DOE/WIPP-14-3532

Waste Isolation Pilot Plant Annual Site Environmental Report for 2013 - EMENDED

U.S. Department of Energy

September 2014

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2013 Annual Site Environmental Report

To our readers:

This Waste Isolation Pilot Plant (WIPP) Annual Site Environmental Report for 2013 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

Am	americium
amsl	above mean sea level
ANOVA	analysis of variance
ANSI	American National Standards Institute
As	arsenic
ASER	Annual Site Environmental Report
Ba	barium
BCG	biota concentration guide
BLM	U.S. Department of the Interior, Bureau of Land Management
Bq	becquerel(s)
Bq/g	becquerels per gram
Bq/kg	becquerels per kilogram
Bq/L	becquerels per liter
Bq/m^3	becquerels per cubic meter
Bq/sample	becquerels per composite air filter sample
CAO	Carlsbad Area Office (now Carlsbad Field Office)
CBFO	Carlsbad Field Office
C&D	construction and demolition
cc	cubic centimeter
CEMRC	Carlsbad Environmental Monitoring and Research Center
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	Code of Federal Regulations
CH	contact-handled
cm	centimeter
Co	cobalt
Cr	chromium
Cs	cesium
CY	calendar year
d	day
DMP	Detection Monitoring Program
DMW	detection monitoring well
DOE	U.S. Department of Energy
DOELAP	DOE Laboratory Accreditation Program
DP	discharge permit
Dup	Duplicate
EDE	effective dose equivalent
EMS	Environmental Management System
EO	Executive Order

EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community Right-to-Know Act*
ft	foot/feet
ft^2/d	square feet per day
ft^3	cubic feet
FY	fiscal year
GC/MS	gas chromatography/mass spectrometry
GHG	greenhouse gas
g/cc	grams per cubic centimeter
g/mL	gram per milliliter
HEAL	Hall Environmental Analysis Laboratory
HEPA	high-efficiency particulate air (filter)
HPS	Health Physics Society
HWDU(s)	Hazardous waste disposal unit(s)
ICP	inductively coupled plasma emission spectroscopy
ICP–MS	inductively coupled plasma emission spectroscopy combined with mass spectrometry
ID	identification
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)*
m	meter(s)
m^2	square meters
m^2/d	square meters per day
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
mGy/d	milligrays per day

mi	mile(s)
mi^2	square miles
mL	milliliter(s)
mm	millimeter(s)
MOC	management and operating contractor
mph	miles per hour
mrem	millirem
mrem/day	millirem per day
MRL	method reporting limit
m/s	meters per second
MS	mass spectrometry
MS/MSD	matrix spike/matrix spike duplicate
mSv	millisievert(s)
MWh	megawatt hour
m/yr	meters per year
N/A	not applicable
NCRP	National Council on Radiation Protection and Measurements
NEPA	*National Environmental Policy Act*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NIST	National Institute of Standards and Technology
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NMSA	New Mexico Statutes Annotated
NPDES	National Pollutant Discharge Elimination System
NRIP	National Institute of Standards and Radiochemistry Intercomparison Program
oz	ounce(s)
PCB	polychlorinated biphenyl
PE	performance evaluation
Permit	WIPP Hazardous Waste Facility Permit
pH	measure of the acidity or alkalinity of a solution
PIP	production-injection packer
ppmv	parts per million by volume
ppbv	parts per billion by volume
PQL	Practical Quantitation Limit
Pu	plutonium
QA	quality assurance
QA/QC	quality assurance/quality control
QC	quality control
rad/d	radiation absorbed dose per day
RCRA	*Resource Conservation and Recovery Act*
rem	roentgen equivalent man

RER	relative error ratio
RH	remote-handled
RPD	relative percent difference
SARA	*Superfund Amendments and Reauthorization Act of 1986*
Sb	antimony
Se	selenium
SEIS	Supplemental Environmental Impact Statement
SERC	State Emergency Response Commission
SNL	Sandia National Laboratories
SOP	standard operating procedure
SOW	statement of work
SPDV	site and preliminary design validation
Sr	strontium
SR/DL	Santa Rosa/Dewey Lake
SSP	Site Sustainability Plan
SSW	shallow subsurface water
SU	standard unit
Sv	sievert
SVOC	semivolatile organic compound
TDS	total dissolved solids
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TPU	total propagated uncertainty
TRU	transuranic
TSDF	treatment, storage, and disposal facility
TSS	total suspended solids
U	uranium
U.S.	United States
U.S.C.	United States Code
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
USFWS	United States Fish and Wildlife Service
UST	underground storage tank
UTLV	upper tolerance limit value
V	vanadium
VOC	volatile organic compound
W	warning
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 2013 (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.
- 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; DOE Order 436.1, *Departmental Sustainability*; 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. In 2013, 5,050 cubic meters (m^3) of TRU waste were disposed of at the WIPP facility, including 5,004 m^3 of contact-handled (CH) TRU waste and 46 m^3 of remote-handled (RH) TRU waste. From the first receipt of waste in March 1999 through the end of 2013, 90,252 m^3 of TRU waste had been disposed of at the WIPP facility.

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.

The *Waste Isolation Pilot Plant Land Management Plan* (DOE/WIPP–93–004) (LMP) was created in compliance with the WIPP *Land Withdrawal Act of 1992* (LWA) (Public Law 102–579, as amended by Public Law 104–201, National Defense Authorization Act for Fiscal Year 1997). This plan 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 surveillance in the region surrounding the site to protect WIPP facilies and land from inadvertant use.

The monitoring and surveillance programs used by the WIPP facility to determine if the local ecosystem has been impacted are listed below:

Environmental Radiological Monitoring Programs

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

Environmental Nonradiological 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 2013, 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 and DOE orders. In order to accomplish and document this compliance, the following routinely submitted documents were among those completed in 2013:

New Mexico Submittals

- 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
- 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
- 2013 Annual Polychlorinated Biphenyls Report
- WIPP Subsidence Monument Leveling Survey
- 2012/2013 Annual Change Report

- *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 fiscal year (FY) 2013, more than 250 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, ensures potential issues are identified and corrective/preventive actions are tracked formally through completion.

Overall, the data provided in the required submissions and the evaluation program results confirmed the WIPP project maintained compliance with environmental requirements during 2013.

Sustainable Practices

WIPP's EMS objectives and targets support achievement of DOE's sustainability goals. Highlights of WIPP's achievement of these goals in 2013 include the following:

- Training of procurement card holders, purchase requisitioners, and projects and procurement personnel on sustainable procurement requirements resulted in 61 percent of office supply funds being spent on sustainable products.
- The generator site audit program implemented an electronic record system that reduced paper use by an estimated 70,000 sheets per audit.
- The percentages of municipal solid waste and construction and demolition (C&D) debris diverted from landfills increased from 15 and 54 to 33 and 63 percent, respectively.
- Site energy use was approximately 3.8 megawatt hours (MWh) per m^3 of TRU waste disposed at the WIPP facility.
- A 37 percent reduction in energy intensity for WIPP site operations compared to the FY 2003 baseline was achieved. Although excellent performance was achieved in this area, a portion of the reduction was due to equipment being down and the percent reduction is expected to decrease for FY 2014 and

beyond. Scope 1 and 2 greenhouse gas (GHG) emissions were 15 percent below the FY 2008 baseline.

- Scope 3 GHG emissions were 46 percent below the FY 2008 baseline.
- Sustainable performance was recognized by the New Mexico Environment Department (NMED) with a Green Zia Environmental Leadership Program award at the Gold performance level. The award was granted based on innovative environmental solutions in the reduction of energy use, water and product use, and hazardous waste generation including:
  - Energy use reduction through cool roof installations and retrofit lighting
  - Hazardous waste reduction from changing a process to eliminate the generation of hazardous waste during groundwater monitoring
  - Water use reduction through fire water distribution system maintenance
  - Recycling of two additional waste streams; alkaline batteries and wood pallets.

EMS 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,* in May 2012. The recertification demonstrates that WIPP continues to meet the President's Council on Environmental Quality and DOE requirements for full implementation of the EMS. Recertification of the WIPP EMS was achieved through successful completion of an in-depth audit by the ISO-accredited registrar, Advanced Waste Management Systems, Inc. In FY 2013, the WIPP EMS successfully underwent two surveillance audits confirming the system continues to meet ISO requirements.

Significant accomplishments of the EMS for 2013 were as follows:

- WIPP had no reportable, unauthorized contaminant releases to the environment.
- WIPP operations remained in compliance with environmental legal requirements.
- Environmental monitoring data continued to demonstrate that there has been no adverse impact to human health or the environment from WIPP facility operations.
- The NMED awarded CBFO a Green Zia Environmental Leadership Program award at the Gold performance level.
- The groundwater monitoring program was selected by Albuquerque Business First as an honoree at the Sustainable Business Summit.

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 millirem (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 NESHAP (National Emissions Standards for Hazardous Air Pollutants). 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, 2007] 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 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.

Total Dose from WIPP Facility Operations

The dose to an individual from the ingestion of WIPP facility–managed radionuclides transported in water is nonexistent because drinking water for communities near the WIPP site comes from groundwater sources that are too far away to be affected by WIPP facility operations.

Game animals sampled during 2013 were quail, a deer, and fish. 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 facility–related radionuclides has been received by any individual from this pathway (i.e., the ingestion of meat from game animals) during 2013.

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," or for air emissions only, the standards of 40 CFR Part 61, Subpart H, "National Emission Standards for Hazardous Air Pollutants." The results indicate that the hypothetical maximally exposed individual (MEI) who resides year-round at the fence line, 350 meters (m) (1,148 feet (ft)) from the exhaust shaft, receives a dose of approximately 5.25E–06 mSv per year (5.25E–04 mrem per year) for the whole body and 1.31E–05 mSv per year (1.31E–03 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 7.39E–08 mSv per year (7.39E–06 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 calendar years (CYs) 1999 through 2013. These EDE values are below the EPA limit specified in 40 CFR Part 191, Subpart A, and 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 (NCRP) and the International Atomic Energy Agency. These absorbed dose limits are listed below:

- Aquatic animals 10 milligrays per day (mGy/d) (1 radiation absorbed dose per day [rad/d])

- Terrestrial plants 10 mGy/d (1 rad/d)
- Terrestrial animals 1 mGy/d (0.1 rad/d)

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 2013. 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 2013.

CHAPTER 1 – INTRODUCTION

The purpose of this report is to provide information needed by the DOE to assess 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 CY 2013 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 TRU radioactive and mixed waste generated through defense activities and programs. TRU waste is defined in the WIPP 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 10 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 m (2,150 ft) below the surface in excavated disposal rooms in the Salado Formation (Salado), which is a thick sequence of Permian Age 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 TRU radioactive 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 1955, 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 (CAO), subsequently redesignated as the 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 km (26 mi) east of Carlsbad, New Mexico, in a region known as Los Medaños (the Dunes).

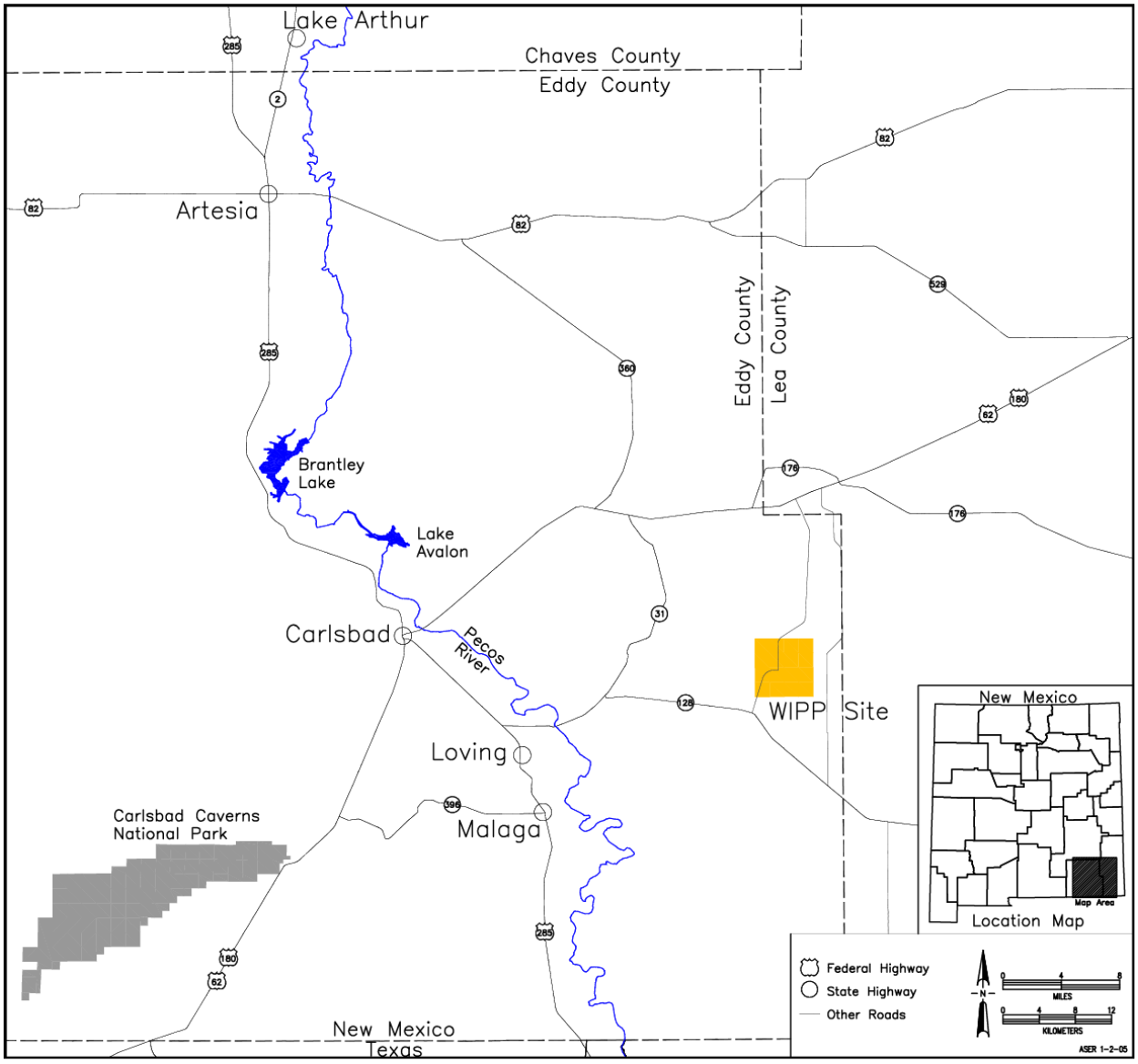


Figure 1.1 – WIPP Site Location

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 uses 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 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 LWA. 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 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 may receive an unanticipated elevated security status would be suitable for designation as Special Management Areas. No areas were designated as Special Management Areas in 2013.

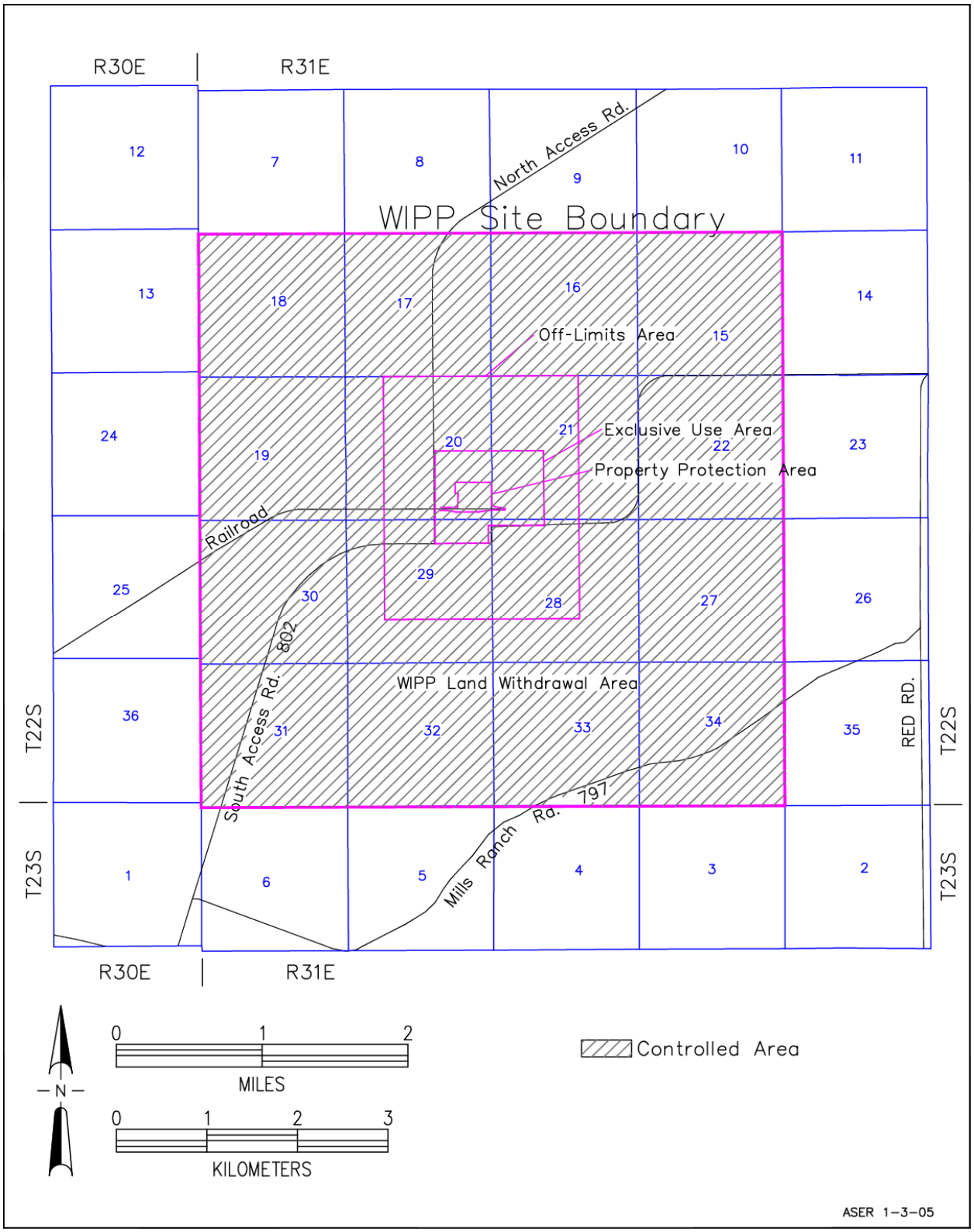


Figure 1.2 – WIPP Property Areas

1.3.2 Population

There are 11 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 also discusses the WIPP project 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 2013 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 VOCs, groundwater chemistry, and other nonradiological environmental parameters, and collection of meteorological data.

Table 1.1 – Environmental Monitoring Sampling[a]

Program	Type of Sample	Number of Sampling Locations	Sampling Frequency
Radiological	Airborne effluent	3	Periodic/confirmatory
	Airborne particulate	7	Weekly
	Sewage treatment system (DP-831)[b]	3	Semiannual
	H-19 (DP–831)[b]	1	Semiannual
	Liquid effluent	1 (WHB sump)	If needed
	Biotic		
	Quail Rabbit Beef/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 (DMP)	6	Annual
Nonradiological	Meteorology	1	Continuous
	Volatile organic compounds (VOCs)		
	VOCs—repository VOCs—disposal room	2 # of active panel disposal rooms	Semiweekly Biweekly
	Hydrogen and methane	18 per filled panel	Monthly
	Groundwater (DMP)	6	Annual
	Shallow Groundwater (DP-831)	12	Semiannual
	Surface water (DP–831)	5 storm water infiltration control	Annual and after major storm events
		4 sewage lagoons	Semiannual

(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 also 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) Includes a nonradiological 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 also 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 Carlsbad and nearby ranches.

Nonradiological 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.

1.5 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 by WIPP environmental policy and the EMS.

In 2013, the WIPP project maintained compliance with applicable environmental laws, regulations, and permit conditions. Furthermore, analyses of the WIPP environmental monitoring data have demonstrated that WIPP operations have not had an adverse impact on the environment. Implementation of the *WIPP Environmental Monitoring Plan* (DOE/WIPP–99–2194) fulfills the environmental monitoring requirements of DOE Order 436.1. Detailed information on WIPP programs are contained in the remaining chapters.

CHAPTER 2 – COMPLIANCE SUMMARY

The WIPP facility is required to comply with the applicable regulations promulgated pursuant to federal and state statutes, DOE orders, and Executive Orders (EOs). 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/regulations applicable to 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 summary of WIPP facility compliance with major environmental regulations is presented below. 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* (CERCLA) (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 CERCLA 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 CBFO 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* [EPCRA]), 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 (LEPC) of any accidental releases of hazardous chemicals in excess of reportable quantities. The list of hazardous chemicals and the Tier II Form are also 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 received.

The LEPC and the SERC are notified whenever 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 LEPC 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 LEPC and the SERC, and to each fire department with which the CBFO maintains a memorandum of understanding. The WIPP facility submitted its 2013 Tier II data to the SERC, the LEPC, and fire departments prior to March 1, 2014, 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 EPA and the resident state if toxic chemicals are stored 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, 2013, reporting deadline. Table 2.1 presents the 2013 EPCRA 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

EPCRA 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	Toxics Release Inventory Reporting	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 2013.

2.2 Resource Conservation and Recovery Act

The *Resource Conservation and Recovery Act* (RCRA) (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* (New Mexico Statutes Annotated [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 Hazardous Waste Facility Permit NM4890139088–TSDF (Permit) authorizes DOE and the MOC (collectively known as the Permittees) to receive, store, and dispose of CH and RH TRU mixed waste at the WIPP facility. Two storage units (the Parking Area Unit and the Waste Handling Building [WHB] Unit) are permitted for storage of TRU mixed waste. Eight underground hazardous waste disposal units (HWDUs) or panels are currently permitted for the disposal of CH and RH TRU mixed waste.

2.2.2 Modification Requests

In 2013, the Permittees submitted permit modification notifications and permit modification requests to NMED, as described in Table 2.2.

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.

Table 2.2 – Permit Modification Notifications and Requests Submitted in 2013

Class	Description	Date Submitted
1	Revise a Training Course Outline; Revise Table and Panel Figures to Include Panel 7; Update Description Related to Type B Packages; and Update TRUPACT-II and HalfPACT Figures	August 29, 2013
2	Modify Excluded Waste Prohibition – Elevated to Class 3 on July 2, 2013	April 8, 2013
3	Panel Closure Redesign, Repository Reconfiguration, Organic Compound Monitoring Program Changes	March 18, 2013

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. 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 2013.

2.2.4 Hazardous Waste Generator Compliance

Nonradioactive hazardous waste is currently generated through routine facility operations and is managed in satellite accumulation areas; a less-than-90-day accumulation area on the surface, and a less-than-90-day accumulation area underground.

Hazardous waste generated at the WIPP facility 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."

2.2.5 Program Deliverables and Schedule

WIPP is 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 1 of even-numbered years. This report, which describes the amounts and types of hazardous wastes generated, received, and/or shipped by the WIPP facility during CY 2013, was submitted to the NMED in February 2014.

- 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 WIPP facility continued to comply with these requirements by preparing and submitting annual reports in October 2013, representing results for July 1, 2012, through June 30, 2013.
- 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 WIPP facility continued to comply with this requirement by preparing and submitting semiannual reports in April 2013, representing results for July 1, 2012, through December 31, 2012, and in October 2013, representing results for January 1, 2013, through June 30, 2013.

- Permit Part 5, Section 5.10.2.1 requires a report of the analytical results for annual Detection Monitoring Program (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 35 was submitted to the NMED in November 2013. Sampling results are summarized in Appendices E and F of this 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 2013 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 2013 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." Title 10 CFR §1021.331 requires that, following completion of each environmental impact statement and its associated record of decision, the DOE 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 annual mitigation report. This report was issued July 9, 2013.

Day-to-day operational compliance with the NEPA at the WIPP facility is achieved through implementation of a NEPA compliance plan and procedure. Sixteen proposed projects were reviewed and approved by the CBFO NEPA Compliance Officer through the NEPA screening and approval process in 2013. These projects were primarily upgrades to WIPP facilities and equipment. The approvals were in addition to routine activities that have been 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 also 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.

CBFO initiated a 5-year Supplemental Analysis for the WIPP project, which is due for completion in 2014. Also in 2013, CBFO issued three Category Exclision Determinations. In February of 2013, CBFO issued a Categorical Exclusion

Determination for a grant for the City of Carlsbad improvement of the City's Double Eagle Well Field; in March of 2013, CBFO issued a Categorical Exclusion Determination for the lease of office space to support WIPP activities; and in August of 2013, CBFO issued a Categorical Exclusion Determination for the removal and disposal of high-efficiency particulate air (HEPA) filters used in WIPP operations.

2.4 Clean Air Act

The *Clean Air Act* (CAA) (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 CAA. 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 CAA permits. In 1993, the DOE did obtain 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 2013 that required reporting under the conditions of the Operating Permit.

The CAA 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.

Volatile organic compound emissions from containers of TRU and TRU mixed waste that are vented to prevent the buildup of gases generated by radiolysis remain less than 10 tons per year for individual VOCs monitored under the Permit.

2.5 Clean Water Act

The *Clean Water Act* (CWA) (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 NPDES 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 NPDES program. Wastewaters generated at the WIPP facility are either disposed of offsite 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 DP designed to prevent impacts to groundwater.

The DOE was issued DP–831 from the NMED Ground Water 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 WIPP Facility will operate under the old DP until the new DP is received.

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 requires the sewage lagoons and H–19 Evaporation Pond to be sampled semiannually and analyzed for nitrate, total Kjeldahl nitrogen (TKN), 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 SSW water level contour mapping and semiannual groundwater sampling for sulfate, chloride, and TDS. Subsurface shallow water monitoring results are discussed in Chapter 6.

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. All 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 the State of New Mexico. Results 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 at the WIPP facility in 2013.

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. Theact 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 2012 was submitted to EPA Region VI prior to the required submission date in 2013.

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 (USFWS). A biological assessment and formal consultation, followed by the issuance of a biological opinion by the USFWS, may be required for any species that is determined to be in potential jeopardy.

During 2013, 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 2013, no activities involving migratory birds took place at the WIPP facility.

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 confirmed that there have been no 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. Results of the monitoring program demonstrate compliance with the dose limits discussed above and are addressed in further detail in Chapter 4.

The WIPP facility is subject to EPA inspections in accordance with 40 CFR §194.21, "Inspections." The EPA conducted an inspection of WIPP waste management and storage operations, emplacement activities, and monitoring program from October 22 through 24, 2013. As a result of the inspection, the EPA stated at the closeout meeting that it would include two observations in the final inspection report: an observation that Station C was out of calibration; and an observation requesting a revision to WIPP Procedure 12-ER4916, Rev. 20, Consequence Assessment Dose Projection.

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 facility 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 RCRA Contingency Plan.

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 have affected or 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 project through the CBFO *Quality Assurance Program Document* (DOE/CBFO–94–1012), which establishes quality assurance (QA) program requirements for all 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 and Certification* (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 comply with the sustainability requirements contained in the two EOs related to governmental sustainability (EOs 13423 and 13514). Sites must also develop, and commit to implement, an annual Site Sustainability Plan (SSP) that identifies their respective contributions toward meeting the DOE's sustainability goals. The site EMS must be used for implementing the SSP. Site EMSs must maintain conformance to ISO 14001:2004. The WIPP SSP for FY 2014 was issued on November 3, 2013. This fourth annual update addresses the WIPP project contribution toward meeting the DOE sustainability goals including the performance status for FY 2013 and planned actions for FY 2014. The SSP becomes a basis for establishing annual site 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-specfied 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.

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.

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 GHG 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 EO are discussed in Chapter 3.

In addition, the order requires more widespread use of 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.I 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 GHG emissions a priority for federal agencies. Goals for improvements were established for federal agencies in the following areas:

- GHG 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, and
- 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 of all activities at the WIPP facility. This commitment is made public in the WIPP Environmental Policy and is carried out through 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 generator sites' TRU and TRU mixed waste at the WIPP facility, the WIPP project's excellent compliance history, and the progress in sustainability.

The EMS was recertified to the ISO standard 14001:2004, *Environmental Management Systems—Requirements with Guidance for Use,* in May 2012. The recertification demonstrates that the WIPP EMS continues to meet the President's Council on Environmental Quality and DOE requirements for full implementation of an EMS. Recertification is based on an in-depth audit by the ISO-accredited registrar, Advanced Waste Management Systems, every three years. In the interim, between recertification audits, surveillance audits are conducted by the registrar. The 2013 surveillance audits confirmed the EMS continues to meet the ISO requirements for certification.

The EMS continued to result in strong environmental performance in 2013 as highlighted in the following paragraphs. First, extensive environmental monitoring conducted during 2013 demonstrates there are no significant environmental impacts (radiological or nonradiological) from operation of the WIPP facility. This is accomplished by personnel carrying out their daily responsibilities in accordance with the WIPP project conduct of operations program, which is the foundation for the operational control element of the EMS. It is also accomplished by the EMS ensuring that potential environmental impacts are identified, and appropriate controls are in place to address them.

Next, the project's commitment to compliance with applicable environmental requirements continues to be excellent, with no reportable, unauthorized contaminant releases and no external agency compliance issues. This is accomplished through implementation of the EMS and its supporting programs, procedures, and work practices.

Sustainability performance was recognized by the NMED with a Green Zia Environmental Leadership Program award. The overall goal of the program is to produce real environmental improvements. The award was granted based on innovative

environmental solutions in the reduction of energy use, hazardous and solid waste generation, water use and the increase in sustainable purchasing and waste streams recycled.

The projects included:

- Energy use reduction through cool roof installations and retrofit lighting.
- Hazardous and solid waste reduction through a process change that eliminated the generation of hazardous waste and reduced the generation of solid waste from the groundwater DMP.
- Water use reduction through fire water distribution system maintenance.
- Sustainable purchasing increase through modifications made to the procurement system.
- Addition of wood and alkaline battery waste streams to the recycling program.

The WIPP facility was also recognized as an honoree by Albuquerque Business First and the New Mexico Green Chamber of Commerce at the New Mexico Sustainable Business Summit for the groundwater DMP process changes that resulted in a reduction of hazardous waste generation.

3.1 EMS 2013 Highlights

Environmental Aspects	No new environmental aspects were identified. Modifications were made to reflect changes in significance ratings or to clarify the scope of an aspect. The significance ranking for the "Operating Rad Con Lab" aspect was reduced based on elimination of laboratory standards and wet chemistry resulting in this aspect no longer being significant. "Manage Site Generated Rad Waste (HEPA Filters)" was added as a separate environmental aspect category to reflect that significance ratings are different from other site generated waste types. E-waste related aspects were combined to reflect servers, personal computers, and other E-waste (circuit boards) because they are best reflected and ranked as one aspect.
Legal and Other Requirements	There were no significant new or revised legal requirements during 2013.
Objectives, Targets, and Program(s)	The WIPP significant aspects and SSP provide the basis for WIPP's environmental objectives and targets. FY 2013 resulted in progress toward each of the WIPP's five environmental objectives and completion of 84 percent of the supporting targets.

Objective 1 – Improve efficiency in TRU waste emplacement.

Actions to institutionalize reduction in laboratory analysis for characterization of TRU waste were completed.

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

WIPP's energy use in FY 2013 was 7 percent lower than in FY 2012. In addition to this improvement, WIPP made progress toward targets that will result in future improvements. High Performance Sustainable Buildings Guiding Principles applicable to the defined scope of work were incorporated into project planning for the repair of the site fitness facility. Photovoltaic equipment was purchased with funds previously spent on Renewable Energy Credits and will be installed during FY 2014.

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

In FY 2013, 33 percent of municipal solid waste and 63 percent of construction and demolition waste were diverted. Completion of the target supporting this objective was achieved resulting in the following improvements: toner cartridges recycled weights are now reported on a quarterly basis helping to improve waste diversion data and employee awareness is improved from completion of an awareness campaign that included a Pollution Prevention News issue and an Earth Day Information poster. All computer profiles are initiated with double-side print as the default. Awareness efforts are ongoing to communicate the expectation that individuals retain the default as double-sided to the greatest extent possible.

Objective 4 – Improve use of sustainable products.

In FY 2013, 61 percent of dollars spent on office products were for products with recycled content. The target supporting this objective was completed with procurement card holders, purchase requisitioners, projects personnel, and procurement staff completing sustainable acquisition awareness training.

Objective 5 – Improve Life Cycle Management of Electronics.

Progress was made with completion of the supporting targets. Fifty percent of servers are now virtualized and a mechanism is in place to quantify and track Skeen-Whitlock Building data center baseline energy use and identify potential improvements.

	The final target, which can support any of the objectives, was establishment of an account for funds from recycling and sale of excess property for use in additional sustainability projects. In the first year, $6,340 was spent on eight electric hand dryers to reduce paper towel use and 25 light-emitting diode (LED) task lights to begin the process of replacing existing fluorescent lights.
Competence, Awareness and Training	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 completed EMS training through initial or annual refresher General Employee Training. FY 2013 Earth Day was celebrated by displaying posters in high traffic areas that highlighted WIPP performance in energy and water use, waste diversion, sustainable purchasing and toward EMS objectives and targets. In addition, employees were provided a “sunflower in a box” to remind them of WIPP’s commitment to protect the environment.
Operational Control	Environmental controls were integrated into procedures and implemented in accordance with the WIPP Conduct of Operations program.
Emergency Preparedness and Response	The Emergency Management Department performed 38 exercises/drills/events.
Monitoring and Measurement	The environmental monitoring program confirmed that there has been no significant environmental impact from WIPP operations.
Evaluation of Compliance	CBFO and the MOC performed over 250 evaluations that checked for compliance and encompassed numerous facets of the WIPP project. No regulatory noncompliance issues were identified from these evaluations.
Nonconformity, Corrective Action, and Preventive Action	The Issues Management and Corrective Action Request programs continued to be robust.

Internal Audit	The internal audit of the WIPP EMS was completed. One finding was identified, and corrective actions were completed.
Management Review	CBFO and MOC senior managers confirmed the five strategic objectives will continue to be the continuous improvement areas where WIPP will focus its efforts for the next 5 to 8 years of operation and approved 12 FY 2014 environmental targets. The objectives and targets were selected to produce continual improvement in efficiency in the waste emplacement process (cleanup of generator sites) and in sustainability performance.

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

This program includes surveillance of drilling activities within the Delaware Basin, with specific emphasis on the nine-township area that includes the WIPP site. The surveillance of drilling activities builds 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 nonradiological 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. Nonradiological monitoring includes meteorology, VOCs, groundwater, hydrogen, methane, nearby hydrocarbon drilling activity, and SSW.

Environmental Compliance Audit

Audits and reviews of compliance are conducted via the MOC Regulatory Compliance Department environmental compliance assessments and the CBFO and MOC QA assessment programs.

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.

NEPA Compliance

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.

Sustainability

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

Sustainable Procurement

This program provides a systematic and cost-effective structure for promoting and procuring sustainable products. 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. 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.

3.3 Environmental Performance Measurement

Extensive monitoring and measurement is conducted by the WIPP 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 was no significant environmental impact from WIPP operations in 2013, as determined from environmental monitoring implementation results. Detailed analyses and summaries of the results of this program are included in Chapters 4, 5, and 6.

3.3.2 EMS Effectiveness

System indicators demonstrate the EMS continues to be suitable and effective for carrying out the WIPP mission and meeting environmental policy commitments. Indicators confirmed that environmental protection is integrated into WIPP processes (e.g., significant aspects/impacts are current, environmental compliance is included in audits). The indicators also demonstrate strong environmental performance with zero compliance issues, zero reportable containment releases, achievement of 84 percent of the year's targets, and implementation of 90 percent of continuous improvement actions directed from the prior year management review.

3.3.3 Sustainability Progress (Continuous Improvement)

Continuous improvement in environmental performance is demonstrated by the WIPP project contribution toward the DOE Sustainability Goals established under EOs 13514 and 13423. As shown in Figure 3.1, the WIPP project meets, is in the process of meeting, or has exceeded 75 percent of DOE goals. Limited progress has been made relative to those remaining DOE goals that have limited applicability to the WIPP project or for which necessary infrastructure precludes cost effectiveness. Performance is summarized in the remainder of this section.

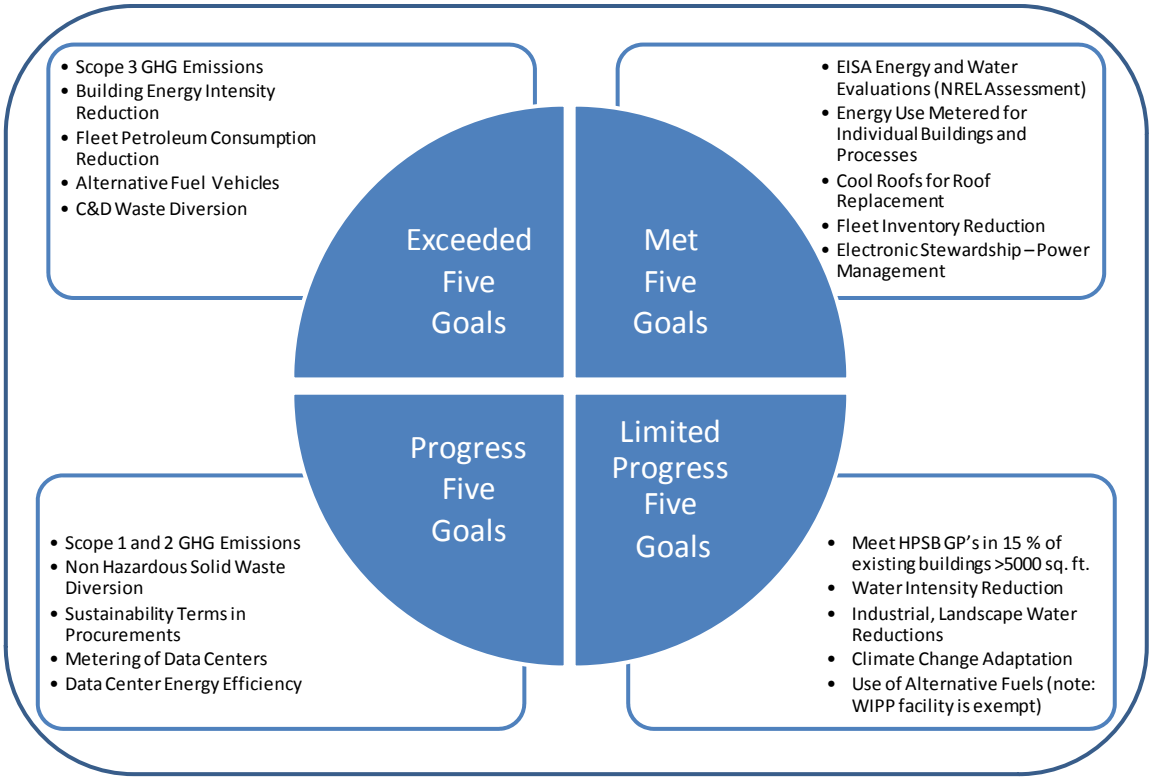


Figure 3.1 – WIPP Project Contribution to DOE Sustainability Goals

Reduce Greenhouse Gas Emissions

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

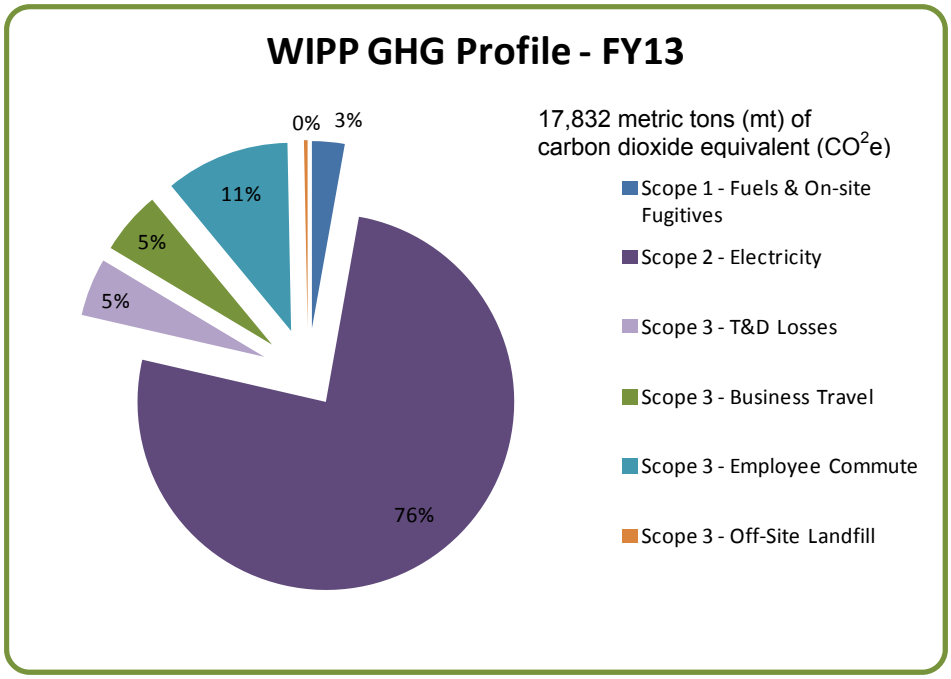
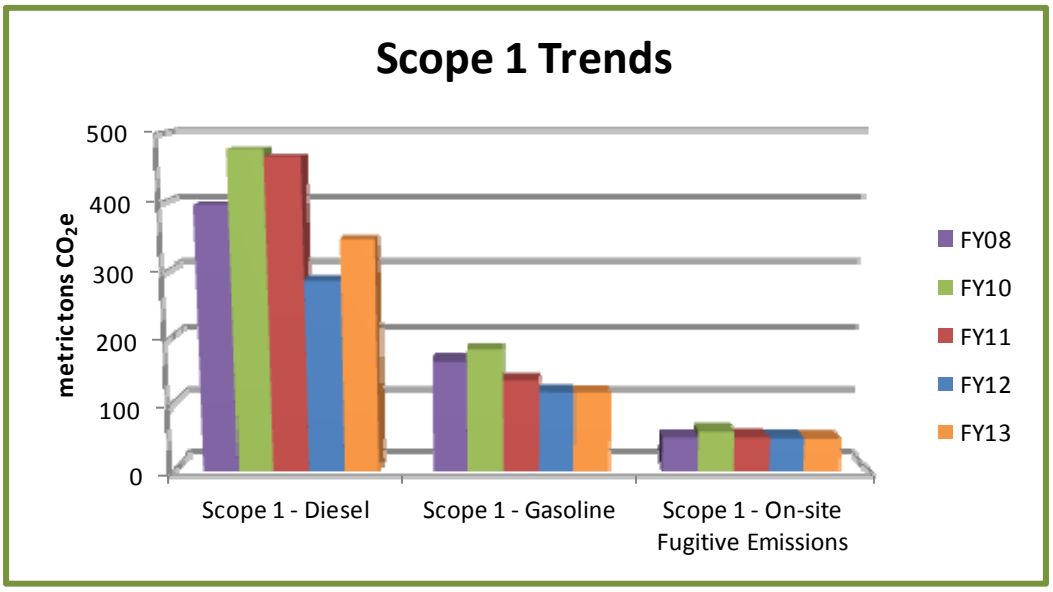


Figure 3.2 – WIPP Project GHG Profile – FY 2013

Given the profile, the priority for GHG reduction at the WIPP project is reducing electricity use. Secondary emphasis is placed on reductions in business travel and petroleum fuel use.

Progress in reducing Scope 1 and Scope 2 GHG emissions are illustrated in Figure 3.3.



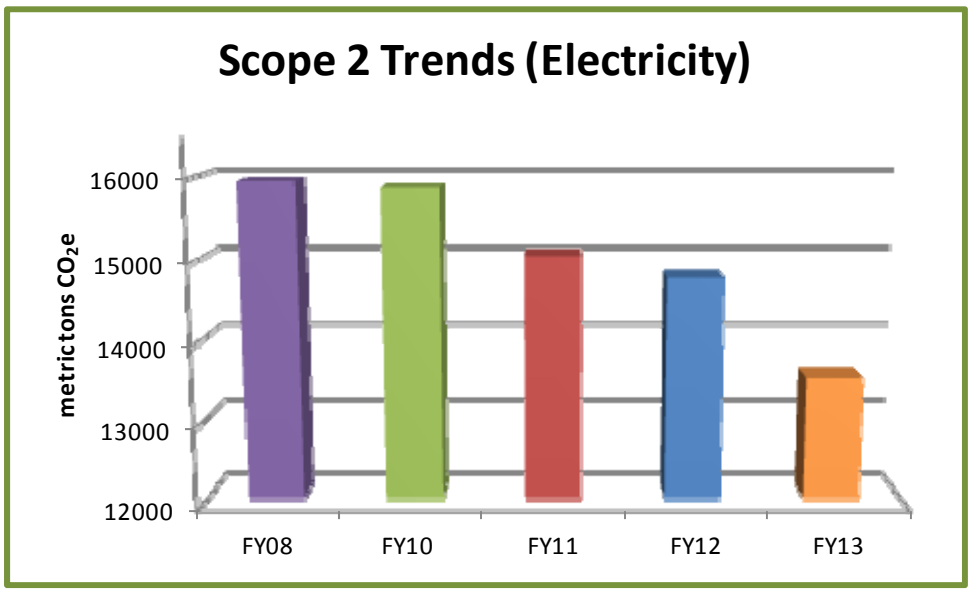


Figure 3.3 – GHG Emission Trends

These graphs demonstrate that the GHG generated by WIPP project use of gasoline and electricity are trending downward. The WIPP SSP reports that Scope 1 and 2 GHG emissions are 15 percent below the FY 2008 baseline (U.S. Department of Energy, 2013). Reductions were achieved in the following areas:

Energy Efficiency

Installed LED lighting in Building 411.

The WIPP primary air compressors were replaced with properly sized units.

Induction light fixtures are used to replace failed perimeter high-pressure sodium light fixtures.

Building Metering

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

Cool Roofs

Cool roof technology (increased roof insulation and reflective surface) has been applied on 13 existing buildings as part of roof repairs.

Fleet/Fuel Improvements

Eighty percent of WIPP project vehicles are alternative-fuel or hybrid vehicles.

The fleet continues to reflect a 35 percent decrease compared to the FY 2005 baseline.

Petroleum use was reduced by 33 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.

Renewable Energy Funds previously used to purchase renewable energy credits were used to purchase photovoltaic equipment in 2013. The equipment is scheduled to be installed in 2014.

Although diesel fuel use increased in FY13 vs FY12 due to an increase in underground activities requiring the use of diesel equipment, GHG emissions from use of diesel remain on a downward trend.

As the graph in Figure 3.4 demonstrates, Scope 3 GHG emissions continue to improve compared to the FY 2008 baseline. The overall Scope 3 reduction in FY 2013 was 46 percent, a significant improvement and well over the DOE's goal of a 13 percent reduction. These reductions resulted from personnel increasing their use of options such as teleconferencing or webcasting.

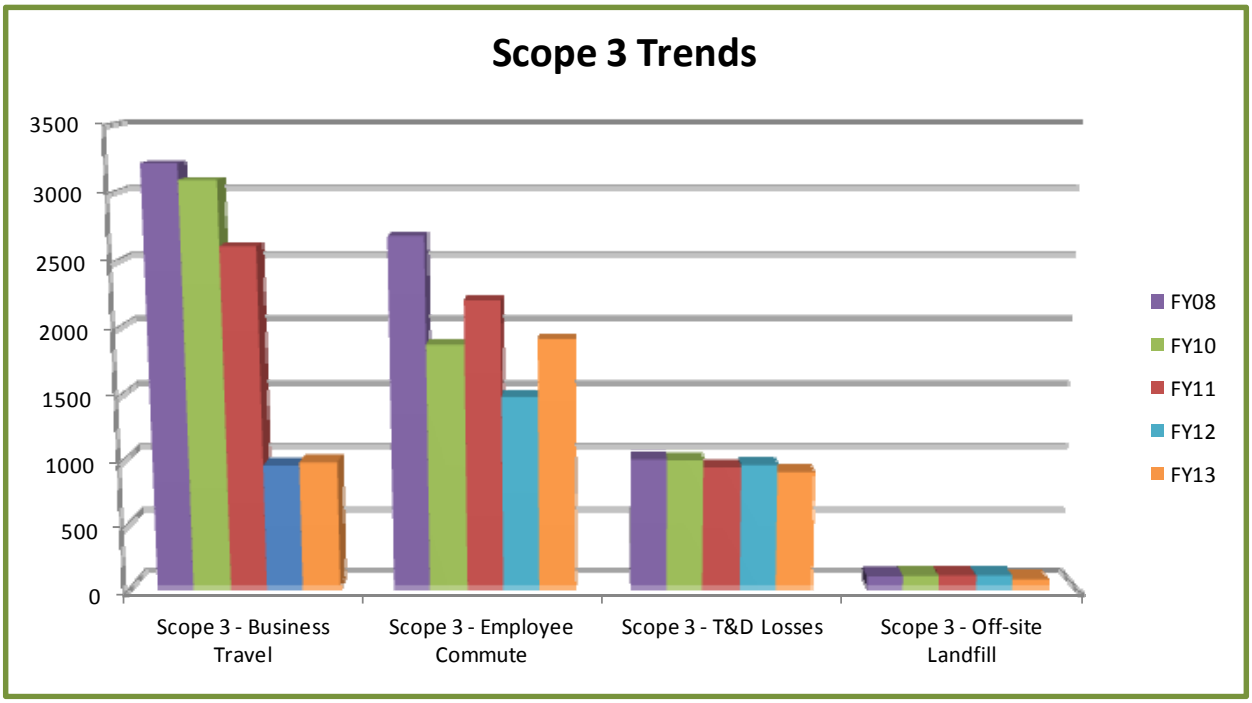


Figure 3.4 – Scope 3 GHG Trend

Water Efficiency and Management

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

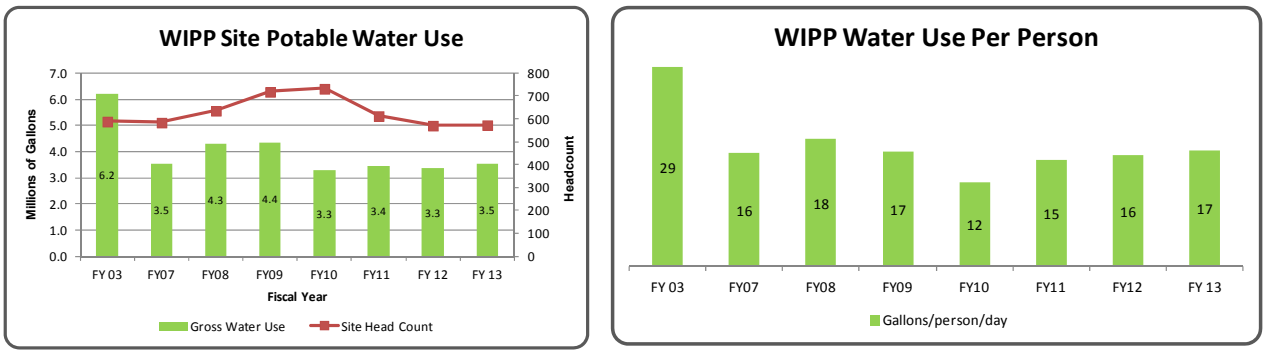


Figure 3.5 – WIPP Site Annual Potable Water Use

As shown in the graph on the left, between FY 2003 and FY 2007, water consumption was reduced significantly, increased in FY 2008 and 2009 and has remained constant from FY 2011 forward. In FY 2008 and 2009, water consumption increased primarily due to a water leak in a fire protection line and increases in site personnel beginning in FY 2008 as projects were implemented to enhance the site's ability to accomplish its mission using *American Recovery and Reinvestment Act* funds. Increases related to mining/waste-related personnel during FY 2008, FY 2009, and portions of FY 2010 resulted in a greater increase in water use compared to increases that would result from primarily adding office personnel on single shifts.

The WIPP project has dedicated resources to water distribution system maintenance for the past six years resulting in the identification and repair of water leaks. However, the consistent levels of water use from FY 2011 forward are reflective of the unchanging headcount and progress made in the firewater system maintenance project. Because of these factors, it is anticipated that further significant water use reductions are not likely.

The graph on the right illustrates that water use per employee is low for an industrial operation. Water use for FY 2013 averaged 17 gallons/person/day and includes all water use at the site. Average water use at a factory or other industrial facility is 25 gallons/person/day, which means that WIPP facility water use is almost 30 percent lower than in a standard industrial facility.

Recycling and Waste Diversion

Waste diversion and recycling are key components of the WIPP project sustainability program. Waste streams that meet regional infrastructure requirements continue to be recycled, including selected nonhazardous, C&D, hazardous, universal, and New Mexico special waste streams.

The WIPP facility recycles alkaline batteries, aluminum cans, cardboard, fencing, paper, plastic, metal, toner cartridges, used motor oil, antifreeze, universal batteries, electronics (i.e., ballasts, computers, circuit boards), wood pallets and fluorescent tubes.

Executive Order 13514 requires that 50 percent of nonhazardous solid waste and C&D debris be diverted by FY 2015. Nonhazardous and C&D materials diverted at the WIPP facility are highlighted in Figure 3.6.

Nonhazardous & C&D Wastes Recycled

Alkaline Batteries
Aluminum Cans
Cardboard
Fencing
Paper
Plastic
Toner Cartridges
Wood Waste
Metals

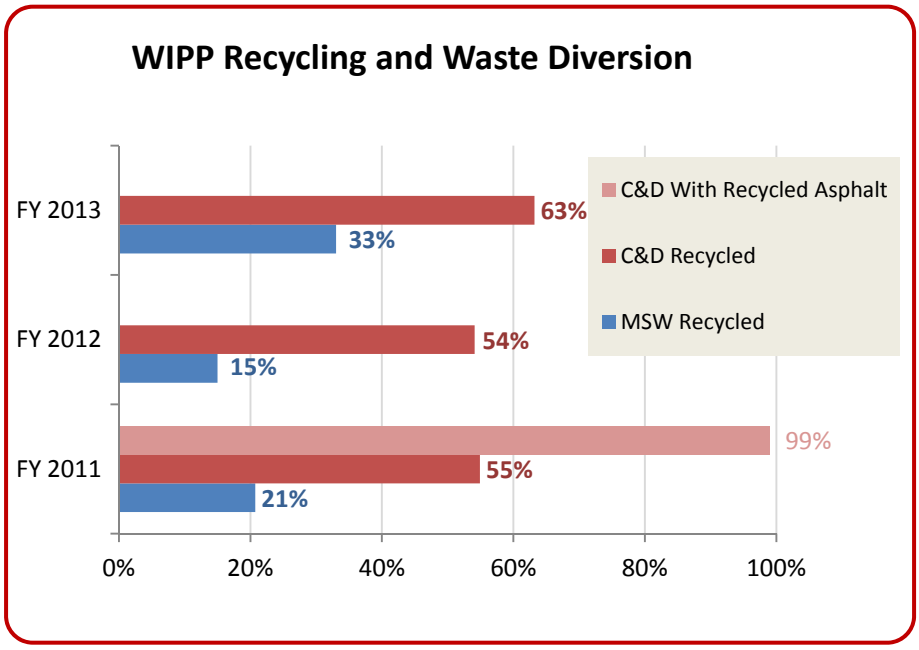


Figure 3.6 – WIPP Project Recycling and Waste Diversion

Sustainability awareness efforts accomplished through the Pollution Prevention News 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

The WIPP project continued to purchase 30 percent recycled content paper and use sustainable products for janitorial services when they meet cost, performance, and availability requirements. Training on sustainable purchasing was provided to procurement card holders, purchase requisitioners, projects personnel, and procurement personnel. Sixty-one percent of office products purchased in FY 2013 contained recycled content, compared to 42 percent in FY 2012.

The WIPP procurement process continues to ensure that ozone-depleting substances are not purchased. The WIPP facility has no Class 1 ozone-depleting substances on site.

Electronics Stewardship and Data Centers

The WIPP project continued to use sustainable life-cycle management of electronics as demonstrated in Figure 3.7.

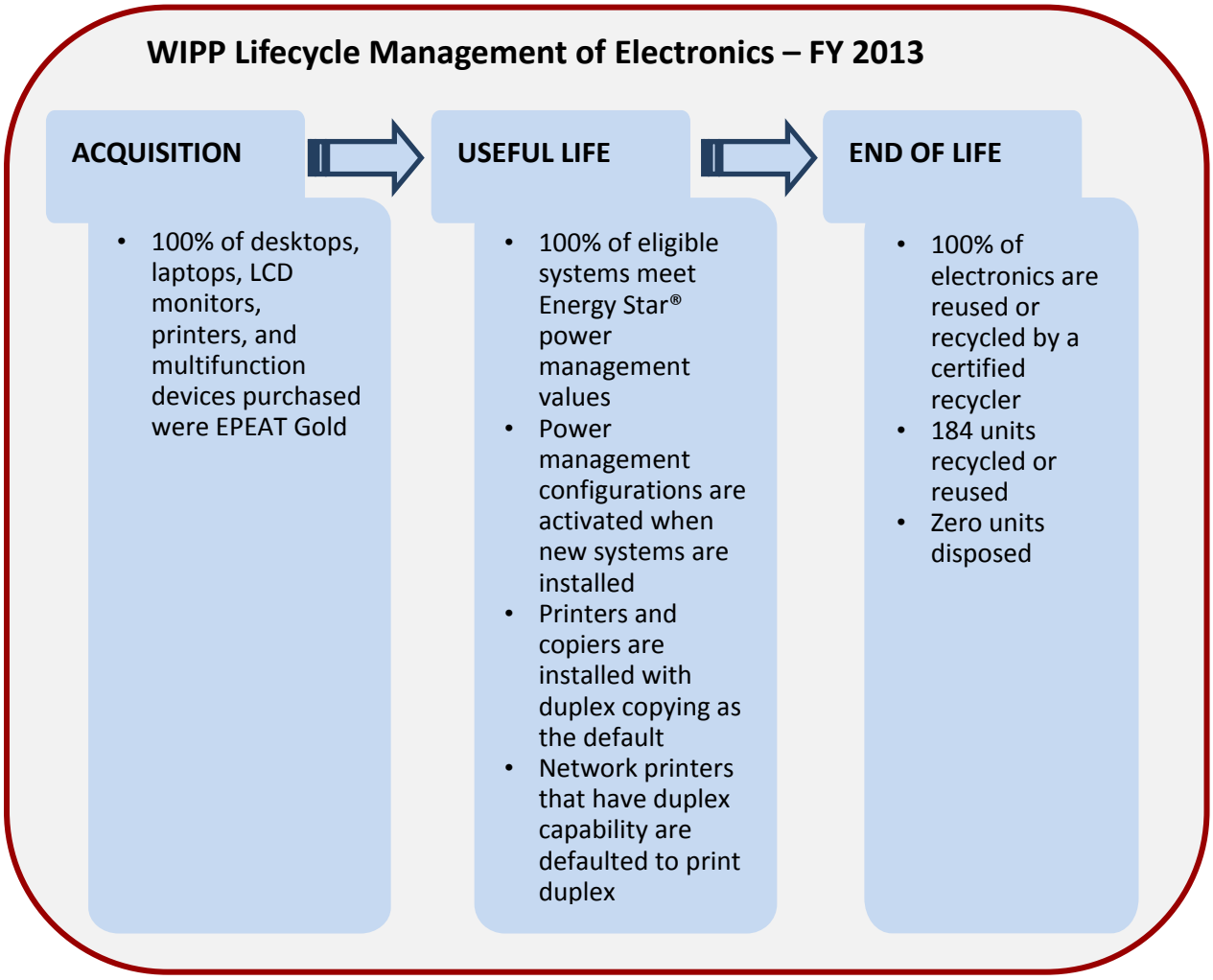


Figure 3.7 – Life Cycle Management of Electronics at the WIPP Project

3.4 EMS Awards

The NMED awarded CBFO a gold level Green Zia Environmental Leadership Program award in 2013. The award program recognizes businesses and other organizations for their commitment to environmental stewardship by implementing pollution prevention practices for excellence in environmental and economic sustainability. The WIPP project and two New

Mexico businesses were selected for the gold honor with a total of ten businesses recognized through the program.

Sustainable efforts at the WIPP project were also recognized at the Albuquerque Business First Sustainable Business Summit. The Summit honors organizations and leaders for whom “green” is not a buzzword, but is integral to the way they operate. Fourteen businesses were recognized for sustainable practices in building, business, leadership, product/service, and workplace. The WIPP project staff was recognized for groundwater DMP process changes that resulted in a reduction in hazardous waste generation.

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CHAPTER 4 – ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

DOE Order 458.1 states that the DOE must conduct radiological activities so that exposure to members of the public is maintained within the dose limits established in the order; control the radiological clearance of DOE real and personal property; ensure that potential radiation exposures to members of the public are as low as is reasonably achievable; ensure that 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 provide protection of the environment from the effects of radiation and radioactive material.

Radionuclides present in the environment, whether naturally occurring or human-made, may contribute to 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.

WIPP personnel 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*.

The WIPP facility 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 at disposal facilities operated by the DOE. 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 waste at the WIPP facility.

The environmental dose standards for the WIPP facility can be found in 40 CFR Part 191, Subpart A. Radionuclides being released from WIPP operations, including the underground TRU waste disposal areas and the WHB, are monitored through the WIPP facility effluent monitoring program. The referenced standard 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 addition, 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, 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 EDE of 10 mrem per year.

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 10 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.

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.

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.

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 ID confidence with which the peak or peaks associated with the particular radionuclide can be identified by the gamma spectroscopy software. In accordance with the statement of work (SOW) for the laboratory analyses, gamma spectroscopy samples with ID confidence less than 90 percent (<0.90) are not considered detects, regardless of their activities compared to the TPU and MDC. A radionuclide with an ID confidence greater than 0.90 may be considered detected even if the activity of the sample is less than the 2 σ TPU and/or MDC.

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 10 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 American National Standards Institute (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 procedurefor 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

The WIPP facility has three airborne effluent monitoring stations, 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.

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 2013, 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 to 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. Isotopes of plutonium and americium 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.

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 (µm) pore-size, 47-millimeter (mm) 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 80.95 m^3 (2,859 cubic feet [ft^3]) of air were filtered through the acrylic copolymer membrane filter.

Weekly (24 hours/seven days per week) filter samples were collected at Station B. Station B samples the underground exhaust air after HEPA filtration, and sometimes the nonfiltered air during maintenance. Each week at Station B, approximately 575.45 m^3 (20,322 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.

Weekly filter samples were collected at Station C sampling the air from the WHB after HEPA filtration. Approximately 4,034.4 m^3 (142,473 ft^3) of air were filtered through the Station C acrylic copolymer membrane filters during 2013. Even though there was a low-flow bias associated with Station C, during CY 2013, 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.

In mid-2013, it was found during a calibration check that the Station C sample flow control valve was biased to read higher than the actual flow through the valve. Since the emissions from WIPP exhaust points are dependent upon accurate ratios of sample flow to exhaust flow, the emissions from Station C were re-calculated assuming that the

bias existed since equipment installation in May 2011. The dose effects were calculated and the changes are included in the tabulated section 4.9 data.

The filter samples for Stations B and C were composited each quarter. Because of the large quantity of filters from Station A, samples were composited monthly. Filter samples 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 monthly and quarterly filter samples were composited. 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 (mL) (0.845 fluid ounce [oz]) of concentrated nitric acid and 1 gram (0.0353 oz) 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 20 total composite samples taken in 2013, 140 analyses were performed, as shown in Tables 4.2, 4.3 and 4.4. The analytes of interest were ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{90}Sr, $^{233/234}$U, ^{238}U and ^{137}Cs.

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 air emissions in CY 2013 are shown in Tables 4.2, 4.3 and 4.4. 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 2013, and the corrections are included in the CY 2013 source term compilation.

Evaluation of the 2013 filter sample results using the latest EPA-approved CAP88-PC code 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).

Table 4.2 – Activity (Bq/sample) of Quarterly Composite Air Samples from the WIPP Effluent Monitoring Station B for 2013

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	2.25E-04	3.13E-04	9.66E-04
2nd	^{241}Am	3.19E-04	6.29E-04	1.07E-03
3rd	^{241}Am	4.29E-04	5.00E-04	8.84E-04
4th	^{241}Am	1.72E-04	4.26E-04	9.14E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238} Pu	2.72E-05	2.82E-04	5.88E-04
2nd	^{238} Pu	2.09E-05	7.70E-04	7.47E-04
3rd	^{238} Pu	5.18E-05	2.86E-04	8.03E-04
4th	^{238} Pu	6.22E-04	7.84E-04	1.15E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{239/240}$Pu	-2.71E-05	1.06E-04	5.18E-04
2nd	$^{239/240}$Pu	-5.81E-05	1.67E-04	5.74E-04
3rd	$^{239/240}$Pu	1.30E-05	3.14E-04	7.25E-04
4th	$^{239/240}$Pu	0.00E+00	0.00E+00	5.29E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{90}Sr	-2.55E-02	2.44E-02	2.38E-02
2nd	^{90}Sr	1.88E-02	3.02E-02	2.39E-02
3rd	^{90}Sr	-1.62E-02	2.96E-02	2.76E-02
4th	^{90}Sr	4.66E-03	2.83E-02	3.05E-02

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{233/234}$U	2.60E-03	1.21E-03	6.92E-04
2nd	$^{233/234}$U	9.36E-04	9.40E-04	8.29E-04
3rd	$^{233/234}$U	1.03E-03	7.96E-04	8.40E-04
4th	$^{233/234}$U	3.85E-03	1.60E-03	6.73E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}U	3.12E-03	1.32E-03	5.51E-04
2nd	^{238}U	3.20E-04	6.14E-04	7.84E-04
3rd	^{238}U	7.84E-04	6.77E-04	7.47E-04
4th	^{238}U	4.37E-03	1.72E-03	7.22E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{137}Cs	-3.39E-01	3.68E-01	3.77E-01
2nd	^{137}Cs	1.92E-02	4.11E-01	4.55E-01
3rd	^{137}Cs	2.67E-01	3.40E-01	3.74E-01
4th	^{137}Cs	-8.21E-02	3.92E-01	4.26E-01

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

Table 4.3 – Activity (Bq/sample) of Quarterly Composite Air Samples from WIPP Effluent Monitoring Station C for 2013

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{241}Am	7.51E-05	7.55E-04	1.05E-03
2nd	^{241}Am	-7.66E-05	4.03E-04	9.81E-04
3rd	^{241}Am	5.11E-04	6.36E-04	1.07E-03
4th	^{241}Am	2.69E-04	4.96E-04	9.62E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238} Pu	-1.39E-04	2.46E-04	5.99E-04
2nd	^{238} Pu	8.47E-06	6.96E-04	7.51E-04
3rd	^{238} Pu	-1.27E-04	2.49E-04	9.81E-04
4th	^{238} Pu	-7.10E-05	2.31E-04	9.88E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{239/240}$Pu	6.73E-05	2.61E-04	5.29E-04
2nd	$^{239/240}$Pu	1.68E-04	4.03E-04	5.77E-04
3rd	$^{239/240}$Pu	-3.16E-05	1.24E-04	6.22E-04
4th	$^{239/240}$Pu	-8.84E-05	2.57E-04	1.01E-03

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{90}Sr	-1.71E-02	1.71E-02	2.32E-02
2nd	^{90}Sr	7.18E-03	2.95E-02	2.38E-02
3rd	^{90}Sr	1.08E-02	2.89E-02	2.78E-02
4th	^{90}Sr	-2.41E-02	2.89E-02	3.05E-02

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	$^{233/234}$U	2.44E-04	4.18E-04	6.66E-04
2nd	$^{233/234}$U	-1.27E-04	2.84E-04	7.33E-04
3rd	$^{233/234}$U	9.58E-05	2.80E-04	7.88E-04
4th	$^{233/234}$U	-4.59E-05	1.50E-04	6.36E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{238}U	1.38E-04	3.53E-04	5.11E-04
2nd	^{238}U	-4.92E-05	1.76E-04	6.85E-04
3rd	^{238}U	3.49E-04	4.51E-04	7.84E-04
4th	^{238}U	-2.29E-05	1.05E-04	6.62E-04

Qtr.	Nuclide	Activity (Bq/Sample)	2σTPU[a]	MDC[b]
1st	^{137}Cs	-1.31E-01	7.99E-01	9.21E-01
2nd	^{137}Cs	2.43E-01	8.92E-01	1.04E+00
3rd	^{137}Cs	1.37E-01	3.05E-01	3.56E-01
4th	^{137}Cs	-5.96E-02	3.54E-01	3.85E-01

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

Table 4.4 – Activity (Bq/sample) of Monthly Composite Air Samples from WIPP Effluent Monitoring Station A for 2013

Month	Nuclide	Activity Bq/sample	2σ TPU[a] Bq/sample	MDC[b] Bq/sample
January	^{241}Am	1.45E-04	3.49E-04	6.51E-04
February	^{241}Am	-7.14E-05	7.62E-04	1.07E-03
March	^{241}Am	1.49E-04	7.92E-04	1.03E-03
April	^{241}Am	1.77E-04	3.66E-04	9.81E-04
May	^{241}Am	1.69E-04	4.07E-04	1.14E-03
June	^{241}Am	-2.41E-04	5.40E-04	7.96E-04
July	^{241}Am	2.15E-04	4.85E-04	9.66E-04
August	^{241}Am	1.12E-04	2.74E-04	9.21E-04
September	^{241}Am	-1.74E-05	1.02E-04	9.36E-04
October	^{241}Am	9.66E-05	6.55E-04	1.13E-03
November	^{241}Am	5.48E-04	9.25E-04	1.32E-03
December	^{241}Am	4.59E-04	5.96E-04	9.58E-04
January	^{238} Pu	3.21E-04	6.62E-04	6.51E-04
February	^{238} Pu	1.42E-04	4.96E-04	6.18E-04
March	^{238} Pu	2.82E-04	5.96E-04	6.36E-04
April	^{238} Pu	-5.29E-05	1.47E-04	5.85E-04
May	^{238} Pu	3.03E-04	4.37E-04	7.62E-04
June	^{238} Pu	-9.07E-05	1.88E-04	6.73E-04
July	^{238} Pu	3.09E-04	4.55E-04	7.88E-04
August	^{238} Pu	-3.70E-05	1.36E-04	8.29E-04
September	^{238} Pu	3.96E-05	2.97E-04	7.99E-04
October	^{238} Pu	-3.30E-04	7.40E-04	1.26E-03
November	^{238} Pu	1.75E-04	3.62E-04	7.77E-04
December	^{238} Pu	-2.39E-04	7.40E-04	1.30E-03
January	$^{233/234}$U	6.55E-04	6.07E-04	7.84E-04
February	$^{233/234}$U	1.29E-03	9.81E-04	7.96E-04
March	$^{233/234}$U	8.25E-04	6.62E-04	6.73E-04
April	$^{233/234}$U	6.07E-04	6.85E-04	7.51E-04
May	$^{233/234}$U	1.05E-03	7.29E-04	5.62E-04
June	$^{233/234}$U	9.66E-04	7.44E-04	6.51E-04
July	$^{233/234}$U	9.84E-05	3.81E-04	8.81E-04
August	$^{233/234}$U	3.36E-04	5.14E-04	8.70E-04
September	$^{233/234}$U	4.33E-04	4.70E-04	7.47E-04
October	$^{233/234}$U	4.33E-04	5.33E-04	7.51E-04
November	$^{233/234}$U	8.77E-05	3.39E-04	7.29E-04
December	$^{233/234}$U	4.70E-04	5.55E-04	6.66E-04
January	^{137}Cs	-8.88E-02	3.24E-01	3.70E-01
February	^{137}Cs	-2.66E-02	1.46E-01	1.68E-01
March	^{137}Cs	1.97E-01	4.07E-01	4.51E-01
April	^{137}Cs	1.78E-01	3.61E-01	3.96E-01
May	^{137}Cs	-7.10E-03	2.98E-01	3.45E-01
June	^{137}Cs	1.57E-01	3.22E-01	3.74E-01
July	^{137}Cs	-5.18E-02	3.33E-01	3.81E-01
August	^{137}Cs	3.59E-01	3.69E-01	4.07E-01
September	^{137}Cs	-1.36E-01	3.22E-01	3.63E-01
October	^{137}Cs	-1.44E-01	3.50E-01	3.74E-01
November	^{137}Cs	1.19E-01	3.49E-01	3.81E-01
December	^{137}Cs	1.24E-01	3.07E-01	3.59E-01

Month	Nuclide	Activity Bq/sample	2σ TPU Bq/sample	MDC Bq/sample
January	$^{239/240}$Pu	2.56E-04	3.74E-04	4.70E-04
February	$^{239/240}$Pu	7.70E-05	2.61E-04	5.37E-04
March	$^{239/240}$Pu	8.40E-05	2.85E-04	5.66E-04
April	$^{239/240}$Pu	3.44E-04	4.55E-04	5.14E-04
May	$^{239/240}$Pu	-2.96E-05	3.52E-04	9.18E-04
June	$^{239/240}$Pu	-5.70E-05	1.49E-04	5.11E-04
July	$^{239/240}$Pu	6.18E-05	2.96E-04	7.33E-04
August	$^{239/240}$Pu	4.26E-04	5.55E-04	9.21E-04
September	$^{239/240}$Pu	2.35E-04	4.59E-04	7.73E-04
October	$^{239/240}$Pu	5.74E-05	3.15E-04	8.25E-04
November	$^{239/240}$Pu	2.10E-04	3.39E-04	5.81E-04
December	$^{239/240}$Pu	2.99E-04	4.37E-04	7.51E-04
January	^{90}Sr	-1.25E-02	2.89E-02	2.56E-02
February	^{90}Sr	1.91E-02	4.03E-02	2.56E-02
March	^{90}Sr	1.15E-04	1.71E-02	2.32E-02
April	^{90}Sr	-7.92E-03	2.58E-02	2.39E-02
May	^{90}Sr	-4.14E-03	4.03E-02	2.26E-02
June	^{90}Sr	1.47E-03	2.67E-02	2.25E-02
July	^{90}Sr	-1.14E-02	3.85E-02	2.14E-02
August	^{90}Sr	1.32E-03	4.03E-02	2.65E-02
September	^{90}Sr	1.64E-02	3.04E-02	2.80E-02
October	^{90}Sr	-2.43E-02	3.23E-02	2.87E-02
November	^{90}Sr	-1.99E-03	3.11E-02	2.89E-02
December	^{90}Sr	-3.28E-02	2.97E-02	3.07E-02
January	^{238}U	6.48E-04	6.07E-04	6.62E-04
February	^{238}U	1.32E-03	9.66E-04	6.33E-04
March	^{238}U	1.30E-03	7.99E-04	5.18E-04
April	^{238}U	8.95E-04	7.96E-04	6.11E-04
May	^{238}U	7.14E-04	6.70E-04	5.11E-04
June	^{238}U	1.05E-03	7.96E-04	5.81E-04
July	^{238}U	2.29E-04	5.18E-04	8.03E-04
August	^{238}U	4.92E-04	5.74E-04	8.21E-04
September	^{238}U	2.15E-04	3.30E-04	6.66E-04
October	^{238}U	5.85E-04	5.74E-04	7.47E-04
November	^{238}U	5.81E-05	3.60E-04	8.25E-04
December	^{238}U	1.02E-03	7.62E-04	6.99E-04

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

4.2 Airborne Particulates

4.2.1 Sample Collection

Weekly airborne particulate samples 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. Location codes are shown in Appendix C. Each week at each sampling location, approximately 600 m^3 (21,187 ft^3) of air were sampled through a 4.7-centimeter (cm) (1.85-inch [in.]) diameter glass microfiber filter using a continuous low-volume air sampler.

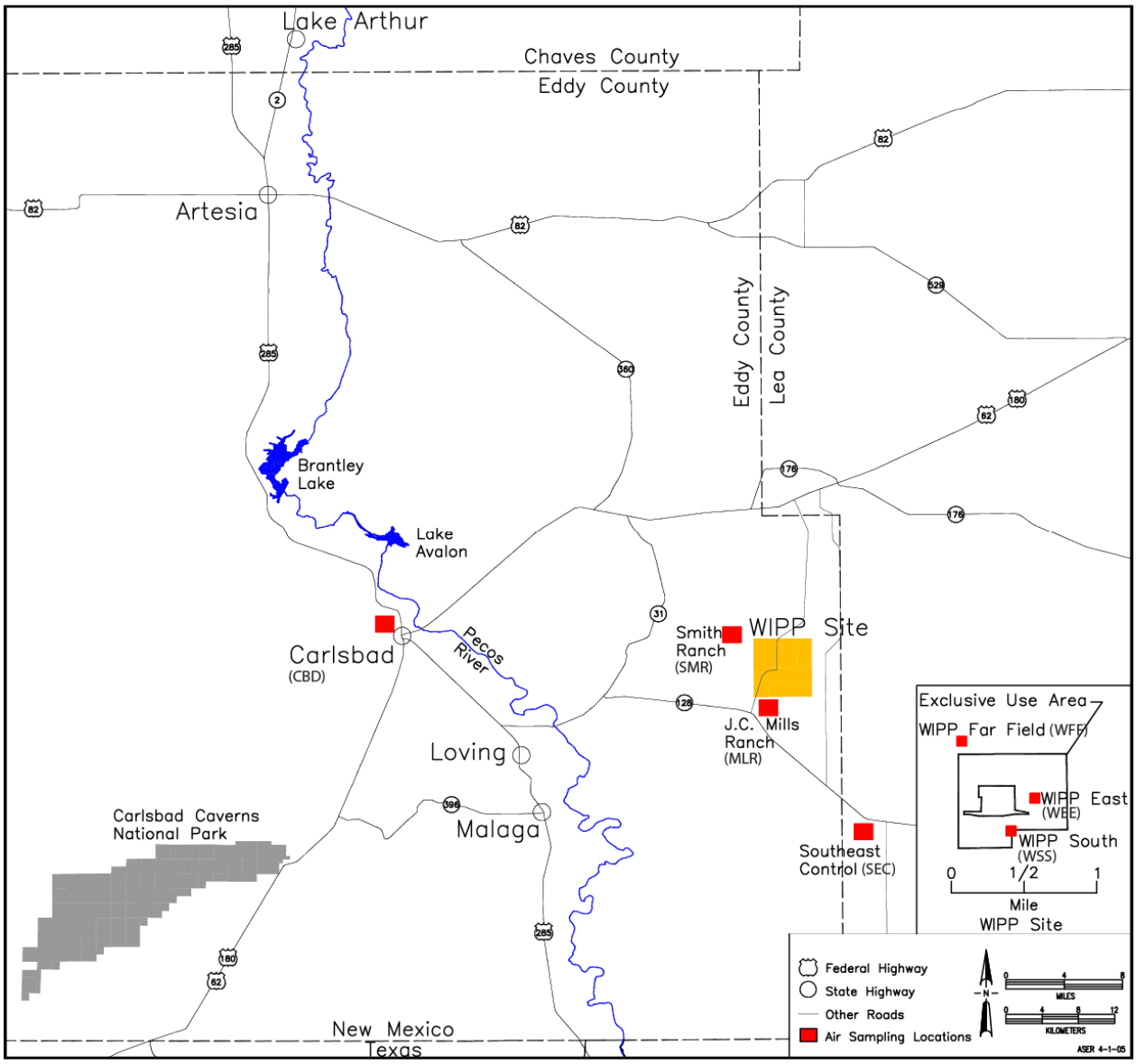

Figure 4.1 – Air Sampling Locations On and Near the WIPP Site

4.2.2 Sample Preparation

Weekly air particulate samples were analyzed for gross alpha and beta and then composited for each quarter. 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 Sr carrier was also 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 polytetra-fluoroethylene 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 mL 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 (1 part nitric acid, 3 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 mL 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, and then 2M aluminum nitrate solution was added. The oxidation states of the target radionuclides (uranium and transuranic 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 (NdF_3) 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 Sr was eluted from the SR 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

Detailed sample analysis data for each sampling station are reported in Appendix G (Table G.1). Whenever the word “sample” is used for air filter samples, it should be taken to mean “composite sample.” Blank filter composite samples were prepared and analyzed, and the results are reported separately for each quarter.

The average concentrations are reported for those locations where duplicate samples were collected using low-volume air samplers. A Qualifier column is included in the data

tables in Appendix G to show whether the activity of the radionuclide is greater than the 2 σ TPU and MDC and thus, whether the radionuclide was detected in the sample. Appendix Table G.2 shows the Bq/sample converted to Becquerels per cubic meter (Bq/m^3) by dividing the sample activity in Bq by the total quarterly air volumes.

Appendix Table G.1 shows that the only radionuclide detections in the air filter composite samples were as follows (see Appendix C for referenced location codes):

- Detection of $^{233/234}U$ in SEC and CBD during the second quarter.
- Detection of ^{238}U in CBD during the first quarter.
- Detection of ^{238}U in WFF, one of the WEE duplicates, WSS, MLR, SEC and CBD during the second quarter.

However, ^{238}U was detected in the WAB blank filter composite samples during the first, second, and third quarters. In addition, $^{233/234}U$ was detected in the WAB blank filter composite samples during the first and second quarters.

The activities of $^{233/234}U$ and ^{238}U in the blank filter composites were very similar to the activities measured in the samples and thus, if any $^{233/234}U$ or ^{238}U were present in the air particulate composite samples, they were present at a very low concentrations.

Since there were no detections at concentrations significantly above the blank filter composite samples in 2013, no ANOVA comparisons were performed between years or between locations.

Table 4.5 shows the combined mean, minimum, and maximum measured activities (Becquerels per composite air filter sample [Bq/sample]) of target radionuclides for the air sampling locations along with the location and sampling quarter for the minimum and maximum activities. The only maximum concentration detection in Table 4.5 is for ^{238}U in the CBD sample from the second quarter. The activity is less than two times the average activity of the blank air filter composite sample and thus, if it is present at all, it is only at very low concentrations. As shown in the table, the highest measured activities varied among locations and quarter with no particular correlations.

The baseline concentration for ^{238}U is 2.40E-06 Bq/m^3. The maximum concentration detected in the second quarter CBD sample is 1.93E-06 Bq/m^3 as shown in the Appendix Table G.2. Thus. the highest measured concentration of ^{238}U was less than the 99 percent baseline confidence interval concentration.

Table 4.5 - 2013 Average, Minimum, and Maximum Concentrations in Air Filter Composite Samples
Units are Bq/sample

Radionuclide		[RN][a]	2 σ TPU[b]	MDC[c]	Location	Quarter
$^{233/234}$U	Mean (d)	4.27E-03	3.28E-03	8.82E-03	NA	NA
	Minimum (e)	7.89E-04	3.83E-03	8.79E-03	WFF	3
	Maximum (e)	1.39E-02	3.75E-03	8.81E-03	CBD	2
^{235}U	Mean (d)	9.30E-05	6.99E-04	1.23E-03	NA	NA
	Minimum (e)	-7.22E-04	8.14E-04	1.41E-03	MLR	3
	Maximum (e,f)	1.05E-03	8.89E-04	1.18E-03	WFF	2
^{238}U	Mean (d)	5.28E-03	3.16E-03	7.86E-03	NA	NA
	Minimum (e)	1.37E-03	3.52E-03	7.65E-03	SMR	3
	Maximum (e)	1.42E-02	3.67E-03	7.72E-03	CBD	2
^{238}Pu	Mean (d)	-2.94E-05	3.40E-04	1.12E-03	NA	NA
	Minimum (e)	-2.85E-04	2.24E-04	1.15E-03	WSS	1
	Maximum (e,f)	2.75E-04	5.25E-04	1.15E-03	WFF	2
$^{239/240}$Pu	Mean (d)	8.14E-05	4.03E-04	8.79E-04	NA	NA
	Minimum (e)	-2.79E-04	3.98E-04	9.35E-04	WSS	4
	Maximum (e,f)	6.73E-04	6.97E-04	1.00E-03	WEE	3
^{241}Am	Mean (d)	-2.80E-06	6.25E-04	1.04E-03	NA	NA
	Minimum (e)	-3.76E-04	5.64E-04	1.10E-03	MLR	3
	Maximum (e,f)	5.72E-04	9.42E-04	1.34E-03	WFF	1
^{40}K	Mean (d)	4.03E+00	7.47E+00	9.11E+00	NA	NA
	Minimum (e)	-3.28E+00	1.82E+01	2.02E+01	WEE	4
	Maximum (e,f)	1.30E+01	1.14E+01	1.75E+01	SEC	3
^{60}Co	Mean (d)	1.90E-01	1.27E+00	8.96E-01	NA	NA
	Minimum (e)	-4.41E-01	6.98E-01	7.46E-01	MLR	2
	Maximum (e,f)	7.18E-01	7.28E-01	8.87E-01	SEC	2
^{137}Cs	Mean (d)	4.92E-02	7.95E-01	8.90E-01	NA	NA
	Minimum (e)	-5.57E-01	8.13E-01	8.54E-01	WSS	3 (Avg)
	Maximum (e,f)	7.65E-01	1.70E+00	2.09E+00	WEE	4
^{90}Sr	Mean (d)	1.75E-04	2.80E-02	3.18E-02	NA	NA
	Minimum (e)	-2.45E-02	2.17E-02	3.97E-02	WEE	4
	Maximum (e,f)	2.18E-02	2.31E-02	3.40E-02	SEC	1

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

(b) Total propagated uncertainty at the 2 sigma 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.

NA Not applicable

The precision of the combined sampling and analysis steps for the air monitoring samples was determined by collecting field duplicate samples at one location each

quarter. During 2013, field duplicate samples were taken from location WFF during the first quarter, location WEE during the second quarter, location WSS during the third quarter, and location MLR during the fourth quarter. Table 4.6 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 only detections for $^{233/234}U$ and ^{238}U in a few of the samples. The precision of the combined sampling and analysis procedures was very good as demonstrated by most RERs being less than one (<1). The only higher RERs were for ^{238}U in the second quarter WEE duplicates (2.1) and for ^{90}Sr in the fourth quarter MLR duplicates (1.2).

Table 4.6 – Precision as RER for 2013 Duplicate Air Filter Composite Samples
Units are in Bq/Sample

See Chapter 6 for Sampling Locations

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]	RER[c]
1	WFF	$^{233/234}U$	2.18E-03	2.23E-03	4.63E-03	2.69E-03	0.701
1	WFF	^{235}U	-4.61E-04	2.65E-04	-4.72E-04	3.30E-04	0.026
1	WFF	^{238}U	2.95E-03	2.22E-03	4.04E-03	2.51E-03	0.325
1	WFF	^{238}Pu	-1.29E-04	4.08E-04	1.10E-04	4.83E-04	0.378
1	WFF	$^{239/240}Pu$	2.20E-04	4.40E-04	7.40E-06	3.12E-04	0.394
1	WFF	^{241}Am	-3.28E-04	4.46E-04	-2.00E-04	4.23E-04	0.208
1	WFF	^{40}K	1.13E+01	6.94E+00	3.48E+00	3.93E+00	0.981
1	WFF	^{60}Co	3.10E-01	6.54E-01	6.74E-02	6.75E-01	0.258
1	WFF	^{137}Cs	3.42E-01	6.35E-01	-4.77E-01	6.53E-01	0.899
1	WFF	^{90}Sr	1.45E-02	2.20E-02	1.08E-02	2.28E-02	0.117

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]	RER[c]
2	WEE	$^{233/234}U$	6.67E-03	2.96E-03	3.09E-03	2.52E-03	0.921
2	WEE	^{235}U	2.96E-04	5.93E-04	1.04E-03	8.73E-04	0.705
2	WEE	^{238}U	9.44E-03	3.17E-03	1.42E-03	2.11E-03	2.106
2	WEE	^{238}Pu	3.13E-04	5.09E-04	-1.68E-05	2.73E-04	0.571
2	WEE	$^{239/240}Pu$	3.57E-04	4.70E-04	1.08E-04	2.95E-04	0.449
2	WEE	^{241}Am	3.86E-04	7.59E-04	3.65E-04	6.00E-04	0.022
2	WEE	^{40}K	2.60E+00	7.02E+00	2.74E+00	7.39E+00	0.014
2	WEE	^{60}Co	5.16E-01	6.83E-01	-4.42E-01	8.37E-01	0.887
2	WEE	^{137}Cs	-1.93E-02	7.57E-01	1.10E-01	8.24E-01	0.116
2	WEE	^{90}Sr	3.64E-03	3.10E-02	-1.32E-03	3.19E-02	0.112

Table 4.6 – Precision as RER for 2013 Duplicate Air Filter Composite Samples
Units are in Bq/Sample

See Chapter 6 for Sampling Locations

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][(a)]	2 σ TPU[(b)]	[RN][(a)]	2 σ TPU[(b)]	RER[(c)]
3	WSS	$^{233/234}$U	3.51E-03	4.07E-03	1.85E-03	3.68E-03	0.303
3	WSS	^{235}U	-5.00E-04	8.31E-04	-4.26E-04	8.73E-04	0.061
3	WSS	^{238}U	3.70E-03	3.87E-03	-6.37E-04	3.31E-03	0.852
3	WSS	^{238}Pu	2.06E-04	3.94E-04	4.05E-05	4.49E-04	0.277
3	WSS	$^{239/240}$Pu	4.64E-05	3.31E-04	1.57E-04	4.35E-04	0.202
3	WSS	^{241}Am	-1.04E-04	6.53E-04	-3.54E-04	5.28E-04	0.298
3	WSS	^{40}K	1.48E+00	6.92E+00	5.19E+00	6.98E+00	0.536
3	WSS	^{60}Co	-1.84E-01	6.78E-01	3.98E-01	7.27E-01	0.585
3	WSS	^{137}Cs	-5.92E-01	7.60E-01	-5.22E-01	8.65E-01	0.061
3	WSS	^{90}Sr	-1.04E-02	3.90E-02	-1.67E-02	3.93E-02	0.114

			Sample 1		Sample 2		
Qtr	Location	Isotope	[RN][(a)]	2 σ TPU[(b)]	[RN][(a)]	2 σ TPU[(b)]	RER[(c)]
4	MLR	$^{233/234}$U	2.57E-03	3.41E-03	2.64E-03	3.99E-03	0.013
4	MLR	^{235}U	4.21E-04	8.06E-04	4.00E-04	8.56E-04	0.018
4	MLR	^{238}U	4.06E-03	3.08E-03	4.91E-03	3.77E-03	0.175
4	MLR	^{238}Pu	1.20E-05	3.38E-04	3.89E-05	3.24E-04	0.057
4	MLR	$^{239/240}$Pu	4.54E-05	5.46E-04	-2.36E-04	3.49E-04	0.434
4	MLR	^{241}Am	4.23E-04	8.62E-04	3.63E-04	7.62E-04	0.052
4	MLR	^{40}K	-4.69E-01	7.85E+00	6.57E+00	6.81E+00	0.677
4	MLR	^{60}Co	-1.81E-01	7.82E-01	-3.06E-02	6.83E-01	0.145
4	MLR	^{137}Cs	-2.09E-01	7.89E-01	-3.17E-01	6.15E-01	0.108
4	MLR	^{90}Sr	2.68E-02	2.03E-02	-6.95E-03	2.23E-02	1.119

(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. Field duplicate RERs less than 1 indicate very 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 additional 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 1. The laboratory generates precision data for all the radionuclides in a sample whether the radionuclides were detected or not, based on the activities compared to the 2 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 2013 were less than 1. The laboratory SOW states that "the Laboratory shall assess the need for corrective actions" if the laboratory duplicate precision yields RERs greater than 1, but there was only one situation where this was required.

4.3 Groundwater

4.3.1 Sample Collection

Groundwater samples were collected only once in 2013 (Round 35) from six different detection monitoring wells (DMWs) 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 DMWs 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 DMW was considered stable (i.e., representative of the undisturbed groundwater found in the formation) and sampled 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 portion (15 L) was 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 transuranic 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 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 2013, as shown by the data in Table 4.7. The concentrations reported in Table 4.7 are from the primary samples collected from each WQSP well. A duplicate sample from each well was also analyzed during each sampling episode. The duplicate sample activities and corresponding 2 sigma TPUs for each radioculide are shown in Table 4.8, which shows the precision of the analysis of the primary and duplicate samples, as discussed in detail below.

The 2013 uranium groundwater concentrations in the DMWs were compared with the concentrations from the same locations in 2012 using ANOVA. The ANOVA calculations were performed using the Round 35 average uranium sample concentrations from 2013 and the average uranium concentrations from Round 34 in 2012.

The concentrations of the uranium isotopes measured in 2013 did not vary significantly from the concentrations measured in the same wells in 2012, 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, $p = 0.965$; ANOVA ^{235}U, $p = 0.983$; and ANOVA ^{238}U, $p = 0.947$).

The average concentrations of the uranium isotopes measured in the groundwater samples in 2013 were also compared to the 2012 concentrations by location. There was significant variation by location between the wells sampled in 2012 and 2013, as demonstrated by the ANOVA results (ANOVA $^{233/234}$U, $p = 1.03\text{E}{-06}$; ANOVA ^{235}U, $p = 2.63\text{E}{-04}$; and ANOVA ^{238}U, $p = 9.73\text{E}{-07}$). 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.

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: $^{233/234}U$ = 1.30 becquerels per liter [Bq/L], ^{235}U = 3.10E–02 Bq/L, and ^{238}U = 3.20E–01 Bq/L). The highest Round 35 concentrations of $^{233/234}U$ of 1.37E+00 Bq/L at WQSP-1 and 1.31E+00 Bq/L at WQSP-2 were slightly higher than the 99 percent confidence interval range of the baseline concentration of 1.30E+00. The highest concentration of ^{235}U of 2.42E-02 Bq/L 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 at WQSP-1 was also lower than the 99 percent confidence interval range of the baseline concentration. All other $^{233/234}U$, ^{235}U and ^{238}U concentrations were well within the 99-percent confidence interval ranges of the baseline concentrations (DOE/WIPP–92–037).

Table 4.7 - 2013 Radionuclide Concentrations in Groundwater from Wells at the WIPP Site
Units are Bq/L
See Chapter 6 for Sampling Locations

Location	Round	[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	35	1.37E+00	2.07E-01	8.44E-04	+	1.42E-02	3.55E-03	6.05E-04	+	2.27E-01	3.55E-02	6.39E-04	+
WQSP-2	35	1.31E+00	2.15E-01	7.79E-04	+	1.15E-02	3.25E-03	6.41E-04	+	1.99E-01	3.38E-02	6.10E-04	+
WQSP-3	35	2.53E-01	4.64E-02	8.28E-04	+	2.76E-03	1.46E-03	6.77E-04	+	3.38E-02	7.38E-03	6.36E-04	+
WQSP-4	35	5.81E-01	9.95E-02	7.65E-04	+	4.10E-03	1.77E-03	6.35E-04	+	1.00E-01	1.83E-02	6.04E-04	+
WQSP-5	35	5.22E-01	7.30E-02	5.39E-04	+	5.58E-03	1.87E-03	4.91E-04	+	7.22E-02	1.13E-02	4.79E-04	+
WQSP-6	35	4.32E-01	9.51E-02	7.08E-04	+	2.34E-03	1.27E-03	5.61E-04	+	5.54E-02	1.31E-02	5.41E-04	+
		^{238}Pu				$^{239/240}$Pu				^{241}Am			
WQSP-1	35	-3.87E-05	3.48E-04	6.70E-04	U	8.51E-05	2.56E-04	5.00E-04	U	3.81E-04	5.44E-04	6.89E-04	U
WQSP-2	35	8.08E-05	3.54E-04	6.20E-04	U	5.38E-05	2.40E-04	4.59E-04	U	2.15E-04	5.17E-04	6.51E-04	U
WQSP-3	35	1.06E-04	4.65E-04	6.83E-04	U	7.51E-05	3.11E-04	5.69E-04	U	6.54E-04	8.21E-04	6.89E-04	U
WQSP-4	35	3.11E-05	5.08E-04	6.61E-04	U	8.90E-05	3.02E-04	5.75E-04	U	-1.87E-04	3.11E-04	8.24E-04	U
WQSP-5	35	2.30E-04	6.22E-04	7.57E-04	U	1.15E-04	3.27E-04	6.10E-04	U	9.10E-04	9.93E-04	1.02E-03	U
WQSP-6	35	3.69E-06	4.37E-04	6.18E-04	U	1.38E-04	3.65E-04	5.32E-04	U	6.08E-04	5.80E-04	1.01E-03	U
		^{40}K				^{60}Co				^{137}Cs			
WQSP-1	35	1.62E+01	4.33E+00	4.48E+00	+	5.40E-02	3.89E-01	4.69E-01	U	1.26E-01	3.01E-01	3.75E-01	U
WQSP-2	35	1.50E+01	4.04E+00	4.07E+00	+	6.64E-02	3.45E-01	4.24E-01	U	2.92E-02	3.21E-01	3.82E-01	U
WQSP-3	35	4.32E+01	7.53E+00	3.84E+00	+	-9.80E-03	3.85E-01	4.43E-01	U	9.41E-02	3.46E-01	4.00E-01	U
WQSP-4	35	2.33E+01	3.86E+00	2.70E+00	+	-9.25E-03	1.82E-01	2.09E-01	U	-5.18E-03	1.19E-01	1.91E-01	U
WQSP-5	35	9.93E+00	3.48E+00	4.19E+00	+	6.60E-02	3.38E-01	4.14E-01	U	2.17E-01	3.08E-01	3.92E-01	U
WQSP-6	35	6.89E+00	3.01E+00	3.94E+00	+	-1.29E-01	3.78E-01	4.02E-01	U	-1.16E-01	3.05E-01	3.45E-01	U
		^{90}Sr											
WQSP-1	35	1.10E-02	3.03E-02	2.67E-02	U								
WQSP-2	35	-1.45E-02	2.27E-02	2.54E-02	U								
WQSP-3	35	-4.21E-02	3.97E-02	2.50E-02	U								
WQSP-4	35	1.27E-02	3.28E-02	2.35E-02	U								
WQSP-5	35	1.01E-02	2.43E-02	2.24E-02	U								
WQSP-6	35	1.93E-03	2.17E-02	2.42E-02	U								

(a) Radionuclide activity of the primary sample. Only radionuclides with activities greater than 2 σ TPU and MDC are considered detections.
(b) Total propagated uncertainty
(c) Minimum detectable concentration
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

The TRU alpha spectroscopy radionuclides, ^{238}Pu, $^{239/240}$Pu, and ^{241}Am, were also analyzed for in the groundwater samples (Table 4.7). These isotopes, which are related to WIPP waste disposal operations, were not detected in any of the groundwater samples, so no ANOVA comparisons between years and among locations could be 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 potassium isotope ^{40}K was detected in all six wells in 2013 (primary samples only for WQSP-5 and WQSP-6). The 2013 concentrations of ^{40}K in the primary groundwater samples did not vary significantly from the 2012 concentrations based on an ANOVA *p* value of 0.755. However, ^{40}K concentrations did vary significantly by location from well to well, yielding an ANOVA *p* value of 3.75E–03. The 2012 and 2013 data for ^{40}K in WQSP-5 and WQSP-6 were not included in the ANOVA calculation because it was detected in only one of the duplicate samples in both 2012 and 2013. 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 2013 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 2013 was 4.32E+01 Bq/L in the primary sample from WQSP–3. This same well yielded the highest ^{40}K concentration in 2012.

The isotopes ^{137}Cs and ^{60}Co were not detected in any of the 2013 groundwater samples, and no ANOVA comparisons were performed.

The precision data for the radionuclides in the duplicate groundwater samples are reported in Table 4.8. Precision data for radionuclides in groundwater (primary and duplicate samples) as well as in duplicate surface water, sediment, soil, and biota samples are being reported for all radionuclides whether or not they were detected. An associated qualifier column will indicate whether the radionuclide was detected.

The Round 35 RERs in Table 4.8 show that all the RERs were less than 1.0, except for ^{235}U in the WQSP-6 duplicate samples where the RER was 1.46, which is less than the 1.96 value referenced above for field duplicate samples. Although the RERs were less than 1 for the ^{40}K analyses, the radionuclide was detected in the primary sample but not the duplicate sample for both WQSP-5 and WQSP-6. This variable detection for ^{40}K has been observed for the two DMWs in recent years. The RER precision data indicate that the reproducibility of the combined sampling and analysis procedures for the primary and duplicate groundwater samples was very good.

Table 4.8 Precision Results for 2013 Field Duplicate Groundwater Sample Analyes from Round 35
See Figure 6.3 for Sampling Locations

		Primary Sample		Duplicate Sample			
		Bq/L					
Location	Radionuclide	[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]	RER[c]	Q[d]
WQSP-1	$^{233/234}$U	1.37E+00	2.07E-01	1.28E+00	1.78E-01	0.329	+
	^{235}U	1.42E-02	3.55E-03	1.91E-02	4.10E-03	0.904	+
	^{238}U	2.27E-01	3.55E-02	2.12E-01	3.07E-02	0.304	+
	^{238}Pu	-3.87E-05	3.48E-04	-1.53E-04	2.73E-04	0.258	U
	$^{239/240}$Pu	8.51E-05	2.56E-04	-5.94E-05	1.70E-04	0.470	U
	^{241}Am	3.81E-04	5.44E-04	5.32E-04	6.64E-04	0.175	U
	^{90}Sr	1.10E-02	3.03E-02	4.94E-03	3.19E-02	0.137	U
	^{40}K	1.62E+01	4.33E+00	1.71E+01	9.55E+00	0.086	+
	^{60}Co	5.40E-02	3.89E-01	-4.77E-01	1.33E+00	0.383	U
	^{137}Cs	1.26E-01	3.01E-01	-1.61E-02	1.03E+00	0.132	U
WQSP-2	$^{233/234}$U	1.31E+00	2.15E-01	1.37E+00	2.46E-01	0.175	+
	^{235}U	1.15E-02	3.25E-03	1.25E-02	3.64E-03	0.207	+
	^{238}U	1.99E-01	3.38E-02	2.22E-01	4.10E-02	0.430	+
	^{238}Pu	8.08E-05	3.54E-04	4.73E-04	6.22E-04	0.548	U
	$^{239/240}$Pu	5.38E-05	2.40E-04	9.29E-05	2.80E-04	0.106	U
	^{241}Am	2.15E-04	5.17E-04	4.26E-04	8.29E-04	0.216	U
	^{90}Sr	-1.45E-02	2.27E-02	7.91E-03	2.57E-02	0.655	U
	^{40}K	1.50E+01	4.04E+00	1.40E+01	3.79E+00	0.181	+
	^{60}Co	6.64E-02	3.45E-01	-3.91E-01	3.97E-01	0.870	U
	^{137}Cs	2.92E-02	3.21E-01	7.94E-02	3.38E-01	0.108	U
WQSP-3	$^{233/234}$U	2.53E-01	4.64E-02	2.53E-01	5.01E-02	0.007	+
	^{235}U	2.76E-03	1.46E-03	2.60E-03	1.47E-03	0.077	+
	^{238}U	3.38E-02	7.38E-03	3.53E-02	8.16E-03	0.137	+
	^{238}Pu	1.06E-04	4.65E-04	-2.27E-05	3.91E-04	0.212	U
	$^{239/240}$Pu	7.51E-05	3.11E-04	-3.62E-05	1.37E-04	0.328	U
	^{241}Am	6.54E-04	8.21E-04	-1.01E-04	7.04E-04	0.698	U
	^{90}Sr	-4.21E-02	3.97E-02	-5.55E-02	3.98E-02	0.237	U
	^{40}K	4.32E+01	7.53E+00	3.11E+01	1.29E+01	0.810	+
	^{60}Co	-9.80E-03	3.85E-01	4.84E-01	1.15E+00	0.407	U
	^{137}Cs	9.41E-02	3.46E-01	8.21E-03	1.12E+00	0.073	U

Table 4.8 Precision Results for 2013 Field Duplicate Groundwater Sample Analyes from Round 35
See Figure 6.3 for Sampling Locations

WQSP-4	$^{233/234}$U	5.81E-01	9.95E-02	5.51E-01	9.18E-02	0.222	+
	^{235}U	4.10E-03	1.77E-03	4.13E-03	1.74E-03	0.010	+
	^{238}U	1.00E-01	1.83E-02	9.75E-02	1.74E-02	0.098	+
	^{238}Pu	3.11E-05	5.08E-04	4.32E-04	6.02E-04	0.509	U
	$^{239/240}$Pu	8.90E-05	3.02E-04	8.87E-05	2.67E-04	0.001	U
	^{241}Am	-1.87E-04	3.11E-04	6.20E-05	5.30E-04	0.406	U
	^{90}Sr	1.27E-02	3.28E-02	1.63E-02	3.28E-02	0.077	U
	^{40}K	2.33E+01	3.86E+00	2.12E+01	6.75E+00	0.270	+
	^{60}Co	-9.25E-03	1.82E-01	-1.15E-01	6.29E-01	0.161	U
	^{137}Cs	-5.18E-03	1.19E-01	2.46E-01	5.22E-01	0.469	U
WQSP-5	$^{233/234}$U	5.22E-01	7.30E-02	5.08E-01	7.60E-02	0.130	+
	^{235}U	5.58E-03	1.87E-03	4.88E-03	1.77E-03	0.271	+
	^{238}U	7.22E-02	1.13E-02	7.49E-02	1.23E-02	0.157	+
	^{238}Pu	2.30E-04	6.22E-04	1.33E-04	4.90E-04	0.123	U
	$^{239/240}$Pu	1.15E-04	3.27E-04	-4.28E-05	1.53E-04	0.438	U
	^{241}Am	9.10E-04	9.93E-04	-2.37E-04	7.56E-04	0.918	U
	^{90}Sr	1.01E-02	2.43E-02	-2.20E-02	2.75E-02	0.876	U
	^{40}K	9.93E+00	3.48E+00	2.29E+01	1.43E+01	0.881	+/- (e)
	^{60}Co	6.60E-02	3.38E-01	-4.67E-01	1.27E+00	0.406	U
	^{137}Cs	2.17E-01	3.08E-01	4.47E-01	9.78E-01	0.224	U
WQSP-6	$^{233/234}$U	4.32E-01	9.51E-02	4.79E-01	7.76E-02	0.382	+
	^{235}U	2.34E-03	1.27E-03	5.88E-03	2.06E-03	1.461	+
	^{238}U	5.54E-02	1.31E-02	6.04E-02	1.10E-02	0.292	+
	^{238}Pu	3.69E-06	4.37E-04	1.76E-04	5.39E-04	0.248	U
	$^{239/240}$Pu	1.38E-04	3.65E-04	1.61E-05	3.43E-04	0.243	U
	^{241}Am	6.08E-04	5.80E-04	3.88E-04	4.41E-04	0.302	U
	^{90}Sr	1.93E-03	2.17E-02	2.44E-03	1.55E-02	0.019	U
	^{40}K	6.89E+00	3.01E+00	-6.44E+00	1.51E+01	0.866	+
	^{60}Co	-1.29E-01	3.78E-01	-1.45E-01	1.09E+00	0.014	U
	^{137}Cs	-1.16E-01	3.05E-01	-5.56E-01	1.06E+00	0.398909	U

(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.

4.4 Surface Water

4.4.1 Sample Collection

Surface water samples were collected from various locations around the WIPP site as shown in Figure 4.2 (see Appendix C for location codes). 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. No sample could be taken from the BHT location in 2013 because the site was made inaccessible by the owner of the property.

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.

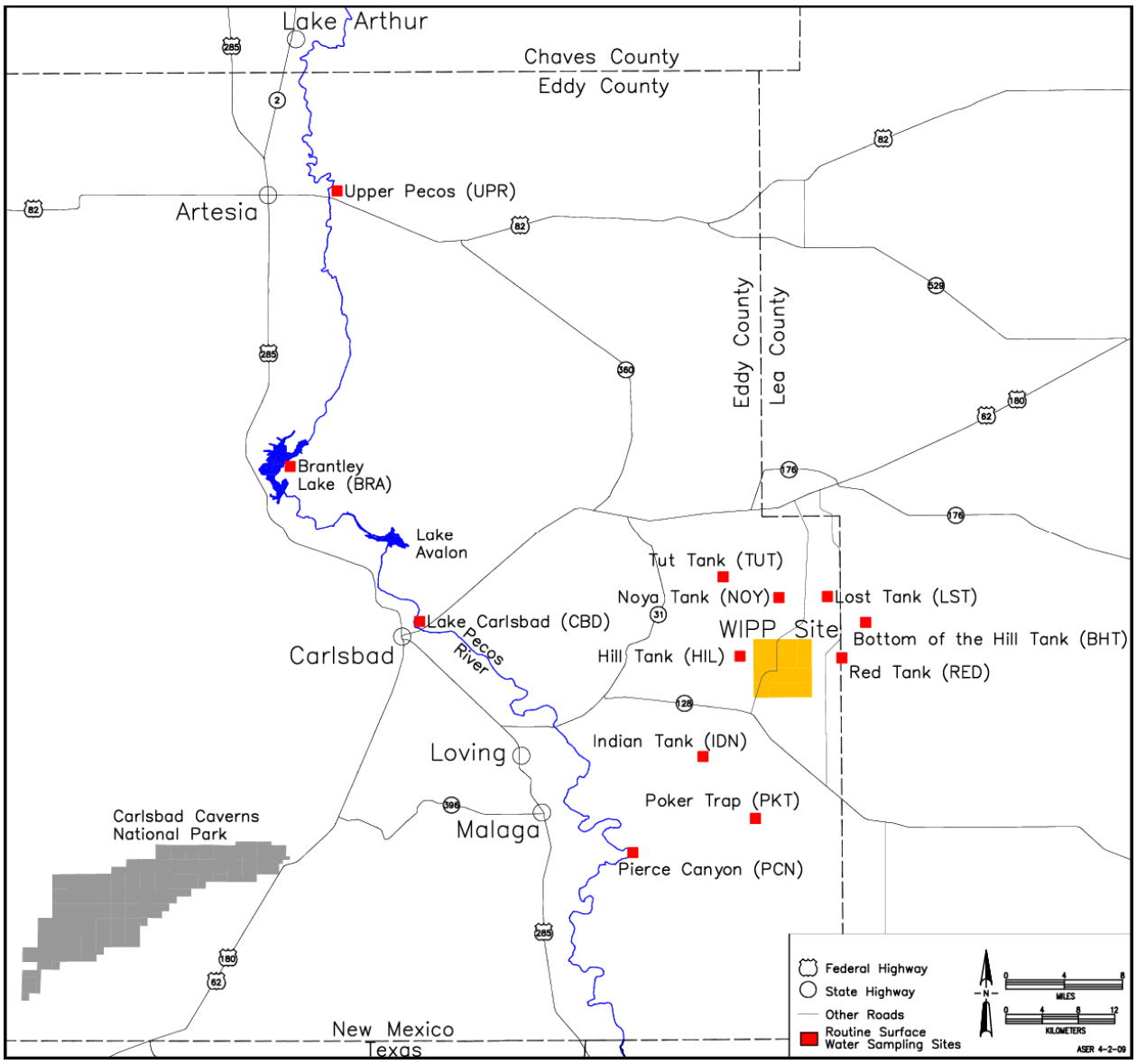

Figure 4.2 – Routine Surface Water Sampling Locations

4.4.4 Results and Discussion

Uranium isotopes were detected in most of the surface water samples, which included 12 separate samples, one set of duplicate samples, and a distilled water field blank, 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 RED, HIL, IDN, PCN, CBD and duplicate (Dup), BRA, and UPR; and detection of ^{238}U in all the samples (not including the COW field blank).

The analysis results for all the uranium isotopes in the surface water samples are shown in Table 4.9.

Table 4.9 - 2013 Uranium Isotope Concentrations in Surface Waters Taken Near WIPP Site
Units are Bq/L
See Appendix C for Sampling Location Codes

	$^{233/234}$U				^{235}U				^{238}U			
Location	[RN][a]	2 x TPU[b]	MDC[c]	Q[(d)]	[RN][a]	2 x TPU[b]	MDC[c]	Q	[RN][a]	2 x TPU[b]	MDC[c]	Q
RED	3.37E-02	7.85E-03	5.20E-04	+	1.88E-03	1.07E-03	4.90E-04	+	3.47E-02	8.07E-03	4.87E-04	+
NOY	5.76E-03	1.76E-03	5.04E-04	+	1.12E-04	2.69E-04	4.70E-04	U	4.42E-03	1.49E-03	4.70E-04	+
HIL	5.16E-02	9.58E-03	7.80E-04	+	1.70E-03	1.07E-03	6.27E-04	+	4.25E-02	8.12E-03	6.12E-04	+
TUT	1.40E-02	3.72E-03	7.50E-04	+	5.84E-04	6.76E-04	6.03E-04	U	1.29E-02	3.50E-03	5.62E-04	+
PKT	6.29E-03	2.21E-03	6.68E-04	+	3.13E-04	4.84E-04	5.97E-04	U	5.50E-03	2.01E-03	6.08E-04	+
FWT	4.52E-02	8.07E-03	7.31E-04	+	3.51E-04	4.91E-04	5.67E-04	U	1.61E-02	3.55E-03	5.63E-04	+
COW (e)	2.39E-04	4.01E-04	7.20E-04	U	-3.47E-05	1.32E-04	5.54E-04	U	1.82E-04	3.11E-04	5.53E-04	U
IDN	1.07E-01	1.85E-02	7.68E-04	+	5.59E-03	2.02E-03	6.13E-04	+	1.02E-01	1.77E-02	6.00E-04	+
PCN	2.56E-01	3.93E-02	7.10E-04	+	7.33E-03	2.29E-03	5.54E-04	+	1.22E-01	1.95E-02	5.22E-04	+
SWL	2.64E-02	9.76E-03	9.56E-04	+	4.78E-04	7.49E-04	8.57E-04	U	1.29E-02	5.31E-03	7.67E-04	+
CBD	8.65E-02	1.43E-02	7.14E-04	+	1.13E-03	8.37E-04	5.58E-04	+	3.54E-02	6.61E-03	5.26E-04	+
CBD Dup	7.55E-02	1.28E-02	7.17E-04	+	1.01E-03	7.84E-04	5.62E-04	+	3.51E-02	6.64E-03	5.28E-04	+
BRA	1.70E-01	2.77E-02	7.11E-04	+	3.29E-03	1.46E-03	5.55E-04	+	7.66E-02	1.32E-02	5.23E-04	+
UPR	2.01E-01	3.70E-02	7.24E-04	+	2.67E-03	1.35E-03	5.72E-04	+	8.83E-02	1.69E-02	5.36E-04	+
LST	7.13E-03	2.35E-03	6.81E-04	+	4.98E-04	6.09E-04	6.13E-04	U	6.54E-03	2.22E-03	6.21E-04	+

(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 distilled water.
CBD used for field duplicate.

The concentrations of the uranium isotopes were compared between 2012 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 TUT and BRA in 2012 and CBD in 2013. In 2012 and 2013, $^{233/234}$U was detected in 13 common locations, ^{235}U was detected in six common locations, and ^{238}U was detected in 13 common locations.

There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2012 and 2013 (ANOVA $^{233/234}$U, p = 0.728; ANOVA ^{235}U, p = 0.220; and ANOVA ^{238}U, p = 0.994).

There also was no significant variation in the 2103 concentrations of the uranium isotopes by location compared to 2012 with ANOVA $^{233/234}$U, p = 0.320; ANOVA ^{235}U, p = 0.152; and ANOVA ^{238}U, p = 0.395.

The 2013 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 2.56E-01 Bq/L of $^{233/234}$U at PCN; 7.33E-03 Bq/L of ^{235}U at PCN; and 1.22E-01 Bq/L of ^{238}U at PCN. The ^{238}U concentration at PCN was slightly higher than the baseline concentration.

The highest concentrations in the surface water samples taken from tanks and tank-like structures (RED, NOY, HIL, TUT, FWT, PKT, IDN, and LST) were taken from the IDN location. The IDN concentrations ($^{233/234}$U = 1.07E-01 Bq/L, ^{235}U = 5.59E-03 Bq/L, and ^{238}U = 1.02E-01 Bq/L) were all higher than the baseline concentrations ($^{233/234}$U = 1.00E–01 Bq/L, ^{235}U = 5.20E–03 Bq/L, and ^{238}U = 3.20E-02 Bq/L). The reason for the higher concentrations of uranium isotopes in the IDN samples in 2013 is not known. The other tank and tank-like structure concentrations that were higher than the baseline concentrations included the ^{238}U concentrations at RED and HIL.

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

The surface water samples were also analyzed for ^{238}Pu, $^{239/240}$Pu, and ^{241}Am as shown in Table 4.10. None of these radionuclides were detected in the surface water samples in 2013. Thus, no ANOVA comparisons between years and among locations could be performed.

Table 4.10 - 2013 Pu Isotope and Am Concentrations in Surface Waters Taken Near WIPP Site
Units are Bq/L
See Appendix C for Sampling Location Codes

	^{238}Pu				$^{239/240}$Pu				^{241}Am			
Location	**[RN]^{a}**	**2 x TPU^{b}**	**MDC^{c}**	**Q$^{(d)}$**	**[RN]^{a}**	**2 x TPU^{b}**	**MDC^{c}**	**Q**	**[RN]^{a}**	**2 x TPU^{b}**	**MDC^{c}**	**Q**
RED	-8.07E-05	3.57E-04	6.96E-04	U	2.75E-04	4.04E-04	5.12E-04	U	3.53E-04	9.70E-04	1.49E-03	U
NOY	2.43E-04	7.57E-04	6.95E-04	U	5.98E-05	2.66E-04	5.15E-04	U	1.12E-04	3.00E-04	1.07E-03	U
HIL	-2.14E-04	7.64E-04	7.07E-04	U	2.99E-04	5.51E-04	5.93E-04	U	4.50E-04	6.44E-04	7.55E-04	U
TUT	-1.55E-04	2.51E-04	6.04E-04	U	2.48E-05	2.76E-04	5.15E-04	U	2.66E-04	7.56E-04	9.96E-04	U
PKT	3.53E-04	6.57E-04	7.08E-04	U	-6.38E-05	1.66E-04	5.43E-04	U	2.76E-04	8.10E-04	8.50E-04	U
FWT	-3.52E-06	2.98E-04	6.10E-04	U	1.60E-04	3.31E-04	4.97E-04	U	1.48E-04	3.94E-04	6.65E-04	U
COW (e)	-4.47E-05	3.16E-04	6.01E-04	U	7.57E-05	2.28E-04	4.88E-04	U	2.92E-04	4.67E-04	6.89E-04	U
IDN	-1.58E-04	2.55E-04	5.81E-04	U	5.58E-04	5.44E-04	5.02E-04	+	4.19E-04	8.79E-04	1.00E-03	U
PCN	-1.13E-04	3.95E-04	6.33E-04	U	1.67E-04	3.67E-04	5.44E-04	U	6.89E-05	4.15E-04	9.74E-04	U
SWL	-2.15E-04	3.53E-04	7.23E-04	U	9.51E-05	3.44E-04	6.34E-04	U	3.20E-04	5.59E-04	1.06E-03	U
CBD	-2.81E-05	3.53E-04	6.43E-04	U	3.14E-04	4.36E-04	5.54E-04	U	-1.09E-04	6.22E-04	9.90E-04	U
CBD Dup	-2.16E-05	3.15E-04	6.09E-04	U	1.87E-04	3.19E-04	5.20E-04	U	-6.96E-05	6.16E-04	9.95E-04	U
BRA	3.22E-04	5.50E-04	6.04E-04	U	2.47E-05	2.76E-04	5.15E-04	U	6.13E-05	6.16E-04	9.75E-04	U
UPR	-1.81E-04	2.78E-04	6.18E-04	U	-9.72E-05	2.04E-04	5.29E-04	U	1.43E-04	5.63E-04	1.01E-03	U
LST	2.78E-04	6.23E-04	6.85E-04	U	4.61E-04	4.82E-04	5.20E-04	U	4.73E-04	6.21E-04	8.00E-04	U

(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 distilled water.
CBD used for field duplicate.

The analysis data for the gamma isotopes and ^{90}Sr are presented in Table 4.11. As shown in the table, ^{40}K was detected in three surface water samples including HIL, PCN, and SWL. The ID Confidence was 0.998 in the HIL sample, and the ^{40}K was considered detected even though the 2 sigma TPU and MDC were higher than the sample concentration. SWL was the only location where ^{40}K was detected in 2012 and 2013; therefore, there were not enough data to perform ANOVA comparisons.

Table 4.11 - 2013 Gamma Radionuclide and ^{90}Sr Concentrations in Surface Waters Taken Near WIPP Site
Units are Bq/L
See Appendix C for Sampling Location Codes

	^{40}K				^{60}Co				^{137}Cs			
Location	**[RN][a]**	**2 x TPU[b]**	**MDC[c]**	**Q**	**[RN][a]**	**2 x TPU[b]**	**MDC[c]**	**Q**	**[RN][a]**	**2 x TPU[b]**	**MDC[c]**	**Q**
RED	6.22E+00	3.14E+00	4.76E+00	U (e)	2.47E-01	3.09E-01	4.11E-01	U	5.35E-02	3.24E-01	3.74E-01	U
NOY	2.08E+00	1.19E+01	1.52E+01	U	1.16E+00	9.67E-01	1.56E+00	U	-4.48E-01	1.09E+00	1.22E+00	U
HIL	2.40E+00	2.51E+00	3.96E+00	+	7.14E-02	2.94E-01	3.69E-01	U	-3.62E-01	3.24E-01	3.20E-01	U
TUT	5.82E+00	3.62E+00	5.12E+00	U (e)	2.34E-01	2.87E-01	3.93E-01	U	1.32E-01	2.71E-01	3.42E-01	U
PKT	7.85E+00	9.38E+00	1.44E+01	U	1.86E-01	1.23E+00	1.57E+00	U	1.40E-01	1.04E+00	1.28E+00	U
FWT	2.51E+00	3.03E+00	4.03E+00	U	2.45E-01	2.97E-01	3.99E-01	U	1.51E-02	3.00E-01	3.43E-01	U
COW (f)	1.00E+00	3.92E+00	4.70E+00	U	-2.04E-01	4.11E-01	4.32E-01	U	1.31E-01	3.34E-01	3.95E-01	U
IDN	-1.14E+00	1.24E+01	1.48E+01	U	6.36E-01	1.14E+00	1.57E+00	U	2.97E-01	9.74E-01	1.24E+00	U
PCN	2.46E+01	9.68E+00	1.86E+01	+	-1.21E-01	1.03E+00	1.26E+00	U	-3.58E-01	1.09E+00	1.22E+00	U
SWL	1.41E+01	3.70E+00	3.48E+00	+	1.29E-01	2.67E-01	3.48E-01	U	-3.46E-02	3.11E-01	3.46E-01	U
CBD	4.19E+00	3.87E+00	5.14E+00	U	3.37E-01	3.01E-01	4.18E-01	U	1.71E-01	2.76E-01	3.49E-01	U
CBD Dup	1.50E+00	1.37E+01	1.70E+01	U	-8.11E-02	1.17E+00	1.42E+00	U	-8.28E-01	1.13E+00	1.19E+00	U
BRA	4.13E+00	3.11E+00	4.37E+00	U	-8.64E-02	3.32E-01	3.67E-01	U	-1.44E-01	3.17E-01	3.32E-01	U
UPR	7.61E-01	3.51E+00	4.29E+00	U	8.94E-02	3.66E-01	4.42E-01	U	2.81E-01	3.44E-01	4.24E-01	U
LST	3.00E+00	3.52E+00	4.63E+00	U	-1.83E-02	3.23E-01	3.78E-01	U	-8.10E-02	3.13E-01	3.61E-01	U

	^{90}Sr			
Location	**[RN][a]**	**2 x TPU[b]**	**MDC[c]**	**Q**
RED	-1.79E-02	3.13E-02	2.33E-02	U
NOY	-2.20E-02	3.14E-02	2.34E-02	U
HIL	1.20E-02	2.90E-02	2.27E-02	U
TUT	7.93E-03	4.41E-02	2.51E-02	U
PKT	5.74E-03	3.93E-02	2.40E-02	U
FWT	2.19E-02	2.81E-02	2.27E-02	U
COW (f)	1.21E-02	2.82E-02	2.27E-02	U
IDN	1.85E-02	2.75E-02	2.27E-02	U
PCN	2.12E-02	3.76E-02	2.48E-02	U
SWL	6.32E-03	4.24E-02	2.53E-02	U
CBD	-1.83E-02	3.88E-02	2.47E-02	U
CBD Dup	7.84E-03	3.48E-02	2.44E-02	U
BRA	1.96E-02	4.09E-02	2.47E-02	U
UPR	-1.66E-02	4.00E-02	2.48E-02	U
LST	4.04E-03	3.93E-02	2.42E-02	U

(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) ^{40}K is undetected because ID Confidence is 0.00
(f) Blind field blank consisting of distilled water.
CBD used for field duplicate.

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 2013 measured concentrations were 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.

Cesium-137, ^{60}Co, and ^{90}Sr, were not detected in any of the surface water samples (Table 4.12). Since these isotopes were not detected, no ANOVA comparisons between years or among locations were performed.

The reproducibility of the sampling and analysis procedures was assessed by collecting and analyzing duplicate samples from location 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 4.12.

Table 4.12 - Precision Results for 2013 Duplicate Surface Water Samples
Units are in Bq/L
See Chapter 6 for Sampling Locations

		Primary Sample		Duplicate Sample			
Location	Radionuclide	[RN][a]	2 σ TPU[b]	[RN][a]	2 σ TPU[b]	RER[c]	Q[d]
CBD and CBD Dup	$^{233/234}U$	8.65E-02	1.43E-02	7.55E-02	1.28E-02	0.573	+
	^{235}U	1.13E-03	8.37E-04	1.01E-03	7.84E-04	0.105	+
	^{238}U	3.54E-02	6.61E-03	3.51E-02	6.64E-03	0.032	+
	^{238}Pu	-2.81E-05	3.53E-04	-2.16E-05	3.15E-04	0.014	U
	$^{239/240}Pu$	3.14E-04	4.36E-04	1.87E-04	3.19E-04	0.235	U
	^{241}Am	-1.09E-04	6.22E-04	-6.96E-05	6.16E-04	0.045	U
	^{40}K	4.19E+00	3.87E+00	1.50E+00	1.37E+01	0.189	U
	^{60}Co	3.37E-01	3.01E-01	-8.11E-02	1.17E+00	0.346	U
	^{137}Cs	1.71E-01	2.76E-01	-8.28E-01	1.13E+00	0.859	U
	^{90}Sr	-1.83E-02	3.88E-02	7.84E-03	3.48E-02	0.502	U

(a) Radionuclide Concentration
(b) Total Propagated Uncertainty
(c) Relative Error Ratio
(d) Qualifier: Indicates whether radionuclide was detected, Plus (+) equals detected
U equals undetected.

The RERs for all radionuclides analyzed in the samples including the detected $^{233/234}U$, ^{235}U, and ^{238}U were all less than 1. The analysis data demonstrate good reproducibility for the combined sampling and analysis procedures.

4.5 Sediments

4.5.1 Sample Collection

Sediment samples were collected from 11 locations around the WIPP site (Figure 4.3), with duplicate samples collected from two sites (13 samples total). No sample could be taken from the BHT location in 2013 because the site was made inaccessible by the owner of the property. See Figure 4.3 for sediment sample locations and Appendix C for location codes. The sites included all the same sites as for 2013 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 the sediments of the water bodies and transferred to WIPP Laboratories for determination of individual radionuclides.

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.

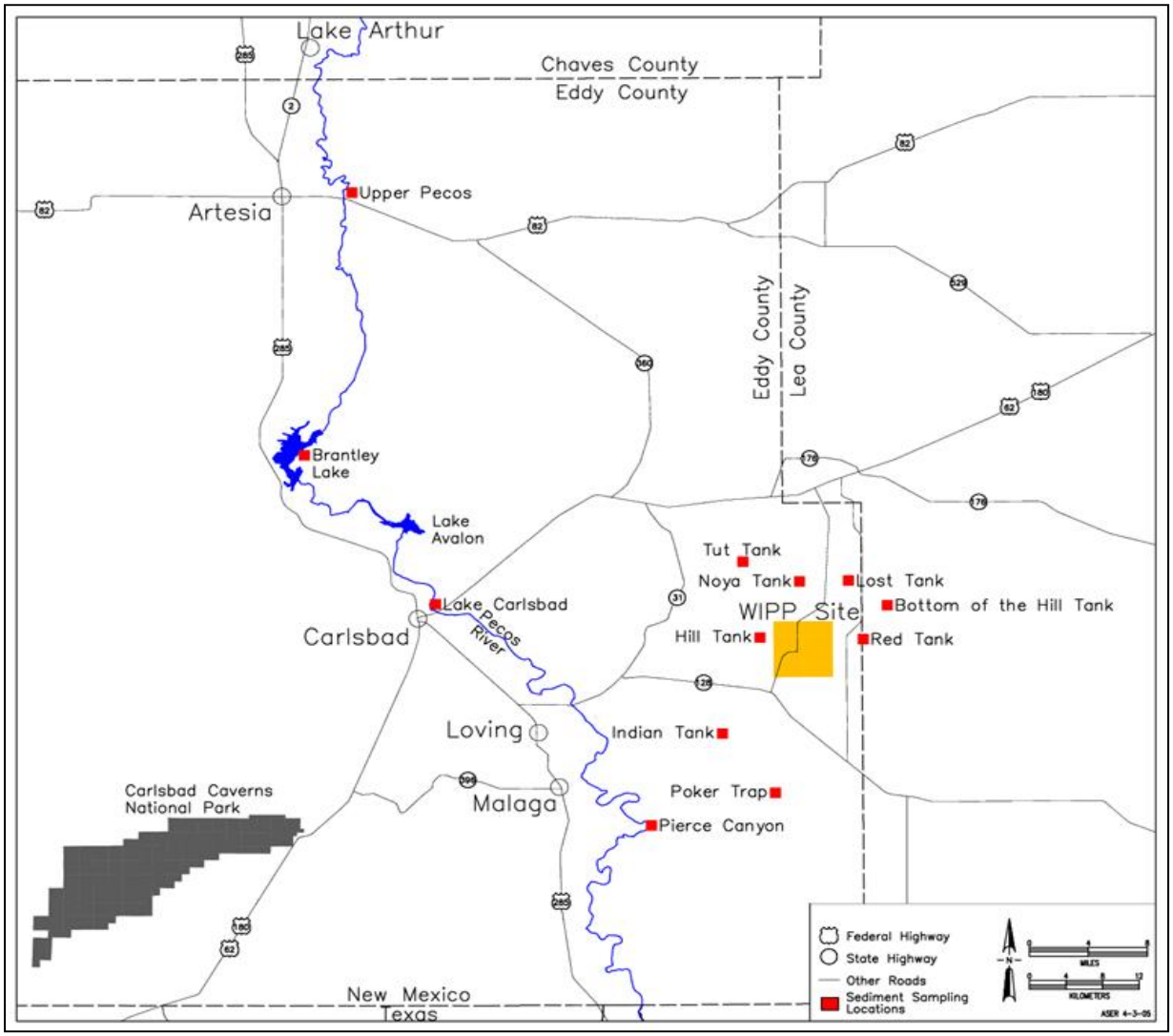

Figure 4.3 – Sediment Sampling Sites

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

Note that the first sample, RED was cut off of Tables 4.13, 4.14, and 4.15.

Table 4.13 - 2013 Uranium Concentrations in Sediment Samples Taken Near the WIPP Site.
Units are Bq/g
See Appendix C for Sampling Location Codes

	$^{233/234}$U				^{235}U				^{238}U			
Location	[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	2.39E-02	4.71E-03	5.38E-04	+	7.92E-04	4.00E-04	3.22E-04	+	2.45E-02	4.83E-03	3.61E-04	+
NOY	1.66E-02	3.15E-03	5.18E-04	+	7.71E-04	3.53E-04	2.97E-04	+	1.72E-02	3.24E-03	3.41E-04	+
HIL	2.49E-02	4.71E-03	5.33E-04	+	1.57E-03	5.77E-04	3.16E-04	+	2.69E-02	5.06E-03	3.57E-04	+
HIL Dup	2.49E-02	5.09E-03	5.37E-04	+	1.41E-03	5.62E-04	3.21E-04	+	2.33E-02	4.79E-03	3.61E-04	+
TUT	1.84E-02	3.26E-03	4.72E-04	+	7.31E-04	3.35E-04	2.55E-04	+	2.10E-02	3.67E-03	2.96E-04	+
PKT	8.05E-03	1.58E-03	3.28E-04	+	4.46E-04	2.66E-04	2.30E-04	+	8.54E-03	1.65E-03	2.63E-04	+
IDN	1.54E-02	4.24E-03	4.84E-04	+	7.06E-04	3.77E-04	2.71E-04	+	1.56E-02	4.28E-03	3.09E-04	+
PCN	3.09E-02	6.66E-03	5.07E-04	+	1.54E-03	6.28E-04	2.98E-04	+	3.13E-02	6.74E-03	3.31E-04	+
CBD	9.57E-03	1.65E-03	4.70E-04	+	5.21E-04	2.71E-04	2.53E-04	+	9.83E-03	1.68E-03	2.95E-04	+
CBD Dup	1.12E-02	1.87E-03	4.70E-04	+	2.58E-04	1.87E-04	2.53E-04	+	1.00E-02	1.70E-03	2.94E-04	+
BRA	2.30E-02	3.84E-03	4.75E-04	+	1.43E-03	4.93E-04	2.59E-04	+	2.10E-02	3.53E-03	2.99E-04	+
UPR	1.82E-02	3.27E-03	4.71E-04	+	5.94E-04	2.96E-04	2.54E-04	+	1.71E-02	3.09E-03	2.95E-04	+
LST	1.79E-02	3.28E-03	5.17E-04	+	6.24E-04	3.14E-04	2.97E-04	+	2.00E-02	3.63E-03	3.41E-04	+

(a) Radionuclide concentration.
(b) Total propagated uncertainty
(c) Minimum detectable concentration.
(d) Qualifier: Indicates whether radionuclide was detected, Plus (+) equals detected, U equals undetected

Using ANOVA, the concentrations of the uranium isotopes were compared between 2012 and 2013 and between sampling locations. Average concentrations were used for HIL and CBD in 2013 and NOY and TUT in 2012. There were 11 common locations for $^{233/234}$U and ^{238}U, with detections in all samples in both 2012 and 2013. There were also 11 common locations where ^{235}U was detected in 2012 and 2013.

The ANOVA calculations showed that the concentrations of $^{233/234}$U, ^{235}U, and ^{238}U did not vary significantly between 2012 and 2013 (ANOVA $^{233/234}$U, p = 0.612; ANOVA ^{235}U, p = 0.969; and ANOVA ^{238}U, p = 0.722).

The ANOVA calculations also showed that the concentrations of all three of the uranium isotopes did not vary significantly between sediment locations (ANOVA $^{233/234}$U, p = 0.305; ANOVA ^{235}U, p = 0.316; and ANOVA ^{238}U, p = 0.255). The p values for location were all lower than for the variation by year, but they were all well above the significance value of 0.05.

The uranium isotope composition of the sediments may not have been impacted as much as in recent years due to the current drought, which minimizes the washing away and re-deposition of sediments.

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 4.14. There was a detection for $^{239/240}$Pu in the duplicate sample from HIL but not in the primary sample. The detection was confirmed by a second analysis of the sample. The detected concentration of 3.47E-04 Bq/g was lower than the baseline concentration of 1.90E-03 Bq/g. There were not enough data to perform ANOVA comparisons for the three radionuclides.

Table 4.14 - 2013 Pu and Am Concentrations in Sediment Samples Taken Near the WIPP Site
Units are Bq/g
See Appendix C for Sampling Location Codes

	^{238}Pu				$^{239/240}$Pu				^{241}Am			
Location	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]
RED	1.17E-04	1.51E-04	3.96E-04	U	2.36E-04	1.66E-04	2.68E-04	U	1.31E-04	1.88E-04	5.26E-04	U
NOY	4.10E-05	1.08E-04	3.92E-04	U	1.24E-04	1.18E-04	2.64E-04	U	7.79E-06	1.59E-04	5.28E-04	U
HIL	2.98E-05	1.05E-04	4.04E-04	U	2.00E-04	1.65E-04	2.77E-04	U	1.98E-04	2.19E-04	5.31E-04	U
HIL Dup	-4.19E-05	6.76E-05	3.59E-04	U	3.47E-04	2.06E-04	2.84E-04	+	3.00E-04	2.26E-04	5.30E-04	U
TUT	-1.87E-05	1.80E-04	3.89E-04	U	9.68E-05	1.39E-04	2.86E-04	U	1.55E-04	4.41E-04	8.61E-04	U
PKT	3.55E-05	1.24E-04	3.82E-04	U	1.92E-05	6.54E-05	2.80E-04	U	1.09E-04	1.92E-04	7.81E-04	U
IDN	-3.10E-05	5.96E-05	3.83E-04	U	9.88E-05	1.26E-04	2.80E-04	U	6.35E-05	1.74E-04	8.11E-04	U
PCN	-2.33E-05	8.14E-05	3.74E-04	U	-1.85E-05	4.13E-05	2.88E-04	U	3.46E-04	3.60E-04	8.35E-04	U
CBD	8.47E-05	1.87E-04	3.76E-04	U	1.41E-05	6.29E-05	2.73E-04	U	1.17E-04	3.44E-04	8.18E-04	U
CBD Dup	2.71E-06	1.49E-04	3.78E-04	U	1.35E-05	6.50E-05	2.75E-04	U	1.40E-04	2.61E-04	7.78E-04	U
BRA	8.47E-05	1.87E-04	3.76E-04	U	1.41E-05	6.29E-05	2.73E-04	U	1.30E-04	3.11E-04	8.06E-04	U
UPR	4.35E-05	1.36E-04	3.78E-04	U	3.26E-05	8.97E-05	2.75E-04	U	-8.95E-05	1.29E-04	7.95E-04	U
LST	7.86E-05	1.25E-04	3.97E-04	U	1.56E-04	1.40E-04	2.69E-04	U	2.31E-04	1.96E-04	5.32E-04	U

(a) Radionuclide concentration.
(b) Total propagated uncertainty
(c) Minimum detectable concentration.
(d) Qualifier: Indicates whether radionuclide was detected, Plus (+) equals detected, U equals undetected

The sediment analysis results for the gamma radionuclides and ^{90}Sr are shown in Table 4.15. 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, and LST. The ^{137}Cs was detected in the same sediment samples in 2013 as in 2012 except that it was not detected in the 2012 TUT sample. Cobalt-60 and ^{90}Sr were not detected in any of the sediment samples.

Table 4.15 - 2013 Gamma Radionuclides and ^{90}Sr Concentrations in Sediment Samples Taken Near WIPP Site
Units are Bq/g
See Appendix C for Sampling Location Codes

	^{40}K				^{60}Co				^{137}Cs			
Location	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]
RED	6.69E-01	9.38E-02	1.63E-02	+	7.90E-04	1.45E-03	1.79E-03	U	4.12E-03	1.65E-03	2.34E-03	+
NOY	7.99E-01	1.09E-01	1.06E-02	+	1.10E-03	1.13E-03	1.39E-03	U	1.39E-03	1.25E-03	1.46E-03	U
HIL	1.41E+00	1.97E-01	2.24E-02	+	-3.00E-03	3.01E-03	3.03E-03	U	9.10E-03	2.29E-03	2.60E-03	+
HIL Dup	1.12E+00	1.52E-01	1.53E-02	+	7.82E-04	1.58E-03	1.89E-03	U	6.58E-03	1.53E-03	1.68E-03	+
TUT	8.09E-01	1.11E-01	1.26E-02	+	-3.36E-04	1.30E-03	1.46E-03	U	9.88E-04	6.40E-04	9.62E-04	+
PKT	4.07E-01	5.56E-02	5.96E-04	+	-1.59E-04	7.45E-04	8.31E-04	U	4.19E-03	7.47E-04	6.00E-04	+
IDN	3.63E-01	5.07E-02	7.46E-03	+	4.23E-04	7.95E-04	9.64E-04	U	8.69E-04	5.45E-04	8.23E-04	+
PCN	1.74E-01	2.73E-02	8.36E-03	+	4.35E-04	7.34E-04	9.93E-04	U	2.80E-04	7.10E-04	8.80E-04	U
CBD	2.09E-01	2.98E-02	5.03E-03	+	3.40E-04	6.03E-04	7.56E-04	U	5.76E-04	5.52E-04	7.03E-04	U
CBD Dup	2.50E-01	3.76E-02	8.03E-03	+	-3.75E-04	1.05E-03	1.18E-03	U	-3.91E-04	8.34E-04	9.33E-04	U
BRA	5.24E-01	7.27E-02	1.07E-02	+	-7.68E-04	1.18E-03	1.21E-03	U	5.64E-04	1.06E-03	1.22E-03	U
UPR	3.73E-01	5.22E-02	9.14E-03	+	7.01E-05	9.37E-04	1.09E-03	U	1.27E-03	1.02E-03	1.21E-03	U (e)
LST	8.21E-01	1.13E-01	1.35E-02	+	9.19E-04	1.32E-03	1.65E-03	U	3.83E-03	1.56E-03	2.23E-03	+

	^{90}Sr			
	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]
RED	5.92E-03	9.77E-03	2.07E-02	U
NOY	2.98E-03	9.59E-03	2.08E-02	U
HIL	2.06E-03	1.01E-02	2.08E-02	U
HIL Dup	-5.88E-03	1.01E-02	2.08E-02	U
TUT	3.98E-03	8.45E-03	2.32E-02	U
PKT	1.67E-03	9.12E-03	2.33E-02	U
IDN	3.89E-04	9.06E-03	2.33E-02	U
PCN	-5.63E-04	8.50E-03	2.32E-02	U
CBD	-2.07E-03	7.76E-03	2.32E-02	U
CBD Dup	-3.50E-04	7.92E-03	2.32E-02	U
BRA	3.34E-04	7.46E-03	2.31E-02	U
UPR	3.15E-04	8.39E-03	2.32E-02	U
LST	4.24E-03	8.67E-03	2.07E-02	U

(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) ^{137}Cs was undetected because the ID Confidence is 0.00

With respect to sediment concentrations associated with tanks and tank-like structures, the concentration ^{40}K detected in the HIL primary sample of 1.41E+00 Bq/g was higher than the 99 percent confidence interval range of baseline concentrations (baseline 99 percent confidence interval concentration: 1.20E+00 Bq/g). The duplicate HIL sample concentration was just below the 99 percent confidence interval range concentration at 1.12E+00 Bq/g.

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 2013 concentrations exceeded the 99 percent confidence interval range of the baseline concentration (BRA with 5.24E-01 Bq/g) and UPR just below at 3.73E-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 = 0.365), or by location (ANOVA ^{40}K, p = 0.445). Again, the dry conditions likely cause less variation from year-to-year in sediment concentrations.

In comparing the ^{137}Cs 2013 data with the 2012 data, ^{137}Cs was detected in five common locations between 2013 and 2012, RED, HIL, PKT, IDN, and LST, all of which are tanks and tank-like structures. There were no significant differences in the concentrations between 2012 and 2013 (ANOVA ^{137}Cs, p = 0.518) or by location (ANOVA ^{137}Cs, p = 0.569). There were no ^{137}Cs detections in the samples from the Pecos River and associated bodies of water (PCN, CBD, BRA, and UPR).

The measured ^{137}Cs concentrations in the sediments associated with tanks and tank-like structures (RED, HIL, TUT, PKT, IDN, and LST) were within the 99-percent confidence interval range of the baseline concentration (3.50E–02 Bq/g). Cesium-137 is a fission product and is consistently found in sediment and soil because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). Thus, it is not being added to 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 (see Table 4.15), no ANOVA 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 4.16 - Precsion Analysis Results for 2013 Sediment Samples
Units are Bq/g

		Primary Sample		Duplicate Sample			
Location	**Radionuclide**	**[RN](a)**	**2 σ TPU(b)**	**[RN](a)**	**2 σ TPU(b)**	**RER(c)**	Q(d)
HIL and	$^{233/234}$U	2.49E-02	4.71E-03	2.49E-02	5.09E-03	0.000	+
HIL Dup	^{235}U	1.57E-03	5.77E-04	1.41E-03	5.62E-04	0.199	+
	^{238}U	2.69E-02	5.06E-03	2.33E-02	4.79E-03	0.517	+
	^{238}Pu	2.98E-05	1.05E-04	-4.19E-05	6.75E-05	0.574	U
	$^{239/240}$Pu	2.00E-04	1.65E-04	3.47E-04	2.06E-04	0.557	U/+ (e)
	^{241}Am	1.98E-04	2.19E-04	3.00E-04	2.26E-04	0.324	U
	^{40}K	1.41E+00	1.97E-01	1.12E+00	1.52E-01	1.165	+
	^{60}Co	-3.00E-03	3.01E-03	7.82E-04	1.58E-03	1.113	U
	^{137}Cs	9.10E-03	2.29E-03	6.58E-03	1.53E-03	0.915	+
	^{90}Sr	2.06E-03	1.01E-02	-5.88E-03	1.01E-02	0.556	U
CBD and	$^{233/234}$U	9.57E-03	1.65E-03	1.12E-02	1.87E-03	0.654	+
CBD Dup	^{235}U	5.21E-04	2.71E-04	2.58E-04	1.87E-04	0.799	+
	^{238}U	9.83E-03	1.68E-03	1.00E-02	1.70E-03	0.071	+
	^{238}Pu	8.47E-05	1.87E-04	2.71E-06	1.49E-04	0.343	U
	$^{239/240}$Pu	1.41E-05	6.29E-05	1.35E-05	6.50E-05	0.007	U
	^{241}Am	1.17E-04	3.44E-04	1.40E-04	2.61E-04	0.053	U
	^{40}K	2.09E-01	2.98E-02	2.50E-01	3.76E-02	0.855	+
	^{60}Co	3.40E-04	6.03E-04	-3.75E-04	1.05E-03	0.591	U
	^{137}Cs	5.76E-04	5.52E-04	-3.91E-04	8.34E-04	0.967	+
	^{90}Sr	-2.07E-03	7.76E-03	-3.50E-04	7.92E-03	0.155	U

(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) $^{239/240}$Pu detected in the duplicate sample but not the primary sample

Two of the RERs in Table 4.16 were slightly greater than 1.00, but less than 1.96, including 1.16 for ^{40}K and 1.11 for ^{60}Co in the HIL duplicate samples. The sediment duplicate analysis results show good precision for the combined sampling and analysis procedures.

4.6 Soil Samples

4.6.1 Sample Collection

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.

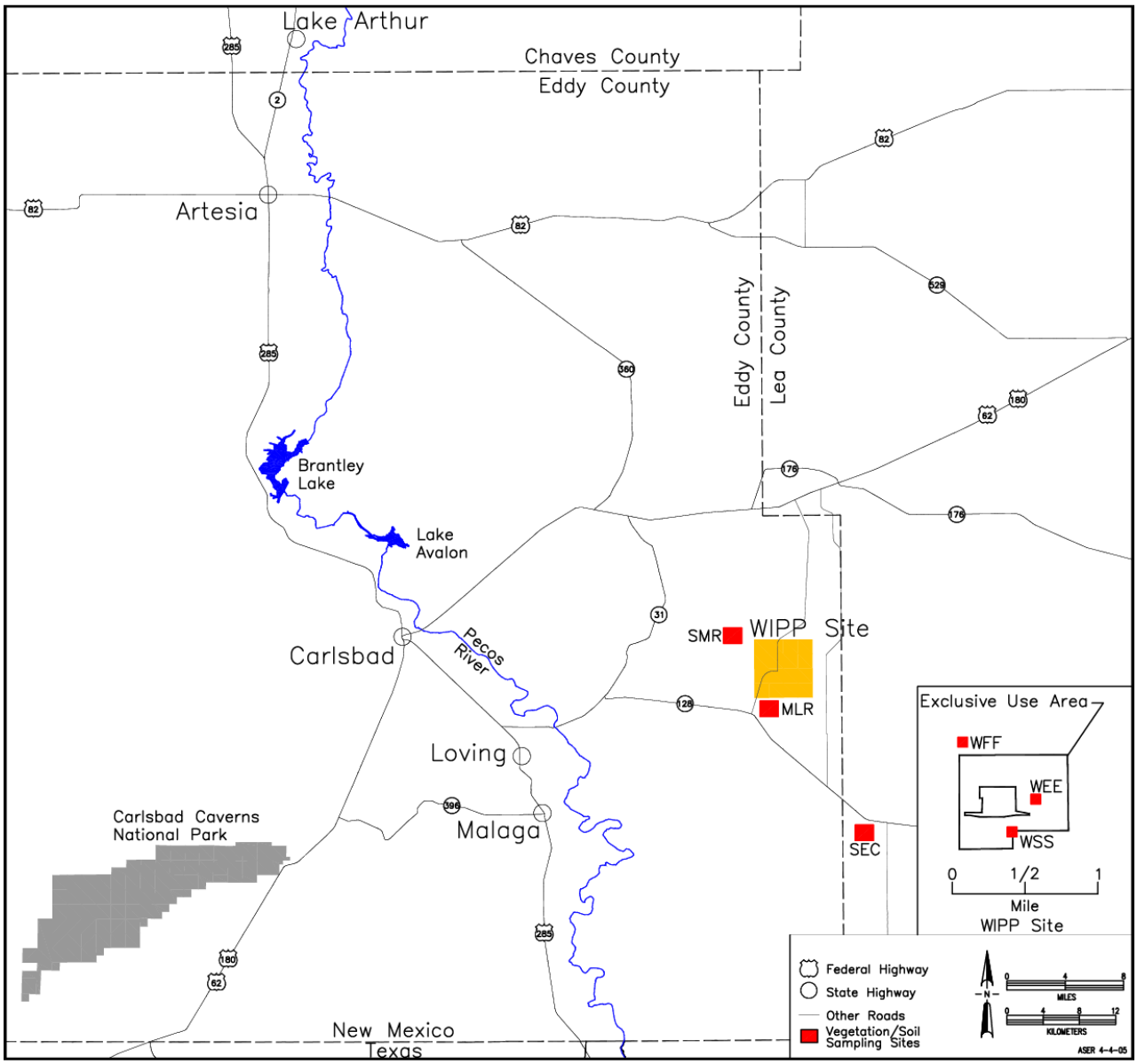

Figure 4.4 – Routine Soil and Vegetation Sampling Areas

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 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

Table 4.17 presents the uranium isotope analysis data for the soil samples collected in 2013. As shown in the table, $^{233/234}$U and ^{238}U were detected in all soil samples, and ^{235}U was detected in about half of the samples. Samples from WEE were collected in duplicate with ^{235}U not detected in the shallow samples, detected in both immediate samples, and only detected in the deep duplicate sample.

Table 4.17 - 2013 Uranium Concentrations in Soil Samples Taken Near the WIPP Site.
Units are Bq/g
See Appendix C for Sampling Location Codes

		$^{233/234}U$				^{235}U				^{238}U			
Location	Depth (cm)	[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	5.72E-03	1.16E-03	7.64E-04	+	1.30E-04	1.39E-04	3.07E-04	U	5.54E-03	1.13E-03	6.59E-04	+
WFF	2 - 5	5.95E-03	1.14E-03	7.63E-04	+	3.34E-04	2.14E-04	3.06E-04	+	5.47E-03	1.07E-03	6.57E-04	+
WFF	5 - 10	5.17E-03	1.04E-03	7.62E-04	+	1.58E-04	1.50E-04	3.04E-04	U	5.33E-03	1.07E-03	6.56E-04	+
WEE	0 - 2	5.71E-03	1.19E-03	7.64E-04	+	2.96E-04	2.10E-04	3.07E-04	U	5.95E-03	1.23E-03	6.59E-04	+
WEE	2 - 5	7.11E-03	1.38E-03	7.65E-04	+	3.74E-04	2.32E-04	3.08E-04	+	6.77E-03	1.33E-03	6.59E-04	+
WEE	5 - 10	6.53E-03	1.70E-03	7.71E-04	+	2.56E-04	2.04E-04	3.16E-04	U	7.20E-03	1.85E-03	6.66E-04	+
WEE Dup	0 - 2	7.98E-03	1.57E-03	6.57E-04	+	1.06E-04	1.34E-04	3.17E-04	U	7.00E-03	1.42E-03	4.79E-04	+
WEE Dup	2 - 5	6.45E-03	1.17E-03	7.42E-04	+	3.03E-04	1.98E-04	2.98E-04	+	6.85E-03	1.22E-03	5.59E-04	+
WEE Dup	5 - 10	8.87E-03	2.34E-03	7.77E-04	+	3.44E-03	1.12E-03	3.41E-04	+	8.26E-03	2.20E-03	5.93E-04	+
WSS	0 - 2	9.29E-03	1.91E-03	7.60E-04	+	4.92E-04	2.90E-04	3.20E-04	+	8.14E-03	1.70E-03	5.76E-04	+
WSS	2 - 5	7.25E-03	1.32E-03	7.50E-04	+	3.74E-04	2.31E-04	3.08E-04	+	7.17E-03	1.31E-03	5.66E-04	+
WSS	5 - 10	7.34E-03	1.48E-03	7.53E-04	+	2.75E-04	2.07E-04	3.11E-04	U	7.30E-03	1.47E-03	5.69E-04	+
MLR	0 - 2	1.24E-02	3.57E-03	6.83E-04	+	5.55E-04	4.01E-04	3.86E-04	+	1.53E-02	4.33E-03	5.20E-04	+
MLR	2 - 5	1.43E-02	2.73E-03	6.35E-04	+	6.94E-04	3.49E-04	3.26E-04	+	1.32E-02	2.53E-03	4.72E-04	+
MLR	5 - 10	1.40E-02	3.12E-03	6.46E-04	+	7.73E-04	4.05E-04	3.40E-04	+	1.42E-02	3.16E-03	4.83E-04	+
SEC	0 - 2	8.81E-03	2.56E-03	6.49E-04	+	1.85E-04	1.93E-04	3.43E-04	U	9.51E-03	2.74E-03	4.86E-04	+
SEC	2 - 5	1.05E-02	2.14E-03	6.35E-04	+	5.28E-04	3.05E-04	3.26E-04	+	9.56E-03	1.97E-03	4.72E-04	+
SEC	5 - 10	8.78E-03	2.94E-03	6.42E-04	+	5.18E-04	3.44E-04	3.35E-04	+	9.09E-03	3.04E-03	4.79E-04	+
SMR	0 - 2	1.69E-02	3.14E-03	6.32E-04	+	9.45E-04	4.13E-04	3.23E-04	+	1.60E-02	2.99E-03	4.69E-04	+
SMR	2 - 5	1.57E-02	3.56E-03	6.48E-04	+	8.83E-04	4.39E-04	3.42E-04	+	1.75E-02	3.95E-03	4.85E-04	+
SMR	5 - 10	1.64E-02	4.90E-03	6.85E-04	+	1.15E-03	6.17E-04	3.88E-04	+	1.78E-02	5.28E-03	5.22E-04	+

(a) Radionuclide concentration
(b) Total propagated uncertainty
(c) Minimum detectable concentration
(d) Qualifier: Indicates whether radionuclide was detected, Plus (+) equals detected, U equals undetected

In comparing the 2013 and 2012 uranium data, the average of the primary and duplicate samples was used for the WFF location in 2012 and the WEE location in 2013. All locations and all depths were common for $^{233/234}$U and ^{238}U in 2013 and 2012. However, for ^{235}U, there were variable detections both years, occasions when the radionuclide was detected in one of the WFF duplicates but not the other in 2012, and in one of the WEE duplicates but not the other in 2013.

ANOVA calculations were performed for the three uranium isotopes. The $^{233/234}$U isotope, which was detected in all the samples, yielded a p value for comparison of the data by year somewhat higher than the 0.05 significance level (ANOVA $^{233/234}$U, p = 0.190). Similarly, ^{238}U, which was detected in all the samples, showed a similar variation by year (ANOVA ^{238}U, p = 0.217). The ^{235}U isotope was only detected in 11 common locations and was only detected in one location (2 - 5 cm at WEE) where samples were collected in duplicate both years. The ANOVA calculation by year for ^{235}U also showed a similar variation in the data by year (ANOVA ^{235}U, p = 0.167).

The ANOVA calculations with respect to location showed significant variation for $^{233/234}$U (ANOVA $^{233/234}$U, p = 2.23E-03) and for ^{238}U (ANOVA ^{238}U, p = 2.05E-03), but less variation for ^{235}U (ANOVA ^{235}U, p = 0.158, which is above the 0.05 significance factor).

The highest concentrations of $^{233/234}$U measured in 2013 of 1.69E–02 Bq/g in the 0–2 cm depth of SMR fell within the 99 percent confidence interval range of the 99 percent confidence interval baseline concentration of 2.20E–02 Bq/g. The highest ^{235}U concentration of 3.44E-03 Bq/g in the duplicate WEE sample at 5-10 cm was higher than the 99 percent confidence interval concentration of 1.70E–03 Bq/g. The highest ^{238}U concentration of 1.78E–02 Bq/g in the 5-10 cm 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). All three depths of MLR samples and all three depths of SMR samples yielded concentrations higher than the 3.40 E-01 Bq/g. The concentrations of all three uranium isotopes were higher at all three depths in samples from SMR in 2013 compared to 2012, while the concentrations of all uranium isotopes at all three depths at MLR were similar in 2012 and 2013. The reason for the higher concentrations at SMR in 2013 is not known, but the detected uranium concentrations in soil follow a pattern of variability consistent with the distribution of natural uranium.

Table 4.18 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. The detected concentration of 3.78E-04 Bq/g is lower than the baseline soil concentration of 1.90E-03 Bq/g. No ANOVA calculations could be performed since there were no Pu detections in 2012.

Table 4.18 - 2013 Plutonium Isotope and Americium Concentrations in Soil Samples Taken Near the WIPP Site.
Units are Bq/g
See Appendix C for Sampling Location Codes

		^{238}Pu				$^{239/240}$Pu				^{241}Am			
Location	Depth (cm)	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]	[RN][a]	2 x TPU[b]	MDC[c]	Q[d]
WFF	0 - 2	0.00E+00	1.31E-04	4.82E-04	U	4.24E-05	1.09E-04	3.16E-04	U	3.96E-05	1.87E-04	5.57E-04	U
WFF	2 - 5	-4.41E-05	7.88E-05	5.09E-04	U	4.89E-05	1.17E-04	3.31E-04	U	-1.79E-05	2.11E-04	7.59E-04	U
WFF	5 - 10	1.03E-04	1.75E-04	5.45E-04	U	3.05E-04	2.45E-04	3.21E-04	U	4.14E-05	1.63E-04	5.02E-04	U
WEE	0 - 2	9.45E-06	9.13E-05	4.87E-04	U	8.97E-05	1.29E-04	5.01E-04	U	2.37E-04	2.76E-04	7.49E-04	U
WEE	2 - 5	6.40E-05	1.11E-04	4.70E-04	U	8.24E-05	1.01E-04	2.75E-04	U	2.91E-04	2.60E-04	6.64E-04	U
WEE	5 - 10	-5.85E-06	8.50E-05	5.16E-04	U	3.31E-05	9.70E-05	2.75E-04	U	-4.96E-05	9.00E-05	4.79E-04	U
WEE Dup	0 - 2	6.30E-06	7.04E-05	4.53E-04	U	1.52E-04	1.34E-04	2.67E-04	U	2.41E-04	2.55E-04	4.56E-04	U
WEE Dup	2 - 5	6.49E-06	6.27E-05	4.46E-04	U	1.59E-04	1.30E-04	2.60E-04	U	-1.54E-05	1.81E-04	4.66E-04	U
WEE Dup	5 - 10	0.00E+00	7.33E-05	4.53E-04	U	1.46E-04	1.32E-04	2.58E-04	U	9.16E-05	1.95E-04	4.78E-04	U
WSS	0 - 2	-5.26E-06	7.64E-05	4.51E-04	U	1.09E-04	1.25E-04	2.65E-04	U	1.23E-04	2.10E-04	4.70E-04	U
WSS	2 - 5	1.74E-05	8.98E-05	4.49E-04	U	1.44E-04	1.24E-04	2.55E-04	U	3.64E-04	2.99E-04	4.72E-04	U
WSS	5 - 10	-2.10E-05	4.42E-05	4.45E-04	U	8.55E-05	1.00E-04	2.60E-04	U	1.51E-04	1.99E-04	4.53E-04	U
MLR	0 - 2	4.59E-05	1.12E-04	4.46E-04	U	3.78E-04	2.04E-04	2.51E-04	+	4.88E-05	2.31E-04	5.04E-04	U
MLR	2 - 5	-3.33E-05	5.97E-05	4.47E-04	U	1.54E-04	1.39E-04	2.52E-04	U	1.74E-04	2.71E-04	4.92E-04	U
MLR	5 - 10	4.48E-05	1.05E-04	4.41E-04	U	9.64E-05	1.05E-04	2.46E-04	U	-5.99E-05	1.12E-04	5.08E-04	U
SEC	0 - 2	-2.99E-05	9.88E-05	4.50E-04	U	1.23E-04	1.36E-04	2.55E-04	U	6.11E-05	1.50E-04	4.62E-04	U
SEC	2 - 5	4.12E-05	1.31E-04	4.55E-04	U	1.42E-04	1.41E-04	2.60E-04	U	2.64E-04	2.49E-04	4.94E-04	U
SEC	5 - 10	1.20E-05	9.85E-05	4.44E-04	U	5.63E-05	1.03E-04	2.49E-04	U	1.51E-04	1.96E-04	4.71E-04	U
SMR	0 - 2	1.53E-05	1.03E-04	4.48E-04	U	6.63E-06	7.38E-05	2.53E-04	U	-1.37E-05	1.99E-04	5.48E-04	U
SMR	2 - 5	2.59E-05	1.10E-04	4.39E-04	U	1.00E-05	6.21E-05	2.44E-04	U	7.81E-05	2.86E-04	5.88E-04	U
SMR	5 - 10	-1.41E-05	7.81E-05	4.39E-04	U	1.57E-05	5.70E-05	2.44E-04	U	4.11E-05	2.60E-04	5.57E-04	U

(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 presents the soil sample analysis data for the gamma radionuclides and ^{90}Sr. The 2013 sample data in Table 4.19 show that ^{40}K was detected in all the samples; ^{137}Cs was detected in all but one of the samples (SMR at 0-2 cm); and ^{60}Co and ^{90}Sr were not detected in any of the samples. For ^{137}Cs, The SMR sample at 0-2 cm showed an activity slightly higher than the 2 σ TPU and MDC, but the ID Confidence was 0.00.

Table 4.19 - 2013 Gamma Radionuclide and ^{90}Sr Concentrations in Soil Samples Taken Near the WIPP Site.
Units are Bq/g
See Appendix C for Sampling Location Codes

Location	Depth (cm)	^{40}K [RN][a]	^{40}K 2 x TPU[b]	^{40}K MDC[c]	^{40}K Q[d]	^{60}Co [RN][a]	^{60}Co 2 x TPU[b]	^{60}Co MDC[c]	^{60}Co Q[d]	^{137}Cs [RN][a]	^{137}Cs 2 x TPU[b]	^{137}Cs MDC[c]	^{137}Cs Q[d]
WFF	0 - 2	1.79E-01	2.62E-02	6.59E-03	+	-1.39E-04	6.04E-04	6.88E-04	U	1.08E-03	4.50E-04	6.16E-04	+
WFF	2 - 5	1.82E-01	2.65E-02	5.81E-03	+	-1.99E-04	4.76E-04	6.91E-04	U	1.16E-03	4.41E-04	5.90E-04	+
WFF	5 - 10	1.86E-01	2.71E-02	6.91E-03	+	-4.07E-04	7.38E-04	7.43E-04	U	1.89E-03	5.24E-04	6.08E-04	+
WEE	0 - 2	2.30E-01	3.31E-02	7.69E-03	+	1.82E-05	6.10E-04	7.20E-04	U	2.06E-03	5.72E-04	6.73E-04	+
WEE	2 - 5	2.35E-01	3.80E-02	9.35E-03	+	-1.21E-04	9.25E-04	1.07E-03	U	3.10E-03	7.99E-04	8.02E-04	+
WEE	5 - 10	2.16E-01	3.08E-02	5.26E-03	+	-1.43E-04	7.03E-04	7.77E-04	U	2.66E-03	5.81E-04	5.55E-04	+
WEE Dup	0 - 2	2.23E-01	3.40E-02	6.79E-03	+	-5.38E-04	7.54E-04	7.57E-04	U	2.49E-03	5.64E-04	4.98E-04	+
WEE Dup	2 - 5	2.27E-01	3.25E-02	6.58E-03	+	-3.59E-05	6.38E-04	7.45E-04	U	2.80E-03	6.19E-04	6.09E-04	+
WEE Dup	5 - 10	2.11E-01	3.24E-02	1.05E-02	+	-7.27E-04	9.08E-04	9.25E-04	U	2.72E-03	7.02E-04	7.54E-04	+
WSS	0 - 2	2.14E-01	3.10E-02	8.86E-03	+	2.10E-04	6.15E-04	7.32E-04	U	1.64E-03	5.45E-04	7.08E-04	+
WSS	2 - 5	2.16E-01	3.10E-02	6.18E-03	+	-1.07E-04	7.48E-04	8.17E-04	U	2.16E-03	5.00E-04	4.85E-04	+
WSS	5 - 10	2.13E-01	3.23E-02	7.65E-03	+	-5.58E-04	1.00E-03	1.04E-03	U	1.87E-03	5.96E-04	7.18E-04	+
MLR	0 - 2	3.87E-01	5.41E-02	9.59E-03	+	5.70E-04	7.60E-04	9.59E-04	U	8.47E-03	1.37E-03	8.59E-04	+
MLR	2 - 5	3.76E-01	5.49E-02	1.04E-02	+	5.30E-05	1.17E-03	1.43E-03	U	2.77E-03	8.74E-04	1.09E-03	+
MLR	5 - 10	3.66E-01	5.14E-02	9.16E-03	+	-9.36E-04	9.61E-04	9.35E-04	U	7.71E-04	5.05E-04	7.64E-04	+
SEC	0 - 2	2.42E-01	3.46E-02	6.51E-03	+	-4.56E-04	9.04E-04	9.30E-04	U	4.75E-03	8.77E-04	7.04E-04	+
SEC	2 - 5	2.26E-01	3.27E-02	8.18E-03	+	-3.16E-05	7.22E-04	8.11E-04	U	3.18E-03	7.50E-04	8.20E-04	+
SEC	5 - 10	2.50E-01	3.78E-02	1.05E-02	+	-1.07E-03	1.17E-03	1.21E-03	U	1.44E-03	6.94E-04	9.94E-04	+
SMR	0 - 2	7.43E-01	1.01E-01	8.80E-03	+	-7.01E-05	9.52E-04	1.08E-03	U	1.19E-03	9.80E-04	1.15E-03	U
SMR	2 - 5	8.09E-01	1.10E-01	1.08E-02	+	6.48E-04	1.21E-03	1.39E-03	U	7.77E-04	5.64E-04	8.67E-04	+
SMR	5 - 10	7.72E-01	1.05E-01	8.80E-03	+	6.26E-05	1.02E-03	1.19E-03	U	6.62E-04	5.96E-04	9.38E-04	+

Location	Depth (cm)	^{90}Sr [RN][a]	^{90}Sr 2 x TPU[b]	^{90}Sr MDC[c]	^{90}Sr Q[d]
WFF	0 - 2	-1.93E-03	6.78E-03	2.55E-02	U
WFF	2 - 5	1.22E-03	7.71E-03	2.55E-02	U
WFF	5 - 10	3.44E-03	7.74E-03	2.55E-02	U
WEE	0 - 2	-9.14E-04	7.48E-03	2.55E-02	U
WEE	2 - 5	1.72E-03	7.36E-03	2.55E-02	U
WEE	5 - 10	1.49E-03	7.58E-03	2.55E-02	U
WEE Dup	0 - 2	1.41E-02	9.18E-03	2.57E-02	U
WEE Dup	2 - 5	1.36E-03	8.02E-03	2.57E-02	U
WEE Dup	5 - 10	-1.47E-03	8.47E-03	2.57E-02	U
WSS	0 - 2	-2.22E-03	8.32E-03	2.57E-02	U
WSS	2 - 5	-3.98E-03	8.16E-03	2.57E-02	U
WSS	5 - 10	-4.70E-03	8.30E-03	2.57E-02	U
MLR	0 - 2	-1.30E-03	9.16E-03	2.48E-02	U
MLR	2 - 5	6.57E-04	9.21E-03	2.48E-02	U
MLR	5 - 10	-1.81E-03	9.14E-03	2.49E-02	U
SEC	0 - 2	2.27E-02	1.08E-02	2.49E-02	U
SEC	2 - 5	1.84E-03	9.29E-03	2.49E-02	U
SEC	5 - 10	-2.88E-03	8.99E-03	2.49E-02	U
SMR	0 - 2	-7.14E-03	9.63E-03	2.49E-02	U
SMR	2 - 5	-2.69E-03	9.05E-03	2.49E-02	U
SMR	5 - 10	-2.06E-03	9.19E-03	2.49E-02	U

(a) Radionuclide Concentration
(b) Total Propagated Uncertainty
(c) Minimum Detectable Concentration
(d) Qualifier: Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undected.

There were 18 common locations where ^{40}K was detected between 2012 and 2013 for ANOVA comparisons. The average concentrations were used for the duplicate samples at WEE in 2013 and WFF in 2012.

There was variation in the ^{40}K concentrations between 2012 and 2013 (ANOVA ^{40}K, p = 0.0445). There was less variation in the concentrations between locations, including the various soil depths (ANOVA ^{40}K, p = 0.208). The primary difference between the two years appears to be an increase in the concentration of ^{40}K at all three depths in the samples from SMR (similar to the uranium isotope concentrations increasing).

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.

The highest ^{40}K concentration of 8.09E–01 Bq/g occurred at the 2-5 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).

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 2012 WFF samples. The ANOVA calculations showed no significant difference between the concentrations in 2012 and 2013 (ANOVA ^{137}Cs, p = 0.688). However, there was a significant difference in the concentrations between the sampling locations (ANOVA ^{137}Cs, p = 8.61E–03).

The 2013 ^{137}Cs concentrations were all within the 99 percent confidence interval range of the baseline concentration (4.00E–02 Bq/g). 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 4.19), there were insufficient data to permit any kind of variance analysis between years or among sampling locations.

Precision analysis results as RER were calculated for all the target radionuclides in the duplicate soil samples collected from all three depths at location WEE. The analysis results are shown in Table 4.20. The qualifier column shows whether the radionuclide was detected in the samples.

The 30 RER calculations showed that three RERs were greater than 1 and only one RER was greater than 1.96 where ^{235}U at the 5 - 10 cm depth was not detected in the primary sample but was detected in the duplicate sample with an activity an order of magnitude higher, which yielded a RER of 2.80. The reason for the difference is not known, but soil samples could be inhomogeneous leading to the different results. The other two RERs greater than 1 were 1.15 for $^{233/234}U$ at 0 – 2 cm (detected) and 1.27 for ^{90}Sr at 0 – 2 cm (not detected). Overall, the precision of the combined sampling and analysis procedures was good.

Table 4.20 - Precision Analysis Results for 2013 Duplicate Soil Samples
Units are Bq/g
See Chapter 6 for Sampling Locations.

			Primary Sample		Duplicate Sample			
Location	Depth cm	Isotope	[RN](a)	2 σ TPU(b)	[RN](a)	2 σ TPU(b)	RER(c)	Q(d)
WEE	0-2	$^{233/234}$U	5.71E-03	1.19E-03	7.98E-03	1.57E-03	1.152	+
WEE	2-5	$^{233/234}$U	7.11E-03	1.38E-03	6.45E-03	1.17E-03	0.365	+
WEE	5-10	$^{233/234}$U	6.53E-03	1.70E-03	8.87E-03	2.34E-03	0.809	+
WEE	0-2	^{235}U	2.96E-04	2.10E-04	1.06E-04	1.34E-04	0.763	U
WEE	2-5	^{235}U	3.74E-04	2.32E-04	3.03E-04	1.98E-04	0.233	+
WEE	5-10	^{235}U	2.56E-04	2.04E-04	3.44E-03	1.12E-03	2.797	U/+(e)
WEE	0-2	^{238}U	5.95E-03	1.23E-03	7.00E-03	1.42E-03	0.559	+
WEE	2-5	^{238}U	6.77E-03	1.33E-03	6.85E-03	1.22E-03	0.044	+
WEE	5-10	^{238}U	7.20E-03	1.85E-03	8.26E-03	2.20E-03	0.369	+
WEE	0-2	^{238}Pu	9.45E-06	9.13E-05	6.30E-06	7.04E-05	0.027	U
WEE	2-5	^{238}Pu	6.40E-05	1.11E-04	6.49E-06	6.27E-05	0.451	U
WEE	5-10	^{238}Pu	-5.85E-06	8.50E-05	0.00E+00	7.33E-05	0.052	U
WEE	0-2	$^{239/240}$Pu	8.97E-05	1.29E-04	1.52E-04	1.34E-04	0.335	U
WEE	2-5	$^{239/240}$Pu	8.24E-05	1.01E-04	1.59E-04	1.30E-04	0.465	U
WEE	5-10	$^{239/240}$Pu	3.31E-05	9.70E-05	1.46E-04	1.32E-04	0.689	U
WEE	0-2	^{241}Am	2.37E-04	2.76E-04	2.41E-04	2.55E-04	0.011	U
WEE	2-5	^{241}Am	2.91E-04	2.60E-04	-1.54E-05	1.81E-04	0.967	U
WEE	5-10	^{241}Am	-4.96E-05	9.00E-05	9.16E-05	1.95E-04	0.657	U
WEE	0-2	^{40}K	2.30E-01	3.31E-02	2.23E-01	3.40E-02	0.148	+
WEE	2-5	^{40}K	2.35E-01	3.80E-02	2.27E-01	3.25E-02	0.160	+
WEE	5-10	^{40}K	2.16E-01	3.08E-02	2.11E-01	3.24E-02	0.112	+
WEE	0-2	^{60}Co	1.82E-05	6.10E-04	-5.38E-04	7.54E-04	0.573	U
WEE	2-5	^{60}Co	-1.21E-04	9.25E-04	-3.59E-05	6.38E-04	0.076	U
WEE	5-10	^{60}Co	-1.43E-04	7.03E-04	-7.27E-04	9.08E-04	0.509	U
WEE	0-2	^{137}Cs	2.06E-03	5.72E-03	2.49E-03	5.64E-04	0.075	+
WEE	2-5	^{137}Cs	3.10E-03	7.99E-04	2.80E-03	6.19E-04	0.297	+
WEE	5-10	^{137}Cs	2.66E-03	5.81E-04	2.72E-03	7.02E-04	0.066	+
WEE	0-2	^{90}Sr	-9.14E-04	7.48E-03	1.41E-02	9.18E-03	1.268	U
WEE	2-5	^{90}Sr	1.72E-03	7.36E-03	1.36E-03	8.02E-03	0.033	U
WEE	5-10	^{90}Sr	1.49E-03	7.58E-03	-1.47E-03	8.47E-03	0.260	U

(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.

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

The 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

4.7.4.1 Vegetation

Table 4.21 presents the analysis results for all the target radionuclides in the vegetation samples from six locations with duplicate samples from WSS. The data in Table 4.21 show that $^{233/234}$U was only detected in the 2013 sample harvested from SMR, and that

^{238}U was only detected in the vegetation harvested from locations MLR, and SMR. The detected $^{233/234}$U concentration at SMR was higher than the average baseline concentration of 6.00E–05 Bq/g. There was only one common location for detection of $^{233/234}$U in vegetation between 2012 and 2013 (SMR) and thus no ANOVA calculations could be performed. The two detections of ^{238}U in 2013 were much lower than the average baseline concentration of 1.40E–02 Bq/g. Since there were no common locations where ^{238}U was detected in 2012 and 2013, no ANOVA calculations could be performed.

Table 4.21 shows that ^{40}K was detected in all the vegetation samples analyzed in 2013 as it was in 2011 and 2012. The average concentrations of ^{40}K were used for ANOVA calculations for WSS in 2013 and SEC in 2012. The ANOVA calculations included six common locations.

Table 4.21 - Radionuclide Concentrations in 2013 Vegetation Samples Taken Near WIPP Site
Units are Bq/g Wet Weight
See Appendix C for Sampling Location Codes

Location	[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	1.42E-04	1.29E-04	5.28E-04	U	1.72E-05	4.23E-05	4.98E-04	U	2.34E-04	1.35E-04	3.30E-04	U
WEE	2.13E-04	1.47E-04	5.41E-04	U	2.08E-05	5.33E-05	5.12E-04	U	6.39E-05	8.88E-05	3.50E-04	U
WSS	3.15E-04	1.44E-04	4.58E-04	U	3.08E-05	4.80E-05	5.25E-04	U	2.05E-04	1.14E-04	3.19E-04	U
WSS Dup	2.19E-04	1.23E-04	4.59E-04	U	-1.70E-05	3.35E-05	5.48E-04	U	1.90E-04	1.14E-04	3.19E-04	U
MLR	4.44E-04	1.54E-04	4.51E-04	U	4.15E-05	4.74E-05	5.17E-04	U	3.18E-04	1.28E-04	3.09E-04	+
SEC	2.25E-04	1.10E-04	4.53E-04	U	-6.36E-06	1.91E-05	5.21E-04	U	2.26E-04	1.10E-04	3.11E-04	U
SMR	4.98E-04	1.91E-04	4.60E-04	+	2.79E-05	5.45E-05	5.29E-04	U	4.10E-04	1.70E-04	3.19E-04	+

	^{238}Pu				$^{239/240}$Pu				^{241}Am			
WFF	-5.64E-06	1.56E-05	4.39E-04	U	-4.20E-06	1.35E-05	2.50E-04	U	1.31E-04	1.04E-04	6.13E-04	U
WEE	4.33E-05	4.53E-05	4.41E-04	U	1.88E-05	3.38E-05	2.50E-04	U	5.56E-05	5.94E-05	5.96E-04	U
WSS	-3.08E-06	6.79E-05	4.48E-04	U	4.62E-06	2.65E-05	2.37E-04	U	8.48E-05	7.41E-05	5.57E-04	U
WSS Dup	-2.05E-05	6.68E-05	4.53E-04	U	0.00E+00	0.00E+00	2.38E-04	U	2.81E-05	3.90E-05	5.57E-04	U
MLR	2.26E-05	4.93E-05	4.43E-04	U	0.00E+00	0.00E+00	2.32E-04	U	4.92E-05	5.84E-05	5.58E-04	U
SEC	2.94E-05	5.40E-05	4.45E-04	U	3.23E-05	4.15E-05	2.37E-04	U	5.36E-05	5.26E-05	5.55E-04	U
SMR	7.97E-06	2.93E-05	4.47E-04	U	-4.78E-06	1.53E-05	2.41E-04	U	2.30E-05	5.06E-05	5.65E-04	U

	^{40}K				^{60}Co				^{137}Cs			
WFF	6.40E-01	1.18E-01	6.95E-02	+	7.05E-03	4.90E-03	7.28E-03	U	6.12E-04	5.47E-03	6.29E-03	U
WEE	7.65E-01	1.35E-01	7.35E-02	+	5.39E-03	4.94E-03	7.07E-03	U	5.16E-03	5.06E-03	6.64E-03	U
WSS	4.98E-01	8.97E-02	5.38E-03	+	2.70E-03	3.57E-03	4.85E-03	U	5.74E-04	3.75E-03	4.55E-03	U
WSS Dup	5.50E-01	9.73E-02	5.07E-02	+	2.59E-04	4.55E-03	5.38E-03	U	1.37E-03	4.41E-03	5.14E-03	U
MLR	6.00E-01	1.03E-01	5.06E-02	+	-1.13E-03	5.05E-03	5.66E-03	U	-3.68E-04	4.90E-03	5.52E-03	U
SEC	6.05E-01	1.32E-01	4.50E-02	+	3.36E-03	0.00E+00	3.36E-03	U	1.38E-03	0.00E+00	1.38E-03	U
SMR	1.10E+00	2.31E-01	7.71E-02	+	2.81E-03	0.00E+00	2.81E-03	U	5.67E-03	0.00E+00	5.67E-03	U

	^{90}Sr			
WFF	2.99E-03	3.22E-03	2.09E-02	U
WEE	5.74E-03	3.91E-03	2.10E-02	U
WSS	1.15E-03	1.86E-03	2.55E-02	U
WSS Dup	2.24E-03	1.88E-03	2.55E-02	U
MLR	1.01E-03	1.75E-03	2.55E-02	U
SEC	2.30E-03	1.77E-03	2.55E-02	U
SMR	1.02E-03	1.82E-03	2.55E-02	U

(a) Radionuclide Concentration
(b) Total Propagated Uncertainty
(c) Minimum Detectable Concentration
(d) Qualifier. Indicates whether radionuclide was detected. Plus (+) equals detected. U equals undetected.

The ANOVA calculations showed no significant statistical difference in ^{40}K vegetation concentrations between 2012 and 2013 (ANOVA ^{40}K, p = 0.206). There was more variation in the concentrations of ^{40}K between locations with the p value at the significance factor of 0.05 (ANOVA ^{40}K, p = 0.0525). The natural variability of this naturally occurring radionuclide in the soil would be expected to yield some variation in the vegetation concentrations between locations.

The highest concentrations of ^{40}K were at SMR in both 2012 and 2013. The 2013 concentrations of ^{40}K were all less than the average vegetation (ash) baseline concentration of 3.2E+00 Bq/g (DOE/WIPP–92–037, March 1992).

Table 4.22 shows the precision analysis results for ^{40}K in the duplicate samples from location WSS. The RER calculated for ^{40}K was 0.393, indicating good precision for the combined sampling and analysis procedures. All the other undetected radionuclides also yielded RERs less than1.

Table 4.22 - Precision Analysis Results for 2013 Duplicate Vegetation Samples
Units are Bq/g
See Chapter 6 for Sampling Location.

		Sample		Duplicate			
Location	Isotope	[RN](a)	2 σ TPU(b)	[RN](a)	2 σ TPU(b)	RER(c)	Q(d)
WSS	$^{233/234}U$	3.15E-04	1.44E-04	2.19E-04	1.23E-04	0.507	U
and Dup	^{235}U	3.08E-05	4.80E-05	-1.70E-05	3.35E-05	0.817	U
	^{238}U	2.05E-04	1.14E-04	1.90E-04	1.14E-04	0.093	U
	^{238}Pu	-3.08E-06	6.79E-05	-2.05E-05	6.68E-05	0.183	U
	$^{239/240}Pu$	4.62E-06	2.65E-05	0.00E+00	0.00E+00	0.174	U
	^{241}Am	8.48E-05	7.41E-05	2.81E-05	3.90E-05	0.677	U
	^{40}K	4.98E-01	8.97E-02	5.50E-01	9.73E-02	0.393	+
	^{60}Co	2.70E-03	3.57E-03	2.59E-04	4.55E-03	0.422	U
	^{137}Cs	5.74E-04	3.75E-03	1.37E-03	4.41E-03	0.138	U
	^{90}Sr	1.15E-03	1.86E-03	2.24E-03	1.88E-03	0.412	U

(a) Radionuclide Concentration
(b) Total Propagated Uncertainty
(c) Relative Error Ratio
(d) Qualifier: Indicates whether radionuclide was detected, plus (+) equals detected
U equals undetected

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.

4.7.4.2 Fauna (Animals)

The fauna analysis results for radionuclides are presented in Table 4.23. The only radionuclides detected in any of the animal samples were ^{40}K, which was detected in the quail, deer, rabbit, and all three fish samples; $^{233/234}U$, which was detected in the fish sample from PCN; and ^{238}U, which was also detected in the fish sample from PCN.

Table 4.23 - 2013 Radionuclide Concentrations in WIPP Site Fauna Samples (Quail, Deer, Rabbit, and Fish)
Units are Bq/g wet mass
See Appendix C for Sampling Location Codes

	[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]
(Location)	$^{233/234}$U				^{235}U				^{238}U			
Quail (WEE)	2.63E-04	4.58E-05	4.70E-04	U	1.15E-05	4.62E-06	2.09E-04	U	2.65E-04	4.61E-05	3.15E-04	U
Deer (SOO)	9.80E-07	8.28E-07	4.70E-04	U	-1.87E-08	1.16E-07	2.08E-04	U	1.46E-06	9.76E-07	3.14E-04	U
Rabbit (SOO)	3.07E-05	9.92E-06	3.80E-04	U	4.94E-07	1.49E-06	1.45E-04	U	2.32E-05	8.23E-06	2.14E-04	U
Fish (PCN)	7.59E-04	1.94E-04	2.38E-04	+	1.26E-05	6.00E-06	1.20E-04	U	3.56E-04	9.24E-05	1.84E-04	+
Fish (CBD)	2.18E-04	3.92E-05	3.13E-04	U	4.45E-06	2.50E-06	1.49E-04	U	1.04E-04	2.01E-05	2.17E-04	U
Fish (BRA)	2.72E-04	5.26E-05	3.18E-04	U	8.40E-06	3.79E-06	4.25E-04	U	1.42E-04	2.89E-05	2.26E-04	U
	^{238}Pu				$^{239/240}$Pu				^{241}Am			
Quail (WEE)	1.77E-08	2.09E-06	3.80E-04	U	1.28E-06	1.99E-06	1.82E-04	U	7.86E-07	2.48E-06	3.31E-04	U
Deer (SOO)	-2.07E-07	3.36E-07	3.79E-04	U	1.75E-07	4.62E-07	1.81E-04	U	5.01E-07	6.92E-07	3.29E-04	U
Rabbit (SOO)	0.00E+00	1.80E-06	3.07E-04	U	6.50E-07	1.28E-06	2.29E-04	U	5.68E-07	3.53E-06	6.59E-04	U
Fish (PCN)	-2.26E-07	3.06E-06	3.88E-04	U	9.54E-07	2.44E-06	2.25E-04	U	2.86E-06	4.99E-06	6.47E-04	UJ
Fish (CBD)	1.33E-06	1.86E-06	3.95E-04	U	2.12E-07	8.75E-07	2.13E-04	U	4.33E-07	1.11E-06	4.97E-04	U
Fish (BRA)	7.01E-07	1.24E-06	4.08E-04	U	1.78E-06	1.62E-06	2.16E-04	U	1.94E-06	1.83E-06	4.78E-04	U
	^{40}K				^{60}Co				^{137}Cs			
Quail (WEE)	1.02E-01	1.51E-02	1.06E-02	+	3.52E-04	9.73E-04	1.09E-03	U	4.89E-04	9.98E-04	1.09E-03	U
Deer (SOO)	1.50E-01	1.88E-02	5.46E-03	+	2.36E-04	4.41E-04	5.08E-04	U	-5.80E-04	4.47E-04	4.82E-04	U
Rabbit (SOO)	1.07E-01	2.43E-02	2.77E-02	+	2.53E-03	2.58E-03	3.13E-03	U	4.05E-03	2.73E-03	3.18E-03	U
Fish (PCN)	1.14E-01	2.08E-02	1.91E-02	+	2.15E-03	1.59E-03	2.02E-03	U	1.17E-03	1.55E-03	1.87E-03	U
Fish (CBD)	1.16E-01	1.98E-02	1.60E-02	+	5.33E-04	1.47E-03	1.74E-03	U	-3.47E-04	1.50E-03	1.72E-03	U
Fish (BRA)	1.08E-01	1.95E-02	1.67E-02	+	1.48E-04	1.60E-03	1.87E-03	U	2.14E-03	1.54E-03	1.90E-03	U
	^{90}Sr											
Quail (WEE)	9.58E-05	8.73E-05	2.44E-02	U								
Deer (SOO)	-1.73E-05	2.67E-05	2.44E-02	U								
Rabbit (SOO)	1.74E-03	3.22E-04	2.25E-02	U								
Fish (PCN)	-1.07E-05	6.41E-05	2.17E-02	U								
Fish (CBD)	-1.36E-05	4.45E-05	1.90E-02	U								
Fish (BRA)	9.37E-05	5.35E-05	1.89E-02	U								

(a) Radionuclide Concentration
(b) Total Propagated Uncertainty
(c) Minimum Detectable Concentration
(d) Qualifier: Indicates whether radionuclide was detected, plus (+) equals detected, U equals undetected
UJ Nuclide not detected above the reported MDC or 2σ counting uncertainty and a quality deficiency affects the data making the reported 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) 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 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 1 except for ^{40}K in the rabbit sample, where both samples showed detection of ^{40}K; however the gamma activities measured in the two samples were over an order of magnitude different, yielding a RER of 1.44.

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, which are 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 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 that occurred from 1945 through 1980, 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 models, 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 CH and RH 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 model 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 2013. 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 2013 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, and $^{233/234}$U and ^{238}U, which were detected in one fish sample. Therefore, no dose from WIPP facility–related radionuclides could have been received by any individual from this pathway during 2013.

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 2013 is summarized in Table 4.24 for the regulations in both 40 CFR §61.92 and 40 CFR §191.03(b).

Table 4.24 – WIPP Radiological Dose and Release Summary

WIPP Radiological Dose and Releases[a] During 2013			
^{238}Pu	$^{239/240}$Pu	^{241}Am	^{90}Sr
3.89E-08 Ci	3.02E-08 Ci	4.86E-08 Ci	2.80E-06 Ci
1,440 Bq	1,118 Bq	1,800 Bq	103,500 Bq
$^{233/234}$U	^{238}U	^{137}Cs	
6.00E-08 Ci	6.63E-08 Ci	3.49E-05 Ci	
2,221 Bq	2,454 Bq	1.29E+06 Bq	

WIPP Radiological Dose Reporting Table for 2013							
Pathway	EDE to the MEI at 7,500 Meters WNW		Percent of EPA 10 mrem/year Limit to Member of the Public	Estimated Population Dose Within 50 Miles		Population Within 50 Miles[b]	Estimated Natural Radiation Population Dose[c]
	(mrem/year)	(mSv/year)		(person-rem/year)	(person-Sv/year)		(person-rem)
Air	7.39E-06	7.39E-08	7.39E-05	1.22E-05	1.22E-07	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 2013						
Pathway	Dose equivalent to the whole body of the receptor who resides year-round at WIPP fence line 350 meters NW		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 350 meters NW		Percent of EPA 75-mrem/year Critical Organ Limit
	(mrem/year)	(mSv/year)		(mrem/year)	(mSv/year)	
Air	5.25E-04	5.25E-06	2.10E-03	1.31E-03	1.31E-05	1.75E-03
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

(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) x (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 fence line in the northwest sector. For 2013, the dose to this receptor was estimated to be 5.25E-06 mSv (5.25E-04 mrem) per year for the whole

body and 1.31E-05 mSv (1.31E–03 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 2013 assumed to be residing 7.5 km (4.66 mi) west-northwest of the WIPP facility is calculated to be 7.39E–08 mSv (7.39E–06 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 1.22E–07 person-sieverts per year (person-Sv/year) (1.22E–05 person-rem/year) in 2013.

4.8.5 Dose to Nonhuman Biota

Dose limits for populations of aquatic and terrestrial organisms are discussed in NCRP 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 mGy/d (1 rad/d)
- Terrestrial plants—10 mGy/d (1 rad/d)
- Terrestrial animals—1 mGy/d (0.1 rad/d)

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 (BCGs) 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 BCGs, 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 2013 using the maximum radionuclide concentrations listed in Table 4.25, and the sum of fractions was less than 1.0 for all media. The element ^{40}K is not included in Table 4.25 because it is a natural component of the earth’s crust and is not part of WIPP-related radionuclides.

Table 4.25 - General Screening Results for Potential Radiation Dose to Nonhuman Biota from 2013 Radionuclide Concentrations in Surface Water (Bq/L), Sediment (Bq/g), and Soil (Bq/g) Near the WIPP Site

Medium	Radionuclide	Maximum Detected Concentration	Loc.	BCG[a]	Concentration/BCG
Aquatic System Evaluation					
Sediment (Bq/g)	$^{233/234}$U	3.09E-02	PCN	2.00E+02	1.55E-04
	^{235}U	1.57E-03	HIL (prim)	1.00E+02	1.57E-05
	^{238}U	3.13E-02	PCN	9.00E+01	3.48E-04
	^{238}Pu	ND[c]		2.00E+02	NA[d]
	$^{239/240}$Pu	3.47E-04	HIL (dup)	2.00E+02	1.74E-06
	^{241}Am	ND[c]		2.00E+02	NA[d]
	^{60}Co	ND[c]		5.00E+01	NA[d]
	^{137}Cs	9.10E-03	HIL (prim)	1.00E+02	9.10E-05
	^{90}Sr	ND[c]		2.00E+01	NA[d]
Surface Water[b] (Bq/L)	$^{233/234}$U	2.56E-01	PCN	7.00E+00	3.66E-02
	^{235}U	7.33E-03	PCN	8.00E+00	9.16E-04
	^{238}U	1.22E-01	PCN	8.00E+00	1.53E-02
	^{238}Pu	ND[c]		7.00E+00	NA[d]
	$^{239/240}$Pu	5.58E-04	IDN	7.00E+00	7.97E-05
	^{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		5.34E-02
Terrestrial System Evaluation					
Soil (Bq/g)	$^{233/234}$U	1.69E-02	SMR (0-2)	2.00E+02	8.45E-05
	^{235}U	3.44E-03	WEE dup (5-10)	1.00E+02	3.44E-05
	^{238}U	1.78E-02	SMR (5-10)	6.00E+01	2.97E-04
	^{238}Pu	ND[c]		2.00E+02	NA[d]
	$^{239/240}$Pu	3.78E-04	MLR (0-2)	2.00E+02	NA[d]
	^{241}Am	ND[c]		1.00E+02	NA[d]
	^{60}Co	ND[c]		3.00E+01	NA[d]
	^{137}Cs	8.47E-03	MLR (0-2)	8.00E-01	1.06E-02
	^{90}Sr	ND[c]		8.00E-01	NA[d]
Surface Water (Bq/L)	$^{233/234}$U	2.56E-01	PCN	1.00E+04	2.56E-05
	^{235}U	7.33E-03	PCN	2.00E+04	3.67E-07
	^{238}U	1.22E-01	PCN	2.00E+04	6.10E-06
	^{238}Pu	ND[c]		7.00E+03	NA[d]
	$^{239/240}$Pu	5.58E-04	IDN	7.00E+03	NA[d]
	^{241}Am	ND[c]		7.00E+03	NA[d]
	^{60}Co	ND[c]		4.00E+04	NA[d]
	^{137}Cs	ND[c]		2.00E+04	NA[d]
	^{90}Sr	ND[c]		2.00E+04	NA[d]
			Sum of Fractions		1.10E-02

(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.
Note: Maximum detected concentrations were compared with 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).

4.8.6 Release of Property Containing Residual Radioactive Material

No radiologically contaminated materials or property were released from the WIPP facility in 2013.

4.9 Radiological Program Conclusions

4.9.1 Effluent Monitoring

For 2013, the calculated EDE to the receptor (hypothetical MEI) who resides year-round at the fence line is 5.25E–06 mSv (5.25E-04 mrem) per year for the whole body and is 1.31E–05 mSv (1.31E–03 mrem) per year for the critical organ. For the WIPP effluent monitoring program, Figure 4.5 and Table 4.26 show the dose to the whole body for the hypothetical MEI for CY 2001 to CY 2013. Figure 4.6 and Table 4.27 show the dose to the critical organ for the hypothetical MEI for CY 2001 to CY 2013. 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 mid-2013, it was found during a calibration check that the Station C sample flow control valve was biased to read higher than the actual flow through the valve. Since the emissions from WIPP exhaust points are dependent upon accurate ratios of sample flow to exhaust flow, the emissions from Station C were re-calculated assuming that the bias existed since equipment installation in May 2011. In CY 2011, the effects were calculated to be negligible (less than 1% change); in CY 2012, the increase in dose was estimated to be about 11% higher than originally reported.

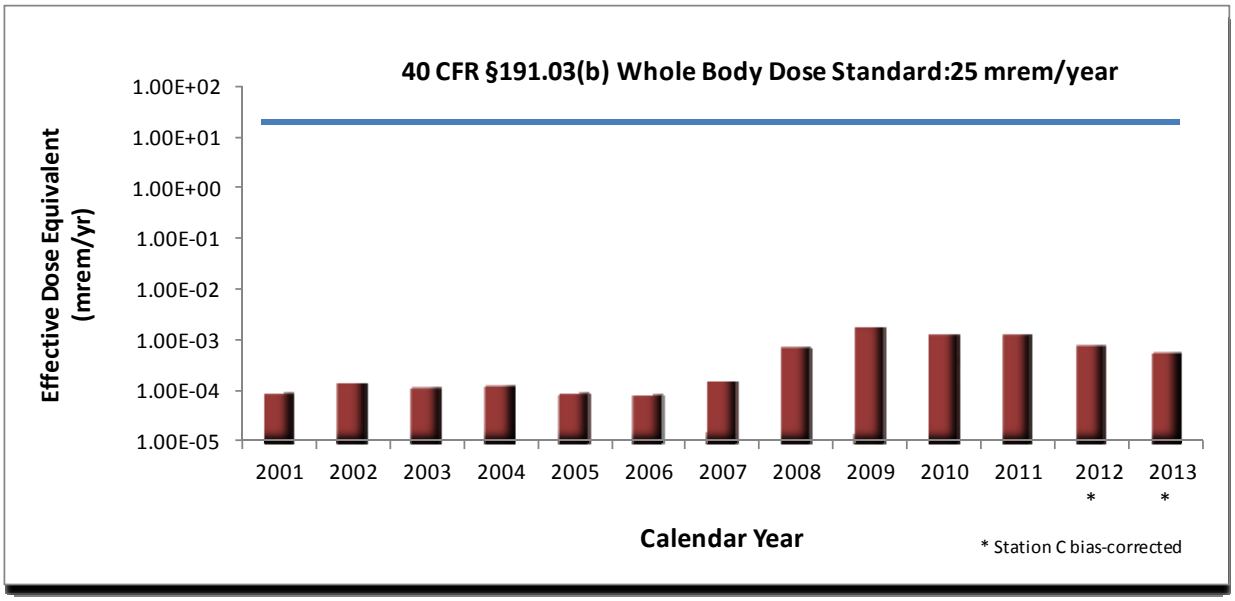

Figure 4.5 – Dose to the Whole Body for the Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.26 – 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
2001	8.99E–05	0.00036
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
2010	1.31E–03	0.00524
2011	1.29E–03	0.00516
2012*	7.55E-04	0.00302
2013*	5.25E-04	0.00210
40 CFR §191.03(b) Whole Body Limit	**25**	
*Station C bias-corrected		

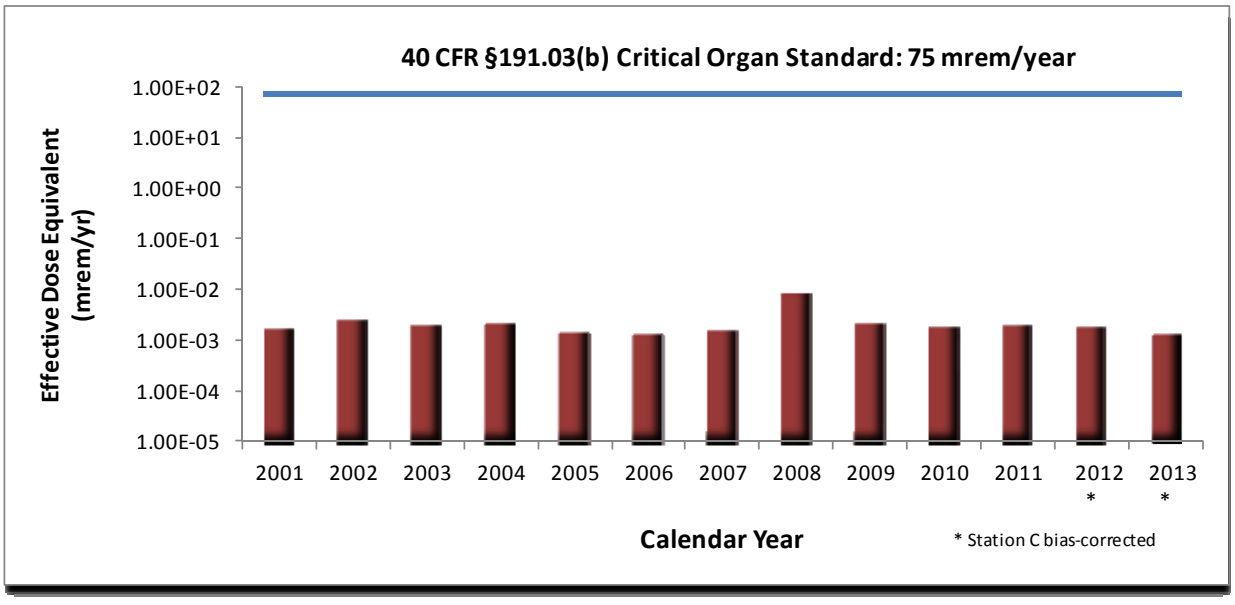

Figure 4.6 – Dose to the Critical Organ for Hypothetical Maximally Exposed Individual at the WIPP Fence Line

Table 4.27 – 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
2001	1.56E–03	0.0021
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
2010	1.73E–03	0.0023
2011	1.86E–03	0.0025
2012*	1.75E-03	0.0023
2013*	1.31E-03	0.0017
40 CFR §191.03(b) Critical Organ Limit	**75**	
*Station C bias-corrected		

For 2013, the calculated EDE to the MEI from normal operations conducted at the WIPP facility is 8.05E–08 mSv (8.05E–06 mrem). For the WIPP effluent monitoring program, Figure 4.7 and Table 4.28 show the EDE to the MEI for CY 2001 to CY 2013. These EDE values are more than six orders of magnitude below the EPA NESHAP standard of 10 mrem per year, as specified in 40 CFR §61.92.

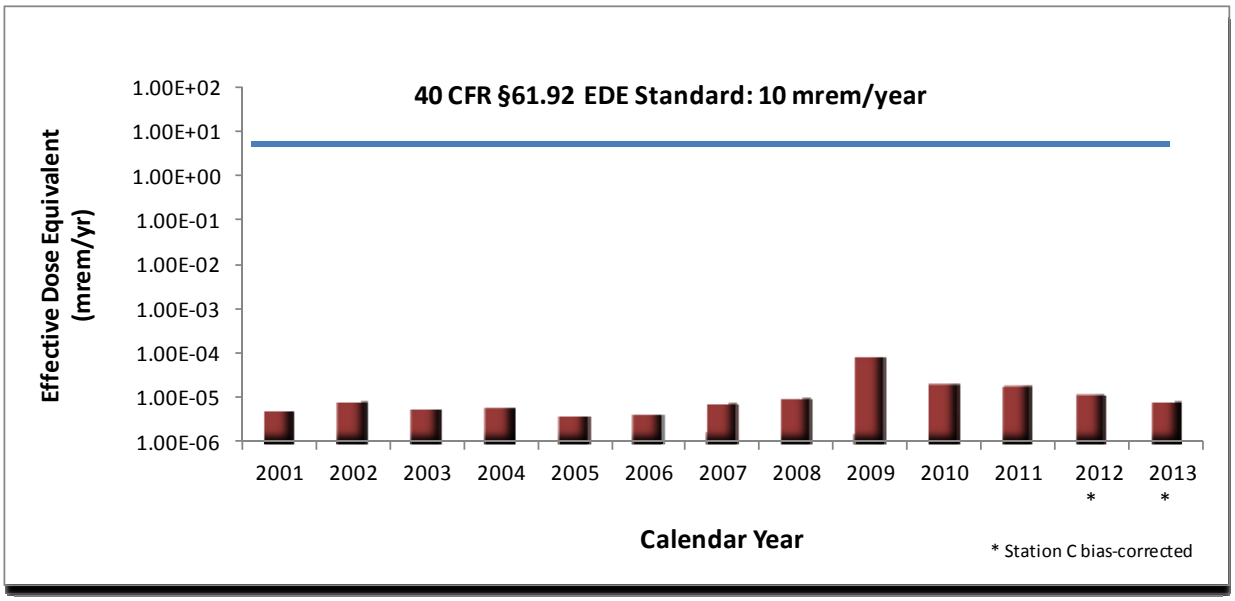

Figure 4.7 – WIPP Effective Dose Equivalent to the Off-Site Maximally Exposed Individual

Table 4.28 – Comparison of EDEs to EPA Standard of 10 mrem/year per 40 CFR §61.92

Year	Annual Dose (mrem/yr)	Percentage of EPA Standard
2001	4.96E–06	0.000050
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
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
NESHAP Limit	**10**	
*Station C bias-corrected		

4.9.2 Environmental Monitoring

Radionuclide concentrations observed in environmental monitoring were extremely small and comparable to radiological baseline levels. Appendix H contains graphs comparing detected radionuclide concentrations to their respective baseline values. In cases where the radionuclide concentrations slightly exceeded baseline levels (uranium isotopes and ^{40}K in some samples), these differences are most likely due to natural spatial variability, and they are so far below the regulatory limit as to be nonimpactive.

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CHAPTER 5 – ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

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

5.1 Principal Functions of Nonradiological Sampling

The principal functions of the nonradiological 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., BLM/DOE 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 2013, two land use requests were submitted to and approved by the Land Use Coordinator.

5.2.2 Wildlife Population Monitoring

In 1995, the USFWS 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 2013, WIPP surveillance teams conducted monthly surveillances and field inspections.

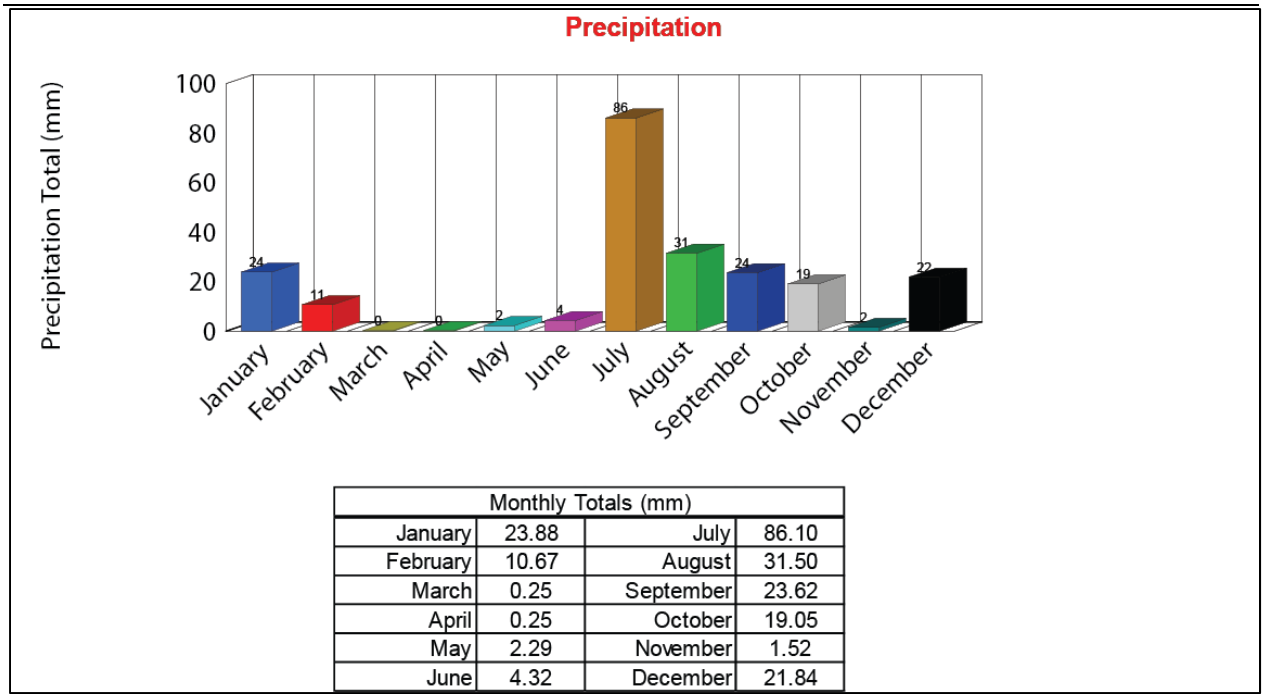
Proposed new well locations staked within 0.621 km (1 mi) of the WIPP site are field-verified. This ensures that the proposed location is of sufficient distance from the WIPP boundary to protect the WIPP withdrawal from potential surface and subsurface trespass. Three new wells were drilled and completed in 2013 within 0.621 km (1 mi) of the WIPP site boundary. If a well is within 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 measures and records 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

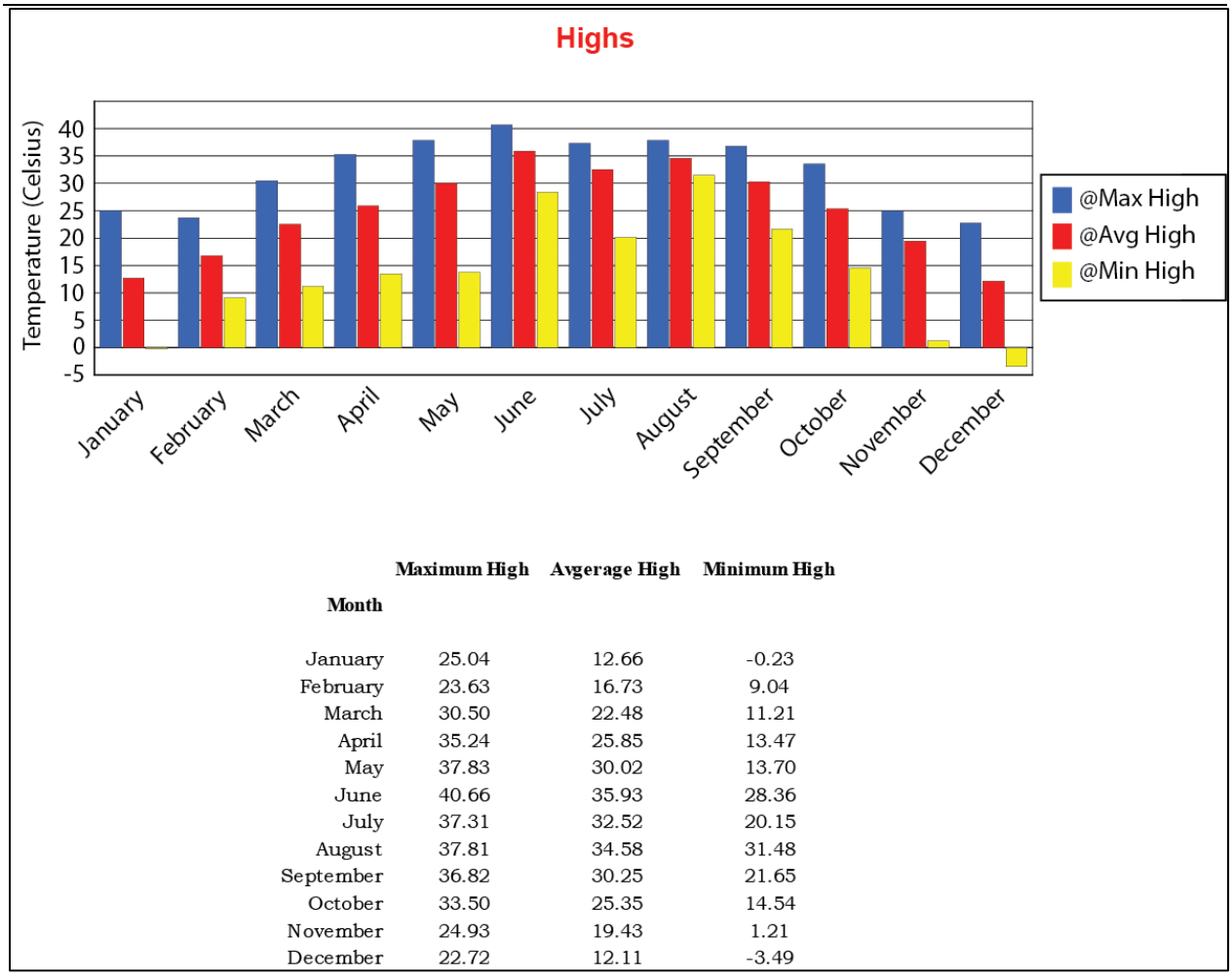
Precipitation at the WIPP site for 2013 was 225.29 mm (8.87 in.). Figure 5.1 displays the monthly precipitation at the WIPP site.



Monthly Totals (mm)			
January	23.88	July	86.10
February	10.67	August	31.50
March	0.25	September	23.62
April	0.25	October	19.05
May	2.29	November	1.52
June	4.32	December	21.84

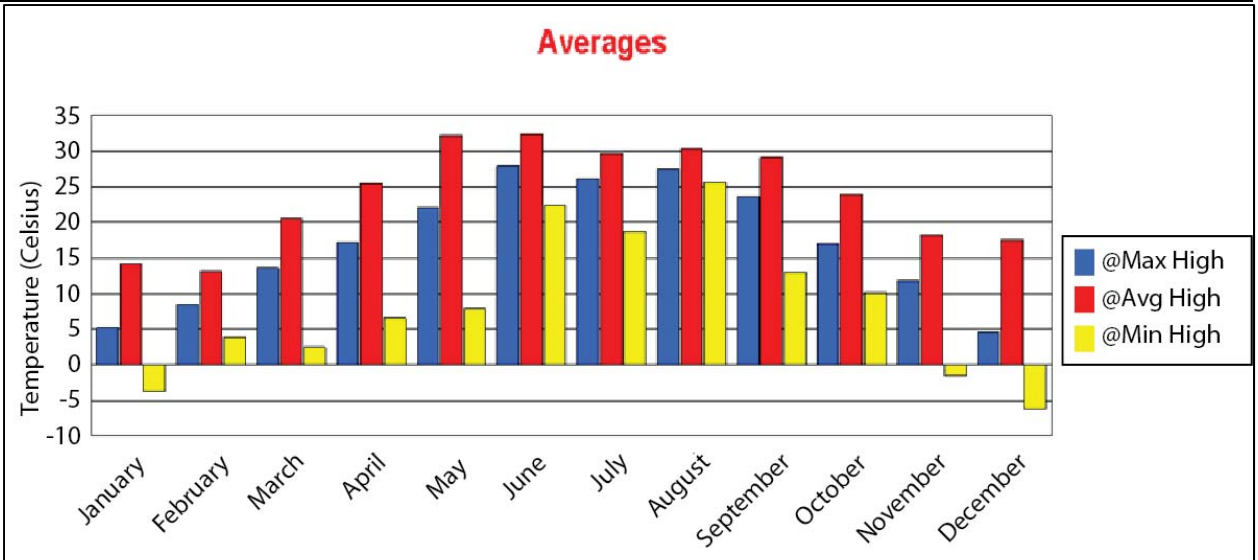
Figure 5.1 – WIPP Site Precipitation Report for 2013

The maximum recorded surface temperature (2-m level) at the WIPP site in 2013 was 40.66 °C (105.19 °F) in June, whereas the lowest surface temperature recorded was −10.83 °C (12.51 °F) in January. Monthly temperatures are illustrated in Figures 5.2, 5.3, and 5.4. The mean temperature at the WIPP site in 2013 was 17.11 °C (62.80 °F). The average monthly temperatures for the WIPP area ranged from 27.97 °C (82.35 °F) during June to 4.59 °C (40.26 °F) in December (Figure 5.3).



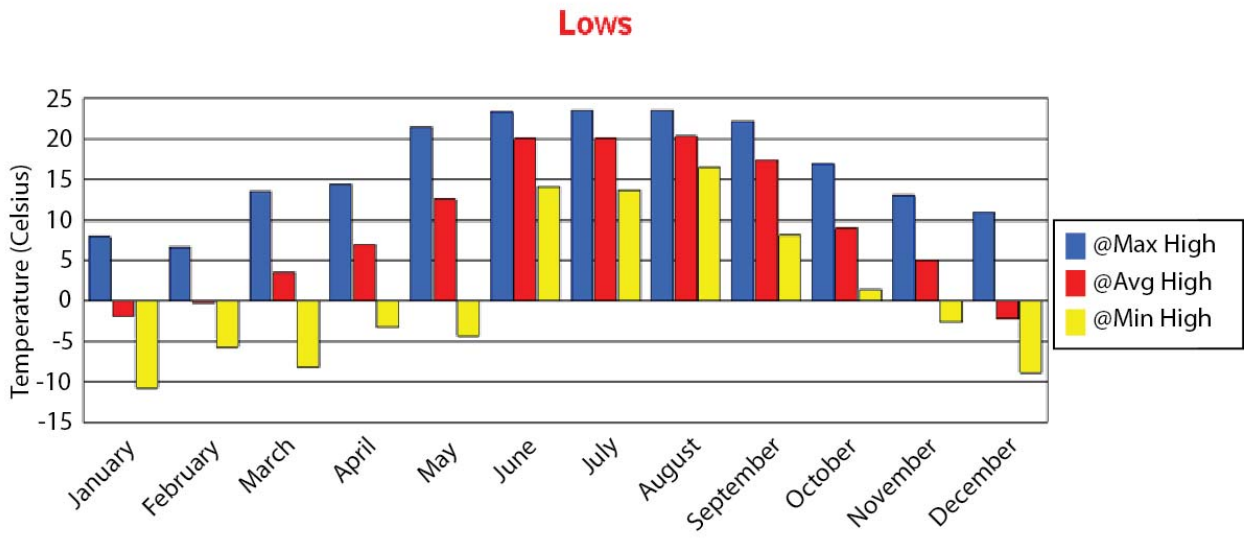
Month	Maximum High	Avgerage High	Minimum High
January	25.04	12.66	-0.23
February	23.63	16.73	9.04
March	30.50	22.48	11.21
April	35.24	25.85	13.47
May	37.83	30.02	13.70
June	40.66	35.93	28.36
July	37.31	32.52	20.15
August	37.81	34.58	31.48
September	36.82	30.25	21.65
October	33.50	25.35	14.54
November	24.93	19.43	1.21
December	22.72	12.11	-3.49

Figure 5.2 – WIPP Site High Temperatures for 2013



Month	Maximum Average	Avgerage Average	Minimum Average
January	14.12	5.19	-3.77
February	13.13	8.40	3.83
March	20.66	13.61	2.47
April	25.49	17.21	6.50
May	32.17	22.04	7.91
June	32.38	27.97	22.50
July	29.70	26.20	18.72
August	30.37	27.52	25.64
September	29.12	23.61	12.98
October	23.93	17.11	10.18
November	18.19	11.89	-1.56
December	17.62	4.59	-6.28

Figure 5.3 – WIPP Site Average Temperatures for 2013

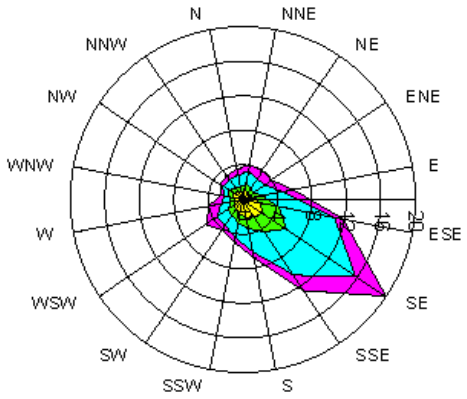


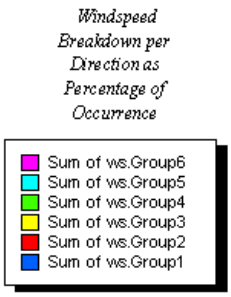
Month	Maximum Low	Avgerage Low	Minimum Low
January	7.92	-1.96	-10.83
February	6.71	-0.28	-5.76
March	13.45	3.46	-8.22
April	14.46	6.91	-3.32
May	21.45	12.58	-4.37
June	23.33	20.05	14.19
July	23.55	20.08	13.72
August	23.60	20.33	16.44
September	22.22	17.45	8.09
October	16.88	8.98	1.35
November	13.04	4.99	-2.68
December	11.04	-2.18	-8.89

Figure 5.4 – WIPP Site Low Temperatures for 2013

5.3.2 Wind Direction and Wind Speed

Winds in the WIPP area are predominantly from the southeast. In 2013, winds of 3.71 to 6.30 meters per second [m/s] (8.30 to 14.09 miles per hour [mph]) were the most prevalent, occurring approximately 42 percent of the time (measured at the 10-m level). There were no tornadoes at the WIPP site in 2013. Figure 5.5 displays the annual wind data at WIPP for 2013.





Group1 = 0.00 - 0.50
Group2 = 0.51 - 1.40
Group3 = 1.41 - 2.80
Group4 = 2.81 - 3.70
Group5 = 3.71 - 6.30
Group6 = 6.31 - XXX
(meters per second)

Wind Direction	Wind Speeds in meters per second						Total Percent Occurrence by Direction
	0.0 - 0.50	0.51 - 1.40	1.41 - 2.80	2.81 - 3.70	3.71 - 6.30	>6.30	
E	0.01	0.28	1.04	1.01	2.47	1.09	5.89
ENE	0.02	0.21	0.63	0.64	1.55	0.94	3.99
NE	0.02	0.25	0.79	0.67	1.29	0.92	3.93
NNE	0.01	0.26	0.92	0.72	1.43	0.76	4.10
N	0.01	0.19	0.72	0.55	1.42	0.66	3.55
NNW	0.02	0.18	0.84	0.56	1.22	0.49	3.31
NW	0.02	0.26	0.98	0.66	0.92	0.25	3.10
WNW	0.02	0.22	0.90	0.49	0.62	0.25	2.49
W	0.01	0.22	0.76	0.49	1.13	1.39	3.99
WSW	0.01	0.29	0.96	0.85	1.57	1.48	5.15
SW	0.01	0.27	1.14	0.89	1.39	0.55	4.25
SSW	0.02	0.31	1.45	1.05	1.75	0.40	4.97
S	0.03	0.44	1.68	1.29	2.81	0.56	6.80
SSE	0.04	0.43	1.90	2.11	6.09	2.17	12.74
SE	0.04	0.43	2.39	3.21	9.69	4.21	19.97
ESE	0.02	0.39	1.63	2.26	6.56	0.93	11.79
	0.29%	4.62%	18.72%	17.43%	41.89%	17.06%	100.00%

Figure 5.5 – WIPP Site Wind Speed (at 10-m level) Report for 2013

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.

The nine target VOCs selected for monitoring were determined to represent approximately 99 percent of the risk due to air emissions. A summary of the target VOC results from samples collected between January 1 and December 31, 2013, and the limits prescribed by Part 4 of the Permit are shown 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 HWDUs. 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 2013, sampling occurred in active and filled rooms of Panel 6 and an active room (i.e., Room 7) of Panel 7 at a frequency of once every two weeks 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 VOC monitoring in Room 1 of a filled panel unless an explosion-isolation wall is installed. For 2013, ongoing disposal room VOC monitoring was conducted in Panels 3 and 4 at a frequency of once per month.

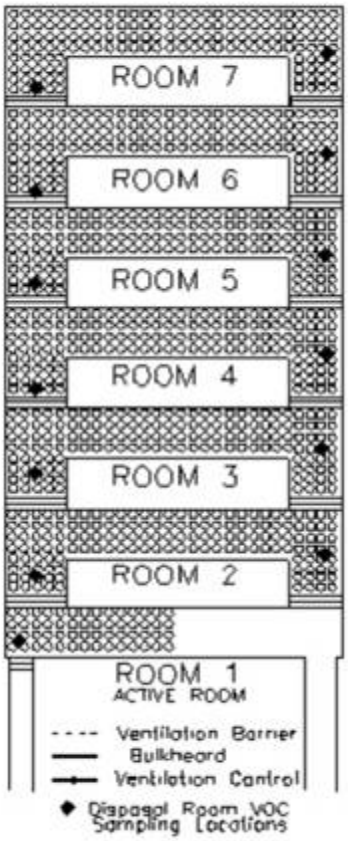


Figure 5.6 – Disposal Room VOC Monitoring

Repository VOC monitoring is performed twice per week at two ambient air monitoring stations: Station VOC-A, sample inlet located downstream from HWDU 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.

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 HWDU 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).

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 GC/MS 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, the results in 2013, compared to 2012, indicate significant increases in the running annual average values for 1,1,1-trichloroethane, chloroform, and carbon tetrachloride. The maximum detected emission concentrations for the four measurable compounds were also higher in 2013 than in 2012. The running annual average and emission concentration maximum values for 2013 are found in Table 5.1. This shows that at no time during 2013 did the concentrations exceed the concentrations of concern.

Table 5.1 – Summary of Repository VOC Monitoring Results

Target Compound	Running Annual Average Max. Value (ppbv)	Emission Concentration Max. Value (ppbv)	Concentration of Concern (ppbv)
Carbon tetrachloride	367.17	928.2	960
Chlorobenzene	0	0	220
Chloroform	32.52	94.4	180
1,1-Dichloroethylene	0	0	100
1,2-Dichloroethane	0	0	45
Methylene chloride	5.18	20.89	1,930
1,1,2,2-Tetrachloroethane	0	0	50
Toluene	0	0	190
1,1,1-Trichloroethane	52.54	111.8	590

ppbv = parts per billion by volume

A summary of disposal room VOC monitoring results for Panels 6 and 7 are shown in Table 5.2. Three of the nine target compounds were detected above the method reporting limit (MRL). During 2013, none of the samples exceeded the 50 or 95 percent action level.

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 Limits (ppmv)
Panel 6				
Carbon tetrachloride	2,209	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	131	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	15.75 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	521	16,850	32,015	33,700
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

ppmv = parts per million by volume
MDL = method detection limit
J = estimated concentration, below MRLs, but above MDL

Ongoing disposal room VOC monitoring was conducted in Panels 3 and 4 during 2013. None of the samples yielded concentrations exceeding the action levels. Ongoing disposal room VOC monitoring results are listed in Table 5.3.

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 Limits (ppmv)
Panel 3				
Carbon tetrachloride	7.54	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	1.32	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<1	1,480	2,812	2,960
Toluene	<1	5,500	10,450	11,000
1,1,1-Trichloroethane	5.36	16,850	32,015	33,700
Panel 4				
Carbon tetrachloride	856.43	4,813	9,145	9,625
Chlorobenzene	<MDL	6,500	12,350	13,000
Chloroform	55.29	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	24.14	50,000	95,000	100,000
1,1,2,2-Tetrachloroethane	<MDL	1,480	2,812	2,960
Toluene	1.97 J	5,500	10,450	11,000
1,1,1-Trichloroethane	144.34	16,850	32,015	33,700

ppmv = parts per million by volume

MDL = method detection limit

J = estimated concentration, below MRLs, but above MDL

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. In 2013, hydrogen and methane monitoring was conducted in Panels 3 and 4.

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 December 31, 2013, the maximum detected value for hydrogen, 400.52 ppmv, was considerably lower than the action levels (10 percent of action level 1 and 5 percent of action level 2, 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	68.48 J	4,000	8,000
Methane	<MDL	5,000	10,000
Panel 4			
Hydrogen	400.52	4,000	8,000
Methane	<MDL	5,000	10,000

ppmv = parts per million by volume

MDL = method detection limit

J = estimated concentration, below MRLs, but above MDL

5.6 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 2013 was approximately 75.1 percent. From January 1 through December 31, 2013, locations for 52 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 2.5) occurred on May 6, 2013, and was located approximately 279 km (173 mi) northeast of the site. The closest earthquake to the site was located approximately 33 km (20 mi) northwest and had a magnitude of 1.1.

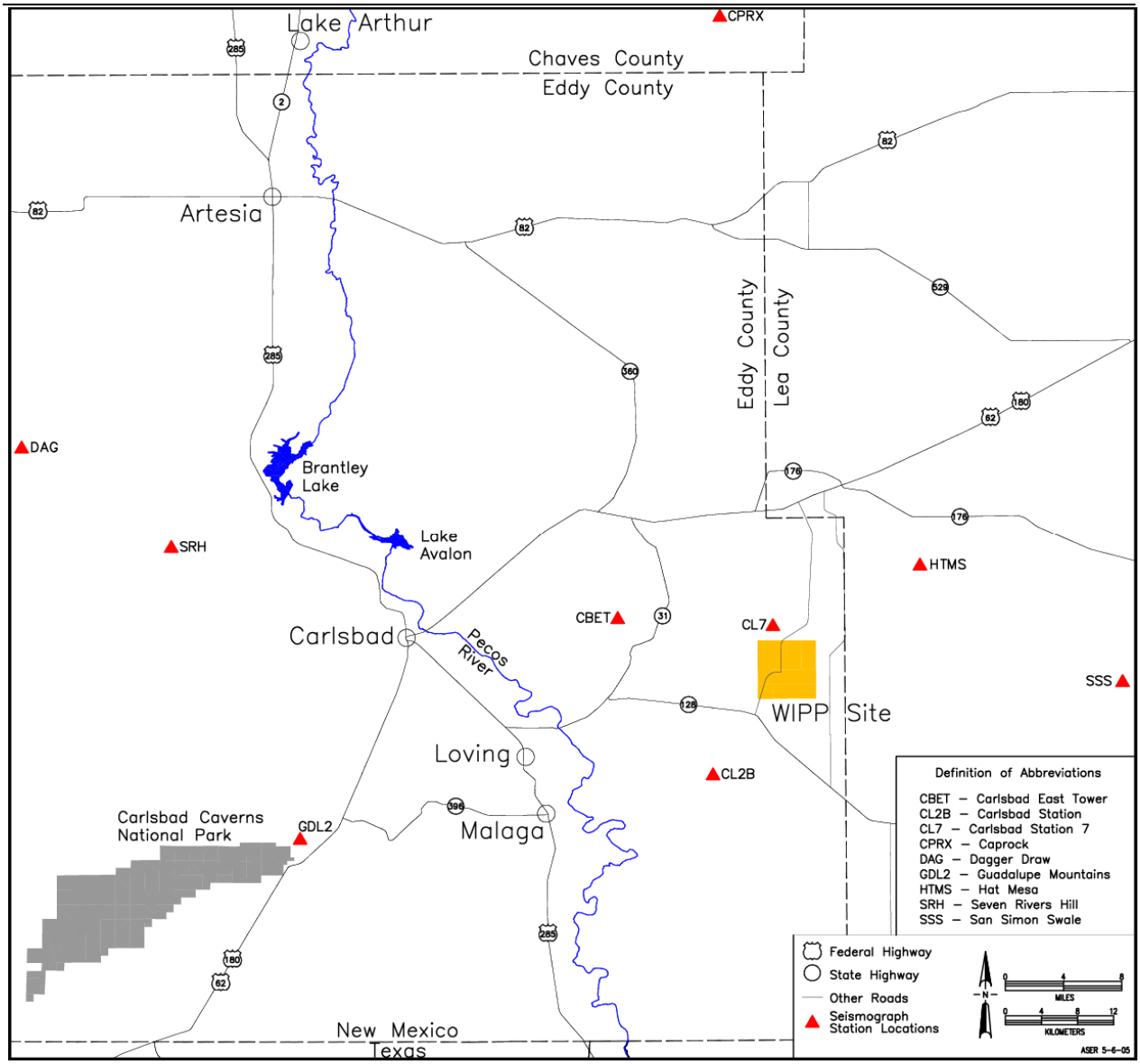


Figure 5.7 – Seismograph Station Locations in the Vicinity of the WIPP Site

5.7 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 September 9, 2008. A modification to the DP was submitted on November 15, 2009, to incorporate a new pond (the Salt Storage Extension Basin II) that was built to provide additional holding and evaporation capacity for runoff from the active Salt Storage Area. Analytical data from the discharge monitoring reports are summarized in Table 5.5 and Table 5.6.

Table 5.5 – Sewage Lagoon and H–19 Analytical Results for Spring 2013

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)	111	N/A	N/A	N/A
TDS (mg/L)	578[(a)]	NS	NS	NS
Sulfate (mg/L)	53[(a)]	NS	NS	NS
Chloride (mg/L)	79[(a)]	NS	NS	NS

N/A = not applicable
ND = non-detect
NS = not sampled
[(a)] = average of duplicate samples

Table 5.6 – Sewage Lagoon, H-19, and Infiltration Control Pond Analytical Results for Fall 2013

Location	Nitrate (mg/L)	TKN (mg/L)	TDS (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
Influent Pond 2A	ND	72.2	499[(a)]	46.9[(a)]	67.3[(a)]
Evaporation Pond B	N/A	N/A	352,000	19,000	260,000
Evaporation Pond C	N/A	N/A	570	72.4	172
H-19 Evaporation Pond	N/A	N/A	404,000	1,660	217,000
Salt Pile Evaporation Pond	N/A	N/A	42,000	254	24,000
Salt Storage Extension Evaporation Basin I	N/A	N/A	340,000	21,300	184,000
Salt Storage Extension Evaporation Basin II	N/A	N/A	266,000	8,950	153,000
Pond 1	N/A	N/A	768.5[(a)]	134.5[(a)]	276.5[(a)]
Pond 2	N/A	N/A	2,500	49.5	1,290
Pond A	N/A	N/A	1,510	99.1	647

[(a)] – average of duplicate samples
N/A – not applicable
ND – non-detect
NS – not sampled
TKN –total Kjeldahl Nitrogen (as N)
TDS – total dissolved solids

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 parameter 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 30 years. A summary of the hydrology in this area is contained in the following sections. Figure 6.1 shows the stratigraphy at the site.

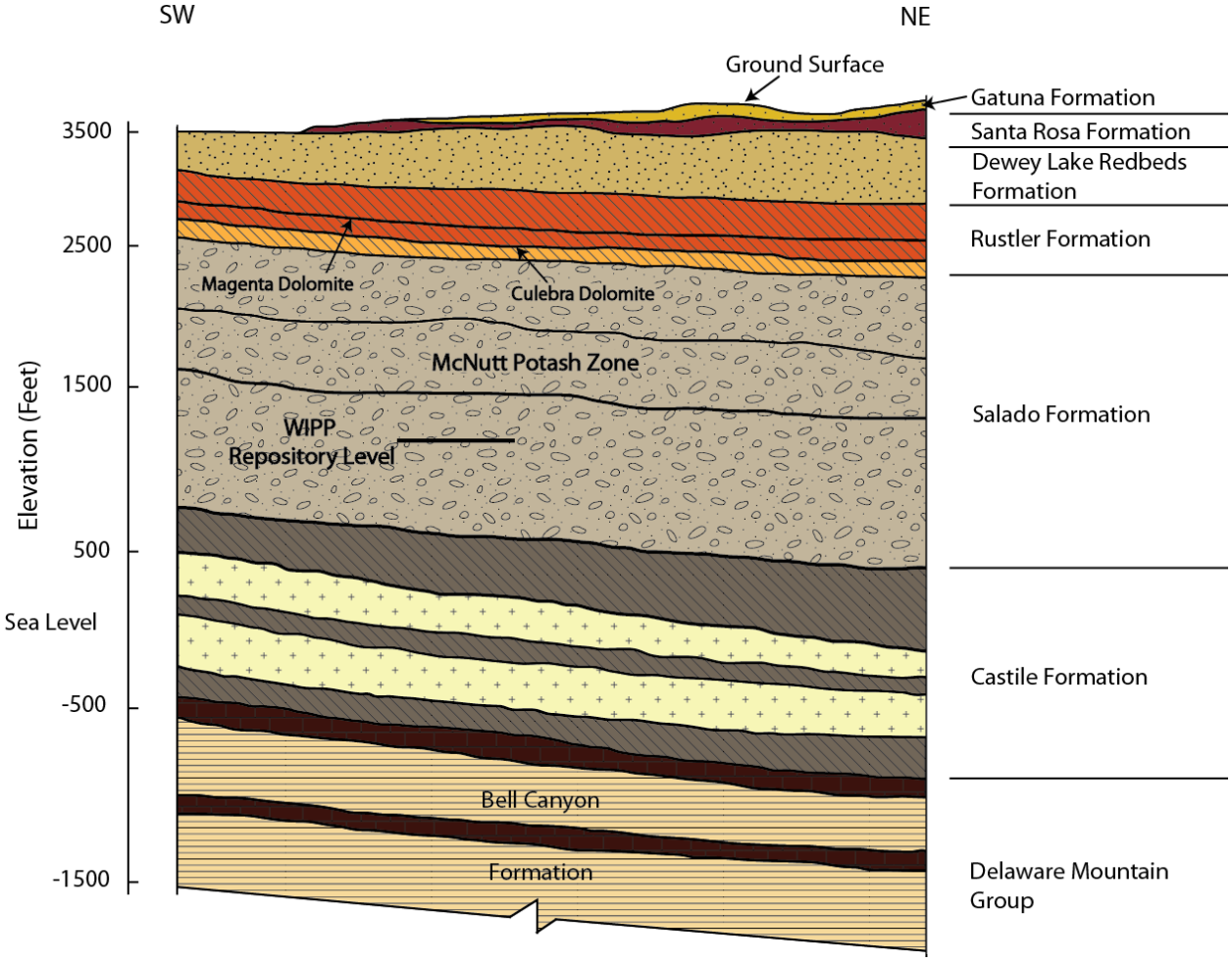


Figure 6.1 – WIPP Stratigraphy

6.1.1 Surface Hydrology

Surface water is absent at 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 km 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 have been 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 mile 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 also 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 WIPP 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 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 (see 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 mile) to the northeast of WQSP–6A on the C–2737 well pad (see Figure 6.2). Approximately 1.61 km (1 mile) 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, and because no water was found in this zone during the mapping of the shafts in 1980s, is deemed to be 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 6.15. During October 2007, three additional piezometers (PZ–13, PZ–14, and PZ–15) were installed around the site and preliminary design validation (SPDV) 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.

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 any 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 RCRA 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 2013 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 2013 included hydraulic testing and non-Permit groundwater quality sampling (Section 6.4). Table 6.1 presents a summary of WIPP groundwater monitoring activities in 2013.

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.8, lists active groundwater monitoring wells used by the DOE for the WIPP facility at the end of 2013.

Radiological data for 2013 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	276[a]
Number of Water Level Measurements	801
Total Number of Individual Analysis	1,206[b]

(a) Includes primary, duplicate, and blank samples taken from six wells during one round in 2013

(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 (PIP) 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 SR/DL [Santa Rosa/Dewey Lake contact] listed in Appendix F, Table F.8), were measured quarterly. Table F.9 shows the water level data. Water level data were not taken where access was unavailable, or in certain wells when testing equipment was present.

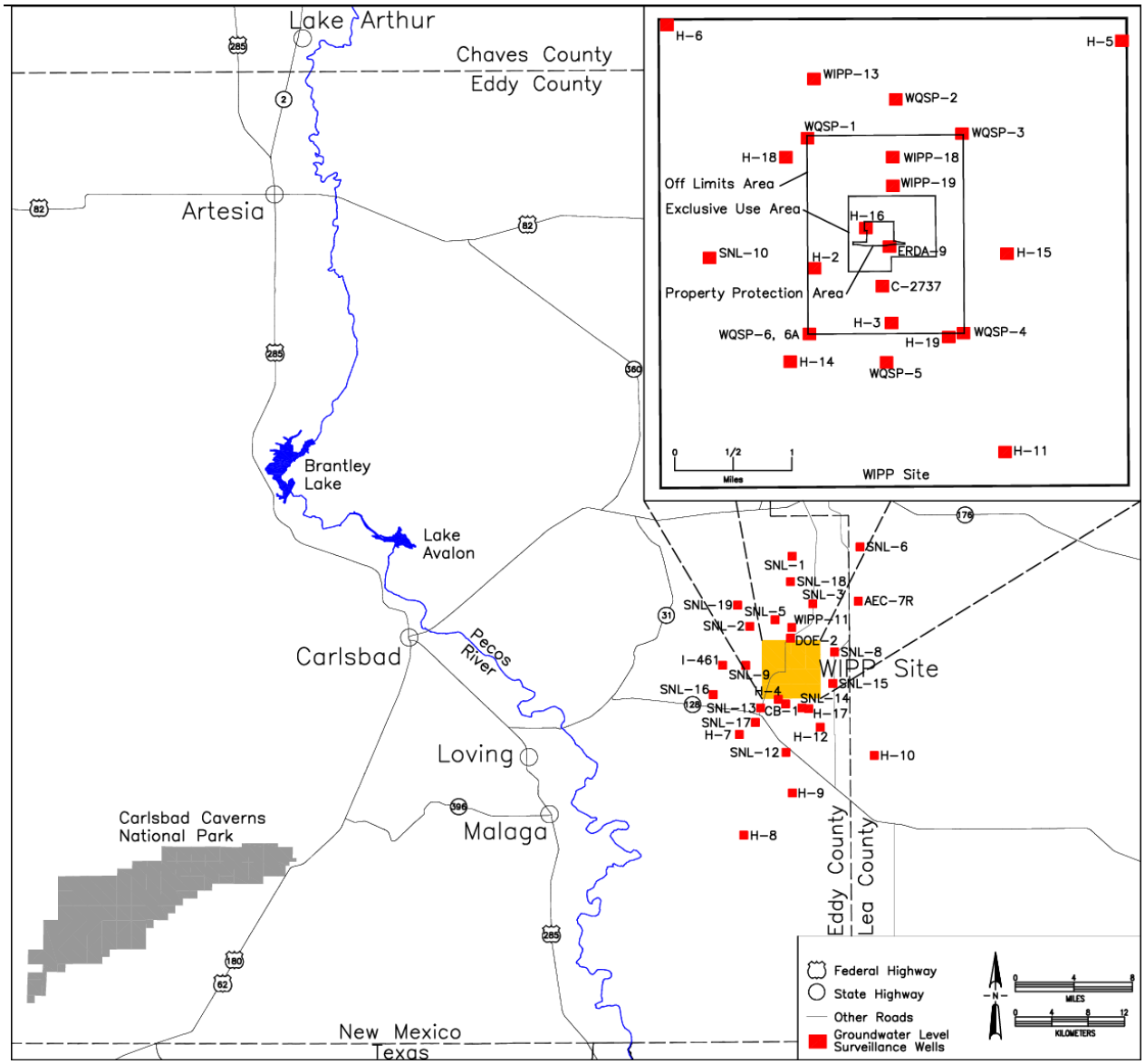


Figure 6.2 – Groundwater Level Surveillance Wells (Inset Represents the Groundwater Surveillance Wells in the WIPP Land Withdrawal Area)

6.2.3 Groundwater Quality Sampling

The Permit requires groundwater quality sampling once a year, from March through May (Round 35 for 2013). 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.

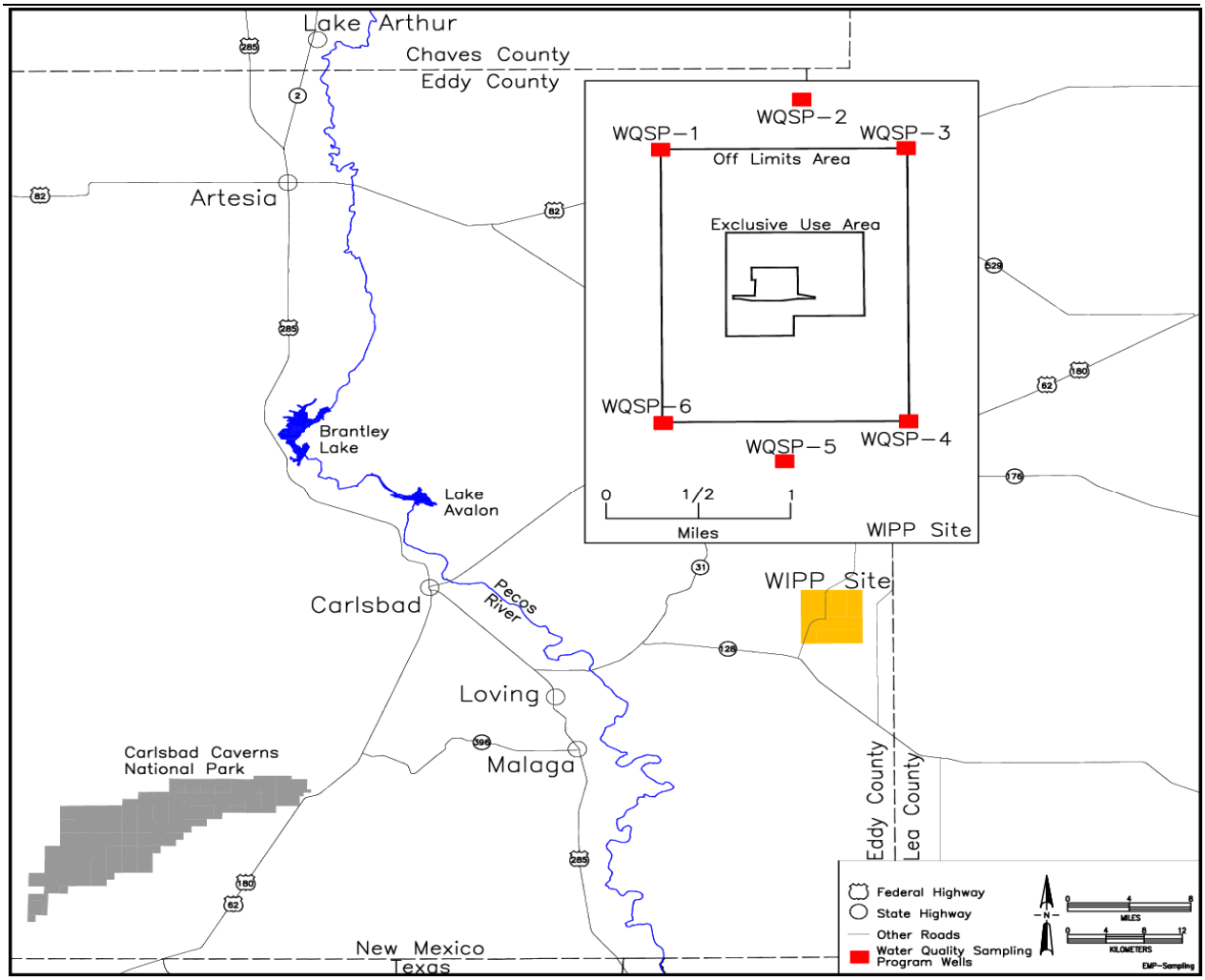


Figure 6.3 – Detection Monitoring Program Wells

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 276 samples analyzed per sampling round.

Wells WQSP–1, WQSP–2, and WQSP–3 are located 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 located downgradient of the WIPP shafts. WQSP–4 was also specifically located to monitor a zone of higher transmissivity.

The difference between the depth of the WIPP repository and the depth of the DMWs 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 2013 groundwater sampling program.

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 milligrams per liter (mg/L). In 2013, TDS concentrations in the Culebra (as measured in DMWs) varied from a low of 14,600 mg/L (WQSP–6) to a high of 220,000 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 2013, the TDS concentrations (Table 6.6) in water from well WQSP–6A, obtained from the Dewey Lake, averaged 3,480 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 2013 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 2013 (Round 35) are summarized in Appendix F, Tables F.1 through F.7. 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 35 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 35, 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 39 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 123 mg/L in the primary groundwater sample and 168 mg/L in the duplicate sample were higher than the 95th percentile concentration of 107 mg/L.
- WQSP–4: The TSS concentrations of 64 mg/L in the duplicate groundwater sample was higher than the 95th percentile concentration of 57.0 mg/L. The primary sample concentration was lower than the 95th percentile concentration at 51 mg/L, but the average of 58 mg/L was just above the 95th percentile.

The Round 35 VOC concentrations reported for man-made organic compounds were less than the Permit background values and less than the MRL in the groundwater samples except for the initial sampling of WQSP-5, which contained toluene. CBFO notified NMED of the toluene found in WQSP-5 with the intent to demonstrate that it was introduced when electrical tape was used to install the new pump. The well was subsequently purged and re-sampled twice. The first re-sampling resulted in the detection of toluene at concentrations of 7.6 ug/L in the primary sample and 8.1 ug/L in the duplicate sample. During the second re-sampling, toluene was detected above the MRL at 2.9 ug/L in both the primary and duplicate sample. All water quality data can be found in the 2013 Annual Culebra Groundwater report.

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 (total dissolved solids) TSS (total suspended solids) **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)
SVOC = semivolatile organic compound
VOC = volatile organic compound
Alkalinity, sodium, and sulfate are parameters for additional analysis

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 (SR/DL contact)
- Dewey Lake
- Magenta (MAG)
- Culebra (CUL)
- Bell Canyon (B/C)

Throughout 2013, 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 monitored. Nineteen wells in the SSW zone of the SR/DL contact were monitored. 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.9). 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 2013 is given in Appendix F, Table F.8. Note that one existing well (Culebra/Magenta C–2737) is completed at multiple depths by using a PIP.

Water elevation trend analysis was performed for 39 of 49 wells completed or isolated in the Culebra. The subset of wells analyzed were those that had a sufficient period of record to analyze through CY 2013 and did not display anomalous levels or trends (Appendix F, Table F.8). Additional filtering of the water level data was performed to remove human-introduced fluctuations, such as a new industrial use water well installed on Mills Ranch, which affected the southern wells toward the end of 2013. Excluded from trend analysis were SNL–6 and SNL–15, which were both in long-term water level recovery. SNL–13 was excluded due to stabilization following the drilling of a new oil or gas well nearby. H-16 was excluded due to its seasonal variations from being located next to the air intake shaft. Because they were only measured quarterly, the redundant H–19 wells were also excluded.

The dominant trend through 2013 was a spatially uniform, decreasing freshwater equivalent level in the Culebra monitoring wells at the WIPP site. The term “dominant” means that (1) water levels fell in 30 of 39 wells from January through December (or shorter periods in wells that still had a discernible trend); (2) the average water-level decrease was 0.30 m (0.99 ft); and (3) the general water-level drop is best indicated as follows: 15 measured water levels decreased in the zero (neutral) to 1-ft range, and 15 decreased more than 1 ft.

In 2013, the Permit required 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. There was no abnormal or unexplained change in the DMP wells outside the regional trend. Hydrographs for all Culebra groundwater wells are included in the *Annual Culebra Groundwater Report* (U.S. Department of Energy, November 2013).

For the Culebra wells in the vicinity of the WIPP site, equivalent freshwater heads for February 2013 were used to calibrate a groundwater flow model, which was used by SNL to compute a potentiometric surface using SNL procedure SP 9–9. This month was judged to have a large 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 (grams/cc)*	Notes
AEC-7	02/08/13	3062.29	1.067	
C-2737 (PIP)	02/12/13	3019.84	1.023	
ERDA-9	02/12/13	3033.27	1.073	
H-02b2	02/12/13	3044.79	1.012	
H-03b2	02/12/13	3011.85	1.036	
H-04bR	02/11/13	3006.48	1.017	
H-05b	02/08/13	3082.84	1.095	
H-06bR	02/11/13	3070.76	1.038	
H-07b1	02/07/13	2998.42	1.007	
H-09bR	01/07/13	2995.38	1.000	January data used as troll data show February was abnormally high.
H-10c	02/08/13	3031.01	1.094	
H-11b4R	02/11/13	3007.25	1.076	
H-12	02/11/13	3013.31	1.113	
H-15R	02/12/13	3017.25	1.118	
H-16	02/12/13	3046.01	1.037	Kept February because troll data show it had recovered from winter fluctuation.

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 (grams/cc)*	Notes
H-17	02/08/13	3007.07	1.133	
H-19b0	02/11/13	3013.48	1.066	
I-461	02/07/13	3041.24	1.000	
SNL-01	02/07/13	3080.22	1.029	
SNL-02	02/07/13	3072.44	1.009	
SNL-03	02/07/13	3078.79	1.028	
SNL-05	02/07/13	3072.74	1.009	
SNL-06	02/08/13	3220.92	1.243	Excluded from mapping.
SNL-08	02/08/13	3053.65	1.094	
SNL-09	02/07/13	3053.87	1.018	
SNL-10	02/07/13	3053.15	1.009	
SNL-12	02/08/13	3002.03	1.006	
SNL-13	02/07/13	3013.84	1.018	
SNL-14	02/08/13	3004.09	1.046	
SNL-15	02/08/13	3019.90	1.229	Excluded from mapping.
SNL-16	02/07/13	3010.31	1.009	
SNL-17	02/08/13	3005.30	1.005	
SNL-18	02/07/13	3072.47	1.005	
SNL-19	02/07/13	3072.48	1.007	
WIPP-11	02/12/13	3080.81	1.038	
WIPP-13	02/12/13	3076.06	1.041	
WIPP-19	02/12/13	3062.78	1.052	
WQSP-1	02/12/13	3075.52	1.051	
WQSP-2	02/12/13	3082.46	1.048	
WQSP-3	02/12/13	3073.16	1.147	
WQSP-4	02/11/13	3015.32	1.077	
WQSP-5	02/12/13	3012.70	1.027	
WQSP-6	02/08/13	3024.18	1.015	

amsl = above mean sea level

cc = cubic centimeter

* = 2013 conversion to specific gravity at 70˚F

Modeled freshwater head contours for February 2013 for the model domain are shown in Figure 6.4. These contours were generated using the results of the Culebra MODFLOW 2K (Harbaugh et al., 2000) run utilizing 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 February 2012 Culebra freshwater heads presented in this report. The portion of the flow domain of interest to the site is extracted as shown in Figure 6.5. The freshwater head values for February 2013 were computed using 2012 densities.

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.

The illustrated particle in Figure 6.5 (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 6,234 years (output from DTRKMF is adjusted from a 7.75 m Culebra thickness), for an average velocity of 0.65 meter per year (m/yr). 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.

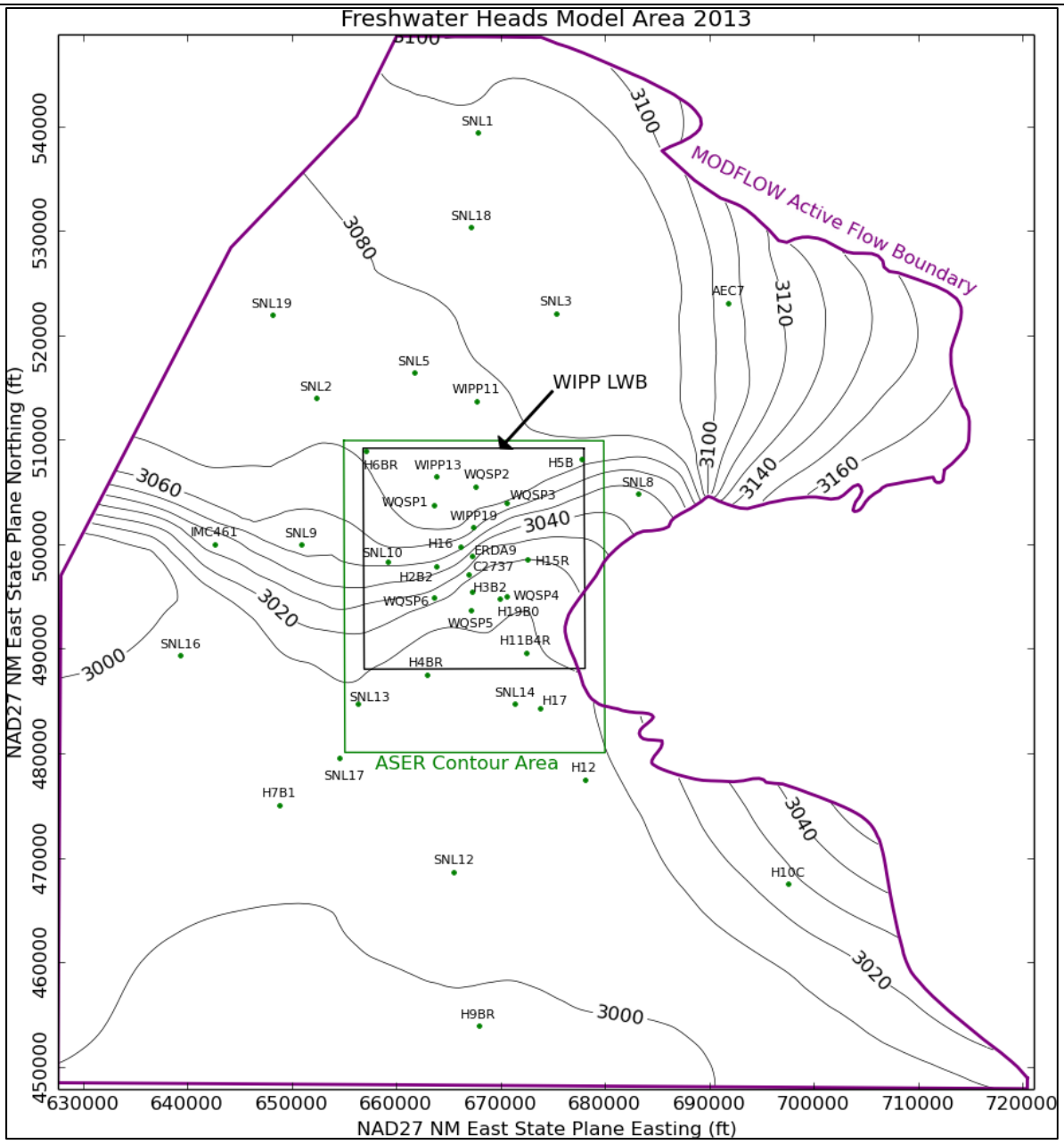


Figure 6.4 – Model-Generated February 2013 Freshwater Head Contours in the Model Domain (contour interval in ft amsl)

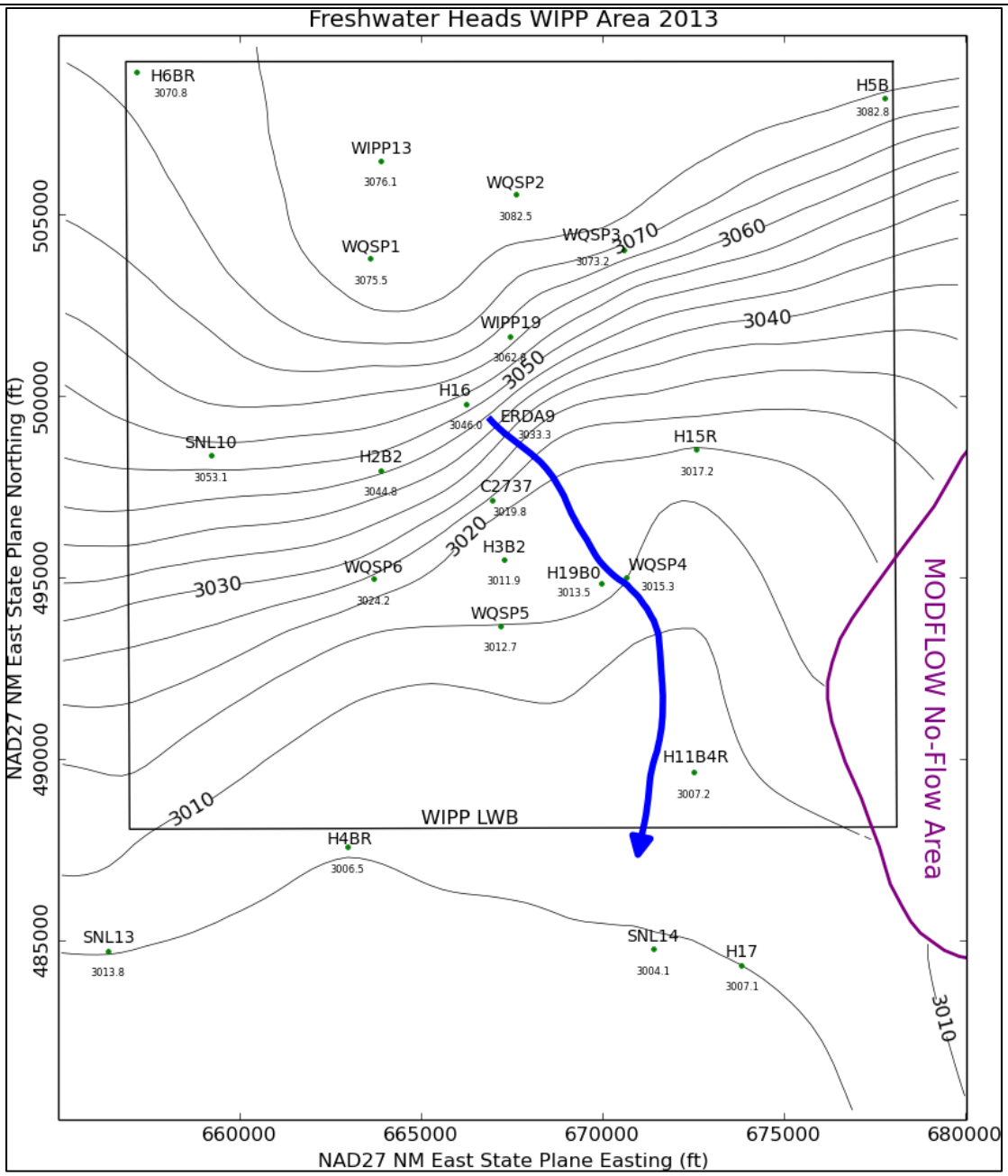


Figure 6.5 – Model-Generated February 2013 Freshwater Head Contours (5-foot Contour Interval) in the WIPP Vicinity with Blue Water Particle Track from Waste-Handling Shaft to WIPP Land Withdrawal Boundary (contour interval in ft amsl)

6.2.6 Fluid Density Surveys

At the WIPP site, variable TDS concentrations result in variability in groundwater density (WP 02–1). WIPP measures 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 2013, densities were derived from 37 wells from pressure transducers installed by SNL (see Table 6.4), six 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, 2011 and 2012 density data are shown. All year-to-year density differences are within the error as described in WP 02-1.

Table 6.4 – Fluid Density Survey for 2013

Well	2011 Fluid Density Survey Result	2011 Conversion to Specific Gravity at 70° F	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	Notes for 2011-2013 Fluid Density Survey
	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	
AEC-7	1.069	1.071	1.065	1.067	1.066	1.068	
C-2737	1.025	1.027	1.021	1.023	1.021	1.023	
ERDA-9	1.071	1.073	1.071	1.073	1.069	1.071	
H-02b2	1.010	1.012	1.010	1.012	1.011	1.013	
H-03b2	1.039	1.041	1.034	1.036	1.030	1.032	
H-04bR	1.015	1.017	1.015	1.017	1.015	1.017	
H-05b	1.095	1.097	1.093	1.095	1.090	1.092	
H-06bR	1.036	1.038	1.036	1.038	1.037	1.039	
H-07b1	1.004	1.006	1.005	1.007	1.005	1.007	
H-9bR	1.000*	1.000*	1.000*	1.000*	0.999	1.001	* Rounded up to 1.000 for 2011 and 2012.
H-10c	1.092	1.094	1.092	1.094	1.093	1.095	
H-11b4	1.039	1.041	NA	NA	NA	NA	Plugged and abandoned in November 2011.
H-11b4R	NA	NA	1.074	1.076	1.074	1.076	New replacement well to H-11b4 drilled in 2011.
H-12	1.105	1.107	1.111	1.113	1.106	1.108	
H-15R	1.117	1.119	1.116	1.118	1.116	1.118	
H-16	1.035	1.037	1.035	1.037	1.034	1.036	
H-17	1.134	1.136	1.131	1.133	1.131	1.133	
H-19b0	1.064	1.066	1.064	1.066	1.064	1.066	
H-19b2	1.059	1.061	1.060	1.062	1.066	1.068	
H-19b3	1.052	1.054	1.064	1.066	1.064	1.066	
H-19b4	1.054	1.056	1.065	1.067	1.064	1.066	
H-19b5	1.062	1.064	1.067	1.069	1.067	1.069	
H-19b6	1.061	1.063	1.068	1.070	1.068	1.070	
H-19b7	1.062	1.064	1.070	1.072	1.068	1.070	
I-461	1.000*	1.000*	1.000*	1.000*	1.000*	1.000*	* Rounded up to 1.000 for 2011–2013.

Table 6.4 – Fluid Density Survey for 2013

Well	2011 Fluid Density Survey Result	2011 Conversion to Specific Gravity at 70° F	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	Notes for 2011-2013 Fluid Density Survey
	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	Density (g/cc)	
SNL-01	1.029	1.031	1.027	1.029	1.028	1.030	
SNL-02	1.007	1.009	1.007	1.009	1.007	1.009	
SNL-03	1.026	1.028	1.026	1.028	1.026	1.028	
SNL-05	1.007	1.009	1.007	1.009	1.007	1.009	
SNL-06	1.239	1.241	1.241	1.243	1.241	1.243	
SNL-08	1.092	1.094	1.092	1.094	1.093	1.095	
SNL-09	1.016	1.018	1.016	1.018	1.016	1.018	
SNL-10	1.007	1.009	1.007	1.009	1.008	1.010	
SNL-12	1.003	1.005	1.004	1.006	1.004	1.006	
SNL-13	1.023	1.025	1.016	1.018	1.015	1.017	
SNL-14	1.045	1.047	1.044	1.046	1.044	1.046	
SNL-15	1.230	1.232	1.227	1.229	1.227	1.229	
SNL-16	1.006	1.008	1.007	1.009	1.006	1.008	
SNL-17	1.004	1.006	1.003	1.005	1.003	1.005	
SNL-18	1.005	1.007	1.003	1.005	1.007	1.009	
SNL-19	1.004	1.006	1.005	1.007	1.005	1.007	
WIPP-11	1.036	1.038	1.036	1.038	1.036	1.038	
WIPP-13	1.041	1.043	1.039	1.041	1.038	1.040	
WIPP-19	1.050	1.052	1.050	1.052	1.050	1.052	
WQSP-1	1.047	1.049	1.049	1.051	1.047	1.049	Average Round 35, field hydrometer.
WQSP-2	1.046	1.048	1.046	1.048	1.045	1.047	Average Round 35, field hydrometer.
WQSP-3	1.143	1.146	1.145	1.147	1.146	1.148	Average Round 35, field hydrometer.
WQSP-4	1.074	1.076	1.075	1.077	1.074	1.076	Average Round 35, field hydrometer.
WQSP-5	1.025	1.027	1.025	1.027	1.025	1.027	Average Round 35, field hydrometer.
WQSP-6	1.015	1.017	1.013	1.015	1.013	1.015	Average Round 35, field hydrometer.

NA= no available measurement

g/cc= grams per cubic centimeter

6.3 Drilling Activities

Well AEC-7 was plugged and abandoned due to its deteriorating condition and replaced by AEC-7R in September 2013. The total depth of the drill hole was 891 ft below ground surface with the screened interval in the Culebra at 875-855 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 also conducted basic water chemistry tests in one other well as listed in Table 6.5.

Table 6.5 – 2013 Well Testing Activities

Well Location	Dates	Activity
AEC-7R, Culebra	September through December 2013	SNL development and pumping test

6.5 Well Maintenance

Well maintenance for 2013 included retrieving broken pieces of polyvinyl chloride pipe left in wells SNL-10 and SNL-18 after past testing activities. SNL-1 was brushed and bailed in May to remove scale buildup on the screen.

6.6 Shallow Subsurface Water Monitoring Program

Shallow subsurface water occurs beneath the WIPP site at a depth of less than 100 ft below ground level at the contact between the Santa Rosa and the Dewey Lake (Figure 6.6). Water yields are generally less than 1 gallon per minute in monitoring wells and piezometers, and the water contains varying concentrations of TDS (1,710 mg/L to 262,000 mg/L) and chloride (348 mg/L to 139,000 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.

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) have been drilled as part of a monitoring program to measure spatial and temporal changes in SSW levels and water quality. Monitoring activities during 2013 included SSW level surveillance at these 19 locations (Figure 6.6).

In addition, drilling in 2007 around the SPDV salt pile tailings revealed shallow water in three piezometers (PZ–13, PZ–14, and PZ–15, shown in Figure 6.6). 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.

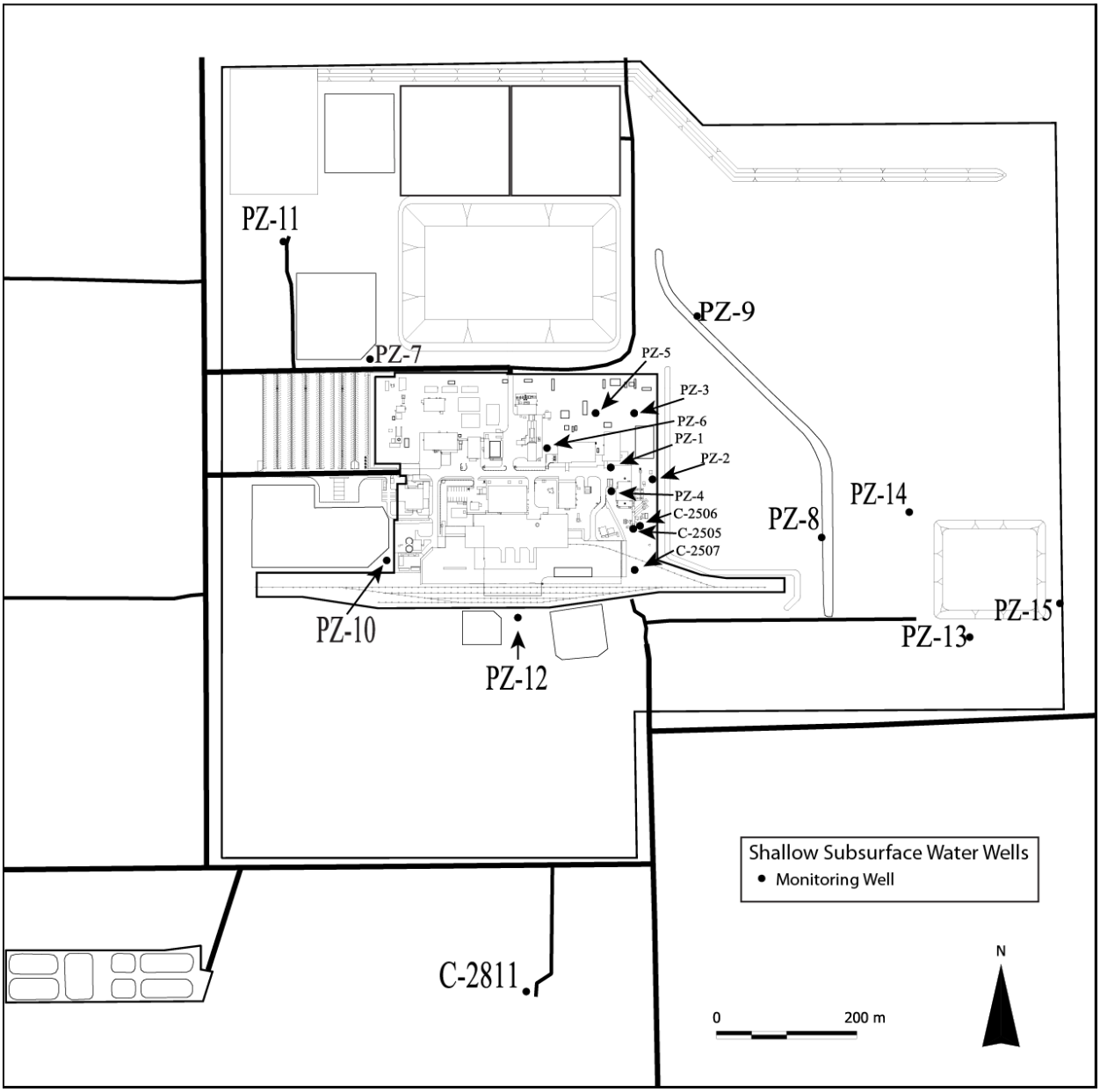


Figure 6.6 – Location of Shallow Subsurface Water Wells (Piezometers PZ–1 through PZ–15, C–2811, C–2505, C–2506, and C–2507)

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 2013, and the parameters shown in Table 6.6 were analyzed.

Table 6.6 – 2013 DP-831 Groundwater Quality Sampling Results

Well	Sample Date	Sulfate (mg/L)	Chloride (mg/L)	TDS (mg/L)	Nitrate (mg/L)	TKN (mg/L)
PZ-1	5/14/2013	1,840	35,800	74,400	NA	NA
PZ-1	10/22/2013	2,050	42,500	100,000	NA	NA
PZ-5	5/15/2013	1,200	9,540	19,200	NA	NA
PZ-5	10/23/2013	1,180	11,400	25,200	NA	NA
PZ-6	5/15/2013	2,060	47,900	86,900	NA	NA
PZ-6	10/22/2013	2,120	46,000	90,500	NA	NA
PZ-7	5/13/2013	3,050	58,500	112,000	NA	NA
PZ-7	10/22/2013	3,100	61,100	126,000	NA	NA
PZ-9	5/14/2013	4,580	82,000	152,000	NA	NA
PZ-9	10/22/2013	4,620	88,200	179,000	NA	NA
PZ-10	5/13/2013	426	394	1,580	NA	NA
PZ-10	10/21/2013	434	348	1,710	NA	NA
PZ-11	5/13/2013	2,270	64,800	105,000	NA	NA
PZ-11	10/21/2013	2,360	59,000	123,000	NA	NA
PZ-12	5/13/2013	449	3,990	7,610	NA	NA
PZ-12	10/21/2013	415	3,320	8,110	NA	NA
PZ-13	5/14/2013	3,130	144,000	260,000	NA	NA
PZ-13	10/22/2013	3,220	139,000	262,000	NA	NA
C-2811	5/13/2013	328	872	2,090	NA	NA
C-2811	10/21/2013	341	838	2,490	NA	NA
C-2507	5/14/2013	704	2,820	6,020	NA	NA
C-2507	10/21/2013	692	3,270	8,350	NA	NA
WQSP-6A	5/14/2013	2,260	318	3,420	5.29	<1.0
WQSP-6A	10/23/2013	1,840	284	3,540	5.85	<1.0
NA: Not analyzed, not required per permit conditions						

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 6.6.

The potentiometric surface for the SSW using December 2013 data is presented in Figure 6.7. 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 SPDV salt pile were estimated by hand.

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 6.7). 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 SPDV 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 SPDV 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 minimized 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 miles south-southwest of the WIPP surface facilities and about 1.75 miles south of WQSP–6A (see Figure 6.2). These wells are used for livestock and industrial purposes. TDS concentrations 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).

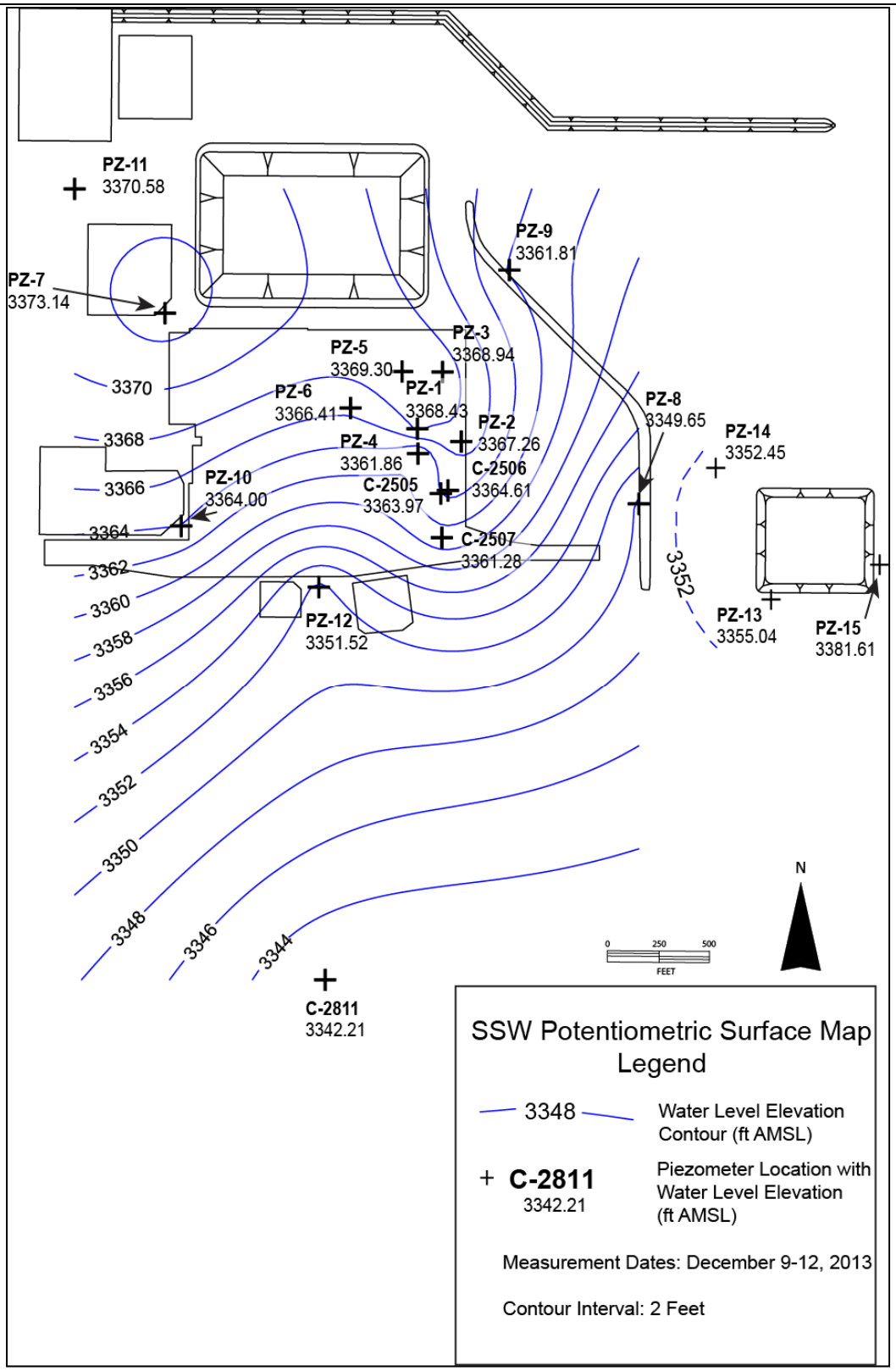


Figure 6.7 – Shallow Subsurface Water Potentiometric Surface

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 2013, 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 nonradiological VOC analyses, and Hall Environmental Analysis Laboratory (HEAL) in Albuquerque, New Mexico, performed the nonradiological 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 [ICP/MS]) and is accredited by The NELAC Institute (TNI). 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 (NIST) Radiochemistry Inter-comparison 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 Nuclear Waste Partnership LLC, *Quality Assurance Program Description* (WP 13–1). The Organic Chemistry Laboratory at CEMRC was not required to participate in inter-comparison programs during 2013.

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 contain such elements as the following:

- Management and organization
- Quality system and description
- Personnel qualification and training
- Procurement of products and services
- Documents and records

- Computer hardware and software
- Planning
- Management of work processes (SOPs)
- Assessment and response
- Quality improvement

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. 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 2013 were representative of the baseline concentrations for the radionuclides of interest.

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 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 2013.

7.1.2 Precision

The SOW states that analytical precision (as evaluated through replicate measurements) will meet or surpass 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:

$$RER = \frac{(Mean\ Activity)ori - (Mean\ Activity)dup}{\sqrt{(2\sigma TPU)^2 ori \mid (2\sigma TPU)^2 dup}}$$

Where:

$(Mean\ Activity)_{ori}$ = mean activity of the original or primary sample
$(Mean\ Activity)_{dup}$ = mean activity of the duplicate sample
2 σ TPU = total propagated errors at the 2 σ level

In order to generate analysis precision data, the laboratory performed duplicate analyses on separate portions of the same homogenized sample. At least one sample was taken from each batch for each type of sample matrix except for air filter composite samples, where only one sample is available. 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 nearly every RER met the WIPP QA objective of less than 1 for the sample batches analyzed in 2013, demonstrating good precision for the analysis procedures. (Note that the WIPP precision requirement of the RER less than 1 is stricter than the precision objective for samples from other clients analyzed by WIPP Laboratories where the RER is less than 2.)

The RERs for field duplicate samples were also 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.

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-CY2008* (Doc. No. S05247, U.S. Department of Energy, April 2009). This source suggests that 85 percent of field duplicates should yield RERs less than1.96. 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 1 was compiled from the data in Tables 4.6, 4.8, 4.12, 4.16, 4.20, and 4.22 (see Appendix C for location codes): Duplicate analysis results for all the target radionuclides are considered, not just those results where the analyte was detected.

1. ^{238}U yielded a RER of 2.11 in the duplicate air filter composite samples collected at location WEE during the second quarter. The ^{238}U was detected in one of the samples but not the other.
2. ^{90}Sr yielded a RER of 1.12 in the duplicate air filter composite samples collected from location MLR during the fourth quarter (^{90}Sr was not detected in the samples).
3. ^{235}U yielded a RER of 1.46 in the duplicate groundwater samples collected from WQSP-6 during Round 35 (^{235}U was detected in the samples).
4. ^{40}K yielded a RER of 1.16 in the duplicate sediment samples collected at location HIL (^{40}K was detected in the samples).
5. ^{60}Co yielded a RER of 1.11 in the duplicate sediment samples collected at location HIL (^{60}Co was not detected in the samples).
6. $^{233/234}$U yielded a RER of 1.15 in the duplicate soil samples taken from 0-2 cm at location WEE ($^{233/234}$U was detected in the samples).
7. ^{235}U yielded a RER of 2.80 in the duplicate soil samples taken from 5-10 cm at location WEE (^{235}U was detected in one of the duplicate samples but not the other).
8. ^{90}Sr yielded a RER of 1.27 in the duplicate soil samples taken from 0-2 cm at location WEE (^{90}Sr was not detected in the samples).

The precision data show that only two air filter composite duplicate sample RERs were greater than one (2.11 and 1.12), with one value greater than 1.96. The ^{238}U was detected in a few of the filters, but also in the filter method blanks. In the case of the duplicate samples from WEE, ^{238}U was detected on one of the air filter composites but not the other. Overall, the precision of the air filter composite field duplicates was very good and demonstrated that the sampling and analysis procedures were performed consistently.

The other samples with RERs greater than1 included ^{235}U in duplicate groundwater samples, ^{40}K in duplicate sediment samples, $^{233/234}U$ in duplicate soil samples, ^{235}U in duplicate soil samples, and ^{90}Sr in duplicate soil samples. The RER for ^{235}U was greater than 1.96 at 2.80, and the radionuclide was detected in one of the duplicate soil samples but not the other.

The precision objective was met for all the target isotopes in the duplicate surface water and vegetation samples.

7.1.3 Accuracy

The accuracy of the radiochemical analyses was checked by analyzing initial and continuing calibration standards, reagent method blanks, some field blanks, and laboratory control samples (LCSs) (blank spikes) 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. Instrument accuracy was assured by using NIST-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 LCS was analyzed to check that the analytical method was in control by measuring the percent recoveries of the target analytes spiked into clean water. Duplicate LCS samples were prepared and analyzed for some of the radiochemical batches.

The radiochemical SOW requires the measured accuracy to meet or surpass 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 samples.

NIST-traceable standards were spiked into clean water or a clean solid matrix to prepare LCS samples. Analysis of LCSs 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. LCS 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 all the radiological LCS 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 (DOELAP), and the NRIP interlaboratory comparison program (through NIST), 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 DOELAP, 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 DOELAP and NRIP programs 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 DOELAP program performance evaluation (PE) 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 PE 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 PE samples distributed as part of inter-laboratory comparison programs by reputable agencies. The DOELAP, MAPEP, and NRIP programs 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 (W) 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 PE samples (Series 27) analyzed in 2013. The acceptable range for the MAPEP samples is a bias less than or equal to ±20 percent; the acceptable range with a warning (W) 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.

Table 7.1 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2013, First Set (Series 27)

	MATRIX: Soil (Bq/kg) MAPEP–12–MaS27				MATRIX: Water (Bq/L) MAPEP–12–MaW27			
Analyte	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E[c]**	**% Bias**	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E**	**% Bias**
^{241}Am	104	111	A	-6.3	1.01	1.06	A	-4.7
^{60}Co	513	531	A	-3.4	30.8	29.3	A	5.1
^{137}Cs	1080	1150	A	-6.1	16.1	16.7	A	-3.6
^{238}Pu	109	105.8	A	3.0	0.0137	0.013	A	(d)
$^{239/240}$Pu	136	134	A	1.5	1.51	1.61	A	-6.2
^{90}Sr	502	508	A	-1.2	12.2	12.2	A	0.0
$^{233/234}$U	58.7	60.3	A	-2.7	0.489	0.451	A	8.4
^{238}U	261	263	A	-0.8	3.24	3.33	A	-2.7
^{40}K	643	632	A	1.7	139	134	A	3.7
	MATRIX: Air Filter (Bq/Filter) MAPEP–12–RdF27				**MATRIX: Vegetation (Bq/Sample) MAPEP–12–RdV27**			
Analyte	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E**	**% Bias**	**Reported [RN][a]**	**MAPEP[b] [RN][a]**	**E**	**% Bias**
^{241}Am	0.0701	0.0780	A	-10.1	0.158	0.163	A	-3.1
^{60}Co	1.86	1.728	A	7.6	5.54	5.12	A	8.2
^{137}Cs	-5.10	NR	A	(e)	6.68	5.66	A	18.0
^{238}Pu	0.0702	0.0625	A	12.3	0.201	0.187	A	7.5
$^{239/240}$Pu	0.00131	0.00081	A	(d)	0.132	0.123	A	7.3
^{90}Sr	1.06	1.03	A	2.9	0.0408	NR	A	(e)
$^{233/234}$U	0.0121	0.0141	A	-14.2	0.0290	0.0257	A	12.8
^{238}U	0.0782	0.100	W	-21.8	0.160	0.158	A	1.3
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

(a) Activity

(b) MAPEP = Mixed Analyte Performance Evaluation Program

(c) E = evaluation rating (A = acceptable, W = acceptable with warning, N = not acceptable)

(d) Sensitivity evaluation

(e) False positive test

Bq/kg = becquerels per kilogram

NR = not reported

NA = not applicable

The WIPP Laboratories analysis results for the soil, water, and vegetation samples showed that the results were acceptable for all the target radionuclides, which included 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 with the exception of a warning evaluation for ^{238}U. The lab also reported gross alpha/beta results for air filter sample MAPEP–12–GrF27. 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.

Table 7.2 presents the results for the second set of MAPEP soil, water, air filter, and vegetation PE samples (MAPEP–13, Series 28) analyzed in 2013. The data in Table 7.2 show that the WIPP Laboratory results for the MAPEP Series 28 samples were acceptable for the target radionuclides in the soil, air filters, and vegetation samples. The results were acceptable for water except for one result for ^{40}K that was not acceptable the radionuclide was not present in the sample, but was reported with a concentration of 12.4 Bq/L.

Table 7.2 – Mixed Analyte Performance Evaluation Program Review for WIPP Laboratories, 2013 Second Set (Series 28)

	MATRIX: Soil (Bq/g) MAPEP–13-MaS28				MATRIX: Water (Bq/L) MAPEP–13–MaW28			
Analyte	**Reported [RN]^{a}**	**MAPEP^{b} [RN]^{a}**	**E^{c}**	**% Bias**	**Reported [RN]^{a}**	**MAPEP^{b} [RN]^{a}**	**E**	**% Bias**
^{241}Am	109	113	A	-3.5	0.671	0.689	A	-2.6
^{60}Co	641	691	A	-7.2	17.9	19.56	A	-8.5
^{137}Cs	529	587	A	-9.9	0.0289	NR	A	(e)
^{238}Pu	0.486	0.52	A	(d)	0.869	0.884	A	-1.7
$^{239/240}$Pu	80.5	79.5	A	1.3	0.0115	0.0096	A	(d)
^{90}Sr	613	628	A	-2.4	9.96	10.5	A	-5.1
$^{233/234}$U	63.1	62.5	A	1.0	0.324	0.315	A	2.9
^{238}U	281	281	A	0.0	1.93	1.95	A	-1.0
^{40}K	634	625.3	A	1.4	12.4	NR	N	(e)
	MATRIX: Air Filter (Bq/filter) MAPEP–13–RdF28				**MATRIX: Vegetation (Bq/Sample) MAPEP–12–RdV27**			
[RN]	**Reported Value**	**MAPEP Value**	**E**	**% Bias**	**Reported Value**	**MAPEP Value**	**E**	**% Bias**
^{241}Am	0.0965	0.104	A	-7.2	0.130	0.140	A	-7.1
^{60}Co	0.0482	NR	A	(e)	6.49	5.85	A	10.9
^{137}Cs	2.67	2.60	A	2.7	7.21	6.87	A	4.9

^{238}Pu	0.134	0.127	A	5.5	0.111	0.110	A	0.9
$^{239/240}Pu$	0.124	0.121	A	2.5	0.123	0.123	A	0.0
^{90}Sr	1.46	1.49	A	-2.0	1.66	1.64	A	1.2
$^{233/234}U$	0.0324	0.0318	A	1.9	0.00338	0.0038	A	(d)
^{238}U	0.230	0.231	A	-0.4	0.00159	0.0022	A	(d)
^{40}K	NR	NR	NA	NA	NR	NR	NA	NA

(a) Activity

(b) MAPEP = Mixed Analyte Performance Evaluation Program

(c) E = evaluation rating (A = acceptable, W = acceptable with warning, N = not acceptable)

(d) Sensitivity evaluation

(e) False positive test

NR = not reported

NA = not applicable

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 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 2013.

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 2013, 635 VOC samples (including field duplicates) were submitted to CEMRC for analysis; 630 of these produced valid data. For repository, disposal room, and ongoing disposal room VOC monitoring, the program completion percentage was greater than 99 percent.

For 2013, 360 hydrogen and methane samples (including field duplicates) were submitted to CEMRC for analysis; 360 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 an LCS and 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:

A = original sample result
B = duplicate sample result

A LCS and a LCSD were generated and evaluated for all data submitted in 2013. All the LCS/LCSD data generated during 2013 yielded RPDs less than or equal to 25.

All 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 2013, 87 of 89 field duplicates met the acceptance criterion. For each hydrogen and methane value reported over MRL, 24 of 24 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.

$$\text{Relative Response Factor} = \frac{(\text{Analyte Response})(\text{Internal Standard Concentration})}{(\text{Internal Standard Response})(\text{Analyte Concentration})}$$

$$\text{Relative Standard Deviation} = \left[\frac{\text{Standard Deviation of Relative Response Factor}}{\text{Average Relative Response Factor of Analyte}} \times 100\right]$$

For hydrogen and methane, the method does not require internal standards.

During 2013, 100 percent of instrument calibrations met the less than or equal to 30 percent criteria.

LCS Recoveries

LCS recoveries are required to have a percent recovery of ±40 percent (60 to 140 percent recovery). LCS recoveries are calculated as:

$$PercentRecovery = \frac{X}{T} \times 100$$

X = experimentally determined value of the analyte recovered from the standard
T = true reference value of the analyte being measured

During 2013, 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 2013, 100 percent of all 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). For 2013, CEMRC completed MDL studies for VOC analyses in August and October and for hydrogen methane analysis in October.

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 2013, all 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 35 groundwater sampling in 2013. 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). HEAL subcontracted the trace metals analysis for antimony (Sb), arsenic (As), selenium (Se), and thallium (Tl) by ICP-MS to Anatek Laboratories in order to achieve the requisite detection limits.

7.3.1 Completeness

Six WQSP monitoring wells were sampled once in 2013 during the period March through May for the WIPP groundwater DMP. The completeness objective was met as analytical results were received for all 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. LCSD samples were only 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 is measured. These methods included GC/MS analyses, ICP analyses, and ICP-MS analyses. MS and MSD samples were generated by spiking the target constituents and general chemistry indicator parameter analytes into separate portions of the primary groundwater samples. The LCS/LCSD 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/LCSD 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 the field sample in duplicate and calculating the associated RPD. The quality assurance objective for the precision of the LCS/LCSD, MS/MSD, and duplicate sample concentrations is less than or equal to 20 RPD for all 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 expected to be consistent.

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 all the groundwater samples including chloride, total organic carbon (TOC), specific gravity, TDS, total suspended solids (TSS), pH, specific conductance, and alkalinity. The precision would not be expected to be as good for constituents and general chemistry parameters with 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. All 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 RPD was greater than 20 for analytes, especially the trace metals that exhibited results at low concentrations between the MDL and the MRL where the concentrations were J-flagged as estimated.

Table 7.3 – Individual Cases Where the Round 35 Groundwater RPDs were >20 for the Primary and Duplicate Groundwater Samples, MS/MSD Pairs, and Laboratory Duplicate QA/QC Samples

DMW[a]	Parameter or Constituent	Primary Sample, Conc. (or as noted)	Duplicate Sample, Conc. (or as noted)	RPD[b]
WQSP-1	Be	0.0047 mg/L J[c]	0.0028 mg/L J	51
WQSP-1	V	0.034 mg/L J	0.026 mg/L J	27
WQSP-1	2,4-dinitrophenol	23.7 ug/L (MS)[d]	49.1 ug/L (MSD)[e]	70
WQSP-1	2-methylphenol	55.0 ug/L (MS)	68.7 ug/L (MSD)	22
WQSP-1	3- + 4-methylphenol	55.1 ug/L (MS)	67.9 ug/L (MSD)	21
WQSP-1	Nitrobenzene	54.2 ug/L (MS)	67.7 ug/L (MSD)	22
WQSP-1	Pentachlorophenol	37.9 ug/L (MS)	59.9 ug/L (MSD)	45
WQSP-1	Pyridine	32.2 ug/L (MS)	17.1 ug/L (MSD)	61
WQSP-2	Ba	0.021 mg/L J	0.027 mg/L J	25
WQSP-2	V	0.020 mg/L J	0.031 mg/L J	43
WQSP-2	2,4-dinitrophenol	16.5 ug/L (MS)	20.4 ug/L (MSD)	21
WQSP-2	Pentachlorophenol	12.7 ug/L (MS)	16.9 ug/L (MSD)	28
WQSP-2	TSS	35 mg/L	24 mg/L (dup)	37
WQSP-3	TSS	123 mg/L	168 mg/L	31
WQSP-4	TSS	51 mg/L	64 mg/L	23
WQSP-5	Toluene (initial sampling)	141 ug/L	82.1 ug/L	53
WQSP-5	Pyridine	50.9 ug/L (MS)	40.9 ug/L (MSD)	22
WQSP-6	V	0.0051 mg/L J	0.0040 mg/L J	24

(a) DMW = Detection Monitoring Well
(b) RPD = relative percent difference
(c) J = estimated concentration between MDL and MRL
(d) MS = matrix spike
(e) MSD = matrix spike duplicate

Table 7.3 contains five entries for trace metals at concentrations between the MDL and MRL; three sample sets where the recoveries of some of the SVOCs were higher in one of the matrix spike samples compared to the other; and three cases where TSS was higher in one of the groundwater samples compared to the other or in one of the duplicates compared to the other. The primary and duplicate groundwater 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.

Considering the hundreds of groundwater sample data points and QA/QC sample data points that were generated during Round 35, the number of duplicate groundwater samples and QA samples that did not meet the precision quality assurance 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 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, 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 for VOCs in LCS samples and MS samples
- 90 – 110 percent for chloride and sulfate in LCS samples
- 80 – 120 percent for mercury and recoverable metals in LCS samples
- 75 – 125 percent for mercury and recoverable metals in MS samples
- 90 – 110 or 80 – 120 percent for general chemistry parameters in LCS samples
- 80 – 120 percent or 75 – 125 percent 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. Preferably there is 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 35 sampling and analysis in 2013. 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 lists only MS and MSD samples associated with analysis of VOCs and SVOCs except for the one recovery of Ni, which barely missed the recovery objective of 75 percent. In some cases the 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 calibration standards. Some MS/MSD recoveries for SVOCs 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, the recoveries were within the lab's historical control chart range and are not 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 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 analysis of these particular polar compounds may result in sorption of the compounds onto the GC column resulting in some tailing of the peaks.

Table 7.4 – Individual Cases where the Round 35 Accuracy Objectives Were Not Met for 2013 QA/QC Samples

DMW[a]	Constituent or Parameter	Sample	% Rec.	Sample	% Rec.
WQSP-1	Isobutyl alcohol	MS[b]	146	MSD[c]	156
WQSP-1	Pyridine	MS	32.2[d]	MSD	17.1
WQSP-2	Isobutyl alcohol	MS	138	MSD	147
WQSP-2	Pentachlorophenol	MS	12.7	MSD	16.9
WQSP-2	Nickel	MS	77.0[d]	MSD	74.6
WQSP-3	Isobutyl alcohol	MS	377	MSD	411
WQSP-3	2-butanone	MS	292	MSD	299
WQSP-3	1,1,2,2-tetrachloroethane	MS	199	MSD	183
WQSP-4	Isobutyl alcohol	MS	202	MSD	213
WQSP-4	2-butanone	MS	152	MSD	163
WQSP-5	Isobutyl alcohol	MS	152	MSD	145

(a) DMW = detection monitoring well
(b) MS = matrix spike
(c) MSD = matrix spike duplicate
(d) MS sample met accuracy objective

None of the constituents and parameters listed in Table 7.4 were detected in any of the groundwater samples.

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 GC/MS 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. All surrogate recoveries met the quality assurance for accuracy.

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 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 limit 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 interlaboratory 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 ICP-MS metals in several sets of performance evaluation samples. In 2013, HEAL analyzed five sets of PE samples, including three Phenova Water Pollution Proficiency Testing (WPPT) and two Phenova Water Supply Proficiency Testing (WSPT) 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, TKN, alkalinity, trace metals, mercury, specific conductance, pH, VOCs, and SVOCs (acids and base-neutrals). The PE samples covered all of 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 HEAL, 2013

PE Source	No. Results	No. Passing	Percent	Missed[a]	Assigned	Reported
Phenova WPPT[b] WP0413	277	274	98.9	Na	45.8 mg/L	52.8 mg/L
Phenova WSPT[c] WS0413	108	107	99.1	Hg	6.06 mg/L	9.27 mg/L
Phenova WPPT WP0513	33	33	100	None	NA	NA
Phenova WPPT[b] WP1013	311	302	97.1	1,2-dichlorobenzene(d) 1,3-dichlorobenzene(d) 1,4-dichlorobenzene(d)	56.5 39.1 50.4 —	37.6 23.4 31.3 —
Phenova WSPT[c] WS1013	112	111	99.1	None	NA	NA

(a) WIPP analytes only

(b) WPPT = Water Pollution Proficiency Testing

(c) WSPT = Water Supply Proficiency Testing

(d) Measured as VOCs

The results shown in table 7.5 show that HEAL earned very high percentages for acceptable analytical results in analyzing five different performance evaluation samples. There were five analytes where HEAL missed the acceptance range on one of the PE samples. The misses included Na in WPPT WP0413; Hg in WSTP WS0413; and the three dichlorobenzene isomers in WPPT WP1013. (Note that Na is not a required target WIPP analyte, but its concentration is needed for the cation-anion balance calculation, which is required.)

However, HEAL reported acceptable results for Na in WPPT WP1013 and WSPT WS1013; acceptable results for Hg in WPPT WP0413 and WSPT WS1013; acceptable results for 1,2-dichlorobenzene and 1,4-dichlorobenzene in WSPT WS1013 and WPPT WP0413; and acceptable results for 1,3-dichlorobenzene in WSPT WS0413, WPPT WP0413, and WSPT WS1013. The dichlorobenzenes can be analyzed both as volatile organic compounds and as semivolatile organic compounds. The PE sample in which Hall had “Not Acceptable” results for the dichlorobenzenes was analyzed for volatile organic compounds, while Hall analyzes for the dichlorobenzenes in groundwater samples as semivolatile organic compounds. All the PE sample results for the dichlorobenzene compounds analyzed as semivolatile organic compounds were Acceptable.

Overall, HEAL PE 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.

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APPENDIX A – REFERENCES

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WP 12–VC.01, *Confirmatory Volatile Organic Compound Monitoring Program*. Nuclear Waste Partnership, LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

WP 12–VC.04, *Quality Assurance Project Plan for Hydrogen and Methane Monitoring*. Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

WP 13–1, *Quality Assurance Program Description*. Nuclear Waste Partnership LLC. Waste Isolation Pilot Plant, Carlsbad, NM.

APPENDIX B – ENVIRONMENTAL PERMITS

Table B.1 – Major Active Environmental Permits for the Waste Isolation Pilot Plant as of December 31, 2013

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	09/09/08	09/09/13	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 1504 Facility Number 31539	7/1/13	6/30/14	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	10/23/12	03/31/14	Active
New Mexico Department of Game and Fish	Biotic Collection Permit	Authorization # 3293	01/26/11	12/31/13	Active

N/A = not applicable

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APPENDIX C – LOCATION CODES

Table C.1 – Codes Used to Identify the Sites from Which Samples Were Collected

Code	Location	Code	Location
BHT	Bottom of the Hill Tank	PD2	SWIC Pond 2 (DP–831)
BLK	Blank	PEC	Pecos River
BRA	Brantley Lake	PKT	Poker Trap
CBD	Carlsbad	PP1	Polishing Pond 1A (DP–831)
COW	Coyote Well (deionized water blank)	PP2	Polishing Pond 2B (DP–831)
COY	Coyote (surface water duplicate)	RED	Red Tank
EBA	SWIC Evaporation Basin A (DP–831)	SEC	Southeast Control
EB1	Salt Storage Extension Basin I (DP–831)	SMR	Smith Ranch
EB2	Salt Storage Extension Basin II (DP–831)	SOO	Sample Of Opportunity*
EPA	Evaporation Pond A (DP–831)	SP1	Settling Pond 1A (DP–831)
EPB	Evaporation Pond B (DP–831)	SP2	Settling Pond 2A (DP–831)
EPC	Evaporation Pond C (DP–831)	SPE	Salt Pile Evaporation Pond (DP–831)
FWT	Fresh Water Tank	SWL	Sewage Lagoons (DP–831)
HIL	Hill Tank	TUT	Tut Tank
H19	H–19 Evaporation Pond (DP–831)	UPR	Upper Pecos River
IDN	Indian Tank	WAB	WIPP Air Blank
LST	Lost Tank	WEE	WIPP East
MLR	Mills Ranch	WFF	WIPP Far Field
NOY	Noya Tank	WIP	WIPP 16 Sections
PCN	Pierce Canyon	WSS	WIPP South
PD1	SWIC Pond 1 (DP–831)		

* Sample taken where found.

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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 [RN] 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 (ID confidence ≥0.90). If the ID Confidence is ≥0.90, the radionuclide may be considered detected even if the sample activity is less than the total propogated uncertainty and/or the minimum detectable concentration.

MINIMUM DETECTABLE CONCENTRATION (MDC)

The 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 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:

- 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 (TPU)

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.

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 (RER)

The 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*).

$$\mathrm{RER} = \frac{(MeanActivity)ori - (MeanActivity)dup}{\sqrt{(2\sigma TPU)^2 ori + (2\sigma TPU)^2 dup}}$$

Where:

$(Mean\ Activity)^{ori}$	=	mean activity of the original or primary sample
$(Mean\ Activity)^{dup}$	=	mean activity of the duplicate sample
$2\sigma TPU$	=	total propagated errors at the 2 sigma level

PERCENT BIAS (% 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.

$$\%\ BIAS = \frac{(A_m - A_k)}{A_k} \times 100$$

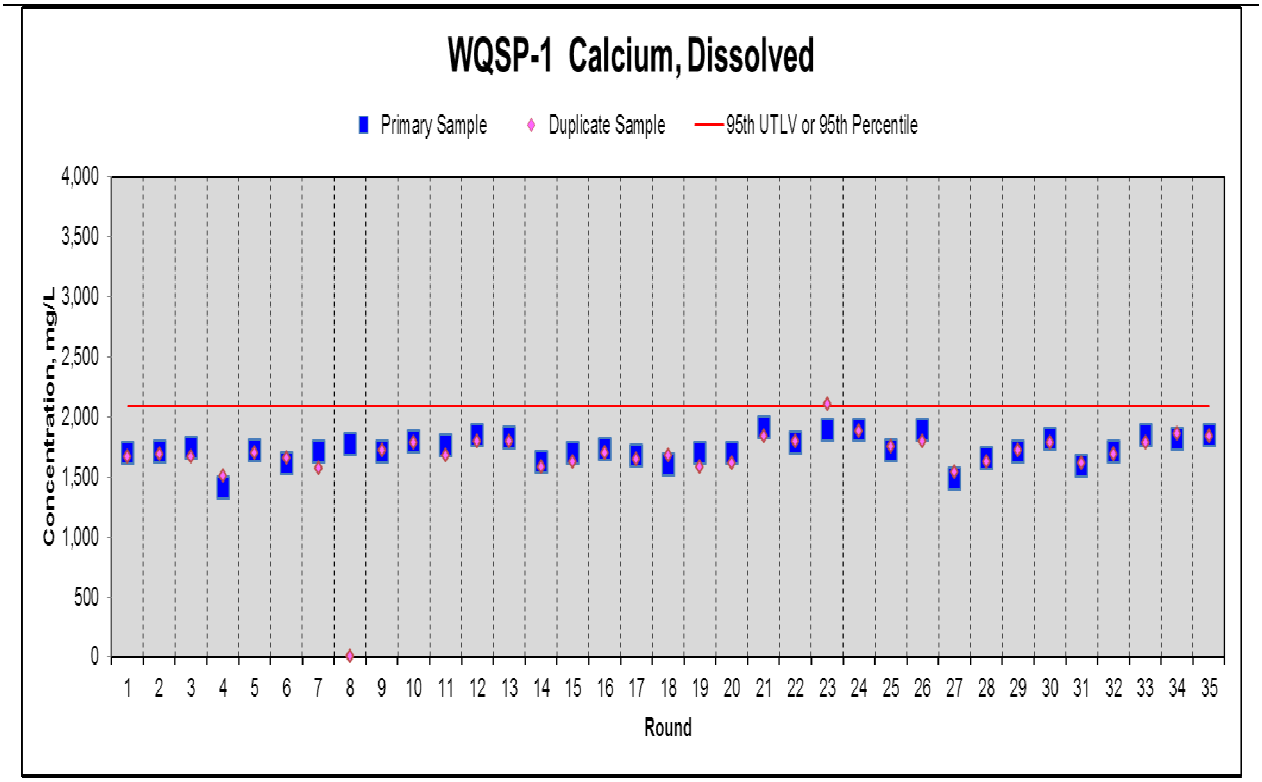
Where:

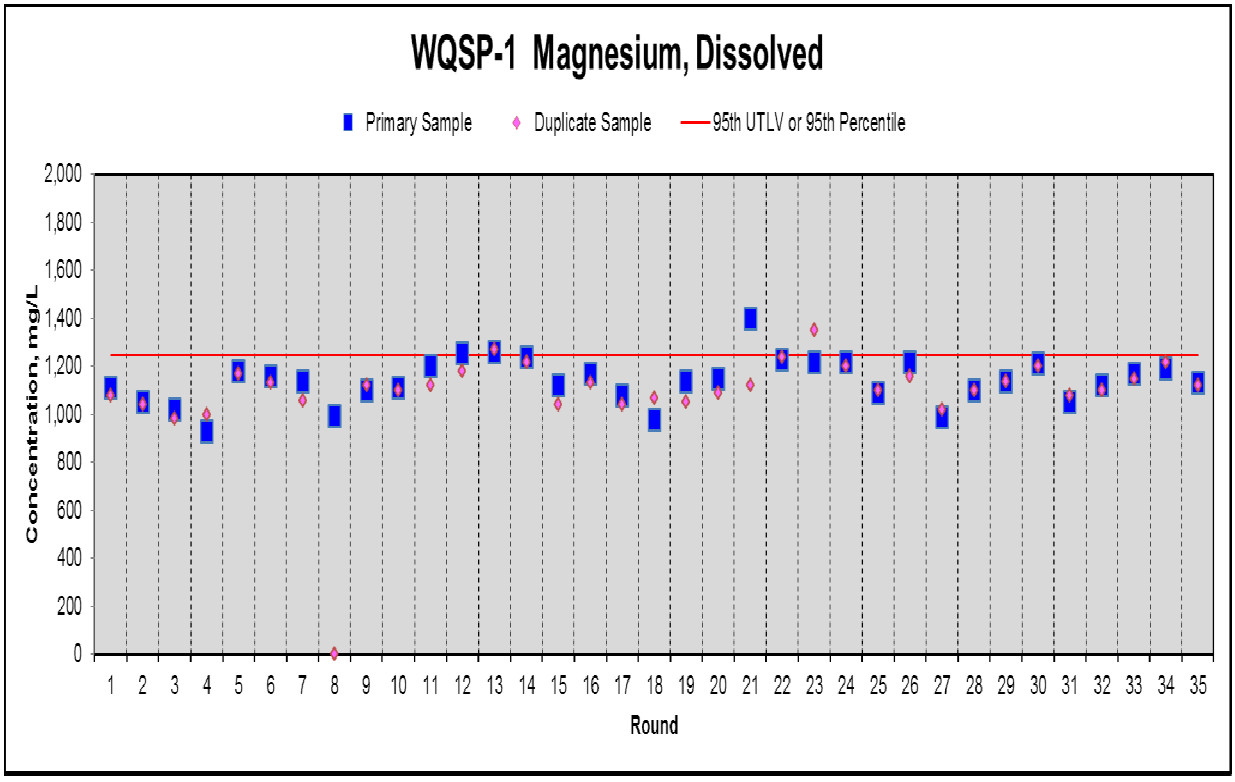
% BIAS	=	percent bias
Am	=	measured sample activity
Ak	=	known sample activity

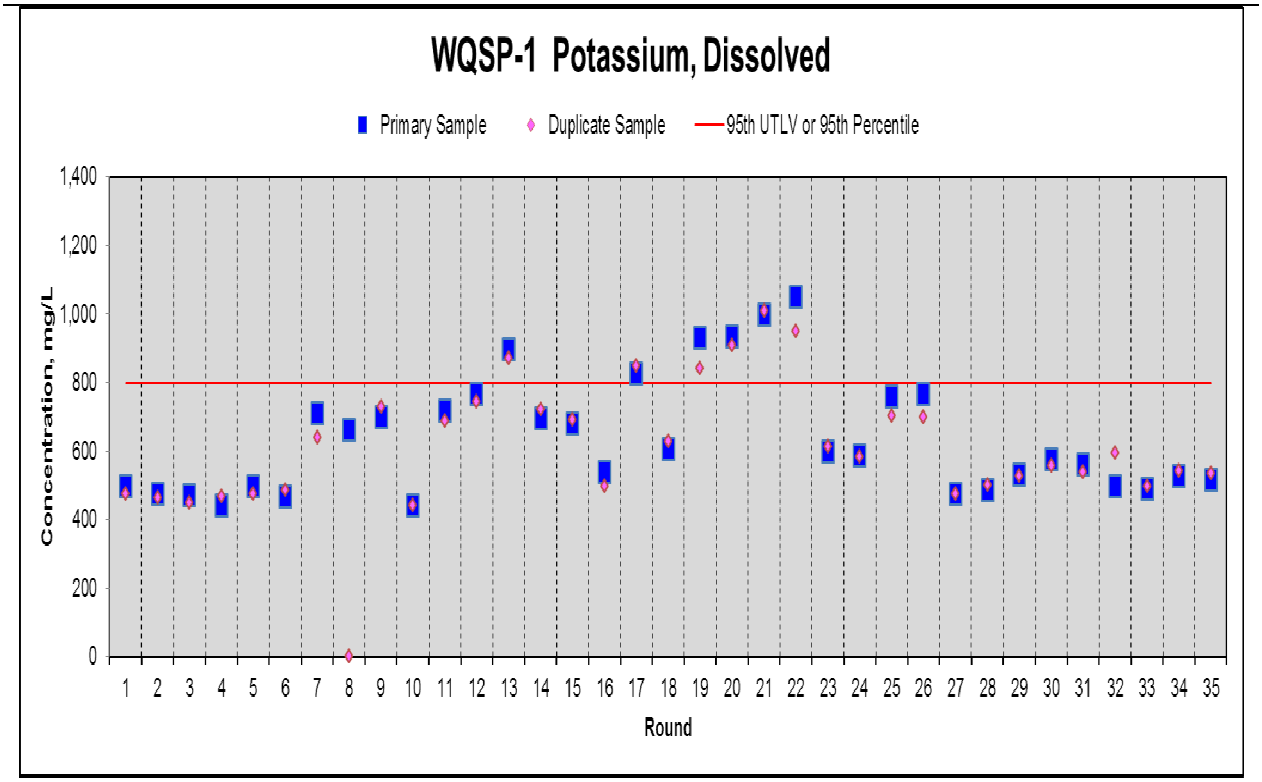
APPENDIX E – TIME TREND PLOTS FOR MAIN PARAMETERS IN GROUNDWATER

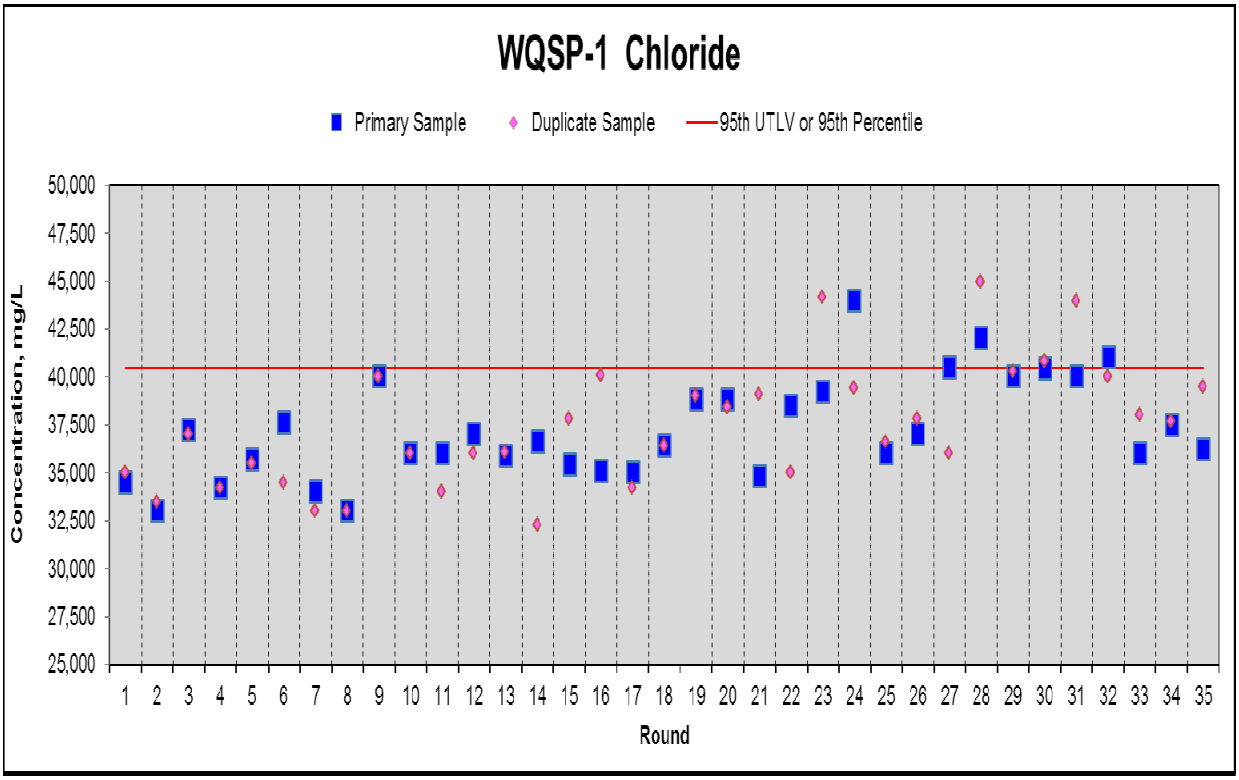
The first 10 sampling rounds were conducted from 1995 through 2000 (prior to receiving mixed waste at the WIPP site) and were used to establish the original baseline for groundwater chemistry at each sampling location. The baseline sample sets are used to determine whether statistically significant changes 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.

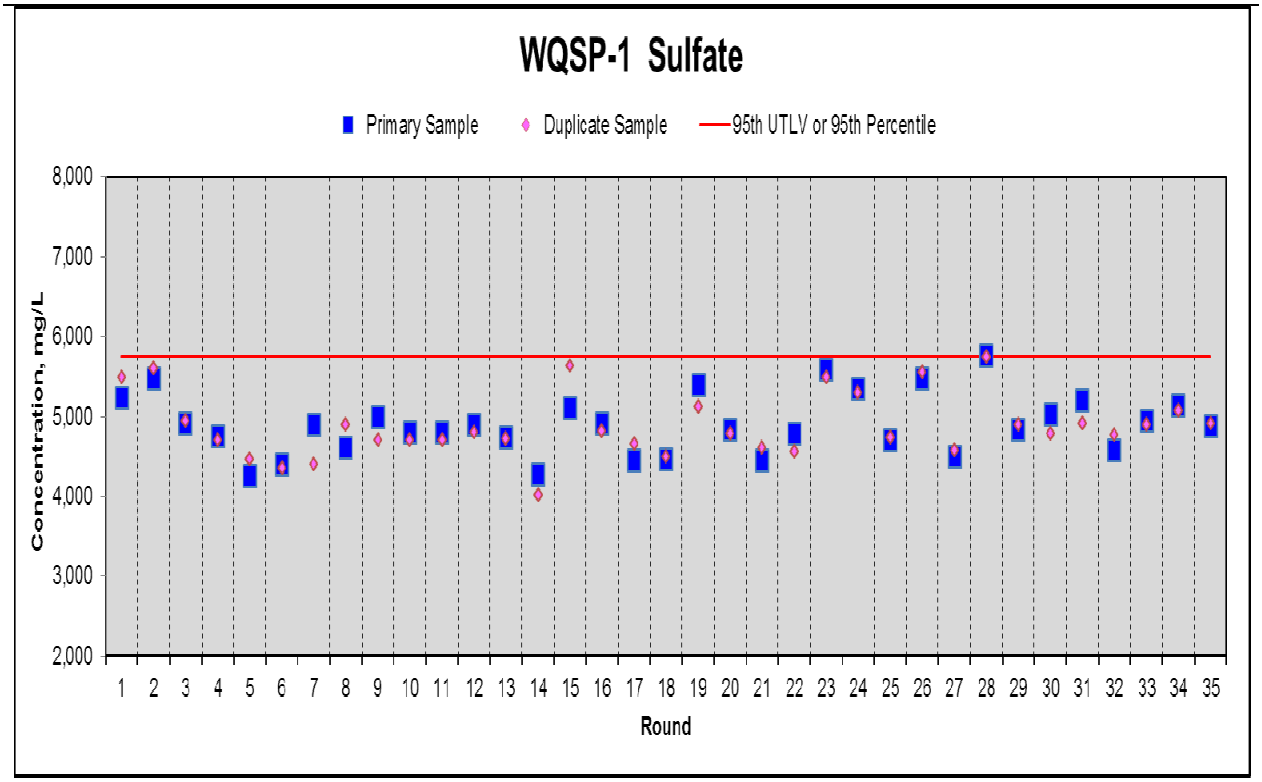
The 2013 laboratory analytical results were verified and validated in accordance with WIPP procedures and U.S. EPA technical guidance. Sampling Round 35 samples were taken March through May 2013. See Appendix F for the concentrations of the target analytes in the DMWs.

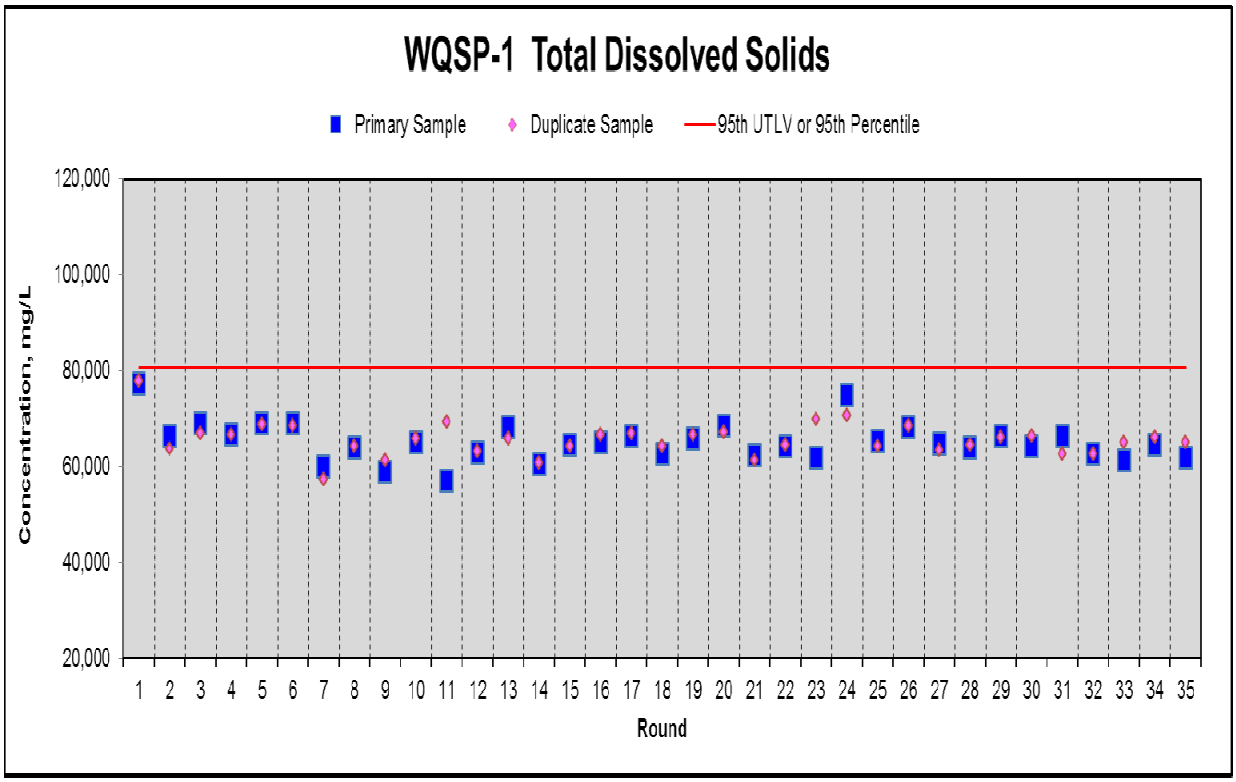

WQSP-1 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

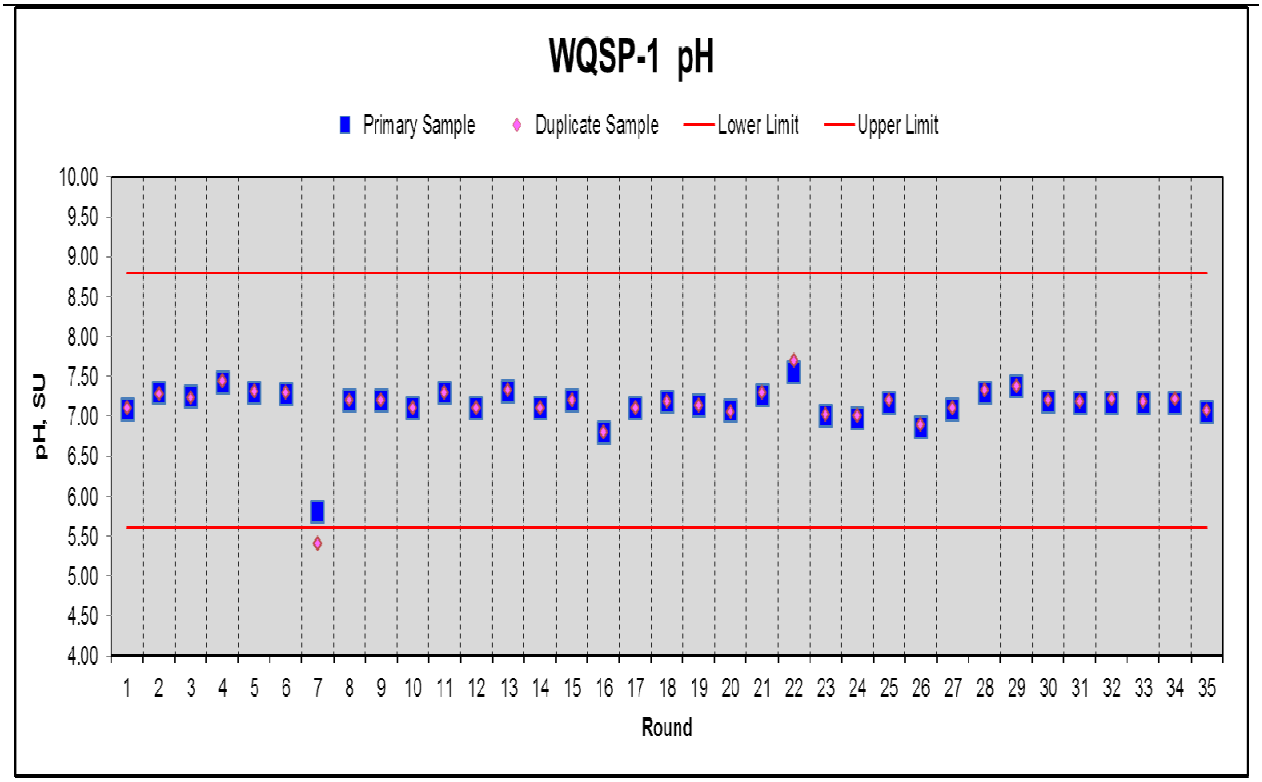

WQSP-1 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

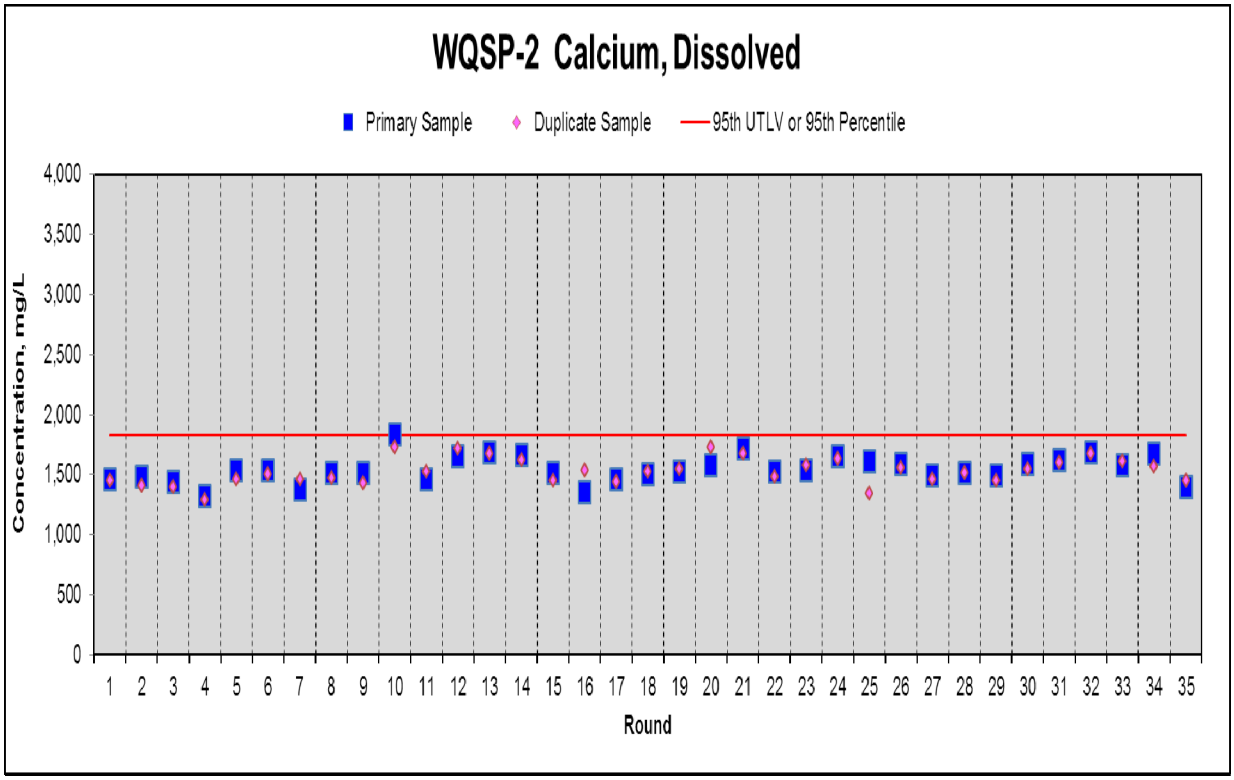

WQSP-1 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

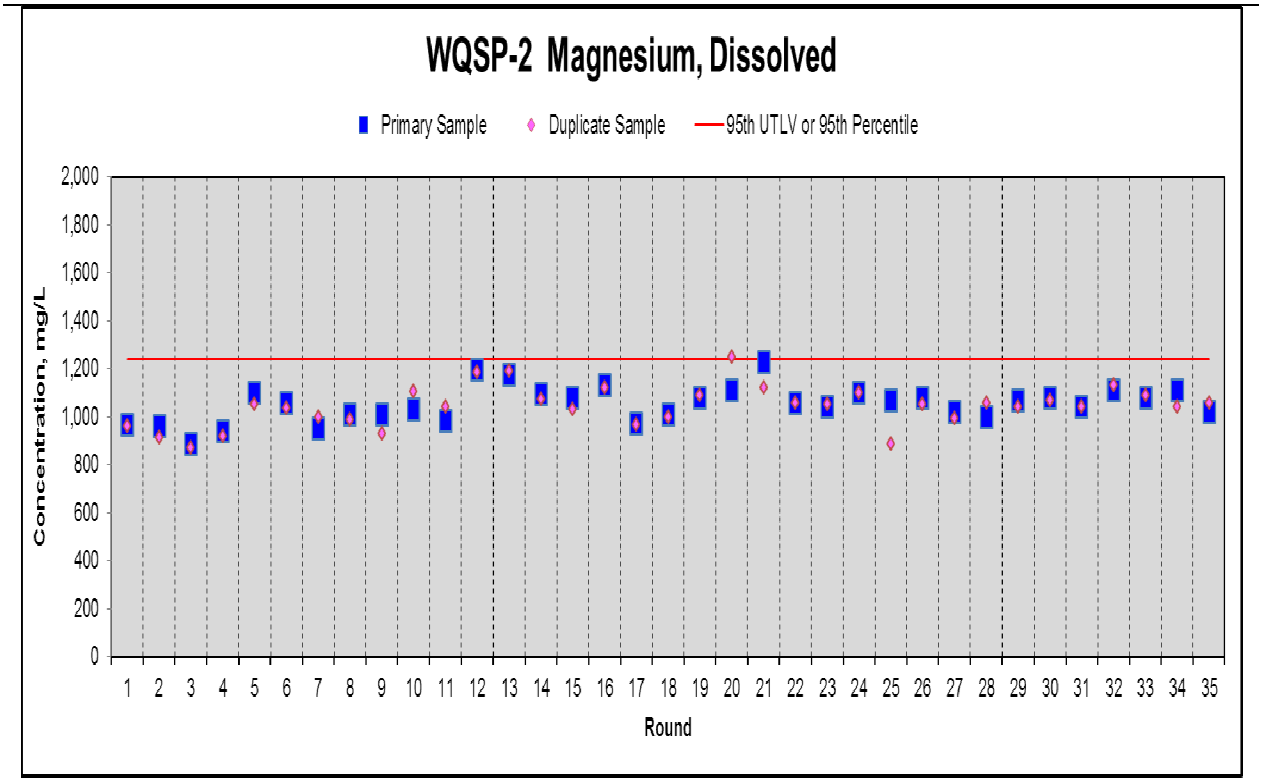

WQSP-1 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

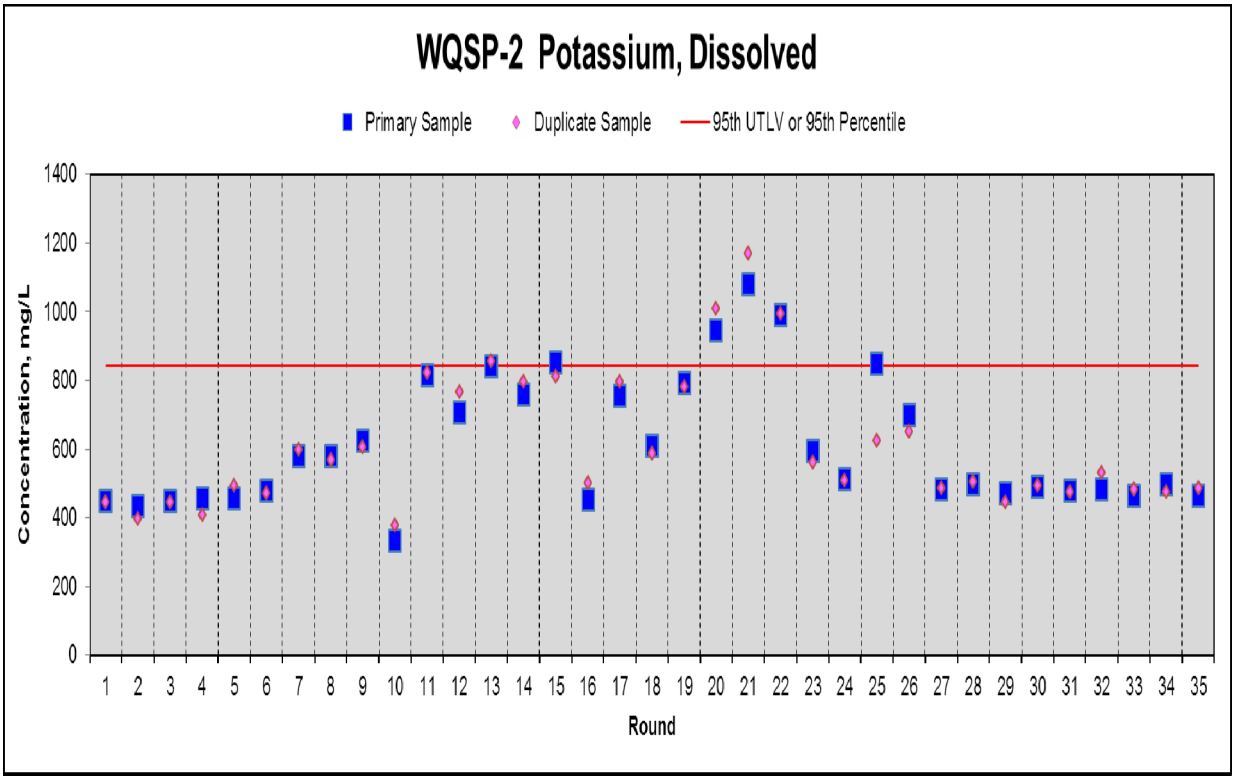

WQSP-1 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

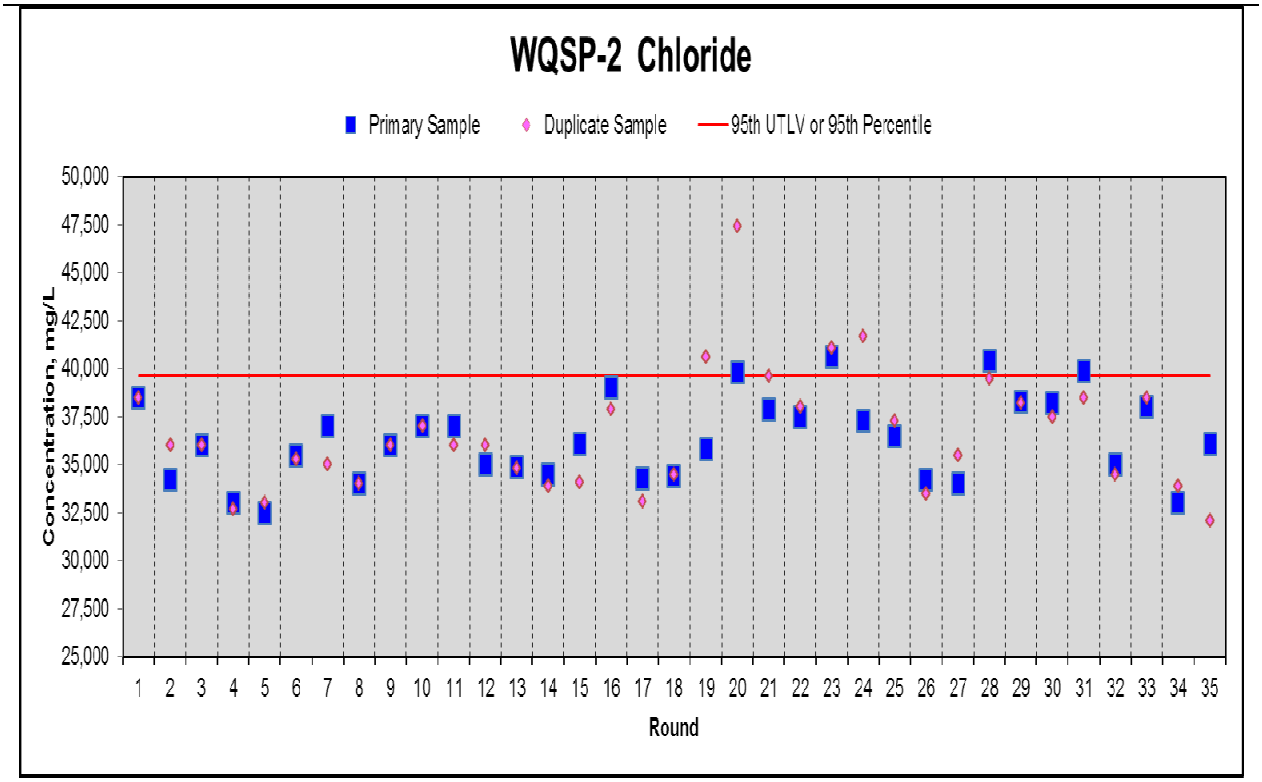

WQSP-1 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

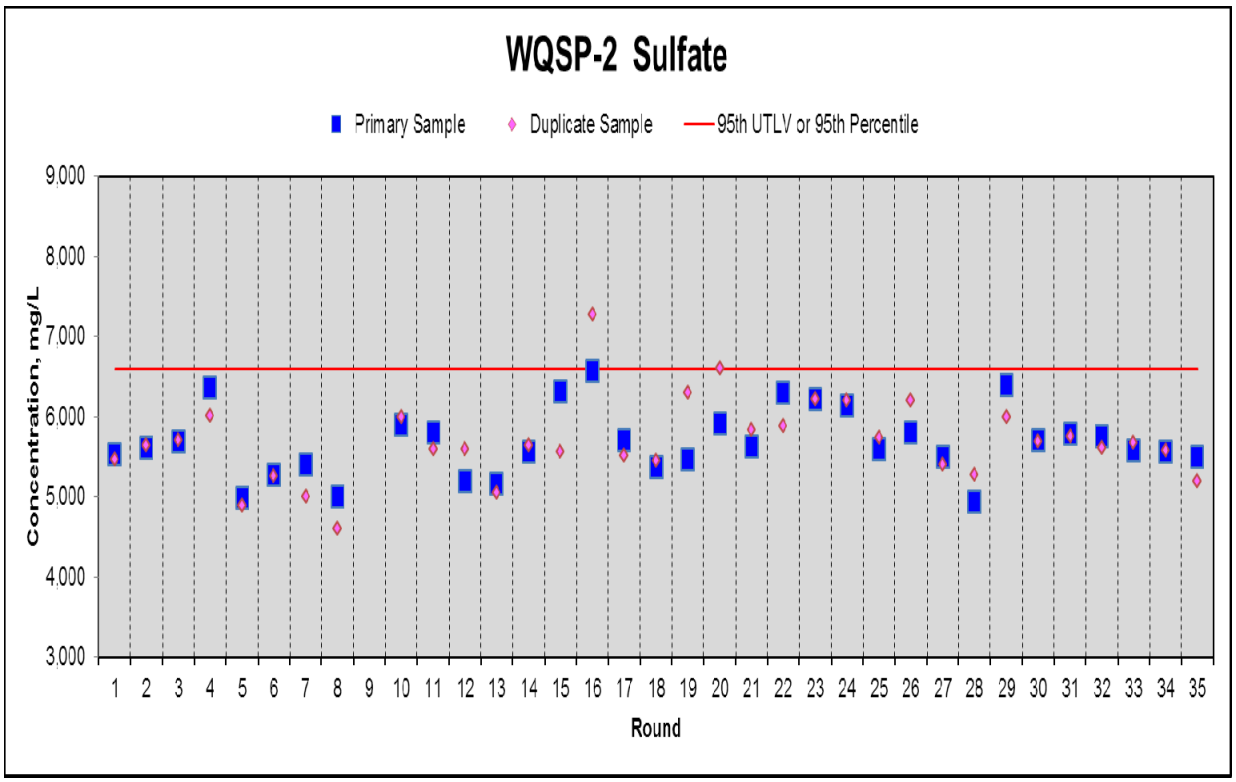

WQSP-1 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
10.00
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

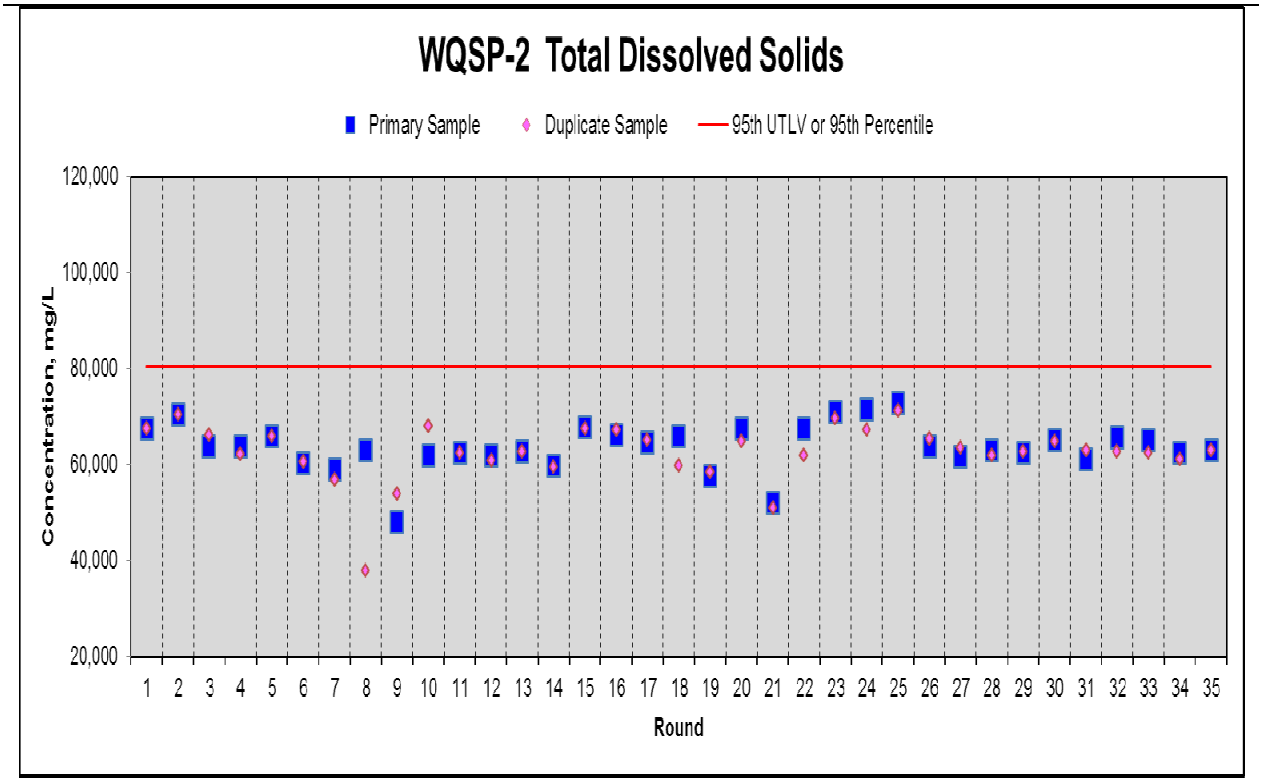

WQSP-2 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

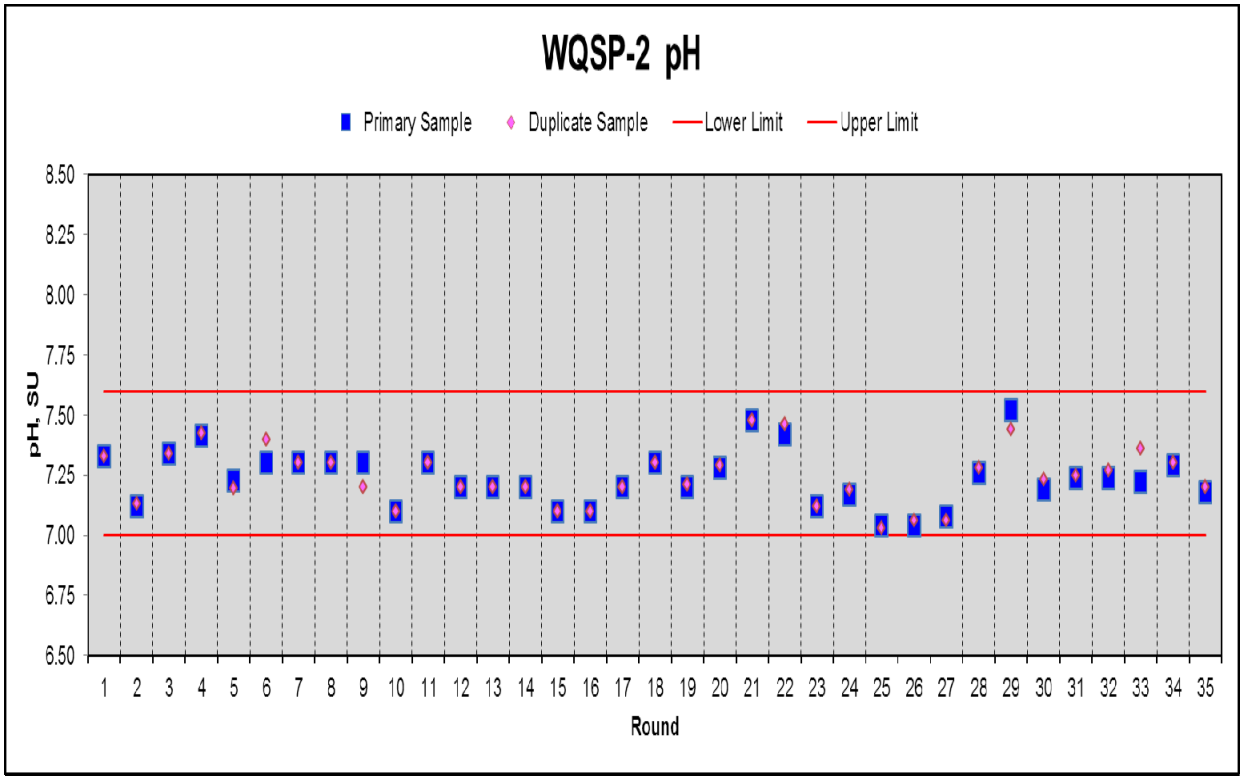

WQSP-2 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

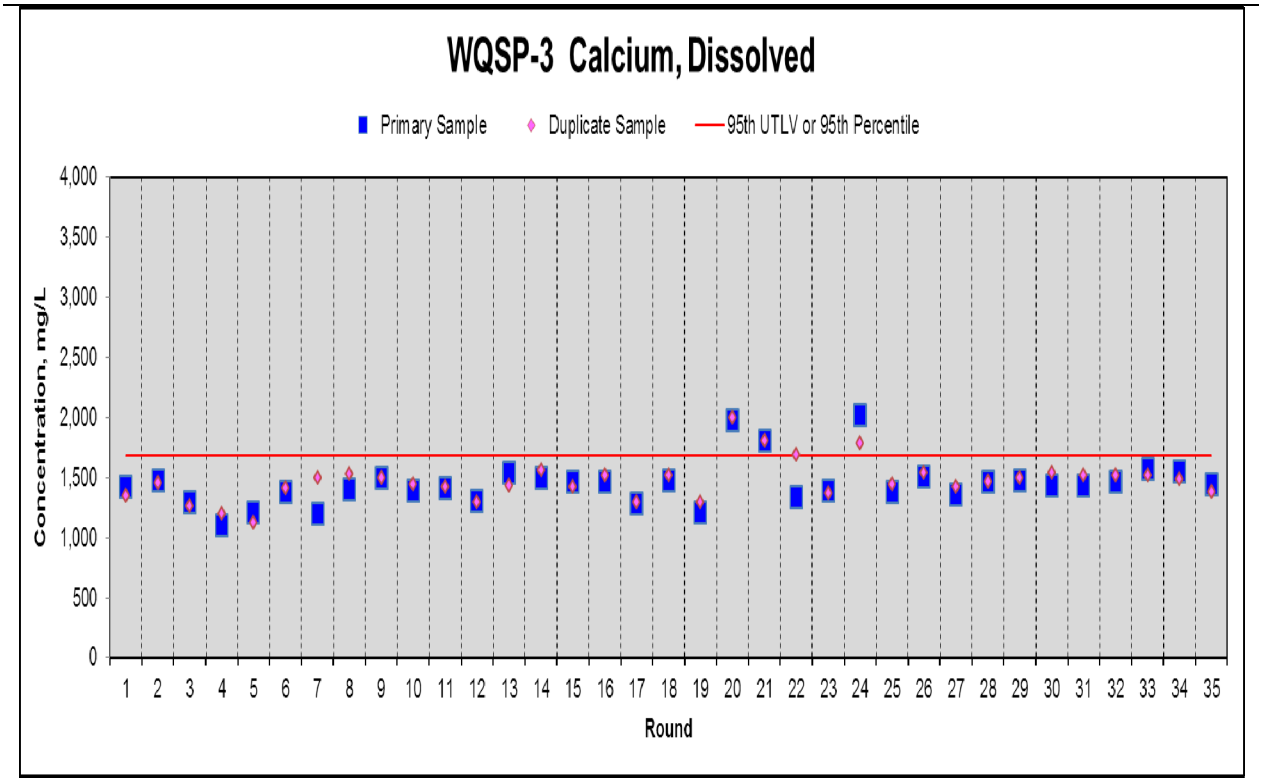

WQSP-2 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1400
1200
1000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

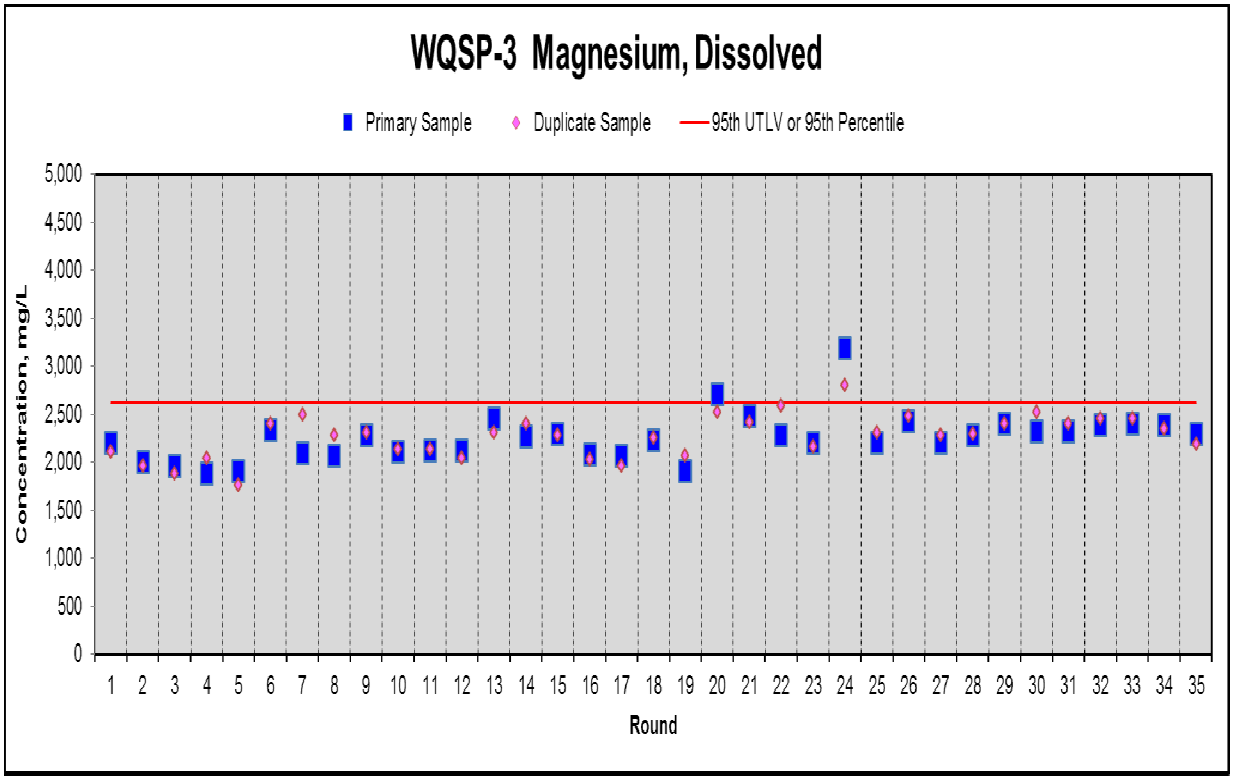

WQSP-2 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
50,000
47,500
45,000
42,500
40,000
37,500
35,000
32,500
30,000
27,500
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

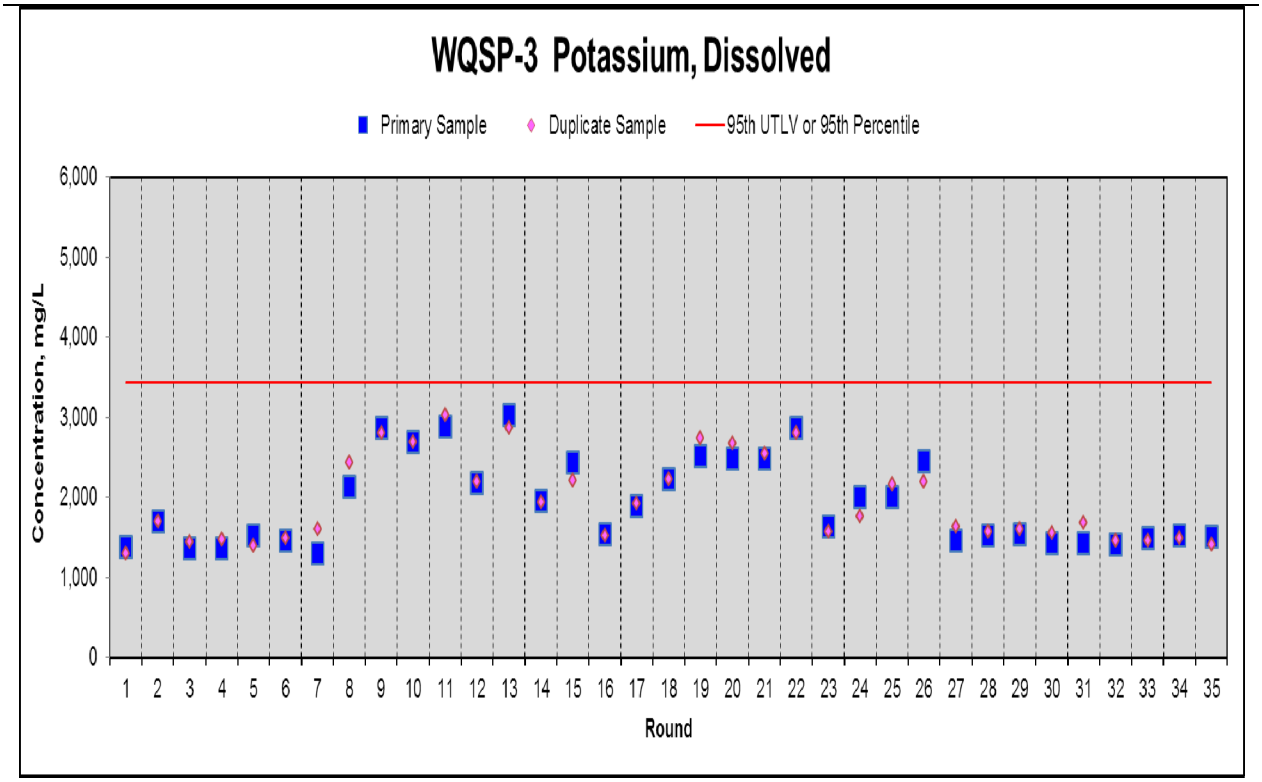

WQSP-2 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
9,000
8,000
7,000
6,000
5,000
4,000
3,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

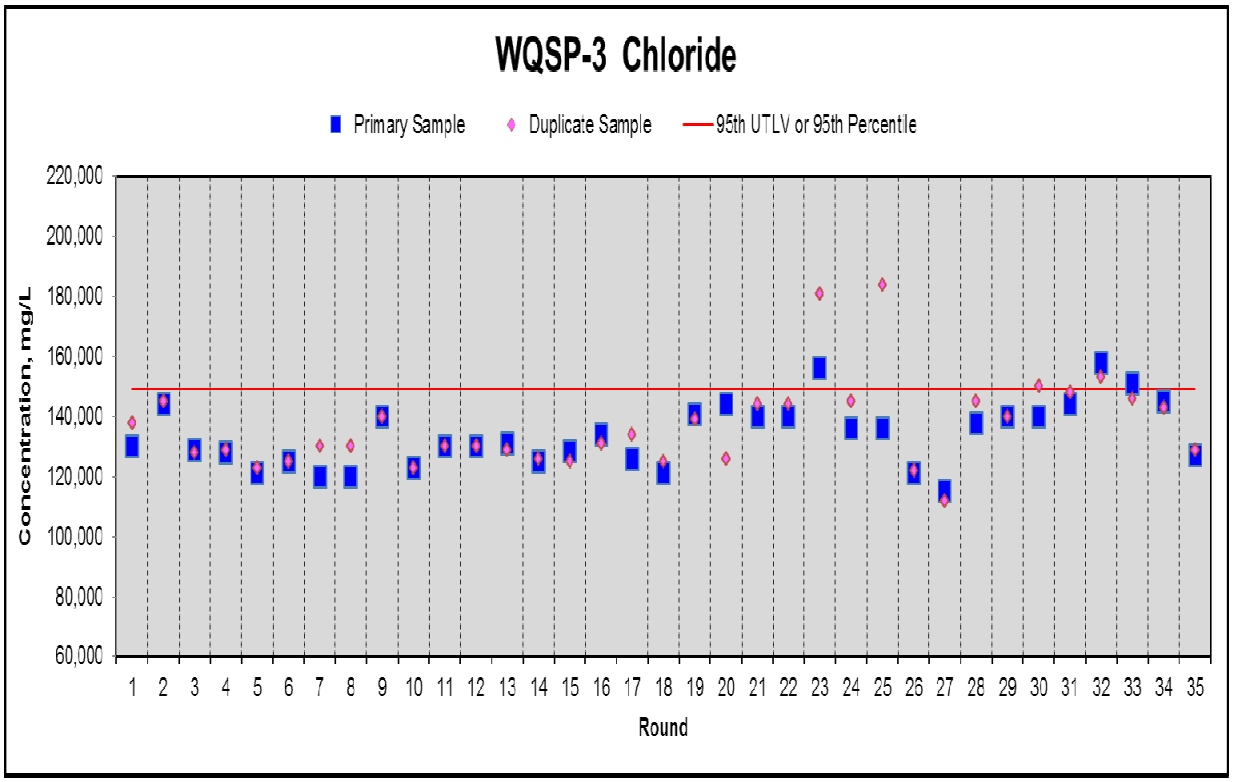

WQSP-2 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
100,000
80,000
60,000
40,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

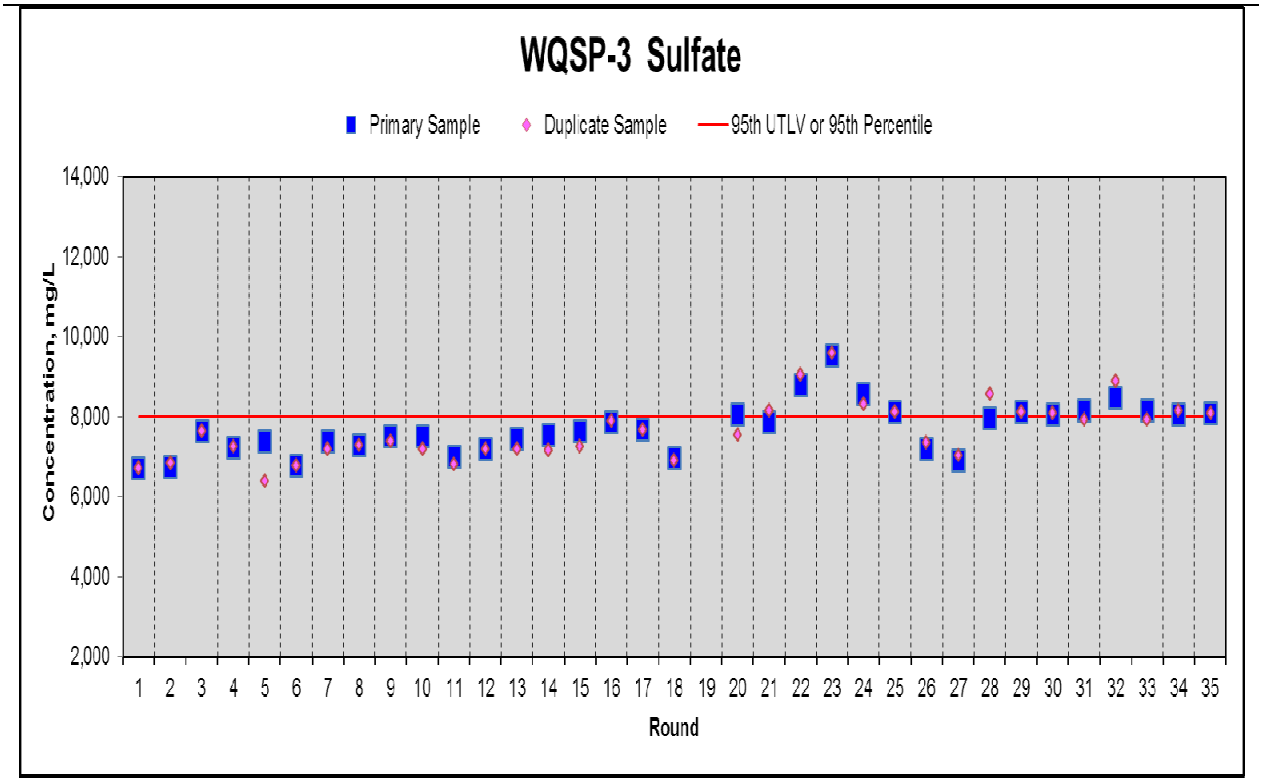

WQSP-2 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

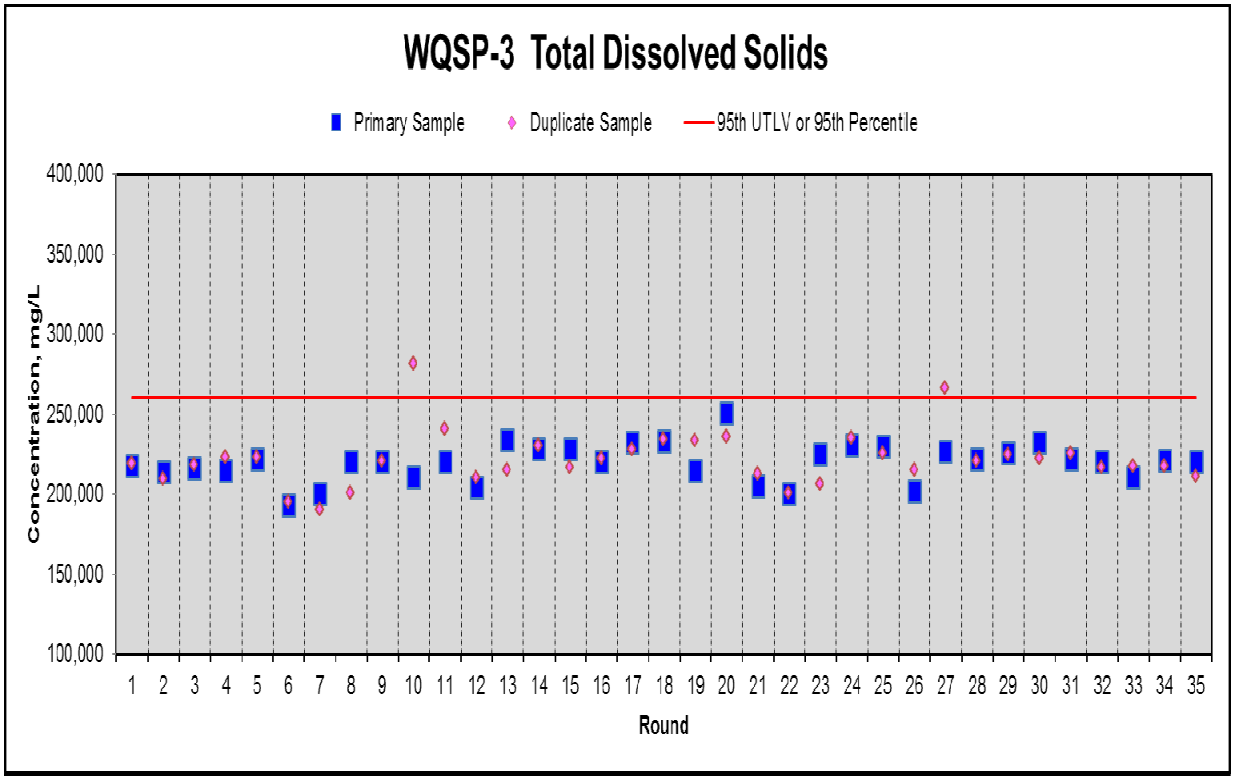

WQSP-3 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

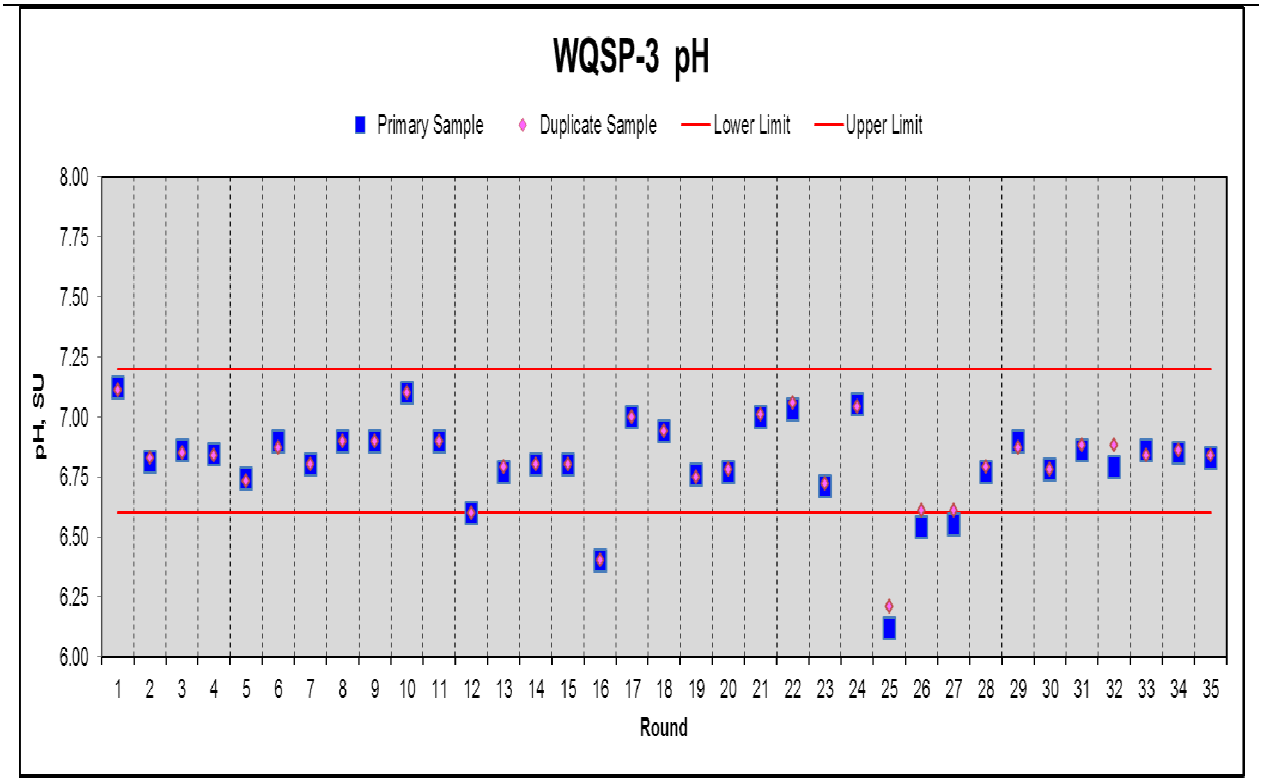

WQSP-3 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

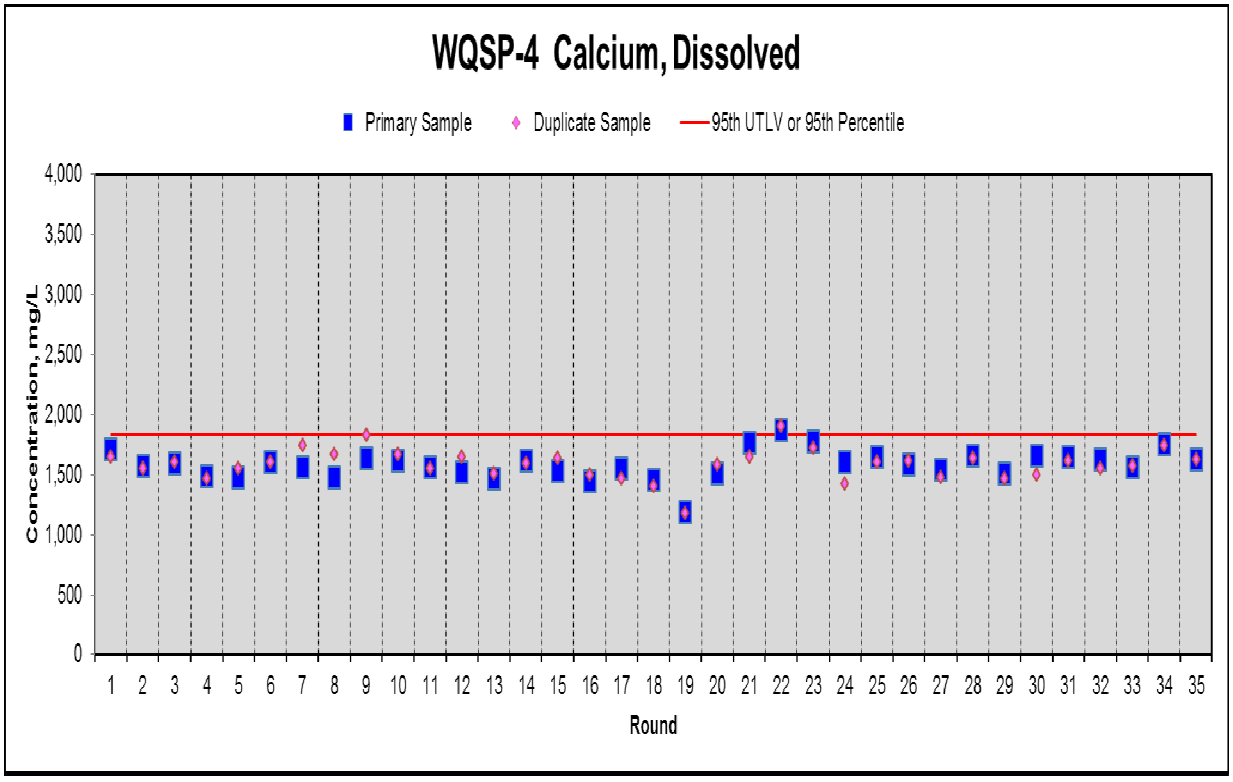

WQSP-3 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
6,000
5,000
4,000
3,000
2,000
1,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

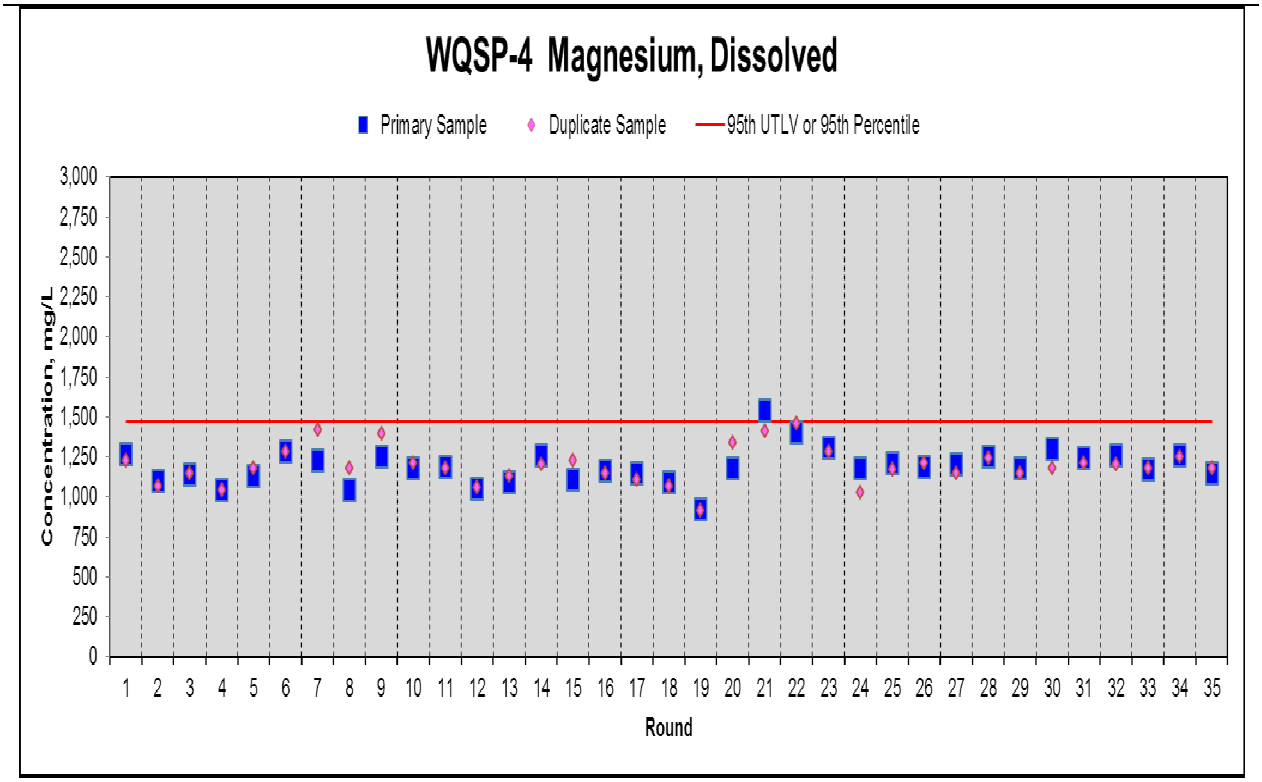

WQSP-3 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
220,000
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

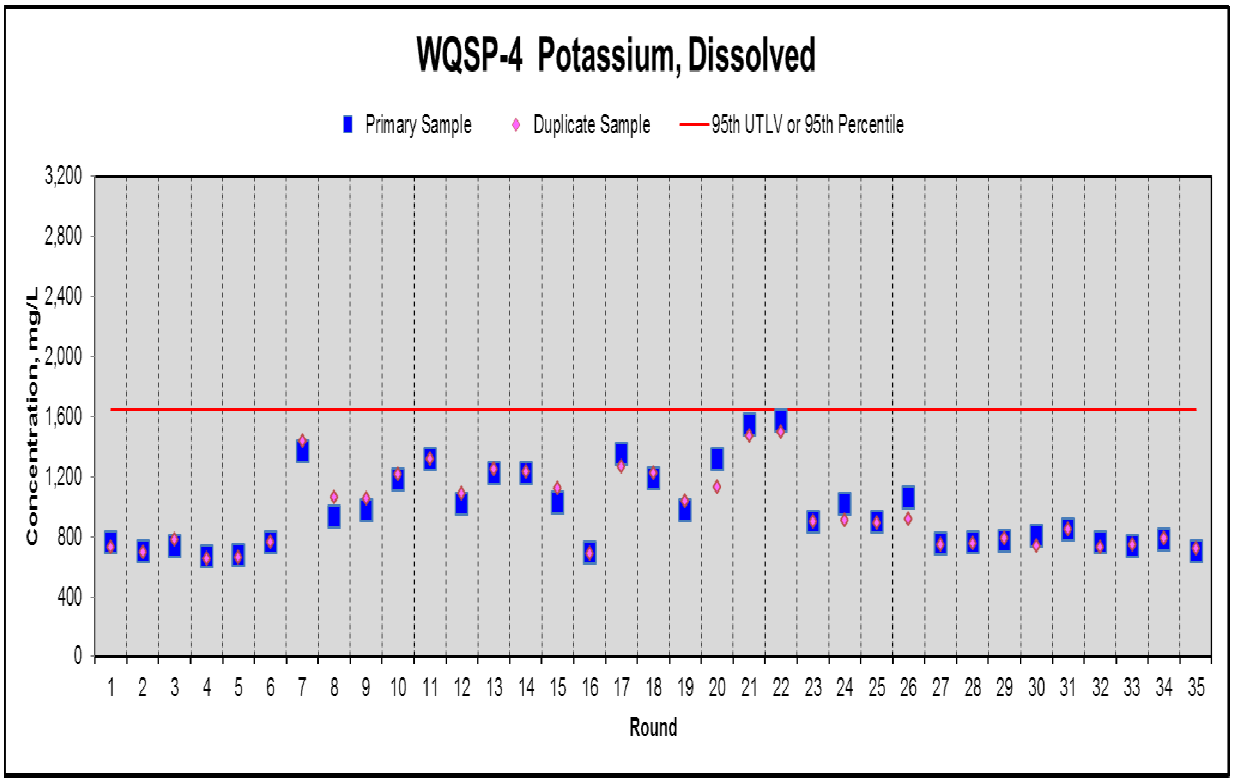

WQSP-3 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

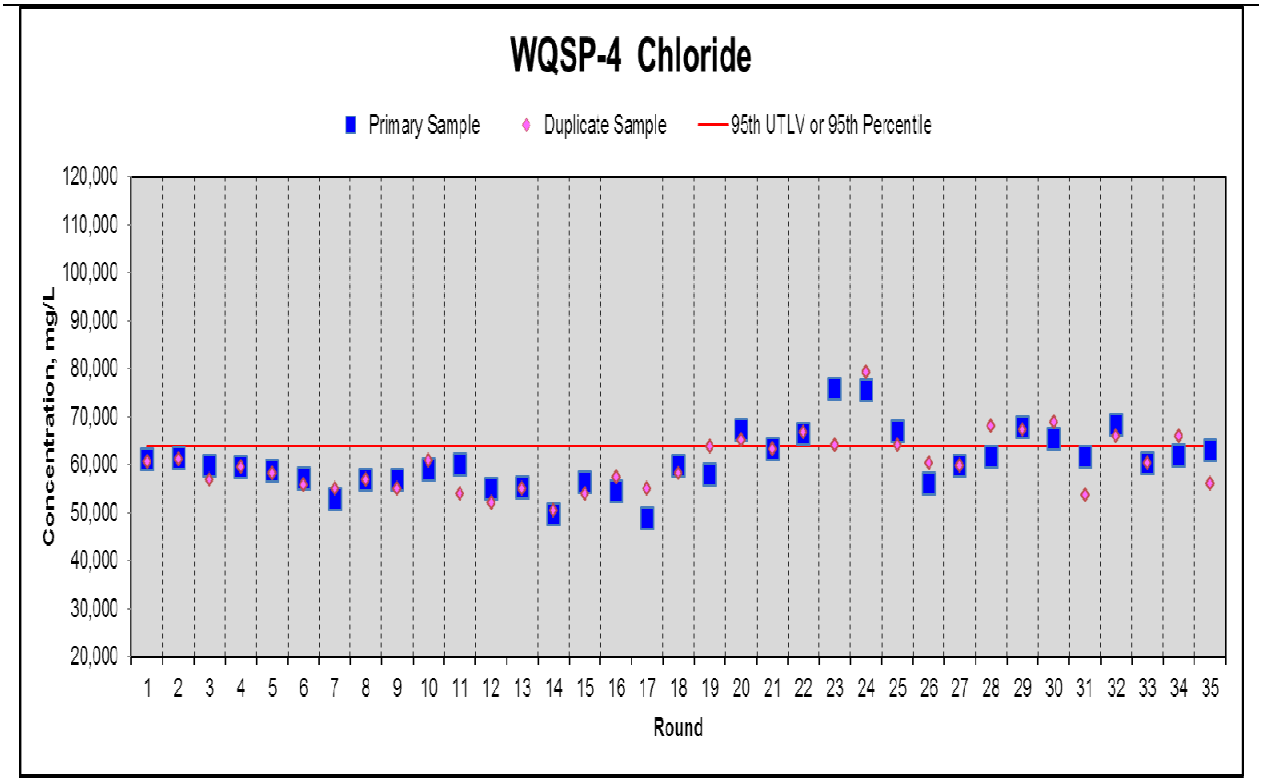

WQSP-3 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
400,000
350,000
300,000
250,000
200,000
150,000
100,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

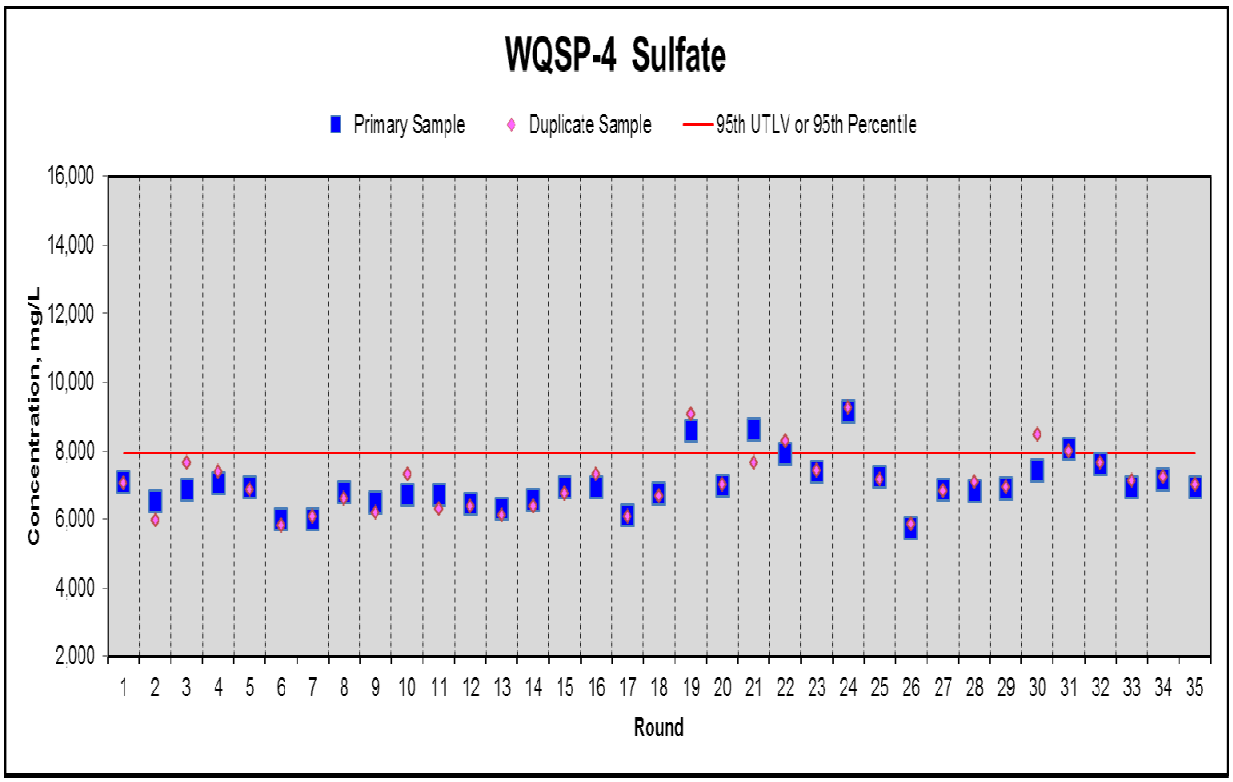

WQSP-3 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

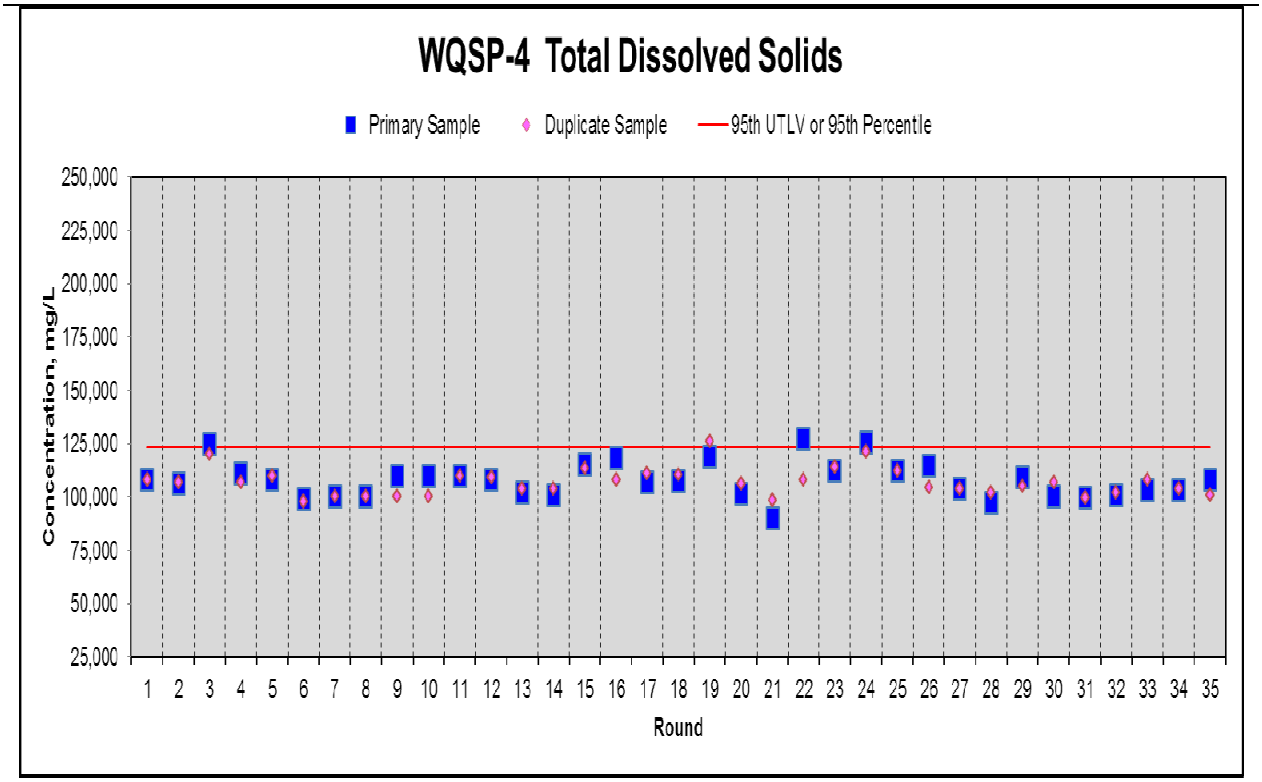

WQSP-4 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

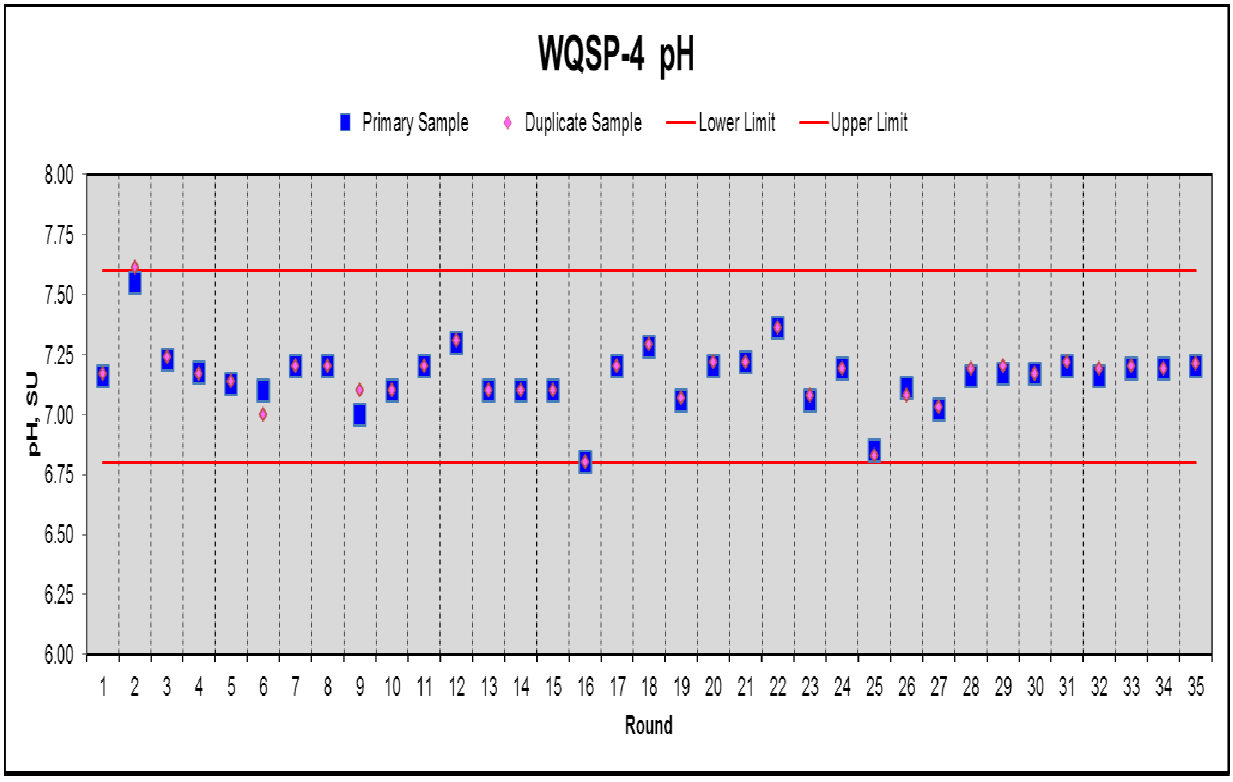

WQSP-4 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,000
2,750
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

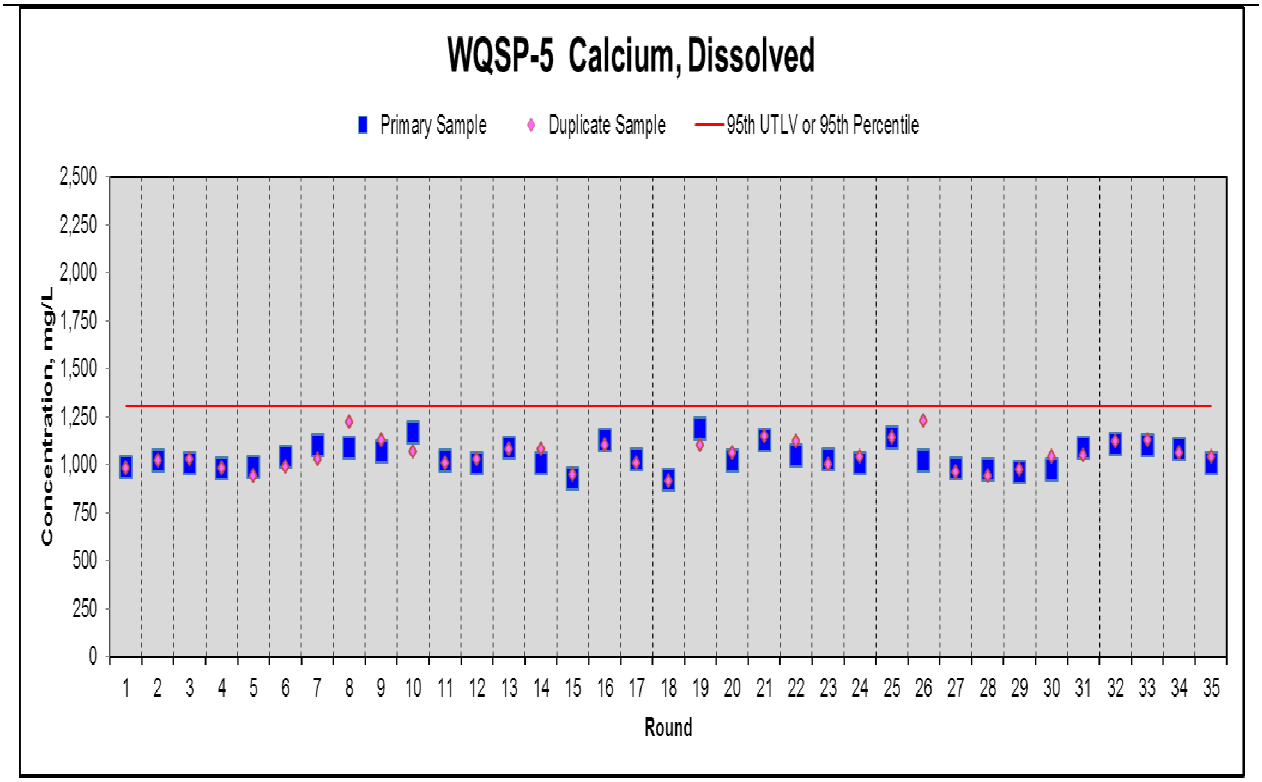

WQSP-4 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

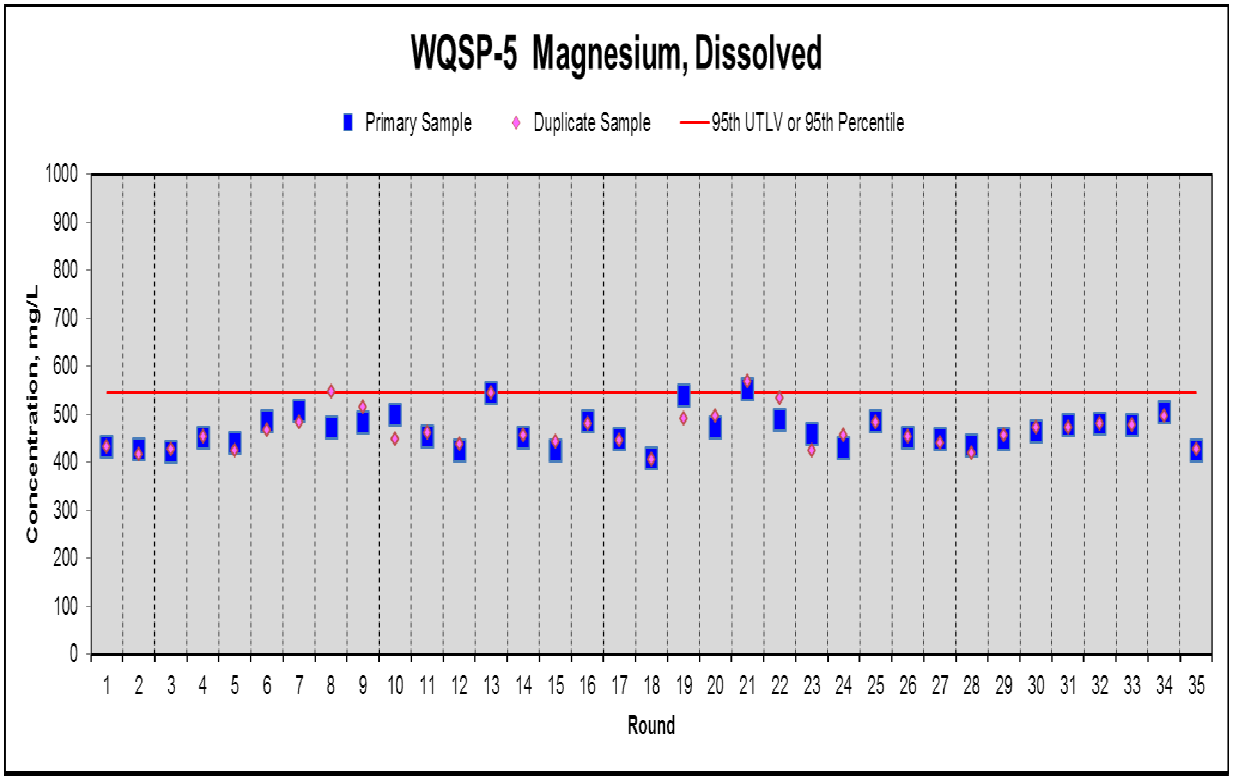

WQSP-4 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

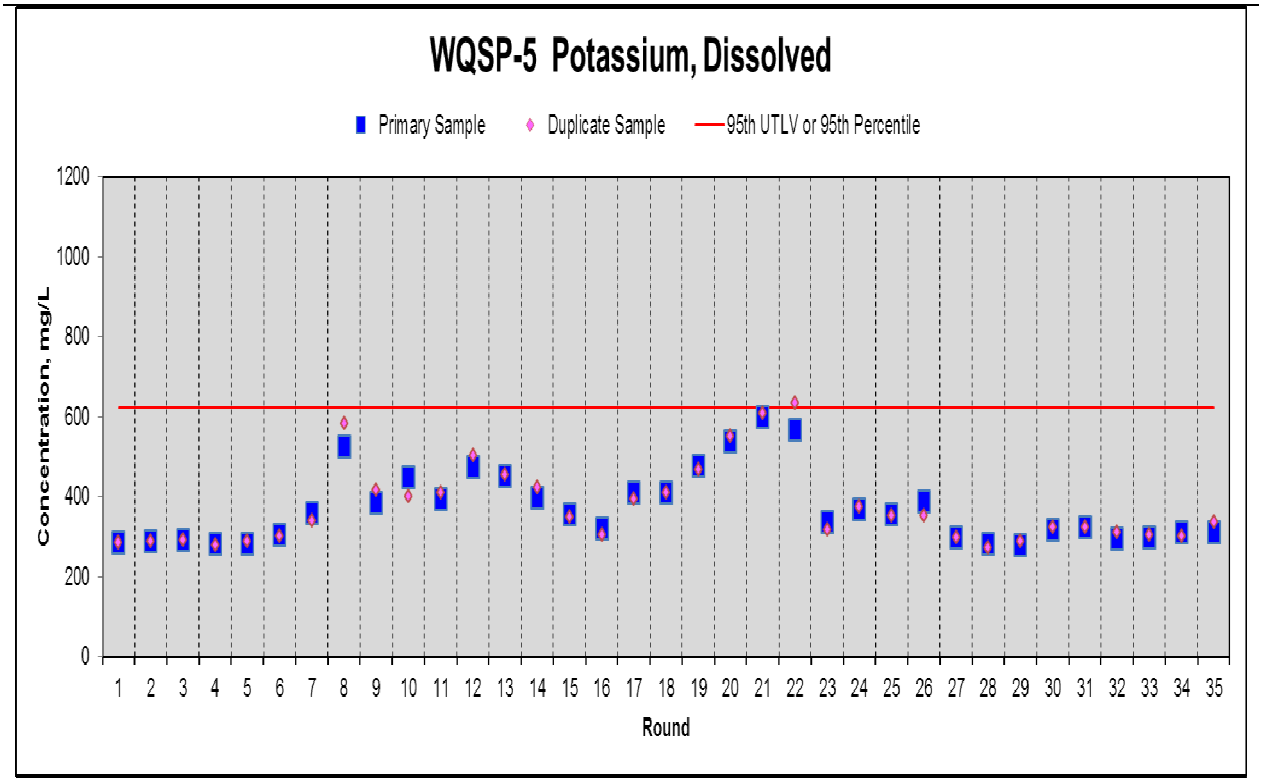

WQSP-4 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

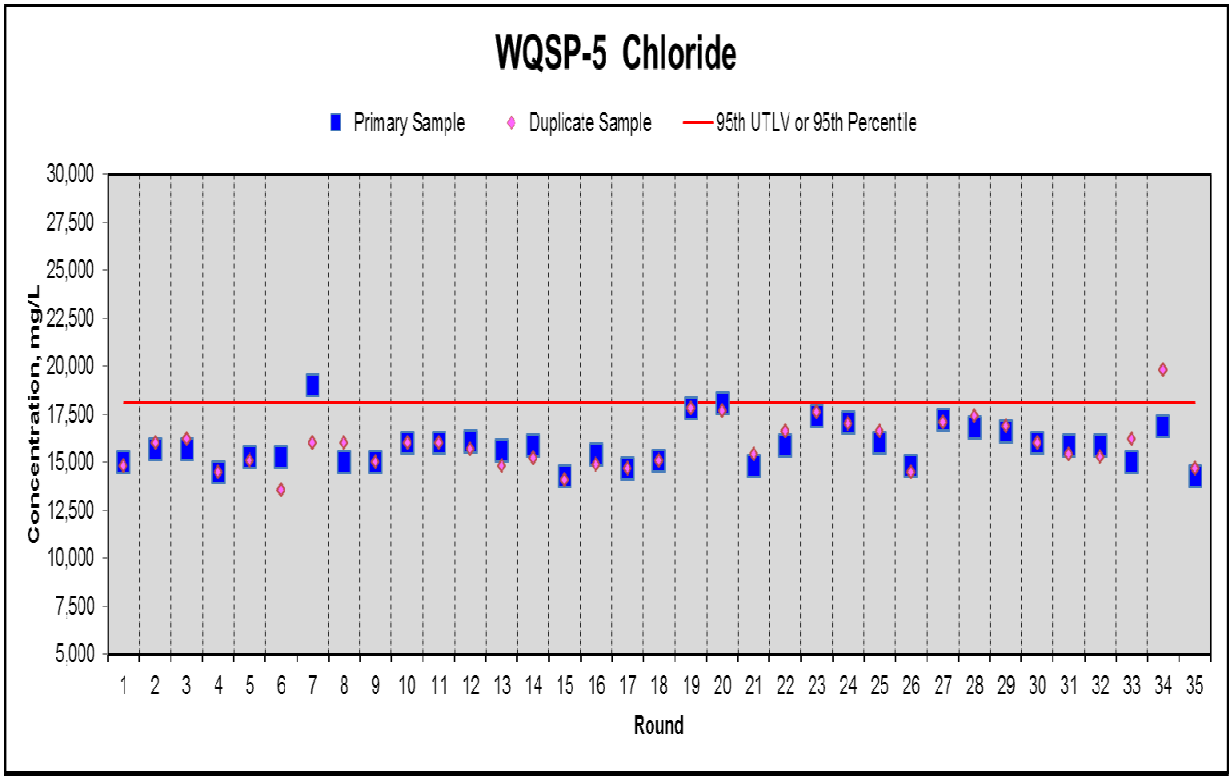

WQSP-4 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
250,000
225,000
200,000
175,000
150,000
125,000
100,000
75,000
50,000
25,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

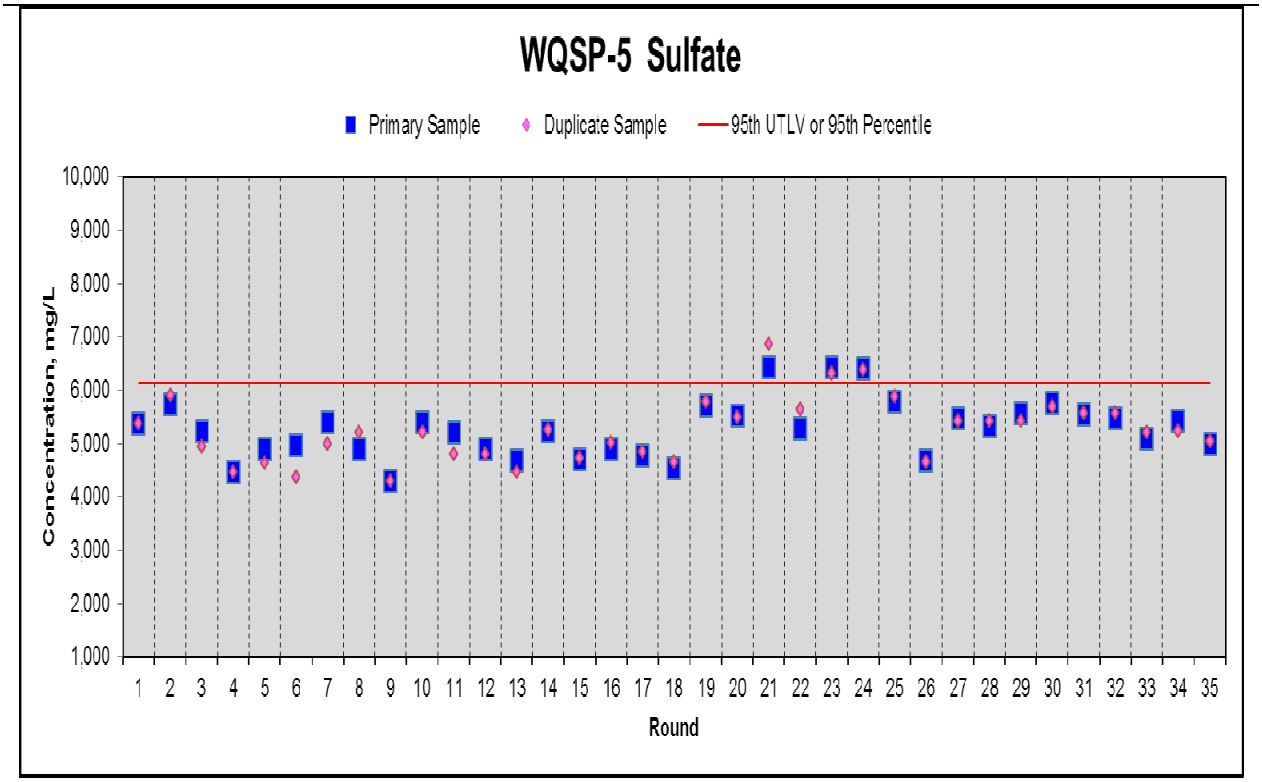

WQSP-4 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.00
7.75
7.50
7.25
7.00
6.75
6.50
6.25
6.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

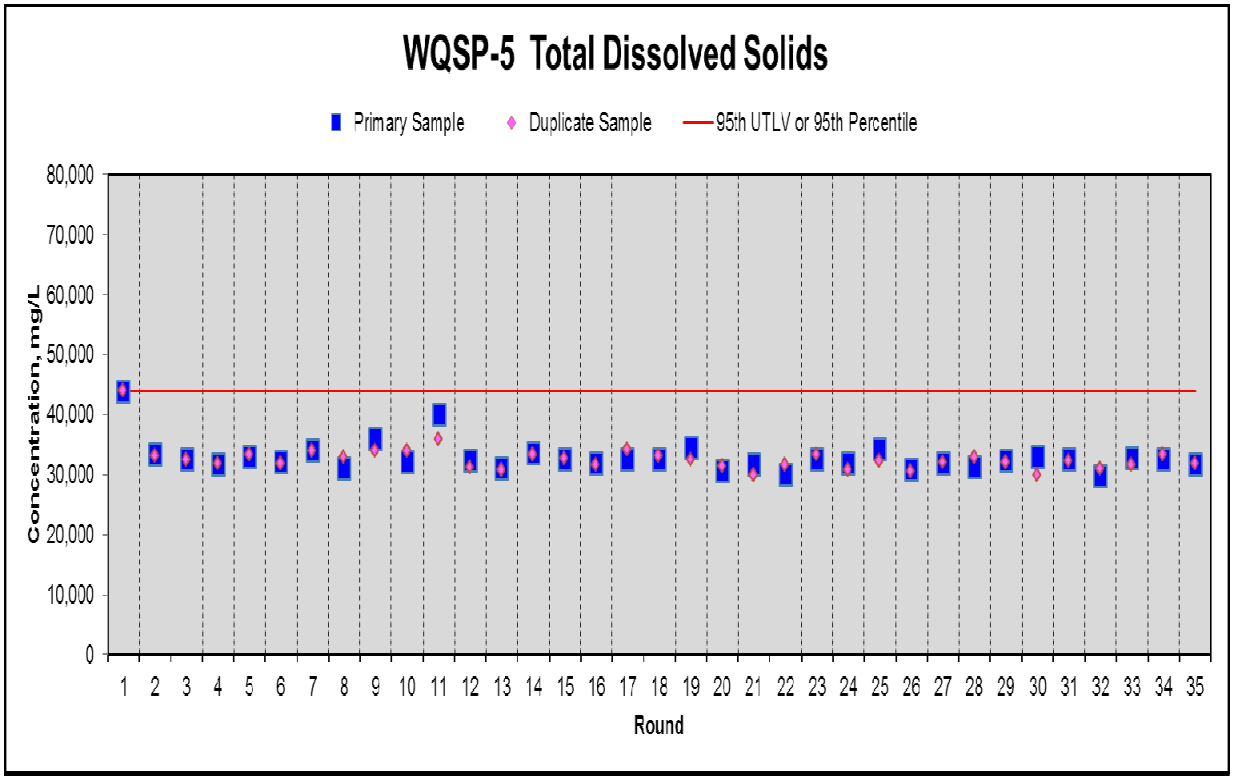

WQSP-5 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
2,500
2,250
2,000
1,750
1,500
1,250
1,000
750
500
250
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

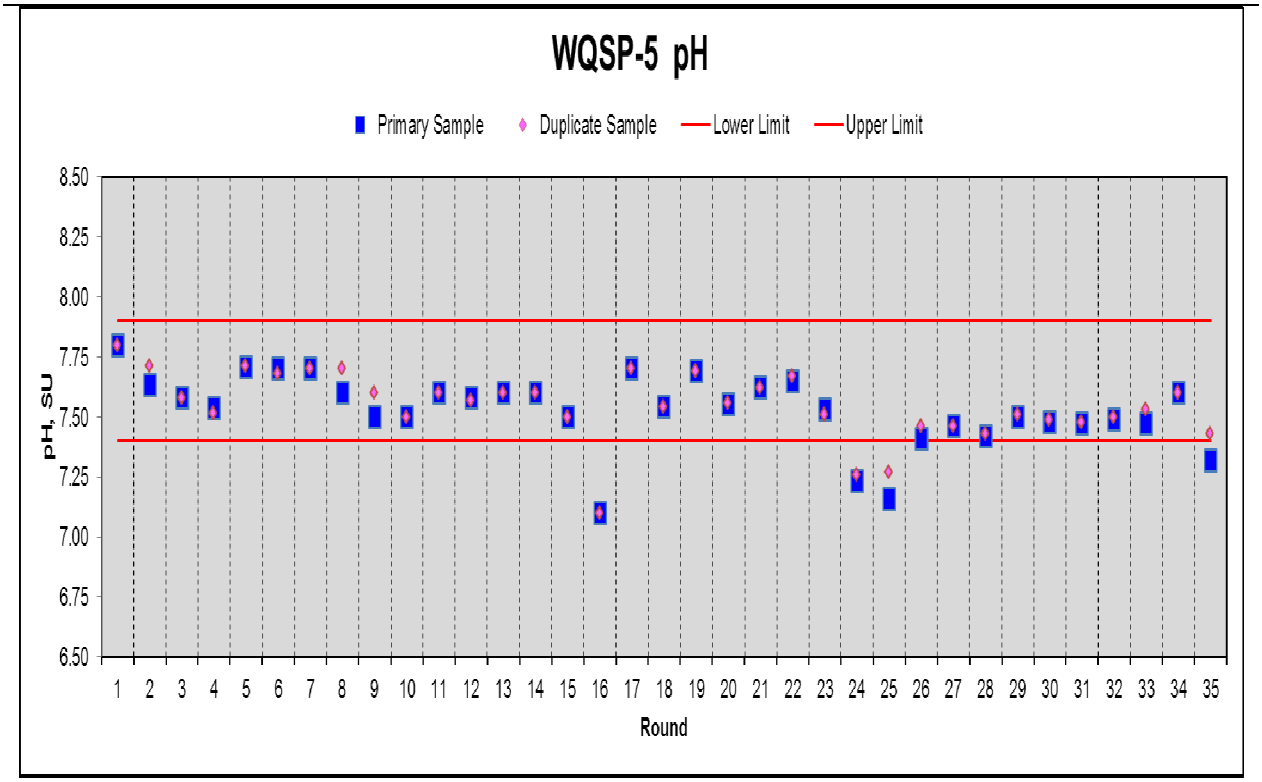

WQSP-5 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1000
900
800
700
600
500
400
300
200
100
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

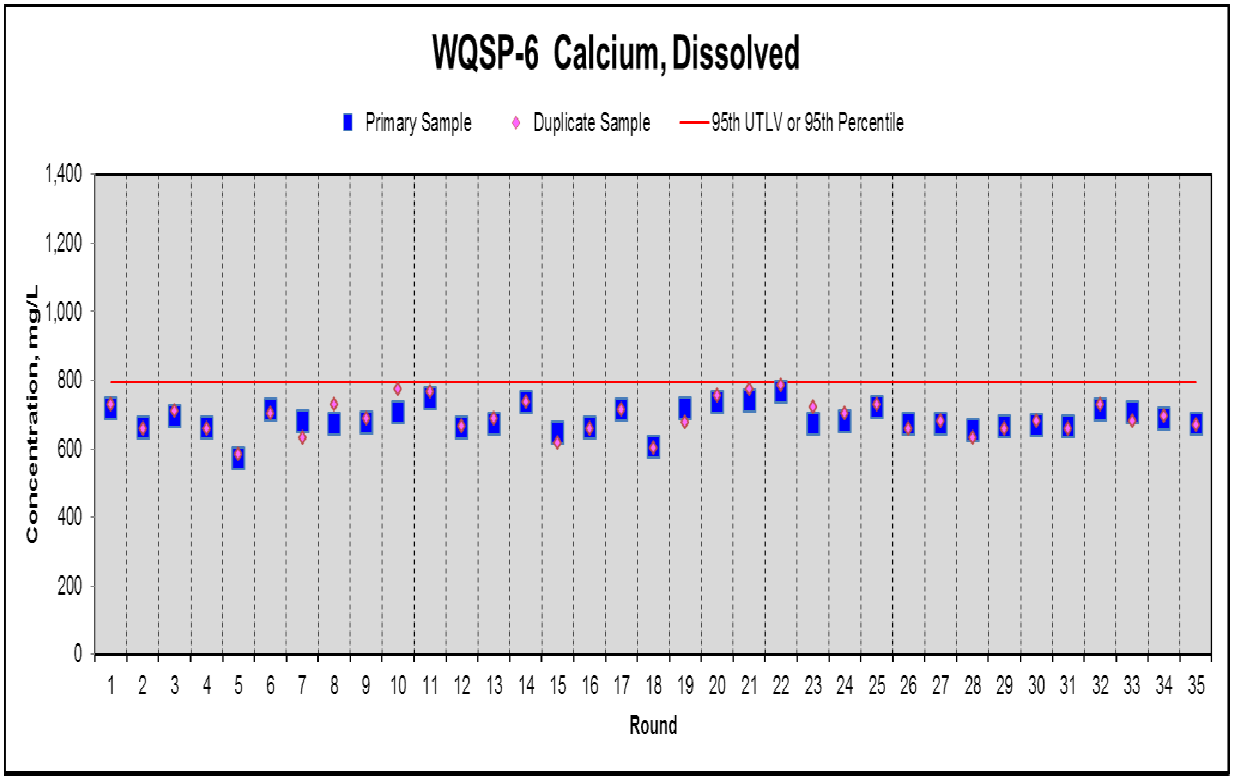

WQSP-5 Potassium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
200
400
600
800
1000
1200
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

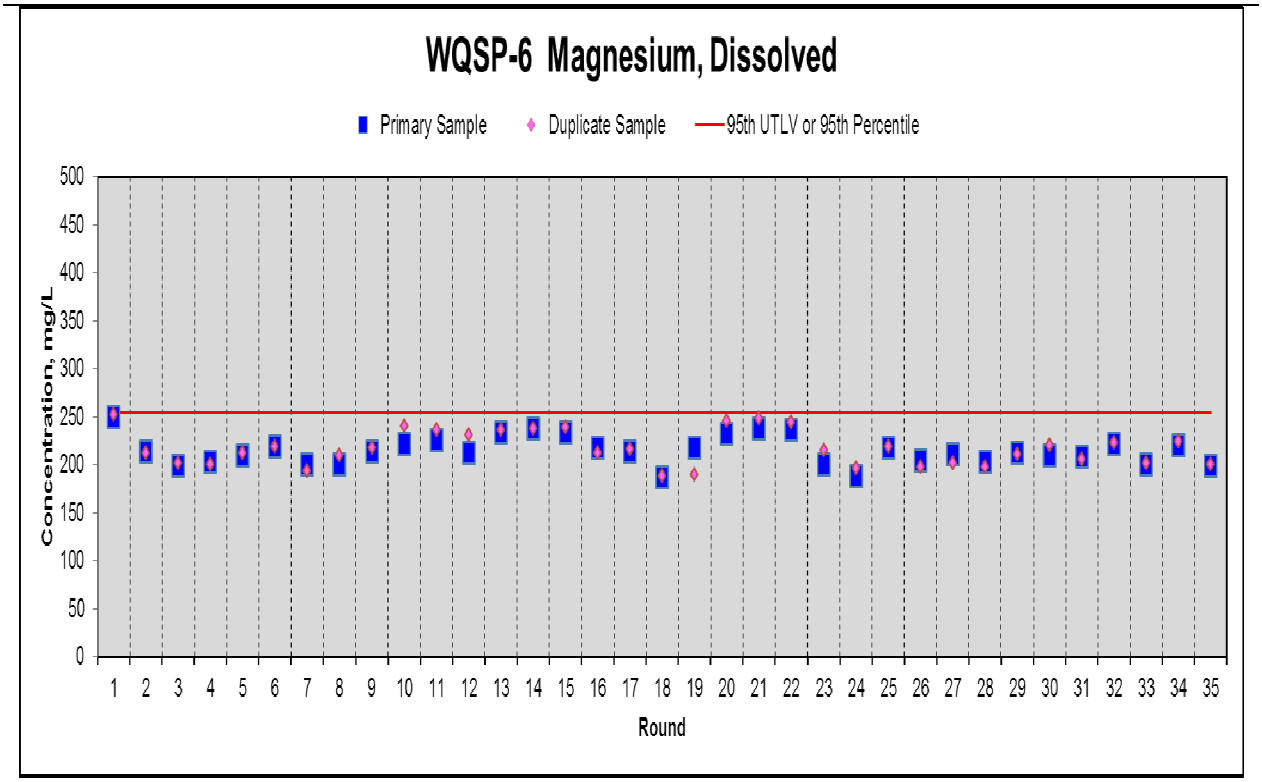

WQSP-5 Chloride
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
5,000
7,500
10,000
12,500
15,000
17,500
20,000
22,500
25,000
27,500
30,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

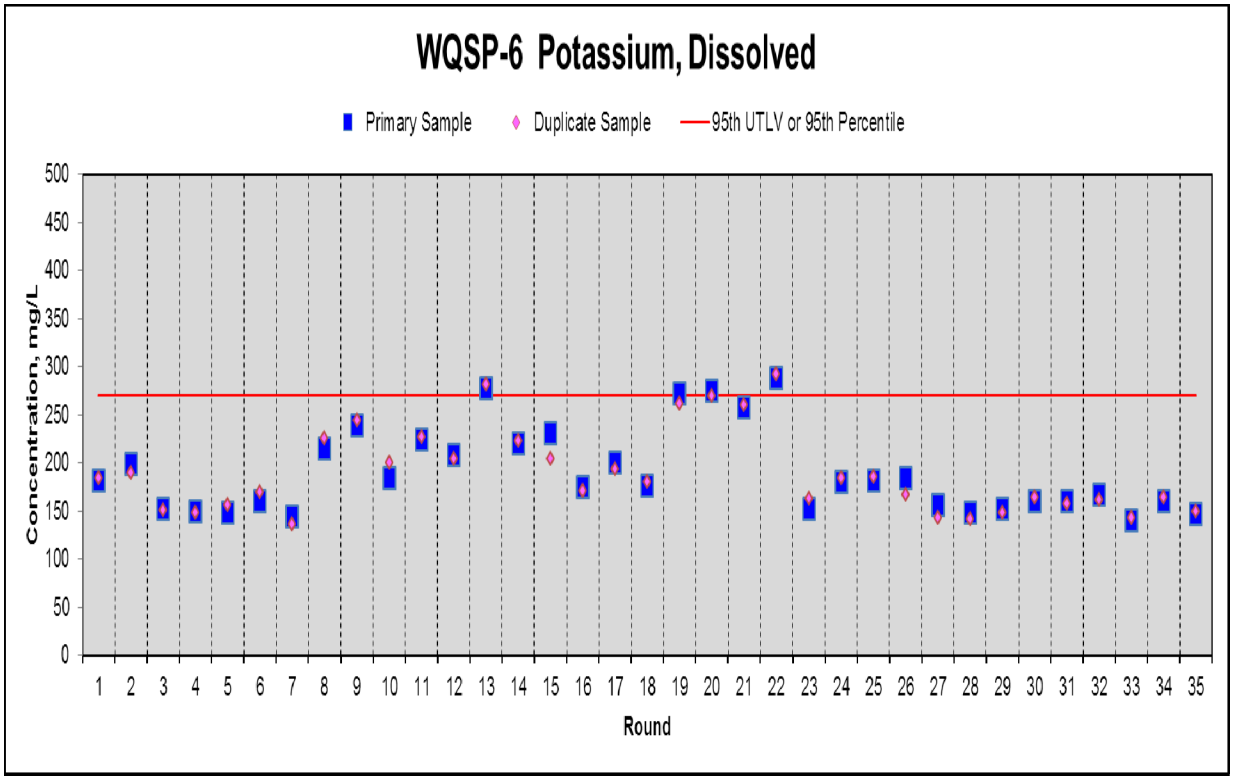

WQSP-5 Sulfate
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

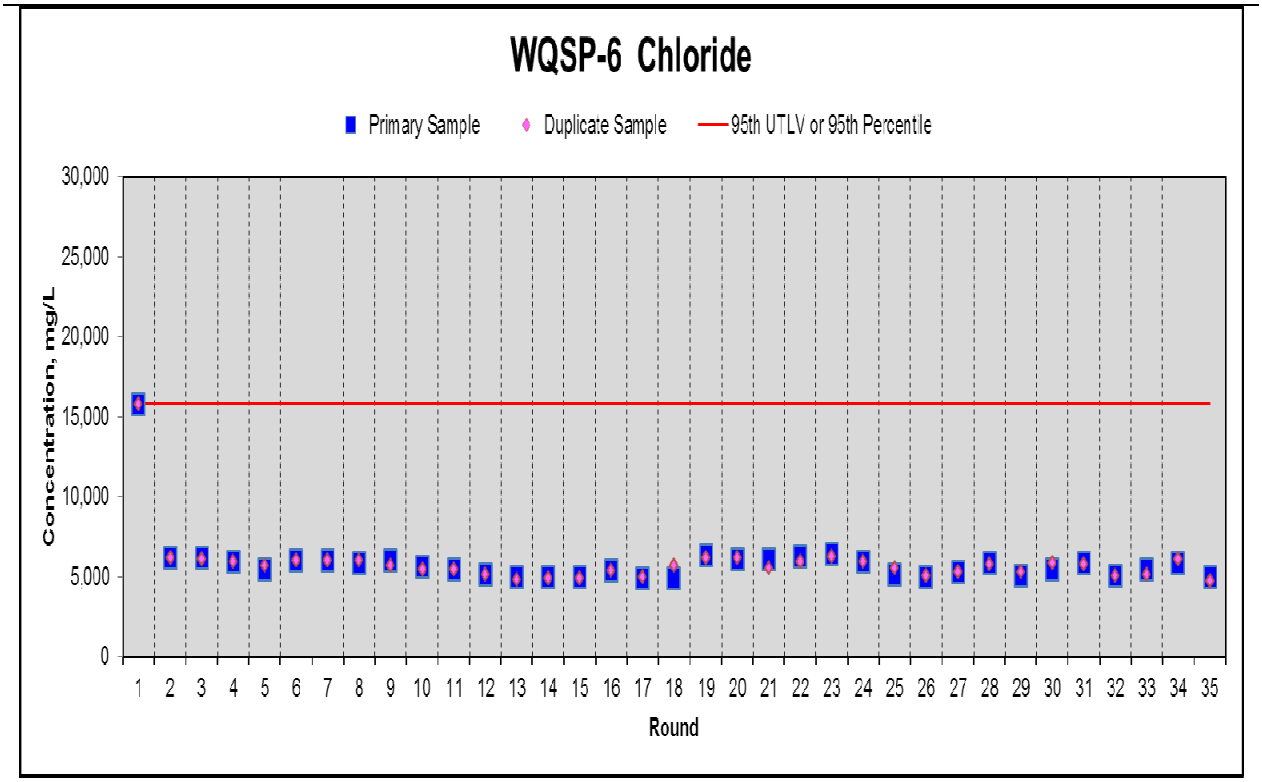

WQSP-5 Total Dissolved Solids
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

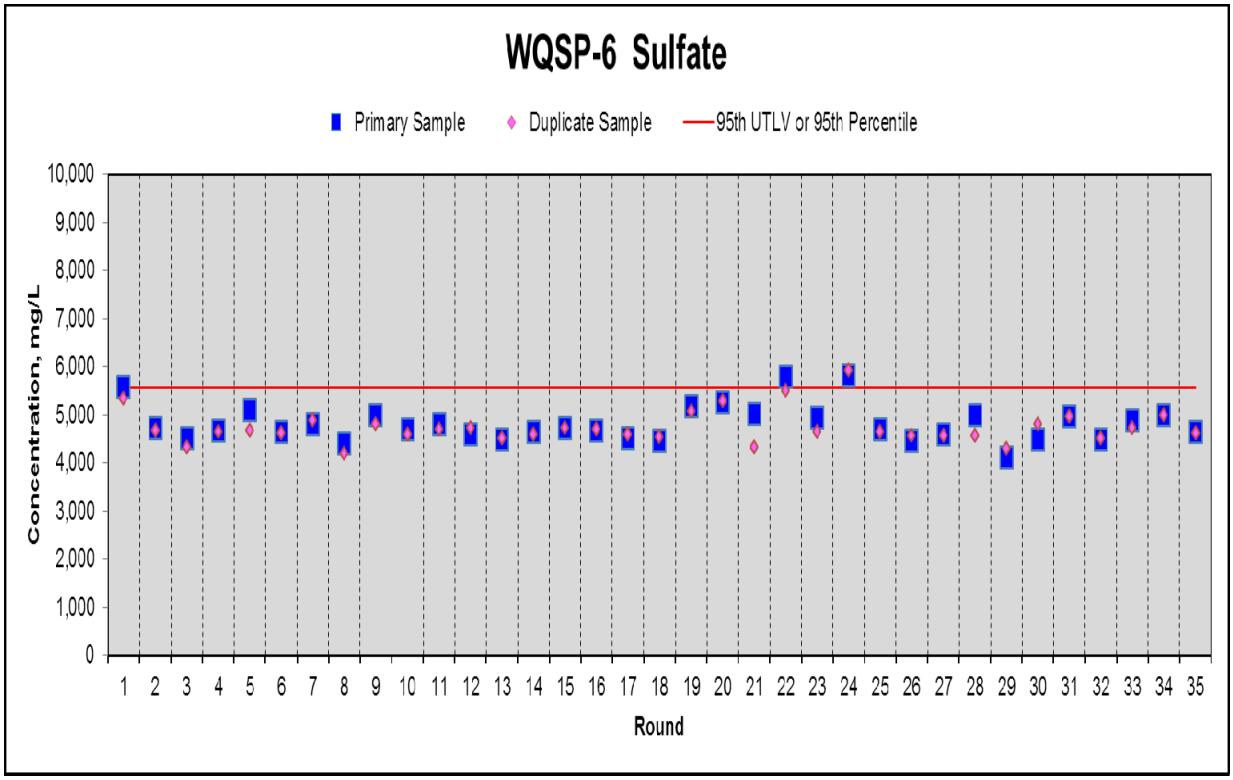

WQSP-5 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
8.50
8.25
8.00
7.75
7.50
7.25
7.00
6.75
6.50
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

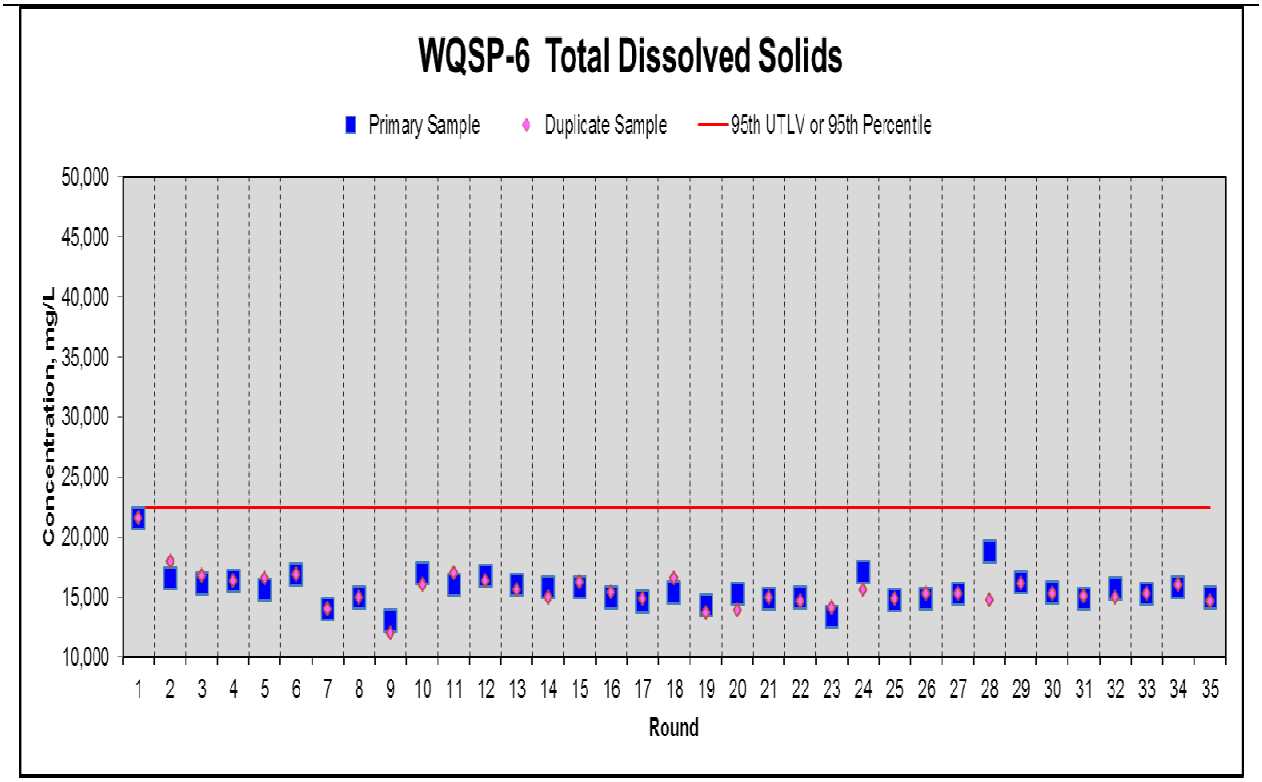

WQSP-6 Calcium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
1,400
1,200
1,000
800
600
400
200
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round

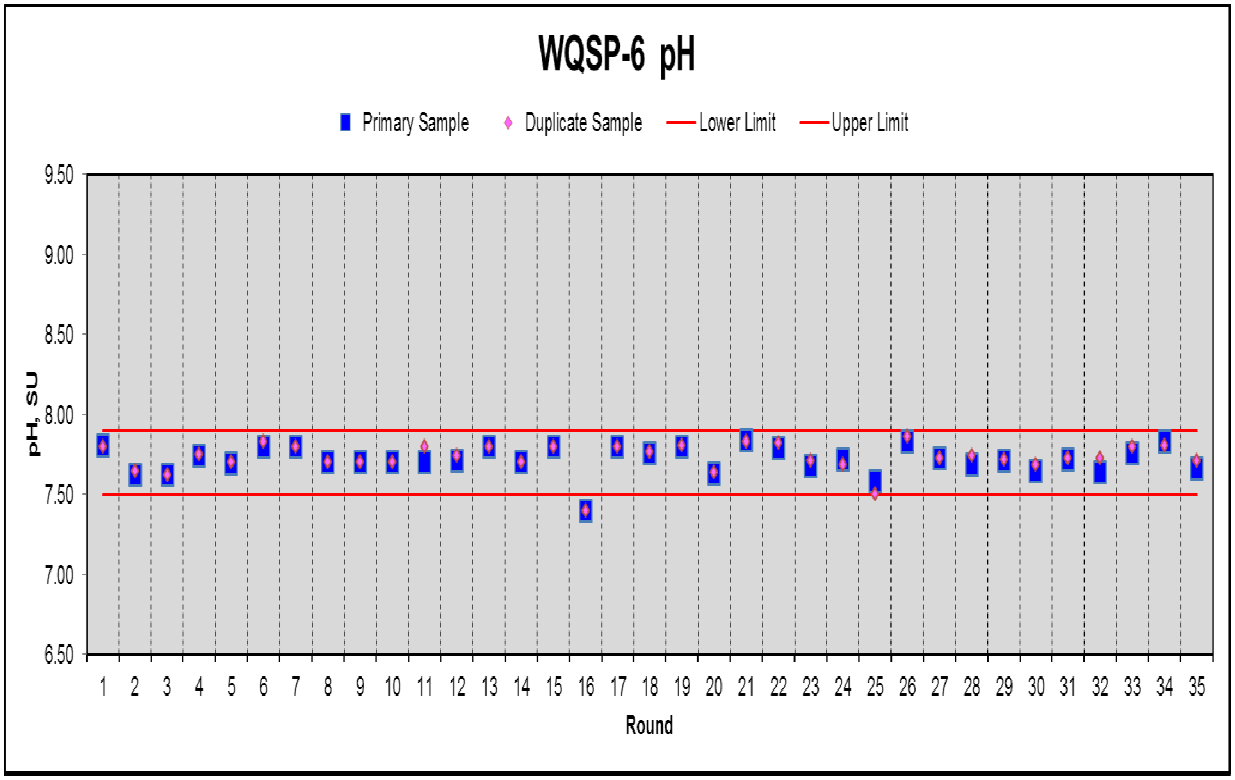

WQSP-6 Magnesium, Dissolved
Primary Sample
Duplicate Sample
95th UTLV or 95th Percentile
Concentration, mg/L
0
50
100
150
200
250
300
350
400
450
500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
Round


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
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
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
Round


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
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
Round


WQSP-6 pH
Primary Sample
Duplicate Sample
Lower Limit
Upper Limit
pH, SU
9.50
9.00
8.50
8.00
7.50
7.00
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
Round

APPENDIX F – GROUNDWATER DATA TABLES

Table F.1 – VOC and SVOC Results for All DMWs in 2013 Were Reported Below the Method Reporting Limit for Each Parameter Shown Below.

Compound[a]	MRL, µg/L
VOCs	
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
SVOCs	
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

[a]: Chemical synonyms used by the current analytical laboratory, HEAL, are noted in parentheses.
[b]: 2-, 3-, and 4-methylphenol, are listed collectively as Cresols in the Permit
µg/L = microgram(s) per liter
VOC = volatile organic compound

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 General Chemistry					
Specific Gravity[b]	1.039	1.038	Normal	1.07	N/A
pH (SU)	7.05	7.07	Lognormal	5.6 – 8.8	N/A
Specific Conductance (μmhos/cm)	115,000	113,000	Lognormal	175,000	N/A
Total Dissolved Solids	61,800	64,700	Lognormal	80,700	N/A
Total Organic Carbon	0.78 J	0.81 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**39**	**40**	Nonparametric	**33.3**	N/A
WQSP-1 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	0.33	0.33
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	<0.1	0.10
Barium	0.031 J	0.029 J	Nonparametric	<1.0	1.00
Beryllium	0.0047 J	0.0028 J	Nonparametric	<0.02	0.02
Cadmium	ND (0.0020)	ND (0.0020)	Nonparametric	<0.2	0.20
Chromium	ND (0.0080)	ND (0.0080)	Nonparametric	<0.5	0.50
Lead	ND (0.026)	ND (0.026)	Nonparametric	0.105	0.11
Mercury	ND (0.00012)	ND (0.00012)	Nonparametric	<0.002	0.002
Nickel	ND (0.0060)	ND (0.0060)	Nonparametric	0.490	0.50
Selenium	ND (0.020)	ND (0.020)	Nonparametric	0.150	0.15
Silver	ND (0.0020)	ND (0.0020)	Nonparametric	<0.5	0.50
Thallium	ND (0.020)	ND (0.020)	Nonparametric	0.98	1.00
Vanadium	0.034 J	0.026 J	Nonparametric	<0.1	0.10
WQSP-1 Major Cations, Dissolved					
Calcium	1,850	1,840	Normal	2,087	N/A
Magnesium	1,130	1,120	Normal	1,247	N/A
Potassium	515	534	Lognormal	799	N/A
WQSP-1 Major Anions					
Chloride	36,200	39,500	Normal	40,472	N/A

Table F.3 – WQSP-2 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-2 General Chemistry					
Specific Gravity[b]	1.044	1.041	Lognormal	1.06	N/A
pH (SU)	7.18	7.20	Normal	7.0–7.6	N/A
Specific Conductance (μmhos/cm)	116,000	119,000	Lognormal	124,000	N/A
Total Dissolved Solids	63,000	63,000	Normal	80,500	N/A
Total Organic Carbon	0.28 J	0.29 J	Nonparametric	7.97	N/A
Total Suspended Solids	35	34	Nonparametric	43.0	N/A
WQSP-2 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	<0.5	0.50
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	0.062	0.06
Barium	0.021 J	0.027 J	Nonparametric	<1.0	1.00
Beryllium	ND (0.0025)	0.0060 J	Nonparametric	<1.0	1.00
Cadmium	ND (0.0040)	ND (0.0040)	Nonparametric	<0.5	0.50
Chromium	ND (0.0075)	ND (0.0075)	Nonparametric	<0.5	0.50
Lead	ND (0.017)	ND (0.017)	Nonparametric	0.163	0.17
Mercury	ND (0.00009)	ND (0.00009)	Nonparametric	<0.002	0.002
Nickel	ND (0.0070)	ND (0.0070)	Nonparametric	0.37	0.50
Selenium	ND (0.020	ND (0.020)	Nonparametric	0.150	0.15
Silver	ND (0.0055)	ND (0.0055)	Nonparametric	<0.5	0.50
Thallium	ND (0.020)	ND (0.020)	Nonparametric	0.980	1.00
Vanadium	0.020 J	0.031 J	Nonparametric	<0.1	0.10
WQSP-2 Major Cations, Dissolved					
Calcium	1,400	1,450	Lognormal	1,827	N/A
Magnesium	1,020	1,060	Normal	1,244	N/A
Potassium	463	485	Lognormal	845	N/A
WQSP-2 Major Anions					
Chloride	36,100	32,100	Normal	39,670	N/A

Table F.4 – WQSP-3 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-3 General Chemistry					
Specific Gravity[b]	1.133	1.034	Normal	1.17	N/A
pH (SU)	6.83	6.84	Lognormal	6.6 – 7.2	N/A
Specific Conductance (μmhos/cm)	383,000	385,000	Normal	517,000	N/A
Total Dissolved Solids	220,000	211,000	Lognormal	261,000	N/A
Total Organic Carbon	0.42 J	0.44 J	Nonparametric	<5.0	N/A
Total Suspended Solids	**123**	**168**	Nonparametric	107	N/A
WQSP-3 Total Trace Metals					
Antimony	ND (0.020)	ND (0.020)	Nonparametric	<1.0	1.00
Arsenic	ND (0.020)	ND (0.020)	Nonparametric	<1.0	0.21
Barium	0.040 J	0.046 J	Nonparametric	<1.0	1.00
Beryllium	0.019 J	0.019 J	Nonparametric	<0.1	0.10
Cadmium	ND (0.020)	ND (0.020)	Nonparametric	<0.5	0.50
Chromium	ND (0.038)	ND (0.038)	Nonparametric	<2.0	2.00
Lead	ND (0.085)	ND (0.085)	Nonparametric	0.8	0.80
Mercury	ND (0.00035)	ND (0.00035)	Nonparametric	<0.002	0.002
Nickel	ND (0.035)	ND (0.035)	Nonparametric	<5.0	5.00
Selenium	ND (0.020)	ND (0.020)	Nonparametric	<2.0	2.00
Silver	ND (0.028)	ND (0.028)	Nonparametric	0.31	0.31
Thallium	ND (0.020)	ND (0.020)	Nonparametric	5.8	5.80
Vanadium	0.16 J	0.16 J	Nonparametric	<5.0	5.00
WQSP-3 Major Cations, Dissolved					
Calcium	1,440	1,380	Normal	1,680	N/A
Magnesium	2,300	2,190	Lognormal	2,625	N/A
Potassium	1,510	1,410	Lognormal	3,438	N/A
WQSP-3 Major Anions					
Chloride	127,000	129,000	Lognormal	149,100	N/A

Table F.5 – WQSP-4 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV Or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-4 General Chemistry					
Specific Gravity[b]	1.062	1.059	Lognormal	1.09	N/A
pH (SU)	7.20	7.21	Lognormal	6.8 – 7.6	N/A
Specific Conductance (μmhos/cm)	193,000	182,000	Lognormal	319,800	N/A
Total Dissolved Solids	108,000	101,000	Normal	123,500	N/A
Total Organic Carbon	0.37 J	ND (0.23)	Nonparametric	<5.0	N/A
Total Suspended Solids	51	**64**	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	0.033 J	0.037 J	Nonparametric	1.00	1.00
Beryllium	0.0053 J	0.0046 J	Nonparametric	0.25	0.25
Cadmium	ND (0.0040)	ND (0.0040)	Nonparametric	<0.5	0.50
Chromium	ND (0.0075)	ND (0.0075)	Nonparametric	<2.0	2.00
Lead	ND (0.017)	ND (0.017)	Nonparametric	0.525	0.53
Mercury	ND (0.00035)	ND (0.00035)	Nonparametric	<0.002	0.002
Nickel	ND (0.0070)	ND (0.0070)	Nonparametric	<5.0	5.00
Selenium	ND (0.020)	ND (0.020)	Nonparametric	2.009	2.00
Silver	ND (0.0055)	ND (0.0055)	Nonparametric	0.519	0.52
Thallium	ND (0.020)	ND (0.020)	Nonparametric	1.00	1.00
Vanadium	0.043 J	0.038 J	Nonparametric	<5.0	5.00
WQSP-4 Major Cations, Dissolved					
Calcium	1,630	1,630	Lognormal	1,834	N/A
Magnesium	1,150	1,180	Lognormal	1,472	N/A
Potassium	701	717	Lognormal	1,648	N/A
WQSP-4 Major Anions					
Chloride	62,900	56,100	Normal	63,960	N/A

Table F.6 – WQSP-5 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-5 General Chemistry					
Specific Gravity[b]	1.020	1.019	Normal	1.04	N/A
pH (SU)	7.32	7.43	Normal	7.4 – 7.9	N/A
Specific Conductance (μmhos/cm)	62,000	61,300	Lognormal	67,700	N/A
Total Dissolved Solids	31,600	31,800	Nonparametric	43,950	N/A
Total Organic Carbon	0.38 J	0.38 J	Nonparametric	<5.0	N/A
Total Suspended Solids	5.0	ND (1.5)	Nonparametric	<10	N/A
WQSP-5 Total Trace Metals					
Antimony	ND (0.010)	ND (0.010)	Nonparametric	0.073	0.07
Arsenic	ND (0.010)	ND (0.010)	Nonparametric	<0.5	0.50
Barium	0.018 J	0.017 J	Nonparametric	<1.0	1.00
Beryllium	0.0015 J	0.0017 J	Nonparametric	<0.02	0.02
Cadmium	ND (0.00080)	ND (0.00080)	Nonparametric	<0.05	0.05
Chromium	ND (0.0015)	ND (0.0015)	Nonparametric	<0.5	0.50
Lead	ND(0.0034)	ND (0.0034)	Nonparametric	<0.05	0.05
Mercury	ND (0.00044)	ND (0.00044)	Nonparametric	<0.002	0.002
Nickel	ND (0.0014)	ND (0.0014)	Nonparametric	<0.1	0.10
Selenium	ND (0.010)	ND (0.010)	Nonparametric	<0.1	0.10
Silver	ND (0.0011)	ND (0.0011)	Nonparametric	<0.5	0.50
Thallium	ND (0.010)	ND (0.010)	Nonparametric	0.209	0.21
Vanadium	0.011 J	0.012 J	Nonparametric	2.70	2.70
WQSP-5 Major Cations, Dissolved					
Calcium	1,010	1,040	Lognormal	1,303	N/A
Magnesium	424	427	Nonparametric	547	N/A
Potassium	313	337	Lognormal	622	N/A
WQSP-5 Major Anions					
Chloride	14,300	14,700	Lognormal	18,100	N/A

Table F.7 WQSP-6 Culebra

Chemical	Concentration (mg/L)		Distribution Type[a]	95th UTLV or 95th Percentile	Permit Table 5.6
	Primary Sample	Duplicate			
WQSP-6 General Chemistry					
Specific Gravity[b]	1.007	1.007	Normal	1.02	N/A
pH (SU)	7.66	7.71	Normal	7.5 – 7.9	N/A
Specific Conductance (μmhos/cm)	25,000	24,000	Lognormal	27,660	N/A
Total Dissolved Solids	15,000	14,600	Lognormal	22,500	N/A
Total Organic Carbon	0.61 J	0.60 J	Nonparametric	10.14	N/A
Total Suspended Solids	9.0	10	Nonparametric	14.8	N/A
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	0.011 J	0.010 J	Nonparametric	<1.0	1.00
Beryllium	0.00064 J	0.00053 J	Nonparametric	<0.02	0.02
Cadmium	ND (0.00080)	ND (0.00080)	Nonparametric	<0.05	0.05
Chromium	ND (0.0015)	ND (0.0015)	Nonparametric	<0.5	0.50
Lead	ND (0.0034)	ND (0.0034)	Nonparametric	0.150	0.15
Mercury	ND (0.00009)	ND (0.00009)	Nonparametric	<0.002	0.002
Nickel	ND (0.0014)	ND (0.0014)	Nonparametric	<0.5	0.50
Selenium	ND (0.020)	ND (0.020)	Nonparametric	0.10	0.10
Silver	ND (0.0011)	ND (0.0011)	Nonparametric	<0.5	0.50
Thallium	ND (0.020)	ND (0.020)	Nonparametric	0.560	0.56
Vanadium	0.0051 J	0.0040 J	Nonparametric	0.070	0.10
WQSP-6 Major Cations, Dissolved					
Calcium	675	671	Normal	796	N/A
Magnesium	199	201	Lognormal	255	N/A
Potassium	147	150	Lognormal	270	N/A
WQSP-6 Major Anions					
Chloride	5,010	4,720	Nonparametric	15,800	N/A

Footnotes for Tables F.2–F.7:

Note: Values (concentrations) in bold exceed, or are outside of the baseline range for the 95th 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 (grams per milliliter) as presented in Addendum 1 (DOE, 2000).

J = Estimated concentration. The concentration is between the laboratory's MDL and the MRL/Practical Quantitation Limit (PQL) for the particular sample.

N/A = Not applicable

ND = The analytical parameter was analyzed, but not detected in sample. The trace metals were analyzed by (inductively coupled plasma emission spectroscopy (ICP). Antimony, As, Se, and Tl were analyzed by ICP/MS. The MDLs 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.8 – WIPP Well Inventory for 2013

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2013			
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-7	CUL	
4	C-2507	SR/DL		4	AEC-7R	CUL	New well September 2013
5	C-2737	MAG/CUL		5	ERDA-9	CUL	
6	C-2811	SR/DL		6	H-02b2	CUL	
7	CB-1(PIP)	B/C		7	H-03b2	CUL	
8	DOE-2	B/C		8	H-04bR	CUL	
9	ERDA-9	CUL		9	H-05b	CUL	
10	H-02b1	MAG		10	H-06bR	CUL	
11	H-02b2	CUL		11	H-07b1	CUL	
12	H-03b1	MAG		12	H-09bR	CUL	
13	H-03b2	CUL		13	H-10c	CUL	
14	H-03D	SR/DL	Dry; not measured in 2013	14	H-11b4R	CUL	
15	H-04bR	CUL		15	H-12	CUL	
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-12	CUL		28	SNL-05	CUL	
29	H-14	MAG		29	SNL-6	CUL	Depressed from projected equilibrium
30	H-15R	CUL		30	SNL-08	CUL	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2013			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
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	
62	PZ-04	SR/DL		62	WIPP-18	MAG	

Sorted by Active Wells at Year-End				Sorted by Formation for Wells Measured at Least Once in 2013			
Count	Well Number	Zone	Comments	Count	Well Number	Zone	Reason Not Assessed for Long-Term Water Level Trend in Culebra
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 in 2013

Table F.9 – Water Levels

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
AEC-7	CUL	01/08/13	612.99	3044.07	3061.45
AEC-7	CUL	02/08/13	612.21	3044.85	3062.29
AEC-7	CUL	03/11/13	613.00	3044.06	3061.44
AEC-7	CUL	04/08/13	612.96	3044.10	3061.49
AEC-7	CUL	05/08/13	613.14	3043.92	3061.29
AEC-7	CUL	06/11/13	612.93	3044.13	3061.52
AEC-7	CUL	07/15/13	613.25	3043.81	3061.18
AEC-7	CUL	08/06/13	613.10	3043.96	3061.34
AEC-7R	CUL	09/09/13	614.14	NA	NA
AEC-7R	CUL	Oct	SNL Testing		
AEC-7R	CUL	Nov	SNL Testing		
AEC-7R	CUL	Dec	SNL Testing		
C-2737 (PIP)	CUL	01/09/13	387.94	3012.82	3019.79
C-2737 (PIP)	CUL	02/12/13	387.89	3012.87	3019.84
C-2737 (PIP)	CUL	03/13/13	388.03	3012.73	3019.70
C-2737 (PIP)	CUL	04/10/13	387.78	3012.98	3019.96
C-2737 (PIP)	CUL	05/13/13	387.89	3012.87	3019.84
C-2737 (PIP)	CUL	06/13/13	387.77	3012.99	3019.97
C-2737 (PIP)	CUL	07/17/13	388.02	3012.74	3019.71
C-2737 (PIP)	CUL	08/09/13	388.41	3012.35	3019.31
C-2737 (PIP)	CUL	09/17/13	388.86	3011.90	3018.85
C-2737 (PIP)	CUL	10/09/13	388.99	3011.77	3018.72
C-2737 (PIP)	CUL	11/13/13	391.70	3009.06	3015.95
C-2737 (PIP)	CUL	12/11/13	394.60	3006.16	3012.98
ERDA-9	CUL	01/09/13	400.03	3010.14	3033.29
ERDA-9	CUL	02/12/13	400.05	3010.12	3033.27
ERDA-9	CUL	03/13/13	400.09	3010.08	3033.23
ERDA-9	CUL	04/10/13	399.81	3010.36	3033.53
ERDA-9	CUL	05/13/13	399.93	3010.24	3033.40
ERDA-9	CUL	06/12/13	399.71	3010.46	3033.63
ERDA-9	CUL	07/17/13	399.83	3010.34	3033.51
ERDA-9	CUL	08/09/13	399.85	3010.32	3033.48
ERDA-9	CUL	09/17/13	400.40	3009.77	3032.89
ERDA-9	CUL	10/09/13	400.76	3009.41	3032.51

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
ERDA-9	CUL	11/13/13	402.55	3007.62	3030.59
ERDA-9	CUL	12/11/13	404.11	3006.06	3028.91
H-02b2	CUL	01/09/13	337.29	3041.07	3044.65
H-02b2	CUL	02/12/13	337.15	3041.21	3044.79
H-02b2	CUL	03/13/13	337.44	3040.92	3044.50
H-02b2	CUL	04/10/13	337.24	3041.12	3044.70
H-02b2	CUL	05/13/13	337.31	3041.05	3044.63
H-02b2	CUL	06/13/13	337.26	3041.10	3044.68
H-02b2	CUL	07/17/13	337.50	3040.86	3044.44
H-02b2	CUL	08/09/13	337.26	3041.10	3044.68
H-02b2	CUL	09/17/13	337.52	3040.84	3044.42
H-02b2	CUL	10/09/13	337.45	3040.91	3044.49
H-02b2	CUL	11/13/13	338.04	3040.32	3043.89
H-02b2	CUL	12/11/13	338.52	3039.84	3043.40
H-03b2	CUL	01/09/13	388.58	3001.33	3012.10
H-03b2	CUL	02/12/13	388.82	3001.09	3011.85
H-03b2	CUL	03/14/13	388.88	3001.03	3011.79
H-03b2	CUL	04/10/13	388.69	3001.22	3011.98
H-03b2	CUL	05/13/13	388.93	3000.98	3011.74
H-03b2	CUL	06/10/13	388.95	3000.96	3011.72
H-03b2	CUL	07/17/13	390.12	2999.79	3010.50
H-03b2	CUL	08/09/13	391.24	2998.67	3009.34
H-03b2	CUL	09/17/13	390.55	2999.36	3010.06
H-03b2	CUL	10/09/13	391.53	2998.38	3009.04
H-03b2	CUL	11/13/13	396.22	2993.69	3004.18
H-03b2	CUL	12/11/13	400.10	2989.81	3000.16
H-04bR	CUL	01/09/13	331.50	3003.14	3006.14
H-04bR	CUL	02/11/13	331.16	3003.48	3006.48
H-04bR	CUL	03/13/13	331.38	3003.26	3006.26
H-04bR	CUL	04/10/13	331.15	3003.49	3006.49
H-04bR	CUL	05/07/13	331.39	3003.25	3006.25
H-04bR	CUL	06/12/13	332.08	3002.56	3005.55
H-04bR	CUL	07/15/13	333.25	3001.39	3004.36
H-04bR	CUL	08/09/13	332.44	3002.20	3005.18
H-04bR	CUL	09/16/13	352.59	2982.05	2984.69
H-04bR	CUL	10/04/13	381.92	2952.72	2954.86

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-04bR	CUL	11/11/13	398.90	2935.74	2937.59
H-04bR	CUL	12/11/13	377.95	2956.69	2958.90
H-05b	CUL	01/07/13	466.11	3040.67	3082.87
H-05b	CUL	02/08/13	466.13	3040.65	3082.84
H-05b	CUL	03/12/13	466.04	3040.74	3082.94
H-05b	CUL	04/09/13	465.76	3041.02	3083.25
H-05b	CUL	05/08/13	465.96	3040.82	3083.03
H-05b	CUL	06/11/13	465.96	3040.82	3083.03
H-05b	CUL	07/15/13	466.06	3040.72	3082.92
H-05b	CUL	08/06/13	466.01	3040.77	3082.98
H-05b	CUL	09/09/13	466.11	3040.67	3082.87
H-05b	CUL	10/07/13	466.31	3040.47	3082.65
H-05b	CUL	11/12/13	466.60	3040.18	3082.33
H-05b	CUL	12/09/13	466.60	3040.18	3082.33
H-06bR	CUL	01/07/13	291.25	3057.97	3070.36
H-06bR	CUL	02/11/13	290.87	3058.35	3070.76
H-06bR	CUL	03/13/13	291.17	3058.05	3070.44
H-06bR	CUL	04/09/13	290.76	3058.46	3070.87
H-06bR	CUL	05/13/13	291.22	3058.00	3070.39
H-06bR	CUL	06/11/13	291.24	3057.98	3070.37
H-06bR	CUL	07/15/13	291.54	3057.68	3070.06
H-06bR	CUL	08/08/13	291.50	3057.72	3070.10
H-06bR	CUL	09/10/13	291.74	3057.48	3069.85
H-06bR	CUL	10/03/13	291.74	3057.48	3069.85
H-06bR	CUL	11/13/13	292.14	3057.08	3069.44
H-06bR	CUL	12/09/13	292.00	3057.22	3069.58
H-07b1	CUL	01/07/13	166.03	2997.69	2998.42
H-07b1	CUL	02/07/13	166.03	2997.69	2998.42
H-07b1	CUL	03/11/13	165.91	2997.81	2998.54
H-07b1	CUL	04/08/13	165.70	2998.02	2998.75
H-07b1	CUL	05/08/13	166.02	2997.70	2998.43
H-07b1	CUL	06/12/13	168.55	2995.17	2995.88
H-07b1	CUL	07/16/13	168.98	2994.74	2995.45
H-07b1	CUL	08/06/13	168.98	2994.74	2995.45
H-07b1	CUL	09/10/13	168.67	2995.05	2995.76
H-07b1	CUL	10/03/13	167.33	2996.39	2997.11

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-07b1	CUL	11/13/13	168.00	2995.72	2996.43
H-07b1	CUL	12/11/13	167.96	2995.76	2996.47
H-09bR	CUL	01/07/13	412.96	2995.38	2995.38
H-09bR	CUL	02/08/13	413.00	2995.34	2995.34
H-09bR	CUL	03/12/13	412.89	2995.45	2995.45
H-09bR	CUL	04/08/13	413.84	2994.50	2994.50
H-09bR	CUL	05/07/13	416.46	2991.88	2991.88
H-09bR	CUL	06/10/13	419.80	2988.54	2988.54
H-09bR	CUL	07/16/13	423.93	2984.41	2984.41
H-09bR	CUL	08/07/13	423.84	2984.50	2984.50
H-09bR	CUL	09/12/13	424.75	2983.59	2983.59
H-09bR	CUL	10/04/13	429.50	2978.84	2978.84
H-09bR	CUL	11/11/13	435.53	2972.81	2972.81
H-09bR	CUL	12/10/13	436.87	2971.47	2971.47
H-10c	CUL	01/07/13	719.08	2969.32	3030.70
H-10c	CUL	02/08/13	718.80	2969.60	3031.01
H-10c	CUL	03/12/13	718.79	2969.61	3031.02
H-10c	CUL	04/09/13	718.34	2970.06	3031.51
H-10c	CUL	05/07/13	718.56	2969.84	3031.27
H-10c	CUL	06/10/13	718.21	2970.19	3031.66
H-10c	CUL	07/16/13	718.50	2969.90	3031.34
H-10c	CUL	08/07/13	718.01	2970.39	3031.87
H-10c	CUL	09/12/13	717.62	2970.78	3032.30
H-10c	CUL	10/04/13	717.53	2970.87	3032.40
H-10c	CUL	11/12/13	717.91	2970.49	3031.98
H-10c	CUL	12/10/13	717.75	2970.65	3032.16
H-11b4R	CUL	01/08/13	428.16	2983.71	3007.09
H-11b4R	CUL	02/11/13	428.02	2983.85	3007.25
H-11b4R	CUL	03/12/13	428.05	2983.82	3007.21
H-11b4R	CUL	04/09/13	427.74	2984.13	3007.55
H-11b4R	CUL	05/07/13	428.30	2983.57	3006.94
H-11b4R	CUL	06/10/13	428.83	2983.04	3006.37
H-11b4R	CUL	07/16/13	430.01	2981.86	3005.10
H-11b4R	CUL	08/08/13	430.58	2981.29	3004.49
H-11b4R	CUL	09/09/13	431.90	2979.97	3003.07
H-11b4R	CUL	10/04/13	441.72	2970.15	2992.50

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-11b4R	CUL	11/12/13	455.45	2956.42	2977.73
H-11b4R	CUL	12/10/13	458.95	2952.92	2973.96
H-12	CUL	01/07/13	457.38	2969.95	3013.01
H-12	CUL	02/11/13	457.11	2970.22	3013.31
H-12	CUL	03/12/13	457.08	2970.25	3013.34
H-12	CUL	04/09/13	456.84	2970.49	3013.61
H-12	CUL	05/07/13	456.94	2970.39	3013.50
H-12	CUL	06/10/13	456.91	2970.42	3013.53
H-12	CUL	07/16/13	457.35	2969.98	3013.04
H-12	CUL	08/07/13	457.55	2969.78	3012.82
H-12	CUL	09/12/13	458.02	2969.31	3012.30
H-12	CUL	10/03/13	458.64	2968.69	3011.61
H-12	CUL	11/12/13	462.94	2964.39	3006.82
H-12	CUL	12/10/13	466.25	2961.08	3003.14
H-15R	CUL	01/09/13	508.10	2973.92	3016.95
H-15R	CUL	02/12/13	507.83	2974.19	3017.25
H-15R	CUL	03/14/13	507.86	2974.16	3017.21
H-15R	CUL	04/10/13	507.59	2974.43	3017.52
H-15R	CUL	05/13/13	507.78	2974.24	3017.30
H-15R	CUL	06/13/13	507.80	2974.22	3017.28
H-15R	CUL	07/17/13	508.35	2973.67	3016.67
H-15R	CUL	08/08/13	508.49	2973.53	3016.51
H-15R	CUL	09/17/13	509.39	2972.63	3015.50
H-15R	CUL	10/04/13	510.52	2971.50	3014.24
H-15R	CUL	11/13/13	517.30	2964.72	3006.66
H-15R	CUL	12/10/13	521.42	2960.60	3002.05
H-16	CUL	01/09/13	377.01	3033.05	3045.53
H-16	CUL	02/12/13	376.55	3033.51	3046.01
H-16	CUL	03/14/13	376.50	3033.56	3046.06
H-16	CUL	04/10/13	375.86	3034.20	3046.73
H-16	CUL	05/14/13	375.64	3034.42	3046.96
H-16	CUL	06/11/13	375.24	3034.82	3047.37
H-16	CUL	07/17/13	375.51	3034.55	3047.09
H-16	CUL	08/09/13	375.32	3034.74	3047.29
H-16	CUL	09/17/13	375.64	3034.42	3046.96
H-16	CUL	10/03/13	375.67	3034.39	3046.92

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-16	CUL	11/13/13	376.71	3033.35	3045.85
H-16	CUL	12/12/13	378.80	3031.26	3043.68
H-17	CUL	01/08/13	418.53	2966.71	3006.86
H-17	CUL	02/08/13	418.35	2966.89	3007.07
H-17	CUL	03/12/13	418.12	2967.12	3007.33
H-17	CUL	04/09/13	417.80	2967.44	3007.69
H-17	CUL	05/07/13	418.31	2966.93	3007.11
H-17	CUL	06/10/13	418.68	2966.56	3006.69
H-17	CUL	07/16/13	419.65	2965.59	3005.60
H-17	CUL	08/08/13	420.19	2965.05	3004.98
H-17	CUL	09/09/13	421.25	2963.99	3003.78
H-17	CUL	10/03/13	426.04	2959.20	2998.36
H-17	CUL	11/12/13	438.86	2946.38	2983.83
H-17	CUL	12/10/13	444.18	2941.06	2977.80
H-19b0	CUL	01/09/13	426.75	2991.58	3013.17
H-19b0	CUL	02/11/13	426.46	2991.87	3013.48
H-19b0	CUL	03/14/13	426.52	2991.81	3013.42
H-19b0	CUL	04/10/13	426.33	2992.00	3013.62
H-19b0	CUL	05/07/13	426.48	2991.85	3013.46
H-19b0	CUL	06/13/13	426.67	2991.66	3013.26
H-19b0	CUL	07/17/13	427.16	2991.17	3012.74
H-19b0	CUL	08/09/13	428.05	2990.28	3011.79
H-19b0	CUL	09/17/13	428.49	2989.84	3011.32
H-19b0	CUL	10/09/13	430.58	2987.75	3009.09
H-19b0	CUL	11/13/13	436.57	2981.76	3002.71
H-19b0	CUL	12/11/13	440.83	2977.50	2998.16
H-19b2	CUL	03/14/13	427.91	2991.02	3011.36
H-19b2	CUL	06/13/13	428.07	2990.86	3011.19
H-19b2	CUL	09/17/13	429.92	2989.01	3009.23
H-19b2	CUL	12/11/13	442.30	2976.63	2996.08
H-19b3	CUL	03/14/13	428.13	2990.89	3012.44
H-19b3	CUL	06/13/13	428.30	2990.72	3012.26
H-19b3	CUL	09/17/13	430.12	2988.90	3010.32
H-19b3	CUL	12/11/13	442.50	2976.52	2997.12
H-19b4	CUL	03/14/13	427.38	2991.60	3013.52
H-19b4	CUL	06/13/13	427.57	2991.41	3013.32

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-19b4	CUL	09/17/13	429.35	2989.63	3011.42
H-19b4	CUL	12/11/13	441.51	2977.47	2998.45
H-19b5	CUL	03/14/13	427.35	2991.23	3013.78
H-19b5	CUL	06/13/13	427.53	2991.05	3013.59
H-19b5	CUL	09/17/13	429.31	2989.27	3011.69
H-19b5	CUL	12/11/13	441.61	2976.97	2998.54
H-19b6	CUL	03/14/13	428.03	2990.99	3013.85
H-19b6	CUL	06/13/13	428.23	2990.79	3013.64
H-19b6	CUL	09/17/13	430.17	2988.85	3011.56
H-19b6	CUL	12/11/13	442.35	2976.67	2998.53
H-19b7	CUL	March	SNL Testing		
H-19b7	CUL	June	SNL Testing		
H-19b7	CUL	Sept.	SNL Testing		
H-19b7	CUL	Dec.	SNL Testing		
I-461	CUL	01/07/13	242.70	3040.91	3040.91
I-461	CUL	02/07/13	242.37	3041.24	3041.24
I-461	CUL	03/11/13	242.31	3041.30	3041.30
I-461	CUL	04/08/13	242.20	3041.41	3041.41
I-461	CUL	05/08/13	242.49	3041.12	3041.12
I-461	CUL	06/11/13	242.74	3040.87	3040.87
I-461	CUL	07/15/13	242.85	3040.76	3040.76
I-461	CUL	08/08/13	242.42	3041.19	3041.19
I-461	CUL	09/10/13	242.21	3041.40	3041.40
I-461	CUL	10/03/13	242.11	3041.50	3041.50
I-461	CUL	11/11/13	242.24	3041.37	3041.37
I-461	CUL	12/09/13	242.28	3041.33	3041.33
SNL-01	CUL	01/08/13	437.46	3075.38	3080.47
SNL-01	CUL	02/07/13	437.70	3075.14	3080.22
SNL-01	CUL	03/11/13	437.96	3074.88	3079.95
SNL-01	CUL	04/08/13	437.75	3075.09	3080.17
SNL-01	CUL	05/08/13	438.25	3074.59	3079.65
SNL-01	CUL	06/11/13	437.61	3075.23	3080.31
SNL-01	CUL	07/15/13	438.90	3073.94	3078.98
SNL-01	CUL	08/06/13	438.91	3073.93	3078.97
SNL-01	CUL	09/12/13	439.31	3073.53	3078.56
SNL-01	CUL	10/07/13	439.34	3073.50	3078.53

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-01	CUL	11/11/13	439.35	3073.49	3078.52
SNL-01	CUL	12/09/13	439.50	3073.34	3078.37
SNL-02	CUL	01/08/13	252.90	3070.16	3072.12
SNL-02	CUL	02/07/13	252.58	3070.48	3072.44
SNL-02	CUL	03/11/13	252.63	3070.43	3072.39
SNL-02	CUL	04/08/13	252.43	3070.63	3072.59
SNL-02	CUL	05/08/13	252.84	3070.22	3072.18
SNL-02	CUL	06/11/13	253.12	3069.94	3071.90
SNL-02	CUL	07/15/13	253.52	3069.54	3071.50
SNL-02	CUL	08/06/13	253.49	3069.57	3071.53
SNL-02	CUL	09/12/13	253.89	3069.17	3071.12
SNL-02	CUL	10/07/13	253.75	3069.31	3071.26
SNL-02	CUL	11/11/13	253.77	3069.29	3071.24
SNL-02	CUL	12/09/13	254.08	3068.98	3070.93
SNL-03	CUL	01/08/13	421.20	3069.15	3078.82
SNL-03	CUL	02/07/13	421.23	3069.12	3078.79
SNL-03	CUL	03/12/13	421.30	3069.05	3078.72
SNL-03	CUL	04/09/13	421.14	3069.21	3078.88
SNL-03	CUL	05/08/13	421.65	3068.70	3078.36
SNL-03	CUL	06/12/13	421.79	3068.56	3078.21
SNL-03	CUL	07/15/13	422.22	3068.13	3077.77
SNL-03	CUL	08/06/13	422.23	3068.12	3077.76
SNL-03	CUL	09/12/13	422.59	3067.76	3077.39
SNL-03	CUL	10/07/13	422.77	3067.58	3077.21
SNL-03	CUL	11/13/13	422.81	3067.54	3077.16
SNL-03	CUL	12/09/13	422.60	3067.75	3077.38
SNL-05	CUL	01/08/13	310.38	3069.60	3072.65
SNL-05	CUL	02/07/13	310.29	3069.69	3072.74
SNL-05	CUL	03/11/13	310.55	3069.43	3072.48
SNL-05	CUL	04/08/13	310.15	3069.83	3072.88
SNL-05	CUL	05/08/13	310.87	3069.11	3072.15
SNL-05	CUL	06/11/13	310.88	3069.10	3072.14
SNL-05	CUL	07/15/13	311.56	3068.42	3071.46
SNL-05	CUL	08/06/13	311.45	3068.53	3071.57
SNL-05	CUL	09/12/13	312.11	3067.87	3070.90
SNL-05	CUL	10/07/13	311.38	3068.60	3071.64

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-05	CUL	11/11/13	311.21	3068.77	3071.81
SNL-05	CUL	12/09/13	311.65	3068.33	3071.37
SNL-06	CUL	01/08/13	607.04	3039.07	3216.74
SNL-06	CUL	02/08/13	603.68	3042.43	3220.92
SNL-06	CUL	03/12/13	600.45	3045.66	3224.94
SNL-06	CUL	04/08/13	597.40	3048.71	3228.73
SNL-06	CUL	05/08/13	594.24	3051.87	3232.65
SNL-06	CUL	06/11/13	590.63	3055.48	3237.14
SNL-06	CUL	07/15/13	587.30	3058.81	3241.28
SNL-06	CUL	08/06/13	585.09	3061.02	3244.03
SNL-06	CUL	09/09/13	581.73	3064.38	3248.20
SNL-06	CUL	10/07/13	579.03	3067.08	3251.56
SNL-06	CUL	11/12/13	575.59	3070.52	3255.84
SNL-06	CUL	12/09/13	572.94	3073.17	3259.13
SNL-08	CUL	01/08/13	542.12	3013.61	3053.81
SNL-08	CUL	02/08/13	542.26	3013.47	3053.65
SNL-08	CUL	03/12/13	542.20	3013.53	3053.72
SNL-08	CUL	04/09/13	541.86	3013.87	3054.09
SNL-08	CUL	05/08/13	542.22	3013.51	3053.70
SNL-08	CUL	06/11/13	542.06	3013.67	3053.87
SNL-08	CUL	07/15/13	542.20	3013.53	3053.72
SNL-08	CUL	08/08/13	541.95	3013.78	3053.99
SNL-08	CUL	09/09/13	541.98	3013.75	3053.96
SNL-08	CUL	10/07/13	542.08	3013.65	3053.85
SNL-08	CUL	11/12/13	542.24	3013.49	3053.67
SNL-08	CUL	12/09/13	542.14	3013.59	3053.78
SNL-09	CUL	01/07/13	312.04	3048.92	3053.51
SNL-09	CUL	02/07/13	311.69	3049.27	3053.87
SNL-09	CUL	03/13/13	311.74	3049.22	3053.82
SNL-09	CUL	04/08/13	311.34	3049.62	3054.22
SNL-09	CUL	05/08/13	311.54	3049.42	3054.02
SNL-09	CUL	06/10/13	311.78	3049.18	3053.78
SNL-09	CUL	07/15/13	312.03	3048.93	3053.52
SNL-09	CUL	08/08/13	311.88	3049.08	3053.68
SNL-09	CUL	09/10/13	311.95	3049.01	3053.60
SNL-09	CUL	10/03/13	311.65	3049.31	3053.91

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-09	CUL	11/11/13	312.80	3048.16	3052.74
SNL-09	CUL	12/09/13	313.18	3047.78	3052.35
SNL-10	CUL	01/08/13	327.30	3050.29	3052.87
SNL-10	CUL	02/07/13	327.02	3050.57	3053.15
SNL-10	CUL	03/11/13	326.93	3050.66	3053.24
SNL-10	CUL	04/08/13	327.45	3050.14	3052.71
SNL-10	CUL	05/08/13	326.72	3050.87	3053.45
SNL-10	CUL	06/12/13	326.86	3050.73	3053.31
SNL-10	CUL	07/16/13	327.08	3050.51	3053.09
SNL-10	CUL	08/06/13	327.02	3050.57	3053.15
SNL-10	CUL	09/10/13	327.09	3050.50	3053.08
SNL-10	CUL	10/09/13	326.87	3050.72	3053.30
SNL-10	CUL	11/11/13	327.91	3049.68	3052.25
SNL-10	CUL	12/11/13	328.86	3048.73	3051.29
SNL-12	CUL	01/07/13	338.78	3000.68	3002.07
SNL-12	CUL	02/08/13	338.82	3000.64	3002.03
SNL-12	CUL	03/12/13	338.61	3000.85	3002.24
SNL-12	CUL	04/08/13	338.28	3001.18	3002.58
SNL-12	CUL	05/07/13	339.22	3000.24	3001.63
SNL-12	CUL	06/10/13	340.59	2998.87	3000.25
SNL-12	CUL	07/16/13	342.51	2996.95	2998.32
SNL-12	CUL	08/07/13	342.55	2996.91	2998.28
SNL-12	CUL	09/12/13	346.00	2993.46	2994.81
SNL-12	CUL	10/04/13	369.06	2970.40	2971.61
SNL-12	CUL	11/11/13	383.29	2956.17	2957.30
SNL-12	CUL	12/10/13	377.25	2962.21	2963.37
SNL-13	CUL	01/07/13	282.35	3011.76	3013.90
SNL-13	CUL	02/07/13	282.40	3011.71	3013.84
SNL-13	CUL	03/11/13	282.75	3011.36	3013.49
SNL-13	CUL	04/08/13	282.66	3011.45	3013.58
SNL-13	CUL	05/08/13	283.01	3011.10	3013.22
SNL-13	CUL	06/12/13	283.30	3010.81	3012.93
SNL-13	CUL	07/15/13	283.68	3010.43	3012.54
SNL-13	CUL	08/06/13	283.75	3010.36	3012.47
SNL-13	CUL	09/10/13	284.19	3009.92	3012.02
SNL-13	CUL	10/04/13	285.15	3008.96	3011.05

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-13	CUL	11/11/13	290.28	3003.83	3005.82
SNL-13	CUL	12/11/13	294.79	2999.32	3001.23
SNL-14	CUL	01/08/13	377.86	2990.55	3003.97
SNL-14	CUL	02/08/13	377.74	2990.67	3004.09
SNL-14	CUL	03/12/13	377.78	2990.63	3004.05
SNL-14	CUL	04/09/13	377.40	2991.01	3004.45
SNL-14	CUL	05/07/13	378.14	2990.27	3003.67
SNL-14	CUL	06/10/13	378.98	2989.43	3002.79
SNL-14	CUL	07/16/13	380.53	2987.88	3001.17
SNL-14	CUL	08/08/13	380.93	2987.48	3000.75
SNL-14	CUL	09/09/13	382.41	2986.00	2999.21
SNL-14	CUL	10/03/13	399.05	2969.36	2981.80
SNL-14	CUL	11/12/13	414.58	2953.83	2965.56
SNL-14	CUL	12/10/13	414.40	2954.01	2965.75
SNL-15	CUL	01/08/13	546.41	2933.52	3019.72
SNL-15	CUL	02/08/13	546.26	2933.67	3019.90
SNL-15	CUL	03/13/13	544.08	2935.85	3022.58
SNL-15	CUL	04/09/13	543.05	2936.88	3023.85
SNL-15	CUL	05/07/13	542.48	2937.45	3024.55
SNL-15	CUL	06/10/13	540.88	2939.05	3026.52
SNL-15	CUL	07/16/13	539.70	2940.23	3027.97
SNL-15	CUL	08/08/13	538.87	2941.06	3028.99
SNL-15	CUL	09/12/13	537.74	2942.19	3030.38
SNL-15	CUL	10/04/13	536.97	2942.96	3031.32
SNL-15	CUL	11/12/13	536.53	2943.40	3031.86
SNL-15	CUL	12/10/13	534.53	2945.40	3034.32
SNL-16	CUL	01/07/13	123.54	3009.46	3010.20
SNL-16	CUL	02/07/13	123.44	3009.56	3010.31
SNL-16	CUL	03/11/13	123.39	3009.61	3010.36
SNL-16	CUL	04/08/13	123.28	3009.72	3010.47
SNL-16	CUL	05/08/13	123.61	3009.39	3010.13
SNL-16	CUL	06/10/13	123.94	3009.06	3009.80
SNL-16	CUL	07/16/13	124.08	3008.92	3009.66
SNL-16	CUL	08/06/13	123.60	3009.40	3010.14
SNL-16	CUL	09/10/13	123.72	3009.28	3010.02
SNL-16	CUL	10/03/13	123.52	3009.48	3010.23

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-16	CUL	11/12/13	124.50	3008.50	3009.24
SNL-16	CUL	12/11/13	123.82	3009.18	3009.92
SNL-17	CUL	01/08/13	233.24	3004.82	3005.40
SNL-17	CUL	02/08/13	233.34	3004.72	3005.30
SNL-17	CUL	03/11/13	233.24	3004.82	3005.40
SNL-17	CUL	04/08/13	233.03	3005.03	3005.61
SNL-17	CUL	05/08/13	233.35	3004.71	3005.29
SNL-17	CUL	06/10/13	233.78	3004.28	3004.86
SNL-17	CUL	07/15/13	234.43	3003.63	3004.21
SNL-17	CUL	08/06/13	234.28	3003.78	3004.36
SNL-17	CUL	09/10/13	234.55	3003.51	3004.09
SNL-17	CUL	10/04/13	244.00	2994.06	2994.59
SNL-17	CUL	11/11/13	248.75	2989.31	2989.81
SNL-17	CUL	12/11/13	244.47	2993.59	2994.12
SNL-18	CUL	01/08/13	304.39	3071.05	3072.28
SNL-18	CUL	02/07/13	304.21	3071.23	3072.47
SNL-18	CUL	03/11/13	304.48	3070.96	3072.19
SNL-18	CUL	04/08/13	304.33	3071.11	3072.34
SNL-18	CUL	05/08/13	304.94	3070.50	3071.73
SNL-18	CUL	06/11/13	304.77	3070.67	3071.90
SNL-18	CUL	07/15/13	305.25	3070.19	3071.42
SNL-18	CUL	08/06/13	302.51	3072.93	3074.17
SNL-18	CUL	09/12/13	306.28	3069.16	3070.38
SNL-18	CUL	10/07/13	304.82	3070.62	3071.85
SNL-18	CUL	11/11/13	305.30	3070.14	3071.37
SNL-18	CUL	12/09/13	305.80	3069.64	3070.87
SNL-19	CUL	01/08/13	151.88	3070.77	3072.19
SNL-19	CUL	02/07/13	151.59	3071.06	3072.48
SNL-19	CUL	03/11/13	151.71	3070.94	3072.36
SNL-19	CUL	04/08/13	151.61	3071.04	3072.46
SNL-19	CUL	05/08/13	152.08	3070.57	3071.99
SNL-19	CUL	06/11/13	152.31	3070.34	3071.76
SNL-19	CUL	07/15/13	152.69	3069.96	3071.38
SNL-19	CUL	08/06/13	152.59	3070.06	3071.48
SNL-19	CUL	09/12/13	153.00	3069.65	3071.06
SNL-19	CUL	10/07/13	152.67	3069.98	3071.40

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
SNL-19	CUL	11/11/13	152.79	3069.86	3071.28
SNL-19	CUL	12/09/13	153.21	3069.44	3070.85
WIPP-11	CUL	01/08/13	365.66	3062.12	3080.82
WIPP-11	CUL	02/12/13	365.67	3062.11	3080.81
WIPP-11	CUL	03/13/13	366.07	3061.71	3080.39
WIPP-11	CUL	04/09/13	365.60	3062.18	3080.88
WIPP-11	CUL	05/13/13	366.16	3061.62	3080.30
WIPP-11	CUL	06/12/13	366.14	3061.64	3080.32
WIPP-11	CUL	07/16/13	366.55	3061.23	3079.90
WIPP-11	CUL	08/08/13	366.54	3061.24	3079.91
WIPP-11	CUL	09/16/13	367.16	3060.62	3079.26
WIPP-11	CUL	10/09/13	366.84	3060.94	3079.60
WIPP-11	CUL	11/13/13	367.02	3060.76	3079.41
WIPP-11	CUL	12/09/13	366.88	3060.90	3079.55
WIPP-13	CUL	01/09/13	345.11	3060.56	3075.74
WIPP-13	CUL	02/12/13	344.80	3060.87	3076.06
WIPP-13	CUL	03/13/13	345.12	3060.55	3075.73
WIPP-13	CUL	04/09/13	344.43	3061.24	3076.45
WIPP-13	CUL	05/13/13	345.15	3060.52	3075.70
WIPP-13	CUL	06/12/13	345.01	3060.66	3075.84
WIPP-13	CUL	07/17/13	345.48	3060.19	3075.36
WIPP-13	CUL	08/08/13	345.30	3060.37	3075.54
WIPP-13	CUL	09/16/13	345.69	3059.98	3075.14
WIPP-13	CUL	10/09/13	345.46	3060.21	3075.38
WIPP-13	CUL	11/13/13	345.45	3060.22	3075.39
WIPP-13	CUL	12/09/13	345.40	3060.27	3075.44
WIPP-19	CUL	01/07/13	391.96	3043.15	3062.81
WIPP-19	CUL	02/12/13	391.99	3043.12	3062.78
WIPP-19	CUL	03/13/13	392.26	3042.85	3062.50
WIPP-19	CUL	04/10/13	392.06	3043.05	3062.71
WIPP-19	CUL	05/13/13	392.26	3042.85	3062.50
WIPP-19	CUL	06/13/13	392.15	3042.96	3062.61
WIPP-19	CUL	07/17/13	392.91	3042.20	3061.81
WIPP-19	CUL	08/08/13	392.24	3042.87	3062.52
WIPP-19	CUL	09/16/13	392.62	3042.49	3062.12
WIPP-19	CUL	10/09/13	392.59	3042.52	3062.15

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WIPP-19	CUL	11/12/13	393.20	3041.91	3061.51
WIPP-19	CUL	12/09/13	393.13	3041.98	3061.58
WQSP-1	CUL	01/10/13	361.79	3057.46	3075.40
WQSP-1	CUL	02/12/13	361.68	3057.57	3075.52
WQSP-1	CUL	03/13/13	361.96	3057.29	3075.23
WQSP-1	CUL	04/10/13	361.81	3057.44	3075.38
WQSP-1	CUL	05/13/13	362.43	3056.82	3074.73
WQSP-1	CUL	06/13/13	362.12	3057.13	3075.06
WQSP-1	CUL	07/17/13	362.63	3056.62	3074.52
WQSP-1	CUL	08/08/13	362.41	3056.84	3074.75
WQSP-1	CUL	09/16/13	362.91	3056.34	3074.23
WQSP-1	CUL	10/09/13	362.69	3056.56	3074.46
WQSP-1	CUL	11/13/13	362.91	3056.34	3074.23
WQSP-1	CUL	12/11/13	362.97	3056.28	3074.16
WQSP-2	CUL	01/08/13	401.72	3062.15	3082.47
WQSP-2	CUL	02/12/13	401.73	3062.14	3082.46
WQSP-2	CUL	03/13/13	402.04	3061.83	3082.14
WQSP-2	CUL	04/10/13	401.95	3061.92	3082.23
WQSP-2	CUL	05/13/13	402.05	3061.82	3082.12
WQSP-2	CUL	06/13/13	402.28	3061.59	3081.88
WQSP-2	CUL	07/17/13	402.74	3061.13	3081.40
WQSP-2	CUL	08/08/13	402.62	3061.25	3081.53
WQSP-2	CUL	09/16/13	403.10	3060.77	3081.02
WQSP-2	CUL	10/09/13	402.91	3060.96	3081.22
WQSP-2	CUL	11/12/13	403.17	3060.70	3080.95
WQSP-2	CUL	12/09/13	402.89	3060.98	3081.24
WQSP-3	CUL	01/07/13	465.22	3014.92	3072.93
WQSP-3	CUL	02/12/13	465.02	3015.12	3073.16
WQSP-3	CUL	03/13/13	465.24	3014.90	3072.91
WQSP-3	CUL	04/10/13	468.39	3011.75	3069.29
WQSP-3	CUL	05/13/13	466.01	3014.13	3072.02
WQSP-3	CUL	06/13/13	465.73	3014.41	3072.34
WQSP-3	CUL	07/17/13	465.94	3014.20	3072.10
WQSP-3	CUL	08/08/13	465.65	3014.49	3072.44
WQSP-3	CUL	09/16/13	465.92	3014.22	3072.13
WQSP-3	CUL	10/09/13	465.89	3014.25	3072.16

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-3	CUL	11/12/13	466.26	3013.88	3071.74
WQSP-3	CUL	12/09/13	465.89	3014.25	3072.16
WQSP-4	CUL	01/09/13	444.11	2988.98	3014.91
WQSP-4	CUL	02/11/13	443.73	2989.36	3015.32
WQSP-4	CUL	03/13/13	443.92	2989.17	3015.12
WQSP-4	CUL	04/10/13	443.65	2989.44	3015.41
WQSP-4	CUL	05/07/13	443.84	2989.25	3015.20
WQSP-4	CUL	06/12/13	443.90	2989.19	3015.14
WQSP-4	CUL	07/17/13	444.70	2988.39	3014.28
WQSP-4	CUL	08/09/13	445.35	2987.74	3013.58
WQSP-4	CUL	09/17/13	445.86	2987.23	3013.03
WQSP-4	CUL	10/09/13	448.07	2985.02	3010.65
WQSP-4	CUL	11/13/13	454.17	2978.92	3004.08
WQSP-4	CUL	12/11/13	458.44	2974.65	2999.48
WQSP-5	CUL	01/09/13	379.51	3004.87	3012.41
WQSP-5	CUL	02/12/13	379.23	3005.15	3012.70
WQSP-5	CUL	03/14/13	379.34	3005.04	3012.58
WQSP-5	CUL	04/10/13	379.17	3005.21	3012.76
WQSP-5	CUL	05/13/13	379.44	3004.94	3012.48
WQSP-5	CUL	06/12/13	379.29	3005.09	3012.63
WQSP-5	CUL	07/15/13	381.19	3003.19	3010.68
WQSP-5	CUL	08/05/13	382.15	3002.23	3009.70
WQSP-5	CUL	09/16/13	380.90	3003.48	3010.98
WQSP-5	CUL	10/09/13	381.30	3003.08	3010.57
WQSP-5	CUL	11/13/13	384.82	2999.56	3006.95
WQSP-5	CUL	12/11/13	388.78	2995.60	3002.89
WQSP-6	CUL	01/09/13	344.45	3020.27	3024.06
WQSP-6	CUL	02/12/13	344.33	3020.39	3024.18
WQSP-6	CUL	03/13/13	344.60	3020.12	3023.91
WQSP-6	CUL	04/10/13	344.33	3020.39	3024.18
WQSP-6	CUL	05/07/13	346.61	3018.11	3021.87
WQSP-6	CUL	06/13/13	344.63	3020.09	3023.88
WQSP-6	CUL	07/17/13	344.76	3019.96	3023.75
WQSP-6	CUL	08/09/13	344.55	3020.17	3023.96
WQSP-6	CUL	09/16/13	345.01	3019.71	3023.49
WQSP-6	CUL	10/09/13	345.07	3019.65	3023.43

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
WQSP-6	CUL	11/13/13	347.10	3017.62	3021.37
WQSP-6	CUL	12/11/13	349.42	3015.30	3019.02
C-2737 (ANNULUS)	MAG	01/09/13	256.06	3144.70	NA
C-2737 (ANNULUS)	MAG	02/12/13	255.94	3144.82	NA
C-2737 (ANNULUS)	MAG	03/13/13	256.16	3144.60	NA
C-2737 (ANNULUS)	MAG	04/10/13	255.87	3144.89	NA
C-2737 (ANNULUS)	MAG	05/13/13	256.00	3144.76	NA
C-2737 (ANNULUS)	MAG	06/13/13	255.82	3144.94	NA
C-2737 (ANNULUS)	MAG	07/17/13	255.95	3144.81	NA
C-2737 (ANNULUS)	MAG	08/09/13	255.80	3144.96	NA
C-2737 (ANNULUS)	MAG	09/17/13	255.79	3144.97	NA
C-2737 (ANNULUS)	MAG	10/09/13	255.54	3145.22	NA
C-2737 (ANNULUS)	MAG	11/13/13	255.75	3145.01	NA
C-2737 (ANNULUS)	MAG	12/11/13	255.56	3145.20	NA
H-02b1	MAG	01/09/13	236.58	3141.91	NA
H-02b1	MAG	02/12/13	236.39	3142.10	NA
H-02b1	MAG	03/13/13	236.28	3142.21	NA
H-02b1	MAG	04/10/13	236.12	3142.37	NA
H-02b1	MAG	05/13/13	235.92	3142.57	NA
H-02b1	MAG	06/13/13	235.83	3142.66	NA
H-02b1	MAG	07/17/13	235.78	3142.71	NA
H-02b1	MAG	08/09/13	235.67	3142.82	NA
H-02b1	MAG	09/17/13	235.55	3142.94	NA
H-02b1	MAG	10/09/13	235.51	3142.98	NA
H-02b1	MAG	11/13/13	235.35	3143.14	NA
H-02b1	MAG	12/11/13	235.40	3143.09	NA
H-03b1	MAG	01/09/13	243.35	3147.37	NA
H-03b1	MAG	02/12/13	243.32	3147.40	NA
H-03b1	MAG	03/13/13	243.45	3147.27	NA
H-03b1	MAG	04/10/13	243.22	3147.50	NA
H-03b1	MAG	05/13/13	243.38	3147.34	NA
H-03b1	MAG	06/10/13	243.20	3147.52	NA
H-03b1	MAG	07/17/13	243.28	3147.44	NA
H-03b1	MAG	08/09/13	243.05	3147.67	NA
H-03b1	MAG	09/17/13	243.13	3147.59	NA
H-03b1	MAG	10/09/13	243.04	3147.68	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-03b1	MAG	11/13/13	243.23	3147.49	NA
H-03b1	MAG	12/11/13	243.05	3147.67	NA
H-04c	MAG	01/09/13	186.94	3147.34	NA
H-04c	MAG	02/11/13	186.72	3147.56	NA
H-04c	MAG	03/13/13	186.86	3147.42	NA
H-04c	MAG	04/10/13	186.62	3147.66	NA
H-04c	MAG	05/07/13	186.68	3147.60	NA
H-04c	MAG	06/12/13	186.51	3147.77	NA
H-04c	MAG	07/15/13	186.50	3147.78	NA
H-04c	MAG	08/09/13	186.38	3147.90	NA
H-04c	MAG	09/16/13	186.43	3147.85	NA
H-04c	MAG	10/04/13	186.28	3148.00	NA
H-04c	MAG	11/11/13	186.44	3147.84	NA
H-04c	MAG	12/11/13	186.30	3147.98	NA
H-06c	MAG	01/07/13	276.84	3071.85	NA
H-06c	MAG	02/11/13	276.75	3071.94	NA
H-06c	MAG	03/13/13	277.08	3071.61	NA
H-06c	MAG	04/09/13	276.64	3072.05	NA
H-06c	MAG	05/13/13	277.02	3071.67	NA
H-06c	MAG	06/11/13	276.89	3071.80	NA
H-06c	MAG	07/15/13	276.97	3071.72	NA
H-06c	MAG	08/08/13	276.82	3071.87	NA
H-06c	MAG	09/10/13	276.93	3071.76	NA
H-06c	MAG	10/03/13	276.93	3071.76	NA
H-06c	MAG	11/13/13	277.32	3071.37	NA
H-06c	MAG	12/09/13	276.96	3071.73	NA
H-08a	MAG	01/07/13	404.05	3029.23	NA
H-08a	MAG	02/08/13	404.10	3029.18	NA
H-08a	MAG	03/12/13	404.17	3029.11	NA
H-08a	MAG	04/08/13	404.20	3029.08	NA
H-08a	MAG	05/07/13	404.33	3028.95	NA
H-08a	MAG	06/10/13	404.45	3028.83	NA
H-08a	MAG	07/16/13	404.54	3028.74	NA
H-08a	MAG	08/07/13	404.42	3028.86	NA
H-08a	MAG	09/16/13	404.53	3028.75	NA
H-08a	MAG	10/07/13	404.50	3028.78	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-08a	MAG	11/11/13	404.53	3028.75	NA
H-08a	MAG	12/11/13	404.52	3028.76	NA
H-09c	MAG	01/07/13	270.99	3136.06	NA
H-09c	MAG	02/08/13	271.09	3135.96	NA
H-09c	MAG	03/12/13	271.12	3135.93	NA
H-09c	MAG	04/08/13	269.91	3137.14	NA
H-09c	MAG	05/07/13	271.14	3135.91	NA
H-09c	MAG	06/10/13	271.16	3135.89	NA
H-09c	MAG	07/16/13	271.30	3135.75	NA
H-09c	MAG	08/07/13	271.12	3135.93	NA
H-09c	MAG	09/12/13	271.28	3135.77	NA
H-09c	MAG	10/04/13	271.11	3135.94	NA
H-09c	MAG	11/11/13	271.28	3135.77	NA
H-09c	MAG	12/10/13	271.41	3135.64	NA
H-10a	MAG	01/07/13	575.95	3112.50	NA
H-10a	MAG	02/11/13	575.83	3112.62	NA
H-10a	MAG	03/12/13	575.88	3112.57	NA
H-10a	MAG	04/09/13	575.91	3112.54	NA
H-10a	MAG	05/07/13	575.88	3112.57	NA
H-10a	MAG	06/10/13	575.85	3112.60	NA
H-10a	MAG	07/16/13	575.93	3112.52	NA
H-10a	MAG	08/07/13	575.80	3112.65	NA
H-10a	MAG	09/12/13	575.57	3112.88	NA
H-10a	MAG	10/04/13	575.90	3112.55	NA
H-10a	MAG	11/12/13	576.11	3112.34	NA
H-10a	MAG	12/10/13	576.10	3112.35	NA
H-11b2	MAG	01/08/13	271.75	3140.11	NA
H-11b2	MAG	02/11/13	271.63	3140.23	NA
H-11b2	MAG	03/12/13	271.59	3140.27	NA
H-11b2	MAG	04/09/13	271.48	3140.38	NA
H-11b2	MAG	05/07/13	271.71	3140.15	NA
H-11b2	MAG	06/10/13	271.29	3140.57	NA
H-11b2	MAG	07/16/13	271.34	3140.52	NA
H-11b2	MAG	08/08/13	271.33	3140.53	NA
H-11b2	MAG	09/09/13	271.32	3140.54	NA
H-11b2	MAG	10/04/13	271.26	3140.60	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-11b2	MAG	11/12/13	271.32	3140.54	NA
H-11b2	MAG	12/10/13	271.35	3140.51	NA
H-14	MAG	01/09/13	207.47	3139.61	NA
H-14	MAG	02/12/13	207.38	3139.70	NA
H-14	MAG	03/13/13	207.30	3139.78	NA
H-14	MAG	04/08/13	207.20	3139.88	NA
H-14	MAG	05/08/13	207.16	3139.92	NA
H-14	MAG	06/12/13	207.07	3140.01	NA
H-14	MAG	07/16/13	207.04	3140.04	NA
H-14	MAG	08/09/13	206.99	3140.09	NA
H-14	MAG	09/16/13	206.53	3140.55	NA
H-14	MAG	10/09/13	206.91	3140.17	NA
H-14	MAG	11/13/13	206.90	3140.18	NA
H-14	MAG	12/11/13	206.85	3140.23	NA
H-15	MAG	01/09/13	335.79	3147.71	NA
H-15	MAG	02/12/13	335.81	3147.69	NA
H-15	MAG	03/13/13	334.87	3148.63	NA
H-15	MAG	04/10/13	336.88	3146.90	NA
H-15	MAG	05/13/13	336.55	3147.23	NA
H-15	MAG	06/13/13	334.32	3149.46	NA
H-15	MAG	07/17/13	334.11	3149.67	NA
H-15	MAG	08/08/13	333.73	3150.05	NA
H-15	MAG	09/17/13	333.51	3150.27	NA
H-15	MAG	10/04/13	333.60	3150.18	NA
H-15	MAG	11/13/13	333.50	3150.28	NA
H-15	MAG	12/10/13	333.34	3150.44	NA
H-18	MAG	01/08/13	257.73	3156.48	NA
H-18	MAG	02/12/13	257.61	3156.60	NA
H-18	MAG	03/13/13	257.74	3156.47	NA
H-18	MAG	04/10/13	257.45	3156.76	NA
H-18	MAG	05/13/13	257.48	3156.73	NA
H-18	MAG	06/11/13	257.26	3156.95	NA
H-18	MAG	07/16/13	257.28	3156.93	NA
H-18	MAG	08/08/13	257.01	3157.20	NA
H-18	MAG	09/16/13	257.09	3157.12	NA
H-18	MAG	10/09/13	256.89	3157.32	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
H-18	MAG	11/12/13	257.22	3156.99	NA
H-18	MAG	12/09/13	256.77	3157.44	NA
WIPP-18	MAG	01/07/13	306.76	3150.81	NA
WIPP-18	MAG	02/12/13	306.48	3151.09	NA
WIPP-18	MAG	03/13/13	306.53	3151.04	NA
WIPP-18	MAG	04/10/13	306.28	3151.29	NA
WIPP-18	MAG	05/13/13	306.34	3151.23	NA
WIPP-18	MAG	06/13/13	306.23	3151.34	NA
WIPP-18	MAG	07/17/13	306.28	3151.29	NA
WIPP-18	MAG	08/08/13	306.05	3151.52	NA
WIPP-18	MAG	09/16/13	306.06	3151.51	NA
WIPP-18	MAG	10/09/13	306.03	3151.54	NA
WIPP-18	MAG	11/12/13	306.14	3151.43	NA
WIPP-18	MAG	12/09/13	305.95	3151.62	NA
WQSP-6a	DL	01/09/13	167.56	3196.24	NA
WQSP-6a	DL	02/12/13	167.49	3196.31	NA
WQSP-6a	DL	03/13/13	167.80	3196.00	NA
WQSP-6a	DL	04/10/13	167.58	3196.22	NA
WQSP-6a	DL	05/07/13	167.45	3196.35	NA
WQSP-6a	DL	06/13/13	167.62	3196.18	NA
WQSP-6a	DL	07/17/13	167.77	3196.03	NA
WQSP-6a	DL	08/09/13	167.60	3196.20	NA
WQSP-6a	DL	09/16/13	167.68	3196.12	NA
WQSP-6a	DL	10/09/13	167.48	3196.32	NA
WQSP-6a	DL	11/11/13	167.32	3196.48	NA
WQSP-6a	DL	12/11/13	167.78	3196.02	NA
CB-1	B/C	01/08/13	305.71	3023.41	NA
CB-1	B/C	02/11/13	305.25	3023.87	NA
CB-1	B/C	03/12/13	304.95	3024.17	NA
CB-1	B/C	04/09/13	304.33	3024.79	NA
CB-1	B/C	05/07/13	304.24	3024.88	NA
CB-1	B/C	06/10/13	303.79	3025.33	NA
CB-1	B/C	07/16/13	303.52	3025.60	NA
CB-1	B/C	08/08/13	303.08	3026.04	NA
CB-1	B/C	09/09/13	302.79	3026.33	NA
CB-1	B/C	10/03/13	302.46	3026.66	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
CB-1	B/C	11/11/13	302.41	3026.71	NA
CB-1	B/C	12/10/13	301.91	3027.21	NA
DOE-2	B/C	01/08/13	351.63	3067.55	NA
DOE-2	B/C	02/12/13	351.45	3067.73	NA
DOE-2	B/C	03/14/13	351.54	3067.64	NA
DOE-2	B/C	04/09/13	351.23	3067.95	NA
DOE-2	B/C	05/13/13	351.42	3067.76	NA
DOE-2	B/C	06/12/13	351.17	3068.01	NA
DOE-2	B/C	07/17/13	351.26	3067.92	NA
DOE-2	B/C	08/08/13	351.09	3068.09	NA
DOE-2	B/C	09/16/13	351.12	3068.06	NA
DOE-2	B/C	10/09/13	351.67	3067.51	NA
DOE-2	B/C	11/13/13	351.26	3067.92	NA
DOE-2	B/C	12/09/13	350.95	3068.23	NA
C-2505	SR/DL	03/14/13	47.89	3365.04	NA
C-2505	SR/DL	06/11/13	48.18	3364.75	NA
C-2505	SR/DL	09/17/13	48.61	3364.32	NA
C-2505	SR/DL	12/12/13	48.96	3363.97	NA
C-2506	SR/DL	03/14/13	47.16	3365.68	NA
C-2506	SR/DL	06/11/13	47.50	3365.34	NA
C-2506	SR/DL	09/17/13	47.90	3364.94	NA
C-2506	SR/DL	12/12/13	48.23	3364.61	NA
C-2507	SR/DL	03/14/13	47.68	3362.23	NA
C-2507	SR/DL	06/11/13	48.01	3361.90	NA
C-2507	SR/DL	09/17/13	48.38	3361.53	NA
C-2507	SR/DL	12/12/13	48.63	3361.28	NA
C-2811	SR/DL	03/13/13	55.87	3342.97	NA
C-2811	SR/DL	06/13/13	55.85	3342.99	NA
C-2811	SR/DL	09/17/13	56.14	3342.70	NA
C-2811	SR/DL	12/11/13	56.63	3342.21	NA
PZ-01	SR/DL	03/14/13	43.69	3369.59	NA
PZ-01	SR/DL	06/11/13	44.10	3369.18	NA
PZ-01	SR/DL	09/17/13	44.29	3368.99	NA
PZ-01	SR/DL	12/12/13	44.85	3368.43	NA
PZ-02	SR/DL	03/14/13	44.97	3368.39	NA
PZ-02	SR/DL	06/11/13	45.16	3368.20	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-02	SR/DL	09/17/13	45.66	3367.70	NA
PZ-02	SR/DL	12/12/13	46.10	3367.26	NA
PZ-03	SR/DL	03/14/13	46.25	3369.87	NA
PZ-03	SR/DL	06/11/13	46.43	3369.69	NA
PZ-03	SR/DL	09/17/13	46.79	3369.33	NA
PZ-03	SR/DL	12/12/13	47.18	3368.94	NA
PZ-04	SR/DL	03/14/13	48.31	3363.70	NA
PZ-04	SR/DL	06/11/13	48.99	3363.02	NA
PZ-04	SR/DL	09/17/13	49.63	3362.38	NA
PZ-04	SR/DL	12/12/13	50.15	3361.86	NA
PZ-05	SR/DL	03/14/13	44.96	3370.28	NA
PZ-05	SR/DL	06/11/13	45.13	3370.11	NA
PZ-05	SR/DL	09/17/13	45.56	3369.68	NA
PZ-05	SR/DL	12/12/13	45.94	3369.30	NA
PZ-06	SR/DL	03/14/13	46.18	3367.15	NA
PZ-06	SR/DL	06/11/13	46.42	3366.91	NA
PZ-06	SR/DL	09/17/13	46.78	3366.55	NA
PZ-06	SR/DL	12/12/13	46.92	3366.41	NA
PZ-07	SR/DL	03/14/13	39.68	3374.16	NA
PZ-07	SR/DL	06/12/13	39.77	3374.07	NA
PZ-07	SR/DL	09/17/13	40.23	3373.61	NA
PZ-07	SR/DL	12/11/13	40.70	3373.14	NA
PZ-08	SR/DL	03/13/13	66.95	3351.24	NA
PZ-08	SR/DL	06/12/13	66.95	3351.24	NA
PZ-08	SR/DL	09/10/13	67.76	3350.43	NA
PZ-08	SR/DL	12/11/13	68.54	3349.65	NA
PZ-09	SR/DL	03/13/13	58.86	3362.23	NA
PZ-09	SR/DL	06/12/13	58.68	3362.41	NA
PZ-09	SR/DL	09/10/13	58.78	3362.31	NA
PZ-09	SR/DL	12/11/13	59.28	3361.81	NA
PZ-10	SR/DL	03/13/13	41.83	3363.90	NA
PZ-10	SR/DL	06/12/13	41.95	3363.78	NA
PZ-10	SR/DL	09/09/13	41.58	3364.15	NA
PZ-10	SR/DL	12/11/13	41.73	3364.00	NA
PZ-11	SR/DL	03/13/13	47.44	3371.34	NA
PZ-11	SR/DL	06/12/13	47.28	3371.50	NA

Well	Zone	Date	Adjusted Depth TOC (ft)	Water Level Elevation (ft amsl)	Adjusted Freshwater Head (ft amsl)
PZ-11	SR/DL	09/09/13	47.46	3371.32	NA
PZ-11	SR/DL	12/11/13	48.20	3370.58	NA
PZ-12	SR/DL	03/13/13	56.61	3352.31	NA
PZ-12	SR/DL	06/12/13	56.84	3352.08	NA
PZ-12	SR/DL	09/10/13	57.00	3351.92	NA
PZ-12	SR/DL	12/11/13	57.40	3351.52	NA
PZ-13	SR/DL	03/13/13	67.08	3355.16	NA
PZ-13	SR/DL	06/12/13	66.95	3355.29	NA
PZ-13	SR/DL	09/09/13	67.03	3355.21	NA
PZ-13	SR/DL	12/09/13	67.20	3355.04	NA
PZ-14	SR/DL	03/13/13	68.00	3352.58	NA
PZ-14	SR/DL	06/12/13	67.82	3352.76	NA
PZ-14	SR/DL	09/09/13	67.84	3352.74	NA
PZ-14	SR/DL	12/09/13	68.13	3352.45	NA
PZ-15	SR/DL	03/13/13	48.95	3381.91	NA
PZ-15	SR/DL	06/12/13	48.97	3381.89	NA
PZ-15	SR/DL	09/09/13	49.10	3381.76	NA
PZ-15	SR/DL	12/09/13	49.25	3381.61	NA

APPENDIX G – AIR SAMPLING DATA: CONCENTRATIONS OF RADIONUCLIDES IN AIR FILTER COMPOSITES

Table G.1 2013 Radionuclide Concentrations (Bq/sample) in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for sampling location codes

		$^{233/234}U$				^{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 (Avg)	3.41E-03	2.46E-03	8.77E-03	U	-4.67E-04	2.97E-04	1.19E-03	U	3.49E-03	2.37E-03	7.95E-03	U
	2	7.31E-03	3.08E-03	8.84E-03	U	1.05E-03	8.89E-04	1.18E-03	U	8.28E-03	3.06E-03	7.75E-03	+
	3	7.89E-04	3.83E-03	8.79E-03	U	1.64E-04	1.05E-03	1.30E-03	U	1.40E-03	3.65E-03	7.69E-03	U
	4	4.05E-03	3.98E-03	8.99E-03	U	1.02E-04	6.80E-04	1.35E-03	U	3.43E-03	3.38E-03	8.14E-03	U
WEE	1	3.05E-03	2.32E-03	8.75E-03	U	-9.67E-05	5.24E-04	1.16E-03	U	2.87E-03	2.20E-03	7.93E-03	U
	2 (Avg)	4.88E-03	2.74E-03	8.83E-03	U	6.68E-04	7.33E-04	1.17E-03	U	5.43E-03	2.64E-03	7.74E-03	+/U (f)
	3	7.92E-04	3.82E-03	8.78E-03	U	7.49E-06	9.80E-04	1.27E-03	U	2.82E-03	3.78E-03	7.69E-03	U
	4	1.68E-03	3.25E-03	8.87E-03	U	8.44E-04	9.03E-04	1.21E-03	U	3.87E-03	2.98E-03	8.02E-03	U
WSS	1	2.38E-03	2.37E-03	8.77E-03	U	-8.17E-05	5.91E-04	1.20E-03	U	3.89E-03	2.45E-03	7.96E-03	U
	2	5.37E-03	2.62E-03	8.80E-03	U	6.25E-04	6.81E-04	1.13E-03	U	8.54E-03	2.86E-03	7.70E-03	+
	3 (Avg)	2.68E-03	3.88E-03	8.77E-03	U	-4.63E-04	8.52E-04	1.28E-03	U	1.53E-03	3.59E-03	7.66E-03	U
	4	2.39E-03	3.40E-03	8.89E-03	U	-1.80E-04	5.49E-04	1.29E-03	U	4.71E-03	3.16E-03	8.04E-03	U
MLR	1	2.75E-03	2.32E-03	8.76E-03	U	6.94E-05	5.98E-04	1.18E-03	U	5.03E-03	2.49E-03	7.94E-03	U
	2	7.76E-03	3.04E-03	8.81E-03	U	1.31E-04	4.76E-04	1.14E-03	U	9.23E-03	3.10E-03	7.72E-03	+
	3	3.51E-03	4.16E-03	8.82E-03	U	-7.22E-04	8.14E-04	1.41E-03	U	2.96E-03	3.88E-03	7.71E-03	U
	4 (Avg)	2.61E-03	3.70E-03	8.97E-03	U	4.11E-04	8.31E-04	1.34E-03	U	4.49E-03	3.43E-03	8.13E-03	U
SEC	1	3.52E-03	2.56E-03	8.79E-03	U	-3.29E-04	4.40E-04	1.21E-03	U	5.98E-03	2.79E-03	7.97E-03	U
	2	1.04E-02	3.52E-03	8.83E-03	+	1.32E-04	5.22E-04	1.17E-03	U	8.56E-03	3.11E-03	7.74E-03	+
	3	2.20E-03	4.02E-03	8.82E-03	U	-9.29E-05	9.45E-04	1.30E-03	U	2.81E-03	3.85E-03	7.72E-03	U
	4	2.59E-03	3.55E-03	8.92E-03	U	3.31E-04	7.98E-04	1.33E-03	U	5.74E-03	3.42E-03	8.07E-03	U
CBD	1	5.68E-03	2.71E-03	8.76E-03	U	-5.99E-05	5.56E-04	1.19E-03	U	9.35E-03	3.08E-03	7.95E-03	+
	2	1.39E-02	3.75E-03	8.81E-03	+	6.90E-04	7.17E-04	1.15E-03	U	1.42E-02	3.67E-03	7.72E-03	+
	3	4.33E-03	4.34E-03	8.83E-03	U	-1.35E-04	9.96E-04	1.36E-03	U	5.47E-03	4.25E-03	7.73E-03	U
	4	5.82E-03	3.79E-03	8.89E-03	U	3.06E-04	7.44E-04	1.25E-03	U	6.37E-03	3.41E-03	8.05E-03	U
SMR	1	4.87E-03	2.70E-03	8.78E-03	U	-3.83E-05	5.86E-04	1.21E-03	U	5.05E-03	2.62E-03	7.96E-03	U
	2	7.35E-03	2.86E-03	8.79E-03	U	1.21E-04	4.40E-04	1.12E-03	U	6.23E-03	2.57E-03	7.70E-03	U
	3	1.60E-03	3.75E-03	8.75E-03	U	-6.95E-05	9.51E-04	1.24E-03	U	1.37E-03	3.52E-03	7.65E-03	U
	4	1.98E-03	3.29E-03	8.87E-03	U	-3.12E-04	4.34E-04	1.22E-03	U	4.87E-03	3.10E-03	8.02E-03	U
Mean		4.27E-03	3.28E-03	8.82E-03	NA	9.30E-05	6.99E-04	1.23E-03	NA	5.28E-03	3.16E-03	7.86E-03	NA
Minimum(e)		7.89E-04	3.83E-03	8.79E-03	WFF (3)	-7.22E-04	8.14E-04	1.41E-03	MLR (3)	1.37E-03	3.52E-03	7.65E-03	SMR (3)
Maximum(f)		1.39E-02	3.75E-03	8.81E-03	CBD (2)	1.05E-03	8.89E-04	1.18E-03	WFF (2)	1.42E-02	3.67E-03	7.72E-03	CBD (2)
WAB (Filter Blank)	1	9.70E-03	2.63E-03	8.79E-03	+	5.92E-04	6.10E-04	1.22E-03	U	8.66E-03	2.44E-03	7.97E-03	+
	2	1.03E-02	2.49E-03	8.80E-03	+	2.43E-04	3.73E-04	1.13E-03	U	8.36E-03	2.16E-03	7.71E-03	+
	3	8.62E-03	2.74E-03	8.81E-03	U	6.33E-04	7.45E-04	1.39E-03	U	7.85E-03	2.57E-03	7.71E-03	+
	4	4.07E-03	1.09E-03	8.70E-03	U	1.36E-04	1.90E-04	9.82E-04	U	3.07E-03	9.15E-04	7.85E-03	U

Table G.1 2013 Radionuclide Concentrations (Bq/sample) in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for sampling location codes

		^{238}Pu				$^{239/240}$PU				^{241}Am			
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 (Avg)	-9.61E-06	4.45E-04	1.16E-03	U	1.14E-04	3.76E-04	8.94E-04	U	-2.64E-04	4.34E-04	8.70E-04	U
	2	2.75E-04	5.25E-04	1.15E-03	U	1.50E-04	3.31E-04	8.91E-04	U	5.01E-04	7.69E-04	1.04E-03	U
	3	-1.56E-05	2.96E-04	1.20E-03	U	5.18E-04	5.37E-04	8.90E-04	U	-2.16E-04	5.96E-04	9.73E-04	U
	4	-1.94E-06	3.80E-04	1.18E-03	U	1.24E-04	5.38E-04	9.21E-04	U	5.72E-04	9.42E-04	1.34E-03	U
WEE	1	-7.53E-05	3.78E-04	1.16E-03	U	-1.15E-04	2.53E-04	8.96E-04	U	-2.89E-04	4.48E-04	9.09E-04	U
	2 (Avg)	1.48E-04	3.91E-04	1.13E-03	U	2.33E-04	3.83E-04	8.70E-04	U	3.76E-04	6.80E-04	1.04E-03	U
	3	-3.46E-05	3.31E-04	1.18E-03	U	6.73E-04	6.97E-04	1.00E-03	U	4.08E-05	6.85E-04	9.42E-04	U
	4	-1.08E-04	2.77E-04	1.15E-03	U	-2.23E-04	3.34E-04	9.07E-04	U	1.36E-04	7.52E-04	1.18E-03	U
WSS	1	-2.85E-04	2.24E-04	1.15E-03	U	3.23E-04	4.74E-04	8.90E-04	U	3.33E-04	7.32E-04	9.44E-04	U
	2	-9.99E-06	3.92E-04	1.11E-03	U	6.44E-05	3.30E-04	8.54E-04	U	-2.90E-04	4.53E-04	1.06E-03	U
	3 (Avg)	1.23E-04	4.22E-04	1.20E-03	U	1.02E-04	3.83E-04	9.16E-04	U	-2.29E-04	5.91E-04	9.79E-04	U
	4	-1.11E-04	2.81E-04	1.16E-03	U	-2.79E-04	3.98E-04	9.35E-04	U	4.40E-04	5.84E-04	9.50E-04	U
MLR	1	2.04E-04	6.07E-04	1.19E-03	U	2.05E-04	5.03E-04	9.23E-04	U	-1.24E-04	5.45E-04	8.76E-04	U
	2	-1.76E-04	2.52E-04	1.12E-03	U	3.14E-04	4.39E-04	8.67E-04	U	2.82E-04	7.26E-04	1.05E-03	U
	3	-8.89E-05	9.56E-05	1.12E-03	U	2.22E-04	4.51E-04	8.98E-04	U	-3.76E-04	5.64E-04	1.10E-03	U
	4 (Avg)	2.54E-05	3.31E-04	1.13E-04	U	-9.51E-05	4.47E-04	9.26E-04	U	3.93E-04	8.12E-04	1.18E-03	U
SEC	1	-1.10E-04	4.54E-04	1.20E-03	U	-3.80E-05	4.06E-04	9.36E-04	U	-6.03E-05	5.34E-04	8.84E-04	U
	2	3.00E-05	4.35E-04	1.15E-03	U	-4.69E-05	3.15E-04	8.97E-04	U	-2.89E-05	5.64E-04	1.10E-03	U
	3	-2.66E-05	4.94E-04	1.23E-03	U	6.31E-05	3.34E-04	9.09E-04	U	-3.66E-04	5.88E-04	1.10E-03	U
	4	1.11E-05	3.36E-04	1.12E-03	U	-2.42E-04	3.57E-04	9.04E-04	U	7.23E-05	5.80E-04	1.12E-03	U
CBD	1	-6.84E-08	4.40E-04	1.15E-03	U	-1.51E-04	2.76E-04	8.92E-04	U	-3.38E-04	4.84E-04	9.15E-04	U
	2	4.24E-05	3.61E-04	1.11E-03	U	6.28E-05	3.27E-04	8.51E-04	U	-7.63E-05	5.72E-04	1.08E-03	U
	3	-7.76E-05	1.23E-05	1.15E-03	U	-3.88E-05	2.26E-04	9.07E-04	U	-3.67E-04	5.41E-04	9.94E-04	U
	4	-9.01E-05	2.49E-04	1.16E-03	U	-1.15E-04	4.26E-04	9.56E-04	U	-1.07E-04	5.70E-04	1.20E-03	U
SMR	1	-2.62E-04	3.51E-04	1.15E-03	U	2.80E-04	4.81E-04	8.85E-04	U	-2.23E-04	5.35E-04	9.03E-04	U
	2	6.74E-06	4.39E-04	1.15E-03	U	-1.04E-05	2.82E-04	8.92E-04	U	5.07E-04	9.39E-04	1.12E-03	U
	3	-1.31E-04	2.06E-04	1.19E-03	U	1.86E-04	5.04E-04	9.25E-04	U	-1.81E-04	6.68E-04	9.70E-04	U
	4	-7.70E-05	2.26E-04	1.09E-03	U	-1.19E-04	3.86E-04	1.97E-04	U	-1.96E-04	4.17E-04	1.15E-03	U
Mean		-2.94E-05	3.40E-04	1.12E-03	NA	7.71E-05	4.01E-04	8.79E-04	NA	-2.80E-06	6.25E-04	1.04E-03	NA
Minimum[e]		-2.85E-04	2.24E-04	1.15E-03	WSS (1)	-2.79E-04	3.98E-04	9.35E-04	WSS (4)	-3.76E-04	5.64E-04	1.10E-03	MLR (3)
Maximum[f]		2.75E-04	5.25E-04	1.15E-03	WFF (2)	6.73E-04	6.97E-04	1.00E-03	WEE (3)	5.72E-04	9.42E-04	1.34E-03	WFF (4)
WAB (Filter Blank)	1	1.62E-04	4.48E-04	1.16E-03	U	1.76E-04	3.24E-04	8.96E-04	U	4.11E-04	5.30E-04	8.49E-04	U
	2	-2.01E-05	2.93E-04	1.11E-03	U	6.02E-05	2.33E-04	8.52E-04	U	0.00E+00	3.50E-04	9.10E-04	U
	3	-7.76E-05	1.76E-04	1.17E-03	U	2.58E-05	2.67E-04	9.35E-04	U	4.51E-04	4.42E-04	8.90E-04	U
	4	6.78E-05	2.44E-04	1.13E-03	U	1.93E-04	3.08E-04	8.66E-04	U	7.98E-05	2.87E-04	9.80E-04	U

Table G.1 2013 Radionuclide Concentrations (Bq/sample) in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for sampling location codes

		^{40}K				^{60}Co				^{137}Cs			
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 (Avg)	7.39E+00	5.43E+00	7.51E+00	U	1.89E-01	6.65E-01	7.88E-01	U	-6.75E-02	6.44E-01	7.38E-01	U
	2	-3.08E+00	7.52E+00	8.12E+00	U	3.40E-01	6.90E-01	8.10E-01	U	1.76E-01	7.53E-01	8.40E-01	U
	3	5.54E+00	6.33E+00	7.67E+00	U	-2.49E-01	6.81E-01	7.39E-01	U	5.43E-01	6.94E-01	7.92E-01	U
	4	8.06E+00	6.91E+00	8.40E+00	U	2.98E-01	6.59E-01	7.76E-01	U	2.38E-01	6.28E-01	7.43E-01	U
WEE	1	4.74E+00	7.34E+00	8.66E+00	U	-2.08E-01	7.33E-01	8.04E-01	U	6.11E-02	7.35E-01	8.13E-01	U
	2 (Avg)	2.67E+00	7.21E+00	8.39E+00	U	3.70E-02	7.60E-01	8.54E-01	U	4.54E-02	7.91E-01	8.80E-01	U
	3	7.14E+00	6.84E+00	8.40E+00	U	4.96E-02	7.76E-01	8.91E-01	U	7.14E-02	8.01E-01	9.00E-01	U
	4	-3.28E+00	1.82E+01	2.02E+01	U	6.37E-01	1.52E+01	1.94E+00	U	7.65E-01	1.70E+00	2.09E+00	U
WSS	1	7.08E+00	7.53E+00	9.11E+00	U	4.67E-01	8.15E-01	9.62E-01	U	-4.08E-01	8.42E-01	9.07E-01	U
	2	1.42E+00	7.55E+00	8.65E+00	U	9.90E-02	6.84E-01	8.03E-01	U	7.25E-02	6.57E-01	7.72E-01	U
	3 (Avg)	3.34E+00	6.95E+00	8.20E+00	U	1.07E-01	7.03E-01	8.04E-01	U	-5.57E-01	8.13E-01	8.54E-01	U
	4	3.12E+00	6.85E+00	7.98E+00	U	7.28E-01	6.28E-01	7.75E-01	U	3.57E-01	7.01E-01	7.88E-01	U
MLR	1	2.83E+00	7.69E+00	8.91E+00	U	6.67E-02	6.92E-01	8.06E-01	U	-3.59E-01	6.66E-01	7.47E-01	U
	2	8.74E+00	7.03E+00	8.58E+00	U	-4.41E-01	6.98E-01	7.46E-01	U	-3.95E-02	6.66E-01	7.74E-01	U
	3	6.53E+00	6.90E+00	8.31E+00	U	3.94E-01	6.40E-01	7.77E-01	U	6.03E-01	6.33E-01	7.65E-01	U
	4 (Avg)	3.05E+00	7.33E+00	8.41E+00	U	-9.20E-01	7.33E-01	8.04E-01	U	-2.63E-01	7.02E-01	7.73E-01	U
SEC	1	6.12E+00	7.25E+00	8.63E+00	U	5.89E-01	7.25E-01	8.67E-01	U	4.06E-01	7.49E-01	8.43E-01	U
	2	9.04E+00	7.46E+00	9.16E+00	U	7.18E-01	7.28E-01	8.87E-01	U	1.99E-01	8.40E-01	9.47E-01	U
	3	1.30E+01	1.14E+01	1.75E+01	U	-4.62E-02	1.54E+00	1.89E+00	U	5.85E-01	1.63E+00	2.00E+00	U
	4	-1.07E+00	7.57E+00	8.20E+00	U	-3.99E-01	8.41E-01	8.74E-01	U	-2.37E-01	7.87E-01	8.59E-01	U
CBD	1	1.99E+00	7.36E+00	8.45E+00	U	1.08E-01	7.19E-01	8.26E-01	U	3.09E-02	7.26E-01	8.03E-01	U
	2	7.09E+00	6.95E+00	8.45E+00	U	6.47E-01	6.57E-01	8.03E-01	U	3.31E-01	7.75E-01	8.69E-01	U
	3	5.45E+00	6.93E+00	8.26E+00	U	5.35E-01	5.96E-01	7.48E-01	U	5.72E-01	6.05E-01	7.40E-01	U
	4	4.77E+00	6.62E+00	7.92E+00	U	1.23E-01	7.10E-01	8.18E-01	U	-2.30E-01	6.43E-01	7.30E-01	U
SMR	1	3.20E+00	7.91E+00	9.23E+00	U	6.04E-01	7.84E-01	9.37E-01	U	-5.16E-01	8.31E-01	8.84E-01	U
	2	-3.99E-01	2.38E+00	8.91E+00	U	2.35E-01	7.81E-01	9.13E-01	U	-3.17E-01	8.81E-01	9.61E-01	U
	3	-8.81E-02	7.24E+00	8.28E+00	U	2.49E-01	7.23E-01	8.48E-01	U	-3.32E-01	8.07E-01	8.69E-01	U
	4	1.16E+00	6.72E+00	7.74E+00	U	-3.41E-01	7.05E-01	7.53E-01	U	-2.54E-01	7.04E-01	7.56E-01	U
	Mean	4.13E+00	7.55E+00	9.21E+00	NA	1.64E-01	1.28E+00	9.06E-01	NA	5.27E-02	8.06E-01	9.15E-01	NA
	Minimum[e]	-3.28E+00	1.82E+01	2.02E+01	WEE (4)	-9.20E-01	7.33E-01	8.04E-01	MLR (4)	-5.57E-01	8.13E-01	8.54E-01	WSS (3)
	Maximum[f]	1.30E+01	1.14E+01	1.75E+01	SEC (3)	7.28E-01	6.28E-01	7.75E-01	WSS (4)	7.65E-01	1.70E+00	2.09E+00	WEE (4)
WAB (Filter Blank)	1	8.89E+00	7.66E+00	9.29E+00	U	3.21E-02	7.05E-01	8.19E-01	U	3.26E-01	6.88E-01	8.17E-01	U
	2	3.07E+00	7.11E+00	8.31E+00	U	-1.69E-01	6.98E-01	7.70E-01	U	2.51E-01	7.67E-01	8.59E-01	U
	3	8.33E+00	6.44E+00	7.94E+00	U	1.52E-01	6.32E-01	7.45E-01	U	-1.16E-01	6.20E-01	7.15E-01	U
	4	-2.40E-01	8.35E+00	9.16E+00	U	3.33E-01	8.61E-01	9.72E-01	U	-8.18E-02	7.95E-01	8.83E-01	U

Table G.1 2013 Radionuclide Concentrations (Bq/sample) in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for sampling location codes

		^{90}Sr			
Location	Quarter	[RN][a]	2 σ TPU[b]	MDC[c]	Q[d]
WFF	1 (Avg)	1.27E-02	2.24E-02	3.39E-02	U
	2	-1.21E-02	3.05E-02	2.38E-02	U
	3	-2.08E-02	3.93E-02	3.00E-02	U
	4	-1.11E-02	2.16E-02	3.98E-02	U
WEE	1	8.04E-03	2.28E-02	3.40E-02	U
	2 (Avg)	1.16E-03	3.15E-02	2.40E-02	U
	3	1.37E-02	3.93E-02	3.00E-02	U
	4	-2.45E-02	2.17E-02	3.97E-02	U
WSS	1	2.04E-02	2.27E-02	3.40E-02	U
	2	1.39E-02	3.22E-02	2.39E-02	U
	3 (Avg)	-1.36E-02	3.92E-02	3.00E-02	U
	4	2.87E-03	2.24E-02	3.98E-02	U
MLR	1	3.09E-03	2.20E-02	3.39E-02	U
	2	-2.55E-03	3.28E-02	2.40E-02	U
	3	-1.24E-02	4.02E-02	3.00E-02	U
	4 (Avg)	9.93E-03	2.13E-02	3.79E-02	U
SEC	1	2.18E-02	2.31E-02	3.40E-02	U
	2	-7.68E-03	3.09E-03	2.39E-02	U
	3	-1.10E-03	3.91E-02	3.00E-02	U
	4	-5.88E-03	2.17E-02	3.98E-02	U
CBD	1	1.56E-02	2.30E-02	3.41E-02	U
	2	-2.45E-03	3.15E-02	2.39E-02	U
	3	6.83E-04	3.95E-02	2.99E-02	U
	4	9.47E-03	2.16E-02	3.98E-02	U
SMR	1	9.83E-03	2.24E-02	3.40E-02	U
	2	-1.27E-02	3.02E-02	2.38E-02	U
	3	-7.61E-03	3.95E-02	2.99E-02	U
	4	-3.49E-03	2.20E-02	3.99E-02	U
Mean		1.85E-04	2.80E-02	3.18E-02	NA
Minimum[e]		-2.45E-02	3.15E-02	2.39E-02	CBD (2)
Maximum[f]		2.18E-02	2.31E-02	3.40E-02	SEC (1)
WAB (Filter Blank)	1	6.34E-03	1.53E-02	3.40E-02	U
	2	1.35E-02	2.19E-02	2.38E-02	U
	3	9.42E-03	2.70E-02	2.98E-02	U
	4	-1.36E-02	1.57E-02	3.98E-02	U

(a) Radionuclide activity. The average is used for duplicate samples. Only radionuclides with activities greater than 2 σ TPU and MDC are
(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.
(f) "+" & "U" indicates isotope detected in one of the duplicate air filter composite samples but not the other.

(a) Radionuclide activity. The average is used for duplicate samples. Only radionuclides with activities greater than 2 σ TPU and MDC are considered detections.
(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.
(f) "+" & "U" indicates isotope detected in one of the duplicate air filter composite samples but not the other.

Table G.2 2013 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding the WIPP Site
See Appendix C for Sample Location Codes

			$^{233/234}$U		^{235}U		^{238}U		^{238}Pu		$^{239/240}$Pu		^{241}Am	
Location	Quarter	Vol, 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	Bq/sample	Bq/m^3
WFF	1 (Avg)	7388.009	3.41E-03	4.61E-07	-4.67E-04	-6.31E-08	3.49E-03	4.73E-07	-9.61E-06	-1.30E-09	1.14E-04	1.54E-08	-2.64E-04	-3.57E-08
	2	7264.295	7.31E-03	1.01E-06	1.05E-03	1.45E-07	8.28E-03	1.14E-06	2.75E-04	3.79E-08	1.50E-04	2.06E-08	5.01E-04	6.90E-08
	3	7480.423	7.89E-04	1.05E-07	1.64E-04	2.19E-08	1.40E-03	1.87E-07	-1.56E-05	-2.09E-09	5.18E-04	6.92E-08	-2.16E-04	-2.89E-08
	4	7261.361	4.05E-03	5.58E-07	1.02E-04	1.40E-08	3.43E-03	4.72E-07	-1.94E-06	-2.67E-10	1.24E-04	1.71E-08	5.72E-04	7.88E-08
WEE	1	7369.721	3.05E-03	4.14E-07	-9.67E-05	-1.31E-08	2.87E-03	3.89E-07	-7.53E-05	-1.02E-08	-1.15E-04	-1.56E-08	-2.89E-04	-3.92E-08
	2 (Avg)	7303.547	4.88E-03	6.68E-07	6.68E-04	9.15E-08	5.43E-03	7.43E-07	1.48E-04	2.03E-08	2.33E-04	3.19E-08	3.76E-04	5.15E-08
	3	7466.676	7.92E-04	1.06E-07	7.49E-06	1.00E-09	2.82E-03	3.78E-07	-3.46E-05	-4.63E-09	6.73E-04	9.01E-08	4.08E-05	5.46E-09
	4	7283.555	1.68E-03	2.31E-07	8.44E-04	1.16E-07	3.87E-03	5.31E-07	-1.08E-04	-1.48E-08	-2.23E-04	-3.06E-08	1.36E-04	1.87E-08
WSS	1	7167.985	2.38E-03	3.32E-07	-8.17E-05	-1.14E-08	3.89E-03	5.43E-07	-2.85E-04	-3.98E-08	3.23E-04	4.51E-08	3.33E-04	4.65E-08
	2	7306.693	5.37E-03	7.35E-07	6.25E-04	8.55E-08	8.54E-03	1.17E-06	-9.99E-06	-1.37E-09	6.44E-05	8.81E-09	-2.90E-04	-3.97E-08
	3 (Avg)	7442.328	2.68E-03	3.60E-07	-4.63E-04	-6.22E-08	1.53E-03	2.06E-07	1.23E-04	1.65E-08	1.02E-04	1.37E-08	-2.29E-04	-3.08E-08
	4	7305.604	2.39E-03	3.27E-07	-1.80E-04	-2.46E-08	4.71E-03	6.45E-07	-1.11E-04	-1.52E-08	-2.79E-04	-3.82E-08	4.40E-04	6.02E-08
MLR	1	7441.877	2.75E-03	3.70E-07	6.94E-05	9.33E-09	5.03E-03	6.76E-07	2.04E-04	2.74E-08	2.05E-04	2.75E-08	-1.24E-04	-1.67E-08
	2	7261.228	7.76E-03	1.07E-06	1.31E-04	1.80E-08	9.23E-03	1.27E-06	-1.76E-04	-2.42E-08	3.14E-04	4.32E-08	2.82E-04	3.88E-08
	3	7531.877	3.51E-03	4.66E-07	-7.22E-04	-9.59E-08	2.96E-03	3.93E-07	-8.89E-05	-1.18E-08	2.22E-04	2.95E-08	-3.76E-04	-4.99E-08
	4 (Avg)	7284.206	2.61E-03	3.58E-07	4.11E-04	5.64E-08	4.49E-03	6.16E-07	2.54E-05	3.49E-09	-9.51E-05	-1.31E-08	3.93E-04	5.40E-08
SEC	1	7456.229	3.52E-03	4.72E-07	-3.29E-04	-4.41E-08	5.98E-03	8.02E-07	-1.10E-04	-1.48E-08	-3.80E-05	-5.10E-09	-6.03E-05	-8.09E-09
	2	7309.440	1.04E-02	1.42E-06	1.32E-04	1.81E-08	8.56E-03	1.17E-06	3.00E-05	4.10E-09	-4.69E-05	-6.42E-09	-2.89E-05	-3.95E-09
	3	7378.502	2.20E-03	2.98E-07	-9.29E-05	-1.26E-08	2.81E-03	3.81E-07	-2.66E-05	-3.61E-09	6.31E-05	8.55E-09	-3.66E-04	-4.96E-08
	4	6794.299	2.59E-03	3.81E-07	3.31E-04	4.87E-08	5.74E-03	8.45E-07	1.11E-05	1.63E-09	-2.42E-04	-3.56E-08	7.23E-05	1.06E-08
CBD	1	7366.621	5.68E-03	7.71E-07	-5.99E-05	-8.13E-09	9.35E-03	1.27E-06	-6.84E-08	-9.29E-12	-1.51E-04	-2.05E-08	-3.38E-04	-4.59E-08
	2	7359.023	1.39E-02	1.89E-06	6.90E-04	9.38E-08	1.42E-02	1.93E-06	4.24E-05	5.76E-09	6.28E-05	8.53E-09	-7.63E-05	-1.04E-08
	3	7445.911	4.33E-03	5.82E-07	-1.35E-04	-1.81E-08	5.47E-03	7.35E-07	-7.76E-05	-1.04E-08	-3.88E-05	-5.21E-09	-3.67E-04	-4.93E-08
	4	7303.621	5.82E-03	7.97E-07	3.06E-04	4.19E-08	6.37E-03	8.72E-07	-9.01E-05	-1.23E-08	-1.15E-04	-1.57E-08	-1.07E-04	-1.47E-08
SMR	1	7361.852	4.87E-03	6.62E-07	-3.83E-05	-5.20E-09	5.05E-03	6.86E-07	-2.62E-04	-3.56E-08	2.80E-04	3.80E-08	-2.23E-04	-3.03E-08
	2	7141.674	7.35E-03	1.03E-06	1.21E-04	1.69E-08	6.23E-03	8.72E-07	6.74E-06	9.44E-10	-1.04E-05	-1.46E-09	5.07E-04	7.10E-08
	3	7043.012	1.60E-03	2.27E-07	-6.95E-05	-9.87E-09	1.37E-03	1.95E-07	-1.31E-04	-1.86E-08	1.86E-04	2.64E-08	-1.81E-04	-2.57E-08
	4	7142.467	1.98E-03	2.77E-07	-3.12E-04	-4.37E-08	4.87E-03	6.82E-07	-7.70E-05	-1.08E-08	-1.19E-04	-1.67E-08	-1.97E-04	-2.75E-08
	Mean	7309.358	4.27E-03	5.85E-07	9.30E-05	1.31E-08	5.28E-03	7.24E-07	-2.94E-05	-4.06E-09	7.71E-05	1.03E-08	-2.81E-06	-6.16E-11
	Minimum	6794.299	7.89E-04	1.05E-07	-7.22E-04	-9.59E-08	1.37E-03	1.87E-07	-2.85E-04	-3.98E-08	-2.79E-04	-3.82E-08	-3.76E-04	-4.99E-08
	Maximum	7531.877	1.39E-02	1.89E-06	1.05E-03	1.45E-07	1.42E-02	1.93E-06	2.75E-04	3.79E-08	6.73E-04	9.01E-08	5.72E-04	7.88E-08

Table G.2 2013 Radionuclide Concentrations in Quarterly Air Filter Composite Samples Collected from Locations Surrounding WIPP Site
See Appendix C for Sample Location Codes

			^{40}K		^{60}Co		^{137}Cs		^{90}Sr	
Location	Quarter	Vol, m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3	Bq/sample	Bq/m^3
WFF	1 (Avg)	7388.009	7.39E+00	1.00E-03	1.89E-01	2.56E-05	-6.75E-02	-9.14E-06	1.27E-02	1.72E-06
	2	7264.295	-3.08E+00	-4.24E-04	3.40E-01	4.68E-05	1.76E-01	2.42E-05	-1.21E-02	-1.67E-06
	3	7480.423	5.54E+00	7.41E-04	-2.49E-01	-3.33E-05	5.43E-01	7.26E-05	-2.08E-02	-2.78E-06
	4	7261.361	8.06E+00	1.11E-03	2.98E-01	4.10E-05	2.38E-01	3.28E-05	-1.11E-02	-1.53E-06
WEE	1	7369.721	4.74E+00	6.43E-04	-2.08E-01	-2.82E-05	6.11E-02	8.29E-06	8.04E-03	1.09E-06
	2 (Avg)	7303.547	2.67E+00	3.66E-04	3.70E-02	5.07E-06	4.54E-02	6.22E-06	1.16E-03	1.59E-07
	3	7466.676	7.14E+00	9.56E-04	4.96E-02	6.64E-06	7.14E-02	9.56E-06	1.37E-02	1.83E-06
	4	7283.555	-3.28E+00	-4.50E-04	6.37E-01	8.75E-05	7.65E-01	1.05E-04	-2.45E-02	-3.36E-06
WSS	1	7167.985	7.08E+00	9.88E-04	4.67E-01	6.52E-05	-4.08E-01	-5.69E-05	2.04E-02	2.85E-06
	2	7306.693	1.42E+00	1.94E-04	9.90E-02	1.35E-05	7.25E-02	9.92E-06	1.39E-02	1.90E-06
	3 (Avg)	7442.328	3.34E+00	4.49E-04	1.07E-01	1.44E-05	-5.57E-01	-7.48E-05	-1.36E-02	-1.83E-06
	4	7305.604	3.12E+00	4.27E-04	7.28E-01	9.96E-05	3.57E-01	4.89E-05	2.87E-03	3.93E-07
MLR	1	7441.877	2.83E+00	3.80E-04	6.67E-02	8.96E-06	-3.59E-01	-4.82E-05	3.09E-03	4.15E-07
	2	7261.228	8.74E+00	1.20E-03	-4.41E-01	-6.07E-05	-3.95E-02	-5.44E-06	-2.55E-03	-3.51E-07
	3	7531.877	6.53E+00	8.67E-04	3.94E-01	5.23E-05	6.03E-01	8.01E-05	-1.24E-02	-1.65E-06
	4 (Avg)	7284.206	3.05E+00	4.19E-04	-9.20E-01	-1.26E-04	-2.63E-01	-3.61E-05	9.93E-03	1.36E-06
SEC	1	7456.229	6.12E+00	8.21E-04	5.89E-01	7.90E-05	4.06E-01	5.45E-05	2.18E-02	2.92E-06
	2	7309.440	9.04E+00	1.24E-03	7.18E-01	9.82E-05	1.99E-01	2.72E-05	-7.68E-03	-1.05E-06
	3	7378.502	1.30E+01	1.76E-03	-4.62E-02	-6.26E-06	5.85E-01	7.93E-05	-1.10E-03	-1.49E-07
	4	6794.299	-1.07E+00	-1.57E-04	-3.99E-01	-5.87E-05	-2.37E-01	-3.49E-05	-5.88E-03	-8.65E-07
CBD	1	7366.621	1.99E+00	2.70E-04	1.08E-01	1.47E-05	3.09E-02	4.19E-06	1.56E-02	2.12E-06
	2	7359.023	7.09E+00	9.63E-04	6.47E-01	8.79E-05	3.31E-01	4.50E-05	-2.45E-03	-3.33E-07
	3	7445.911	5.45E+00	7.32E-04	5.35E-01	7.19E-05	5.72E-01	7.68E-05	6.83E-04	9.17E-08
	4	7303.621	4.77E+00	6.53E-04	1.23E-01	1.68E-05	-2.30E-01	-3.15E-05	9.47E-03	1.30E-06
SMR	1	7361.852	3.20E+00	4.35E-04	6.04E-01	8.20E-05	-5.16E-01	-7.01E-05	9.83E-03	1.34E-06
	2	7141.674	-3.99E-01	-5.59E-05	2.35E-01	3.29E-05	-3.17E-01	-4.44E-05	-1.27E-02	-1.78E-06
	3	7043.012	-8.81E-02	-1.25E-05	2.49E-01	3.54E-05	-3.32E-01	-4.71E-05	-7.61E-03	-1.08E-06
	4	7142.467	1.16E+00	1.62E-04	-3.41E-01	-4.77E-05	-2.54E-01	-3.56E-05	-3.49E-03	-4.89E-07
	Mean	7309.3584	4.13E+00	5.60E-04	1.65E-01	2.23E-05	5.27E-02	6.80E-06	1.86E-04	2.07E-08
	Minimum	6794.299	-3.28E+00	-4.50E-04	-9.20E-01	-1.26E-04	-5.57E-01	-7.48E-05	-2.45E-02	-3.36E-06
	Maximum	7531.877	1.30E+01	1.76E-03	7.28E-01	9.96E-05	7.65E-01	1.05E-04	2.18E-02	2.92E-06

APPENDIX H – COMPARISON OF DETECTED RADIONUCLIDES TO THE RADIOLOGICAL BASELINE

The figures in this appendix show the highest detected radionuclides from 2013 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 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; therefore, vegetation sample results are compared to the baseline mean values.

A few items to note from the figures include the following:

- Figures for air filter composites are not included in Appendix H. The only radionuclides detected were $^{233/234}$U in the second quarter air filter composites from SEC and CBD and ^{238}U in the second quarter air fitler composite from WFF. The measured concentrations were very similar to the concentrations measured in the blank air filters.

- WQSP-1 groundwater contained the highest concentrations of all three uranium isotopes. The 2013 measured concentration of $^{233/234}$U was higher than the 99 percent confidence interval range of the groundwater baseline, while ^{235}U and ^{238}U were lower than the 99 percent baseline confidence interval range.

- Pierce Canyon (PCN) contained the highest concentrations of the three uranium isotopes and ^{40}K detected in surface water with the concentration of ^{238}U higher than the 99 percent confidence interval range of the baseline.

- PCN also contained the highest concentrations of the uranium isotopes in sediment samples although the primary HIL sample contained a slightly higher ^{235}U concentration. None of the measured uranium isotope concentrations in sediment samples were higher than the 99 percent confidence interval range of the baseline. The HIL duplicate sediment samples also contained the highest concentrations of ^{40}K and ^{137}Cs and the only detection of $^{239/240}$Pu in sediments. The concentration of ^{40}K in the primary HIL sediment sample was higher than the 99 percent confidence interval range of the baseline concentrations, but the duplicate sample concentration was just below the baseline concentration.

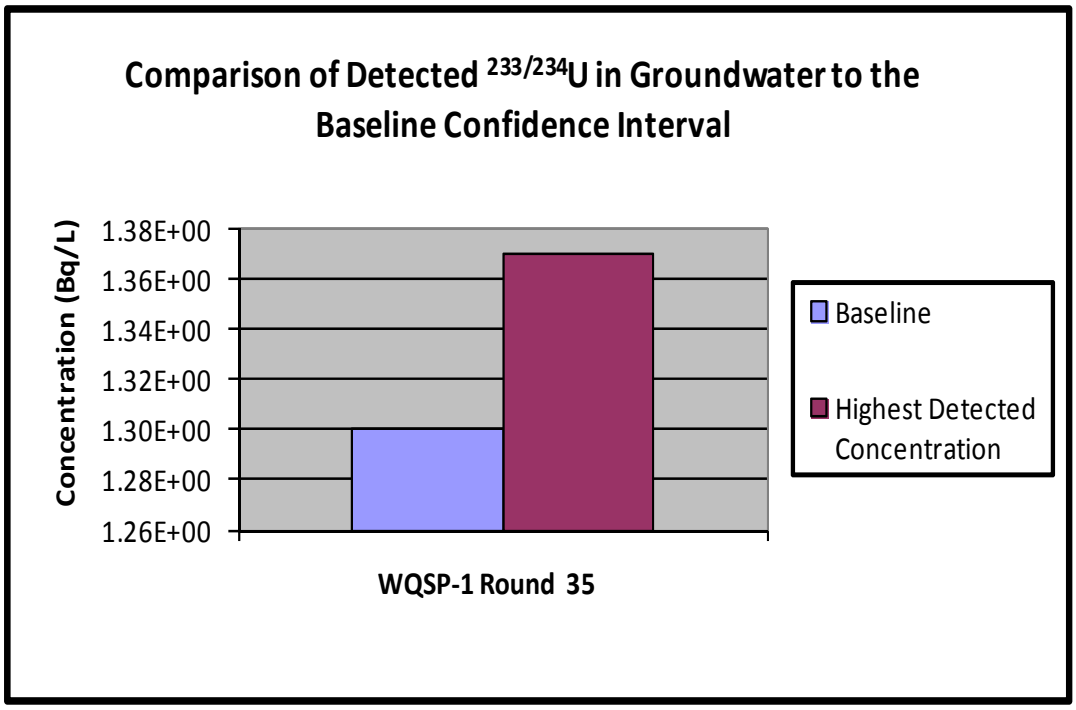
- Most of the highest concentrations of detected radionuclides in soil samples were at MLR and SMR. MLR (0 – 2 cm) contained the only detection of $^{239/240}$Pu in any of the soil samples. The WEE primary soil sample contained the highest ^{235}U of any of the soil samples, but the isotope was not detected in the duplicate sample. The concentration in the primary WEE sample was higher than the 99 percent baseline confidence interval concentration. The ^{238}U concentration in the 5 – 10 cm depth of SMR and the ^{40}K concentration in the 0 – 2 cm depth of SMR

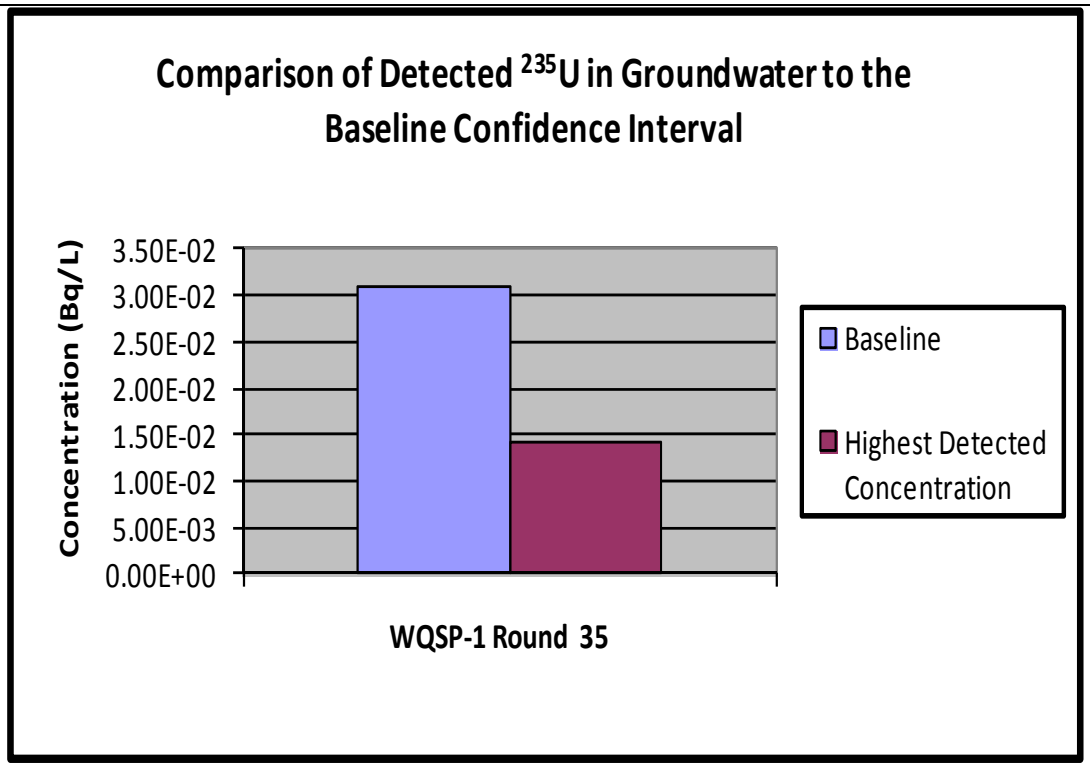
were both higher than the 99 percent baseline confidence interval concentrations.

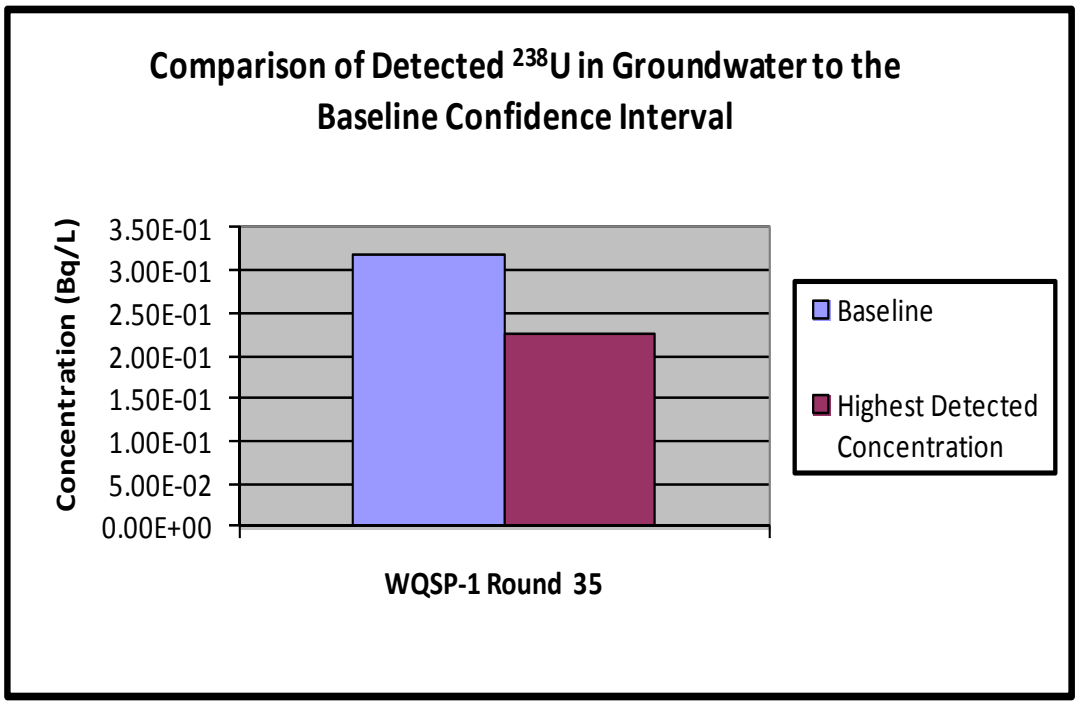
- The vegetation samples showed detection of ^{40}K in all the samples. The vegetation samples also showed trace detection of $^{233/234}U$ in the sample from MLR and trace detection of ^{238}U in the samples froml MLR and SMR. The baseline concentrations of the isotopes were only available for ashed vegetation samples.

- All the animal biota samples contained ^{40}K. The fish sample from PCN was the only surface water that contained detectable $^{233/234}U$ and ^{238}U. (The PCN surface water contained the highest concentrations of dissolved uranium isotopes).

A detailed discussion of environmental monitoring radionuclide sample results is presented in Chapter 4.




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
WQSP-1 Round 35
Baseline
Highest Detected Concentration


Comparison of Detected 238U in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
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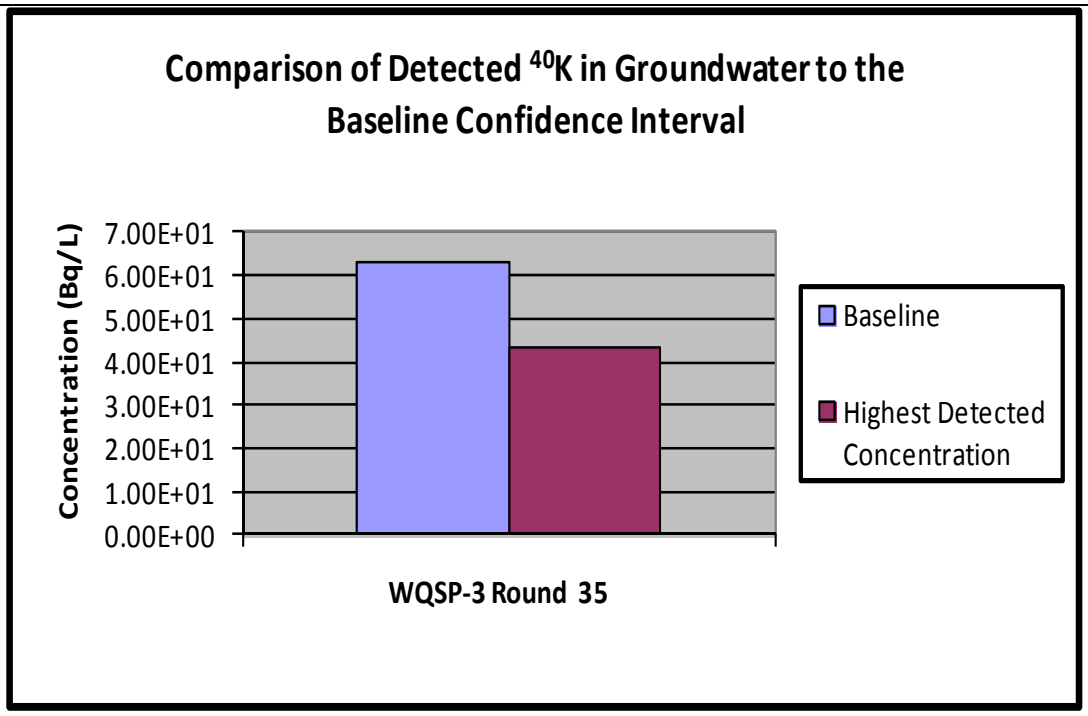
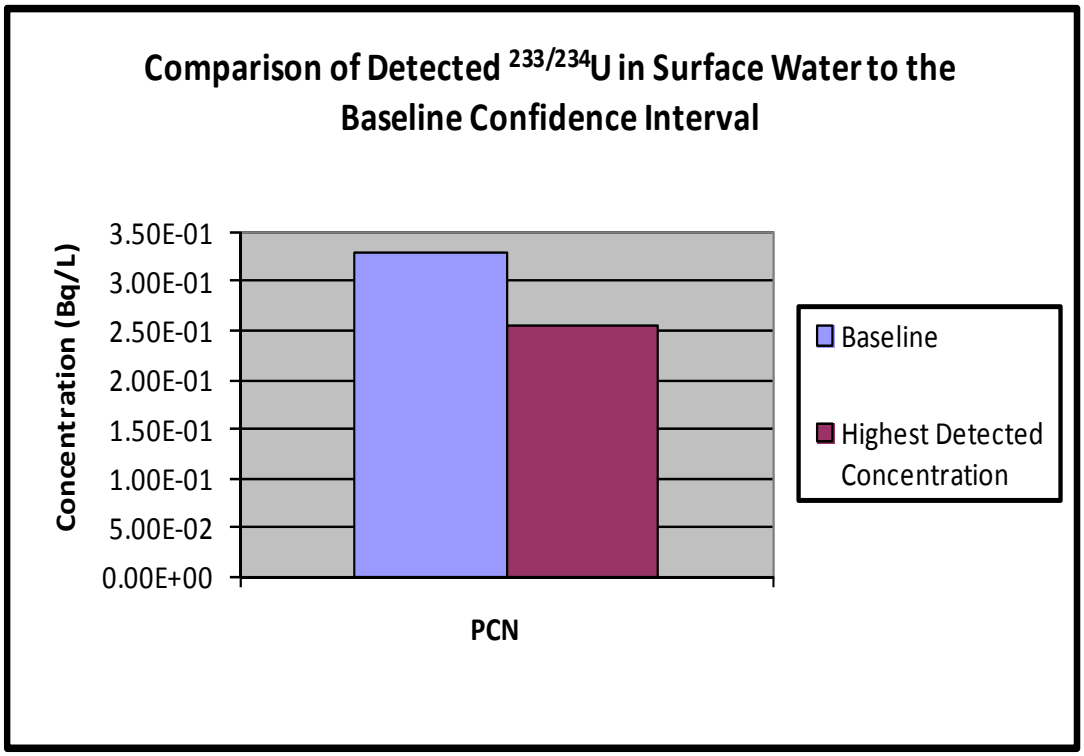
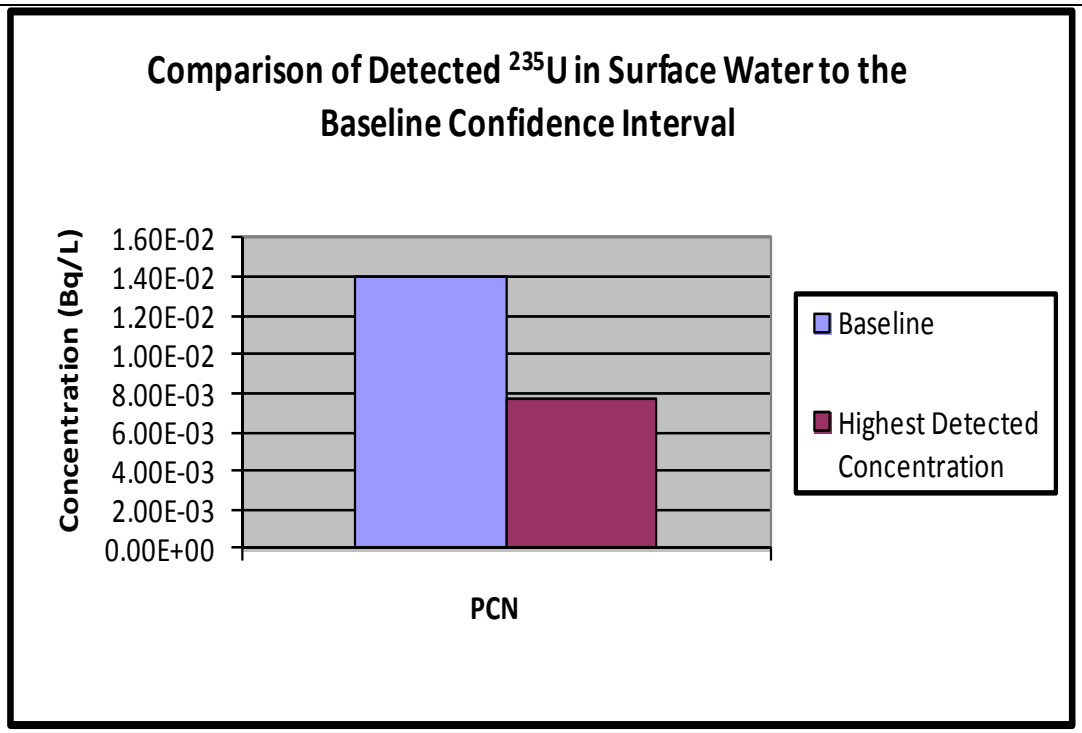
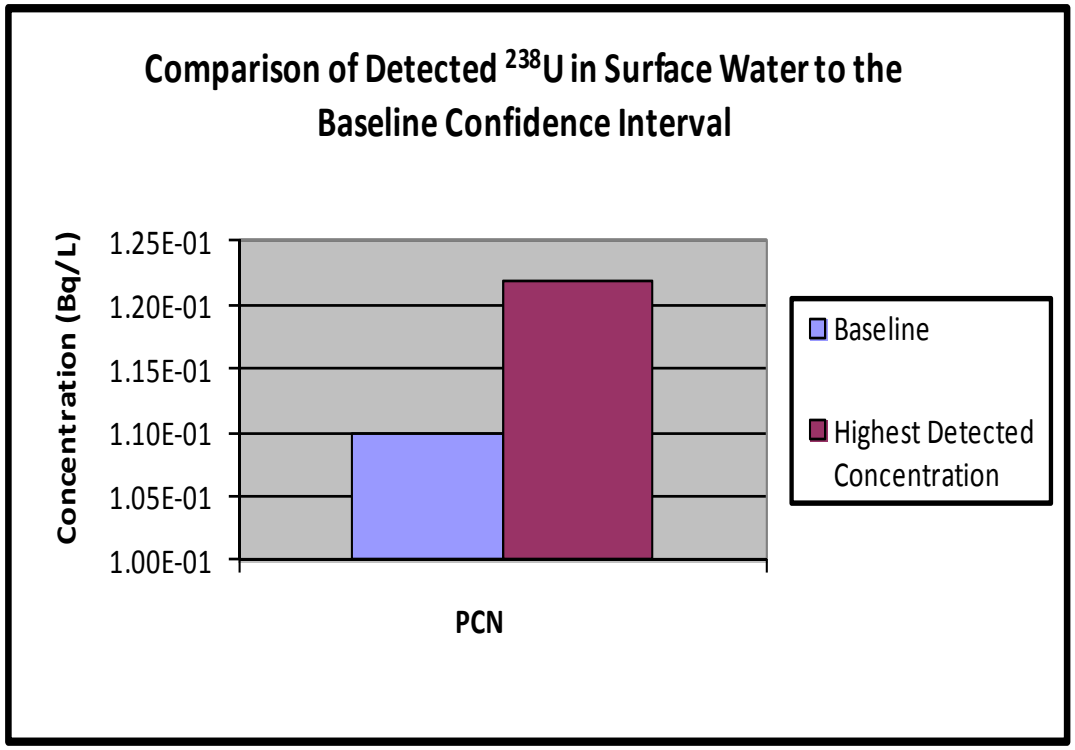
3.00E-01
2.50E-01
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
WQSP-1 Round 35
Baseline
Highest Detected Concentration


Comparison of Detected 40K in Groundwater to the Baseline Confidence Interval
Concentration (Bq/L)
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
WQSP-3 Round 35
Baseline
Highest Detected Concentration


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
Highest Detected Concentration


Comparison of Detected 235U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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
PCN
Baseline
Highest Detected Concentration


Comparison of Detected 238U in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
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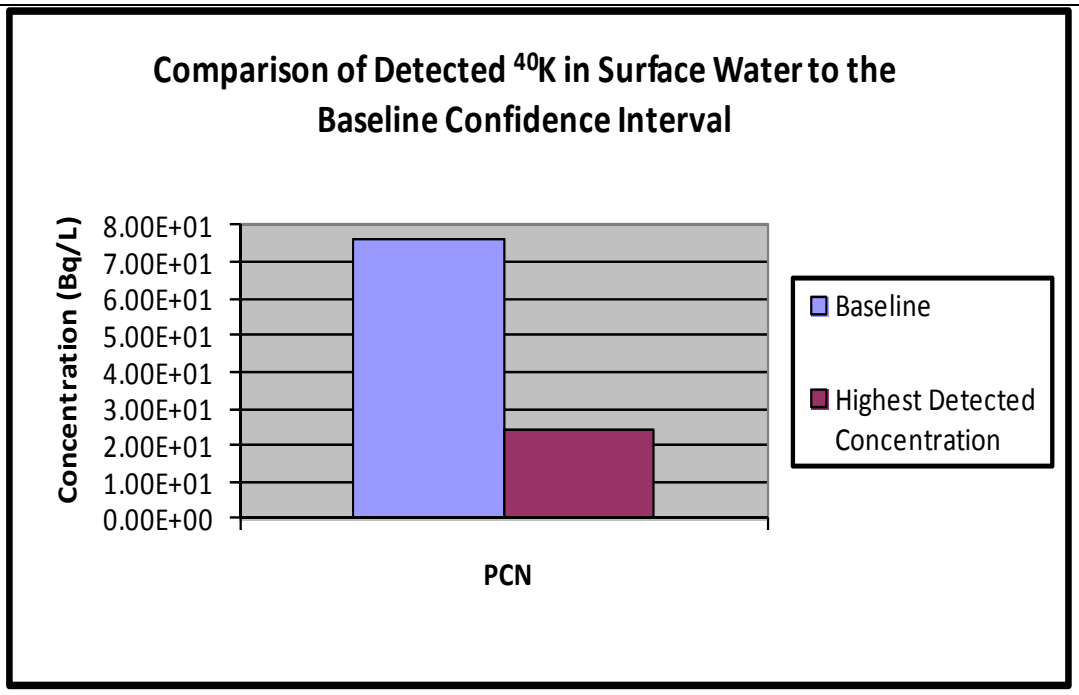
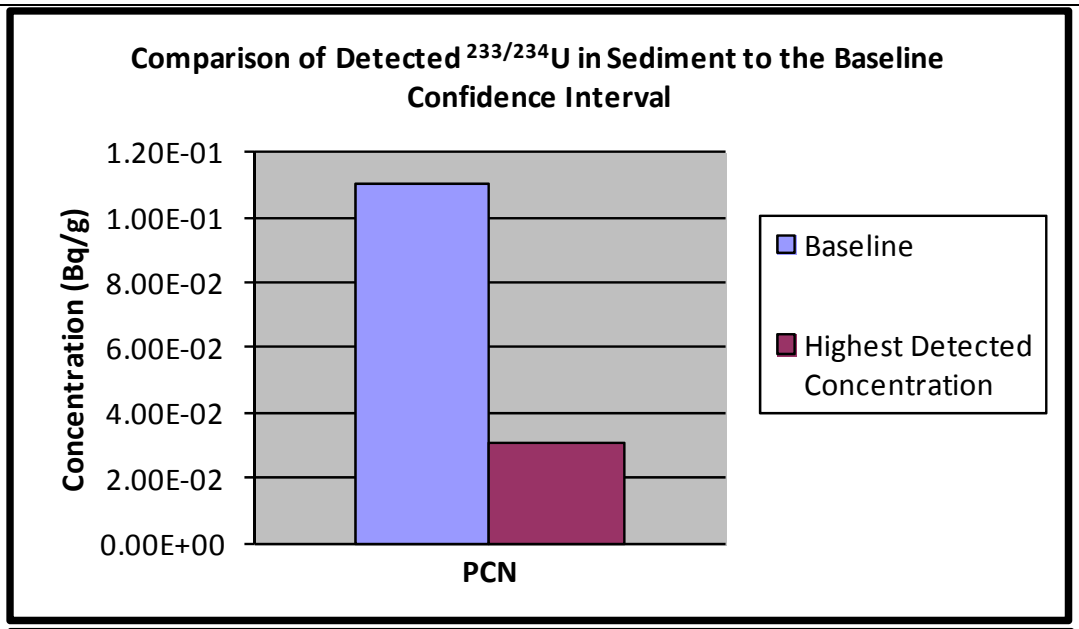
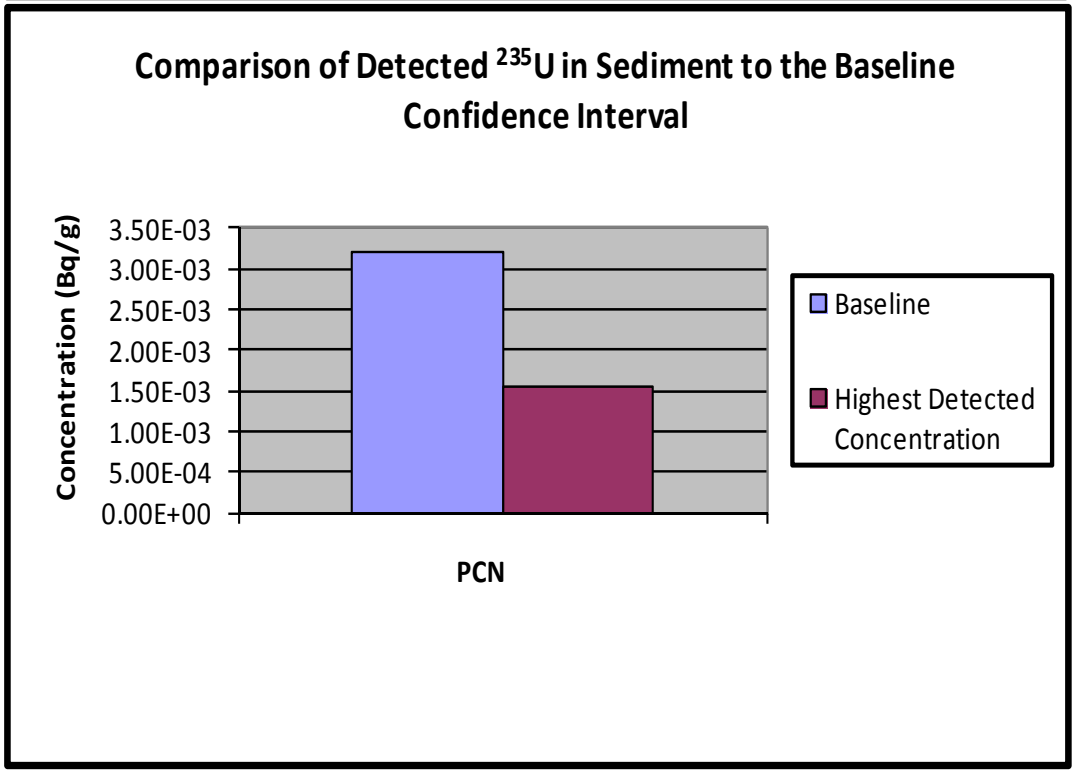
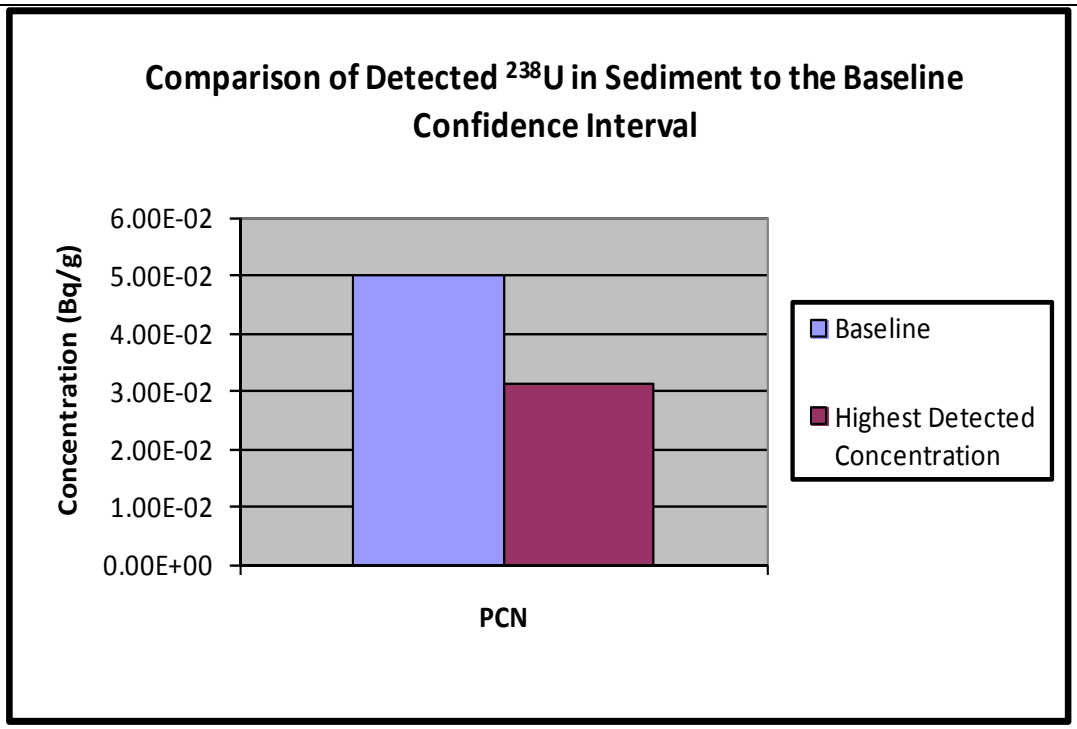
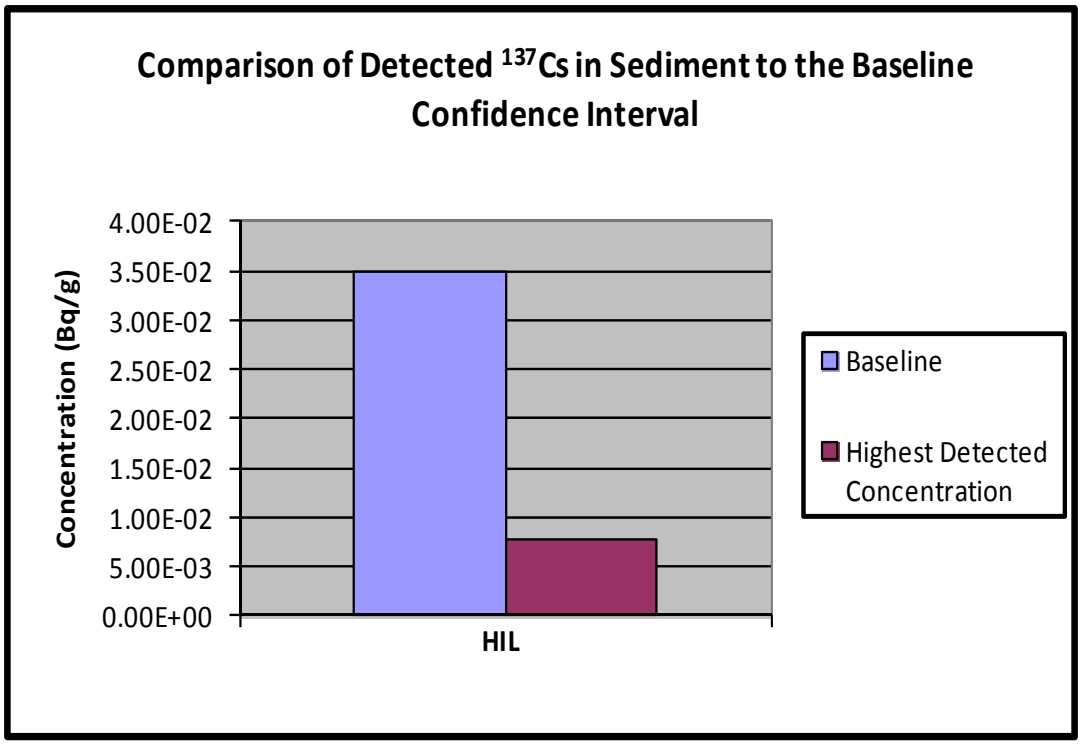
1.20E-01
1.15E-01
1.10E-01
1.05E-01
1.00E-01
PCN
Baseline
Highest Detected Concentration

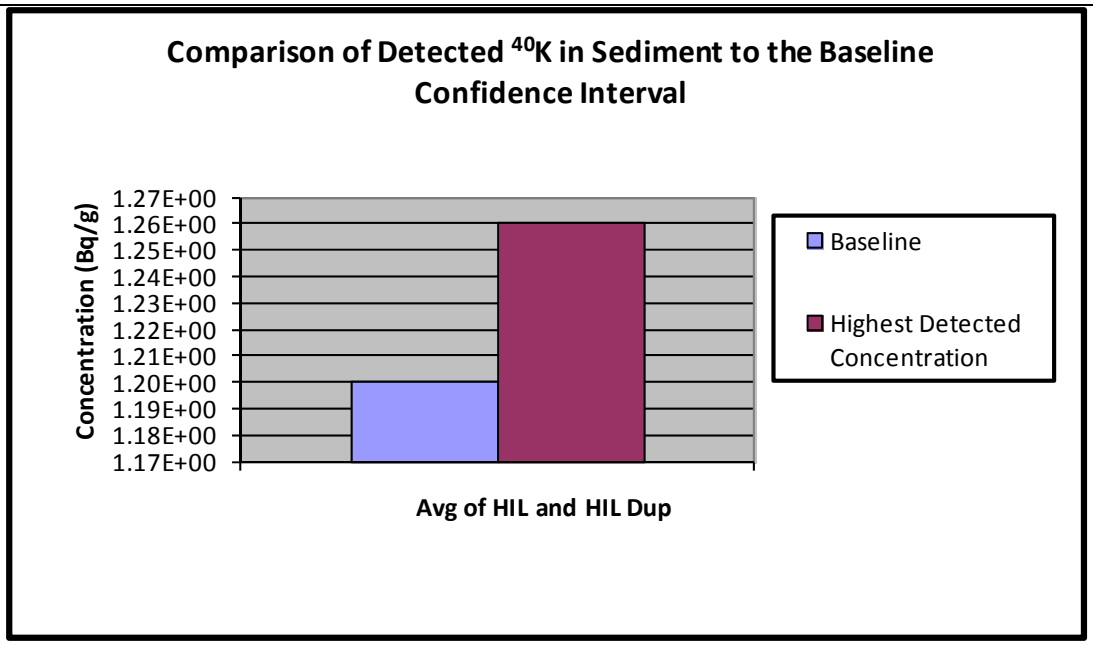

Comparison of Detected 40K in Surface Water to the Baseline Confidence Interval
Concentration (Bq/L)
8.00E+01
7.00E+01
6.00E+01
5.00E+01
4.00E+01
3.00E+01
2.00E+01
1.00E+01
0.00E+00
PCN
Baseline
Highest Detected Concentration

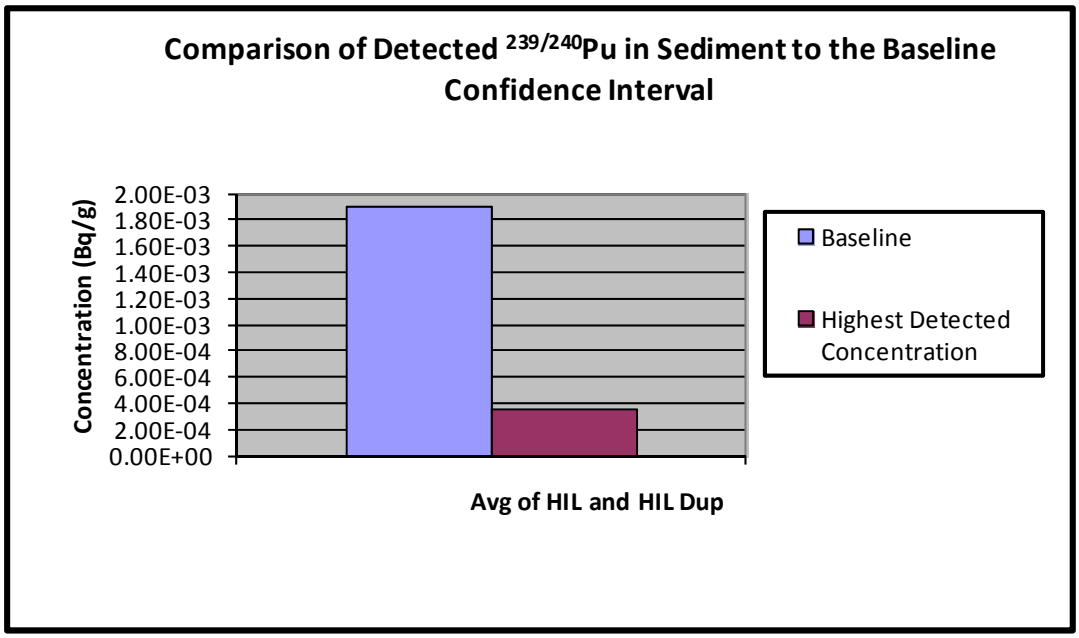

Comparison of Detected 233/234U in Sediment to the Baseline Confidence Interval
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Concentration (Bq/g)
PCN
Baseline
Highest Detected Concentration

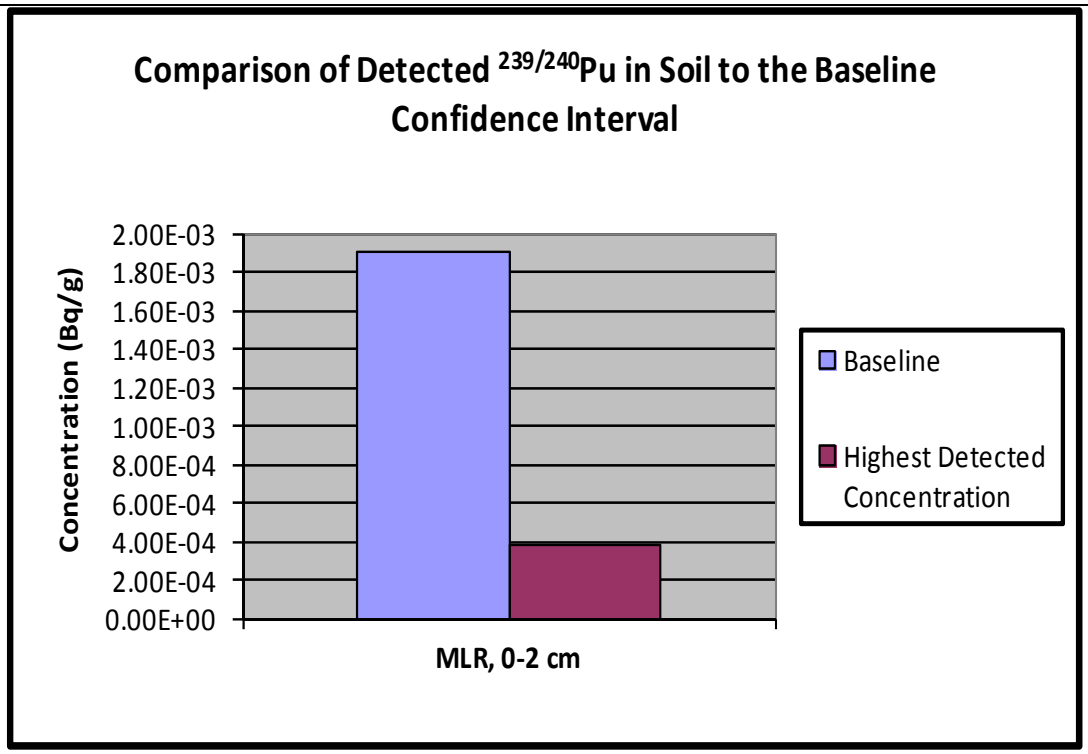

Comparison of Detected 235U in Sediment to the Baseline Confidence Interval
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Concentration (Bq/g)
PCN
Baseline
Highest Detected Concentration

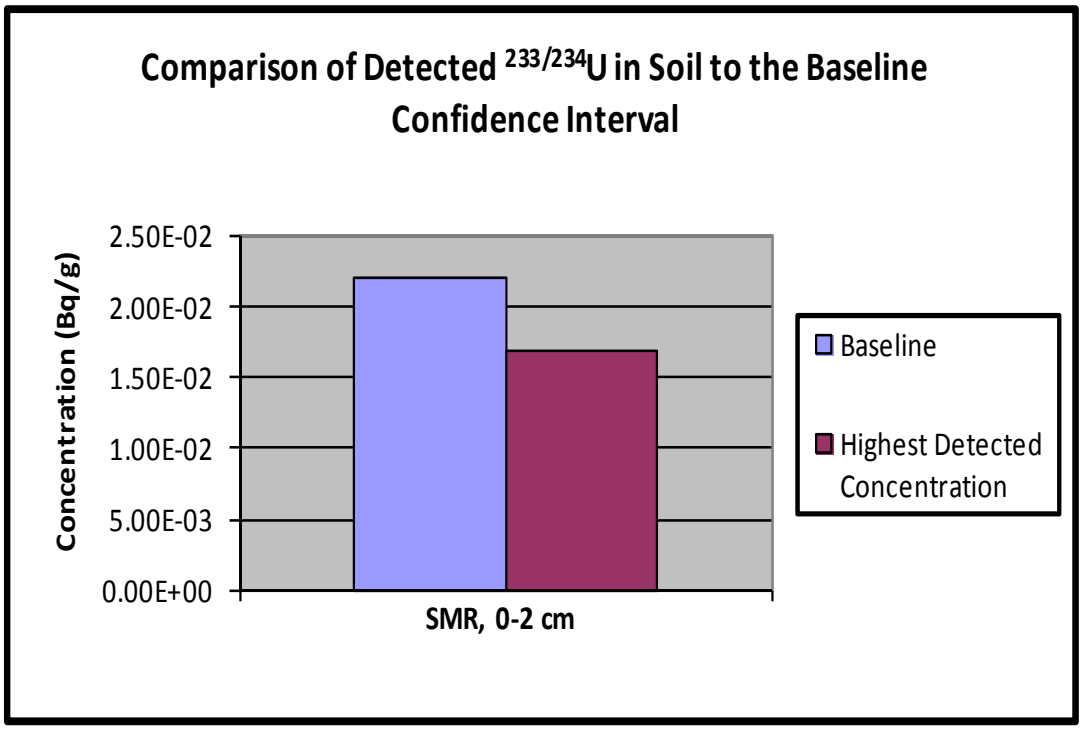

Comparison of Detected 238U in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
PCN
Baseline
Highest Detected Concentration

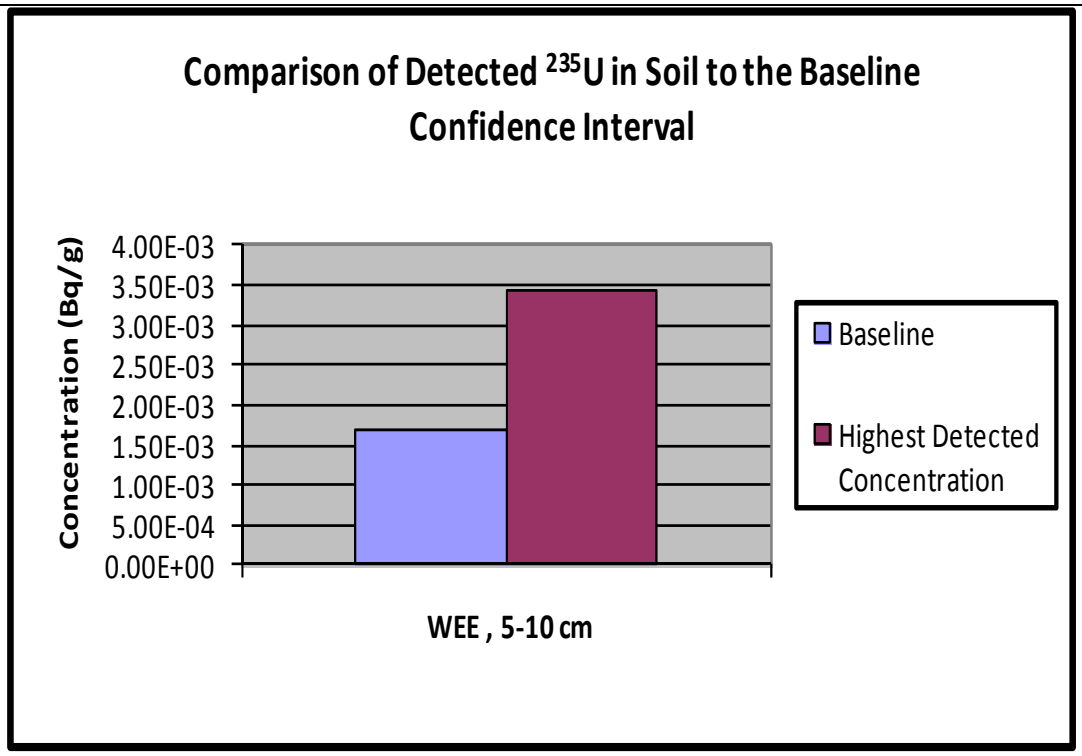

Comparison of Detected 137Cs in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
4.00E-02
3.50E-02
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
HIL
Baseline
Highest Detected Concentration

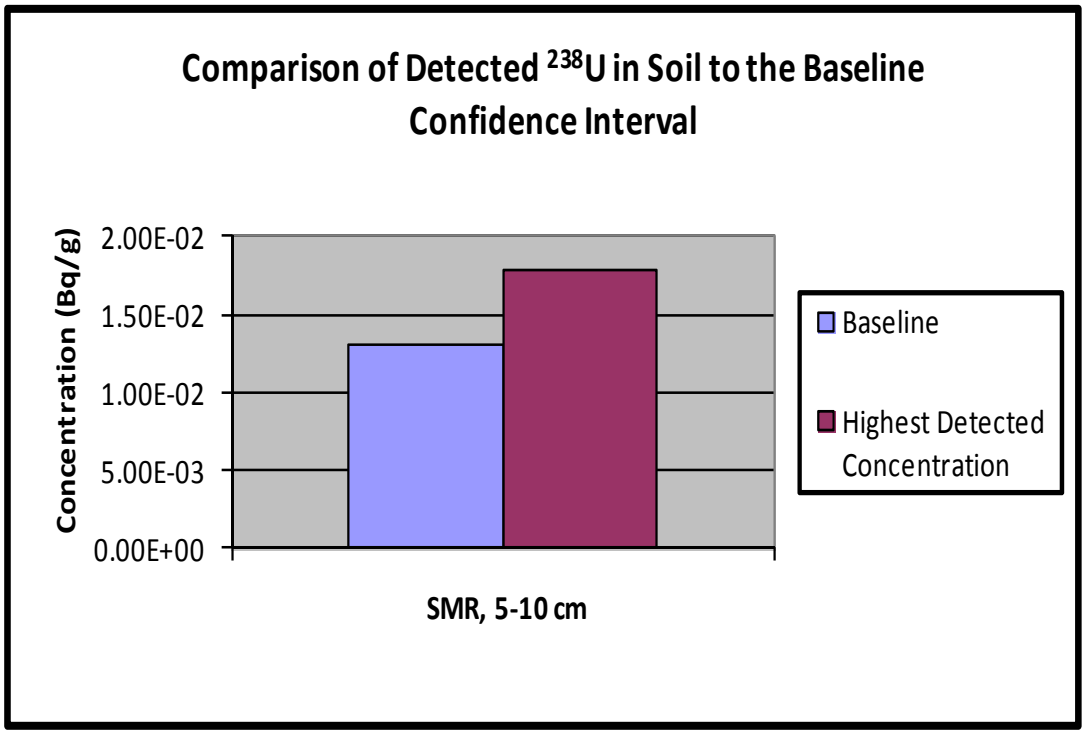

Comparison of Detected 40K in Sediment to the Baseline Confidence Interval
Concentration (Bq/g)
1.27E+00
1.26E+00
1.25E+00
1.24E+00
1.23E+00
1.22E+00
1.21E+00
1.20E+00
1.19E+00
1.18E+00
1.17E+00
Avg of HIL and HIL Dup
Baseline
Highest Detected Concentration


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
Avg of HIL and HIL Dup
Baseline
Highest Detected Concentration


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
Highest Detected Concentration


Comparison of Detected 233/234U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
SMR, 0-2 cm
Baseline
Highest Detected Concentration


Comparison of Detected 235U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
4.00E-03
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Baseline
Highest Detected Concentration
WEE , 5-10 cm


Comparison of Detected 238U in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
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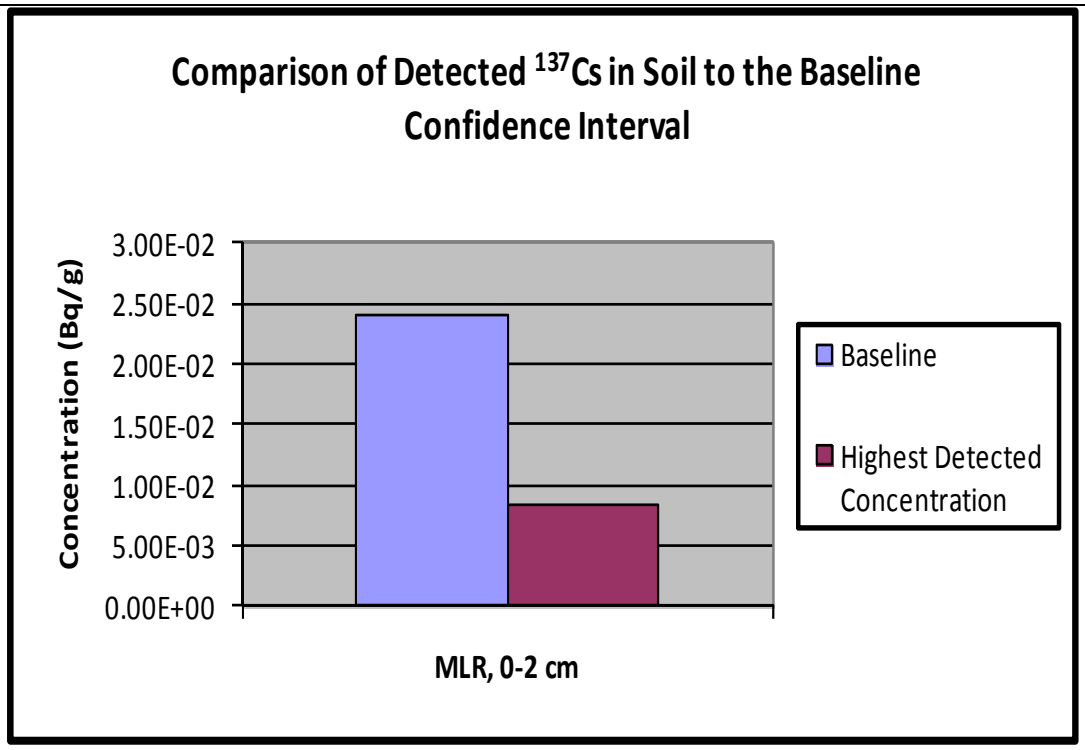
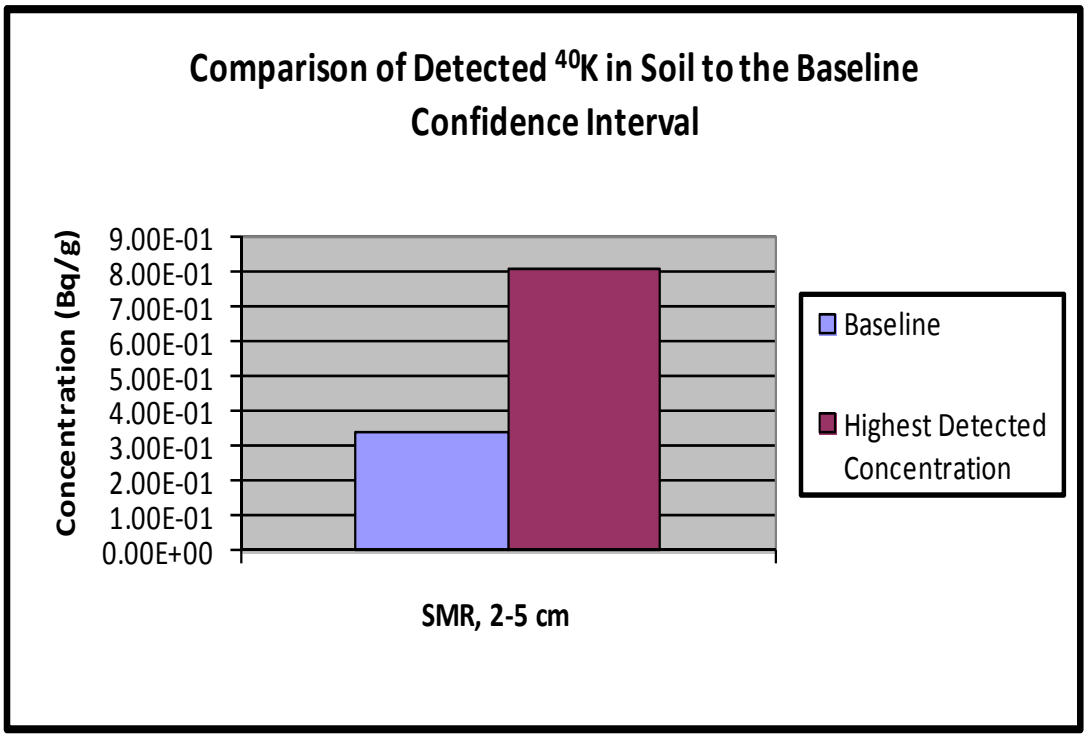
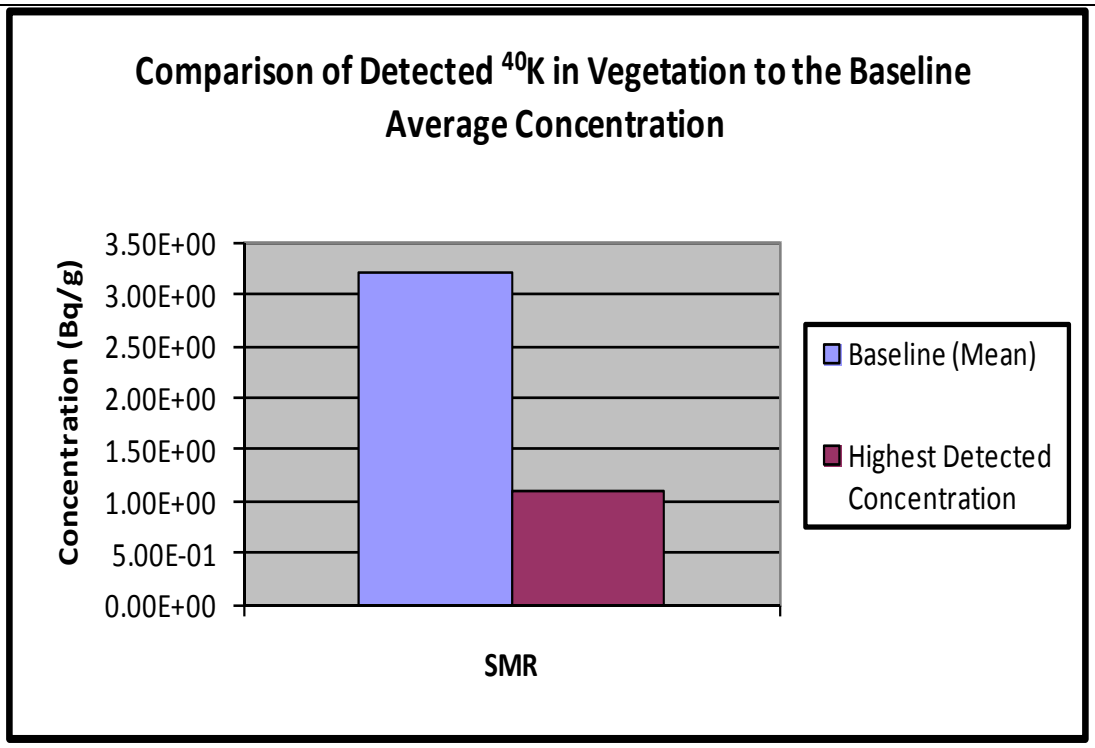
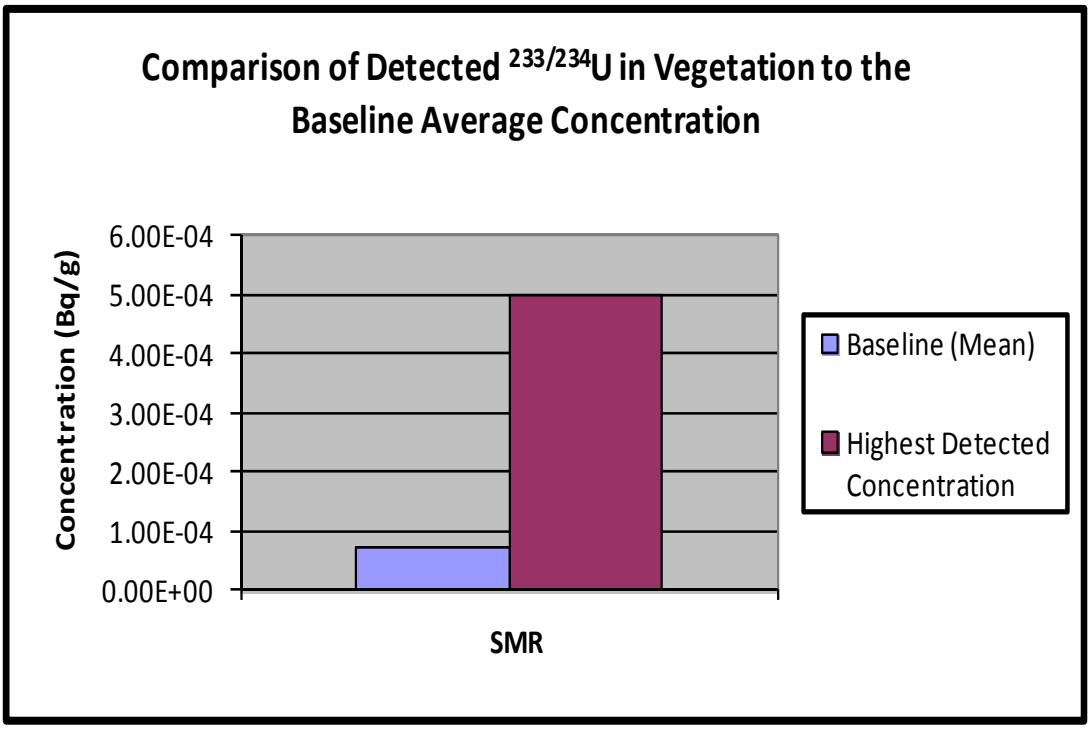
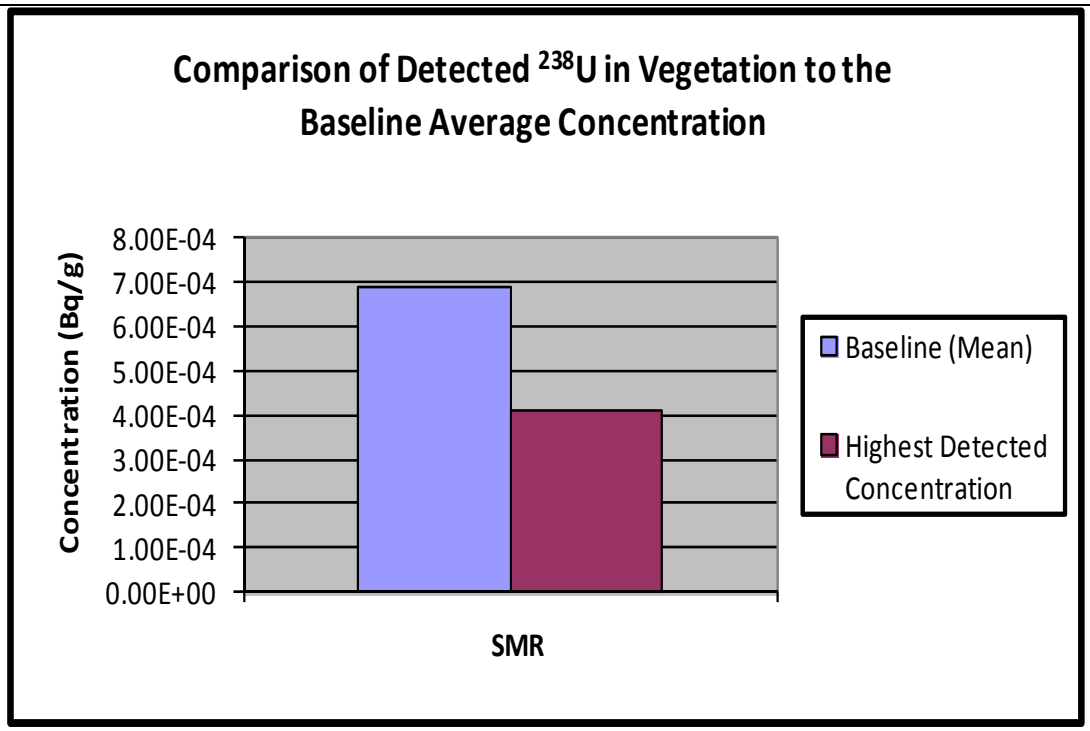
1.50E-02
1.00E-02
5.00E-03
0.00E+00
Baseline
Highest Detected Concentration
SMR, 5-10 cm

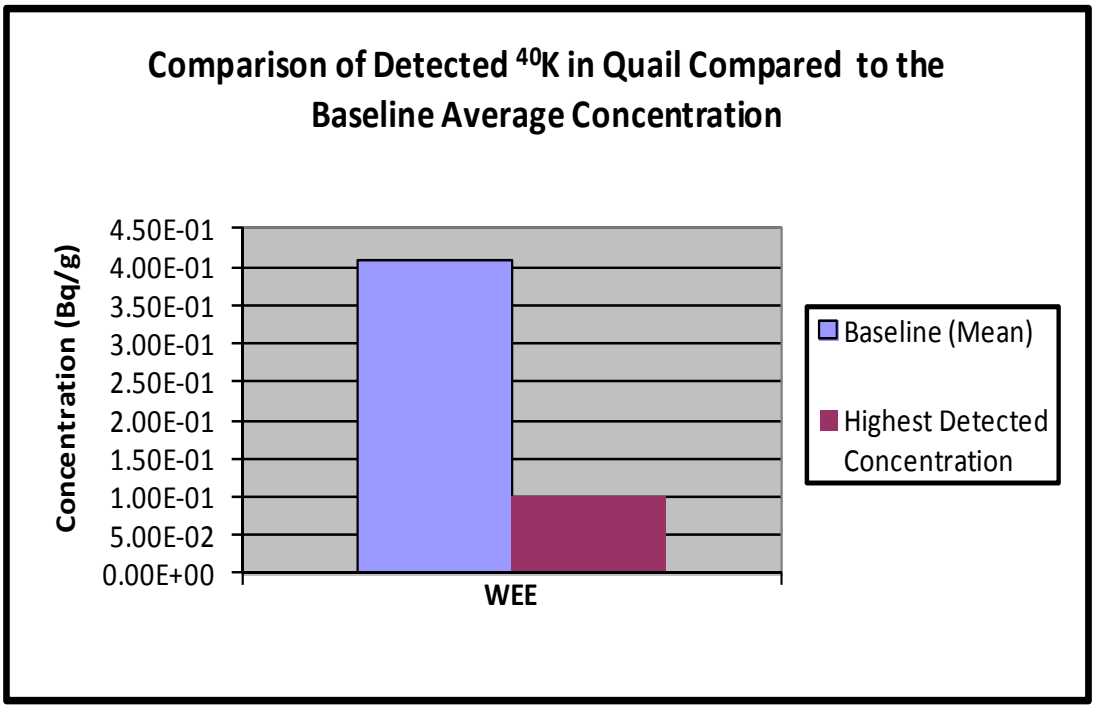

Comparison of Detected 137Cs in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
3.00E-02
2.50E-02
2.00E-02
1.50E-02
1.00E-02
5.00E-03
0.00E+00
MLR, 0-2 cm
Baseline
Highest Detected Concentration

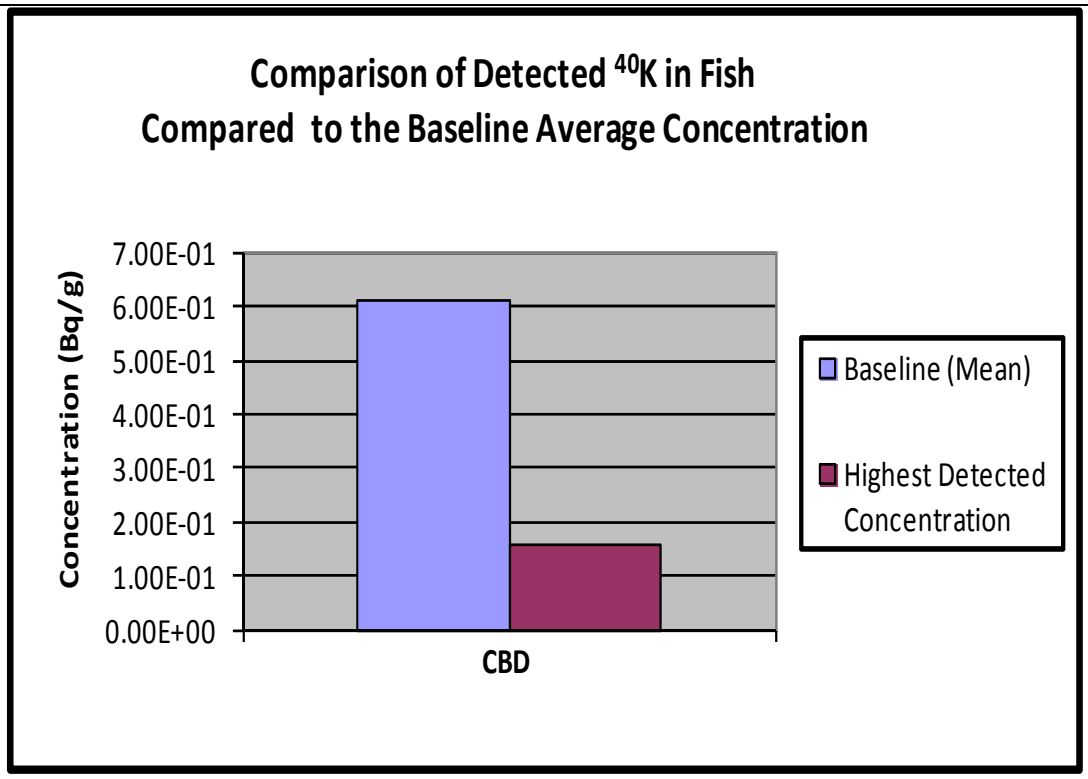

Comparison of Detected 40K in Soil to the Baseline Confidence Interval
Concentration (Bq/g)
9.00E-01
8.00E-01
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
SMR, 2-5 cm
Baseline
Highest Detected Concentration

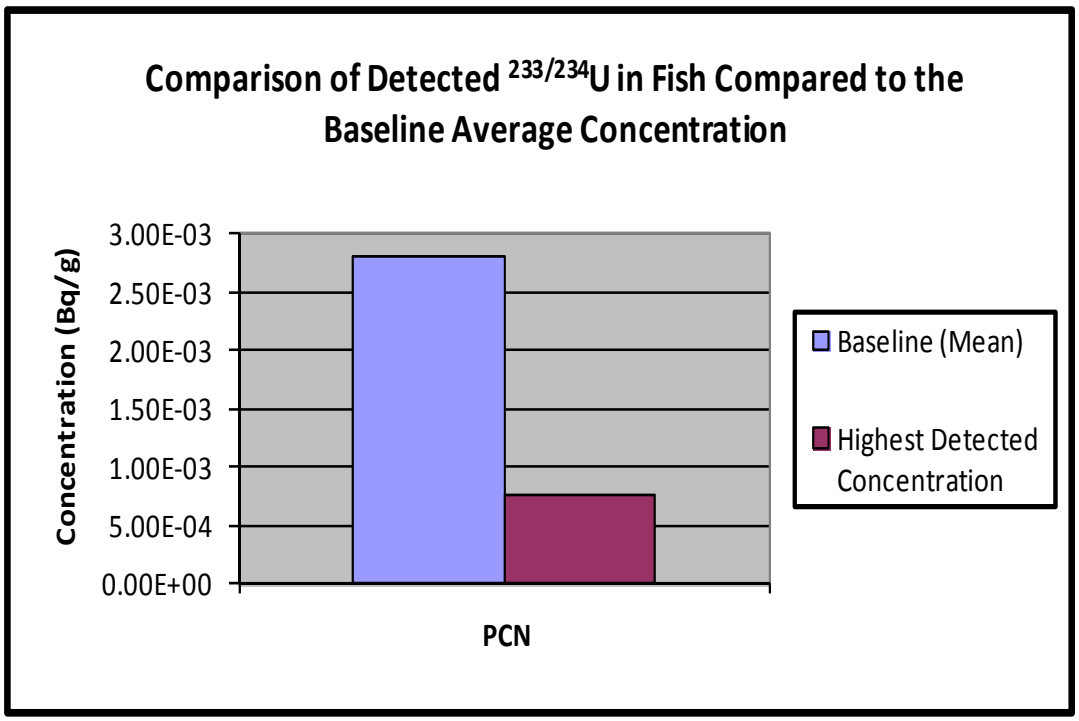

Comparison of Detected 40K in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
SMR
Baseline (Mean)
Highest Detected Concentration

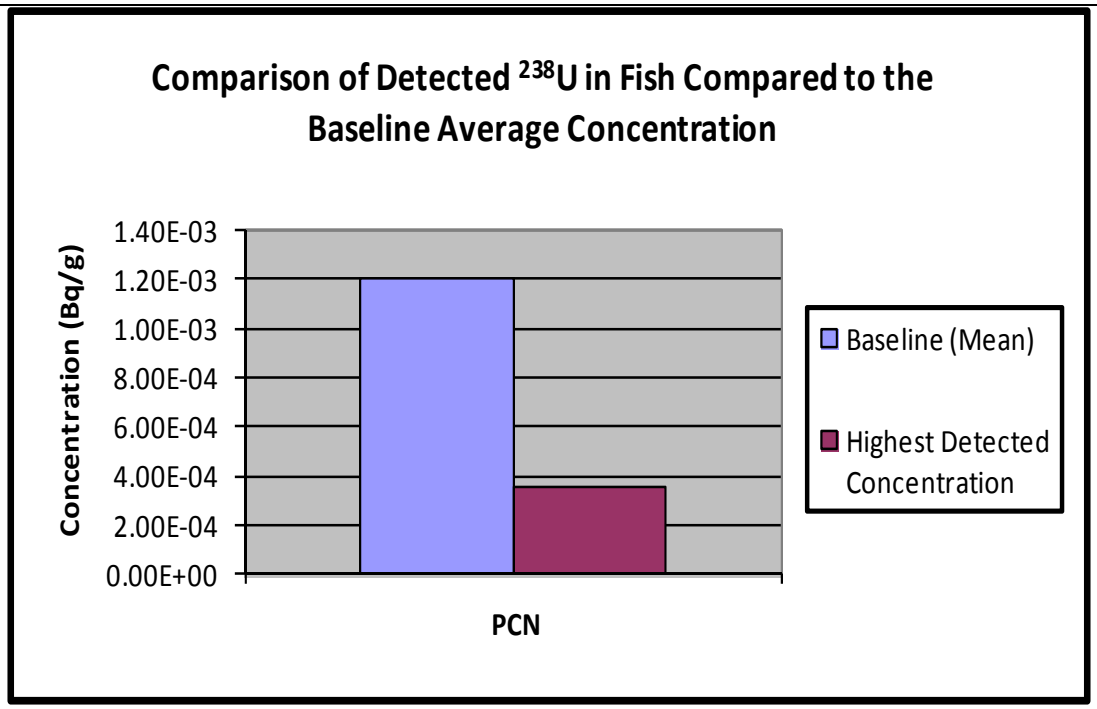

Comparison of Detected 233/234U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
SMR
Baseline (Mean)
Highest Detected Concentration


Comparison of Detected 238U in Vegetation to the Baseline Average Concentration
Concentration (Bq/g)
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
SMR
Baseline (Mean)
Highest Detected Concentration


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)
Highest Detected Concentration


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
CBD
Baseline (Mean)
Highest Detected Concentration


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
PCN
Baseline (Mean)
Highest Detected Concentration


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
PCN
Baseline (Mean)
Highest Detected Concentration

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