2507	SR/DL		4	ERDA-9	CUL	
5	C-2737	MAG/CUL		5	H-02b2	CUL	
6	C-2811	SR/DL		6	H-03b2	CUL	
7	CB-1(PIP)	B/C		7	H-04bR	CUL	
8	DOE-2	B/C		8	H-05b	CUL	
9	ERDA-9	CUL		9	H-06bR	CUL	
10	H-02b1	MAG		10	H-07b1	CUL	
11	H-02b2	CUL		11	H-09bR	CUL	
12	H-03b1	MAG		12	H-10cR	CUL	
13	H-03b2	CUL		13	H-10c	CUL	
14	H-03D	SR/DL	Dry; not measured in 2013	14	H-12R	CUL	Completed in September 2014
15	H-04bR	CUL		15	H-12	CUL	Plugged in September 2014
16	H-04c	MAG		16	H-17	CUL	
17	H-05b	CUL		17	H-19b0	CUL	
18	H-06bR	CUL		18	H-19b2	CUL	Redundant to H19b0
19	H-06c	MAG		19	H-19b3	CUL	Redundant to H19b0
20	H-07b1	CUL		20	H-19b4	CUL	Redundant to H19b0
21	H-08a	MAG		21	H-19b5	CUL	Redundant to H19b0
22	H-09c	MAG		22	H-19b6	CUL	Redundant to H19b0
23	H-09bR	CUL		23	H-19b7	CUL	Redundant to H19b0
24	H-10a	MAG		24	I-461	CUL	
25	H-10c	CUL		25	SNL-01	CUL	
26	H-11b2	MAG		26	SNL-02	CUL	
27	H-11b4R	CUL		27	SNL-03	CUL	
28	H-12R	CUL		28	SNL-05	CUL	
29	H-14	MAG		29	SNL-6	CUL	Depressed from projected equilibrium

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2014			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
30	H-15R	CUL		30	SNL-08	CUL	
31	H-15	MAG		31	SNL-09	CUL	
32	H-16	CUL		32	H-15R	CUL	
33	H-17	CUL		33	SNL-10	CUL	
34	H-18	MAG		34	H-16	CUL	Seasonal changes
35	H-19b0	CUL		35	SNL-12	CUL	
36	H-19b2	CUL		36	SNL-13	CUL	Rise from oil field activities
37	H-19b3	CUL		37	SNL-14	CUL	
38	H-19b4	CUL		38	SNL-15	CUL	Depressed from projected equilibrium
39	H-19b5	CUL		39	SNL-16	CUL	
40	H-19b6	CUL		40	SNL-17	CUL	
41	H-19b7	CUL		41	SNL-18	CUL	
42	I-461	CUL		42	SNL-19	CUL	
43	SNL-01	CUL		43	WIPP-11	CUL	
44	SNL-02	CUL		44	WIPP-13	CUL	
45	SNL-03	CUL		45	WIPP-19	CUL	
46	SNL-05	CUL		46	WQSP-1	CUL	
47	SNL-06	CUL		47	WQSP-2	CUL	
48	SNL-08	CUL		48	WQSP-3	CUL	
49	SNL-09	CUL		49	WQSP-4	CUL	
50	SNL-10	CUL		50	WQSP-5	CUL	
51	SNL-12	CUL		51	WQSP-6	CUL	
52	SNL-13	CUL		52	WQSP-6A	DL	
53	SNL-14	CUL		53	H-02b1	MAG	
54	SNL-15	CUL		54	H-03b1	MAG	
55	SNL-16	CUL		55	H-04c	MAG	
56	SNL-17	CUL		56	H-06c	MAG	
57	SNL-18	CUL		57	H-08a	MAG	
58	SNL-19	CUL		58	H-10a	MAG	
59	PZ-01	SR/DL		59	H-11b2	MAG	
60	PZ-02	SR/DL		60	H-14	MAG	
61	PZ-03	SR/DL		61	H-18	MAG	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2014			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
62	PZ-04	SR/DL		62	WIPP-18	MAG	
63	PZ-05	SR/DL		63	H-15	MAG	
64	PZ-06	SR/DL		64	H-09c	MAG	
65	PZ-07	SR/DL		65	C-2737	MAG/CUL	
66	PZ-08	SR/DL		66	C-2505	SR/DL	
67	PZ-09	SR/DL		67	C-2506	SR/DL	
68	PZ-10	SR/DL		68	C-2507	SR/DL	
69	PZ-11	SR/DL		69	C-2811	SR/DL	
70	PZ-12	SR/DL		70	PZ-01	SR/DL	
71	PZ-13	SR/DL		71	PZ-02	SR/DL	
72	PZ-14	SR/DL		72	PZ-03	SR/DL	
73	PZ-15	SR/DL		73	PZ-04	SR/DL	
74	WIPP-11	CUL		74	PZ-05	SR/DL	
75	WIPP-13	CUL		75	PZ-06	SR/DL	
76	WIPP-18	MAG		76	PZ-07	SR/DL	
77	WIPP-19	CUL		77	PZ-08	SR/DL	
78	WQSP-1	CUL		78	PZ-09	SR/DL	
79	WQSP-2	CUL		79	PZ-10	SR/DL	
80	WQSP-3	CUL		80	PZ-11	SR/DL	
81	WQSP-4	CUL		81	PZ-12	SR/DL	
82	WQSP-5	CUL		82	PZ-13	SR/DL	
83	WQSP-6	CUL		83	PZ-14	SR/DL	
84	WQSP-6A	DL		84	PZ-15	SR/DL	
				85	H-03D	SR/DL	Dry; not measured since 2013

Table F.4 – Water Levels

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7R	CUL	January	SNL Test		
AEC-7R	CUL	02/04/14	619.17	NA	NA
AEC-7R	CUL	03/15/14	616.40	NA	NA
AEC-7R	CUL	04/08/14	616.00	NA	NA
AEC-7R	CUL	February		SNL Test	
AEC-7R	CUL	March		SNL Test	
AEC-7R	CUL	April		SNL Test	
AEC-7R	CUL	May		SNL Test	
AEC-7R	CUL	June		SNL Test	
AEC-7R	CUL	July		SNL Test	
AEC-7R	CUL	August		SNL Test	
AEC-7R	CUL	September		SNL Test	
C-2737 (PIP)	CUL	01/09/14	397.42	3003.34	3010.09
C-2737 (PIP)	CUL	02/12/14	399.51	3001.25	3007.96
C-2737 (PIP)	CUL	03/18/14	401.63	2999.13	3005.79
C-2737 (PIP)	CUL	04/10/14	403.50	2997.26	3003.87
C-2737 (PIP)	CUL	05/07/14	405.76	2995.00	3001.56
C-2737 (PIP)	CUL	06/04/14	408.31	2992.45	2998.95
C-2737 (PIP)	CUL	07/10/14	411.39	2989.37	2995.80
C-2737 (PIP)	CUL	08/12/14	413.70	2987.06	2993.44
C-2737 (PIP)	CUL	09/04/14	414.62	2986.14	2992.50
C-2737 (PIP)	CUL	10/03/14	415.62	2985.14	2991.48
C-2737 (PIP)	CUL	11/12/14	415.70	2985.06	2991.39
C-2737 (PIP)	CUL	12/08/14	416.18	2984.58	2990.90
ERDA-9	CUL	01/09/14	406.40	3003.77	3025.83
ERDA-9	CUL	02/12/14	408.42	3001.75	3023.67
ERDA-9	CUL	03/18/14	409.94	3000.23	3022.04
ERDA-9	CUL	04/10/14	411.23	2998.94	3020.66
ERDA-9	CUL	05/07/14	412.85	2997.32	3018.93
ERDA-9	CUL	06/05/14	414.70	2995.47	3016.95
ERDA-9	CUL	07/07/14	416.75	2993.42	3014.75
ERDA-9	CUL	08/07/14	418.05	2992.12	3013.36
ERDA-9	CUL	09/03/14	418.98	2991.19	3012.36
ERDA-9	CUL	10/03/14	417.83	2992.34	3013.59
ERDA-9	CUL	11/11/14	420.32	2989.85	3010.93
ERDA-9	CUL	12/04/14	420.72	2989.45	3010.50
H-02b2	CUL	01/09/14	339.09	3039.27	3043.12
H-02b2	CUL	02/12/14	340.35	3038.01	3041.85

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-02b2	CUL	03/18/14	341.22	3037.14	3040.97
H-02b2	CUL	04/10/14	342.22	3036.14	3039.95
H-02b2	CUL	05/07/14	343.03	3035.33	3039.13
H-02b2	CUL	06/05/14	344.19	3034.17	3037.96
H-02b2	CUL	07/10/14	345.77	3032.59	3036.36
H-02b2	CUL	08/12/14	347.10	3031.26	3035.01
H-02b2	CUL	09/04/14	347.72	3030.64	3034.38
H-02b2	CUL	10/01/14	348.00	3030.36	3034.10
H-02b2	CUL	11/12/14	349.20	3029.16	3032.88
H-02b2	CUL	12/08/14	349.46	3028.90	3032.62
H-03b2	CUL	01/08/14	402.55	2987.36	2996.49
H-03b2	CUL	02/12/14	405.84	2984.07	2993.09
H-03b2	CUL	03/18/14	408.18	2981.73	2990.67
H-03b2	CUL	04/10/14	410.85	2979.06	2987.92
H-03b2	CUL	05/07/14	414.15	2975.76	2984.51
H-03b2	CUL	06/04/14	417.12	2972.79	2981.45
H-03b2	CUL	07/10/14	421.60	2968.31	2976.83
H-03b2	CUL	08/07/14	421.32	2968.59	2977.11
H-03b2	CUL	09/04/14	422.85	2967.06	2975.54
H-03b2	CUL	10/03/14	423.60	2966.31	2974.76
H-03b2	CUL	11/11/14	423.31	2966.60	2975.06
H-03b2	CUL	12/04/14	423.97	2965.94	2974.38
H-04bR	CUL	01/08/14	380.55	2954.09	2956.25
H-04bR	CUL	02/12/14	384.44	2950.20	2952.30
H-04bR	CUL	03/11/14	405.04	2929.60	2931.35
H-04bR	CUL	04/09/14	414.85	2919.79	2921.37
H-04bR	CUL	05/05/14	420.62	2914.02	2915.50
H-04bR	CUL	06/03/14	421.36	2913.28	2914.75
H-04bR	CUL	07/07/14	406.64	2928.00	2929.72
H-04bR	CUL	08/06/14	412.02	2922.62	2924.25
H-04bR	CUL	09/04/14	404.91	2929.73	2931.48
H-04bR	CUL	10/03/14	382.19	2952.45	2954.59
H-04bR	CUL	11/11/14	407.20	2927.44	2929.15
H-04bR	CUL	12/04/14	408.64	2926.00	2927.69
H-05b	CUL	01/09/14	466.46	3040.32	3081.15
H-05b	CUL	02/10/14	466.23	3040.55	3081.40
H-05b	CUL	03/05/14	466.02	3040.76	3081.63
H-05b	CUL	04/08/14	465.80	3040.98	3081.87
H-05b	CUL	05/06/14	465.64	3041.14	3082.05
H-05b	CUL	06/02/14	465.56	3041.22	3082.13

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-05b	CUL	07/08/14	465.64	3041.14	3082.05
H-05b	CUL	08/05/14	465.85	3040.93	3081.82
H-05b	CUL	09/03/14	465.81	3040.97	3081.86
H-05b	CUL	10/01/14	465.66	3041.12	3082.03
H-05b	CUL	11/10/14	465.89	3040.89	3081.77
H-05b	CUL	12/01/14	466.13	3040.65	3081.51
H-06bR	CUL	01/08/14	292.11	3057.11	3069.79
H-06bR	CUL	02/11/14	292.63	3056.59	3069.25
H-06bR	CUL	03/05/14	292.69	3056.53	3069.19
H-06bR	CUL	04/10/14	293.01	3056.21	3068.86
H-06bR	CUL	05/05/14	293.19	3056.03	3068.67
H-06bR	CUL	06/02/14	293.30	3055.92	3068.56
H-06bR	CUL	07/09/14	293.30	3055.92	3068.56
H-06bR	CUL	08/04/14	293.47	3055.75	3068.38
H-06bR	CUL	09/03/14	293.71	3055.51	3068.13
H-06bR	CUL	10/01/14	291.72	3057.50	3070.20
H-06bR	CUL	11/12/14	291.32	3057.90	3070.61
H-06bR	CUL	12/03/14	291.17	3058.05	3070.77
H-07b1	CUL	01/07/14	167.83	2995.89	2996.60
H-07b1	CUL	02/04/14	167.70	2996.02	2996.74
H-07b1	CUL	03/04/14	170.22	2993.50	2994.20
H-07b1	CUL	04/08/14	171.32	2992.40	2993.09
H-07b1	CUL	05/05/14	170.45	2993.27	2993.97
H-07b1	CUL	06/02/14	169.32	2994.40	2995.10
H-07b1	CUL	07/09/14	171.32	2992.40	2993.09
H-07b1	CUL	08/04/14	170.16	2993.56	2994.26
H-07b1	CUL	09/03/14	171.47	2992.25	2992.94
H-07b1	CUL	10/01/14	170.81	2992.91	2993.60
H-07b1	CUL	11/10/14	166.81	2996.91	2997.63
H-07b1	CUL	12/02/14	166.40	2997.32	2998.04
H-09bR	CUL	01/07/14	436.55	2971.79	2972.02
H-09bR	CUL	02/04/14	437.26	2971.08	2971.31
H-09bR	CUL	03/04/14	439.22	2969.12	2969.35
H-09bR	CUL	04/09/14	444.44	2963.90	2964.12
H-09bR	CUL	05/06/14	446.00	2962.34	2962.56
H-09bR	CUL	06/03/14	447.67	2960.67	2960.89
H-09bR	CUL	07/08/14	446.68	2961.66	2961.88
H-09bR	CUL	08/05/14	446.65	2961.69	2961.91
H-09bR	CUL	09/03/14	446.51	2961.83	2962.05
H-09bR	CUL	10/03/14	443.34	2965.00	2965.22

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-09bR	CUL	11/10/14	444.14	2964.20	2964.42
H-09bR	CUL	12/03/14	445.51	2962.83	2963.05
H-10c	CUL	01/07/14	717.61	2970.79	3032.97
H-10c	CUL	02/10/14	717.43	2970.97	3033.16
H-10c	CUL	03/04/14	717.45	2970.95	3033.14
H-10c	CUL	04/09/14	717.43	2970.97	3033.16
H-10c	CUL	05/06/14	717.21	2971.19	3033.40
H-10c	CUL	06/03/14	716.72	2971.68	3033.94
H-10c	CUL	07/08/14	717.29	2971.11	3033.32
H-10c	CUL	08/05/14	717.40	2971.00	3033.20
H-10c	CUL	09/03/14	717.37	2971.03	3033.23
H-10c	CUL	10/03/14	716.13	2972.27	3034.59
H-10c	CUL	11/11/14	714.83	2973.57	3036.01
H-10c	CUL	12/04/14	712.51	2975.89	3038.55
H-11b4R	CUL	01/09/14	458.40	2953.47	2974.56
H-11b4R	CUL	02/11/14	461.64	2950.23	2971.07
H-11b4R	CUL	03/11/14	464.00	2947.87	2968.53
H-11b4R	CUL	04/09/14	471.11	2940.76	2960.88
H-11b4R	CUL	05/06/14	475.06	2936.81	2956.63
H-11b4R	CUL	06/05/14	477.87	2934.00	2953.61
H-11b4R	CUL	07/07/14	475.64	2936.23	2956.01
H-11b4R	CUL	08/06/14	476.47	2935.40	2955.11
H-11b4R	CUL	09/04/14	476.52	2935.35	2955.06
H-11b4R	CUL	10/02/14	472.80	2939.07	2959.06
H-11b4R	CUL	11/11/14	473.52	2938.35	2958.29
H-11b4R	CUL	12/03/14	474.57	2937.30	2957.16
H-12	CUL	01/07/14	468.47	2958.86	2998.82
H-12	CUL	02/10/14	470.76	2956.57	2996.28
H-12	CUL	03/04/14	472.12	2955.21	2994.77
H-12	CUL	04/09/14	474.79	2952.54	2991.81
H-12	CUL	05/06/14	477.24	2950.09	2989.10
H-12	CUL	06/03/14	479.65	2947.68	2986.43
H-12	CUL	07/07/14	482.18	2945.15	2983.63
H-12	CUL	08/05/14	488.70	2938.63	2976.40
H-12R	CUL	08/12/14	495.99		
H-12R	CUL	September		SNL Test	
H-12R	CUL	November		SNL Test	
H-12R	CUL	December		SNL Test	
H-15R	CUL	01/08/14	523.49	2958.53	2999.74
H-15R	CUL	02/12/14	526.38	2955.64	2996.51

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-15R	CUL	03/18/14	528.50	2953.52	2994.14
H-15R	CUL	04/10/14	531.26	2950.76	2991.05
H-15R	CUL	05/07/14	534.34	2947.68	2987.61
H-15R	CUL	06/05/14	537.32	2944.70	2984.28
H-15R	CUL	07/10/14	539.62	2942.40	2981.71
H-15R	CUL	08/12/14	540.60	2941.42	2980.61
H-15R	CUL	09/04/14	541.35	2940.67	2979.77
H-15R	CUL	10/03/14	541.74	2940.28	2979.34
H-15R	CUL	11/12/14	541.09	2940.93	2980.06
H-15R	CUL	12/04/14	541.57	2940.45	2979.53
H-16	CUL	01/08/14	379.78	3030.28	3042.33
H-16	CUL	02/11/14	381.15	3028.91	3040.91
H-16	CUL	March		Inaccessible due to event	
H-16	CUL	04/24/14	382.13	3027.93	3039.89
H-16	CUL	05/05/14	382.37	3027.69	3039.64
H-16	CUL	06/04/14	383.18	3026.88	3038.81
H-16	CUL	07/10/14	384.42	3025.64	3037.52
H-16	CUL	08/12/14	385.48	3024.58	3036.42
H-16	CUL	09/02/14	385.88	3024.18	3036.01
H-16	CUL	10/06/14	386.34	3023.72	3035.53
H-16	CUL	11/12/14	387.00	3023.06	3034.85
H-16	CUL	12/04/14	387.00	3023.06	3034.85
H-17	CUL	01/09/14	444.99	2940.25	2976.88
H-17	CUL	02/11/14	448.14	2937.10	2973.32
H-17	CUL	03/11/14	449.83	2935.41	2971.40
H-17	CUL	04/09/14	455.23	2930.01	2965.28
H-17	CUL	05/07/14	459.33	2925.91	2960.64
H-17	CUL	06/03/14	462.23	2923.01	2957.35
H-17	CUL	07/07/14	462.49	2922.75	2957.06
H-17	CUL	08/05/14	462.43	2922.81	2957.13
H-17	CUL	09/04/14	462.93	2922.31	2956.56
H-17	CUL	10/02/14	461.46	2923.78	2958.22
H-17	CUL	11/11/14	459.85	2925.39	2960.05
H-17	CUL	12/03/14	460.68	2924.56	2959.11
H-19b0	CUL	01/07/14	442.81	2975.52	2996.05
H-19b0	CUL	02/12/14	446.08	2972.25	2992.57
H-19b0	CUL	03/18/14	448.38	2969.95	2990.12
H-19b0	CUL	04/09/14	451.34	2966.99	2986.96
H-19b0	CUL	05/07/14	454.81	2963.52	2983.26

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-19b0	CUL	06/04/14	457.78	2960.55	2980.10
H-19b0	CUL	07/07/14	460.21	2958.12	2977.51
H-19b0	CUL	08/06/14	461.24	2957.09	2976.41
H-19b0	CUL	09/05/14	462.48	2955.85	2975.09
H-19b0	CUL	10/01/14	462.50	2955.83	2975.06
H-19b0	CUL	11/11/14	462.21	2956.12	2975.37
H-19b0	CUL	12/08/14	463.09	2955.24	2974.44
H-19b2	CUL	03/18/14	449.82	2969.11	2989.93
H-19b2	CUL	06/04/14	459.27	2959.66	2979.84
H-19b2	CUL	09/05/14	463.93	2955.00	2974.86
H-19b2	CUL	12/08/14	464.55	2954.38	2974.20
H-19b3	CUL	03/18/14	450.01	2969.01	2989.11
H-19b3	CUL	06/04/14	459.42	2959.60	2979.08
H-19b3	CUL	09/05/14	464.09	2954.93	2974.10
H-19b3	CUL	12/08/14	464.73	2954.29	2973.42
H-19b4	CUL	03/18/14	449.15	2969.83	2989.99
H-19b4	CUL	06/04/14	458.52	2960.46	2980.00
H-19b4	CUL	09/05/14	463.27	2955.71	2974.94
H-19b4	CUL	12/08/14	463.93	2955.05	2974.23
H-19b5	CUL	03/18/14	449.15	2969.43	2990.48
H-19b5	CUL	06/04/14	458.68	2959.90	2980.29
H-19b5	CUL	09/05/14	463.33	2955.25	2975.32
H-19b5	CUL	12/08/14	463.97	2954.61	2974.63
H-19b6	CUL	03/18/14	449.10	2969.92	2991.31
H-19b6	CUL	06/04/14	459.34	2959.68	2980.35
H-19b6	CUL	09/05/14	464.02	2955.00	2975.34
H-19b6	CUL	12/01/14	464.56	2954.46	2974.76
H-19b7	CUL	March		SNL Test	
H-19b7	CUL	June		SNL Test	
H-19b7	CUL	September		SNL Test	
H-19b7	CUL	December		SNL Test	
H-19b7	CUL	12/08/14	464.45	2954.49	2974.80
I-461	CUL	01/07/14	239.58	3044.03	3044.03
I-461	CUL	02/04/14	242.62	3040.99	3040.99
I-461	CUL	03/04/14	242.89	3040.72	3040.72
I-461	CUL	04/08/14	243.40	3040.21	3040.21
I-461	CUL	05/05/14	243.46	3040.15	3040.15
I-461	CUL	06/02/14	243.62	3039.99	3039.99
I-461	CUL	07/07/14	243.29	3040.32	3040.32
I-461	CUL	08/04/14	243.58	3040.03	3040.03

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
I-461	CUL	09/02/14	243.80	3039.81	3039.81
I-461	CUL	10/01/14	239.01	3044.60	3044.60
I-461	CUL	11/10/14	238.04	3045.57	3045.57
I-461	CUL	12/02/14	238.70	3044.91	3044.91
SNL-01	CUL	01/07/14	439.86	3072.98	3078.17
SNL-01	CUL	02/04/14	439.72	3073.12	3078.31
SNL-01	CUL	03/04/14	440.20	3072.64	3077.82
SNL-01	CUL	04/08/14	440.82	3072.02	3077.18
SNL-01	CUL	05/06/14	440.73	3072.11	3077.27
SNL-01	CUL	06/02/14	440.81	3072.03	3077.19
SNL-01	CUL	07/08/14	441.08	3071.76	3076.91
SNL-01	CUL	08/04/14	441.21	3071.63	3076.78
SNL-01	CUL	09/02/14	441.18	3071.66	3076.81
SNL-01	CUL	10/02/14	441.12	3071.72	3076.87
SNL-01	CUL	11/11/14	440.40	3072.44	3077.61
SNL-01	CUL	12/03/14	439.97	3072.87	3078.06
SNL-02	CUL	01/07/14	254.33	3068.73	3070.68
SNL-02	CUL	02/04/14	254.46	3068.60	3070.55
SNL-02	CUL	03/04/14	254.81	3068.25	3070.19
SNL-02	CUL	04/08/14	255.30	3067.76	3069.70
SNL-02	CUL	05/05/14	255.38	3067.68	3069.62
SNL-02	CUL	06/02/14	255.62	3067.44	3069.38
SNL-02	CUL	07/08/14	255.88	3067.18	3069.11
SNL-02	CUL	08/04/14	255.97	3067.09	3069.02
SNL-02	CUL	09/02/14	256.16	3066.90	3068.83
SNL-02	CUL	10/02/14	251.68	3071.38	3073.35
SNL-02	CUL	11/10/14	251.61	3071.45	3073.42
SNL-02	CUL	12/03/14	252.39	3070.67	3072.64
SNL-03	CUL	01/08/14	422.75	3067.60	3077.23
SNL-03	CUL	02/11/14	423.02	3067.33	3076.95
SNL-03	CUL	03/05/14	423.21	3067.14	3076.75
SNL-03	CUL	04/08/14	423.85	3066.50	3076.10
SNL-03	CUL	05/05/14	423.78	3066.57	3076.17
SNL-03	CUL	06/03/14	423.72	3066.63	3076.23
SNL-03	CUL	07/09/14	423.89	3066.46	3076.05
SNL-03	CUL	08/04/14	423.79	3066.56	3076.16
SNL-03	CUL	09/04/14	423.87	3066.48	3076.08
SNL-03	CUL	10/01/14	423.38	3066.97	3076.58
SNL-03	CUL	11/10/14	422.68	3067.67	3077.30
SNL-03	CUL	12/02/14	422.71	3067.64	3077.27

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-05	CUL	01/07/14	311.76	3068.22	3071.25
SNL-05	CUL	02/04/14	311.78	3068.20	3071.23
SNL-05	CUL	03/04/14	312.39	3067.59	3070.62
SNL-05	CUL	04/08/14	313.31	3066.67	3069.69
SNL-05	CUL	04/08/14	313.31	3066.67	3069.69
SNL-05	CUL	05/06/14	312.97	3067.01	3070.03
SNL-05	CUL	06/02/14	312.24	3067.74	3070.77
SNL-05	CUL	07/08/14	312.25	3067.73	3070.76
SNL-05	CUL	08/04/14	312.23	3067.75	3070.78
SNL-05	CUL	09/02/14	312.22	3067.76	3070.79
SNL-05	CUL	10/02/14	311.49	3068.49	3071.53
SNL-05	CUL	11/10/14	310.00	3069.98	3073.03
SNL-05	CUL	12/03/14	310.11	3069.87	3072.92
SNL-06	CUL	01/09/14	569.99	3076.12	3262.80
SNL-06	CUL	02/05/14	567.17	3078.94	3266.30
SNL-06	CUL	03/05/14	565.08	3081.03	3268.90
SNL-06	CUL	04/08/14	562.00	3084.11	3272.73
SNL-06	CUL	05/05/14	559.51	3086.60	3275.82
SNL-06	CUL	06/02/14	557.60	3088.51	3278.20
SNL-06	CUL	07/08/14	553.93	3092.18	3282.76
SNL-06	CUL	08/05/14	551.17	3094.94	3286.19
SNL-06	CUL	09/03/14	548.49	3097.62	3289.52
SNL-06	CUL	10/03/14	546.67	3099.44	3291.78
SNL-06	CUL	11/11/14	543.50	3102.61	3295.72
SNL-06	CUL	12/01/14	541.80	3104.31	3297.84
SNL-08	CUL	01/09/14	541.88	3013.85	3054.50
SNL-08	CUL	02/10/14	541.93	3013.80	3054.44
SNL-08	CUL	03/18/14	541.47	3014.26	3054.94
SNL-08	CUL	04/08/14	541.80	3013.93	3054.58
SNL-08	CUL	05/06/14	541.36	3014.37	3055.07
SNL-08	CUL	06/02/14	541.31	3014.42	3055.12
SNL-08	CUL	07/08/14	541.35	3014.38	3055.08
SNL-08	CUL	08/04/14	541.25	3014.48	3055.19
SNL-08	CUL	09/03/14	540.92	3014.81	3055.55
SNL-08	CUL	10/01/14	540.60	3015.13	3055.90
SNL-08	CUL	11/11/14	540.80	3014.93	3055.68
SNL-08	CUL	12/01/14	540.70	3015.03	3055.79
SNL-09	CUL	01/08/14	313.16	3047.80	3052.37
SNL-09	CUL	02/11/14	313.80	3047.16	3051.72
SNL-09	CUL	03/05/14	313.84	3047.12	3051.68

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-09	CUL	04/08/14	313.51	3047.45	3052.02
SNL-09	CUL	05/05/14	314.63	3046.33	3050.88
SNL-09	CUL	06/02/14	314.94	3046.02	3050.56
SNL-09	CUL	07/07/14	314.88	3046.08	3050.62
SNL-09	CUL	08/04/14	315.08	3045.88	3050.42
SNL-09	CUL	09/03/14	315.35	3045.61	3050.14
SNL-09	CUL	10/01/14	312.89	3048.07	3052.65
SNL-09	CUL	11/10/14	311.52	3049.44	3054.04
SNL-09	CUL	12/03/14	312.03	3048.93	3053.52
SNL-10	CUL	01/08/14	329.14	3048.45	3051.29
SNL-10	CUL	02/04/14	329.39	3048.20	3051.04
SNL-10	CUL	03/05/14	329.99	3047.60	3050.44
SNL-10	CUL	04/10/14	329.65	3047.94	3050.78
SNL-10	CUL	05/06/14	331.12	3046.47	3049.29
SNL-10	CUL	06/02/14	331.75	3045.84	3048.66
SNL-10	CUL	07/07/14	332.40	3045.19	3048.00
SNL-10	CUL	08/04/14	332.68	3044.91	3047.72
SNL-10	CUL	09/03/14	332.83	3044.76	3047.57
SNL-10	CUL	10/01/14	332.41	3045.18	3047.99
SNL-10	CUL	11/10/14	330.74	3046.85	3049.68
SNL-10	CUL	12/03/14	330.82	3046.77	3049.60
SNL-12	CUL	01/07/14	377.64	2961.82	2962.98
SNL-12	CUL	02/04/14	383.59	2955.87	2956.99
SNL-12	CUL	03/04/14	384.54	2954.92	2956.04
SNL-12	CUL	04/09/14	396.90	2942.56	2943.60
SNL-12	CUL	05/06/14	400.73	2938.73	2939.75
SNL-12	CUL	06/03/14	402.15	2937.31	2938.32
SNL-12	CUL	07/08/14	394.35	2945.11	2946.17
SNL-12	CUL	08/05/14	396.78	2942.68	2943.72
SNL-12	CUL	09/03/14	393.44	2946.02	2947.08
SNL-12	CUL	10/03/14	382.13	2957.33	2958.46
SNL-12	CUL	11/10/14	392.25	2947.21	2948.28
SNL-12	CUL	12/03/14	393.90	2945.56	2946.62
SNL-13	CUL	01/08/14	297.33	2996.78	2998.54
SNL-13	CUL	02/12/14	300.46	2993.65	2995.36
SNL-13	CUL	03/11/14	301.75	2992.36	2994.05
SNL-13	CUL	04/09/14	303.42	2990.69	2992.35

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-13	CUL	05/05/14	305.85	2988.26	2989.88
SNL-13	CUL	06/02/14	308.83	2985.28	2986.85
SNL-13	CUL	07/07/14	312.01	2982.10	2983.61
SNL-13	CUL	08/04/14	313.41	2980.70	2982.19
SNL-13	CUL	09/03/14	314.57	2979.54	2981.01
SNL-13	CUL	10/01/14	315.36	2978.75	2980.21
SNL-13	CUL	11/11/14	315.57	2978.54	2979.99
SNL-13	CUL	12/03/14	315.97	2978.14	2979.59
SNL-14	CUL	01/08/14	412.59	2955.82	2967.64
SNL-14	CUL	02/11/14	416.08	2952.33	2963.99
SNL-14	CUL	03/11/14	420.42	2947.99	2959.45
SNL-14	CUL	04/09/14	428.83	2939.58	2950.65
SNL-14	CUL	05/07/14	432.83	2935.58	2946.47
SNL-14	CUL	06/03/14	434.82	2933.59	2944.39
SNL-14	CUL	07/07/14	429.18	2939.23	2950.29
SNL-14	CUL	08/05/14	430.79	2937.62	2948.60
SNL-14	CUL	09/04/14	429.52	2938.89	2949.93
SNL-14	CUL	10/02/14	421.79	2946.62	2958.02
SNL-14	CUL	11/11/14	427.22	2941.19	2952.34
SNL-14	CUL	12/03/14	428.40	2940.01	2951.10
SNL-15	CUL	01/09/14	533.53	2946.40	3035.55
SNL-15	CUL	02/10/14	532.58	2947.35	3036.72
SNL-15	CUL	03/18/14	532.83	2947.10	3036.41
SNL-15	CUL	04/08/14	530.92	2949.01	3038.76
SNL-15	CUL	05/06/14	529.98	2949.95	3039.91
SNL-15	CUL	06/03/14	530.36	2949.57	3039.45
SNL-15	CUL	07/10/14	527.62	2952.31	3042.81
SNL-15	CUL	08/05/14	526.88	2953.05	3043.72
SNL-15	CUL	09/04/14	526.02	2953.91	3044.78
SNL-15	CUL	10/02/14	525.26	2954.67	3045.71
SNL-15	CUL	11/11/14	524.28	2955.65	3046.92
SNL-15	CUL	12/03/14	523.58	2956.35	3047.78
SNL-16	CUL	01/07/14	123.51	3009.49	3010.15
SNL-16	CUL	02/04/14	123.54	3009.46	3010.12
SNL-16	CUL	03/04/14	123.82	3009.18	3009.84
SNL-16	CUL	04/08/14	124.47	3008.53	3009.18
SNL-16	CUL	05/05/14	124.44	3008.56	3009.21

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-16	CUL	06/02/14	124.65	3008.35	3009.00
SNL-16	CUL	07/09/14	124.39	3008.61	3009.27
SNL-16	CUL	08/04/14	124.50	3008.50	3009.15
SNL-16	CUL	09/02/14	125.66	3007.34	3007.99
SNL-16	CUL	10/01/14	117.70	3015.30	3016.01
SNL-16	CUL	11/10/14	117.90	3015.10	3015.81
SNL-16	CUL	12/02/14	118.43	3014.57	3015.27
SNL-17	CUL	01/07/14	246.14	2991.92	2992.44
SNL-17	CUL	02/10/14	248.42	2989.64	2990.15
SNL-17	CUL	03/04/14	249.45	2988.61	2989.11
SNL-17	CUL	04/09/14	254.56	2983.50	2983.98
SNL-17	CUL	05/06/14	256.03	2982.03	2982.50
SNL-17	CUL	06/02/14	256.76	2981.30	2981.76
SNL-17	CUL	07/08/14	254.68	2983.38	2983.85
SNL-17	CUL	08/05/14	255.70	2982.36	2982.83
SNL-17	CUL	09/04/14	254.92	2983.14	2983.61
SNL-17	CUL	10/01/14	247.31	2990.75	2991.26
SNL-17	CUL	11/10/14	250.50	2987.56	2988.06
SNL-17	CUL	12/03/14	250.98	2987.08	2987.57
SNL-18	CUL	01/07/14	305.49	3069.95	3072.16
SNL-18	CUL	02/04/14	305.56	3069.88	3072.09
SNL-18	CUL	03/04/14	306.08	3069.36	3071.57
SNL-18	CUL	04/08/14	307.15	3068.29	3070.49
SNL-18	CUL	05/06/14	306.74	3068.70	3070.90
SNL-18	CUL	06/02/14	305.69	3069.75	3071.96
SNL-18	CUL	07/08/14	305.73	3069.71	3071.92
SNL-18	CUL	08/04/14	305.75	3069.69	3071.90
SNL-18	CUL	09/02/14	305.82	3069.62	3071.83
SNL-18	CUL	10/02/14	304.90	3070.54	3072.76
SNL-18	CUL	11/11/14	303.89	3071.55	3073.78
SNL-18	CUL	12/03/14	303.68	3071.76	3073.99
SNL-19	CUL	01/07/14	153.38	3069.27	3070.68
SNL-19	CUL	02/04/14	153.56	3069.09	3070.50
SNL-19	CUL	03/04/14	153.97	3068.68	3070.09
SNL-19	CUL	04/08/14	154.44	3068.21	3069.61
SNL-19	CUL	05/05/14	154.51	3068.14	3069.54
SNL-19	CUL	06/02/14	154.58	3068.07	3069.47

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-19	CUL	07/08/14	154.68	3067.97	3069.37
SNL-19	CUL	08/04/14	154.82	3067.83	3069.23
SNL-19	CUL	09/02/14	155.04	3067.61	3069.01
SNL-19	CUL	10/02/14	150.89	3071.76	3073.19
SNL-19	CUL	11/10/14	150.58	3072.07	3073.50
SNL-19	CUL	12/03/14	151.28	3071.37	3072.80
WIPP-11	CUL	01/08/14	367.03	3060.75	3079.40
WIPP-11	CUL	02/11/14	367.43	3060.35	3078.98
WIPP-11	CUL	03/05/14	367.55	3060.23	3078.86
WIPP-11	CUL	04/10/14	368.05	3059.73	3078.34
WIPP-11	CUL	05/05/14	368.14	3059.64	3078.25
WIPP-11	CUL	06/03/14	368.00	3059.78	3078.39
WIPP-11	CUL	07/09/14	368.10	3059.68	3078.29
WIPP-11	CUL	08/12/14	368.19	3059.59	3078.19
WIPP-11	CUL	09/04/14	368.15	3059.63	3078.24
WIPP-11	CUL	10/01/14	367.55	3060.23	3078.86
WIPP-11	CUL	11/10/14	366.45	3061.33	3080.00
WIPP-11	CUL	12/02/14	366.59	3061.19	3079.86
WIPP-13	CUL	01/08/14	345.51	3060.16	3074.95
WIPP-13	CUL	02/11/14	345.87	3059.80	3074.58
WIPP-13	CUL	03/18/14	345.70	3059.97	3074.76
WIPP-13	CUL	04/10/14	346.35	3059.32	3074.08
WIPP-13	CUL	05/06/14	346.28	3059.39	3074.15
WIPP-13	CUL	06/04/14	346.15	3059.52	3074.29
WIPP-13	CUL	07/09/14	346.32	3059.35	3074.11
WIPP-13	CUL	08/04/14	346.13	3059.54	3074.31
WIPP-13	CUL	09/04/14	346.20	3059.47	3074.24
WIPP-13	CUL	10/01/14	345.55	3060.12	3074.91
WIPP-13	CUL	11/12/14	344.75	3060.92	3075.74
WIPP-13	CUL	12/04/14	344.15	3061.52	3076.37
WIPP-19	CUL	01/09/14	393.59	3041.52	3061.10
WIPP-19	CUL	02/12/14	394.41	3040.70	3060.24
WIPP-19	CUL	03/18/14	394.74	3040.37	3059.89
WIPP-19	CUL	04/10/14	395.35	3039.76	3059.25
WIPP-19	CUL	05/07/14	395.75	3039.36	3058.83
WIPP-19	CUL	06/03/14	396.41	3038.70	3058.13
WIPP-19	CUL	07/09/14	397.08	3038.03	3057.43

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-19	CUL	08/12/14	397.73	3037.38	3056.74
WIPP-19	CUL	09/04/14	397.88	3037.23	3056.59
WIPP-19	CUL	10/03/14	398.00	3037.11	3056.46
WIPP-19	CUL	11/12/14	398.11	3037.00	3056.34
WIPP-19	CUL	12/04/14	397.83	3037.28	3056.64
WQSP-1	CUL	01/08/14	362.89	3056.36	3073.55
WQSP-1	CUL	02/12/14	363.18	3056.07	3073.24
WQSP-1	CUL	03/20/14	363.54	3055.71	3072.87
WQSP-1	CUL	04/10/14	363.82	3055.43	3072.57
WQSP-1	CUL	05/06/14	363.85	3055.40	3072.54
WQSP-1	CUL	06/03/14	363.85	3055.40	3072.54
WQSP-1	CUL	07/10/14	364.03	3055.22	3072.35
WQSP-1	CUL	08/12/14	364.16	3055.09	3072.22
WQSP-1	CUL	09/04/14	364.03	3055.22	3072.35
WQSP-1	CUL	10/03/14	363.61	3055.64	3072.79
WQSP-1	CUL	11/12/14	362.84	3056.41	3073.60
WQSP-1	CUL	12/04/14	362.22	3057.03	3074.25
WQSP-2	CUL	01/09/14	402.96	3060.91	3080.75
WQSP-2	CUL	02/12/14	403.33	3060.54	3080.36
WQSP-2	CUL	03/20/14	403.69	3060.18	3079.98
WQSP-2	CUL	04/10/14	404.01	3059.86	3079.65
WQSP-2	CUL	05/07/14	404.04	3059.83	3079.62
WQSP-2	CUL	06/05/14	403.98	3059.89	3079.68
WQSP-2	CUL	07/09/14	404.18	3059.69	3079.47
WQSP-2	CUL	08/12/14	404.21	3059.66	3079.44
WQSP-2	CUL	09/04/14	404.11	3059.76	3079.55
WQSP-2	CUL	10/03/14	403.76	3060.11	3079.91
WQSP-2	CUL	11/12/14	402.98	3060.89	3080.73
WQSP-2	CUL	12/04/14	402.47	3061.40	3081.26
WQSP-3	CUL	01/07/14	466.06	3014.08	3072.36
WQSP-3	CUL	02/12/14	466.29	3013.85	3072.10
WQSP-3	CUL	03/20/14	466.51	3013.63	3071.84
WQSP-3	CUL	04/10/14	466.64	3013.50	3071.69
WQSP-3	CUL	05/07/14	466.82	3013.32	3071.49
WQSP-3	CUL	06/03/14	467.14	3013.00	3071.12
WQSP-3	CUL	07/09/14	469.47	3010.67	3068.44
WQSP-3	CUL	08/12/14	468.70	3011.44	3069.33

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-3	CUL	09/04/14	468.63	3011.51	3069.41
WQSP-3	CUL	10/03/14	468.63	3011.51	3069.41
WQSP-3	CUL	11/12/14	468.52	3011.62	3069.54
WQSP-3	CUL	12/04/14	468.23	3011.91	3069.87
WQSP-4	CUL	01/07/14	460.39	2972.70	2997.06
WQSP-4	CUL	02/12/14	463.62	2969.47	2993.58
WQSP-4	CUL	03/20/14	466.43	2966.66	2990.56
WQSP-4	CUL	04/08/14	468.87	2964.22	2987.93
WQSP-4	CUL	05/07/14	472.39	2960.70	2984.15
WQSP-4	CUL	06/04/14	475.35	2957.74	2980.96
WQSP-4	CUL	07/07/14	477.72	2955.37	2978.41
WQSP-4	CUL	08/06/14	478.73	2954.36	2977.32
WQSP-4	CUL	09/05/14	479.95	2953.14	2976.01
WQSP-4	CUL	10/01/14	479.86	2953.23	2976.11
WQSP-4	CUL	11/11/14	479.56	2953.53	2976.43
WQSP-4	CUL	12/08/14	480.50	2952.59	2975.42
WQSP-5	CUL	01/08/14	391.29	2993.09	3000.31
WQSP-5	CUL	02/12/14	394.71	2989.67	2996.80
WQSP-5	CUL	03/20/14	397.73	2986.65	2993.70
WQSP-5	CUL	04/09/14	399.70	2984.68	2991.67
WQSP-5	CUL	05/07/14	403.14	2981.24	2988.14
WQSP-5	CUL	06/04/14	406.09	2978.29	2985.11
WQSP-5	CUL	07/07/14	409.33	2975.05	2981.78
WQSP-5	CUL	08/07/14	411.15	2973.23	2979.91
WQSP-5	CUL	09/04/14	412.70	2971.68	2978.32
WQSP-5	CUL	10/03/14	413.73	2970.65	2977.26
WQSP-5	CUL	11/11/14	413.98	2970.40	2977.01
WQSP-5	CUL	12/04/14	414.49	2969.89	2976.48
WQSP-6	CUL	01/08/14	351.65	3013.07	3016.75
WQSP-6	CUL	02/12/14	354.44	3010.28	3013.92
WQSP-6	CUL	03/20/14	357.02	3007.70	3011.30
WQSP-6	CUL	04/09/14	358.48	3006.24	3009.82
WQSP-6	CUL	05/05/14	360.54	3004.18	3007.73
WQSP-6	CUL	06/03/14	363.65	3001.07	3004.57
WQSP-6	CUL	07/10/14	366.55	2998.17	3001.63
WQSP-6	CUL	08/06/14	368.38	2996.34	2999.77
WQSP-6	CUL	09/04/14	369.85	2994.87	2998.28

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6	CUL	10/03/14	370.89	2993.83	2997.22
WQSP-6	CUL	11/11/14	371.87	2992.85	2996.23
WQSP-6	CUL	12/04/14	372.29	2992.43	2995.80
C-2737 (ANNULUS)	MAG	01/09/14	255.35	3145.41	*
C-2737 (ANNULUS)	MAG	02/12/14	255.42	3145.34	*
C-2737 (ANNULUS)	MAG	03/18/14	255.15	3145.61	*
C-2737 (ANNULUS)	MAG	04/10/14	255.28	3145.48	*
C-2737 (ANNULUS)	MAG	05/07/14	255.12	3145.64	*
C-2737 (ANNULUS)	MAG	06/04/14	255.09	3145.67	*
C-2737 (ANNULUS)	MAG	07/10/14	255.13	3145.63	*
C-2737 (ANNULUS)	MAG	08/12/14	255.08	3145.68	*
C-2737 (ANNULUS)	MAG	09/04/14	254.98	3145.78	*
C-2737 (ANNULUS)	MAG	10/03/14	254.75	3146.01	*
C-2737 (ANNULUS)	MAG	11/12/14	254.79	3145.97	*
C-2737 (ANNULUS)	MAG	12/08/14	254.79	3145.97	*
H-02b1	MAG	01/09/14	235.30	3143.19	*
H-02b1	MAG	02/12/14	235.27	3143.22	*
H-02b1	MAG	03/18/14	235.10	3143.39	*
H-02b1	MAG	04/10/14	235.00	3143.49	*
H-02b1	MAG	05/07/14	234.87	3143.62	*
H-02b1	MAG	06/05/14	234.74	3143.75	*
H-02b1	MAG	07/10/14	234.65	3143.84	*
H-02b1	MAG	08/12/14	234.57	3143.92	*
H-02b1	MAG	09/04/14	234.51	3143.98	*
H-02b1	MAG	10/01/14	234.39	3144.10	*
H-02b1	MAG	11/12/14	234.15	3144.34	*
H-02b1	MAG	12/08/14	234.10	3144.39	*
H-03b1	MAG	01/08/14	242.96	3147.76	*
H-03b1	MAG	02/12/14	242.92	3147.80	*
H-03b1	MAG	03/18/14	242.69	3148.03	*
H-03b1	MAG	04/10/14	242.78	3147.94	*
H-03b1	MAG	05/07/14	242.62	3148.10	*
H-03b1	MAG	06/04/14	242.62	3148.10	*
H-03b1	MAG	07/10/14	242.55	3148.17	*
H-03b1	MAG	08/07/14	242.60	3148.12	*
H-03b1	MAG	09/04/14	242.45	3148.27	*
H-03b1	MAG	10/03/14	242.09	3148.63	*
H-03b1	MAG	11/11/14	242.07	3148.65	*
H-03b1	MAG	12/04/14	242.10	3148.62	*
H-04c	MAG	01/08/14	186.25	3148.03	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-04c	MAG	02/12/14	186.15	3148.13	*
H-04c	MAG	03/11/14	186.07	3148.21	*
H-04c	MAG	04/09/14	185.97	3148.31	*
H-04c	MAG	05/05/14	185.94	3148.34	*
H-04c	MAG	06/03/14	185.79	3148.49	*
H-04c	MAG	07/07/14	185.77	3148.51	*
H-04c	MAG	08/06/14	185.76	3148.52	*
H-04c	MAG	09/04/14	185.61	3148.67	*
H-04c	MAG	10/03/14	185.30	3148.98	*
H-04c	MAG	11/11/14	185.19	3149.09	*
H-04c	MAG	12/04/14	185.25	3149.03	*
H-06c	MAG	01/08/14	277.02	3071.67	*
H-06c	MAG	02/11/14	277.17	3071.52	*
H-06c	MAG	03/05/14	277.04	3071.65	*
H-06c	MAG	04/10/14	277.07	3071.62	*
H-06c	MAG	05/05/14	277.10	3071.59	*
H-06c	MAG	06/02/14	276.99	3071.70	*
H-06c	MAG	07/09/14	277.21	3071.48	*
H-06c	MAG	08/04/14	277.29	3071.40	*
H-06c	MAG	09/03/14	277.28	3071.41	*
H-06c	MAG	10/01/14	276.81	3071.88	*
H-06c	MAG	11/12/14	277.06	3071.63	*
H-06c	MAG	12/03/14	276.82	3071.87	*
H-08a	MAG	01/07/14	404.47	3028.81	*
H-08a	MAG	02/04/14	404.40	3028.88	*
H-08a	MAG	03/04/14	404.38	3028.90	*
H-08a	MAG	04/09/14	404.33	3028.95	*
H-08a	MAG	05/06/14	404.28	3029.00	*
H-08a	MAG	06/03/14	404.28	3029.00	*
H-08a	MAG	07/09/14	404.19	3029.09	*
H-08a	MAG	08/05/14	404.25	3029.03	*
H-08a	MAG	09/04/14	404.30	3028.98	*
H-08a	MAG	10/03/14	404.22	3029.06	*
H-08a	MAG	11/10/14	404.00	3029.28	*
H-08a	MAG	12/03/14	404.02	3029.26	*
H-09c	MAG	01/07/14	271.29	3135.76	*
H-09c	MAG	02/04/14	269.97	3137.08	*
H-09c	MAG	03/04/14	271.27	3135.78	*
H-09c	MAG	04/09/14	271.23	3135.82	*
H-09c	MAG	05/06/14	271.08	3135.97	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-09c	MAG	06/03/14	271.04	3136.01	*
H-09c	MAG	07/08/14	271.18	3135.87	*
H-09c	MAG	08/05/14	271.27	3135.78	*
H-09c	MAG	09/03/14	271.25	3135.80	*
H-09c	MAG	10/03/14	271.01	3136.04	*
H-09c	MAG	11/10/14	271.03	3136.02	*
H-09c	MAG	12/03/14	271.30	3135.75	*
H-10a	MAG	01/07/14	576.12	3112.33	*
H-10a	MAG	02/10/14	576.10	3112.35	*
H-10a	MAG	03/04/14	576.15	3112.30	*
H-10a	MAG	04/09/14	576.12	3112.33	*
H-10a	MAG	05/06/14	576.12	3112.33	*
H-10a	MAG	06/03/14	576.16	3112.29	*
H-10a	MAG	07/08/14	576.13	3112.32	*
H-10a	MAG	08/05/14	576.21	3112.24	*
H-10a	MAG	09/03/14	576.25	3112.20	*
H-10a	MAG	10/03/14	576.15	3112.30	*
H-10a	MAG	11/11/14	575.35	3113.10	*
H-10a	MAG	12/04/14	575.06	3113.39	*
H-11b2	MAG	01/09/14	271.28	3140.58	*
H-11b2	MAG	02/11/14	271.31	3140.55	*
H-11b2	MAG	03/11/14	271.23	3140.63	*
H-11b2	MAG	04/09/14	271.15	3140.71	*
H-11b2	MAG	05/06/14	271.16	3140.70	*
H-11b2	MAG	06/05/14	271.07	3140.79	*
H-11b2	MAG	07/07/14	271.08	3140.78	*
H-11b2	MAG	08/06/14	271.06	3140.80	*
H-11b2	MAG	09/04/14	271.12	3140.74	*
H-11b2	MAG	10/02/14	271.75	3140.11	*
H-11b2	MAG	11/11/14	270.80	3141.06	*
H-11b2	MAG	12/03/14	270.86	3141.00	*
H-14	MAG	01/08/14	206.83	3140.25	*
H-14	MAG	02/12/14	206.81	3140.27	*
H-14	MAG	03/11/14	206.73	3140.35	*
H-14	MAG	04/10/14	206.66	3140.42	*
H-14	MAG	05/06/14	206.64	3140.44	*
H-14	MAG	06/03/14	206.52	3140.56	*
H-14	MAG	07/07/14	206.45	3140.63	*
H-14	MAG	08/07/14	206.39	3140.69	*
H-14	MAG	09/04/14	206.35	3140.73	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-14	MAG	10/01/14	206.36	3140.72	*
H-14	MAG	11/11/14	206.12	3140.96	*
H-14	MAG	12/02/14	206.09	3140.99	*
H-15	MAG	01/08/14	332.81	3150.97	*
H-15	MAG	02/12/14	333.13	3150.65	*
H-15	MAG	03/18/14	332.76	3151.02	*
H-15	MAG	04/10/14	332.83	3150.95	*
H-15	MAG	05/07/14	332.29	3151.49	*
H-15	MAG	06/05/14	332.52	3151.26	*
H-15	MAG	07/10/14	332.61	3151.17	*
H-15	MAG	08/12/14	332.54	3151.24	*
H-15	MAG	09/04/14	332.34	3151.44	*
H-15	MAG	10/03/14	331.93	3151.85	*
H-15	MAG	11/12/14	332.04	3151.74	*
H-15	MAG	12/04/14	331.89	3151.89	*
H-18	MAG	01/08/14	256.63	3157.58	*
H-18	MAG	02/12/14	256.68	3157.53	*
H-18	MAG	03/18/14	256.28	3157.93	*
H-18	MAG	04/10/14	256.41	3157.80	*
H-18	MAG	05/06/14	256.23	3157.98	*
H-18	MAG	06/02/14	256.19	3158.02	*
H-18	MAG	07/10/14	256.15	3158.06	*
H-18	MAG	08/07/14	256.04	3158.17	*
H-18	MAG	09/03/14	255.97	3158.24	*
H-18	MAG	10/01/14	255.48	3158.73	*
H-18	MAG	11/12/14	255.68	3158.53	*
H-18	MAG	12/04/14	255.45	3158.76	*
WIPP-18	MAG	01/09/14	305.86	3151.71	*
WIPP-18	MAG	02/12/14	305.82	3151.75	*
WIPP-18	MAG	03/18/14	305.65	3151.92	*
WIPP-18	MAG	04/10/14	305.66	3151.91	*
WIPP-18	MAG	05/07/14	305.56	3152.01	*
WIPP-18	MAG	06/03/14	305.51	3152.06	*
WIPP-18	MAG	07/09/14	305.50	3152.07	*
WIPP-18	MAG	08/12/14	305.54	3152.03	*
WIPP-18	MAG	09/04/14	305.44	3152.13	*
WIPP-18	MAG	10/03/14	305.11	3152.46	*
WIPP-18	MAG	11/12/14	305.19	3152.38	*
WIPP-18	MAG	12/04/14	305.15	3152.42	*
WQSP-6a	DL	01/08/14	167.40	3196.40	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6a	DL	02/12/14	167.74	3196.06	*
WQSP-6a	DL	03/20/14	167.80	3196.00	*
WQSP-6a	DL	04/09/14	167.78	3196.02	*
WQSP-6a	DL	05/05/14	167.67	3196.13	*
WQSP-6a	DL	06/03/14	167.68	3196.12	*
WQSP-6a	DL	07/10/14	167.76	3196.04	*
WQSP-6a	DL	08/06/14	167.72	3196.08	*
WQSP-6a	DL	09/04/14	167.70	3196.10	*
WQSP-6a	DL	10/03/14	167.82	3195.98	*
WQSP-6a	DL	11/11/14	167.76	3196.04	*
WQSP-6a	DL	12/04/14	167.75	3196.05	*
CB-1	B/C	01/09/14	301.36	3027.76	*
CB-1	B/C	02/11/14	301.14	3027.98	*
CB-1	B/C	03/11/14	300.63	3028.49	*
CB-1	B/C	04/09/14	300.55	3028.57	*
CB-1	B/C	05/07/14	300.09	3029.03	*
CB-1	B/C	06/03/14	299.87	3029.25	*
CB-1	B/C	07/07/14	299.71	3029.41	*
CB-1	B/C	08/05/14	299.57	3029.55	*
CB-1	B/C	09/04/14	299.35	3029.77	*
CB-1	B/C	10/02/14	298.86	3030.26	*
CB-1	B/C	11/11/14	298.69	3030.43	*
CB-1	B/C	12/01/14	298.75	3030.37	*
DOE-2	B/C	01/08/14	350.96	3068.22	*
DOE-2	B/C	02/11/14	350.98	3068.20	*
DOE-2	B/C	03/18/14	350.85	3068.33	*
DOE-2	B/C	04/10/14	350.88	3068.30	*
DOE-2	B/C	05/06/14	350.82	3068.36	*
DOE-2	B/C	06/03/14	350.73	3068.45	*
DOE-2	B/C	07/09/14	350.81	3068.37	*
DOE-2	B/C	08/12/14	350.75	3068.43	*
DOE-2	B/C	09/04/14	350.63	3068.55	*
DOE-2	B/C	10/03/14	350.45	3068.73	*
DOE-2	B/C	11/12/14	350.39	3068.79	*
DOE-2	B/C	12/04/14	350.34	3068.84	*
C-2505	SR/DL	March	Inaccessible due to event		*
C-2505	SR/DL	06/04/14	48.77	3364.16	*
C-2505	SR/DL	09/02/14	48.25	3364.68	*
C-2505	SR/DL	12/04/14	46.79	3366.14	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
C-2506	SR/DL	March	Inaccessible due to event		*
C-2506	SR/DL	06/04/14	48.00	3364.84	*
C-2506	SR/DL	09/02/14	49.02	3363.82	*
C-2506	SR/DL	12/04/14	46.03	3366.81	*
C-2507	SR/DL	March	Inaccessible due to event		*
C-2507	SR/DL	06/04/14	48.66	3361.25	*
C-2507	SR/DL	09/02/14	49.01	3360.90	*
C-2507	SR/DL	12/04/14	46.90	3363.01	*
C-2811	SR/DL	03/18/14	55.99	3342.85	*
C-2811	SR/DL	06/04/14	56.22	3342.62	
C-2811	SR/DL	09/04/14	56.58	3342.26	*
C-2811	SR/DL	12/08/14	54.95	3343.89	*
PZ-01	SR/DL	March	Inaccessible due to event		*
PZ-01	SR/DL	06/04/14	44.82	3368.46	*
PZ-01	SR/DL	09/02/14	45.09	3368.19	*
PZ-01	SR/DL	12/04/14	44.44	3368.84	*
PZ-02	SR/DL	March	Inaccessible due to event		*
PZ-02	SR/DL	06/04/14	45.78	3367.58	*
PZ-02	SR/DL	09/02/14	46.02	3367.34	*
PZ-02	SR/DL	12/04/14	45.07	3368.29	*
PZ-03	SR/DL	March	Inaccessible due to event		*
PZ-03	SR/DL	06/04/14	47.03	3369.09	*
PZ-03	SR/DL	09/02/14	47.32	3368.80	*
PZ-03	SR/DL	12/04/14	46.82	3369.30	*
PZ-04	SR/DL	March	Inaccessible due to event		*
PZ-04	SR/DL	June	Inaccessible due to event		*
PZ-04	SR/DL	12/04/14	48.66	3363.35	*
PZ-05	SR/DL	March	Inaccessible due to event		*
PZ-05	SR/DL	06/04/14	45.84	3369.40	*
PZ-05	SR/DL	09/02/14	46.15	3369.09	*
PZ-05	SR/DL	12/04/14	45.49	3369.75	*
PZ-06	SR/DL	March	Inaccessible due to event		*
PZ-06	SR/DL	06/04/14	47.00	3366.33	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-06	SR/DL	09/02/14	47.28	3366.05	*
PZ-06	SR/DL	12/04/14	45.88	3367.45	*
PZ-07	SR/DL	03/18/14	40.28	3373.56	*
PZ-07	SR/DL	06/05/14	40.55	3373.29	*
PZ-07	SR/DL	09/03/14	40.92	3372.92	*
PZ-07	SR/DL	12/04/14	39.92	3373.92	*
PZ-08	SR/DL	03/18/14	68.83	3349.36	*
PZ-08	SR/DL	06/05/14	68.81	3349.38	*
PZ-08	SR/DL	09/03/14	68.83	3349.36	*
PZ-08	SR/DL	12/04/14	68.80	3349.39	*
PZ-09	SR/DL	03/18/14	58.85	3362.24	*
PZ-09	SR/DL	06/05/14	59.08	3362.01	*
PZ-09	SR/DL	09/03/14	59.27	3361.82	*
PZ-09	SR/DL	12/04/14	59.35	3361.74	*
PZ-10	SR/DL	03/18/14	41.60	3364.13	*
PZ-10	SR/DL	06/04/14	42.23	3363.50	*
PZ-10	SR/DL	09/03/14	42.50	3363.23	*
PZ-10	SR/DL	12/04/14	39.34	3366.39	*
PZ-11	SR/DL	03/18/14	47.74	3371.04	*
PZ-11	SR/DL	06/05/14	47.96	3370.82	*
PZ-11	SR/DL	09/03/14	48.33	3370.45	*
PZ-11	SR/DL	12/04/14	47.83	3370.95	*
PZ-12	SR/DL	03/18/14	56.97	3351.95	*
PZ-12	SR/DL	06/05/14	57.48	3351.44	*
PZ-12	SR/DL	09/03/14	58.06	3350.86	*
PZ-12	SR/DL	12/04/14	55.76	3353.16	*
PZ-13	SR/DL	03/18/14	67.08	3355.16	*
PZ-13	SR/DL	06/05/14	67.23	3355.01	*
PZ-13	SR/DL	09/03/14	67.45	3354.79	*
PZ-13	SR/DL	12/04/14	67.54	3354.70	*
PZ-14	SR/DL	03/18/14	67.92	3352.66	*
PZ-14	SR/DL	06/05/14	67.96	3352.62	*
PZ-14	SR/DL	09/03/14	68.09	3352.49	*
PZ-14	SR/DL	12/04/14	68.15	3352.43	*
PZ-15	SR/DL	03/18/14	49.36	3381.50	*
PZ-15	SR/DL	06/05/14	49.45	3381.41	*
PZ-15	SR/DL	09/03/14	49.59	3381.27	*
PZ-15	SR/DL	12/04/14	47.88	3382.98	*

Well	Zone	Date	Adjusted Depth Total Organic Compound (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)

Notes:

* Not Applicable

amsl above mean sea level

ft feet or foot

NA Not Available

APPENDIX G – AIR SAMPLING DATA: CONCENTRATIONS OF RADIONUCLIDES IN AIR FILTER COMPOSITES

Table G.1 2014 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for sampling location codes
Units are Bq/sample

		$^{233/234}U$				^{235}U				^{238}U			
Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	1	2.97E-03	2.54E-03	1.09E-02	U	5.22E-04	8.53E-04	1.33E-03	U	1.87E-03	2.45E-03	9.73E-03	U
	2	1.06E-03	2.20E-03	1.11E-02	U	2.93E-04	6.00E-04	1.24E-03	U	4.57E-03	2.28E-03	1.01E-02	U
	3	1.17E-03	4.15E-03	1.08E-02	U	-2.60E-04	1.00E-03	1.28E-03	U	2.82E-03	3.98E-03	9.70E-03	U
	4 (Avg)	2.22E-03	3.51E-03	1.09E-02	U	2.98E-04	8.48E-04	1.23E-03	U	3.46E-03	3.13E-03	9.85E-03	U
WEE	1	-9.37E-04	1.99E-03	1.09E-02	U	2.43E-04	5.97E-04	1.27E-03	U	7.07E-04	2.25E-03	9.71E-03	U
	2	2.55E-03	8.45E-03	1.10E-02	U	4.36E-04	1.51E-03	1.35E-03	U	2.11E-03	6.95E-03	1.00E-02	U
	3	4.27E-03	4.60E-03	1.09E-02	U	5.88E-04	1.23E-03	1.32E-03	U	1.87E-03	4.07E-03	9.75E-03	U
	4	8.33E-04	3.33E-03	1.08E-02	U	1.33E-04	8.10E-04	1.17E-03	U	1.29E-03	2.86E-03	9.81E-03	U
WSS	1	1.62E-03	2.16E-03	1.08E-02	U	6.70E-04	8.44E-04	1.26E-03	U	6.94E-04	2.16E-03	9.66E-03	U
	2	3.06E-03	4.57E-03	1.11E-02	U	4.44E-04	9.07E-04	1.42E-03	U	4.23E-03	5.74E-03	1.01E-02	U
	3	6.53E-04	4.08E-03	1.08E-02	U	-2.57E-04	9.97E-04	1.28E-03	U	4.18E-05	3.75E-03	9.70E-03	U
	4	1.36E-03	3.49E-03	1.09E-02	U	1.81E-04	8.87E-04	1.34E-03	U	3.59E-03	3.19E-03	9.86E-03	U
MLR	1	2.35E-03	2.38E-03	1.09E-02	U	4.81E-04	8.42E-04	1.31E-03	U	1.93E-03	2.41E-03	9.71E-03	U
	2	1.16E-03	2.25E-03	1.11E-02	U	1.91E-04	5.18E-04	1.27E-03	U	3.75E-03	2.22E-03	1.01E-02	U
	3	5.83E-04	4.05E-03	1.08E-02	U	-5.88E-04	9.18E-04	1.26E-03	U	1.62E-03	3.82E-03	9.68E-03	U
	4	8.27E-04	3.40E-03	1.09E-02	U	2.05E-04	8.20E-04	1.24E-03	U	3.00E-03	3.07E-03	9.84E-03	U
SEC	1 (Avg)	2.50E-03	2.47E-03	1.10E-02	U	-2.95E-05	7.50E-04	1.45E-03	U	1.29E-03	2.23E-03	9.69E-03	U
	2	2.04E-03	2.26E-03	1.10E-02	U	-1.42E-04	2.68E-04	1.21E-03	U	3.32E-03	2.03E-03	1.00E-02	U
	3	1.88E-03	4.27E-03	1.08E-02	U	-5.65E-04	9.20E-04	1.30E-03	U	1.92E-03	3.97E-03	9.70E-03	U
	4	2.86E-03	3.59E-03	1.09E-02	U	6.01E-05	7.95E-04	1.22E-03	U	4.37E-03	3.24E-03	9.85E-03	U
CBD	1	3.33E-03	2.52E-03	1.09E-02	U	4.96E-04	8.18E-04	1.31E-03	U	2.07E-03	2.45E-03	9.71E-03	U
	2 (Avg)	2.98E-03	2.59E-03	1.13E-02	U	-3.50E-05	6.18E-04	2.28E-03	U	4.26E-03	2.37E-03	1.02E-02	U
	3	2.92E-03	4.55E-03	1.09E-02	U	-2.30E-04	1.27E-03	1.61E-03	U	4.57E-03	4.38E-03	9.78E-03	U
	4	4.51E-03	3.86E-03	1.09E-02	U	1.05E-03	1.14E-03	1.28E-03	U	5.11E-03	3.45E-03	9.89E-03	U
SMR	1	1.13E-04	2.04E-03	1.08E-02	U	2.78E-04	7.02E-04	1.28E-03	U	-9.93E-05	2.11E-03	9.67E-03	U
	2	2.81E-03	2.43E-03	1.11E-02	U	4.61E-04	6.68E-04	1.25E-03	U	6.44E-03	2.59E-03	1.00E-02	U
	3 (Avg)	2.12E-03	4.47E-03	1.09E-02	U	-4.45E-04	9.69E-04	1.38E-03	U	3.28E-03	4.27E-03	9.77E-03	U
	4	2.93E-03	3.62E-03	1.09E-02	U	7.03E-05	8.08E-04	1.26E-03	U	4.68E-03	3.29E-03	9.86E-03	U
	Mean	2.03E-03	3.42E-03	1.09E-02	NA	1.62E-04	8.54E-04	1.34E-03	NA	2.81E-03	3.24E-03	9.83E-03	NA
	Minimum(e)	-9.37E-04	1.99E-03	1.09E-02	WEE (1)	-5.88E-04	9.18E-04	1.26E-03	MLR (3)	-9.93E-05	2.11E-03	9.67E-03	CBD (4)
	Maximum(f)	4.51E-03	3.86E-03	1.09E-02	CBD (4)	1.05E-03	1.14E-03	1.28E-03	CBD (4)	6.44E-03	2.59E-03	1.00E-02	SMR (2)
WAB (Filter Blank)	1	3.06E-03	1.56E-03	1.10E-02	U	7.89E-05	4.76E-04	1.46E-03	U	3.48E-03	1.63E-03	9.78E-03	U
	2	3.67E-03	1.49E-03	1.11E-02	U	-8.09E-05	2.18E-04	1.40E-03	U	2.37E-03	1.16E-03	1.02E-02	U
	3	9.47E-03	3.10E-03	1.09E-02	U	6.57E-04	8.42E-04	1.48E-03	U	8.65E-03	2.88E-03	9.80E-03	U
	4	7.38E-03	2.64E-03	1.10E-02	U	2.93E-04	6.23E-04	1.47E-03	U	5.83E-03	2.26E-03	9.99E-03	U

Location	Quarter	^{238}Pu				$^{239/240}$PU				^{241}Am			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	1	-2.73E-04	5.44E-04	1.03E-03	U	1.99E-04	4.70E-04	8.76E-04	U	-6.90E-04	9.94E-04	1.03E-03	U
	2	-2.79E-04	3.02E-04	7.82E-04	U	-1.83E-04	4.05E-04	7.78E-04	U	1.74E-04	8.76E-04	1.23E-03	U
	3	-3.67E-04	7.57E-04	1.32E-03	U	2.27E-04	7.10E-04	1.26E-03	U	1.31E-04	9.60E-04	1.23E-03	U
	4 (Avg)	-2.58E-04	6.98E-04	1.06E-03	U	-4.32E-04	7.50E-04	9.07E-04	U	-1.03E-04	1.03E-03	1.59E-03	U
WEE	1	-9.63E-05	8.71E-04	1.26E-03	U	9.55E-05	5.13E-04	8.22E-04	U	-4.58E-04	1.17E-03	1.34E-03	U
	2	-1.06E-04	5.69E-04	1.00E-03	U	-1.30E-04	3.38E-04	6.87E-04	U	-3.47E-04	5.27E-04	1.04E-03	U
	3	-3.90E-04	5.98E-04	1.31E-03	U	4.05E-04	6.98E-04	1.08E-03	U	1.55E-04	8.75E-04	1.05E-03	U
	4	-6.35E-04	6.18E-04	1.21E-03	U	-7.06E-04	6.56E-04	8.41E-04	U	-3.78E-04	8.48E-04	1.22E-03	U
WSS	1	-5.89E-04	7.46E-04	1.30E-03	U	-1.09E-04	3.75E-04	8.13E-04	U	-3.98E-05	1.17E-03	1.20E-03	U
	2	-2.91E-04	3.21E-04	1.00E-03	U	4.30E-06	3.85E-04	6.14E-04	U	-1.05E-04	6.62E-04	1.03E-03	U
	3	-2.43E-04	6.35E-04	1.27E-03	U	-8.07E-05	3.35E-04	9.12E-04	U	-6.15E-05	7.93E-04	1.20E-03	U
	4	-1.89E-04	3.43E-04	7.67E-04	U	-7.92E-04	7.31E-04	9.99E-04	U	7.47E-04	8.11E-04	1.00E-03	U
MLR	1	2.52E-05	4.18E-04	7.10E-04	U	-1.02E-04	3.12E-04	6.63E-04	U	1.35E-04	1.16E-03	1.18E-03	U
	2	-2.76E-04	5.11E-04	9.36E-04	U	-5.32E-05	4.59E-04	8.26E-04	U	-7.69E-04	9.50E-04	1.56E-03	U
	3	-2.92E-04	5.08E-04	1.15E-03	U	2.42E-04	6.07E-04	1.12E-03	U	4.87E-06	9.45E-04	1.38E-03	U
	4	-1.92E-04	3.78E-04	9.54E-04	U	-7.30E-04	6.72E-04	8.88E-04	U	-2.78E-04	5.52E-04	1.53E-03	U
SEC	1 (Avg)	-1.06E-04	3.95E-04	8.87E-04	U	1.02E-04	4.16E-04	7.49E-04	U	-5.45E-05	1.11E-03	1.19E-03	U
	2	-2.51E-04	2.55E-04	7.06E-04	U	6.88E-05	4.82E-04	6.38E-04	U	-6.54E-05	7.50E-04	1.10E-03	U
	3	-1.93E-04	5.90E-04	1.24E-03	U	-1.58E-04	4.35E-04	9.82E-04	U	-5.60E-05	8.28E-04	1.22E-03	U
	4	-2.67E-04	2.25E-04	7.66E-04	U	-6.58E-04	6.22E-04	8.12E-04	U	1.34E-05	5.59E-04	1.26E-03	U
CBD	1	-1.82E-04	7.33E-04	8.69E-04	U	-1.82E-04	1.98E-04	7.24E-04	U	-5.17E-04	9.18E-04	1.11E-03	U
	2 (Avg)	-1.51E-04	4.00E-04	8.37E-04	U	-8.87E-05	4.04E-04	7.33E-04	U	2.48E-04	8.59E-04	1.16E-03	U
	3	-3.18E-05	5.78E-04	1.05E-03	U	1.10E-05	4.33E-04	8.58E-04	U	1.88E-04	8.45E-04	9.48E-04	U
	4	-5.55E-05	5.40E-04	7.76E-04	U	-7.22E-04	6.67E-04	9.48E-04	U	3.68E-04	1.17E-03	1.33E-03	U
SMR	1	-2.16E-04	4.98E-04	8.53E-04	U	1.70E-05	4.57E-04	9.78E-04	U	3.99E-04	1.28E-03	1.27E-03	U
	2	-1.18E-04	3.50E-04	7.43E-04	U	-3.70E-07	3.89E-04	6.65E-04	U	-1.08E-05	1.03E-03	1.45E-03	U
	3 (Avg)	-1.38E-04	4.43E-04	1.03E-03	U	7.95E-05	4.89E-04	8.65E-04	U	4.60E-05	1.02E-03	1.49E-03	U
	4	-3.51E-04	3.53E-04	8.89E-04	U	-5.57E-04	6.73E-04	8.40E-04	U	3.74E-04	8.39E-04	1.07E-03	U
Mean		-2.33E-04	5.05E-04	9.88E-04	NA	-1.51E-04	5.04E-04	8.52E-04	NA	-3.39E-05	9.09E-04	1.24E-03	NA
Minimum[e]		-6.35E-04	6.18E-04	1.21E-03	WEE (4)	-7.92E-04	7.31E-04	9.99E-04	WSS (4)	-7.69E-04	9.50E-04	1.56E-03	MLR (2)
Maximum[f]		2.52E-05	4.18E-04	7.10E-04	MLR (1)	4.05E-04	6.98E-04	1.08E-03	WEE (3)	7.47E-04	8.11E-04	1.00E-03	WSS (4)
WAB (Filter Blank)	1	2.08E-05	4.05E-04	8.20E-04	U	-1.34E-04	2.33E-04	9.08E-04	U	6.01E-04	8.94E-04	1.59E-03	U
	2	-1.84E-04	2.97E-04	1.08E-03	U	-7.27E-05	3.90E-04	1.14E-03	U	-2.50E-04	6.71E-04	1.29E-03	U
	3	1.62E-04	4.22E-04	1.11E-03	U	-3.23E-05	3.80E-04	1.20E-03	U	1.06E-04	7.72E-04	1.23E-03	U
	4	-2.12E-04	3.09E-04	8.75E-04	U	6.32E-04	6.69E-04	1.11E-03	U	-1.18E-04	5.27E-04	1.19E-03	U

Location	Quarter	^{40}K				^{60}Co				^{137}Cs			
		[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	1	6.68E+00	5.63E+00	7.04E+00	U	-9.91E-02	6.07E-01	6.69E-01	U	-1.53E-01	6.15E-01	6.65E-01	U
	2	2.99E+00	6.19E+00	7.19E+00	U	-2.07E-01	6.15E-01	6.69E-01	U	2.83E-02	6.69E-01	7.42E-01	U
	3	7.00E+00	6.50E+00	7.92E+00	U	5.55E-01	6.53E-01	7.88E-01	U	-2.58E-01	6.22E-01	7.00E-01	U
	4 (Avg)	3.51E+00	7.94E+00	9.06E+00	U	2.91E-01	7.91E-01	9.11E-01	U	2.11E-01	8.42E-01	9.24E-01	U
WEE	1	-1.18E-01	6.08E+00	6.77E+00	U	3.86E-01	6.17E-01	7.30E-01	U	2.35E-01	6.03E-01	6.84E-01	U
	2	6.78E+00	5.85E+00	7.26E+00	U	3.39E-01	6.53E-01	7.73E-01	U	-3.91E-01	6.77E-01	7.08E-01	U
	3	4.18E+00	6.58E+00	7.82E+00	U	1.88E-01	6.55E-01	7.58E-01	U	-5.17E-01	6.93E-01	7.17E-01	U
	4	9.62E+00	6.99E+00	8.43E+00	U	5.03E-01	6.61E-01	7.93E-01	U	5.34E-01	7.15E-01	8.08E-01	U
WSS	1	7.41E+00	5.80E+00	7.25E+00	U	8.50E-01	5.68E-01	7.42E-01	U	2.11E-01	5.39E-01	6.47E-01	U
	2	3.90E+00	5.88E+00	7.07E+00	U	-3.12E-01	6.53E-01	6.97E-01	U	6.37E-01	5.38E-01	6.65E-01	U
	3	-2.03E+00	6.40E+00	7.00E+00	U	-4.08E-01	7.17E-01	7.58E-01	U	-1.27E-02	6.38E-01	7.07E-01	U
	4	1.20E+01	6.64E+00	8.28E+00	U	-1.40E-01	6.70E-01	7.42E-01	U	-4.13E-01	7.57E-01	7.95E-01	U
MLR	1	1.03E+00	6.03E+00	6.94E+00	U	1.47E-01	6.27E-01	7.26E-01	U	2.71E-01	6.24E-01	7.05E-01	U
	2	3.02E+00	8.16E+00	9.21E+00	U	6.71E-01	8.50E-01	1.01E+00	U	-6.24E-01	9.88E-01	9.91E-01	U
	3	2.40E+00	7.30E+00	8.27E+00	U	2.82E-02	7.87E-01	8.68E-01	U	-3.60E-01	8.08E-01	8.72E-01	U
	4	4.01E+02	7.15E+00	8.20E+00	U	-6.29E-01	7.30E-01	7.31E-01	U	2.56E-01	7.03E-01	7.88E-01	U
SEC	1 (Avg)	5.00E-02	6.64E+00	7.61E+00	U	2.95E-01	7.30E-01	8.68E-01	U	5.45E-02	6.69E-01	7.81E-01	U
	2	4.41E+00	7.20E+00	8.32E+00	U	-2.53E-01	7.23E-01	7.82E-01	U	-5.20E-01	7.35E-01	7.61E-01	U
	3	4.42E+00	6.63E+00	7.87E+00	U	7.60E-03	6.48E-01	7.40E-01	U	-4.43E-01	6.48E-01	7.17E-01	U
	4	6.69E+00	6.24E+00	7.63E+00	U	5.62E-01	6.21E-01	7.54E-01	U	1.44E-01	6.86E-01	7.63E-01	U
CBD	1	8.02E+00	6.57E+00	8.50E+00	U	7.36E-03	8.41E-01	9.71E-01	U	6.54E-01	7.39E-01	9.01E-01	U
	2 (Avg)	8.65E-01	6.08E+00	6.90E+00	U	-1.35E-03	6.46E-01	7.26E-01	U	-6.27E-02	6.00E-01	6.77E-01	U
	3	5.58E+00	6.13E+00	7.48E+00	U	1.95E-01	6.52E-01	7.58E-01	U	-6.92E-02	6.92E-01	7.58E-01	U
	4	5.27E+00	6.11E+00	7.38E+00	U	-2.76E-01	6.83E-01	7.27E-01	U	-5.41E-02	6.05E-01	7.05E-01	U
SMR	1	3.17E+00	5.73E+00	6.84E+00	U	-3.97E-01	6.78E-01	7.12E-01	U	2.72E-01	5.81E-01	6.62E-01	U
	2	6.91E+00	6.69E+00	8.03E+00	U	-2.18E-01	6.73E-01	7.25E-01	U	-1.57E-01	6.66E-01	7.22E-01	U
	3 (Avg)	2.31E+00	8.00E+00	9.24E+00	U	6.52E-01	7.89E-01	9.49E-01	U	-1.91E-01	8.09E-01	9.10E-01	U
	4	3.79E+00	8.32E+00	9.47E+00	U	1.92E-01	8.53E-01	9.66E-01	U	-4.02E-01	9.85E-01	1.02E+00	U
Mean		1.86E+01	6.66E+00	7.85E+00	NA	1.05E-01	6.96E-01	7.92E-01	NA	-4.00E-02	6.97E-01	7.71E-01	NA
Minimum[e]		-2.03E+00	6.40E+00	7.00E+00	WSS (3)	-6.29E-01	7.30E-01	7.31E-01	MLR (4)	-6.24E-01	9.88E-01	9.91E-01	MLR (2)
Maximum[f]		4.01E+02	7.15E+00	8.20E+00	MLR (4)	8.50E-01	5.68E-01	7.42E-01	WSS (1)	6.54E-01	7.39E-01	9.01E-01	CBD (1)
WAB (Filter Blank)	1	-1.65E+00	6.11E+00	6.72E+00	U	-8.77E-03	6.30E-01	7.16E-01	U	1.77E-01	5.47E-01	6.52E-01	U
	2	3.65E+00	6.05E+00	7.24E+00	U	-3.69E-01	7.18E-01	7.58E-01	U	1.81E-01	6.48E-01	7.28E-01	U
	3	6.65E+00	9.78E+00	1.25E+01	U	-7.92E-02	1.13E+00	1.26E+00	U	3.00E-01	1.19E+00	1.36E+00	U
	4	1.53E+01	6.32E+00	8.29E+00	U	-1.43E-01	6.78E-01	7.52E-01	U	5.88E-01	7.05E-01	8.08E-01	U

Location	Quarter	^{90}Sr [RN][a]	^{90}Sr 2 σ TPU[b]	^{90}Sr MDC[c]	^{90}Sr Q[d]
WFF	1	1.11E-04	3.03E-02	2.13E-02	U
	2	-3.19E-03	2.50E-02	2.50E-02	U
	3	-1.56E-02	2.68E-02	2.27E-02	U
	4 (Avg)	-2.93E-03	2.47E-02	2.53E-02	U
WEE	1	6.52E-03	2.66E-02	2.11E-02	U
	2	-1.64E-02	2.38E-02	2.48E-02	U
	3	1.10E-02	2.77E-02	2.27E-02	U
	4	1.68E-02	2.50E-02	2.54E-02	U
WSS	1	1.18E-02	2.75E-02	2.12E-02	U
	2	-8.23E-03	2.47E-02	2.49E-02	U
	3	1.14E-02	2.63E-02	2.25E-02	U
	4	8.88E-03	2.43E-02	2.53E-02	U
MLR	1	1.59E-02	3.07E-02	2.13E-02	U
	2	-1.76E-02	2.46E-02	2.49E-02	U
	3	-3.28E-03	2.65E-02	2.25E-02	U
	4	-9.53E-03	2.35E-02	2.52E-02	U
SEC	1 (Avg)	1.04E-02	2.96E-02	2.13E-02	U
	2	2.04E-03	2.28E-02	2.45E-02	U
	3	1.73E-03	2.93E-02	2.30E-02	U
	4	1.07E-02	2.38E-02	2.52E-02	U
CBD	1	9.10E-03	2.99E-02	2.14E-02	U
	2 (Avg)	-1.53E-02	2.23E-02	2.45E-02	U
	3	6.52E-03	2.78E-02	2.28E-02	U
	4	-9.93E-03	2.59E-02	2.54E-02	U
SMR	1	1.15E-02	2.95E-02	2.12E-02	U
	2	-1.63E-02	2.30E-02	2.46E-02	U
	3 (Avg)	1.88E-02	2.96E-02	2.29E-02	U
	4	3.64E-04	2.29E-02	2.51E-02	U
	Mean	1.26E-03	2.61E-02	2.36E-02	NA
	Minimum[e]	-1.76E-02	2.46E-02	2.49E-02	MLR (2)
	Maximum[f]	1.88E-02	2.96E-02	2.29E-02	SMR (3)
WAB (Filter Blank)	1	-1.37E-03	2.05E-02	2.12E-02	U
	2	1.03E-02	1.62E-02	2.46E-02	U
	3	2.68E-03	1.98E-02	2.28E-02	U
	4	-1.23E-03	1.78E-02	2.54E-02	U

(a) Radionuclide activity. The average is used for duplicate samples. Only radionuclides with activities greater than 2 σ TPU and the MDC are considered detections except for gamma radionuclides which are detected when the ID Confidence is >0.90.

(b) Total Propagated Uncertainty

(c) Minimum Detectable Concentration

(d) Qualitifer. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

(e) Minimum and maximum reported concentrations for each radionuclide are based on the sample's activity, [RN], while the associated 2 σ TPU and MDC are inherited with the specific [RN], i.e., they are not averages.

Table G.2 2014 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding the WIPP Site
See Appendix C for Sample Location Codes

Location	Quarter	Vol, m^3	$^{233/234}U$		^{235}U		^{238}U		^{238}Pu		$^{239/240}Pu$		^{241}Am	
			Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3
WFF	1	3370.76	2.97E-03	8.81E-07	5.22E-04	1.55E-07	1.87E-03	5.55E-07	-2.73E-04	-8.10E-08	1.99E-04	5.90E-08	-6.90E-04	-2.05E-07
	2	3981.63	1.06E-03	2.66E-07	2.93E-04	7.36E-08	4.57E-03	1.15E-06	-2.79E-04	-7.01E-08	-1.83E-04	-4.60E-08	1.74E-04	4.37E-08
	3	7939.39	1.17E-03	1.47E-07	-2.60E-04	-3.27E-08	2.82E-03	3.55E-07	-3.67E-04	-4.62E-08	2.27E-04	2.85E-08	1.31E-04	1.65E-08
	4 (Avg)	7381.14	2.22E-03	3.01E-07	2.98E-04	4.05E-08	3.46E-03	4.68E-07	-2.58E-04	-3.48E-08	-4.32E-04	-5.85E-08	-1.03E-04	-1.38E-08
WEE	1	3396.01	-9.37E-04	-2.76E-07	2.43E-04	7.16E-08	7.07E-04	2.08E-07	-9.63E-05	-2.84E-08	9.55E-05	2.81E-08	-4.58E-04	-1.35E-07
	2	3924.16	2.55E-03	6.50E-07	4.36E-04	1.11E-07	2.11E-03	5.38E-07	-1.06E-04	-2.70E-08	-1.30E-04	-3.31E-08	-3.47E-04	-8.84E-08
	3	7972.12	4.27E-03	5.35E-07	5.88E-04	7.38E-08	1.87E-03	2.34E-07	-3.90E-04	-4.89E-08	4.05E-04	5.08E-08	1.55E-04	1.95E-08
	4	7515.99	8.33E-04	1.11E-07	1.33E-04	1.77E-08	1.29E-03	1.71E-07	-6.35E-04	-8.44E-08	-7.06E-04	-9.39E-08	-3.78E-04	-5.04E-08
WSS	1	3372.37	1.62E-03	4.80E-07	6.70E-04	1.99E-07	6.94E-04	2.06E-07	-5.89E-04	-1.75E-07	-1.09E-04	-3.23E-08	-3.98E-05	-1.18E-08
	2	3910.46	3.06E-03	7.83E-07	4.44E-04	1.14E-07	4.23E-03	1.08E-06	-2.91E-04	-7.44E-08	4.30E-06	1.10E-09	-1.05E-04	-2.69E-08
	3	7918.35	6.53E-04	8.25E-08	-2.57E-04	-3.24E-08	4.18E-05	5.28E-09	-2.43E-04	-3.07E-08	-8.07E-05	-1.02E-08	-6.15E-05	-7.77E-09
	4	7112.51	1.36E-03	1.91E-07	1.81E-04	2.55E-08	3.59E-03	5.05E-07	-1.89E-04	-2.66E-08	-7.92E-04	-1.11E-07	7.47E-04	1.05E-07
MLR	1	3404.61	2.35E-03	6.90E-07	4.81E-04	1.41E-07	1.93E-03	5.67E-07	2.52E-05	7.40E-09	-1.02E-04	-3.00E-08	1.35E-04	3.97E-08
	2	3905.65	1.16E-03	2.97E-07	1.91E-04	4.89E-08	3.75E-03	9.60E-07	-2.76E-04	-7.07E-08	-5.32E-05	-1.36E-08	-7.69E-04	-1.97E-07
	3	8030.72	5.83E-04	7.26E-08	-5.88E-04	-7.33E-08	1.62E-03	2.02E-07	-2.92E-04	-3.63E-08	2.42E-04	3.01E-08	4.87E-06	6.06E-10
	4	7257.87	8.27E-04	1.14E-07	2.05E-04	2.83E-08	3.00E-03	4.14E-07	-1.92E-04	-2.65E-08	-7.30E-04	-1.01E-07	-2.78E-04	-3.82E-08
SEC	1 (Avg)	3359.135	2.50E-03	7.43E-07	-2.95E-05	-8.90E-09	6.71E-04	3.85E-07	-1.06E-04	-3.17E-08	1.02E-04	3.04E-08	-5.45E-05	-1.64E-08
	2	3924.50	2.04E-03	5.20E-07	-1.42E-04	-3.62E-08	3.32E-03	8.46E-07	-2.51E-04	-6.40E-08	6.88E-05	1.75E-08	-6.54E-05	-1.67E-08
	3	7854.79	1.88E-03	2.40E-07	-5.65E-04	-7.19E-08	1.92E-03	2.44E-07	-1.93E-04	-2.46E-08	-1.58E-04	-2.01E-08	-5.60E-05	-7.13E-09
	4	7153.79	2.86E-03	3.99E-07	6.01E-05	8.40E-09	4.37E-03	6.11E-07	-2.67E-04	-3.74E-08	-6.58E-04	-9.19E-08	1.34E-05	1.87E-09
CBD	1	3379.44	3.33E-03	9.85E-07	4.96E-04	1.47E-07	2.07E-03	6.13E-07	-1.82E-04	-5.39E-08	-1.82E-04	-5.39E-08	-5.17E-04	-1.53E-07
	2 (Avg)	3310.10	2.98E-03	8.99E-07	-3.50E-05	-1.07E-08	4.26E-03	1.29E-06	-1.51E-04	-4.57E-08	-8.87E-05	-2.69E-08	2.48E-04	7.51E-08
	3	7927.26	2.92E-03	3.68E-07	-2.30E-04	-2.90E-08	4.57E-03	5.76E-07	-3.18E-05	-4.02E-09	1.10E-05	1.39E-09	1.88E-04	2.38E-08
	4	7113.81	4.51E-03	6.34E-07	1.05E-03	1.48E-07	5.11E-03	7.18E-07	-5.55E-05	-7.81E-09	-7.22E-04	-1.02E-07	3.68E-04	5.18E-08
SMR	1	3235.27	1.13E-04	3.49E-08	2.78E-04	8.59E-08	-9.93E-05	-3.07E-08	-2.16E-04	-6.68E-08	1.70E-05	5.25E-09	3.99E-04	1.23E-07
	2	3918.89	2.81E-03	7.17E-07	4.61E-04	1.18E-07	6.44E-03	1.64E-06	-1.18E-04	-3.01E-08	-3.70E-07	-9.44E-11	-1.08E-05	-2.76E-09
	3 (Avg)	5733.970	2.12E-03	3.70E-07	-4.45E-04	-7.77E-08	3.28E-03	5.73E-07	-1.38E-04	-2.41E-08	7.95E-05	1.38E-08	4.60E-05	8.03E-09
	4	7463.36	2.93E-03	3.93E-07	7.03E-05	9.42E-09	4.68E-03	6.27E-07	-3.51E-04	-4.70E-08	-5.57E-04	-7.47E-08	3.74E-04	5.01E-08
	Mean	5527.43	2.03E-03	4.15E-07	1.62E-04	4.44E-08	2.79E-03	5.61E-07	-2.33E-04	-4.61E-08	-1.51E-04	-2.26E-08	-3.39E-05	-1.47E-08
	Minimum	3235.27	-9.37E-04	-2.76E-07	-5.88E-04	-7.77E-08	-9.93E-05	-3.07E-08	-6.35E-04	-1.75E-07	-7.92E-04	-1.11E-07	-7.69E-04	-2.05E-07
	Maximum	8030.72	4.51E-03	9.85E-07	1.05E-03	1.99E-07	6.44E-03	1.64E-06	2.52E-05	7.40E-09	4.05E-04	5.90E-08	7.47E-04	1.23E-07

Location	Quarter	Vol, m^3	^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
			Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3
WFF	1	3370.76	6.68E+00	1.98E-03	-9.91E-02	-2.94E-05	-1.53E-01	-4.54E-05	1.11E-04	3.29E-08
	2	3981.63	2.99E+00	7.51E-04	-2.07E-01	-5.20E-05	2.83E-02	7.11E-06	-3.19E-03	-8.01E-07
	3	7939.39	7.00E+00	8.82E-04	5.55E-01	6.99E-05	-2.58E-01	-3.25E-05	-1.56E-02	-1.97E-06
	4 (Avg)	7381.14	3.51E+00	4.76E-04	2.91E-01	3.93E-05	2.11E-01	2.86E-05	-2.93E-03	-3.97E-07
WEE	1	3396.01	-1.18E-01	-3.47E-05	3.86E-01	1.14E-04	2.35E-01	6.92E-05	6.52E-03	1.92E-06
	2	3924.16	6.78E+00	1.73E-03	3.39E-01	8.64E-05	-3.91E-01	-9.96E-05	-1.64E-02	-4.18E-06
	3	7972.12	4.18E+00	5.25E-04	1.88E-01	2.36E-05	-5.17E-01	-6.48E-05	1.10E-02	1.38E-06
	4	7515.99	9.62E+00	1.28E-03	5.03E-01	6.69E-05	5.34E-01	7.11E-05	1.68E-02	2.24E-06
WSS	1	3372.37	7.41E+00	2.20E-03	8.50E-01	2.52E-04	2.11E-01	6.26E-05	1.18E-02	3.50E-06
	2	3910.46	3.90E+00	9.97E-04	-3.12E-01	-7.98E-05	6.37E-01	1.63E-04	-8.23E-03	-2.10E-06
	3	7918.35	-2.03E+00	-2.57E-04	-4.08E-01	-5.16E-05	-1.27E-02	-1.60E-06	1.14E-02	1.43E-06
	4	7112.51	1.20E+01	1.69E-03	-1.40E-01	-1.97E-05	-4.13E-01	-5.80E-05	8.88E-03	1.25E-06
MLR	1	3404.61	1.03E+00	3.03E-04	1.47E-01	4.32E-05	2.71E-01	7.96E-05	1.59E-02	4.67E-06
	2	3905.65	3.02E+00	7.73E-04	6.71E-01	1.72E-04	-6.24E-01	-1.60E-04	-1.76E-02	-4.51E-06
	3	8030.72	2.40E+00	2.99E-04	2.82E-02	3.51E-06	-3.60E-01	-4.48E-05	-3.28E-03	-4.09E-07
	4	7257.87	4.01E+02	5.53E-02	-6.29E-01	-8.67E-05	2.56E-01	3.53E-05	-9.53E-03	-1.31E-06
SEC	1 (Avg)	3359.135	5.00E-02	1.55E-05	2.95E-01	8.74E-05	5.45E-02	1.63E-05	1.04E-02	3.08E-06
	2	3924.50	4.41E+00	1.12E-03	-2.53E-01	-6.45E-05	-5.20E-01	-1.33E-04	2.04E-03	5.20E-07
	3	7854.79	4.42E+00	5.62E-04	7.60E-03	9.68E-07	-4.43E-01	-5.64E-05	1.73E-03	2.21E-07
	4	7153.79	6.69E+00	9.35E-04	5.62E-01	7.86E-05	1.44E-01	2.01E-05	1.07E-02	1.50E-06
CBD	1	3379.44	8.02E+00	2.37E-03	7.36E-03	2.18E-06	6.54E-01	1.94E-04	9.10E-03	2.69E-06
	(Avg)	3310.10	8.65E-01	2.60E-04	-1.35E-03	-4.00E-07	-6.27E-02	-1.90E-05	-1.53E-02	-4.62E-06
	3	7927.26	5.58E+00	7.04E-04	1.95E-01	2.46E-05	-6.92E-02	-8.73E-06	6.52E-03	8.22E-07
	4	7113.81	5.27E+00	7.41E-04	-2.76E-01	-3.87E-05	-5.41E-02	-7.61E-06	-9.93E-03	-1.40E-06
SMR	1	3235.27	3.17E+00	9.80E-04	-3.97E-01	-1.23E-04	2.72E-01	8.41E-05	1.15E-02	3.55E-06
	2	3918.89	6.91E+00	1.76E-03	-2.18E-01	-5.56E-05	-1.57E-01	-4.01E-05	-1.63E-02	-4.16E-06
	(Avg)	5733.970	2.31E+00	4.03E-04	6.52E-01	1.14E-04	-1.91E-01	-3.34E-05	1.88E-02	3.27E-06
	4	7463.36	3.79E+00	5.08E-04	1.92E-01	2.57E-05	-4.02E-01	-5.39E-05	3.64E-04	4.88E-08
Mean		5527.43	1.86E+01	2.83E-03	1.05E-01	2.15E-05	-4.00E-02	-9.94E-07	1.26E-03	2.24E-07
Minimum		3235.27	-2.03E+00	-2.57E-04	-6.29E-01	-1.23E-04	-6.24E-01	-1.60E-04	-1.76E-02	-4.62E-06
Maximum		8030.72	4.01E+02	5.53E-02	8.50E-01	2.52E-04	6.54E-01	1.94E-04	1.88E-02	4.67E-06

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APPENDIX H – COMPARISON OF DETECTED RADIONUCLIDES TO THE RADIOLOGICAL BASELINE

The figures in this appendix show the highest detected radionuclides from 2014 environmental monitoring sample analysis results compared to the 99 percent confidence interval radiological baseline values established for these isotopes (DOE/WIPP–92–037). The figures include air filter particulate, groundwater, surface water, sediment, soil, vegetation and fauna radiochemical analysis results. Note that all results with the exception of vegetation and fauna were compared to the baseline upper 99 percentile probability value. The baseline did not include probability distributions for vegetation and fauna; therefore, vegetation and fauna sample results are compared to the baseline mean values.

A few items to note from the figures include the following:

- Figures are provided for the weekly low-volume event evaluation samples. None of the quarterly air filter composite samples contained detectable concentrations of the target radionuclides.

- WQSP-1 and WQSP-2 groundwater concentrations for $^{233/234}$U were very similar at 1.22E+00 Bq/L and 1.21E+00 Bq/L, respectively. The concentrations were close to but below the 99 percent confidence interval range of the groundwater baseline concentration. The ^{235}U and ^{238}U concentrations were highest at WQSP-1 but were lower than the 99 percent baseline confidence interval range. The highest ^{40}K concentration was at WQSP-3, but the concentration was lower than the 99 percent confidence interval concentration range of the baseline.

- The highest concentrations of detected radionuclides in surface water samples were from locations associated with the Pecos River and all were associated with Pierce Canyon (PCN). PCN contained the highest concentrations of the three uranium isotopes and ^{40}K detected in surface water, but none of the concentrations were higher than the 99 percent confidence interval range of the baseline.

- PCN did not contain the highest concentrations of the uranium isotopes in sediment samples in 2014. The tank and tank-like structure location PKT contained the highest concentrations of $^{233/234}$U and ^{238}U as well as ^{137}Cs. Location BHT contained the highest concentration of ^{235}U, and HIL Tank contained the highest concentration of ^{40}K. None of the concentrations were higher than the 99 percent confidence interval range of the baseline, although the HIL Tank duplicate sample matched the ^{40}K 99 percent confidence interval concentration of 1.20 Bq/g, and the average of the duplicates was 1.18 Bq/g. There were no detections of $^{239/240}$Pu in any sediment samples in 2014.

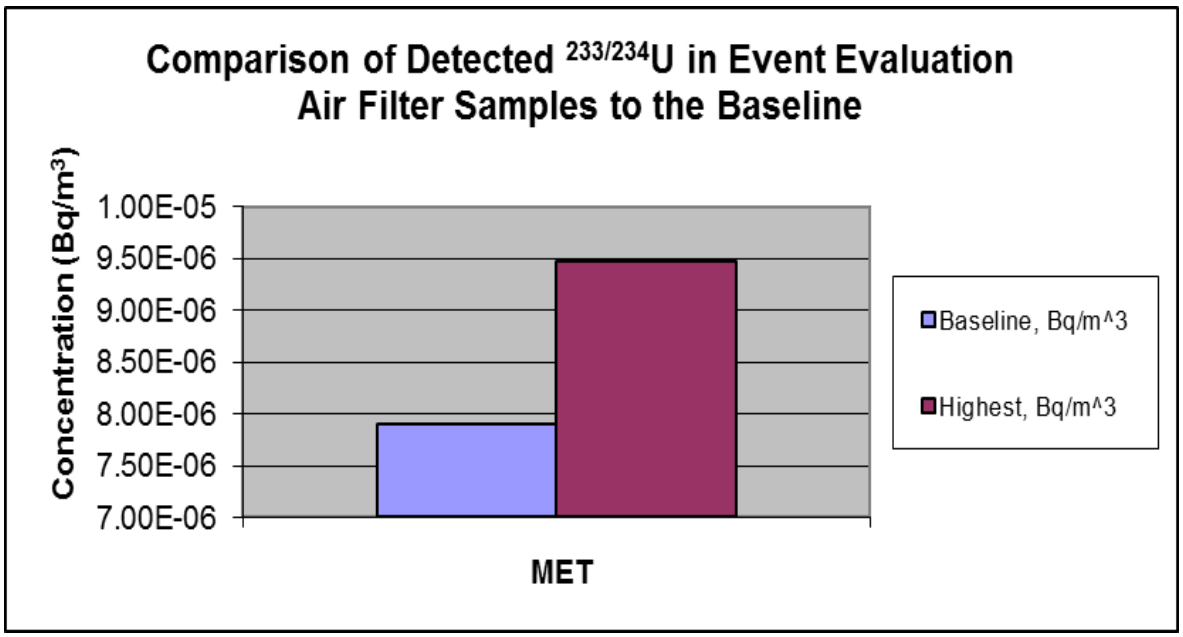
- Most of the highest concentrations of detected radionuclides in soil samples were at MLR and SMR. As was the case in 2013, MLR (0 – 2 cm) contained the

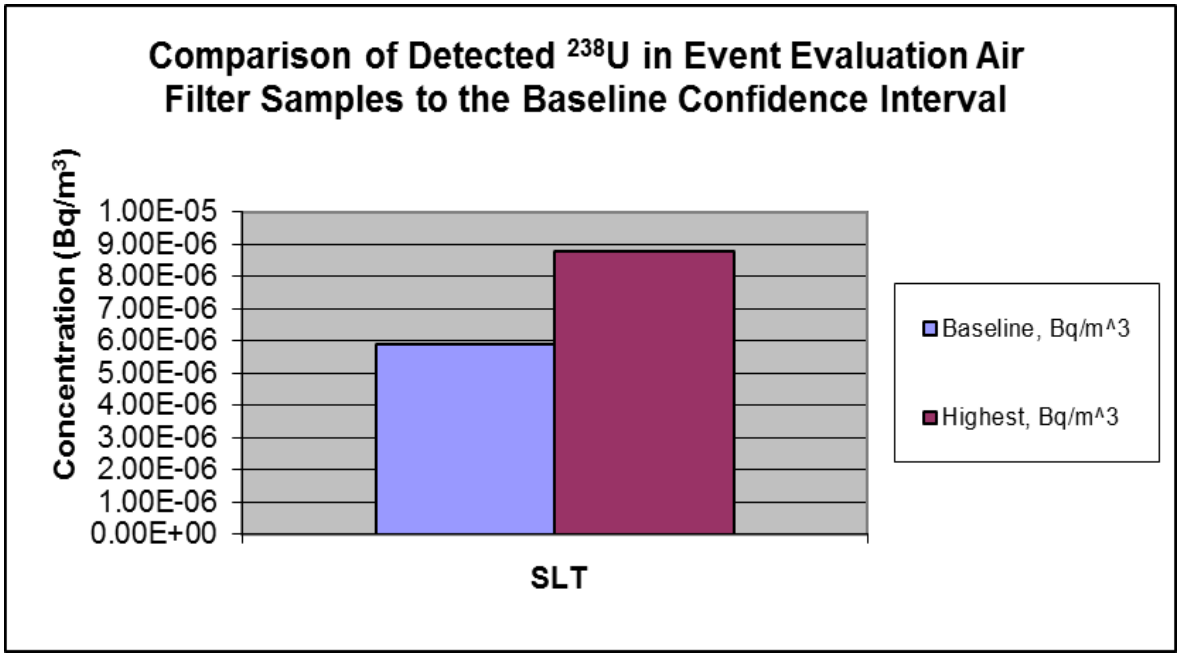
only detection of $^{239/240}$Pu in any of the soil samples. Following the initial detection of $^{239/240}$Pu in the sample, a second sample was acquired, and it also contained measurable $^{239/240}$Pu. The concentrations were similar ranging from 4.0E-04 Bq/g to 5.6E-04 Bq/g. Measured concentrations that were higher than the 99 percent baseline confidence interval concentration included ^{238}U at both the 2-5 cm and 5-10 cm depths at SMR and ^{40}K at the 5-10 cm depth at SMR. K-40 was detected in all the soil samples, and ^{137}Cs was detected in all the soil samples except for the 5-10 cm depth at SMR. None of the ^{137}Cs concentrations were higher than the 99 percent baseline confidence interval concentration.

- The vegetation samples showed detection of ^{40}K in all the samples with the highest detected concentration at SMR. The SMR concentration was lower than the 99 percent baseline confidence interval concentration. The vegetation samples also showed detection of $^{233/234}$U in the samples from WEE (duplicate only), SEC, and SMR. U-238 was also detected in the duplicate sample from WEE and the samples from WSS, MLR, and SMR. The measured $^{233/234}$U concentration of 1.65E-03 Bq/g in the WEE duplicate sample was much higher than the 99 percent baseline confidence interval concentration of 6.00E-05 Bq/g, and the measured ^{238}U concentration of 1.43E-03 Bq/g was higher than the 99 percent baseline confidence interval concentration of 6.90E-04 Bq/g.

All the animal biota samples contained ^{40}K. The concentrations were lower than the baseline mean concentrations, although there is no baseline mean concentration for deer. Uranium isotopes were not detected in any of the animal biota samples in 2014. A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.

Note: Graphs with no location only display the baseline as no detections were encountered for that radionuclide.


Comparison of Detected 233/234U in Event Evaluation Air Filter Samples to the Baseline
Concentration (Bq/m3)
1.00E-05
9.50E-06
9.00E-06
8.50E-06
8.00E-06
7.50E-06
7.00E-06
MET
Baseline, Bq/m^3
Highest, Bq/m^3


Comparison of Detected 238U in Event Evaluation Air Filter Samples to the Baseline Confidence Interval
Concentration (Bq/m3)
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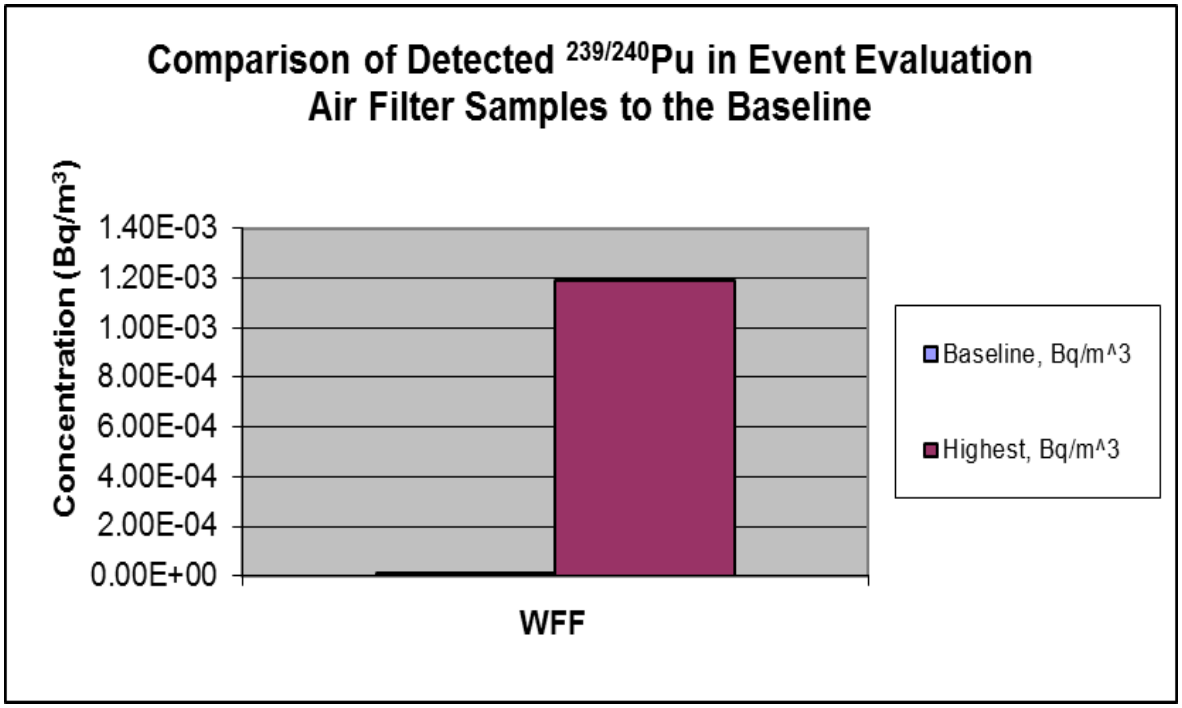
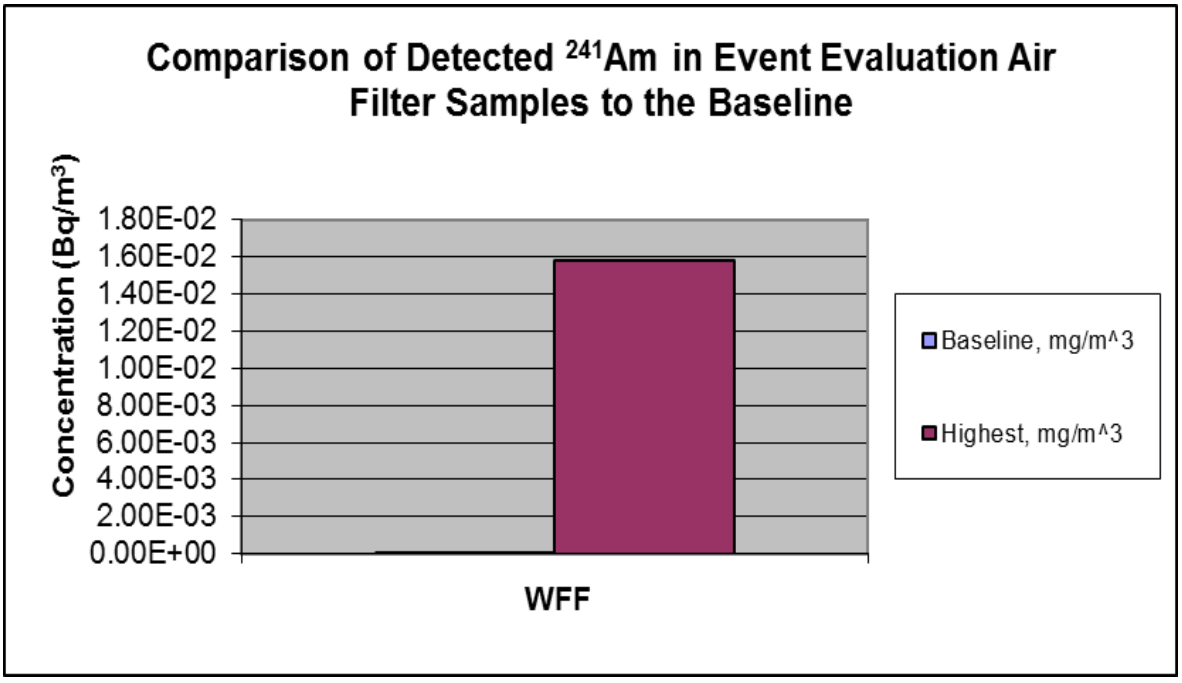
9.00E-06
8.00E-06
7.00E-06
6.00E-06
5.00E-06
4.00E-06
3.00E-06
2.00E-06
1.00E-06
0.00E+00
SLT
Baseline, Bq/m^3
Highest, Bq/m^3


Comparison of Detected 239/240Pu in Event Evaluation Air Filter Samples to the Baseline
Concentration (Bq/m3)
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
WFF
Baseline, Bq/m^3
Highest, Bq/m^3


Comparison of Detected 241Am in Event Evaluation Air Filter Samples to the Baseline
Concentration (Bq/m3)
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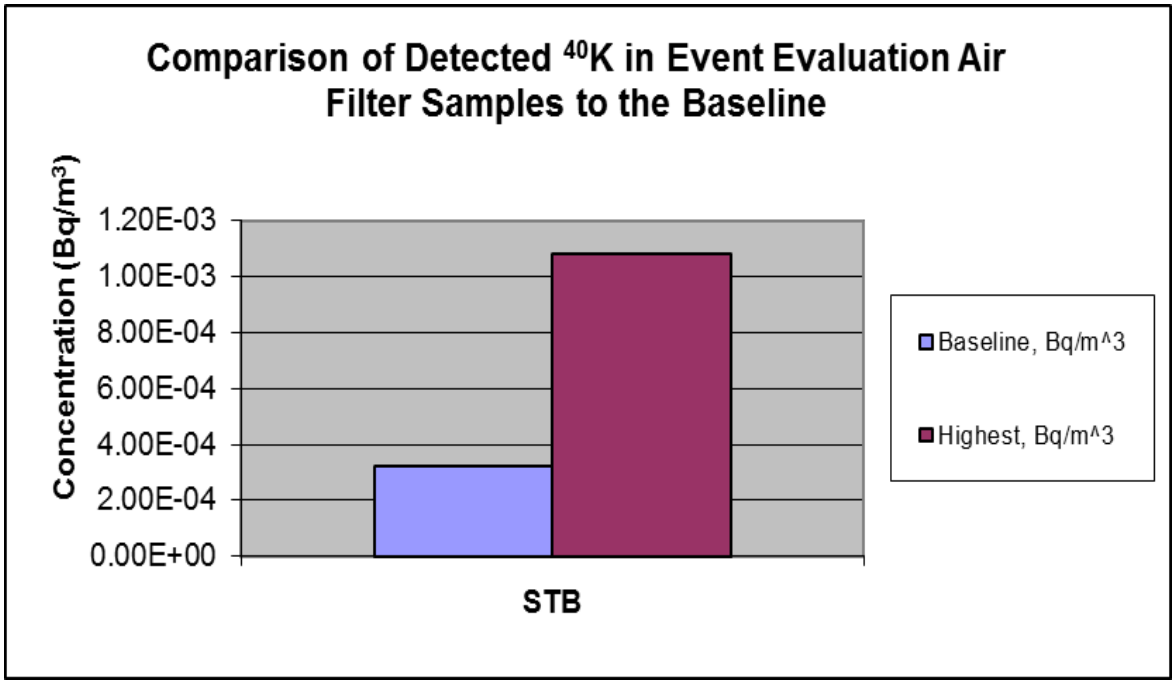
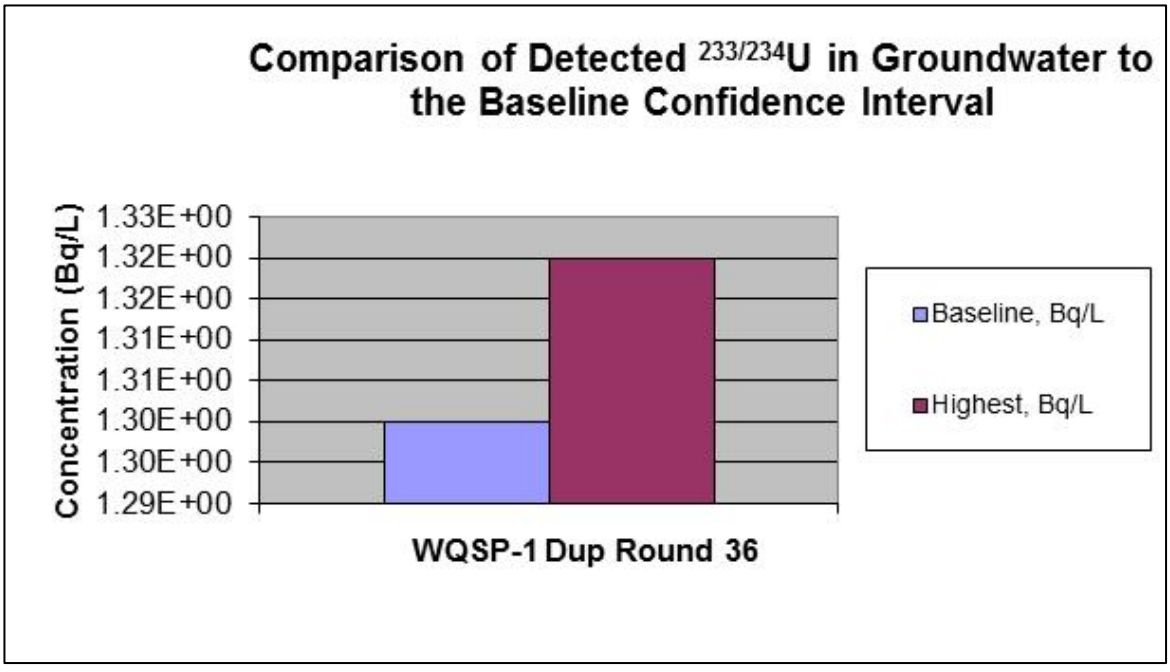
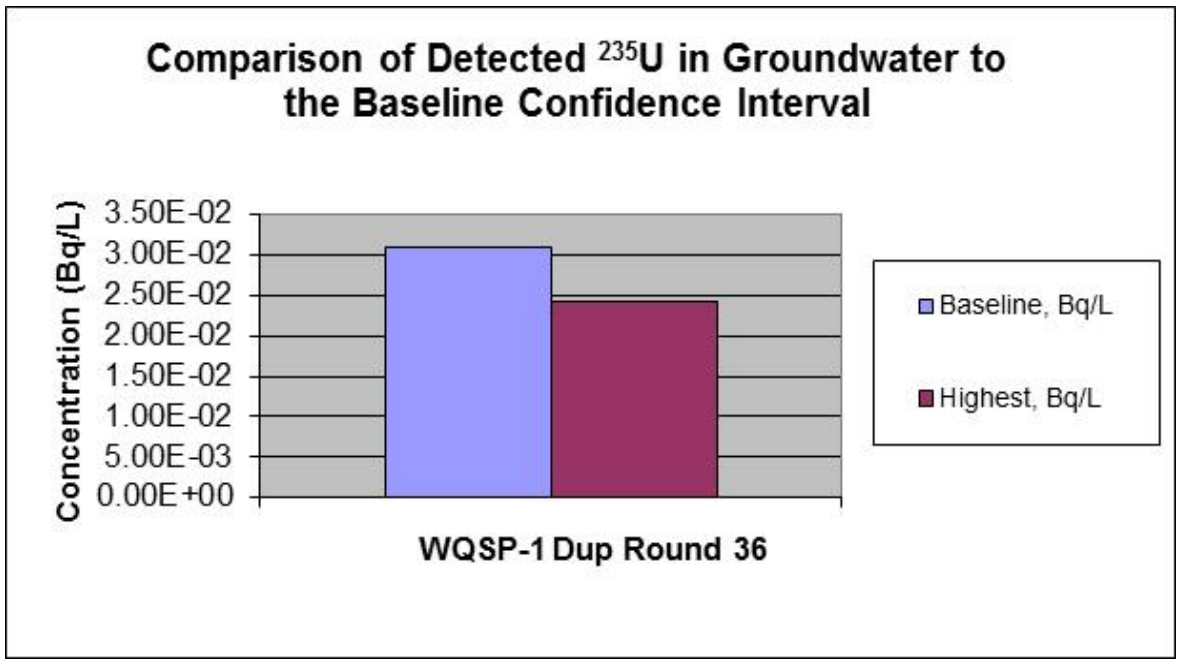
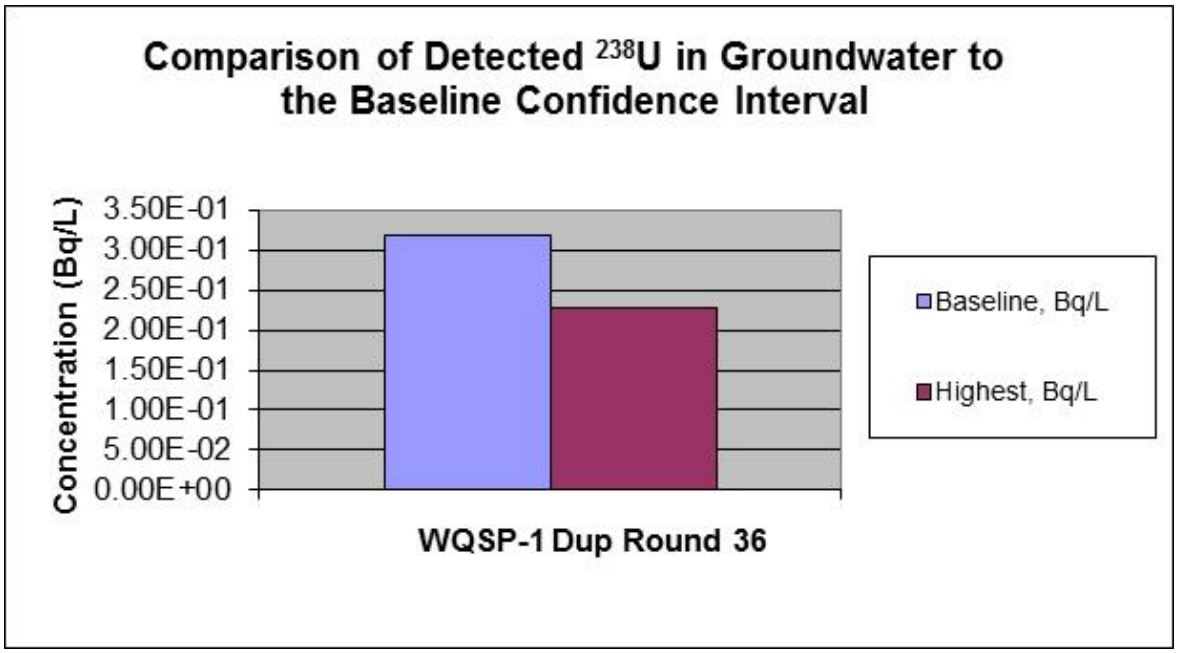
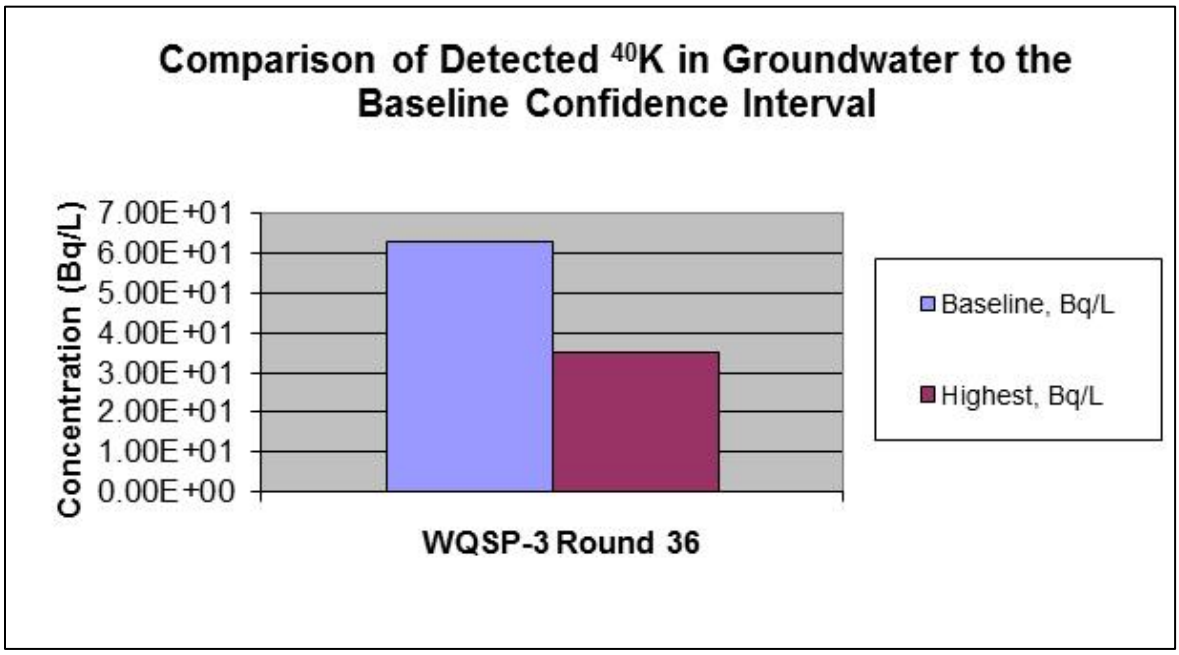
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
WFF
Baseline, mg/m^3
Highest, mg/m^3


Comparison of Detected 40K in Event Evaluation Air Filter Samples to the Baseline
Concentration (Bq/m3)
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
STB
Baseline, Bq/m^3
Highest, Bq/m^3


Comparison of Detected 233/234U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
1.33E+00
1.32E+00
1.32E+00
1.31E+00
1.31E+00
1.30E+00
1.30E+00
1.29E+00
WQSP-1 Dup Round 36
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 235U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
Baseline, Bq/L
Highest, Bq/L
WQSP-1 Dup Round 36


Comparison of Detected 238U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Baseline, Bq/L
Highest, Bq/L
WQSP-1 Dup Round 36


Comparison of Detected 40K in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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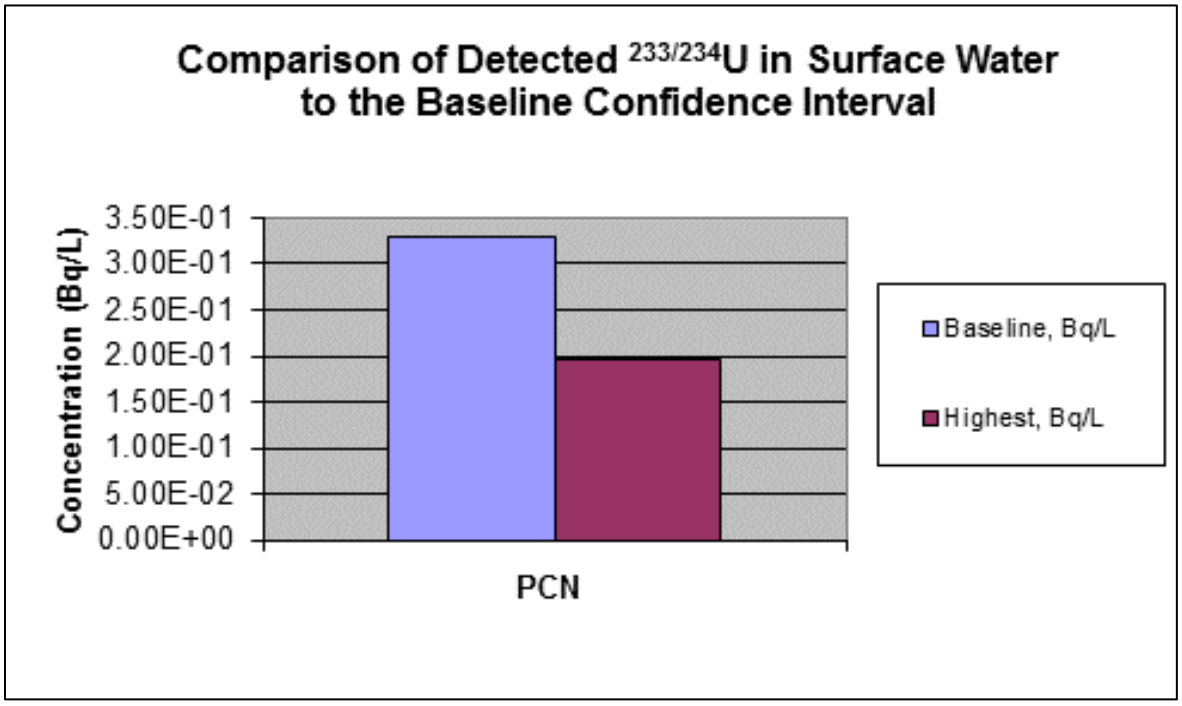
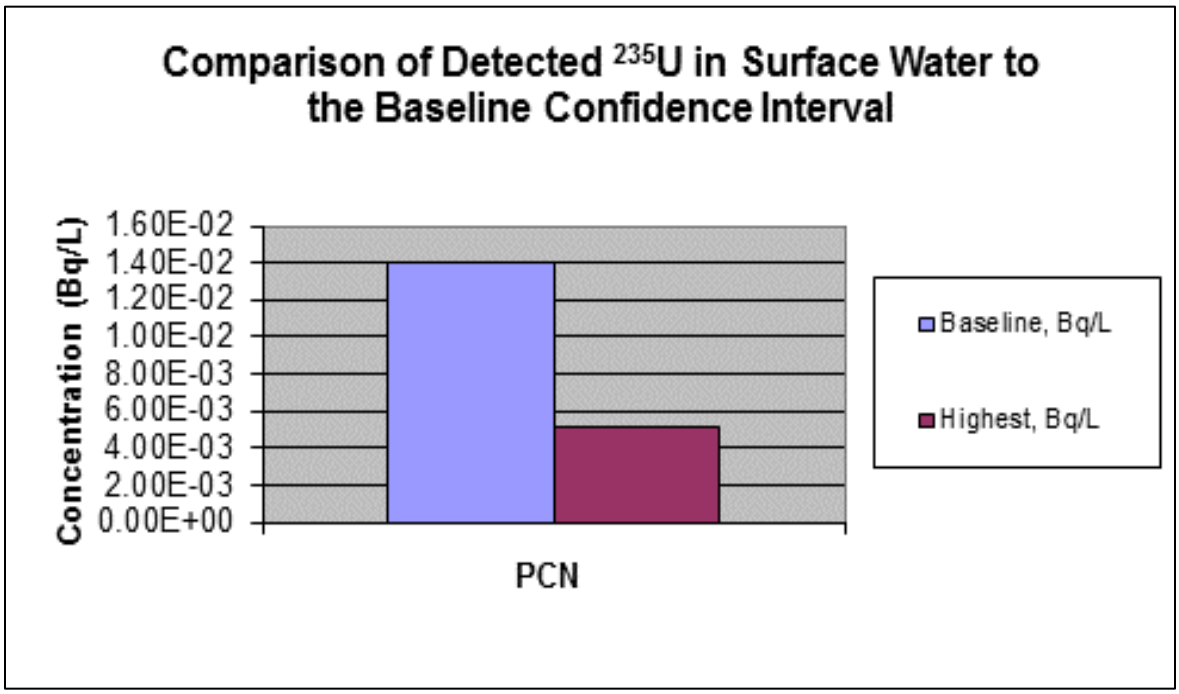
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
WQSP-3 Round 36
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 233/234U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 235U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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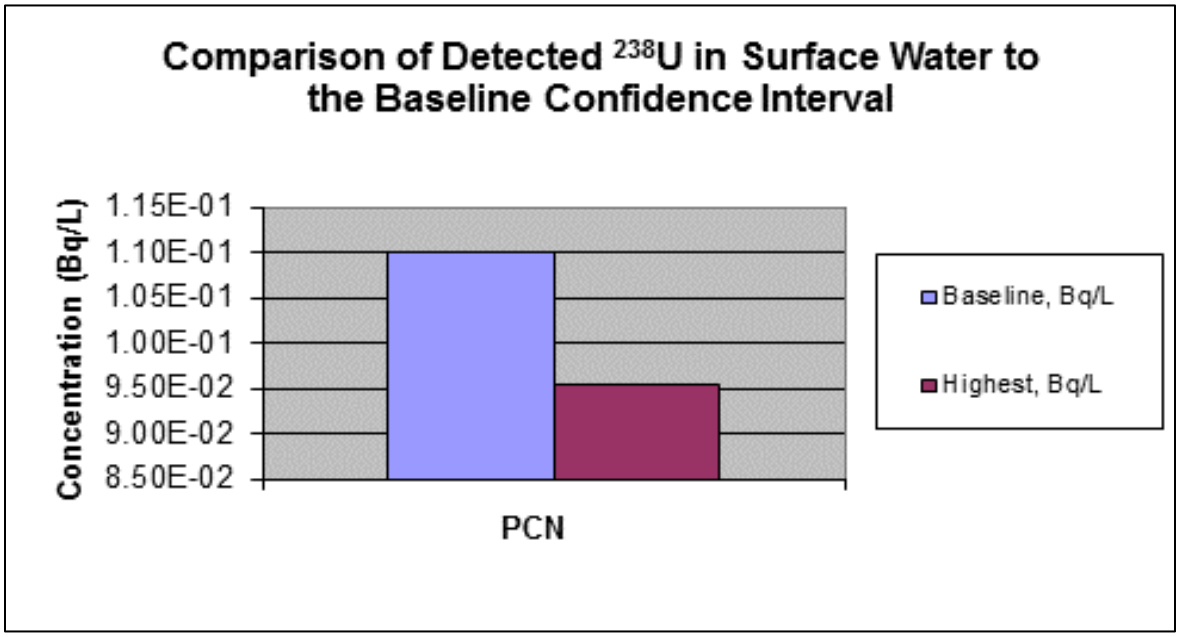
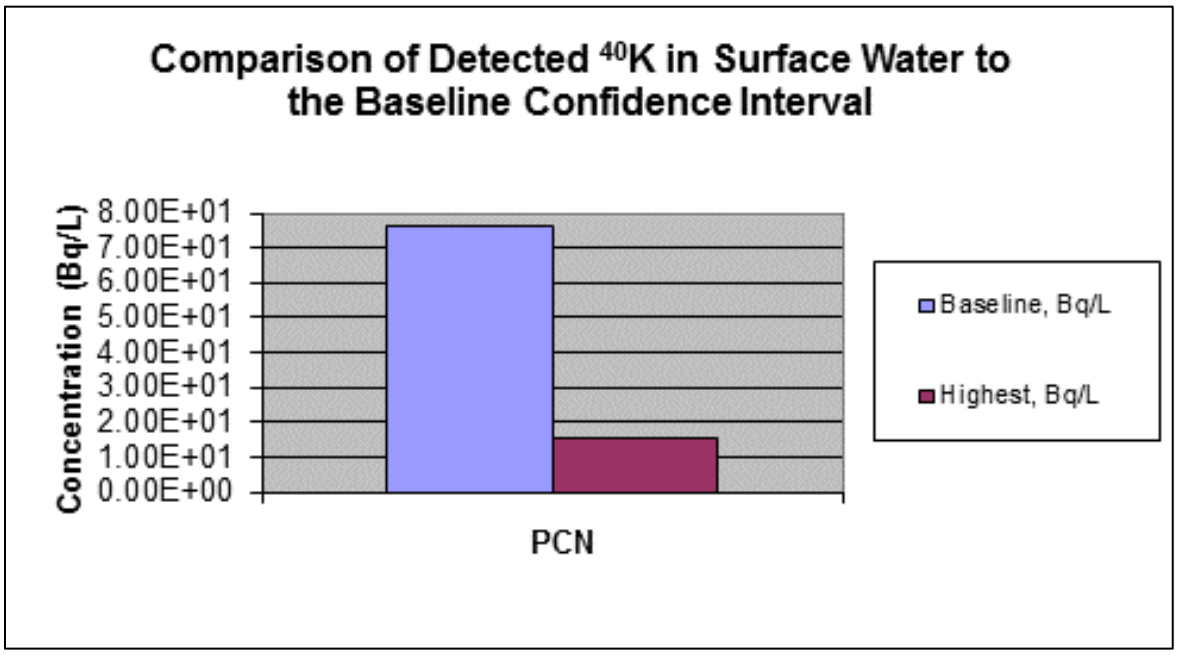
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 238U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
1.15E-01
1.10E-01
1.05E-01
1.00E-01
9.50E-02
9.00E-02
8.50E-02
PCN
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 40K in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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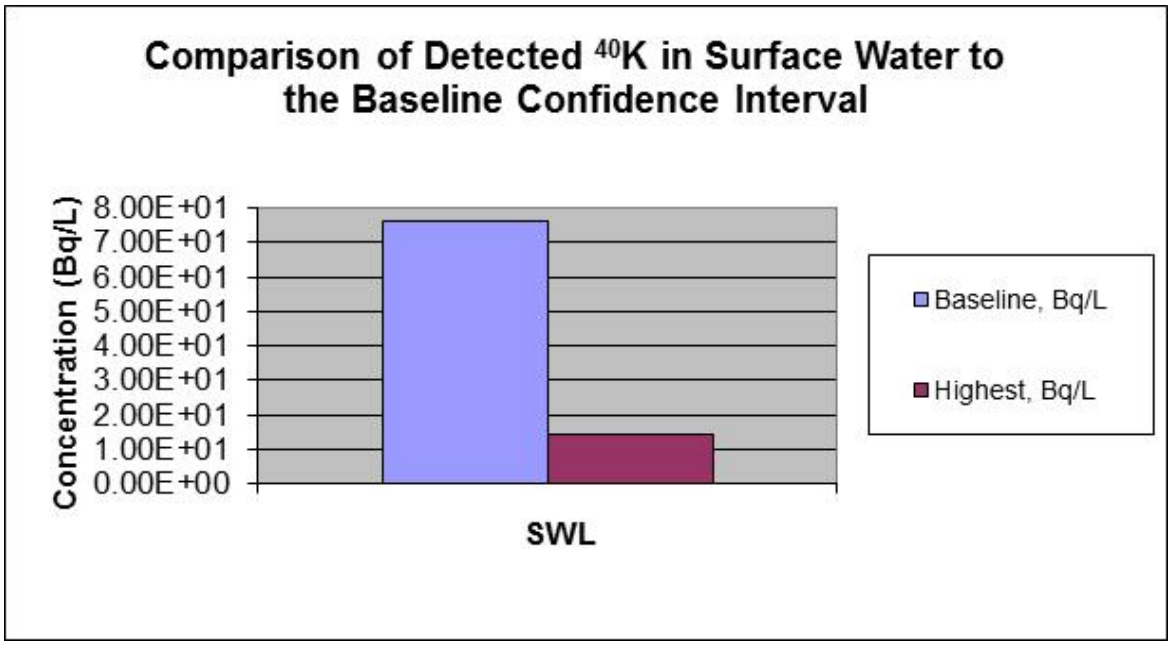
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
PCN
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 40K in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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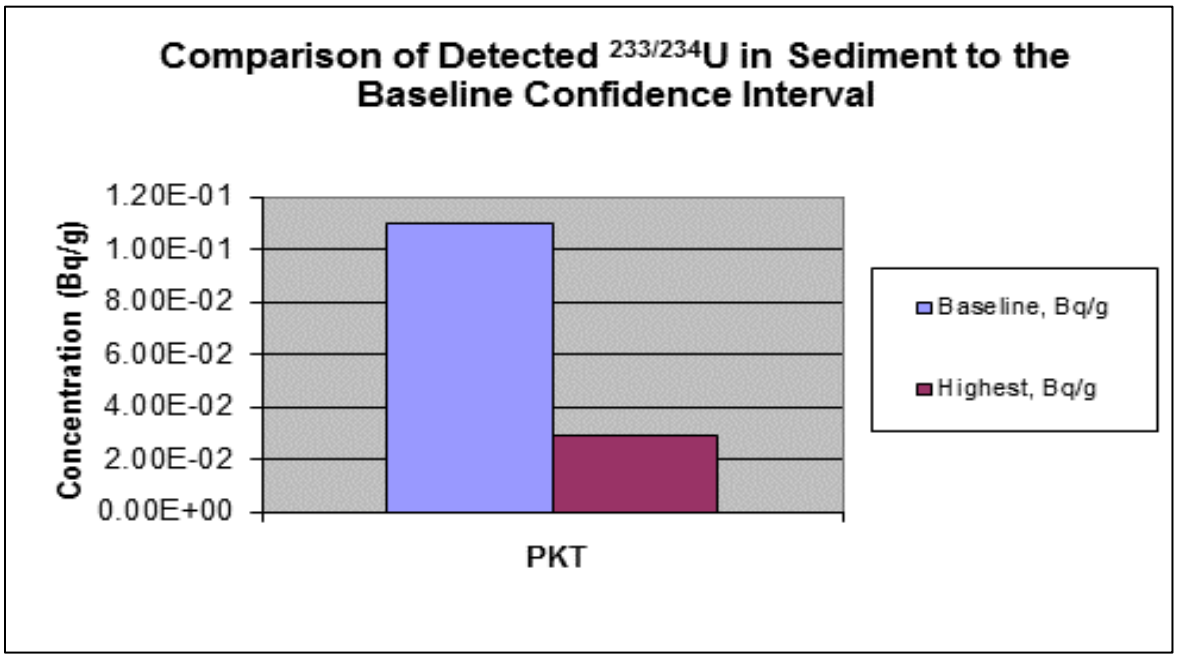
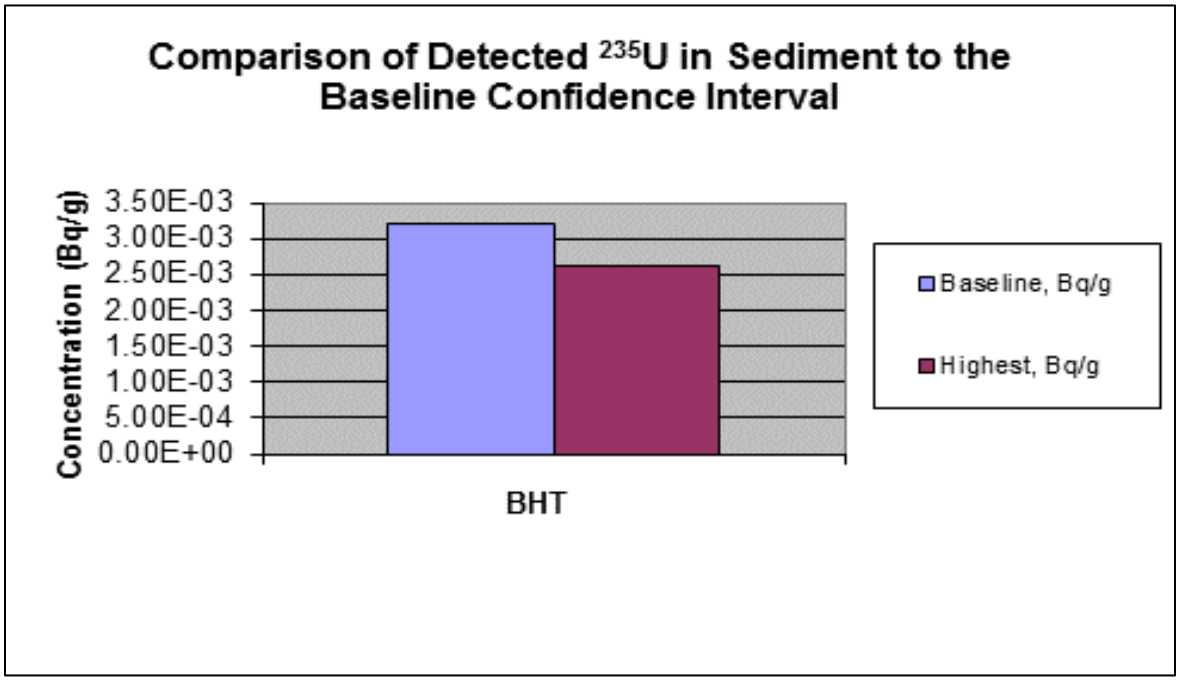
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
SWL
Baseline, Bq/L
Highest, Bq/L


Comparison of Detected 233/234U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
PKT
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 235U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
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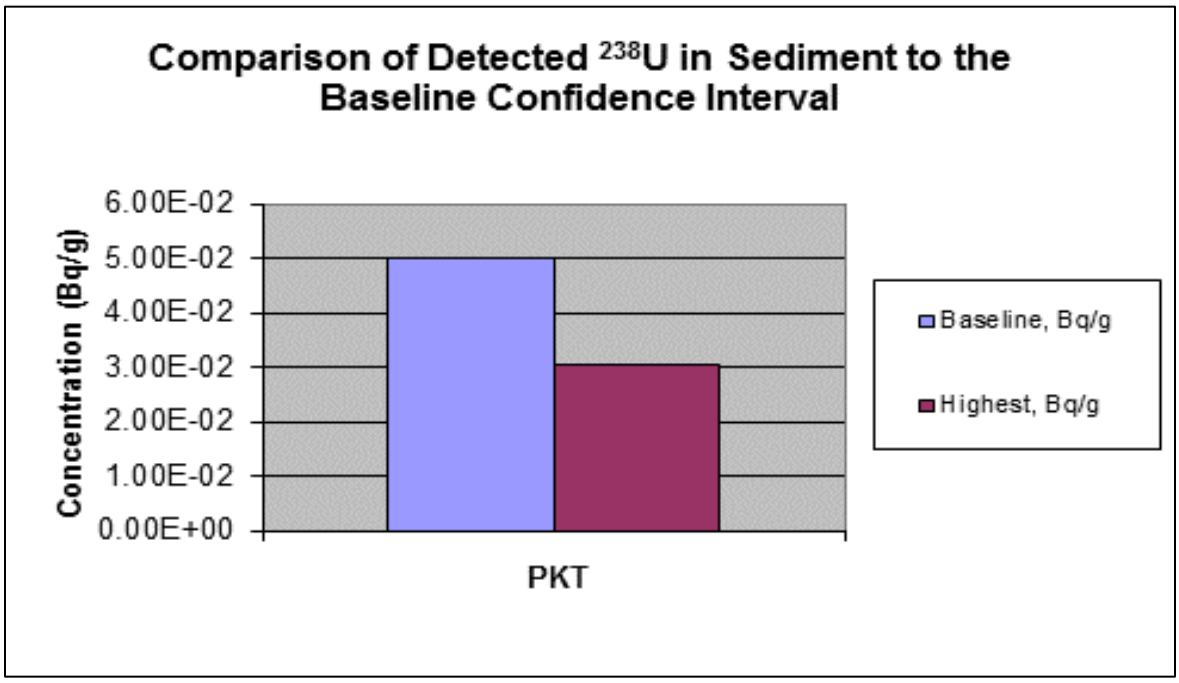
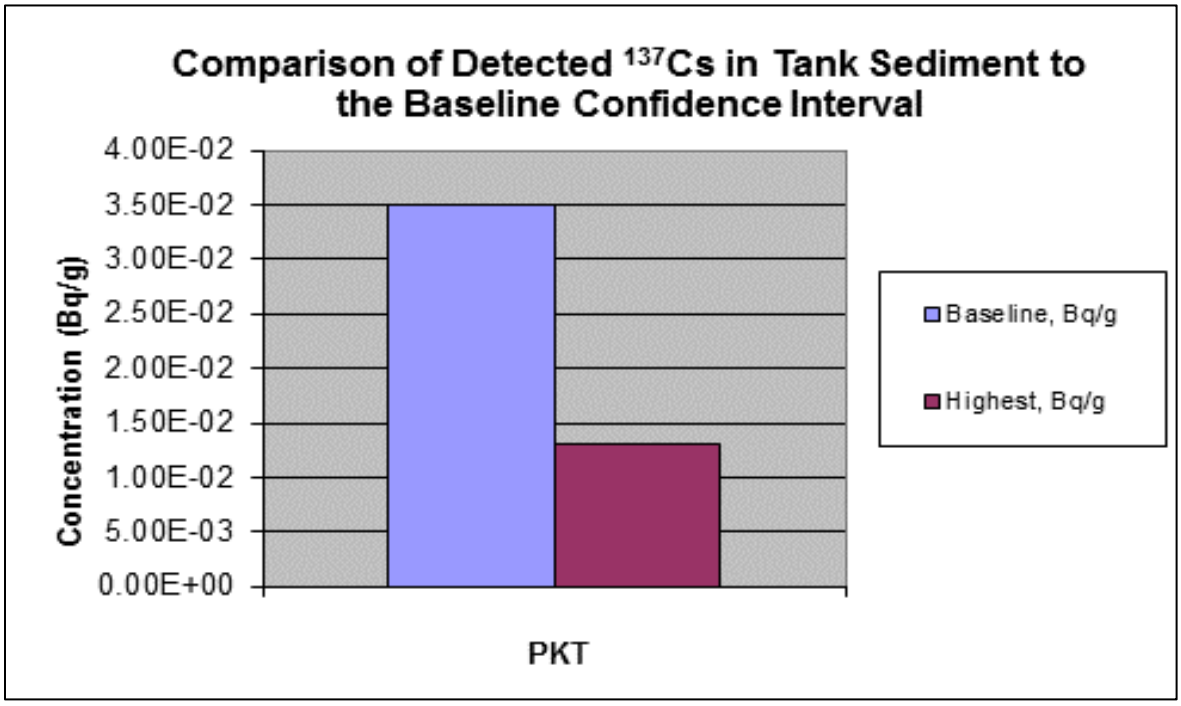
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
BHT
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 238U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
PKT
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 137Cs in Tank Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
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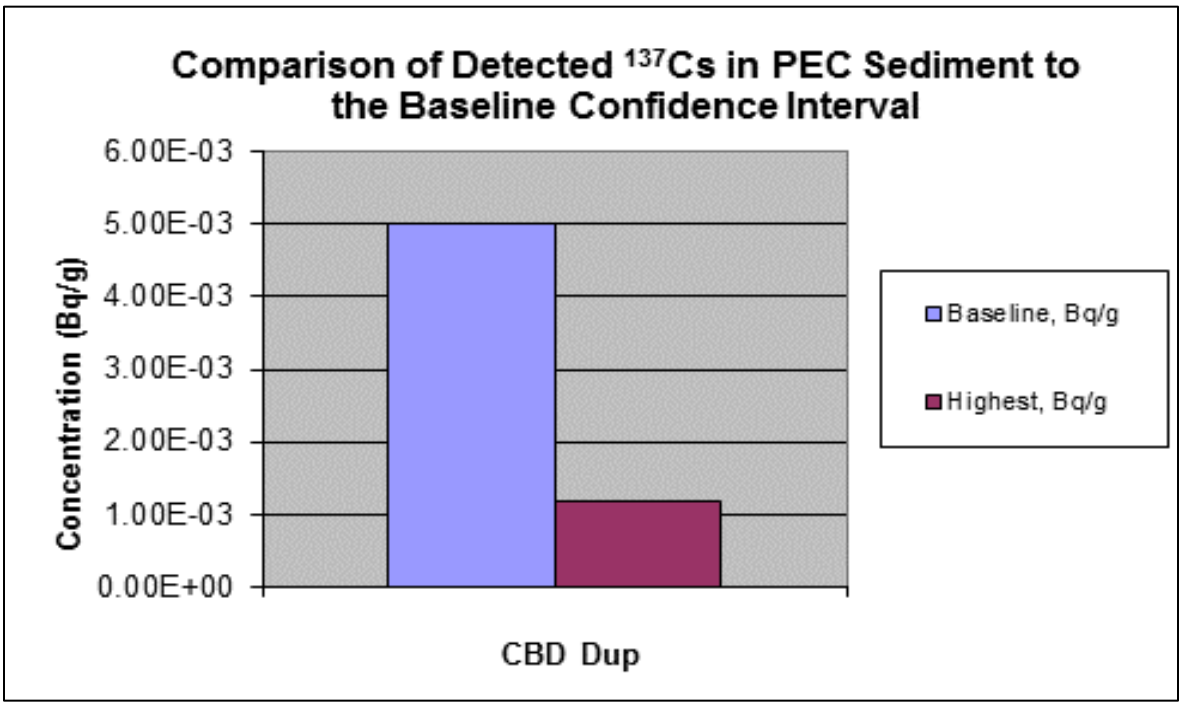
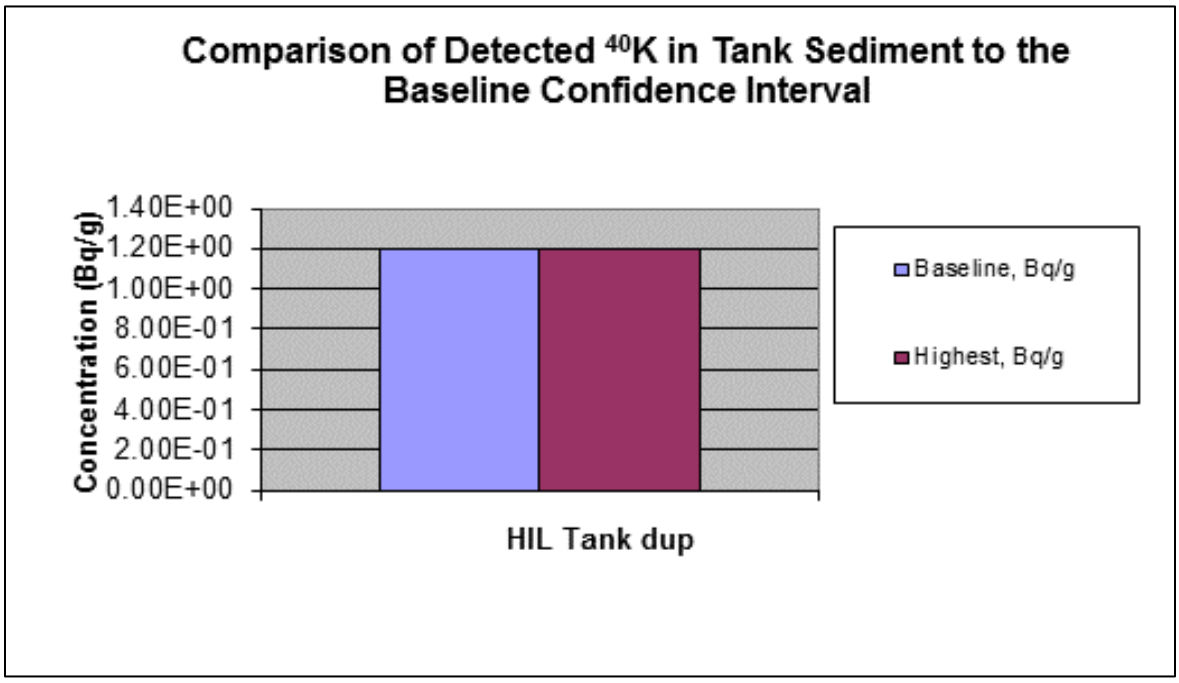
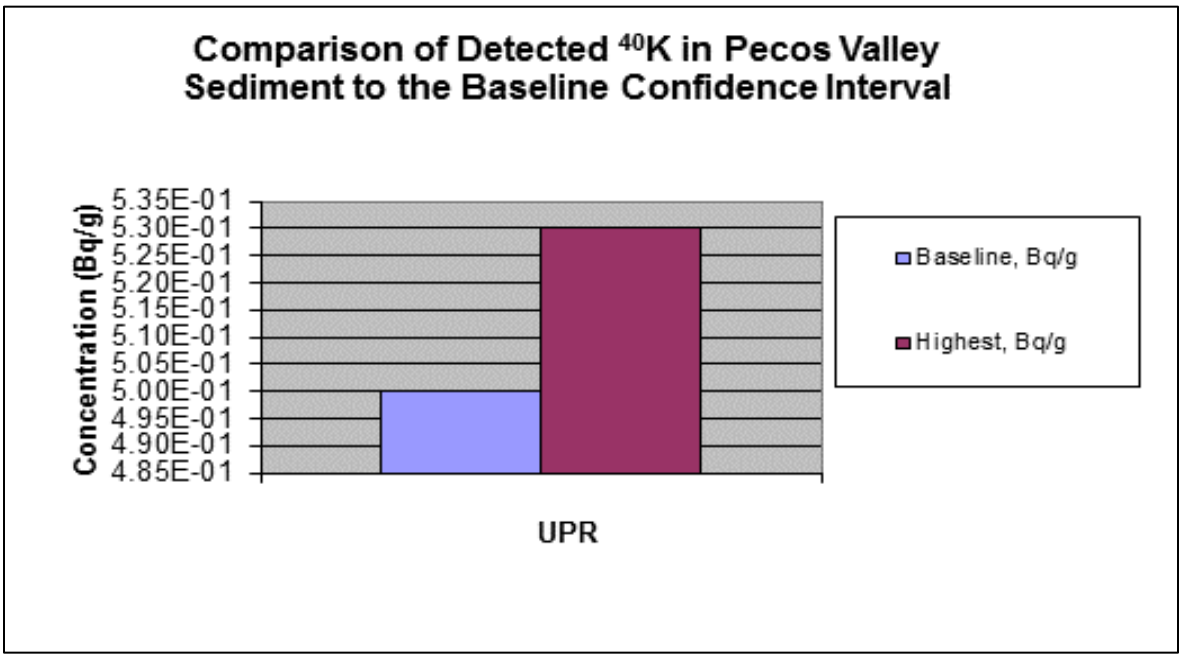
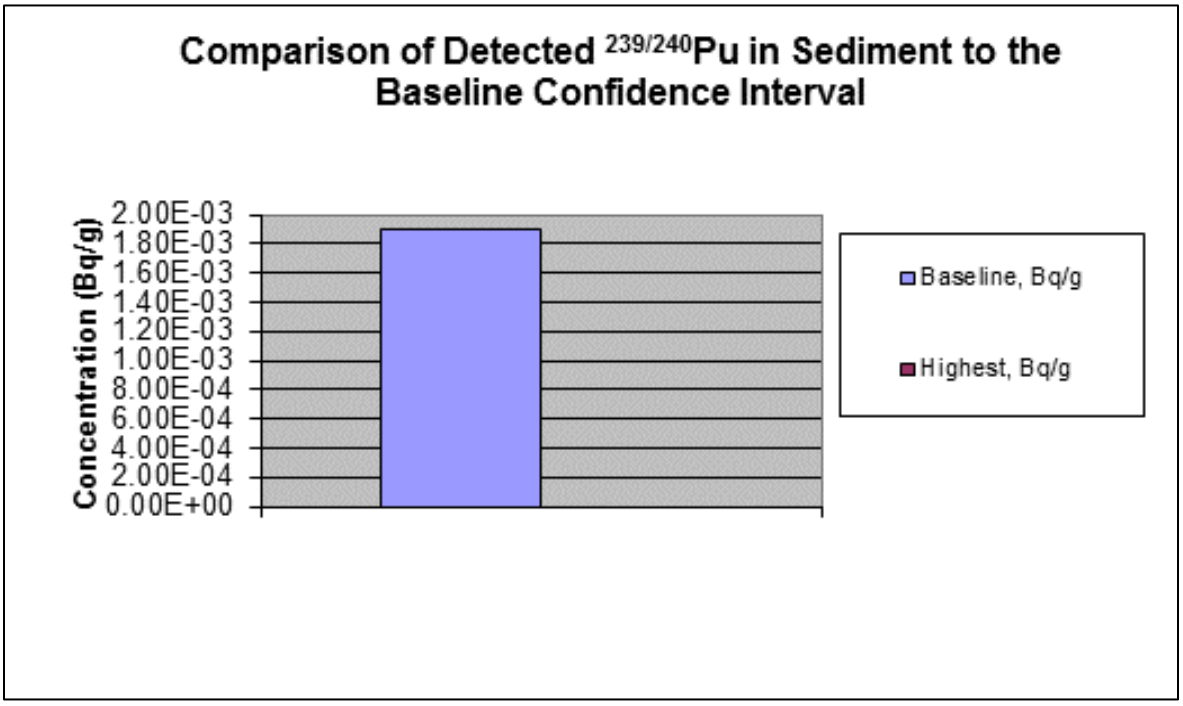
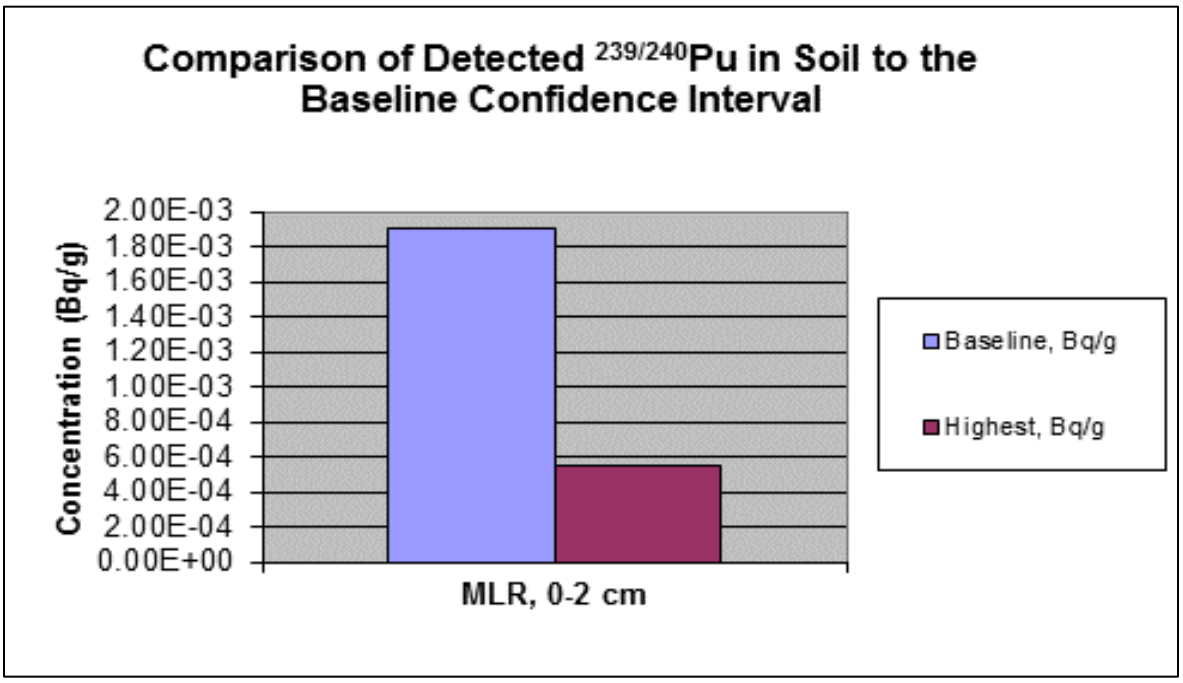
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
PKT
Baseline, Bq/g
Highest, Bq/g

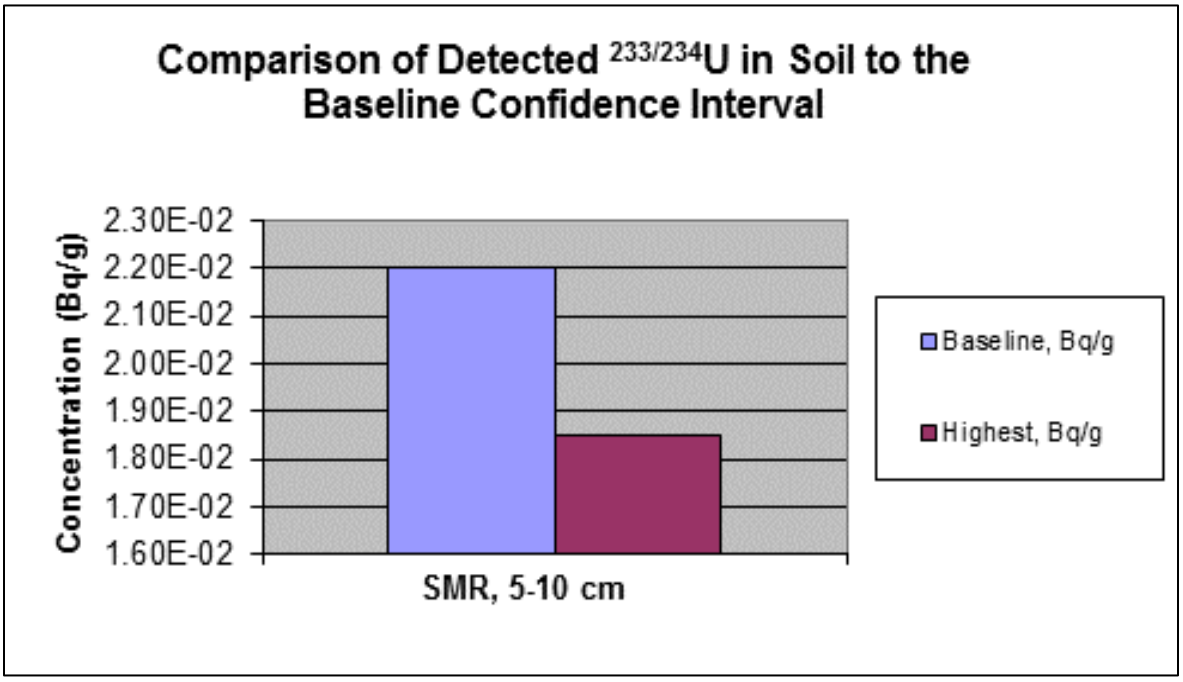

Comparison of Detected 137Cs in PEC Sediment to the Baseline Confidence Interval
6.00E-03
5.00E-03
4.00E-03
3.00E-03
2.00E-03
1.00E-03
0.00E+00
Concentration (Bq/g)
Baseline, Bq/g
Highest, Bq/g
CBD Dup

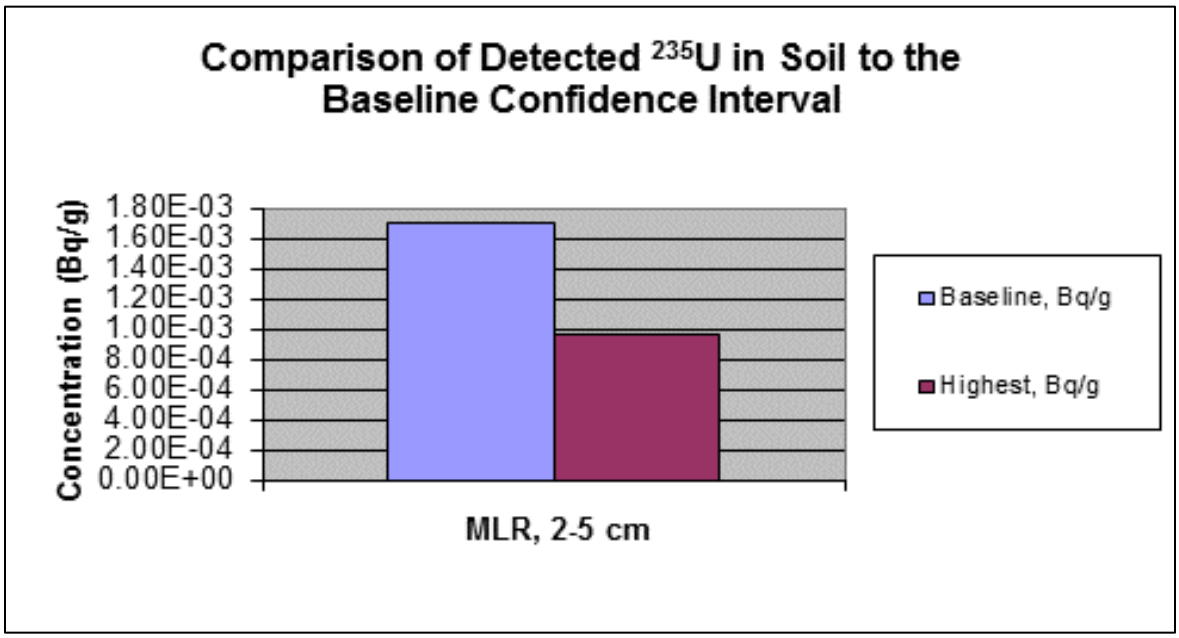

Comparison of Detected 40K in Tank Sediment to the Baseline Confidence Interval
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
Concentration (Bq/g)
Baseline, Bq/g
Highest, Bq/g
HIL Tank dup

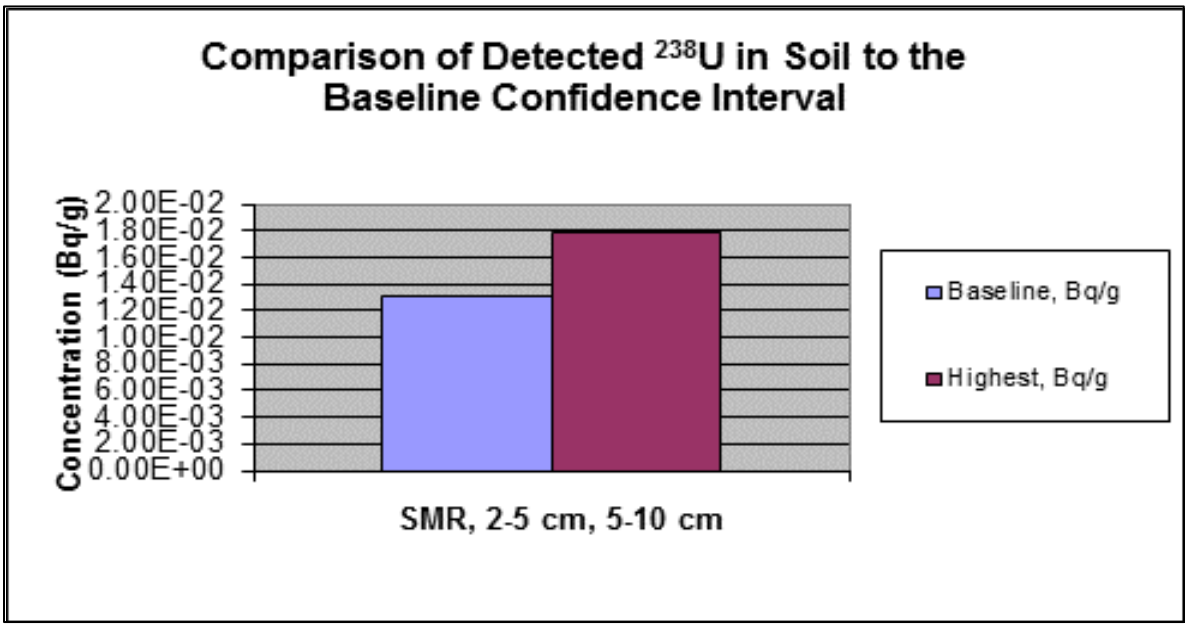

Comparison of Detected 40K in Pecos Valley Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
5.35E-01
5.30E-01
5.25E-01
5.20E-01
5.15E-01
5.10E-01
5.05E-01
5.00E-01
4.95E-01
4.90E-01
4.85E-01
UPR
Baseline, Bq/g
Highest, Bq/g

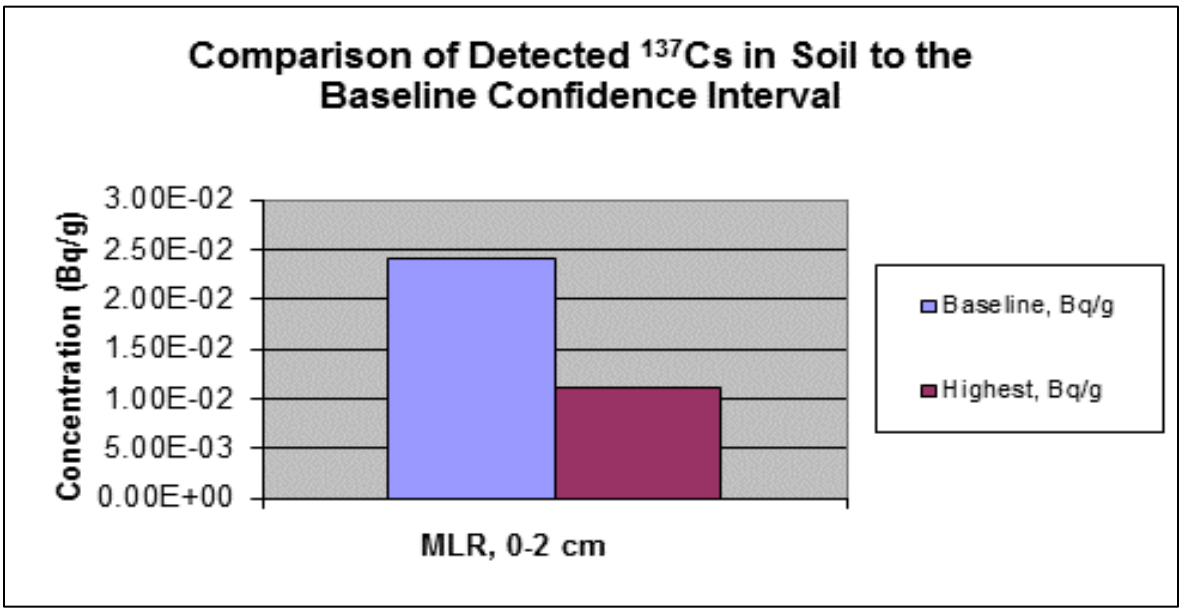

Comparison of Detected 239/240Pu in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-03
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
Baseline, Bq/g
Highest, Bq/g

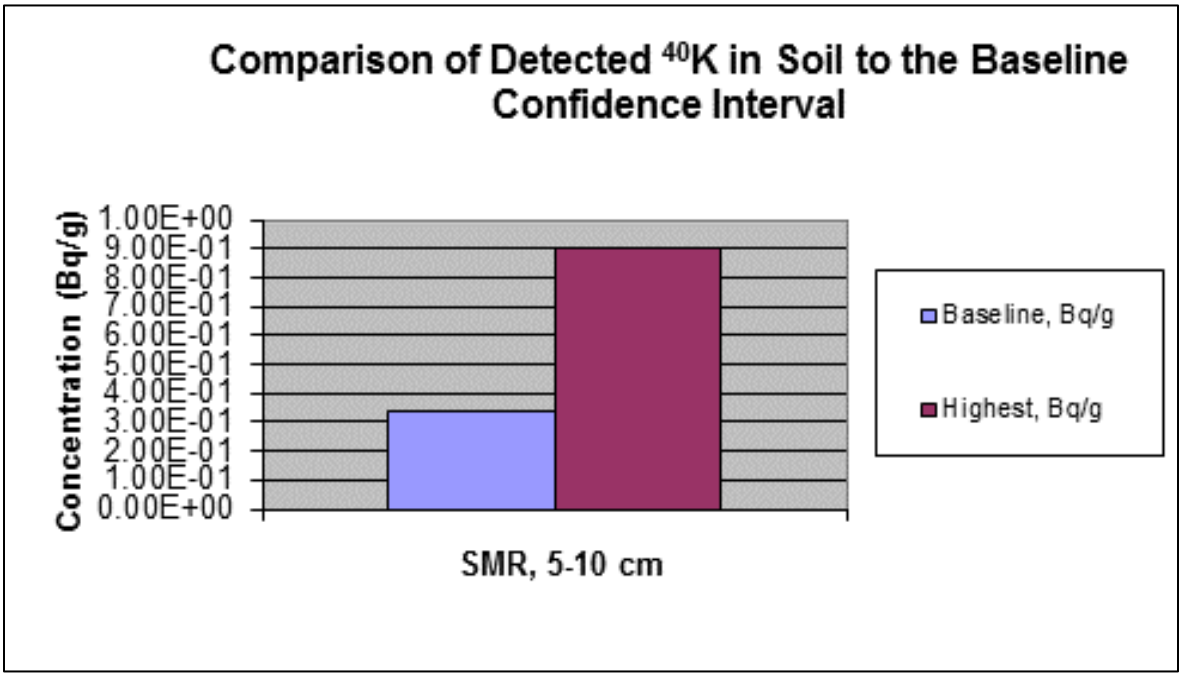

Comparison of Detected 239/240Pu in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-03
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
MLR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

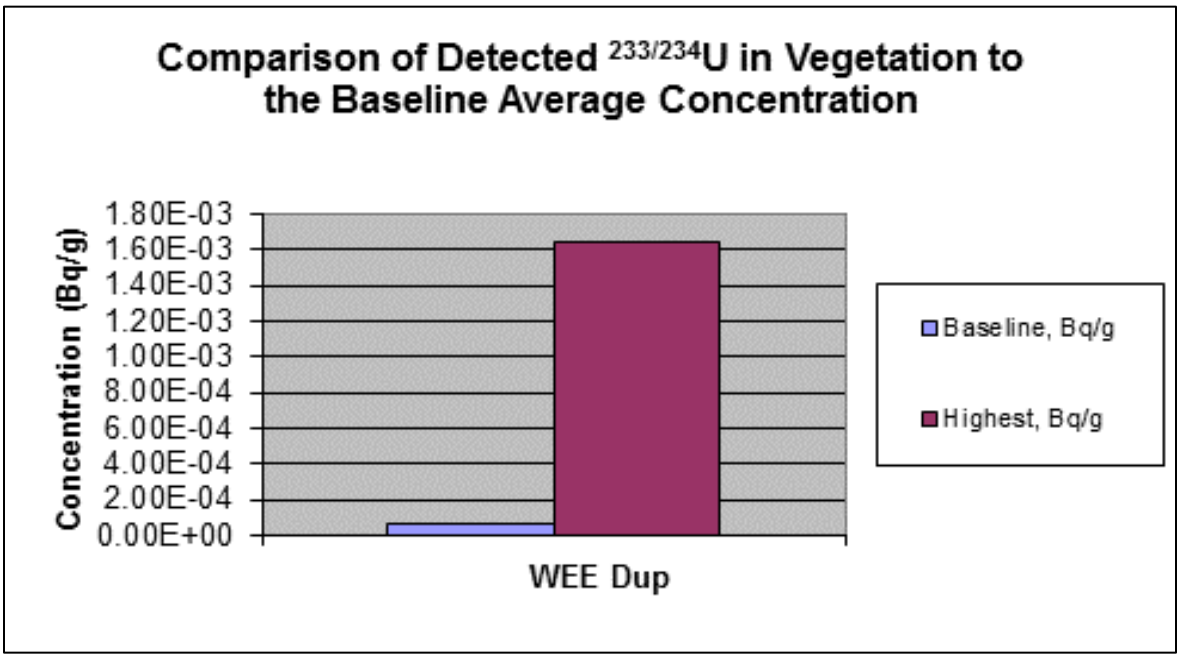

Comparison of Detected 233/234U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.30E-02
2.20E-02
2.10E-02
2.00E-02
1.90E-02
1.80E-02
1.70E-02
1.60E-02
SMR, 5-10 cm
Baseline, Bq/g
Highest, Bq/g

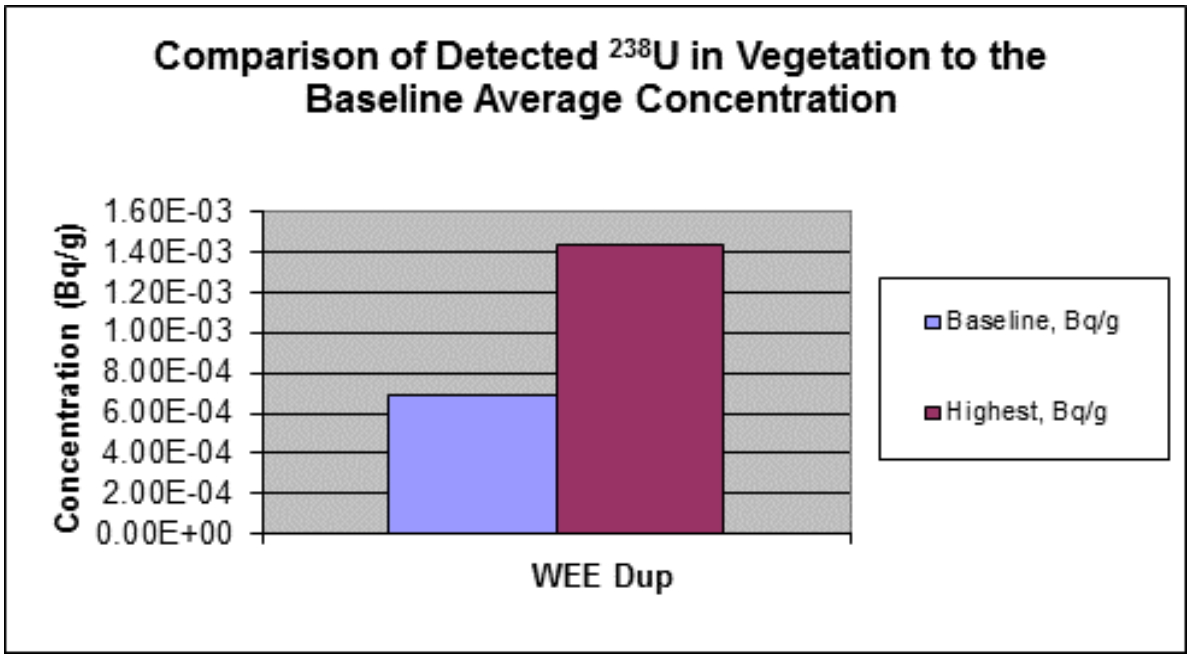

Comparison of Detected 235U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
MLR, 2-5 cm
Baseline, Bq/g
Highest, Bq/g

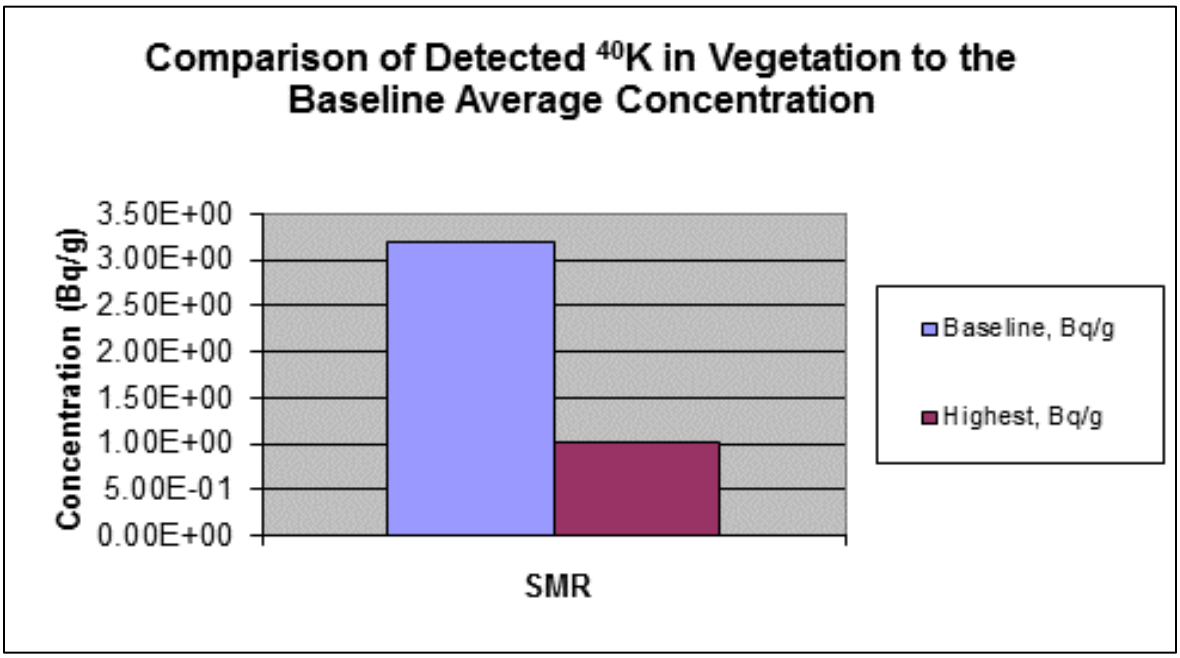

Comparison of Detected 238U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.00E-02
1.80E-02
1.60E-02
1.40E-02
1.20E-02
1.00E-02
8.00E-03
6.00E-03
4.00E-03
2.00E-03
0.00E+00
SMR, 2-5 cm, 5-10 cm
Baseline, Bq/g
Highest, Bq/g

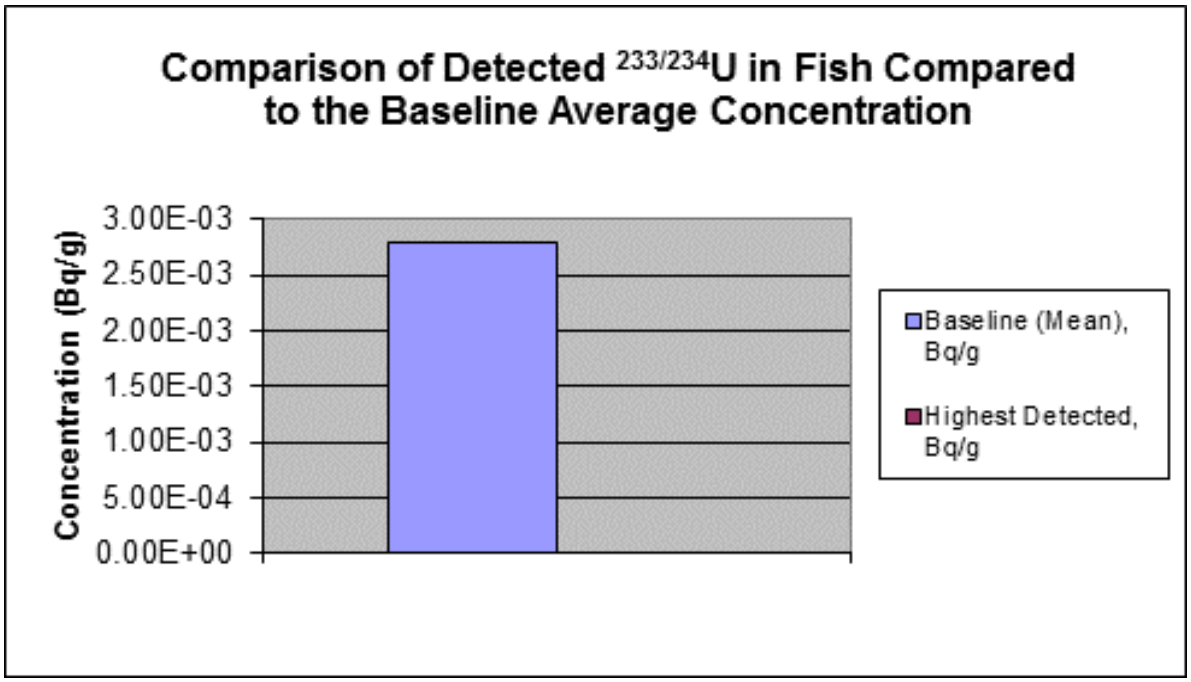

Comparison of Detected 137Cs in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
MLR, 0-2 cm
Baseline, Bq/g
Highest, Bq/g

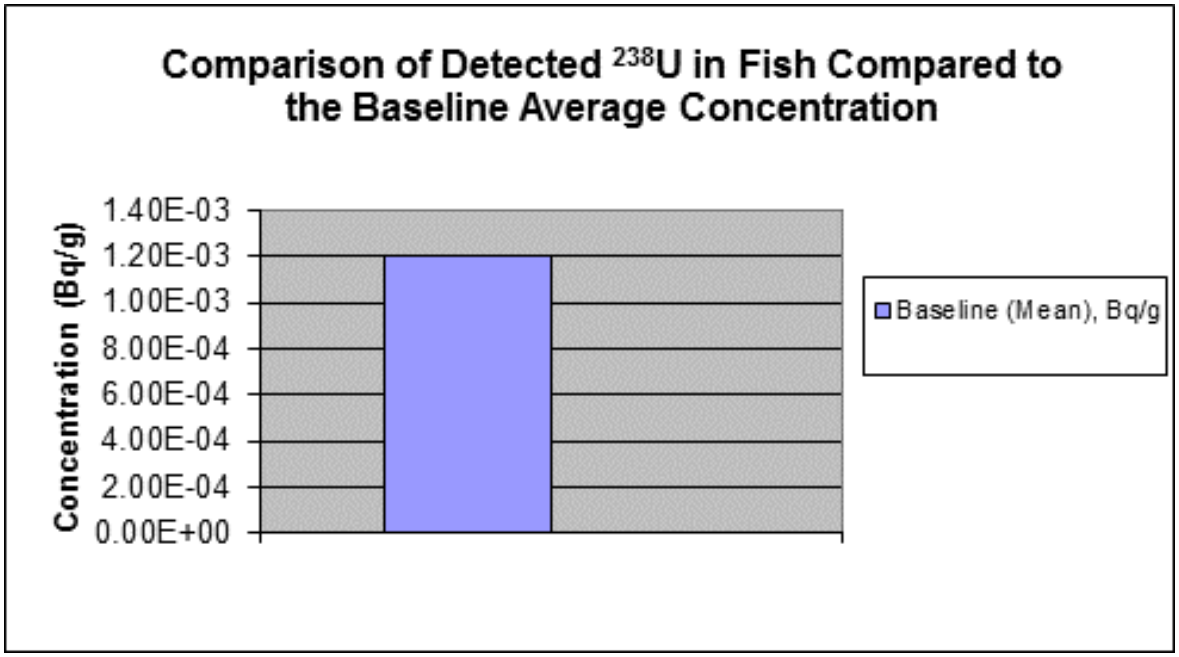

Comparison of Detected 40K in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
1.00E+00
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
SMR, 5-10 cm
Baseline, Bq/g
Highest, Bq/g

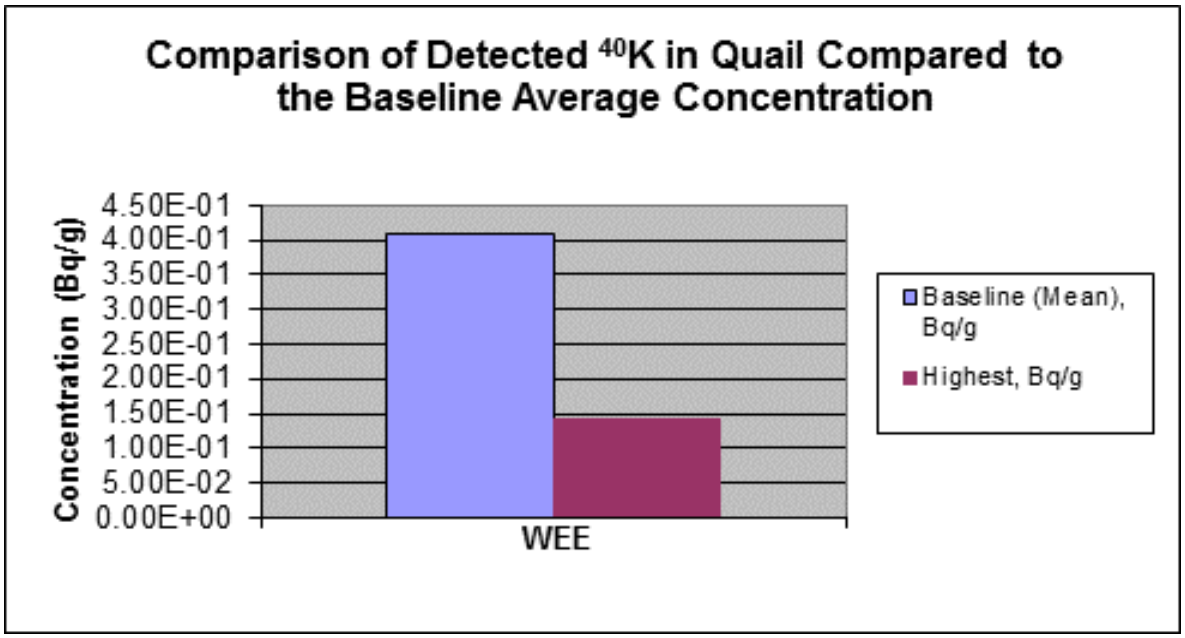

Comparison of Detected 233/234U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
1.80E-03
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
WEE Dup
Baseline, Bq/g
Highest, Bq/g

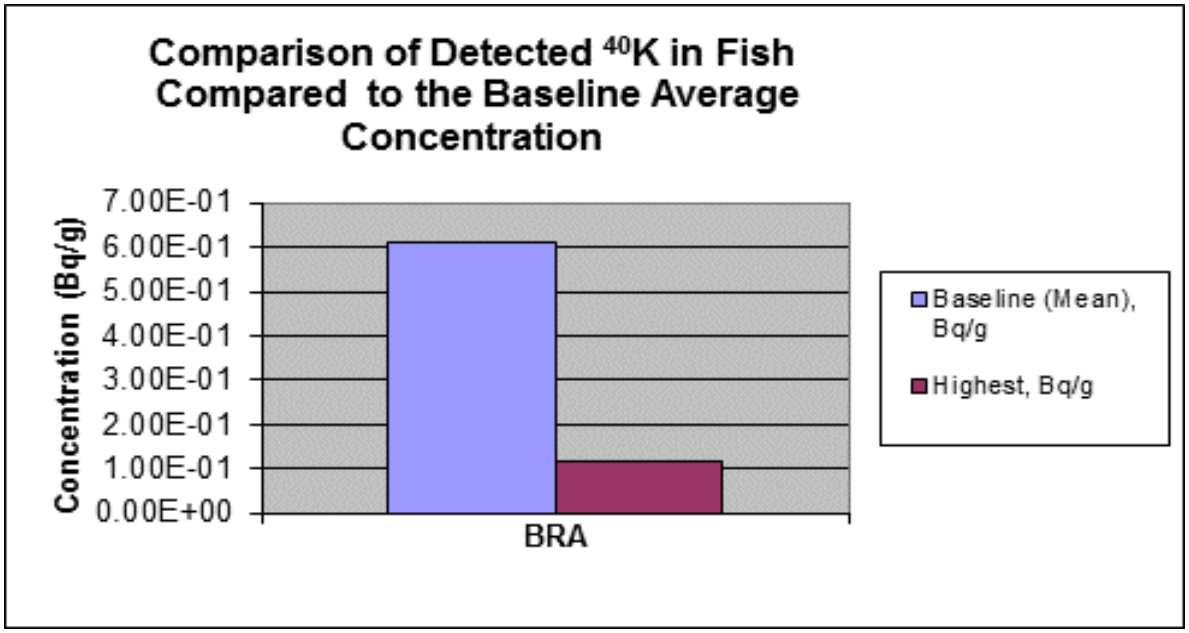

Comparison of Detected 238U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
1.60E-03
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
WEE Dup
Baseline, Bq/g
Highest, Bq/g

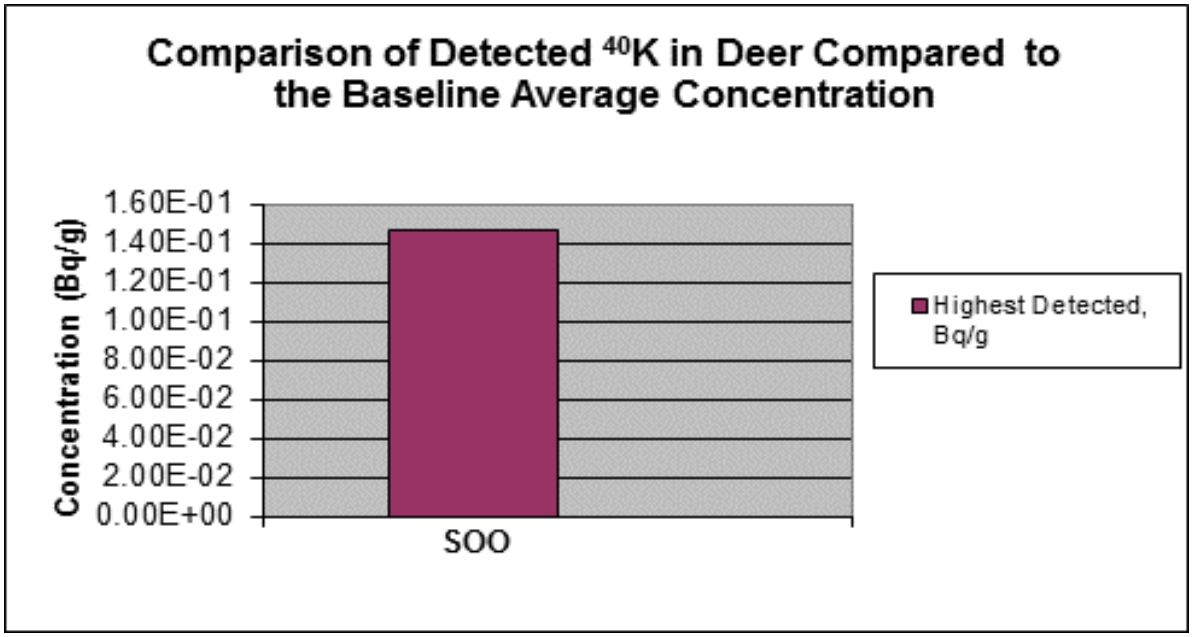

Comparison of Detected 40K in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
SMR
Baseline, Bq/g
Highest, Bq/g


Comparison of Detected 233/234U in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Baseline (Mean), Bq/g
Highest Detected, Bq/g


Comparison of Detected 238U in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
1.40E-03
1.20E-03
1.00E-03
8.00E-04
6.00E-04
4.00E-04
2.00E-04
0.00E+00
Baseline (Mean), Bq/g


Comparison of Detected 40K in Quail Compared to the Baseline Average Concentration
Concentration (Bq/g)
4.50E-01
4.00E-01
3.50E-01
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
WEE
Baseline (Mean), Bq/g
Highest, Bq/g


Comparison of Detected 40K in Fish Compared to the Baseline Average Concentration
Concentration (Bq/g)
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
BRA
Baseline (Mean), Bq/g
Highest, Bq/g


Comparison of Detected 40K in Deer Compared to the Baseline Average Concentration
Concentration (Bq/g)
1.60E-01
1.40E-01
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
SOO
Highest Detected, Bq/g

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