# ANNUAL REPORT

## 2022

**CARLSBAD ENVIRONMENTAL MONITORING & RESEARCH CENTER**

1400 University Drive
Carlsbad, NM 88220

*CEMRC-22-0001*

# Annual Independent Environmental Site Report for Calendar Year 2022

**Prepared by:**

Carlsbad Environmental Monitoring & Research Center
under a financial assistance grant from
U.S. Department of Energy, Carlsbad Field Office (CBFO)
Award No. DE-EM0005195

November 2024

# TABLE OF CONTENTS

# LIST OF APPENDICES

# LIST OF TABLES

# LIST OF FIGURES

This page intentionally left blank

# ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

| | |
|---|---|
| Am | americium |
| Al | aluminum |
| ANSI | American National Standards Institute |
| ASER | Annual Site Environmental Report |
| | |
| B | boron |
| Ba | barium |
| 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 |
| BOMAB | Bottle Mannikin Absorber |
| | |
| CBFO | (U.S. Department of Energy) Carlsbad Field Office |
| CEMRC | Carlsbad Environmental Monitoring and Research Center |
| CFR | Code of Federal Regulations |
| cm | centimeter |
| Ca | calcium |
| Ce | cerium |
| Co | cobalt |
| Cd | cadmium |
| Cs | cesium |
| Cr | chromium |
| Cu | copper |
| CY | Calendar Year |
| | |
| DOE | U.S. Department of Energy |
| Dy | dysprosium |
| | |
| EEG | Environmental Evaluation Group |
| EPA | U.S. Environmental Protection Agency |
| Er | erbium |
| Eu | europium |
| | |
| FAS | Fixed Air sample(r/s) |
| Fe | iron |
| | |
| Ga | gallium |
| GC-MS | Gas Chromatography-Mass Spectrometry |
| Gd | gadolinium |
| | |
| HEPA | High-Efficiency Particulate Air (Filter) |
| Hg | mercury |

| | |
|---|---|
| HPGe | High Purity germanium |
| | |
| ICP-MS | Inductively Coupled Plasma Mass Spectrometry |
| ID | Internal Dosimetry |
| Ir | iridium |
| | |
| K | potassium |
| km | kilometer |
| | |
| L | liter |
| La | lanthanum |
| $L_c$ | Decision Level |
| LDBC | Lie Down and Be Counted |
| LWBC | Lung and Whole-Body Counting (facility) |
| Li | lithium |
| LWA | (Waste Isolation Pilot Plant) Land Withdrawal Act (as amended) |
| | |
| m | meter |
| $m^3$ | cubic meter |
| $m^3$/min | cubic meters per minute |
| mBq | millibecquerel |
| MAPEP | Mixed Analyte Performance Evaluation Program |
| MDC | Minimum Detectable Concentration |
| MDL | Method Detection Limit |
| mg/L | milligrams per liter |
| mi | mile |
| min | minute |
| mL | milliliter |
| Mn | manganese |
| Mo | molybdenum |
| MOC | Management and Operating Contractor |
| Mg | magnesium |
| | |
| N/A | not applicable |
| Na | sodium |
| NATTS | National Air Toxics Trends Station |
| Nd | neodymium |
| NIST | National Institute of Standards and Technology |
| NMED | New Mexico Environment Department |
| NMSU | New Mexico State University |
| NRIP | National Institute of Standards and Technology Radiochemistry Intercomparison Program |
| NWP | Nuclear Waste Partnership LLC |
| | |
| P | phosphorus |
| Pb | lead |
| pCi/L | picocurie per liter |
| pH | negative logarithm of the hydrogen ion activity in a solution (a measure of the acidity or alkalinity of a solution) |

| | |
|---|---|
| Pr | praseodymium |
| PT | Proficiency Testing |
| Pu | plutonium |
| QA | Quality Assurance |
| QA/QC | Quality Assurance / Quality Control |
| Sb | antimony |
| Sc | scandium |
| Se | selenium |
| Si | silicon |
| Sr | strontium |
| Th | thorium |
| Tl | thallium |
| Ti | titanium |
| TRU | transuranic |
| U | uranium |
| Unc. | uncertainty |
| U.S. | United States |
| V | vanadium |
| VOC | volatile organic compound(s) |
| WIPP | Waste Isolation Pilot Plant |
| WIPP-EM | Waste Isolation Pilot Plant-Environmental Monitoring |
| Zn | zinc |

## SYMBOLS

| | |
|---|---|
| ˚C | degrees Celsius |
| > | greater than |
| < | less than |
| ≤ | less than or equal to |
| $\mu g/m^3$ | micrograms per cubic meter |
| $ng/m^3$ | nanograms per cubic meter |
| µg/L | micrograms per liter |
| % | percent |

# EXECUTIVE SUMMARY

The role of the Carlsbad Environmental Monitoring and Research Center's (CEMRC's) Environmental Monitoring Program is to establish and maintain a health and environmental monitoring program in the vicinity of the U.S. Department of Energy's (DOE's) Waste Isolation Pilot Plant (WIPP). The DOE funds CEMRC through a Financial Assistance Grant in which an important distinguishing feature from other funding mechanisms is the absence of substantial federal involvement in or contribution to the technical aspects of the project. The project was implemented during the WIPP pre-operational phase and continues during the operational (disposal) phase. Under the CEMRC monitoring program, air (ambient as well as WIPP exhaust air), water (drinking and surface waters), soil, sediment, vegetation, and people (whole-body counting for the public as well as workers) are analyzed. The results of the monitoring program are easily available to all interested parties. Public access to the monitoring data and the public's ability to directly participate in CEMRC's whole-body counting program provides a key element of trust and transparency.

The mission of the WIPP is to provide permanent, underground disposal of defense-related transuranic (TRU) and TRU-mixed wastes (wastes that also have hazardous chemical components). TRU waste is defined as having alpha activity greater than 37000 Bq/g for radioactive isotopes with atomic numbers higher than uranium and half-life greater than 20 years.

CEMRC's 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 people (whole-body counting for the public as well as workers), water (drinking and surface waters), soil, sediment, vegetation, air (ambient as well as WIPP effluent air), and volatile organic compounds (VOCs). The monitoring program's goal is to determine if the local ecosystem has been, or is being, adversely impacted by WIPP facility operations and if so, to evaluate the severity, extent, and environmental significance of those impacts.

## Important Aspects of the CEMRC Monitoring Program

### Timely Analyses

- Monthly summary of gross alpha and beta measurements from airborne effluent monitoring are provided to the DOE within fourteen (14) days of the end of each month.
- Any anomalies in airborne effluent gross alpha and beta measurements, for example because of rock falls or due to investigative and clean-up efforts by underground personnel, are immediately reported to DOE verbally and in writing within eight (8) hours of discovery.

- While filters have been collected from Station A by other entities, CEMRC is the only organization that has been continuously performing actinide analysis on Station A filters.

## Unique Capabilities

- The CEMRC program has capabilities to detect radionuclides rapidly in case of accidental releases from the repository or from the nuclear facilities anywhere in the world.
- A state-of-the-art whole-body counting system that can measure the body burden of radioactive elements, including transuranics, at extremely low levels.
- Ability to monitor to below background levels by increasing the counting time on alpha spectroscopy to 5 days and on gamma spectroscopy to 2 days, unlike most environmental programs that only monitor down to compliance or action levels.
- Public's access to the monitoring data and their direct participation in CEMRC's whole-body counting program aids in minimizing concern in the region over radioactive releases.

## Key Highlights of the Monitoring Results

- Gross alpha and beta activities remained mostly close to the normal background levels in 2022.
- Trace levels of $^{241}$Am, $^{238}$Pu, and $^{239+240}$Pu were detected in most weekly composite filters from Station A. In all cases, the concentrations were close to the detection levels of these analyses that are already very low.
- The concentrations of actinides and other radionuclides in air particulates were consistent with measurements in previous years.
- No transuranic radionuclides were detected in any drinking water samples.
- Trace levels of $^{239+240}$Pu were detected in sediments of two regional reservoirs and trace levels of $^{238}$Pu and $^{241}$Am were detected in sediments of one of the three regional reservoirs. The levels detected were within the normal background for these reservoirs.
- Non-radiological monitoring of effluent air, drinking water, surface water, and the surface VOCs showed no increase in contaminants that could be attributed to the WIPP operations in any way.

In summary, the results of these programs, including observations, analytical data, interpretations, and trend analysis demonstrated that the operations at the WIPP facility have not had a negative impact on human health or the environment.

# CHAPTER 1 - INTRODUCTION

The Carlsbad Environmental Monitoring and Research Center (CEMRC) is an independent organization that conducts health and environmental monitoring in the vicinity of the Waste Isolation Pilot Plant (WIPP) site. The CEMRC is funded by the U.S. Department of Energy (DOE) and is part of New Mexico State University's (NMSU) College of Engineering.

The primary purpose of CEMRC is to evaluate the radiological fingerprint of the WIPP facility throughout its operational lifetime. This is accomplished by comparing the current radiation levels to an established baseline that was determined before operations began. The CEMRC has been conducting independent monitoring since 1998 and has made the results easily accessible to all interested parties. This public access helps to build trust and transparency between the CEMRC and the community.

The WIPP is a deep geologic repository operated by the DOE. The purpose of the repository is to dispose of defense-related transuranic (TRU) waste. TRU waste is a type of radioactive waste that contains elements heavier than uranium, such as plutonium and americium. The TRU waste inventory at the WIPP consists mostly of contaminated industrial trash, as well as sludges from solidified liquids, glass, metal, construction debris, and other materials.

The upper waste acceptance criteria for the WIPP are less than 0.85 TBq/L (less than 23 Ci/L) of total activity and less than 10 Sv/h dose rate on contact with unshielded waste containers. Two types of TRU waste are currently stored in the WIPP repository: (1) TRU waste, containing only radioactive elements, and (2) mixed transuranic waste (MTRU), containing hazardous waste components, in addition to the radioactive elements.

The WIPP facility became operational on March 26, 1999, and the first waste shipment was received on April 28, 1999. The WIPP facility was operated without incident until February 2014, when a fire on February 5 and an unrelated accidental radiological release on February 14 resulted in the temporary suspension of shipments to the facility. The facility resumed accepting waste shipments on April 10, 2017.

## 1.1 Environmental Setting of the WIPP

The WIPP facility is currently the world’s only licensed deep geologic repository permitted to permanently dispose of transuranic waste generated from defense operations. The WIPP facility is located in Eddy County, in southeastern New Mexico, approximately 42 km (26 mi) east of Carlsbad (Figure 1.1). The facility is located on a sandy plain at an elevation of 1,040 m (3,410 ft) above sea level. Prominent natural features near the facility include Livingston Ridge and Nash Draw, about 8 km (5 mi) west of the facility. Nash Draw is a shallow, dog bone-shaped drainage course between 14 km (8.5 mi) and 18 km (11 mi) wide and characterized by surface impoundments of brine. Livingston Ridge is a bluff that marks the eastern edges of Nash Draw. Other prominent features of the region include the Pecos River, located about 22 km (14 mi) west of the facility, and Carlsbad Caverns National Park, located about 68 km (42 mi) west-southwest of the WIPP facility.

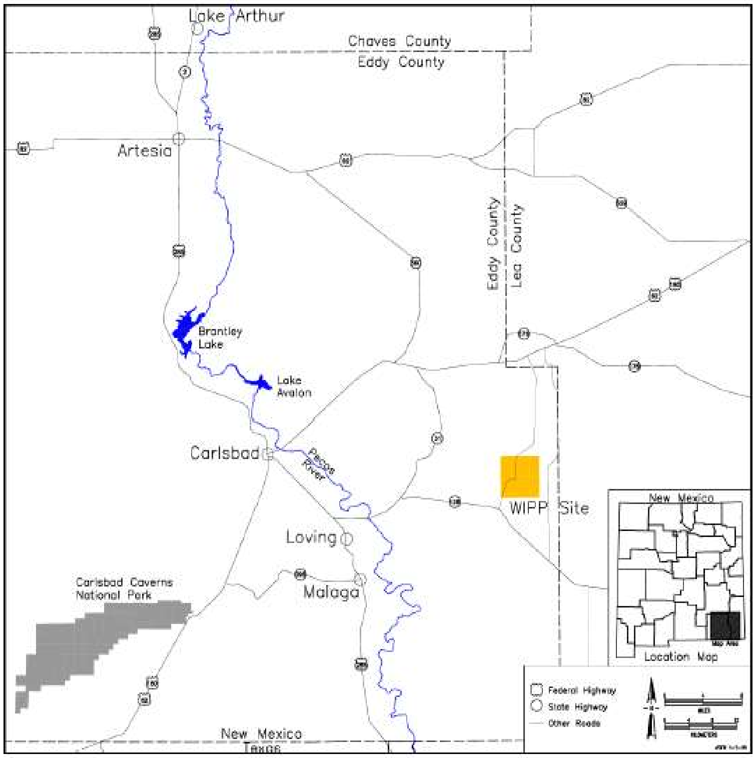


**Figure 1.1. Location of the WIPP Site Identified by the Orange Box (DOE/WIPP-99-2194, Rev.14)**

The climate of the facility's region is semi-arid, with a typical annual precipitation ranging between 280 and 300 mm (11 to 13 inches), with much of this precipitation falling during intense thunderstorms in the spring and summer seasons. Winds are generally from the southeast with an average speed of 14 km/h (8.8 mi/h).

The majority of the local population within 80 km (50 mi) of the WIPP site is concentrated in and around the New Mexico communities of Carlsbad, Hobbs, Eunice, Loving, Jal, Lovington, and Artesia.

According to the latest census data, the estimated population within this radius was 88,952. The nearest community is the village of Loving (with an approximate population of 1,400), 29 km (18 mi) west-southwest of the WIPP site. The closest majorly populated area is Carlsbad, 42 km (26 mi) west of the WIPP site. The 2020 census reported the population of Carlsbad as 32,238.

The transient population within 10 miles of WIPP is associated with ranching, oil and gas exploration and production, and potash mining. Three ranchers, Mills, Smith, and Mobley, have properties in the vicinity of the WIPP facility. The Mills ranch headquarters is located 5.6 km (3.5 mi) south-southwest of the facility center, the Smith headquarters is 8.8 km (5.5 mi) west-northwest of the facility, and the Mobley ranch is 9.6 km (6 mi) southwest of the facility. Although there are no dairies near the WIPP facility, the area produces a large amount of alfalfa. The alfalfa crop is used in cattle feeding operations, mainly in New Mexico and Texas.

In addition to alfalfa, cotton and pecans are the other major crops grown in the Pecos Valley region.

## 1.2 Repository Configuration and Effluent Monitoring

Figure 1.2 shows the current configuration of the WIPP site. The site consists of surface facilities and the underground repository. The repository currently comprises eight waste-disposal panels, each consisting of seven waste disposal rooms approximately 91 m (300 ft) long, 10 m (33 ft) wide, and 4.5 m (15 ft) high.

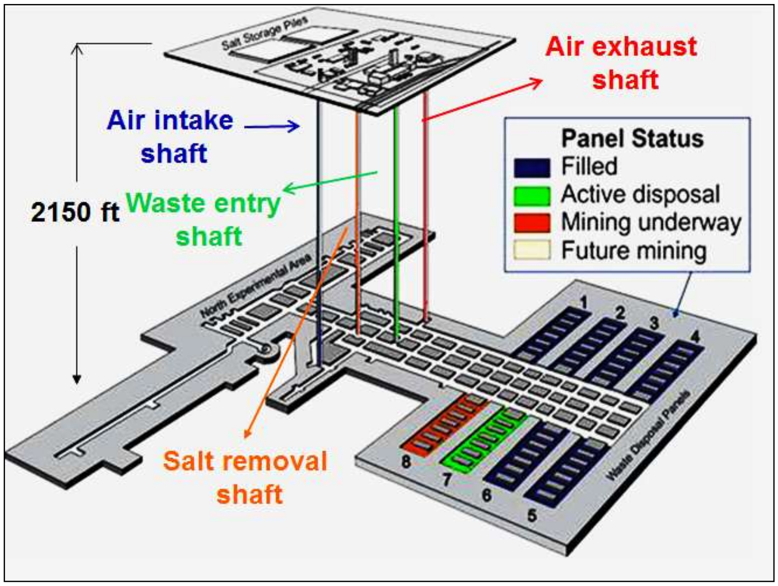


**Figure 1.2. WIPP Layout**

As of 2022, seven of the panels have been excavated in the repository, while mining was underway in the eighth; the first six have been closed and sealed from ventilation air. The repository consists of common drifts for access and ventilation to the disposal panels as well as four shafts connecting surface operations to underground emplacement activities and above ground waste receipt and handling facilities. Ventilation of the repository occurs by drawing air from the surface into the underground. Because the air in the repository exits to the surface through an exhaust shaft, this shaft is the sole potential pathway for any contaminants to be released from the repository during normal operations. The release of contaminants to the atmosphere is mitigated by High-Efficiency Particulate Air (HEPA) filters that are located at the surface. Additionally, continuous air monitors (CAM) in the underground areas control whether ventilated air returning to the surface passes through the HEPA filter systems or is released directly to the atmosphere.

Both filtered and unfiltered exhaust air streams exiting the repository are monitored at the effluent air monitoring stations. Each station is equipped with at least one fixed air sampler (FAS) that collects representative particulate samples from the effluent air stream. Under normal operating conditions, unfiltered air is drawn through the repository and exhausted from the repository directly to the environment after passing by the Station A sampling port. Therefore, during normal operating conditions, the activities measured at Station A would represent the radiological activities present in the air within the repository and would be reflective of the level of contamination released directly to the environment. However, once contamination is detected in the underground via continuous air monitoring, the system shifts into "filtration mode" and the exhaust air is routed through the HEPA filters before being released into the environment. Monitoring of the exhaust air occurs at the Station B sampling port. Exhaust at Station B is representative of the level of contamination ultimately released into the environment while operating in filtration mode. Three organizations, CEMRC, the New Mexico Environment Department DOE Oversight Bureau (NMED-DOE-OB), and the WIPP Management and Operation contractor (M&OC) independently analyze particulate samples collected at Stations A and B.

## 1.3 Environmental Monitoring

The scope of CEMRC's WIPP environmental monitoring activities is broad and falls into three categories:

1) Collecting and analyzing environmental samples for a variety of radiological, non-radiological, and hazardous contaminants

2) Radiological screening of workers and local citizens

3) Evaluating whether WIPP-related activities have any environmental impacts

The environmental samples analyzed include ambient air, surface- and drinking water, soil, sediment, and vegetation. Ambient air monitoring establishes a baseline against which operational monitoring data are compared to identify any releases. For ambient air analyses, CEMRC operates four ambient air samplers in and around the WIPP site and two ambient air samplers in the two communities nearest to WIPP, Loving and Carlsbad. Public drinking water sources are sampled and analyzed to establish a baseline because water consumption is a primary pathway for contaminant ingestion. Soil, sediment, and surface water samples are also collected and analyzed to determine contaminant concentrations and establish the variability of background radioactivity as well as to allow the detection of potential releases. Finally, vegetation is also analyzed because consumption of potentially contaminated vegetation by livestock is another pathway for human exposure.

CEMRC also performs routine monitoring of workers and residents living within a 100-mile radius of the WIPP facility for the presence of gamma-emitting radioisotopes through its *Lie Down and Be Counted* (LDBC) program. As in other aspects of the WIPP-EM program, *in vivo* bioassay testing was used to establish a baseline profile of internally deposited radionuclides in a sample of local residents before disposal phase operations began. This testing has continued throughout the disposal phase into the present.

This report describes sample collection and analysis from January 2022 through December 2022, with historical data for the past twenty years. It evaluates environmental monitoring data and identifies trends that are important for demonstrating any impact WIPP operations might have on the local environment. Results from this year’s monitoring shows that WIPP operations did not have an adverse effect on human health or the environment.

# CHAPTER 2 - AIRBORNE EFFLUENT MONITORING

The WIPP repository is ventilated by drawing ambient air down three shafts (the air intake shaft, salt shaft, and waste handling shaft) to the underground then exhausting it out the exhaust shaft. Unfiltered exhaust air is sampled at Station A to quantify radionuclides released from the repository. Effluent monitoring at Station A provides the means for monitoring repository exhaust for radionuclides and other potentially harmful substances. A second sampling station, Station B, is used to sample the underground exhaust air after HEPA filtration. In 2022, samples from Station B were analyzed by CEMRC, the New Mexico Environment Department (NMED), and WIPP's contractor Nuclear Waste Partnership (NWP).

Effluent monitoring at Stations A and B is a major component of both the WIPP Environmental Monitoring (WIPP-EM) program and CEMRC's monitoring program. CEMRC has been sampling and analyzing WIPP exhaust air since December 12, 1998. Before the 2014 accidental release, Station A was used to monitor exhaust air compliance. Since 2014, Station B has been the sample point of record for emissions from the underground. The current scope-of-work requires particulate matter in the repository exhaust air to be collected daily at all Fixed Air Sampler (FAS) locations and composited for analysis. Individual samples are analyzed to determine total suspended particulates collected and to quantify gross alpha and gross beta activities. Radiological analyses are used to quantify radionuclides of concern. Details of the sample collection and analyses are described in the following sections.

A schematic of the WIPP ventilation system and normal underground airflow is shown in Figure 2.1. WIPP effluent sampling systems are designed to collect at least 50% of the 10 μm diameter aerosols under the expected range of exhaust air velocities. Prior to the 2014 radiologic event, in normal operation, the ventilation system discharged unfiltered air. One or two of the unfiltered 700 fans were typically operated to generate approximately 225 $m^3/s$ (475,000 $ft^3/min$) of unfiltered air underground. Since the radiologic event, the ventilation system has been maintained in filtration mode. In this mode, one of three filtration 860 fans operates to deliver 28.3 $m^3/s$ (60,000 $ft^3/min$) to the underground.

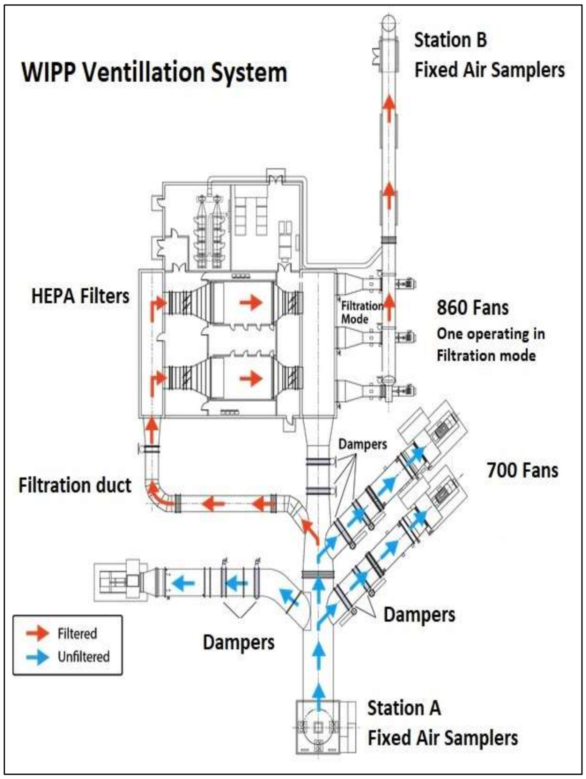


**Figure 2.1. Schematic of WIPP Ventilation System**

Quarterly composites were initially used to determine the actinide activities, but monthly compositing was implemented by CEMRC in July 2004 for better comparison with other groups who use monthly composites. These monthly composites are used to determine the gamma-emitting radionuclides as well. After the gamma measurements, the sample aliquot is archived.

For some time following the radiation release event, filters at Station A were changed every 8 hours; measurements were performed on each filter by CEMRC (and later daily combined filters) depending on the levels of contamination found. As airborne concentrations receded, the frequency of Station A filter collection was reduced to daily, but actinide measurements continue to be performed on weekly composite samples.

Both Station A and Station B are above-ground sampling platforms that collect particulates in exhaust air from the repository before and after HEPA filtration (Figure 2.2). Each station is equipped with three shrouded-probe aerosol samplers along with three separate sampling skids, denoted as A1, A2, and A3 (Figure 2.3). The airstream sampled by each skid is split among three legs allowing three concurrent samples to be collected from each skid. A total of three concurrent samples can be collected from each FAS, one each for CEMRC, the site contractor (WIPP Labs), and NMED.

Figure 2.2. Sampling Station A (top) and Station B (bottom)

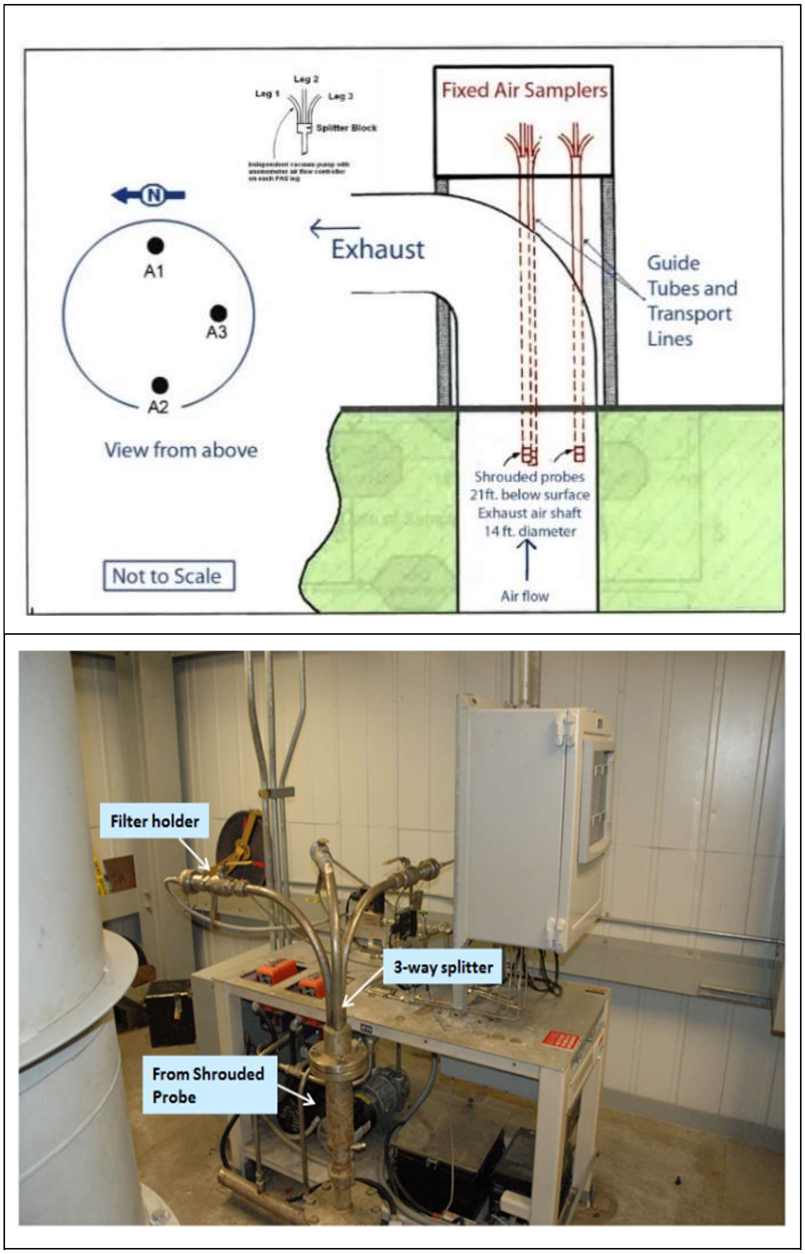


**Figure 2.3. Schematic of Station A (top) and Fixed Air Samplers at Station A (bottom)**

## 2.1 Sample Collection

Particulates in the exhaust air are collected on 47 mm diameter, pore size 3 μm membrane filters (Versapor™ membrane filter, PALL Corporation, Port Washington, NY, USA) with the use of a cylindrical shrouded probe, commonly referred to as a fixed air sampler or FAS. The airflow through the FAS is approximately 170 L/min (6.0 $ft^3$/min). The samples at Station A are typically collected daily except for weekends (the weekend samples run from Friday to Monday, so the coverage is continuous). Occasionally, however, more than one sample per day is still collected when the flow rate on any of the sampler legs drops below 50 L/min (1.8 $ft^3$/min). If this occurs, a low-flow alarm on the sampler is activated and the filters are changed as needed by WIPP radiological control technicians. Under normal operating conditions, approximately 81 $m^3$ (2,875 $ft^3$) of air is filtered through each of the Versapor™ membrane filters at Station A and Station B each day.

The ventilation flow capacity of the Station B exhaust duct was increased in the fall of 2016 from 60,000 $ft^3$/min to 114,000 $ft^3$/min by the addition of two more HEPA filter trains, parallel to the existing two HEPA filter trains that have been in continuous use since the February 2014 radiological event. During 2022, the ventilation system associated with Station B operated normally at a nominal flow rate of 114,000 $ft^3$/min.

## 2.2 Sample Preparation and Analysis

### 2.2.1 Gross Alpha and Beta Analysis

Once the samples are collected from the site and returned to the laboratory, individual filters are desiccated for a minimum of 48 hours to guarantee that any moisture on the filters is evaporated and to ensure the complete decay of the immediate daughter products of $^{222}$Rn and $^{220}$Rn. Once dried, the filters are then weighed to determine mass loading concentrations. Following the desiccating and weighing process, the Station A and B filters are counted for gross alpha and beta activities on a Protean MPC 9604 low background gas proportional counter for 1200 min (20 h). Daily performance checks are executed using calibration sources, $^{239}$Pu for alpha and $^{90}$Sr/$^{90}$Y for beta, for efficiency control charting (2σ warning and 3σ limits) and to ensure that alpha/beta cross-talk is within limits (less than 0.1% alpha into beta and less than 0.1% beta into alpha). Sixty-minute background counts are also recorded daily by counting an empty planchet. The mean counting efficiencies for the systems are around 25% for alpha and 38% for beta activities.

### 2.2.2 Radiochemical Analysis

After gross alpha/beta measurements, daily filters collected over a period of one week are grouped into weekly composites for Station A and monthly composites for Station B. Filter samples for radiochemical analysis are prepared by wet digestion with nitric acid ($HNO_3$), hydrochloric acid (HCl), and perchloric acid ($HClO_4$) until the filter is totally dissolved. Generally, half of the sample is used for the determination of the actinide activities, while the other half is used for the gamma analysis. Gamma-emitting radionuclides in the air filters are measured by gamma spectroscopy, while alpha-emitting radionuclides are co-precipitated, separated on anion exchange and chromatography columns, and analyzed by alpha spectroscopy as described in previous CEMRC reports (http://www.cemrc.org/annual-reports). The samples are counted for 5 d for alpha and 2 d for gamma-radiation-emitting radionuclides as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}$Sr is subsequently measured using liquid scintillation counting.

## 2.3 Results and Discussion

The activities of radionuclides in the WIPP underground air samples are reported in the following two ways: Activity Concentration in Bq/m$^3$ and Specific Activity in Bq/g. Activity Concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of air in cubic meters (m$^3$). Specific Activity is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the aerosol mass collected on the filter in grams (g). Individual results for actinides at Station A can be found in Appendix A, Tables A.1 – A.14, while results for Station B can be found in Tables A.15 – A.28. The results for $^{90}$Sr are shown in Tables A.29 – A.32.

### 2.3.1 Gross Alpha and Beta Concentrations at Station A

The pre- and post-release gross alpha and gross beta concentrations in Station A filters are shown in Figure 2.4 and Figure 2.5 for trend analysis purposes over a period of over twenty years. There are no data for the period between February and June 2014 because gross alpha and beta screening was not performed immediately following the February 14, 2014, underground radiation release event. Instead, an emergency actinide separation campaign was carried out for each individual or daily filter collected from Station A and Station B. However, as radiation levels receded, the gross alpha and beta analysis resumed beginning in March 2014 for the Station A filters and July 2014 for the Station B filters.

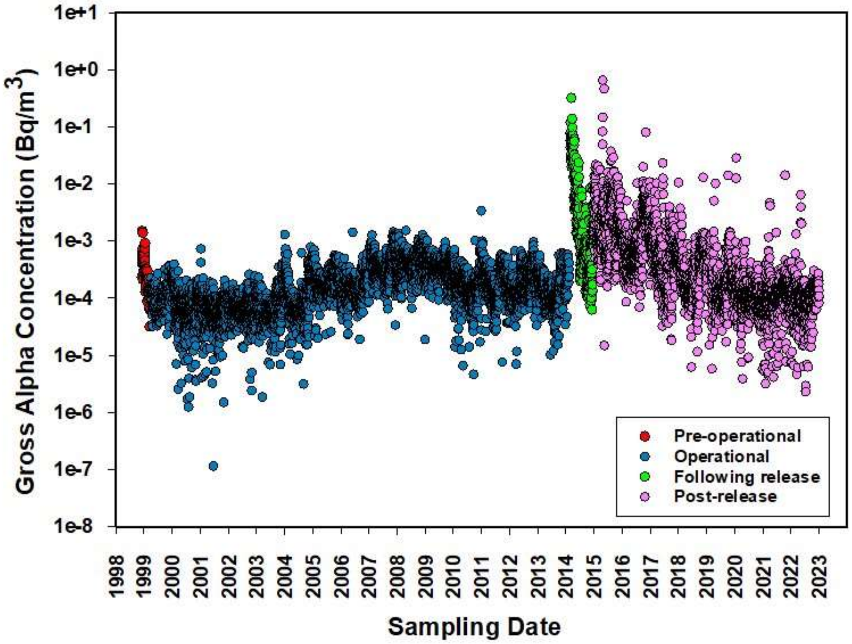


**Figure 2.4. Historical Gross Alpha Concentrations at Station A**

The two samples with elevated gross beta activity concentrations of approximately 0.058 Bq/m$^3$ observed in early 2001 are because of contamination released from an underground fire extinguisher (Figure 2.5). Follow-up measurements confirmed that the fire retardant containing $^{40}$K was the cause of the elevated results and that WIPP waste had not been released.

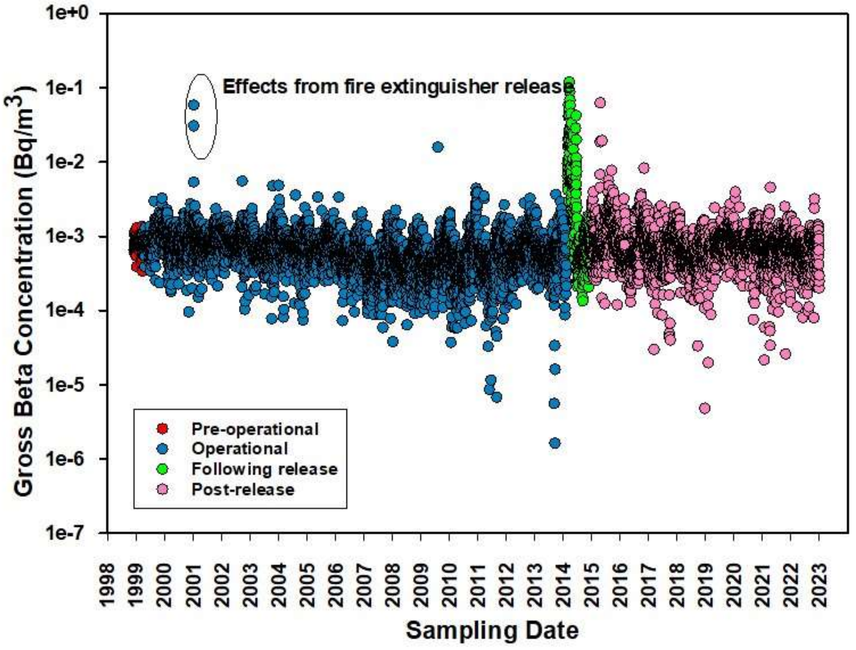


**Figure 2.5. Historical Gross Beta Concentrations at Station A**

The pre- and post-release gross alpha and gross beta specific activities (Bq/g) are shown in Figure 2.6 and Figure 2.7, respectively, for trend analysis purposes over a period of over twenty years. The gross alpha and beta activities appear to have returned to the pre-release levels in recent years.

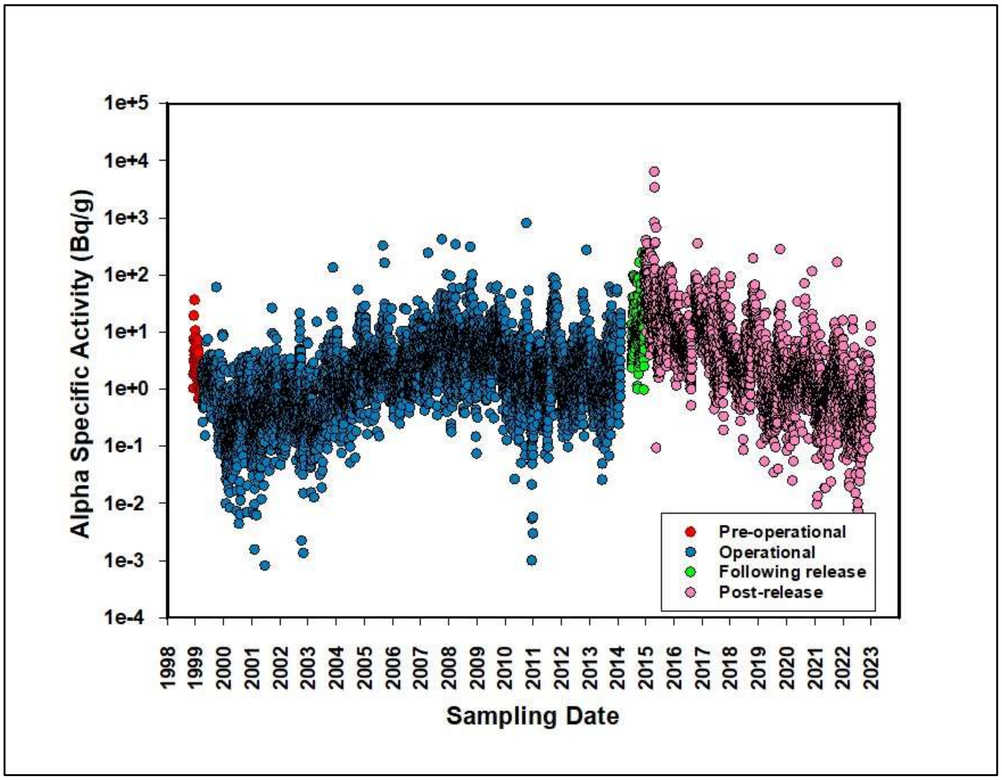


**Figure 2.6. Historical Gross Alpha Specific Activities at Station A**

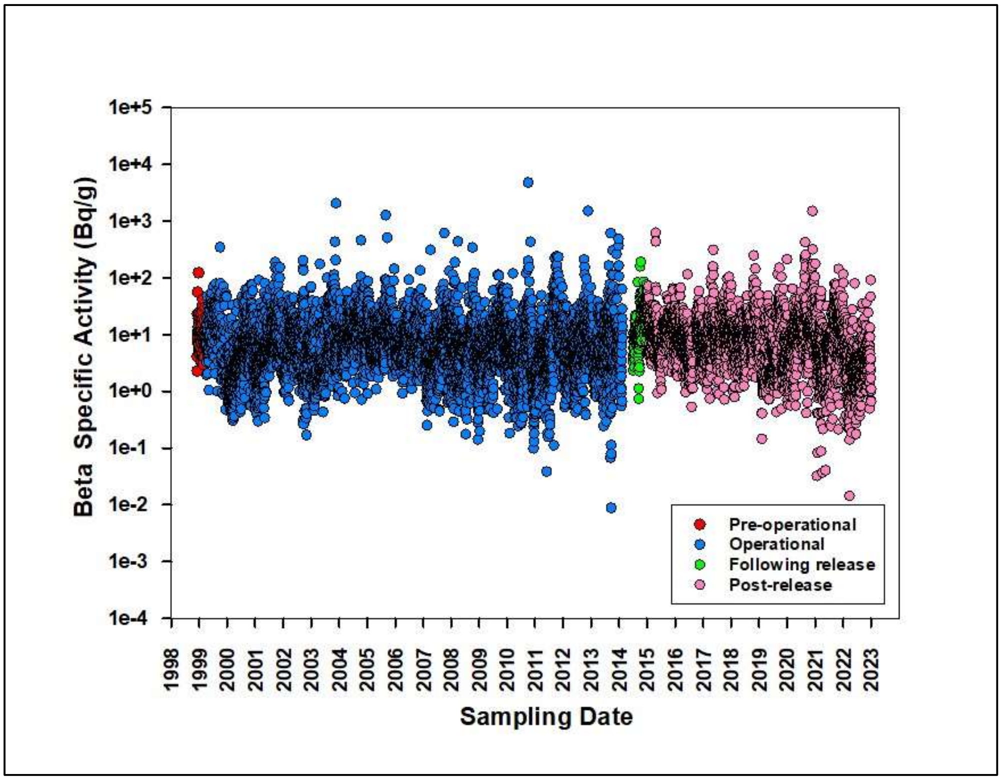


**Figure 2.7. Historical Gross Beta Specific Activities at Station A**

The daily gross alpha and gross beta concentrations in the unfiltered underground air are shown in Figure 2.8 and Figure 2.9, respectively. The gross alpha and beta activity in the air filters prior to the arrival of waste at the WIPP were used as a baseline concentration. The baseline concentrations of gross alpha and gross beta activities were 1.49 mBq/m$^3$ for alpha and 4.90 mBq/m$^3$ for beta. The current levels are within the range of normal background levels for Station A.

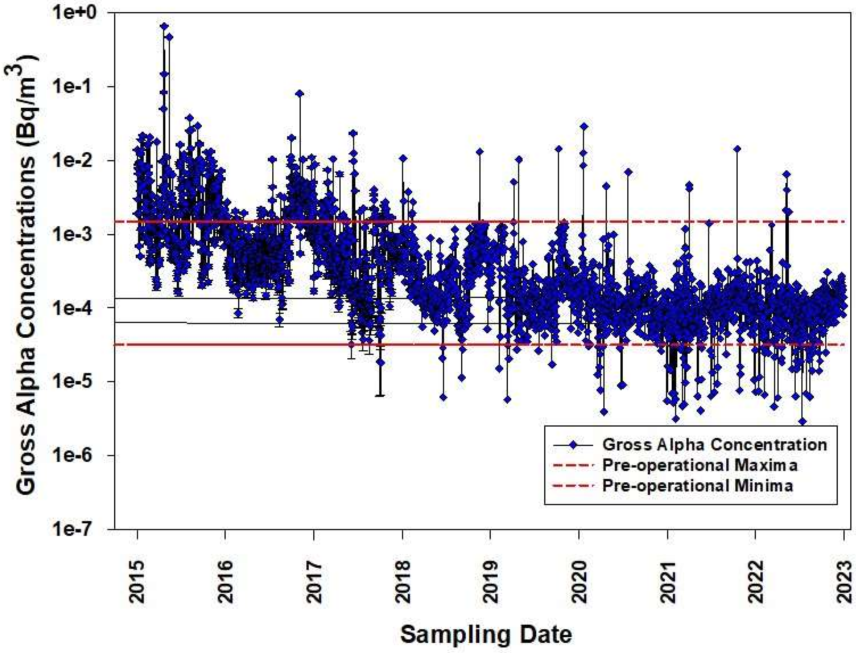


**Figure 2.8. Gross Alpha Concentrations at Station A during 2015-2022**

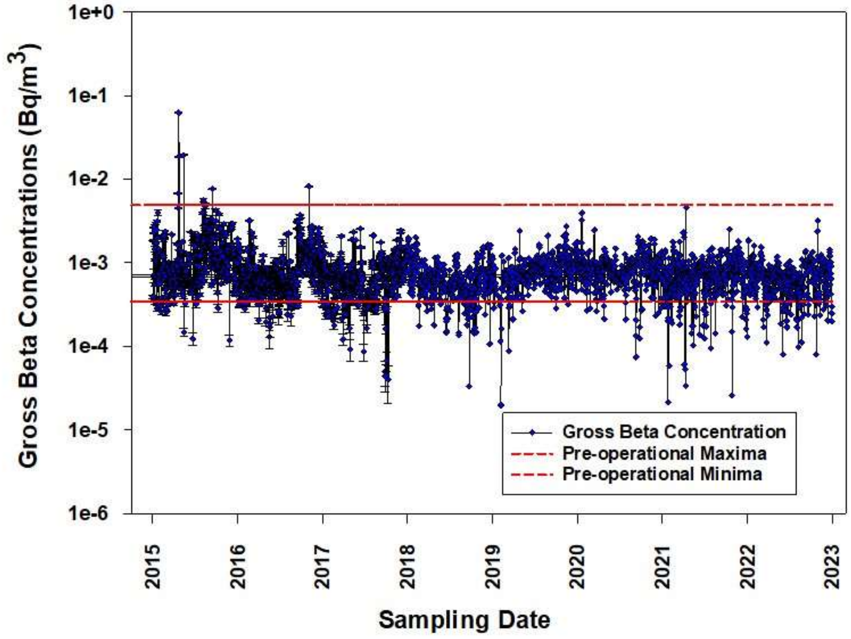


Figure 2.9. Gross Beta Concentrations at Station A during 2015-2022

These data are then compared against disposal phase data to assess the integrity of the WIPP project. The minimum detectable activity concentrations for the gross alpha emitters are ~ $3.18\times10^{-6}$ Bq/m$^3$, while for gross beta emitters the corresponding value is ~ $2.15\times10^{-5}$ Bq/m$^3$. During 2022, the alpha activity in the unfiltered exhaust air was in the range of <MDC-6.41mBq/m$^3$ with a mean value of 0.12±0.39 mBq/m$^3$, and beta activity was in the range of <MDC-3.20 mBq/m$^3$ with a mean value of 0.68±0.32 mBq/m$^3$. A spike in gross alpha activity during the third week of November 2018 is attributed to the rockfall in Room 6, Panel 7. Other small sporadic increases in gross alpha concentrations, shown in Figure 2.8, can be attributed to the disturbance of entrained materials, which allows them to be transported in the WIPP underground air due to ongoing investigative and clean-up efforts by underground personnel.

### 2.3.1.1 Actinide Concentrations at Station A

The weekly concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu at Station A are shown in Figure 2.10; the individual values are listed in Tables A.1 through A.3 (Appendix A). Although the values that were measured were above the pre-release background levels, it is important to note that the levels detected were very low and well below any level of public health or environmental concern. The specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu measured at Station A are shown in Figure 2.11 and the values are listed in Tables A.4 through A.6 (Appendix A).

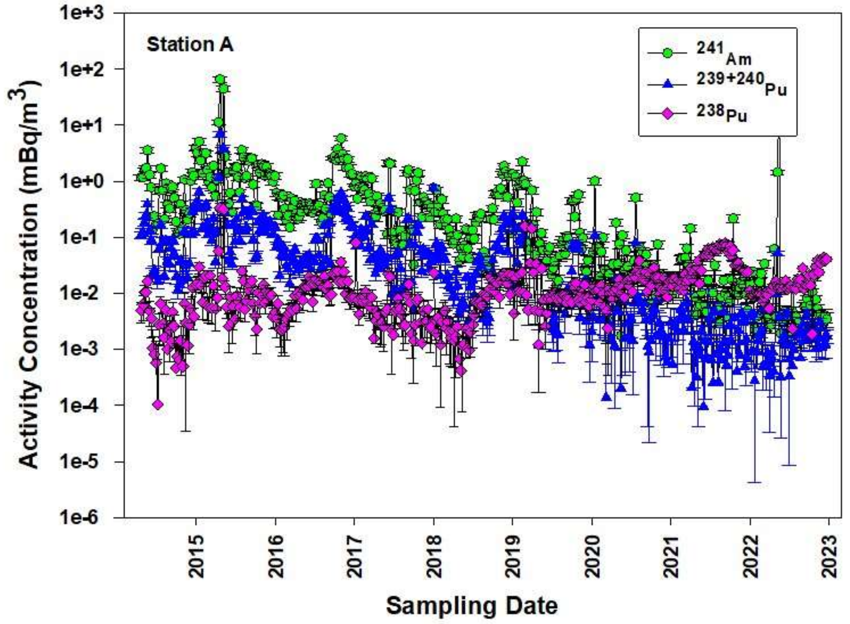


Figure 2.10. Weekly Concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu at Station A

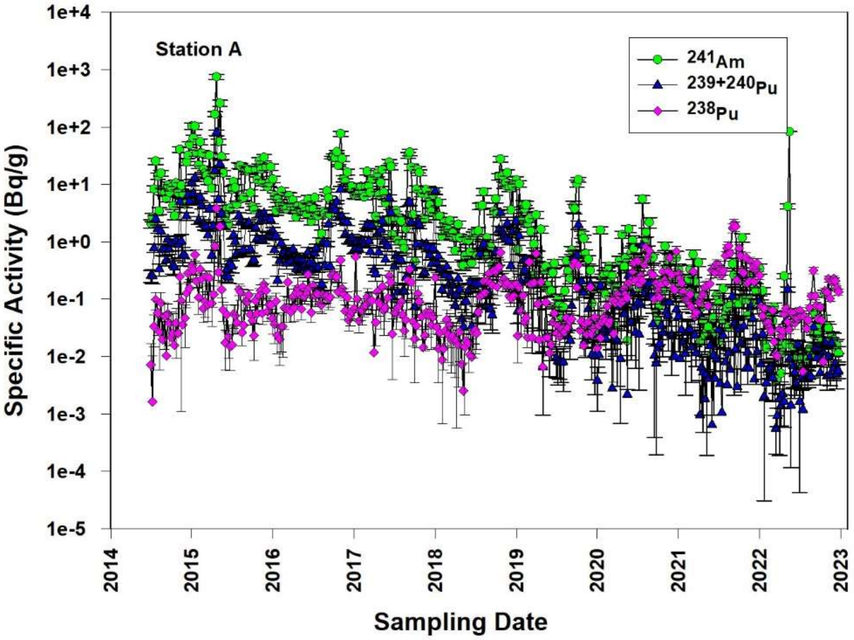
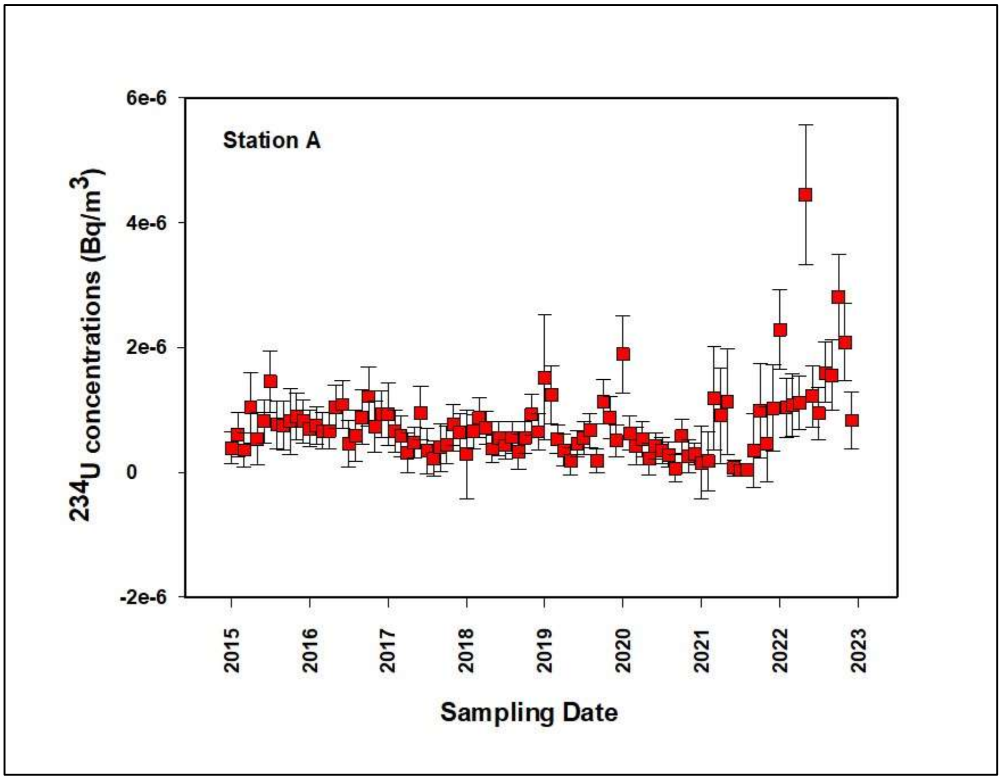


Figure 2.11. Weekly Specific Activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu at Station A

### 2.3.1.2 Uranium Concentrations at Station A

Uranium isotopes, naturally occurring radionuclides found in the environment, were detected in some monthly composite samples collected from Station A during 2022. The individual uranium activity concentrations and specific activity measured in monthly composite samples are summarized in Tables A.7 and A.8 (Appendix A).



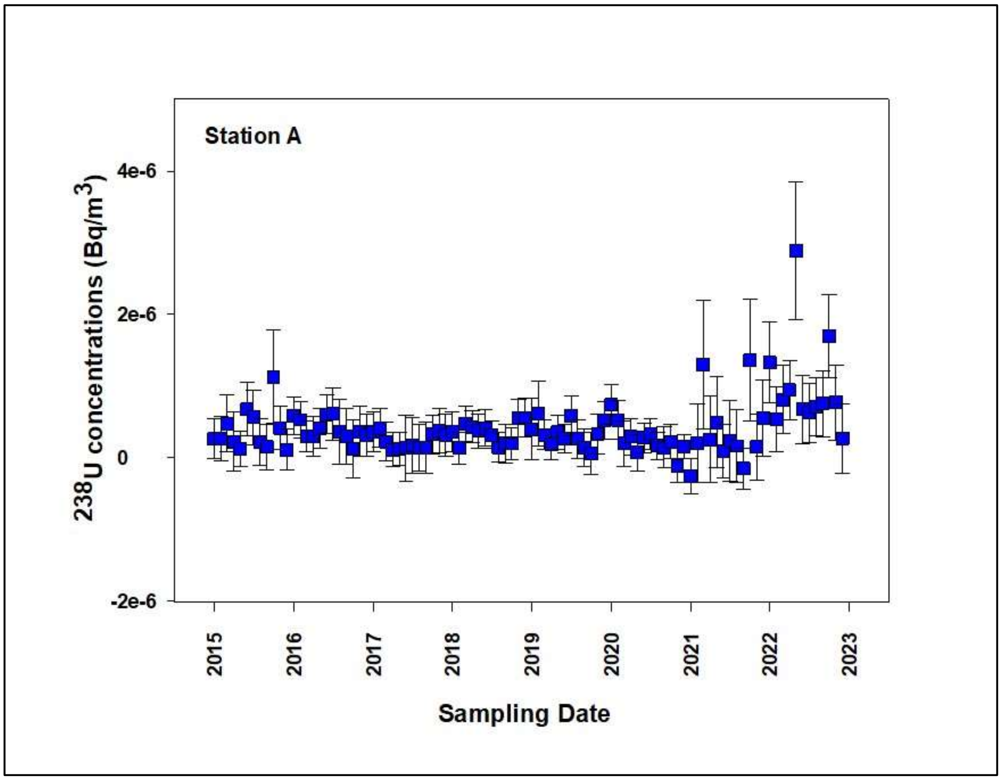
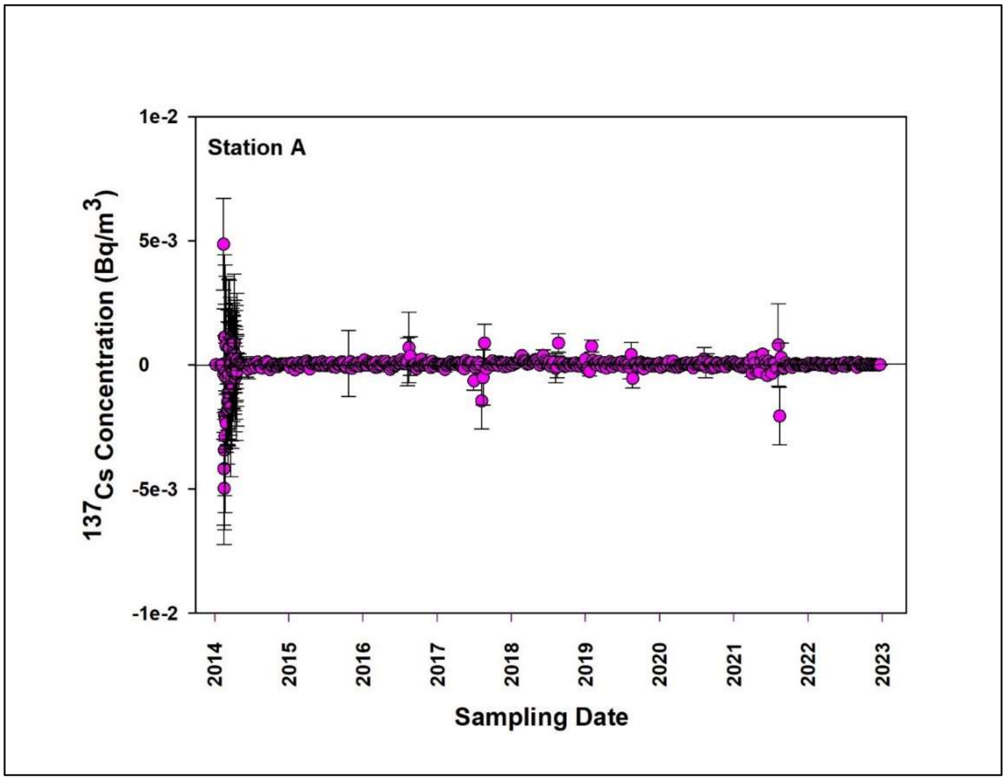
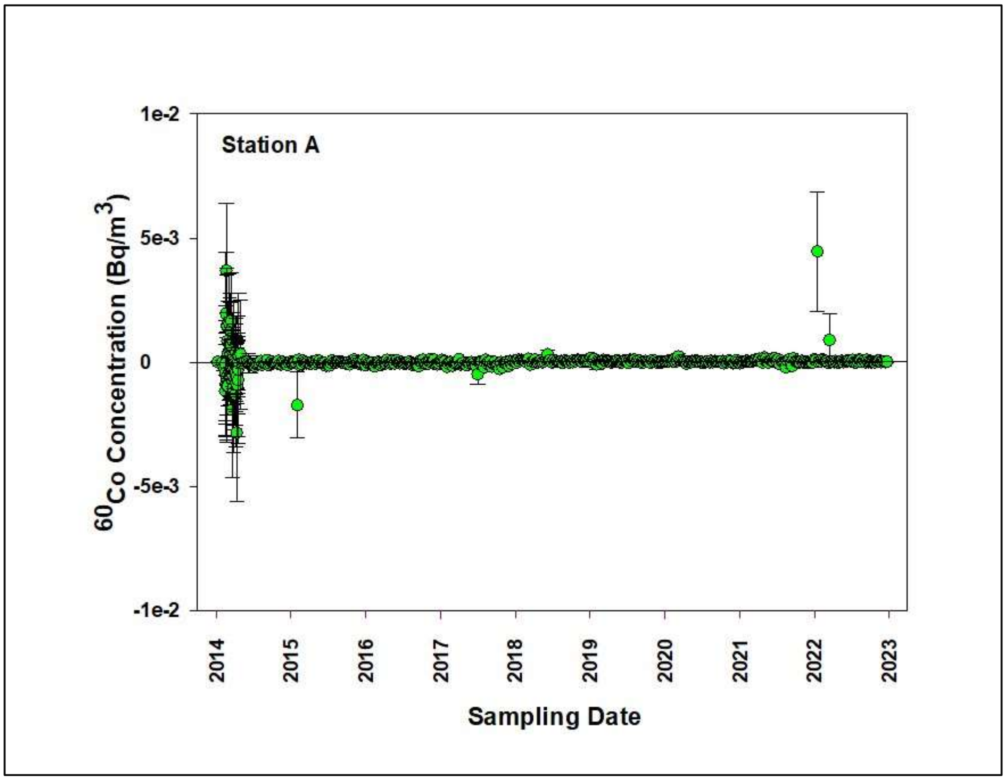


Figure 2.12. The $^{234}$U (top) and $^{238}$U (bottom) Activity Concentrations at Station A

#### 2.3.1.3 Gamma Radionuclide Concentrations at Station A

The $^{137}$Cs, $^{60}$Co, and $^{40}$K isotopes were not detected in any of the weekly composite samples. The concentrations of the gamma-radiation-emitting radionuclides $^{137}$Cs, $^{60}$Co, and $^{40}$K measured in Station A filter samples are shown in Figure 2.13. The concentrations and specific activity of gamma-radiation-emitting radionuclides are summarized in Appendix A, Tables A.9 through A.14. An analysis of historical operational data indicates that, except for the occasional detections of $^{40}$K and the one-time detection of $^{137}$Cs on February 14, 2014, immediately following the radiological release event at the WIPP, no detectable gamma-emitting radionuclides have been observed during the last sixteen years of monitoring.


Station A
$^{137}$Cs Concentration (Bq/m$^3$)
1e-2
5e-3
0
-5e-3
-1e-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date


Station A
$^{60}$Co Concentration (Bq/m$^3$)
1e-2
5e-3
0
-5e-3
-1e-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date

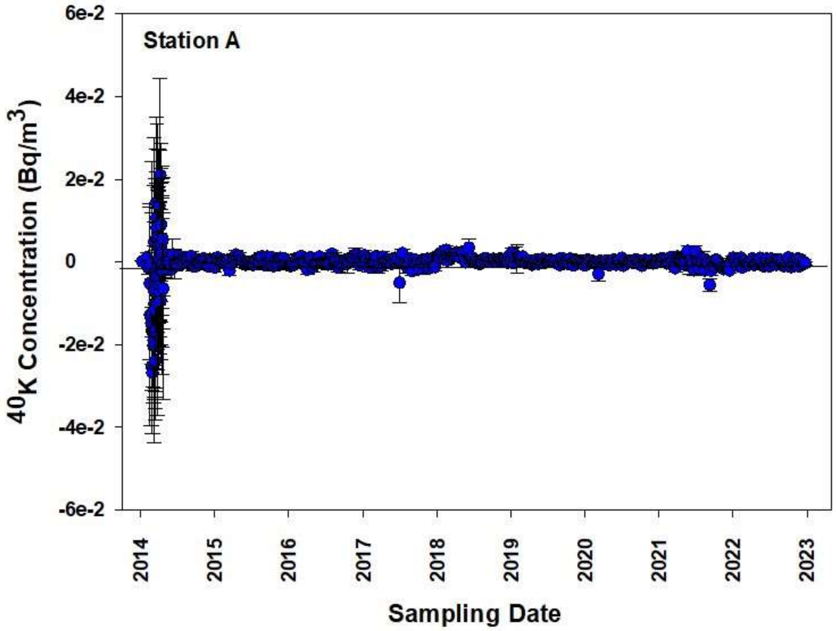


**Figure 2.13. Concentrations of Gamma Emitting Radionuclides $^{137}$Cs (top), $^{60}$Co (middle), and $^{40}$K (bottom) at Station A**

### 2.3.1.4 Historical Concentrations of Actinides at Station A

An analysis of historical operational data from Station A indicates occasional detections of trace amounts of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am in the exhaust air released from the WIPP over time (Figure 2.14). From 2000 through 2013, only nine Station A measurements could be declared as containing a certain detection of a radionuclide. Detectable concentrations of Pu isotopes ($^{239+240}$Pu or $^{238}$Pu) and $^{241}$Am only occurred in four monthly composite samples from 2003, 2008, 2009, and 2010 (CEMRC Report 2011). As $^{238}$Pu concentrations were above detection limits in two of the monthly composite samples (February 2008 and April 2009), these two composite samples were used to calculate the activity ratios between $^{238}$Pu and $^{239+240}$Pu. The February 2008 sample ratio was 0.039; the April 2009 sample ratio was 0.023. A mean $^{238}$Pu /$^{239+240}$Pu activity ratio of 0.025±0.004 (0.019-0.039) is consistent with a global fallout origin, as reported in different studies (Kelly et al., 1999, Hardy et al., 1973). It is important to note that activities detected in those four composites were extremely low and did not trigger the underground Continuous Air Monitors (CAM) that detect any release of radioactivity. Based on extensive analyses of these data, CEMRC concludes that there has been no unambiguous evidence of releases from WIPP operations prior to the February 14, 2014, underground radiation release event.

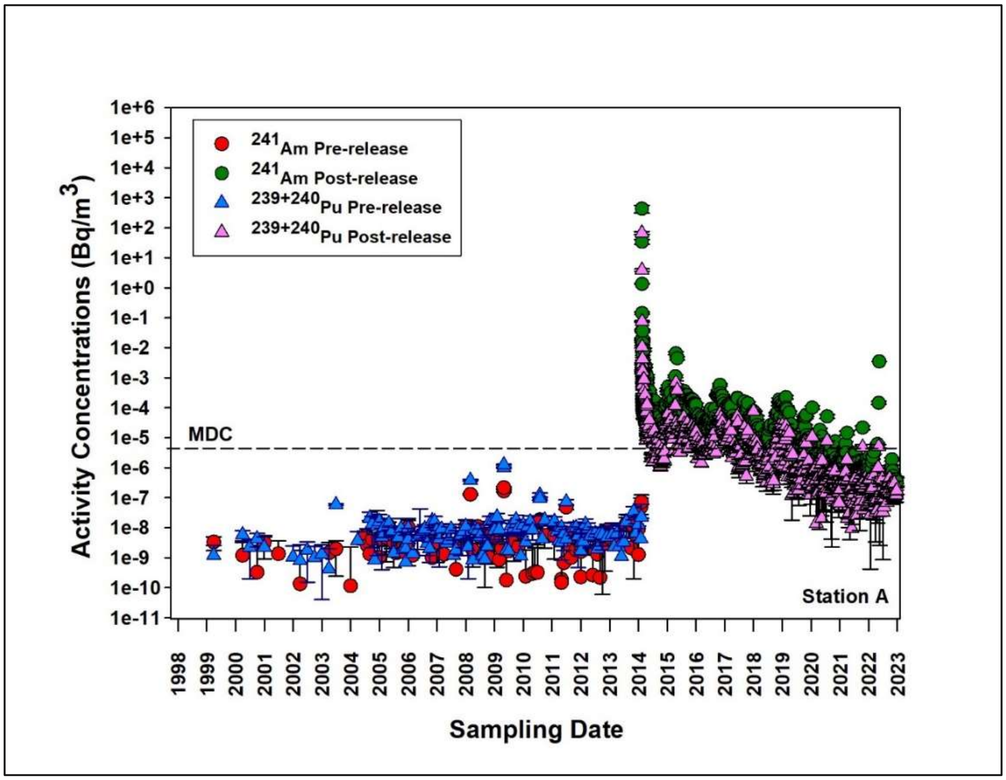


**Figure 2.14. Historical Concentrations of $^{241}$Am and $^{239+240}$Pu at Station A**

### 2.3.1.5 Strontium Concentration at Station A

In 2022, the beta-radiation-emitting radionuclide $^{90}$Sr was not detected in most of the weekly composite samples, except samples in the second and third weeks of November. The weekly composite concentrations of $^{90}$Sr in these two samples were $1.49\times10^{-2}$and $1.42\times10^{-2}$ Bq/m$^3$, respectively. The corresponding $^{90}$Sr specific activities (activity per unit mass) were 86.6 and 61.0 Bq/g, respectively.

## 2.3.2 Gross Alpha and Beta Concentrations at Station B

The daily gross alpha and gross beta activity concentrations at Station B are shown in Figure 2.15. It is important to note that CEMRC has been performing gross alpha and gross beta analyses on Station B filters since July 2014. Filter samples collected prior to July 2014 were not counted for gross alpha and gross beta concentrations; instead, an emergency actinide separation campaign was carried out on the individual or daily filters collected from Station B to provide isotopic results to interested parties as quickly as possible. The pre-operational gross alpha and gross beta concentration values measured at Station A were used as a baseline concentration for the filter samples collected from Station B because CEMRC had not routinely conducted gross alpha/beta analyses on Station B filters prior to February 14, 2014. As would be expected, the Station B analyses showed much lower levels of activity as compared to those of Station A.

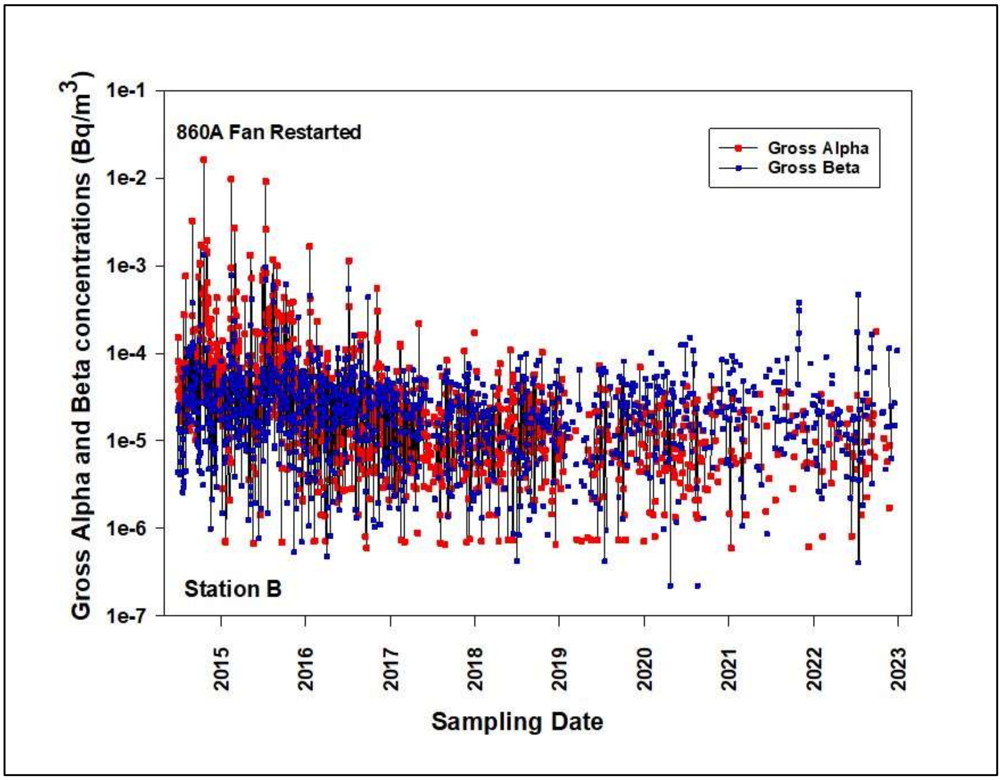


**Figure 2.15. Daily Gross Alpha and Gross Beta Activity Concentrations at Station B**

A spike in gross alpha activity during the third week of October 2014 is attributed to the restart of the 860A fan on October 21, 2014. The 860A fan ran for approximately two months following the February 2014 underground radiological incident before being taken off-line for maintenance-related activities. Since that time, the 860B or the 860C fans have been operated to continue the air filtration process. Because the 860A fan was operational immediately following the radiological release, it could be expected that a small amount of residual contamination might be present in the adjacent ductwork and the interior workings of the fan, which could result in a low level of contamination being released, as seen in the spikes between 2015 - 2017. The current gross alpha and beta activities at Station B are comparable to the pre-operational gross alpha and beta values measured for Station A filters prior to the arrival of TRU wastes in the WIPP and are typical “background gross alpha and beta” values.

### 2.3.2.1 Actinide Concentrations at Station B

The concentrations and specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in monthly composite samples from Station B are summarized in Appendix A, Tables A.15 through A.20. The concentrations of $^{241}$Am were in the range of $5.32\times10^{-4}$-$2.82\times10^{-2}$ mBq/m$^3$, while that of $^{239+240}$Pu were in the range of $1.16\times10^{-4}$-$3.76\times10^{-3}$ mBq/m$^3$. The specific activity of $^{241}$Am at Station B was in the range of $6.79\times10^{-2}$-9.98 Bq/g, while that of $^{239+240}$Pu was in the range of $2.19\times10^{-2}$ - -1.33 Bq/g. The concentrations and specific activity of $^{241}$Am and $^{239+240}$Pu measured at Station B are shown in Figure 2.16.

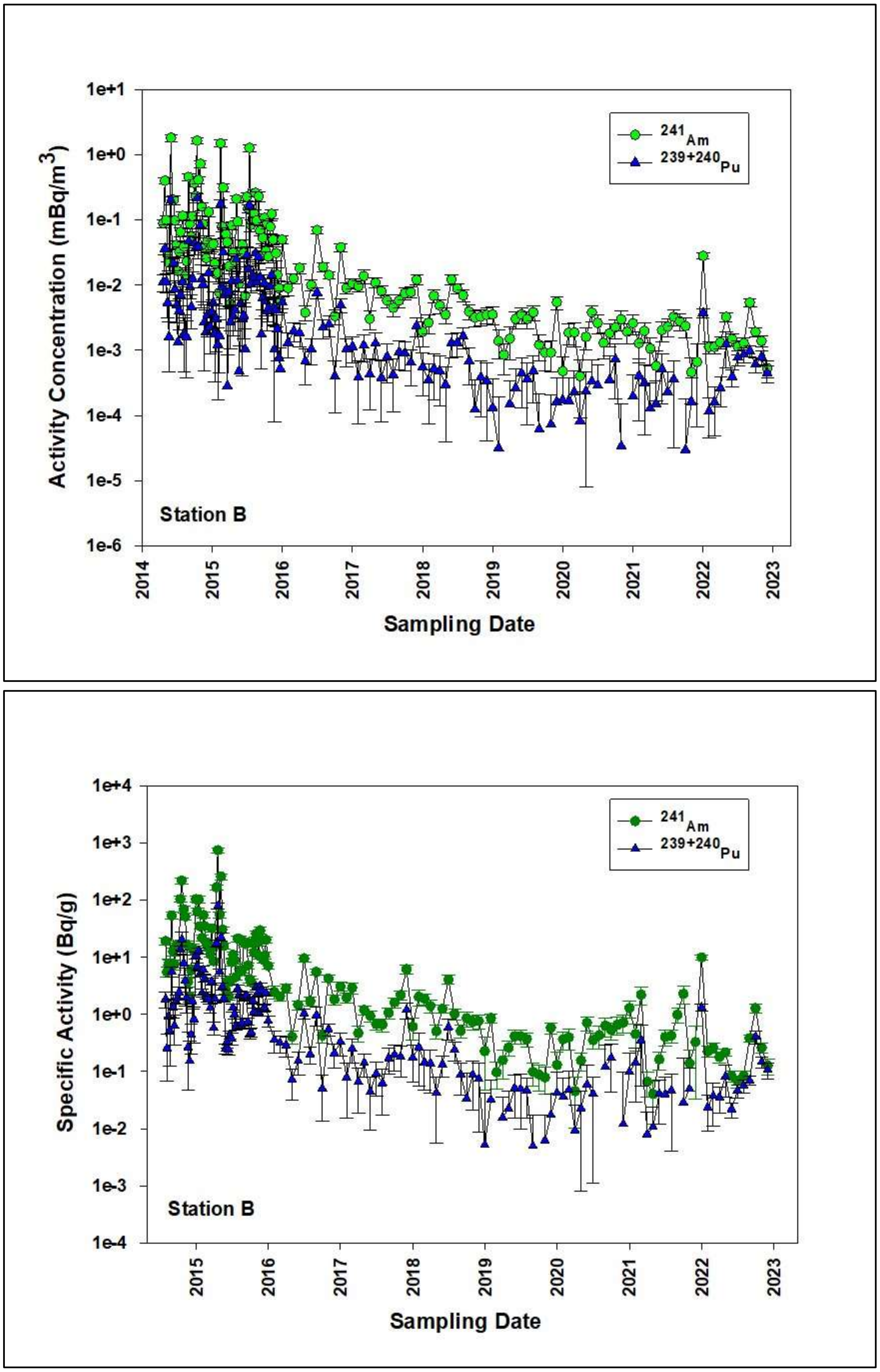
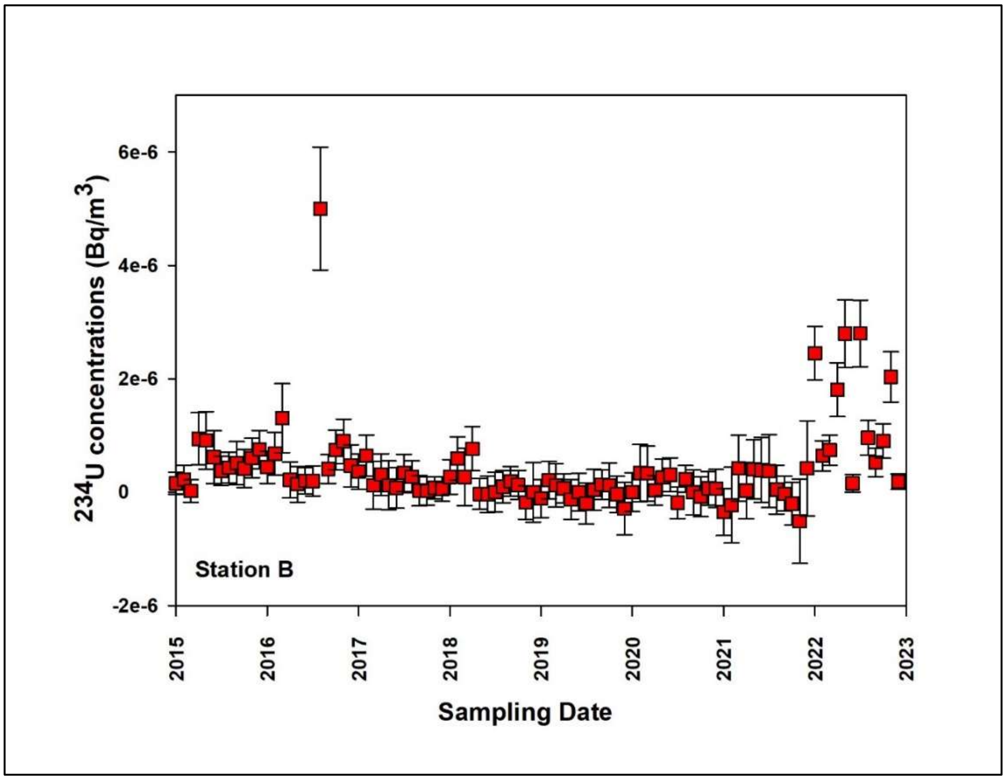


**Figure 2.16. Activity Concentrations (top) and Specific Activities (bottom) of $^{241}$Am and $^{239+240}$Pu at Station B**

### 2.3.2.2 Uranium Concentrations at Station B

From the naturally occurring isotopes of U, $^{234}$U, $^{235}$U, and $^{238}$U were detected above the MDC in some monthly composite samples from Station B in 2022. Isotopes of uranium have occasionally been detected at Station B. The activity concentrations of U isotopes measured in Station B filter samples are shown in Figure 2.17. The individual uranium activity concentrations and specific activity measured in monthly composite samples are summarized in Appendix A, Tables A.21 and A.22.



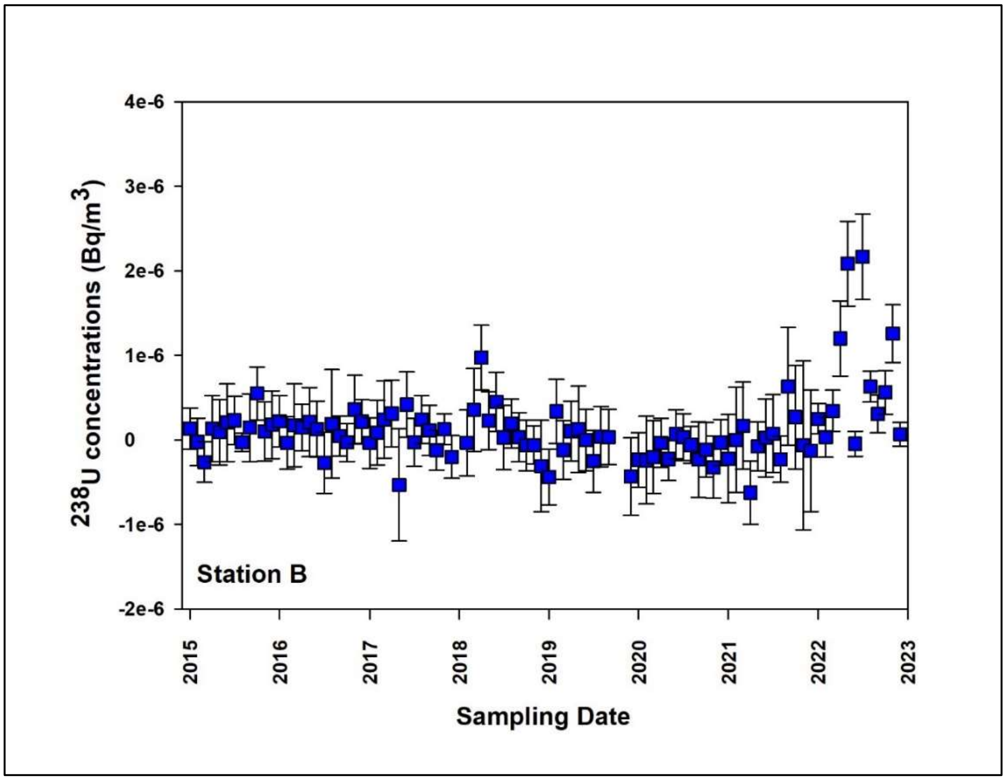
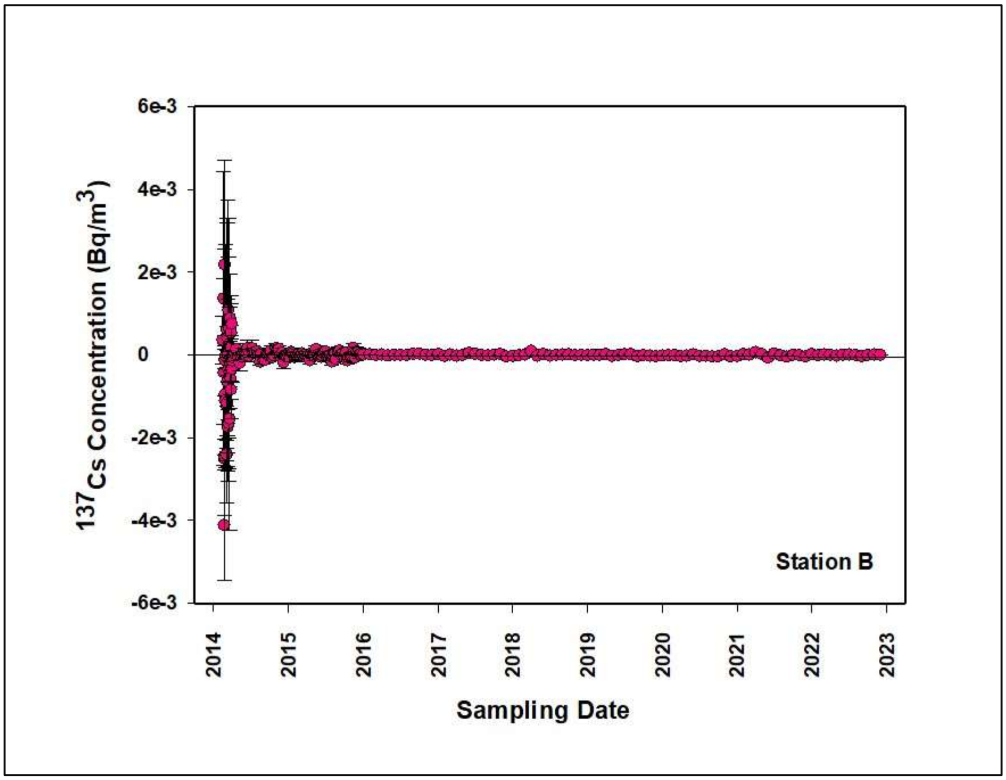
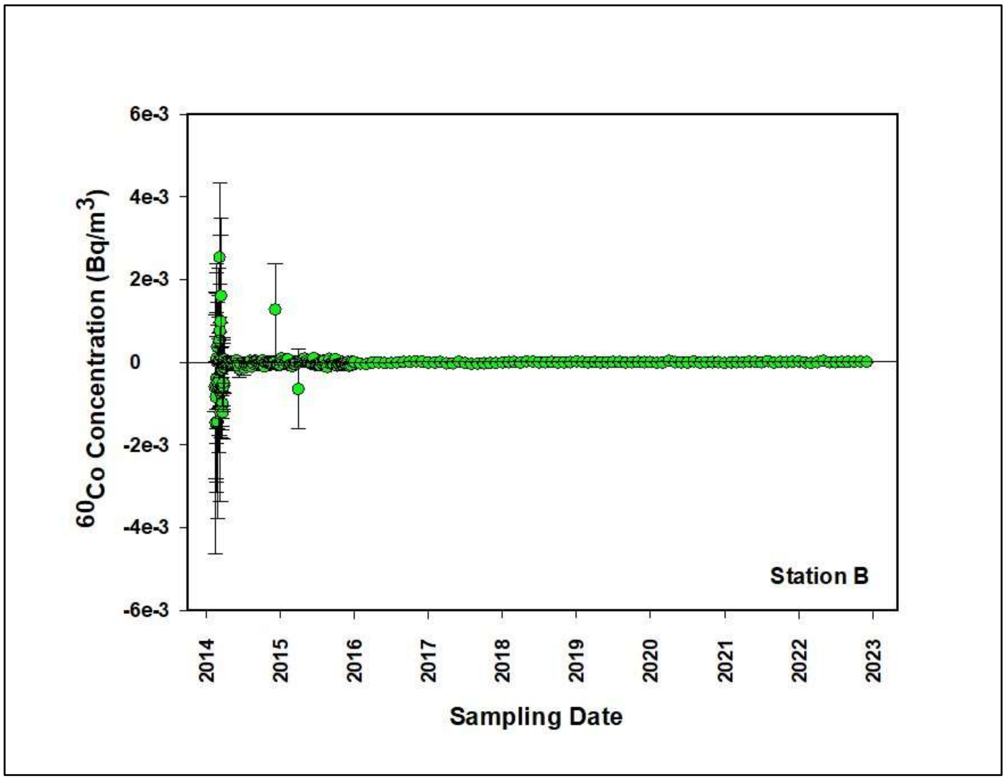


**Figure 2.17. The $^{234}$U (top) and $^{238}$U (bottom) Activity Concentrations at Station B**

#### 2.3.2.3 Gamma Radionuclide Concentrations at Station B

The concentrations of the gamma-radiation-emitters $^{137}$Cs, $^{40}$K, and $^{60}$Co in Station B filter samples are shown in Figure 2.18. No detectable gamma-emitting radionuclides were observed in any of the filter samples collected from Station B in 2022. The concentrations and specific activities of these gamma-emitting radionuclides are summarized in Appendix A, Tables A.23 through A.28.


6e-3
4e-3
2e-3
0
-2e-3
-4e-3
-6e-3
$^{137}$Cs Concentration (Bq/m$^3$)
Station B
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date


6e-3
4e-3
2e-3
0
-2e-3
-4e-3
-6e-3
$^{60}$Co Concentration (Bq/m$^3$)
Station B
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date

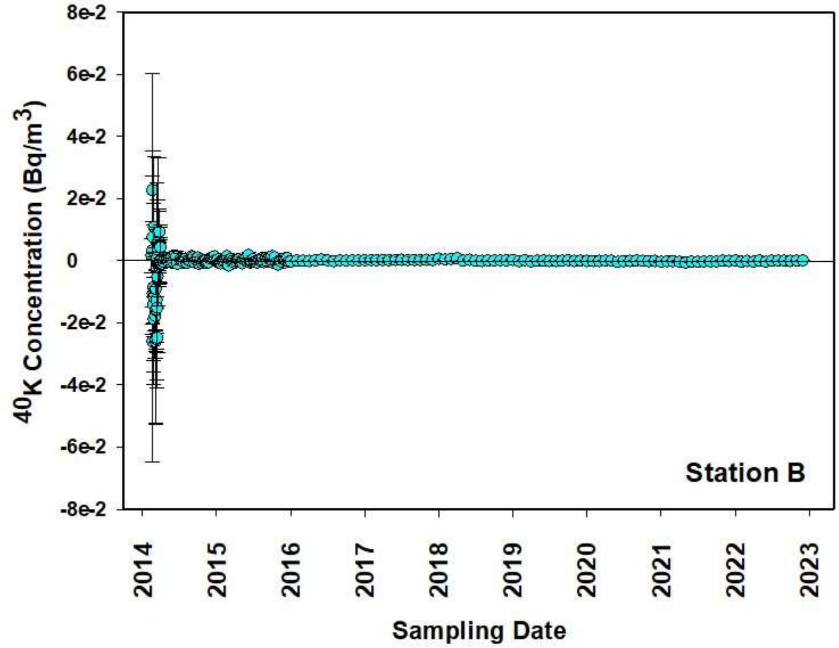


**Figure 2.18. The Concentrations of Gamma Emitting Radionuclides $^{137}$Cs (top), $^{60}$Co (middle), and $^{40}$K (bottom) at Station B**

### 2.3.2.4 Historical Concentrations of Actinides at Station B

Before the 2014 accidental release, the concentrations of $^{241}$Am and $^{239+240}$Pu were all below the MDC. Since CEMRC was not performing Station B analyses before the events, the WIPP contractor's NWP data were used to show the historical trend (ASER Report, wipp.energy.gov). It should be noted that quarterly composite samples were used from 1999 until 2013 by NWP to determine the actinides. The current concentrations of $^{241}$Am and $^{239+240}$Pu at Station B are close and, in some instances, below the corresponding MDC values (Figure 2.19).

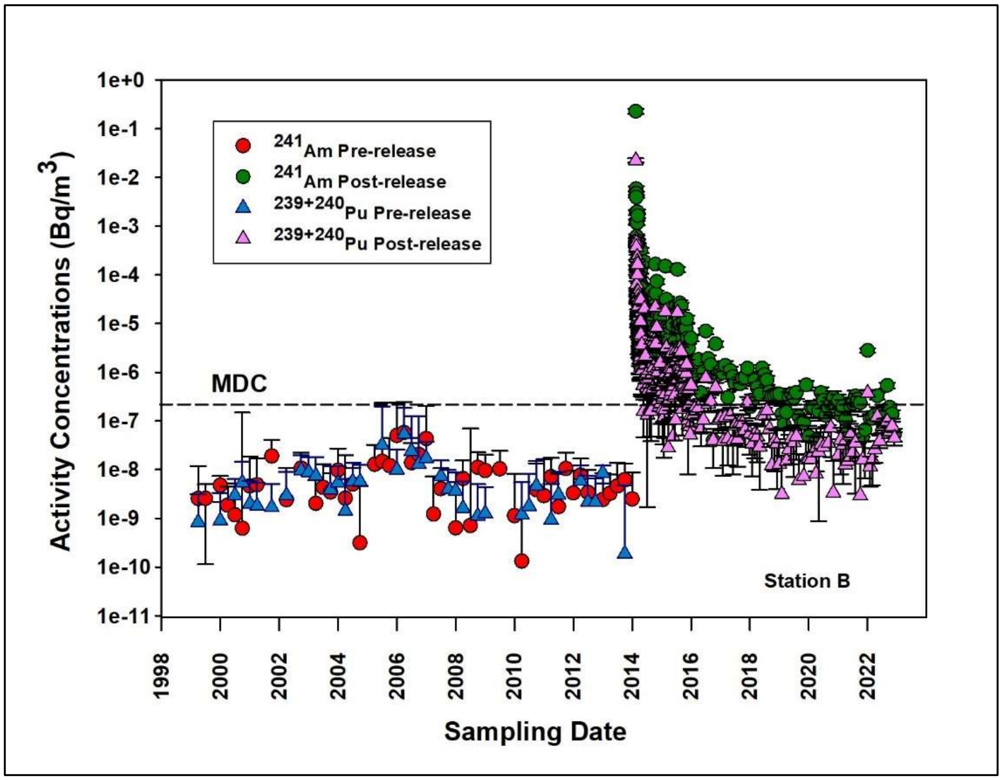


**Figure 2.19. Historical Concentrations of $^{241}$Am and $^{239+240}$Pu and at Station B**

### 2.3.2.5 Strontium Concentration at Station B

The beta-emitting radionuclide $^{90}$Sr was not detected in any of the monthly composite samples at Station B.

## 2.4 Conclusions

This chapter summarizes the results of the effluent air-monitoring program for the calendar year 2022. For this monitoring period, the alpha activity at Station A was in the range of <MDC-6.41 mBq/m$^3$ with a mean value of 0.12±0.39 mBq/m$^3$, and beta activity was in the range of <MDC-3.20 mBq/m$^3$ with a mean value of 0.68±0.32 mBq/m$^3$. The gross alpha and beta activities appear to have reverted to the pre-release levels in recent years. The activity concentrations of actinides were in the range of $1.66\times10^{-3}$-35.1 mBq/m$^3$ for $^{241}$Am; $2.75\times10^{-4}$-$5.21\times10^{-2}$ mBq/m$^3$ for $^{239+240}$Pu; and $1.87\times10^{-3}$-$4.38\times10^{-2}$ mBq/m$^3$ for $^{238}$Pu at Station A, while at Station B they varied in the range of $5.32\times10^{-4}$-$2.82\times10^{-2}$ mBq/m$^3$ for $^{241}$Am and $1.16\times10^{-4}$-$3.76\times10^{-3}$ mBq/m$^3$ for $^{239+240}$Pu. These levels continued to be lower than the levels measured in previous years. As expected, the naturally occurring isotopes of U were detected in some monthly composite samples collected from both Station A and Station B. Gamma radionuclides were not detected in any of the weekly/monthly composite samples from Station A and Station B. However, CEMRC's historical operational data show occasional detections of $^{40}$K at Station A. The $^{40}$K isotope is a naturally occurring gamma-radiation-emitting radionuclide that is ubiquitous in soils, and therefore it would be expected to be detected from time to time in the WIPP exhaust air samples. The beta-radiation-emitting $^{90}$Sr radionuclide

was detected in only two weekly composite samples from Station A in November and it was not detected in any monthly composite samples at Station B.

# CHAPTER 3 - AIRBORNE PARTICULATE MONITORING

Airborne particulate monitoring plays a crucial role in the comprehensive environmental monitoring program of the Carlsbad Environmental Monitoring and Research Center (CEMRC). This program is designed to monitor both routine and unforeseen releases of airborne particles, ensuring that the facility remains compliant with public radiological dose limits. The data collected from this monitoring effort are utilized to assess any potential impacts on the environment over time. Furthermore, the program serves as a precautionary measure in the event of an accidental release of radioactive materials.

The primary objective of CEMRC's ambient air monitoring program is to ascertain whether the handling and storage operations of nuclear waste at the Waste Isolation Pilot Plant (WIPP) have resulted in the release of radionuclides into the surrounding environment. To achieve this, CEMRC maintains a network of continuously operating samplers at six strategically chosen locations near the WIPP site and the adjacent communities. These monitoring sites are positioned based on prevalent wind directions from the facility, ensuring accurate detection of any potential releases. Additionally, monitoring sites in the nearby communities of Loving and Carlsbad provide supplementary information to local residents and maintain public confidence, as these communities are in closest proximity to the WIPP.

Earlier studies conducted by CEMRC yielded significant findings. One notable discovery was the correlation between plutonium activity and the concentration of aluminum in ambient air particles. This correlation was attributed to the resuspension of dust particles contaminated with radioactive fallout from historical nuclear weapons testing. Similar results were observed for americium and aluminum. Concurrent soil studies conducted within and around the WIPP site also revealed correlations between aluminum and naturally occurring as well as bomb-derived radionuclides, including $^{239+240Pu}$ (Kirchner et al., 2002).

In the current scope of work, particulate samples are collected at varying frequencies determined by mass loading and airflow from all designated monitoring locations. Each individual sample undergoes analysis to determine the total suspended particulates collected and to quantify the presence of gamma-emitting radionuclides and actinides of concern. Specific details regarding sample collection methodologies and analytical procedures are provided in the subsequent sections.

## 3.1 Sample Collection

Particulates in the ambient air are collected using high-volume samplers (“HiVols,” flow rate approximately 1.13 $m^3$/min) from six monitoring stations. These stations are at the following locations: (1) Onsite, which is 0.1 km northwest of the WIPP exhaust shaft; (2) the East Side of the WIPP facility (3) Near Field, about 1 km northwest of the facility, (4) Cactus Flats, about 19 km southeast of the WIPP site; (5) Carlsbad (west of the CEMRC facility), and (6) the south side of Loving. These samplers are primarily located in the prevailing downwind direction and were selected based on an analysis of probable wind-direction and speed scenarios in case of an accident involving a release of radioactivity during the operation of

WIPP. Ambient air sampling locations and a typical high-volume air sampling station are shown in Figure 3.1.

Particulates in the ambient air were collected on 20×25 cm A/E$^{TM}$ glass fiber filters with a pore size 1 µm (Pall German Laboratory, Ann Arbor, MI, USA). A typical sampling period lasts about three to four weeks depending on the levels of particulate matter that accumulates on the filters. These samplers are operated to maximize particulate loading without impacting airflow; if the flow rate drops to 0.99 m$^3$/min, the filters are changed. Filter change-outs also occur in the event of a power outage or if a sampler stops due to some mechanical issue. Each filter is weighed before and after sampling to determine the mass of aerosol material collected. Actinide analyses are performed on individual filters by CEMRC. The sampling height of each aerosol station is approximately 5 m from the ground.

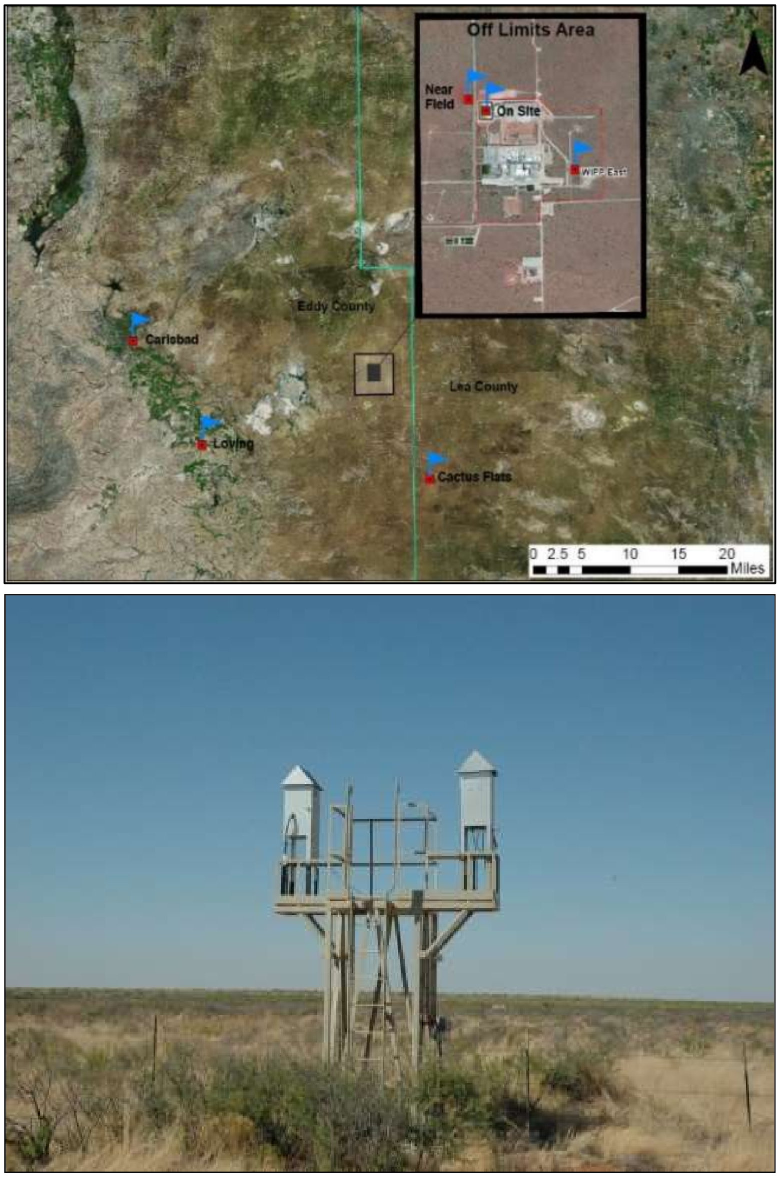


**Figure 3.1. Ambient Air Sampling Locations (top) and Typical High-Volume Sampling Station (bottom)**

## 3.2 Sample Preparation and Analysis

The individual filters are heated in a muffle furnace at 500 °C for six hours. Filter samples for radiochemical analysis are prepared by wet digestion with nitric acid ($HNO_3$), hydrochloric acid (HCl), and hydrofluoric acid (HF) until completely dry. The mixture is then heated with concentrated perchloric acid ($HClO_4$) to ensure that all residual HF is removed from the sample matrix. The residues are then dissolved in 1.0 M HCl for subsequent radionuclide separation and analysis. The activity measured is multiplied by two to account for the total activity in the filter.

## 3.3 Radiochemical Analysis

The acid digestate from the filter samples is then split into two fractions. One-half of each sample is used for gamma analysis of $^{137}$Cs, $^{40}$K, and $^{60}$Co. The other half is analyzed for the actinides after $Fe(OH)_3$ coprecipitation and separation occur using an anion exchange and chromatography column as described in previous CEMRC reports (http://www.cemrc.org/annual-reports). Gamma-radiation-emitting radionuclides in the ambient air filters are measured by gamma spectroscopy for 48 hours, while alpha-radiation-emitting radionuclides are measured using alpha spectroscopy (Mirion Technologies Inc, San Ramon, CA, USA) for five days as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}$Sr is subsequently measured using liquid scintillation counting.

## 3.4 Results and Discussion

The activities of the actinides and gamma-emitting radionuclides in air samples are reported in the following two ways. Activity Concentration in Bq/m$^3$ and Specific Activity in Bq/g. Activity Concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of air in cubic meters (m$^3$). Specific Activity is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the aerosol mass collected on the filter in grams (g).

### 3.4.1 Actinide Concentrations in Ambient Air

The concentrations of $^{241}$Am and $^{239+240}$Pu slightly above the MDC were detected in a few ambient air samples at some monitoring stations. Detecting these radionuclides generally depends on the amount of dust collected on the filters. More dust is collected during dry and windy seasons, typically from March to June. Therefore, during most years studied, the positive detections of $^{239+240}$Pu or $^{241}$Am occur during the March to June timeframe, which is when strong and gusty winds in the area frequently give rise to blowing dust. The concentrations of $^{239+240}$Pu measured were in the range of $-9.10\times10^{-10}$ to $6.08\times10^{-9}$ Bq/m$^3$ at the Onsite station, $4.05\times10^{-10}$ to $8.66\times10^{-9}$ Bq/m$^3$ at the Near Field station, $8.81\times10^{-10}$ to $9.45\times10^{-9}$ Bq/m$^3$ at the Cactus Flats station, 0 to $6.69\times10^{-9}$ Bq/m$^3$ at the Loving station, $-1.75\times10^{-9}$ to $9.83\times10^{-9}$ Bq/m$^3$ at the Carlsbad station, and $-3.35\times10^{-10}$ to $7.05\times10^{-9}$ Bq/m$^3$ at the WIPP's East station. The corresponding concentrations of $^{241}$Am were in the range from $-1.89\times10^{-8}$ to $7.65\times10^{-9}$ Bq/m$^3$ at the Onsite station, $-8.64\times10^{-9}$ to $7.33\times10^{-9}$ Bq/m$^3$ at the Near Field station, $-2.04\times10^{-8}$ to $5.01\times10^{-9}$ Bq/m$^3$ at the Cactus Flats station, $-9.49\times10^{-9}$ to $1.20\times10^{-8}$ Bq/m$^3$ at the Loving station, $-1.09\times10^{-8}$ to $6.78\times10^{-9}$ Bq/m$^3$ at the Carlsbad station, and $-6.79\times10^{-8}$ to $7.34\times10^{-9}$ Bq/m$^3$ at the WIPP's East station.

The WIPP's historical ambient air monitoring data indicate frequent detection of $^{239+240}$Pu and $^{241}$Am in ambient aerosol samples collected on filters around the WIPP. Peaks in the $^{239+240}$Pu and $^{241}$Am activity concentrations in aerosol samples from the three study sites generally occur from March to June, which is when strong and gusty winds in the area frequently give rise to blowing dust. The observed seasonality in Pu and Am activity concentrations in the WIPP environment is, therefore, attributable to the re-suspension of contaminated soil dust. Furthermore, $^{241}$Am and $^{239+240}$Pu activities were highly correlated, and their concentrations were similar at all stations. Figure 3.2 and Figure 3.3 show the concentrations of $^{239+240}$Pu and $^{241}$Am at the Cactus Flats, Near Field, and Onsite monitoring stations, while Figure 3.4 and Figure 3.5 show the concentrations of these two radionuclides at the Carlsbad, Loving, and WIPP east monitoring stations. The detection of $^{238}$Pu is relatively infrequent because the origin of this radionuclide is not primarily weapons fallout but rather a release by the burn-up of nuclear-powered satellites, such as the SNAP-9A (Hardy et al., 1973, Harley 1980). Unlike previous years, $^{238}$Pu was detected in some more ambient air samples in 2022. The number of $^{238}$Pu detections was three at the Onsite station, two at the Cactus Flats station, four at the Loving station, and two Carlsbad stations. The concentrations measured were in the range of $-1.37\times10^{-9}$ to $4.97\times10^{-9}$ Bq/m$^3$ at the Onsite station, $-1.49\times10^{-9}$ to $3.40\times10^{-9}$ Bq/m$^3$ at the Cactus Flats station, $-2.47\times10^{-9}$ to $4.66\times10^{-9}$ Bq/m$^3$ at the Loving station, and $-4.08\times10^{-9}$ to $1.89\times10^{-8}$ Bq/m$^3$ at the Carlsbad station. The concentrations of $^{239+240}$Pu, $^{241}$Am, and $^{238}$Pu in ambient air filters measured during 2022 are listed in Appendix B, Tables B.1 to B.3 for the Onsite Station, Tables B.4 to B.6 for the Near Field Station, Tables B.7 to B.9 for the Cactus Flats Station, Table B.10 for the Loving monitoring station, Table B.11 for the Carlsbad monitoring station, and Table B.12 for the WIPP East monitoring station.

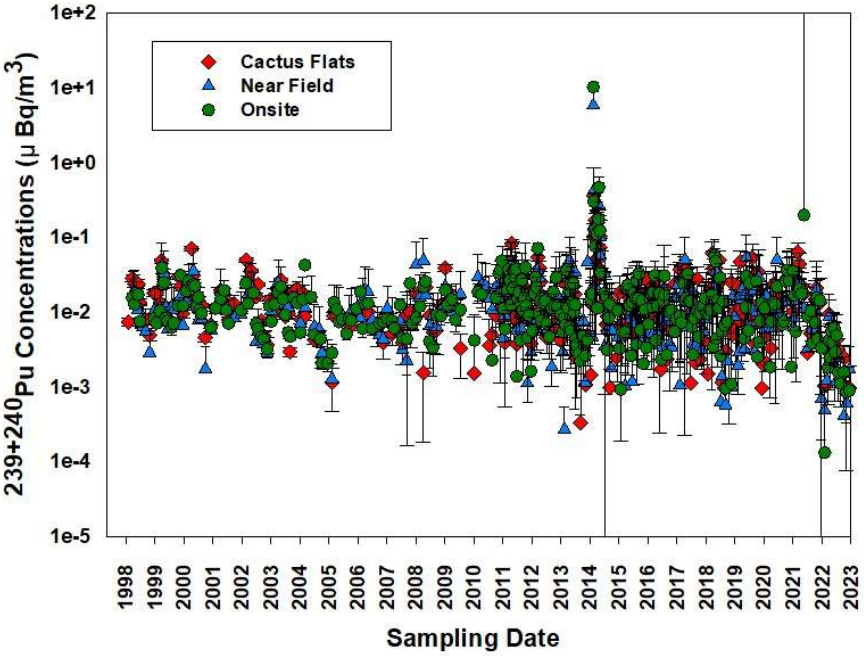


Figure 3.2. Historical $^{239+240}$Pu Concentrations at the Cactus Flats, Near Field, and Onsite Stations

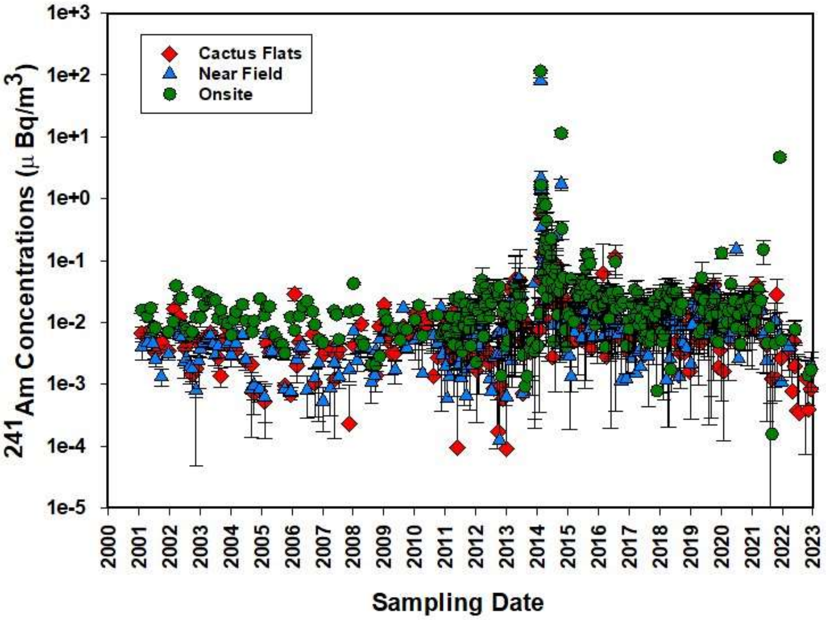


Figure 3.3. Historical $^{241}$Am Concentrations at the Cactus Flats, Near Field, and Onsite Stations

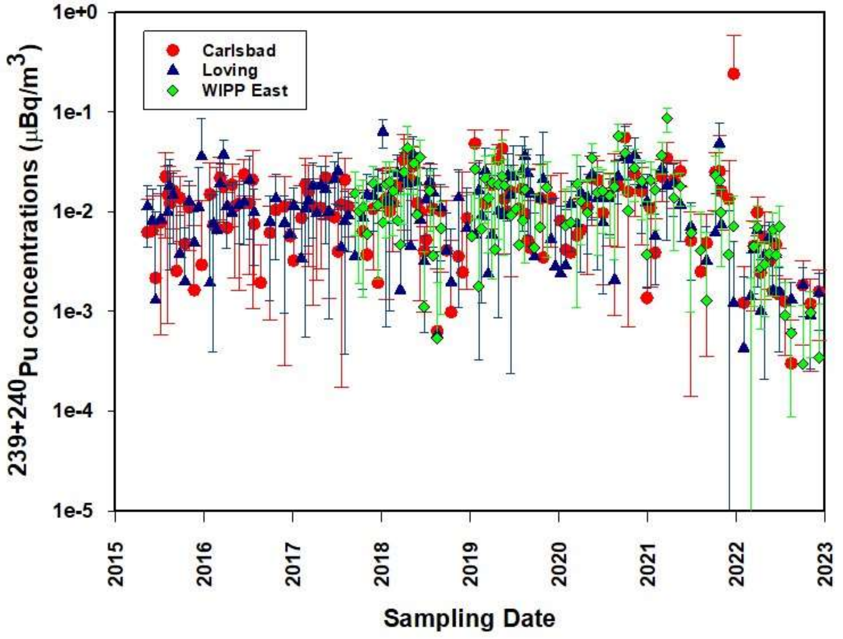


Figure 3.4. Historical $^{239+240}$Pu Concentrations at the Carlsbad, Loving, and WIPP East Stations

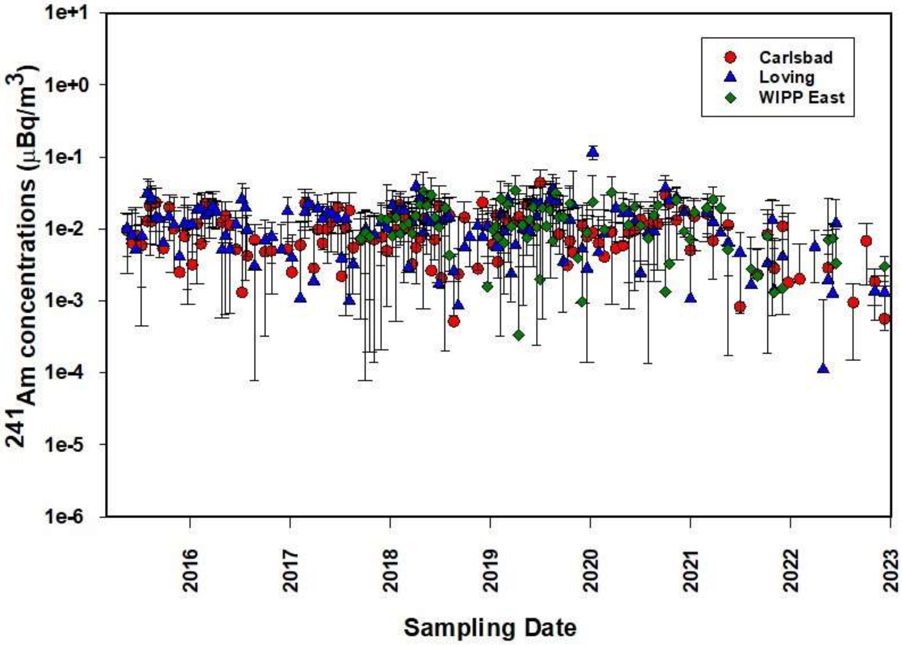
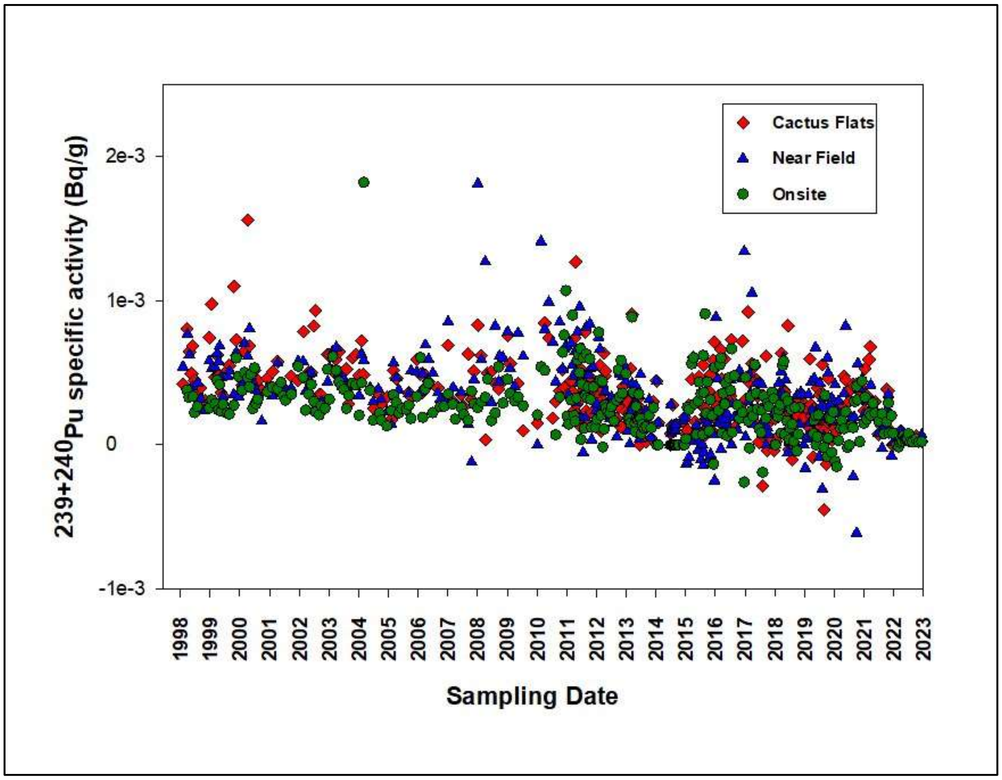


Figure 3.5. Historical $^{241}$Am Concentrations at the Carlsbad, Loving, and WIPP East Stations

The $^{239+240}$Pu specific activity (activity per unit mass aerosol collected) was in the range of -0.01-0.08 mBq/g at the Onsite station, 0.01-0.10 mBq/g at the Near Field station, 0.02-0.10 mBq/g at the Cactus Flats station, 0.00-0.06 mBq/g at the Loving Station, -0.02-0.09 at the Carlsbad station, and -0.01-0.11 mBq/g at the WIPP's East station. The $^{241}$Am was in the range of -0.18-0.06 mBq/g at the Onsite station, -0.24-0.09 mBq/g at the Near Field station, -0.25-0.06 mBq/g at the Cactus Flats station, -0.10-0.19 mBq/g at the Loving Station, -0.14-0.22 at the Carlsbad station, and -0.58-0.09 mBq/g at the WIPP's East station. The aerosol mass loadings recorded in these sampling stations were in the range from 1.19-4.10 g at the Onsite, 0.72-3.01 g at the Near Field, 1.35-2.76 g at the Cactus Flats, 0.94-3.95 g at the Loving Station, 1.11-2.64 g at the Carlsbad station, and 1.22-2.92 g at the WIPP's East station. The mass loadings at all stations tend to track one another remarkably well as shown in Figure 3.6 for the Onsite, Near Field, and Cactus Flats monitoring stations and Figure 3.7 for the Carlsbad, Loving, and WIPP east monitoring. The specific activity of $^{239+240}$Pu, $^{241}$Am, and $^{238}$Pu in ambient air filters during 2022 are listed in Appendix B Tables B.13 to B.15 (Onsite Station), Tables B.16 to B.18 (Near Field Station), Tables B.19 to B.21 (Cactus Flats Station), Tables B.22 (Loving station), Tables B.23 (Carlsbad Station) and Tables B.24 (WIPP's East Tower).



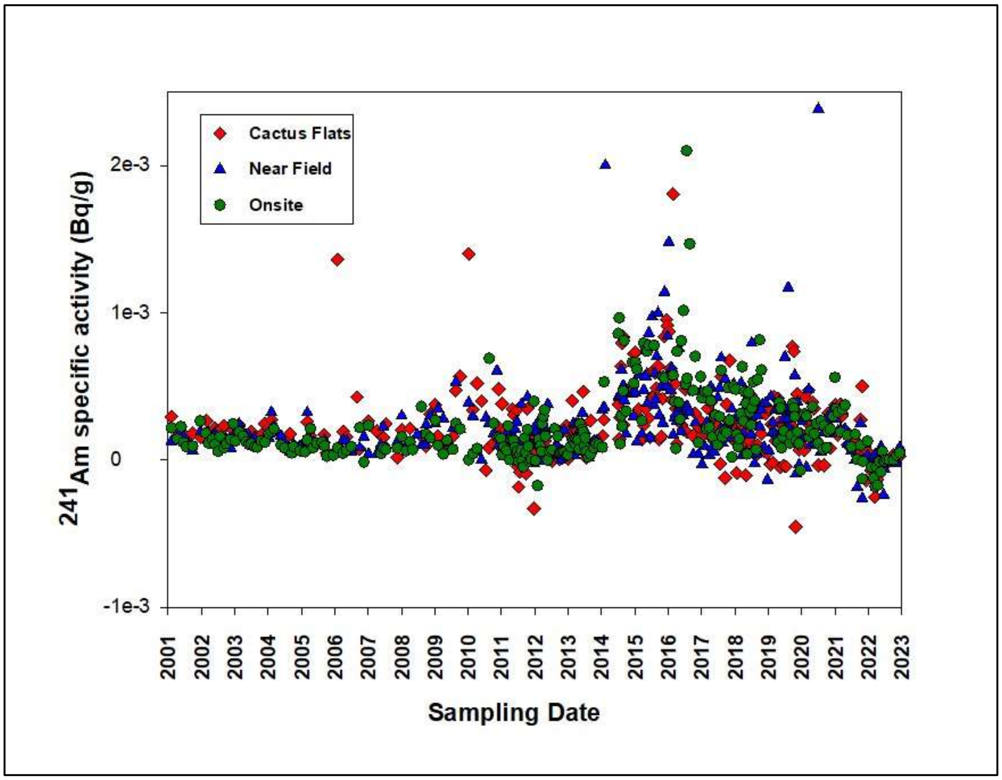
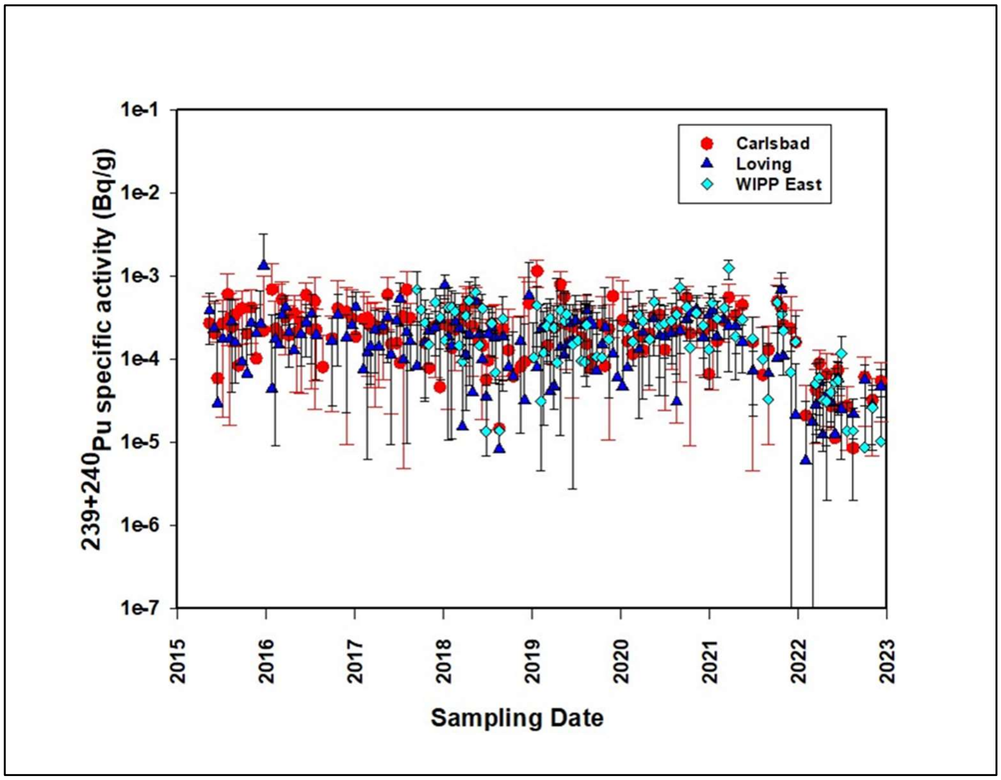


**Figure 3.6. Historical $^{239+240}$Pu (top) and $^{241}$Am (bottom) Specific Activities at the Cactus Flats, Near Field, and Onsite Stations**



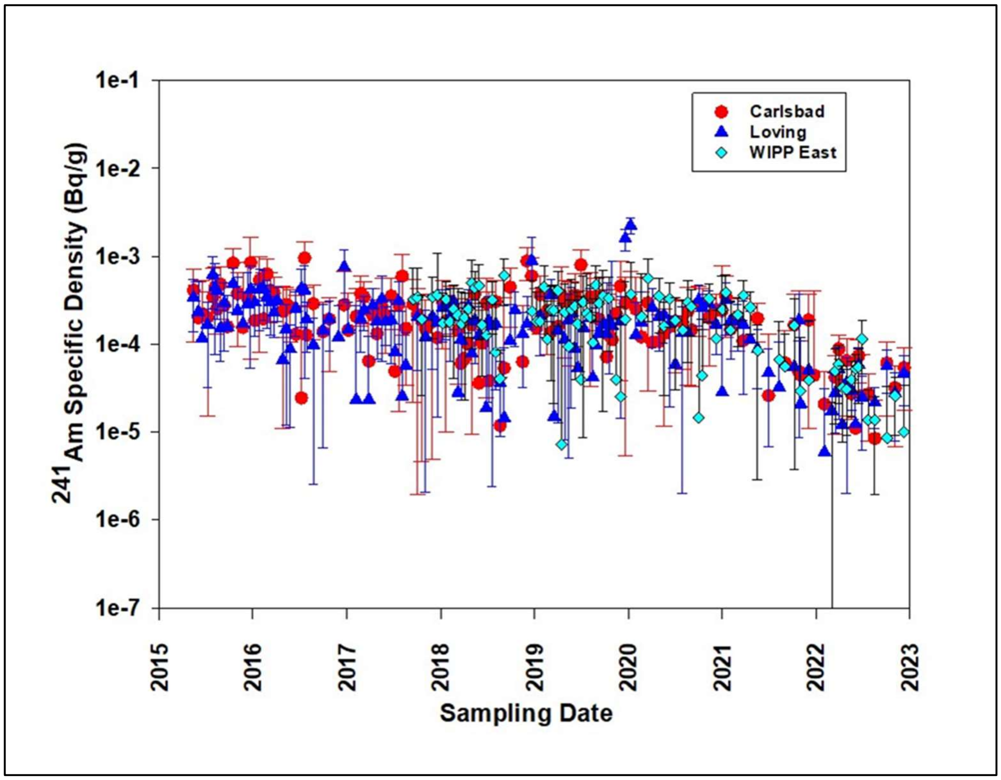


**Figure 3.7. Historical $^{239+240}$Pu (top) and $^{241}$Am (bottom) Specific Activities at the Carlsbad, Loving, and WIPP East Stations**

## 3.4.2 Uranium Concentrations in Ambient Air

Uranium isotopes were detected in most samples and at all sampling locations in 2022. Uranium occurs naturally in all rocks and soil with typical background levels ranging from approximately 2 to 4 mg/kg (Ahrens 1965, Wedepohl 1968). Thus, the detection of U in ambient air is normal. Natural sources of U in ambient air include re-suspended soil, volcanic eruptions (ATSDR 1999; Kuroda et al. 1984), and airborne particulates from coal and fuel combustion. The concentrations of uranium isotopes measured in ambient air samples are shown in Figure 3.8 for the Onsite, Near Field, and Cactus Flats stations and Figure 3.9 for the Loving, Carlsbad, and WIPP East Tower.

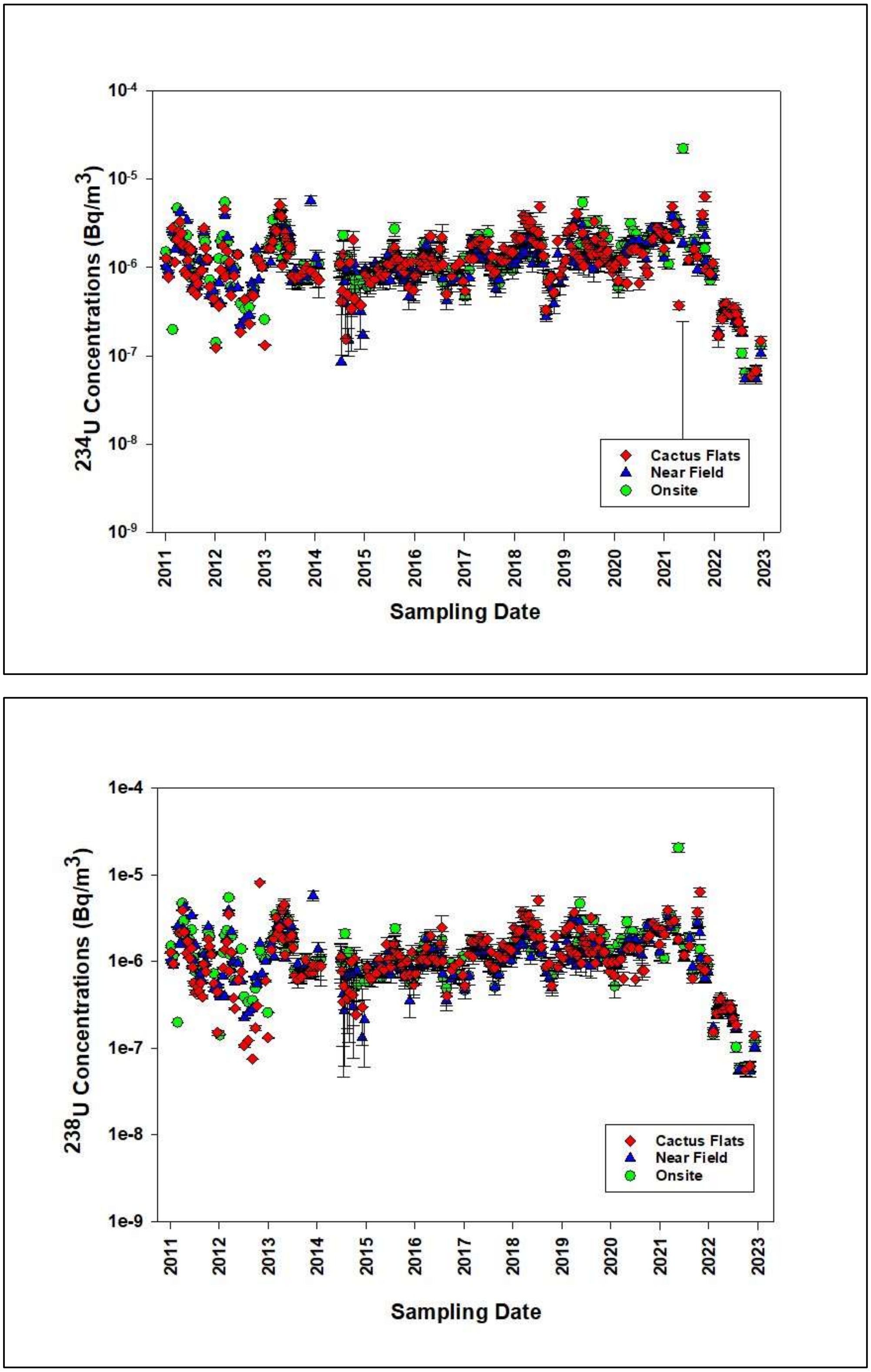
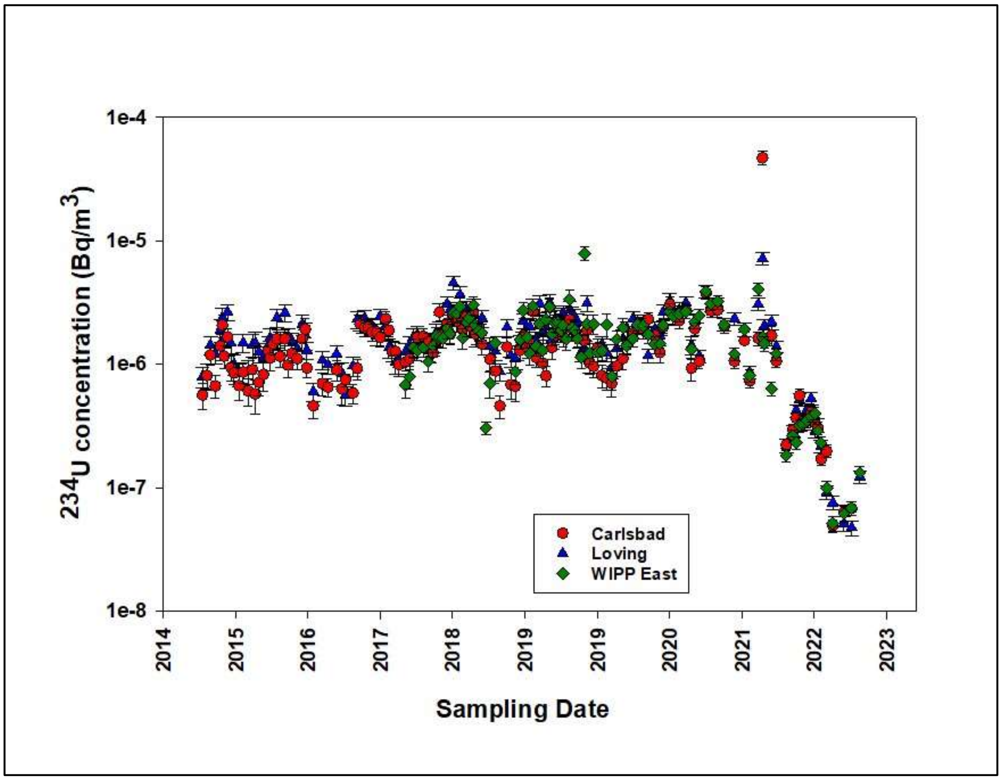


**Figure 3.8.** $^{234}$U (top) and $^{238}$U (bottom) Concentrations at the Cactus Flats, Near Field, and Onsite Stations



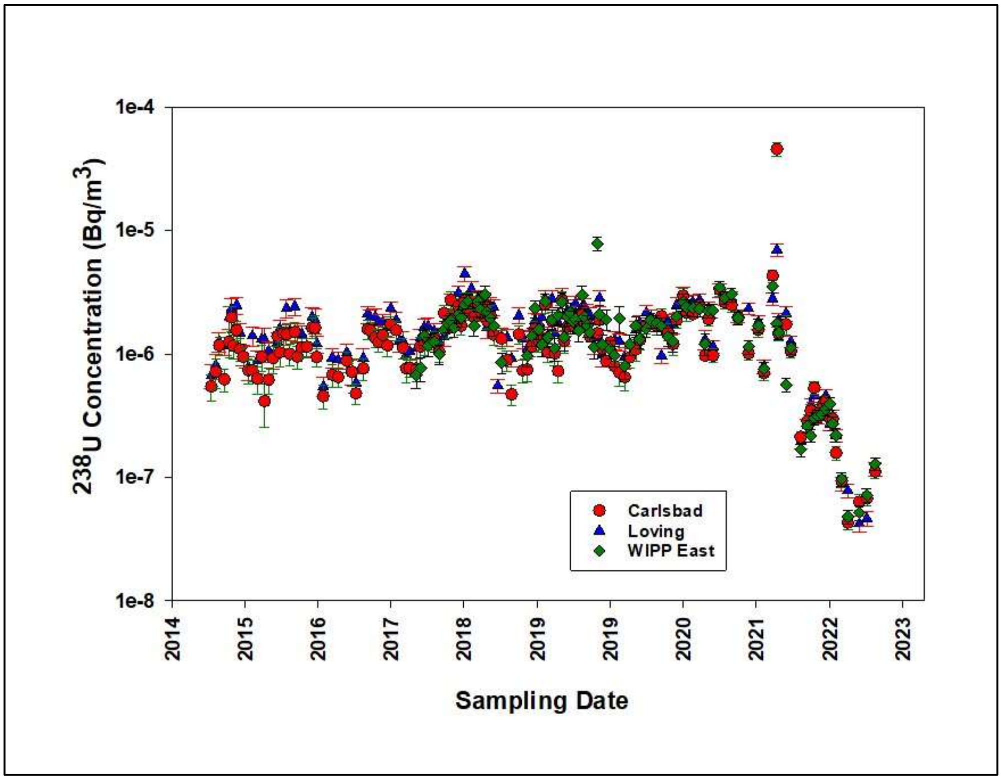


**Figure 3.9.** $^{234}$U and $^{238}$U Concentrations at the Carlsbad, Loving, and WIPP East Stations

The concentrations of $^{238}$U measured were in the range of 5.88×10$^{-8}$ to 3.37×10$^{-7}$ Bq/m$^3$ at the Onsite station, 5.35×10$^{-8}$ to 3.83×10$^{-7}$ Bq/m$^3$ at the Near Field station, -1.40×10$^{-7}$ to 3.67×10$^{-7}$ Bq/m$^3$ at the Cactus Flats station, 4.20×10$^{-8}$ to 4.62×10$^{-7}$ Bq/m$^3$ at the Loving station, 4.29×10$^{-8}$ to 5.32×10$^{-7}$ Bq/m$^3$ at the Carlsbad station, and 4.80×10$^{-8}$ to 3.92×10$^{-7}$ Bq/m$^3$ at the WIPP's East Tower. The corresponding concentrations of $^{234}$U were in the range of 6.13×10$^{-8}$ to 3.78×10$^{-7}$ Bq/m$^3$ at the Onsite station, 5.45×10$^{-8}$ to 3.91×10$^{-7}$ Bq/m$^3$ at the Near Field station, -7.04×10$^{-7}$ to 3.94×10$^{-7}$ Bq/m$^3$ at the Cactus Flats station, 4.73×10$^{-8}$ to 5.27×10$^{-7}$ Bq/m$^3$ at the Loving station, 4.90×10$^{-8}$ to 5.56×10$^{-7}$ Bq/m$^3$ at the Carlsbad station, and 5.13×10$^{-8}$ to 4.00×10$^{-7}$ Bq/m$^3$ at the WIPP's East Tower. There was no significant difference in the concentrations of U isotopes among locations. The individual concentrations of uranium isotopes in ambient air samples are summarized in Appendix B, Tables B.25 through B.30. Uranium ratios are used to determine the type of uranium present in the environment. Natural uranium has a $^{235}$U/$^{238}$U ratio of 0.00725 and $^{234}$U/$^{238}$U ratio of 1.0. The average annual $^{234}$U/$^{238}$U ratios at the sites are consistent with naturally occurring U. The specific activities of U isotopes measured in the ambient air at all the monitoring locations are listed in Appendix B, Tables B.31 through B.36.

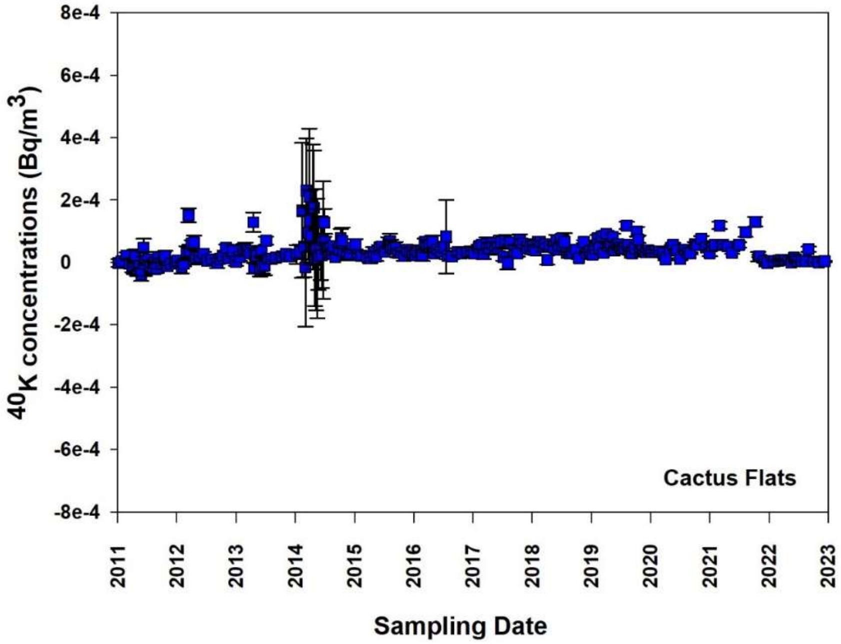
### 3.4.3 Gamma Radionuclide Concentrations in Ambient Air

The gamma-emitting radionuclides $^{137}$Cs, $^{40}$K, and $^{60}$Co were detected in some ambient air samples at a few monitoring stations. The $^{40}$K is ubiquitous in the earth's crust and thus would be expected to show up in environmental air samples. On the other hand, $^{137}$Cs is a fallout radionuclide and is expected to be detected from time to time in air samples depending on the dust loading on the filters.

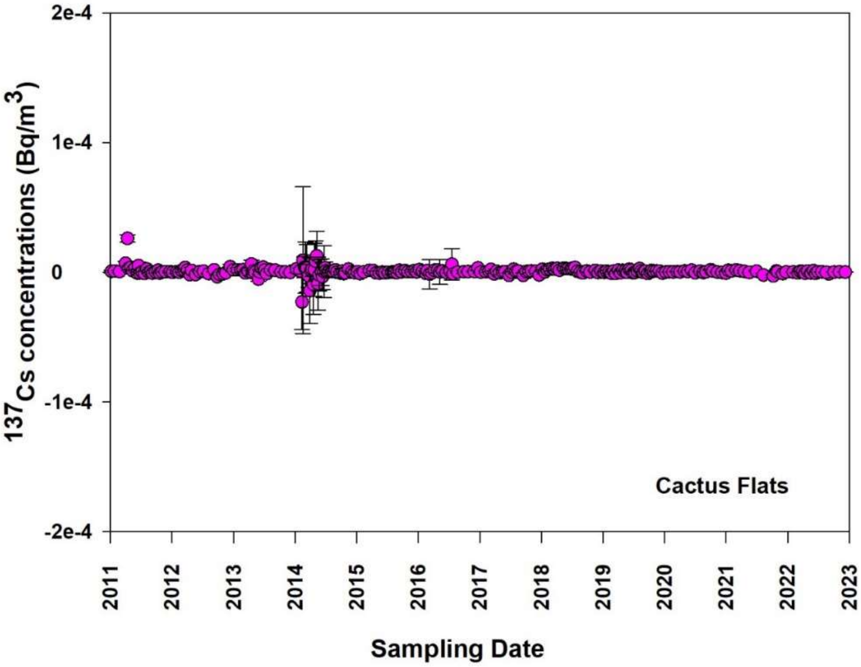
The number of $^{40}$K detections was four at the Onsite station, two each at the Loving and Carlsbad stations, and one each at the Near Field and Cactus Flats stations. The $^{40}$K concentrations measured were in the range of -2.10×10$^{-6}$ to 1.48×10$^{-5}$ Bq/m$^3$ at the Onsite station, -2.84×10$^{-6}$ to 1.79×10$^{-5}$ Bq/m$^3$ at the Loving station, -4.19×10$^{-7}$ to 1.51×10$^{-5}$ Bq/m$^3$ at the Carlsbad station, -2.40×10$^{-6}$ to 1.00×10$^{-5}$ Bq/m$^3$ at the Near Field station, and -8.22×10$^{-7}$ to 1.48×10$^{-5}$ Bq/m$^3$ at the Cactus Flats station. The detection of $^{137}$Cs was less frequent than $^{40}$K.

The number of $^{137}$Cs detections was three at the Cactus Flats station, and one each at the Onsite and Carlsbad stations. The concentrations measured were in the range of -8.53×10$^{-7}$ to 1.16×10$^{-6}$ Bq/m$^3$ at the Cactus Flats station, -4.03×10$^{-7}$ to 7.03×10$^{-7}$ Bq/m$^3$ at the Onsite station and -9.45×10$^{-7}$ to 1.13×10$^{-6}$ Bq/m$^3$ at the Carlsbad station.

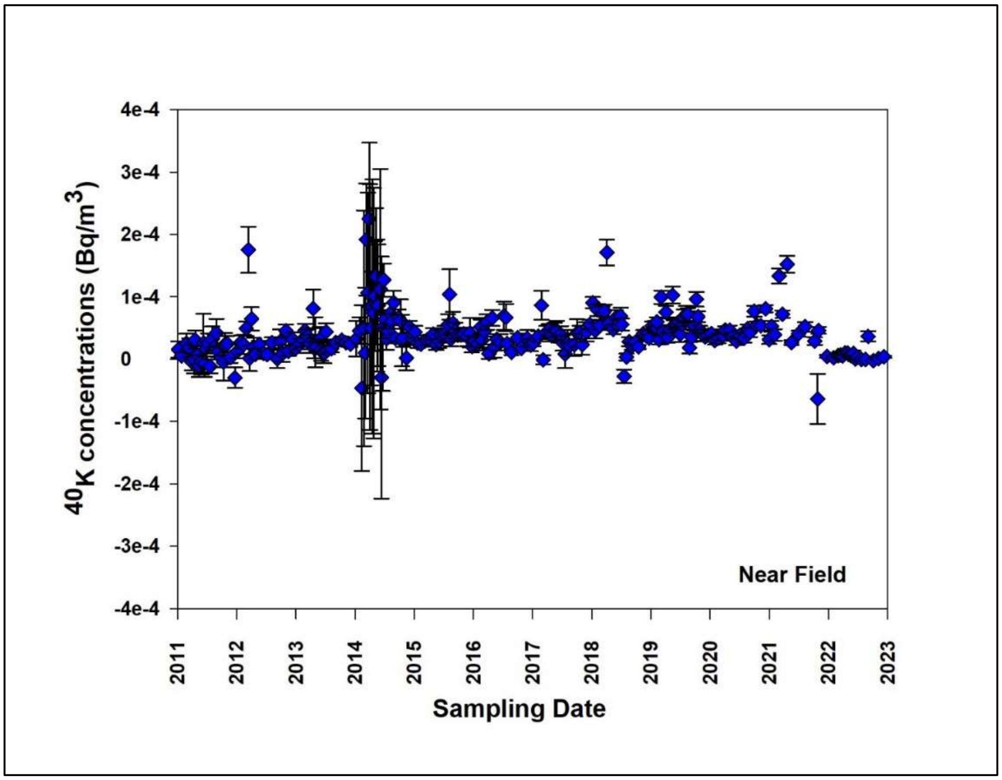
The concentrations of gamma-emitting radionuclides $^{137}$Cs and $^{40}$K in ambient air samples are shown in Figure 3.10 and Figure 3.11. The individual concentrations measured are shown in Appendix B, Tables B.37 through B.42. The analysis of historical operational data shows an occasional detection of $^{137}$Cs and $^{40}$K in ambient air filters at all locations. The concentrations measured in 2022 were less than those measured in previous years.



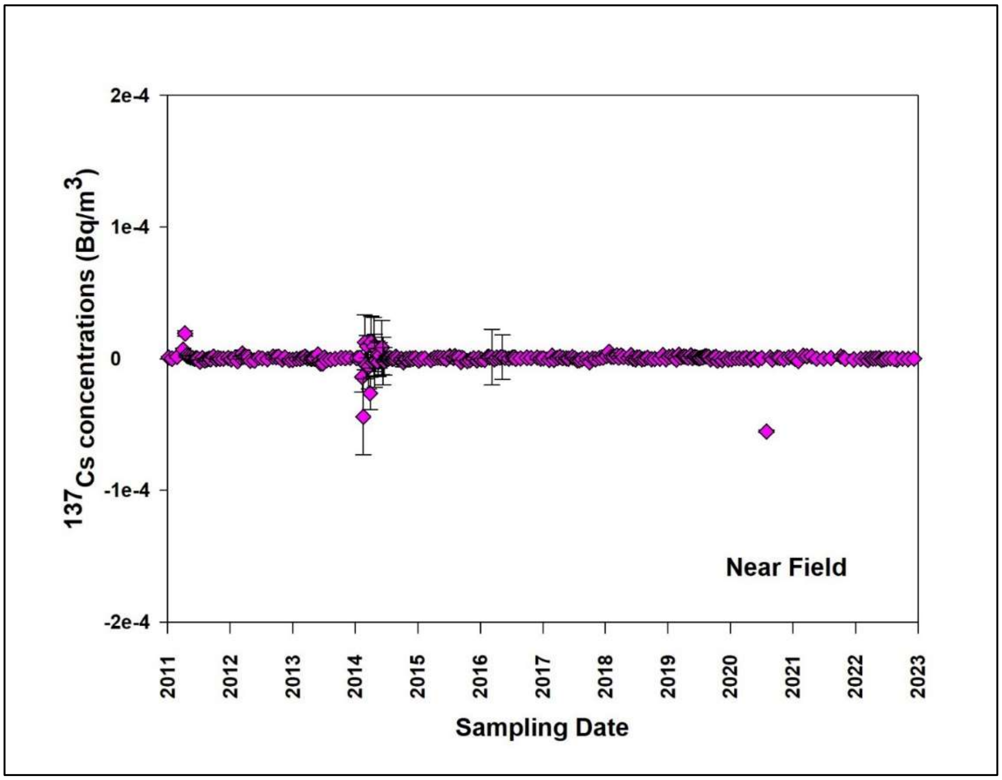
$^{40}$K concentrations (Bq/m$^3$)
8e-4
6e-4
4e-4
2e-4
0
-2e-4
-4e-4
-6e-4
-8e-4
Cactus Flats
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



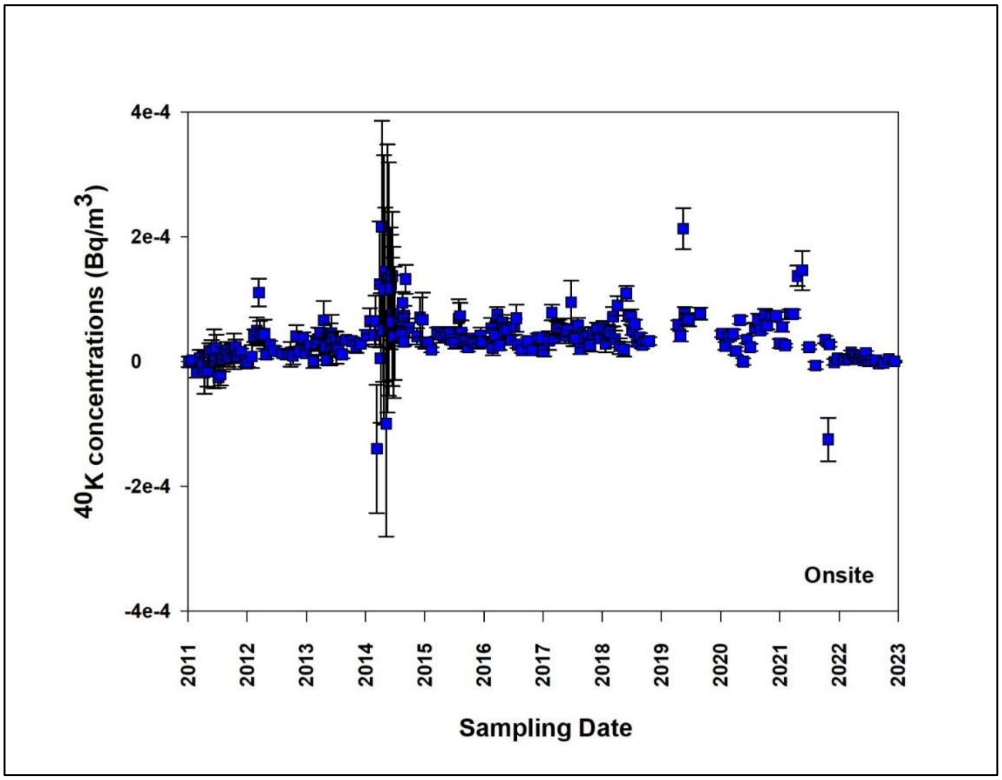
$^{137}$Cs concentrations (Bq/m$^3$)
2e-4
1e-4
0
-1e-4
-2e-4
Cactus Flats
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



4e-4
3e-4
2e-4
1e-4
0
-1e-4
-2e-4
-3e-4
-4e-4
$^{40}$K concentrations (Bq/m$^3$)
Near Field
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



2e-4
1e-4
0
-1e-4
-2e-4
$^{137}$Cs concentrations (Bq/m$^3$)
Near Field
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



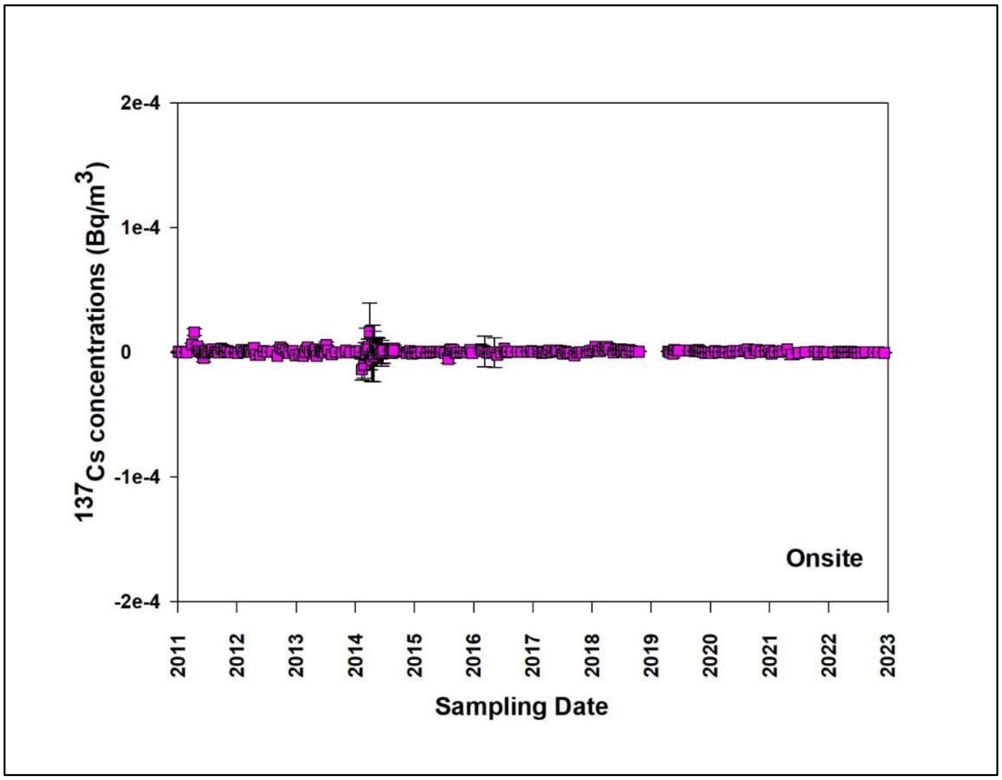
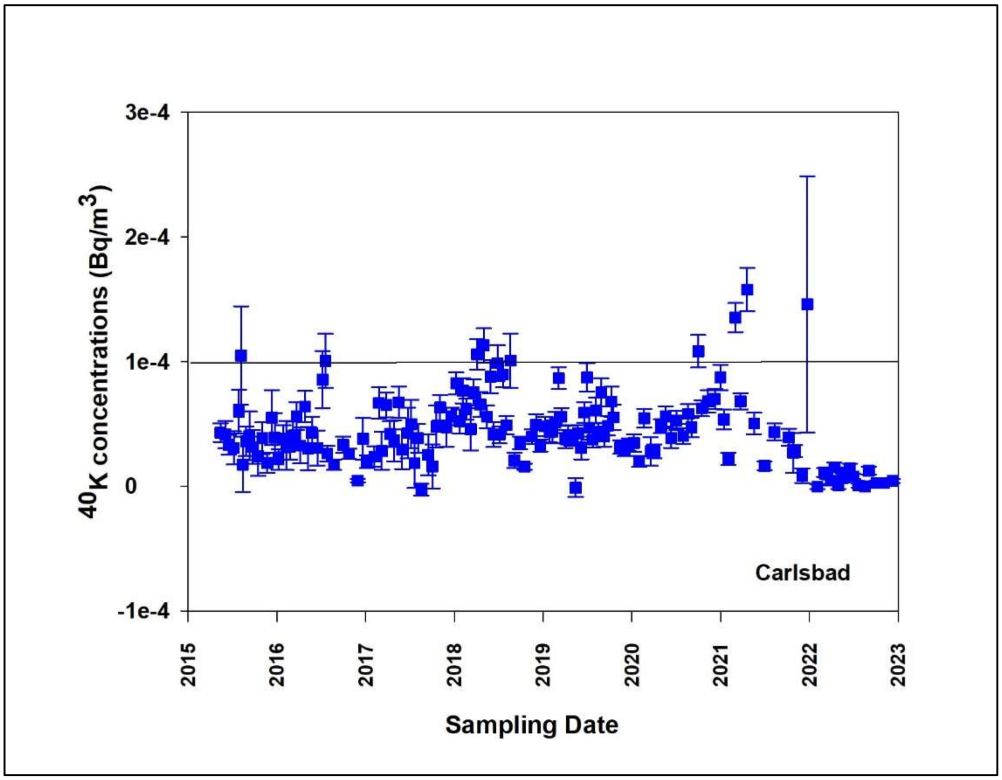
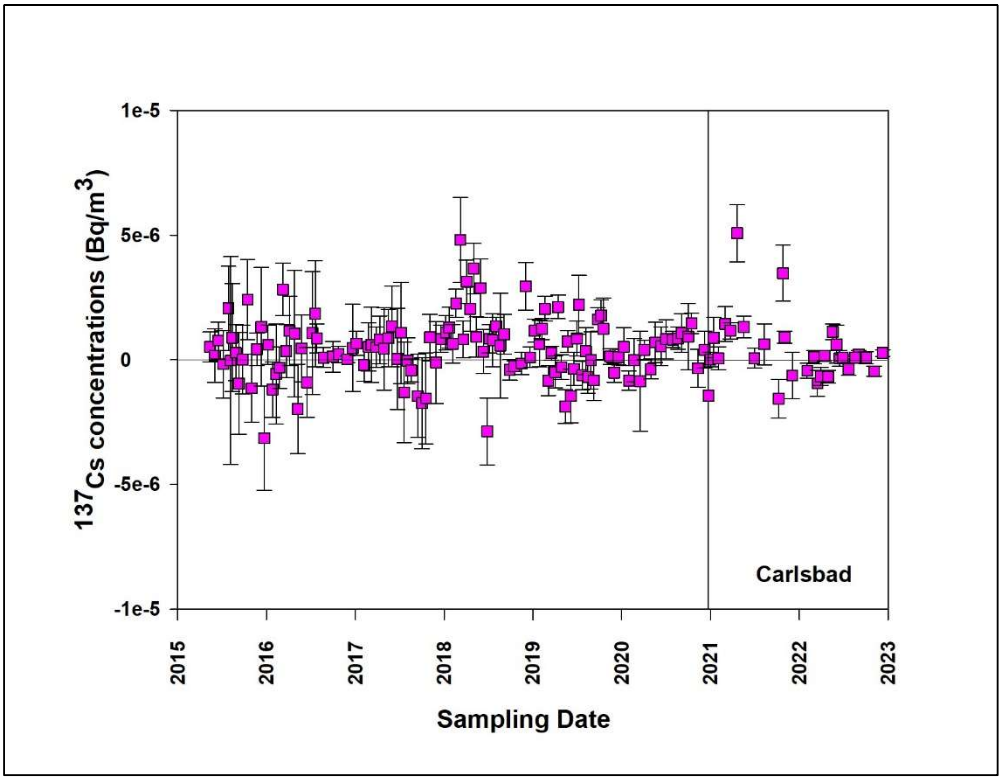


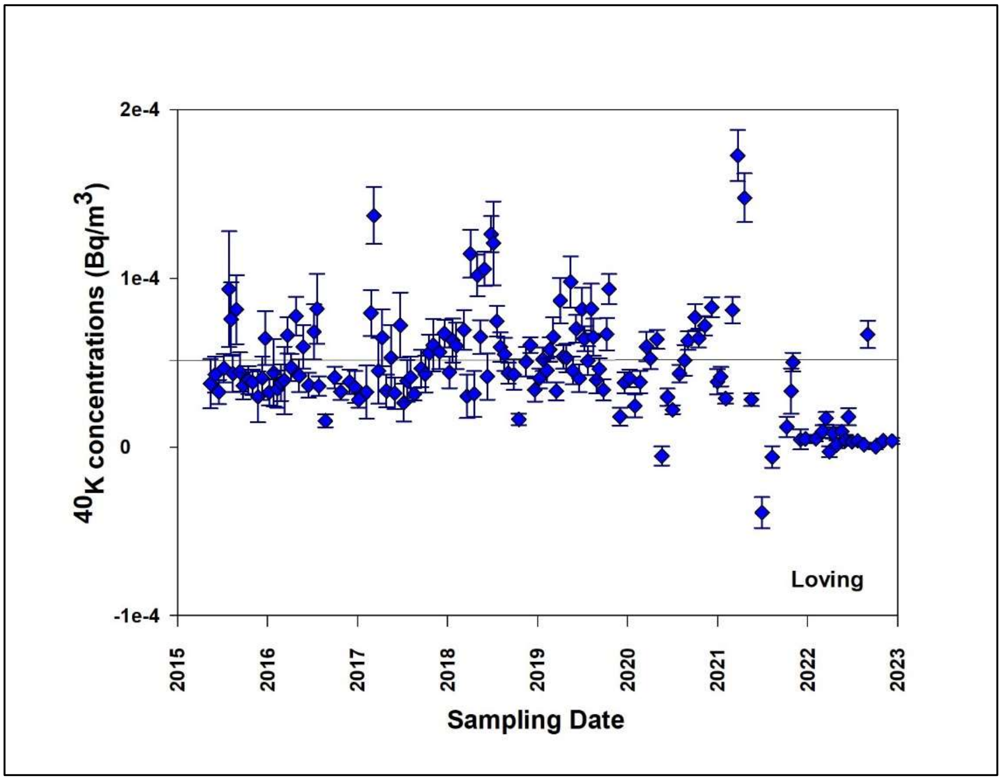
**Figure 3.10. Concentrations of $^{137}$Cs and $^{40}$K at the Cactus Flats (a and b), Near Field (c and d), and Onsite (e and f) Stations**

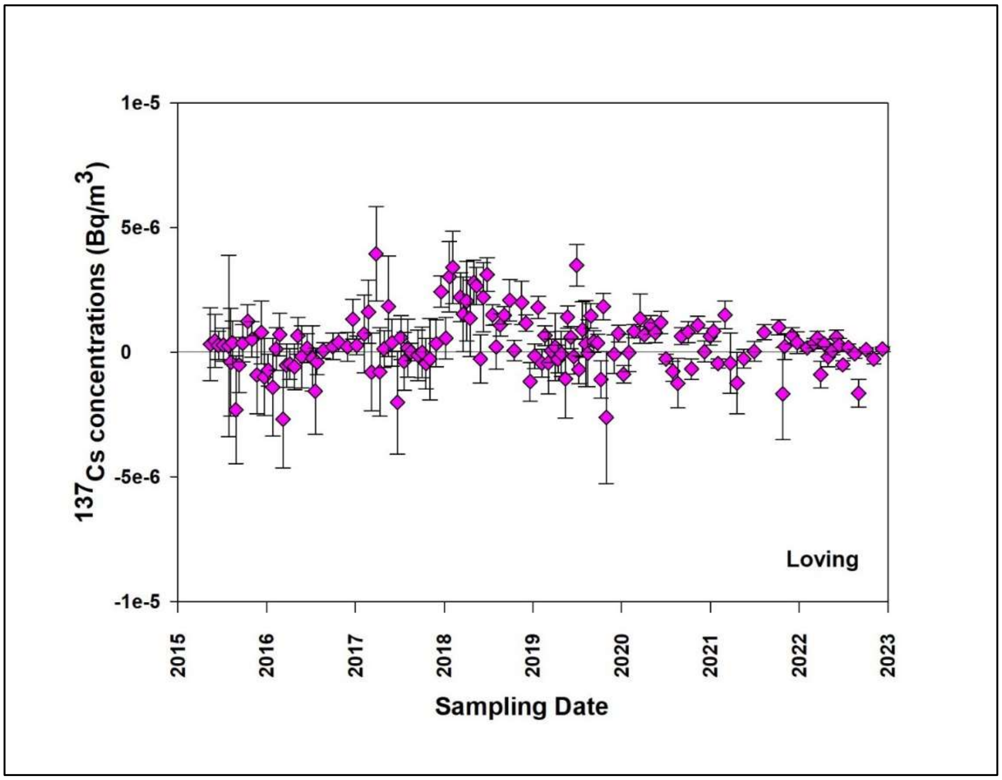


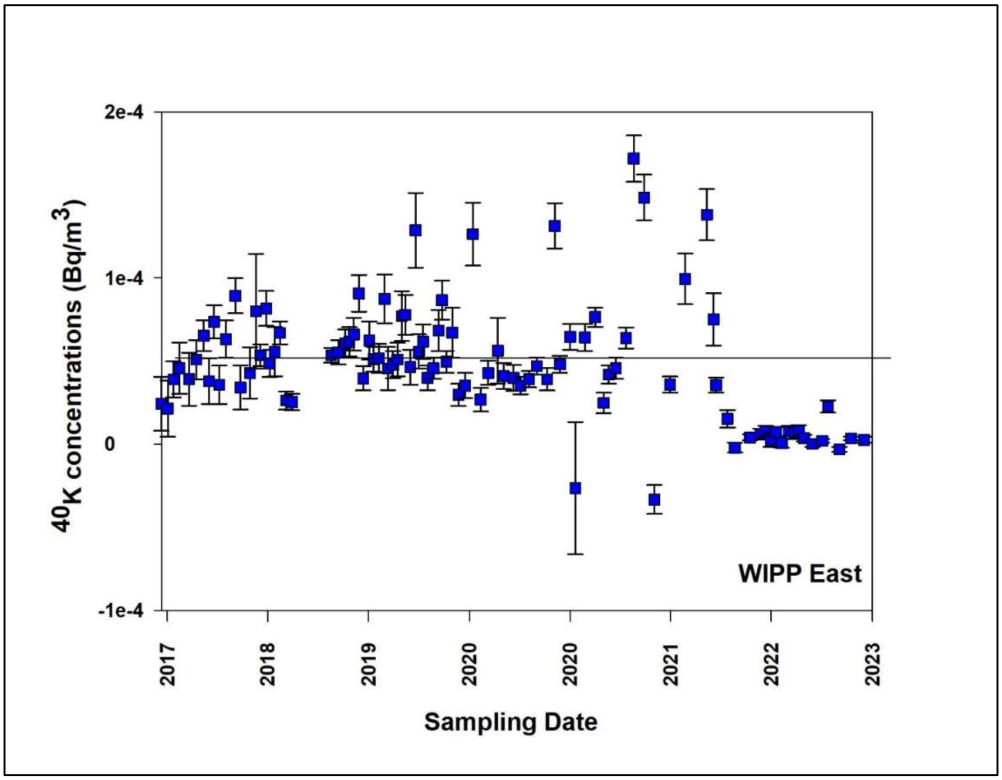
3e-4
2e-4
1e-4
0
-1e-4
$^{40}$K concentrations (Bq/m$^3$)
Carlsbad
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



1e-5
5e-6
0
-5e-6
-1e-5
$^{137}$Cs concentrations (Bq/m$^3$)
Carlsbad
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date


2e-4
1e-4
0
-1e-4
$^{40}$K concentrations (Bq/m$^3$)
Loving
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date


1e-5
5e-6
0
-5e-6
-1e-5
$^{137}$Cs concentrations (Bq/m$^3$)
Loving
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



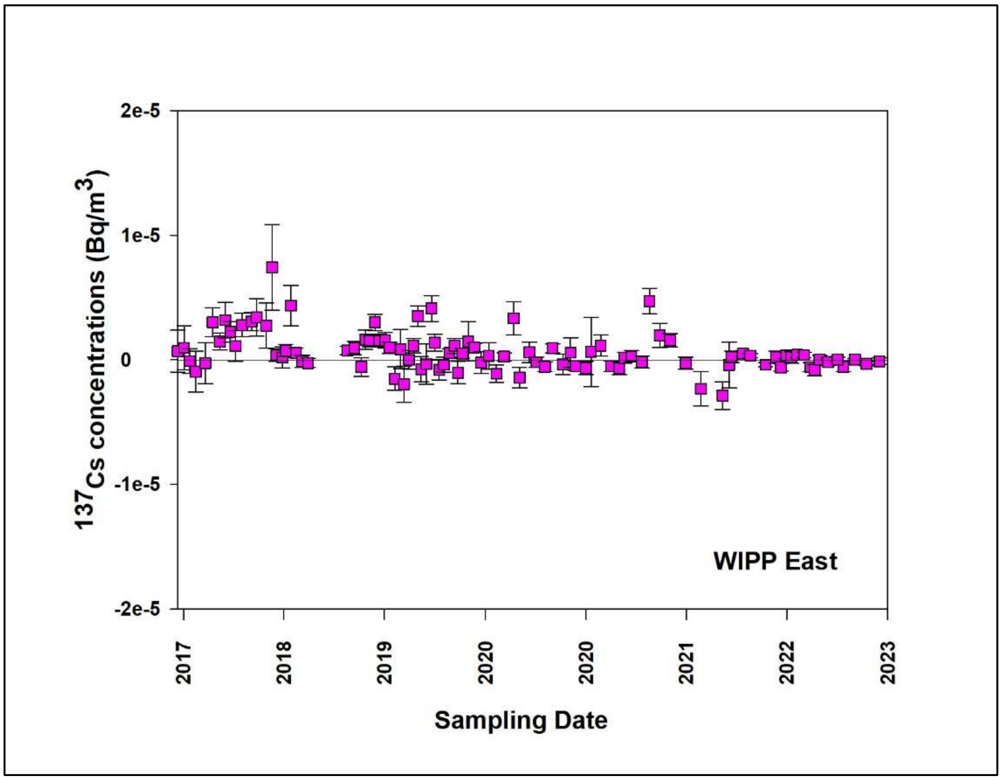


Figure 3.11. Concentrations of $^{137}$Cs and $^{40}$K Concentrations at the Carlsbad (a and b), Loving (c and d), and WIPP East (e and f) Stations

Unlike previous years, $^{60}$Co was detected in a few airborne particulate samples in 2022. Specifically, the $^{60}$Co isotope was detected in three samples at the Cactus Flats station, in two samples at the Near Field station, and in one sample each at the Onsite and Carlsbad stations. The concentrations measured were in the range of $7.30\times10^{-8}$ to $9.09\times10^{-7}$ Bq/m$^3$ at the Cactus Flats station, $-1.20\times10^{-7}$ to $1.24\times10^{-6}$ Bq/m$^3$ at the Near Field station, $3.52\times10^{-8}$ to $1.00\times10^{-6}$ Bq/m$^3$ at the Onsite station, and $-1.29\times10^{-8}$ to $9.84\times10^{-7}$ Bq/m$^3$ at the Carlsbad station.

### 3.4.4 Strontium Concentrations in Ambient Air

The beta-radiation-emitting radionuclide $^{90}$Sr was detected in some ambient particulate samples at all monitoring stations in 2022. The $^{90}$Sr isotope was detected in four samples at the Onsite station, five samples at the Near Field station, three samples at the Cactus Flats station, six samples at the Loving station, five samples at the Carlsbad station, and 10 out of the 15 samples at the East Tower station. The concentrations measured were in the range of $3.11\times10^{-5}$ to $1.43\times10^{-4}$ Bq/m$^3$ at the Onsite station, $3.57\times10^{-5}$ to $1.62\times10^{-4}$ Bq/m$^3$ at the Near Field station, $3.48\times10^{-5}$ to $1.57\times10^{-4}$ Bq/m$^3$ at the Cactus Flats station, $3.89\times10^{-5}$ to $1.68\times10^{-4}$ Bq/m$^3$ at the Loving station, $3.89\times10^{-5}$ to $1.85\times10^{-4}$ Bq/m$^3$ at the Carlsbad station, and $4.32\times10^{-5}$ to $1.38\times10^{-3}$ Bq/m$^3$ at the East Tower station.

## 3.5 Conclusions

The results of the airborne particulate monitoring program for the year 2022 are summarized in this chapter. During this monitoring period, the concentrations of $^{239+240}$Pu and $^{241}$Am slightly exceeded the minimum detectable concentration (MDC) and were detected in all the monitoring stations. The concentrations of $^{239+240}$Pu ranged from -0.01-0.08 mBq/g at the Onsite station, 0.01-0.10 mBq/g at the Near Field station, 0.02-0.10 mBq/g at the Cactus Flats station, 0.00-0.06 mBq/g at the Loving Station, -0.02-0.09 at the Carlsbad station, and -0.01-0.11 mBq/g at the WIPP's East station.

Similarly, the corresponding concentrations of $^{241}$Am ranged from -0.18-0.06 mBq/g at the Onsite station, -0.24-0.09 mBq/g at the Near Field station, -0.25-0.06 mBq/g at the Cactus Flats station, -0.10-0.19 mBq/g at the Loving Station, -0.14-0.22 at the Carlsbad station, and -0.58-0.09 mBq/g at the WIPP's East station. The aerosol mass loadings recorded at these sampling stations ranged from 1.19-4.10 g at the Onsite, 0.72-3.01 g at the Near Field, 1.35-2.76 g at the Cactus Flats, 0.94-3.95 g at the Loving Station, 1.11-2.64 g at the Carlsbad station, and 1.22-2.92 g at the WIPP's East station. These levels are consistent with the measurements obtained in previous years. As expected, uranium isotopes were detected at all the sampling locations. The highest concentration of uranium was observed at the Carlsbad location, with levels of $5.32\times10^{-7}$ Bq/m$^3$ for $^{238}$U and $5.56\times10^{-7}$ Bq/m$^3$ for $^{234}$U. In a few ambient air samples from all monitoring stations, gamma-emitting radionuclides such as $^{137}$Cs, $^{60}$Co, and $^{40}$K were detected in a few ambient air samples from some monitoring stations. It is important to note that $^{40}$K is naturally present in the Earth's crust, so its presence in environmental air samples is expected. On the other hand$^{137}$Cs is a fallout radionuclide and its detection in air samples depends on the amount of dust on the filters.

Based on historical ambient air data from WIPP, it is evident that, except for the 2014 release event, the presence and levels of Pu and Am in the environment surrounding the WIPP area are primarily a result of soil particle resuspension, which is contaminated due to weapons fallout. There is no evidence indicating an increase in radionuclide activity concentrations in the region that can be attributed to releases from the WIPP. Finally, the $^{90}$Sr radionuclide was detected in some of the ambient air samples and at all monitoring stations in 2022.

# CHAPTER 4 - SOIL MONITORING

Soil is a crucial component of the natural environment, formed through the weathering process of rocks and the accumulation of organic matter. It plays a vital role in sustaining plant growth and overall ecosystem health. However, soil can also be susceptible to contamination from various sources, including direct releases into the ground, atmospheric deposition, and liquid effluents.

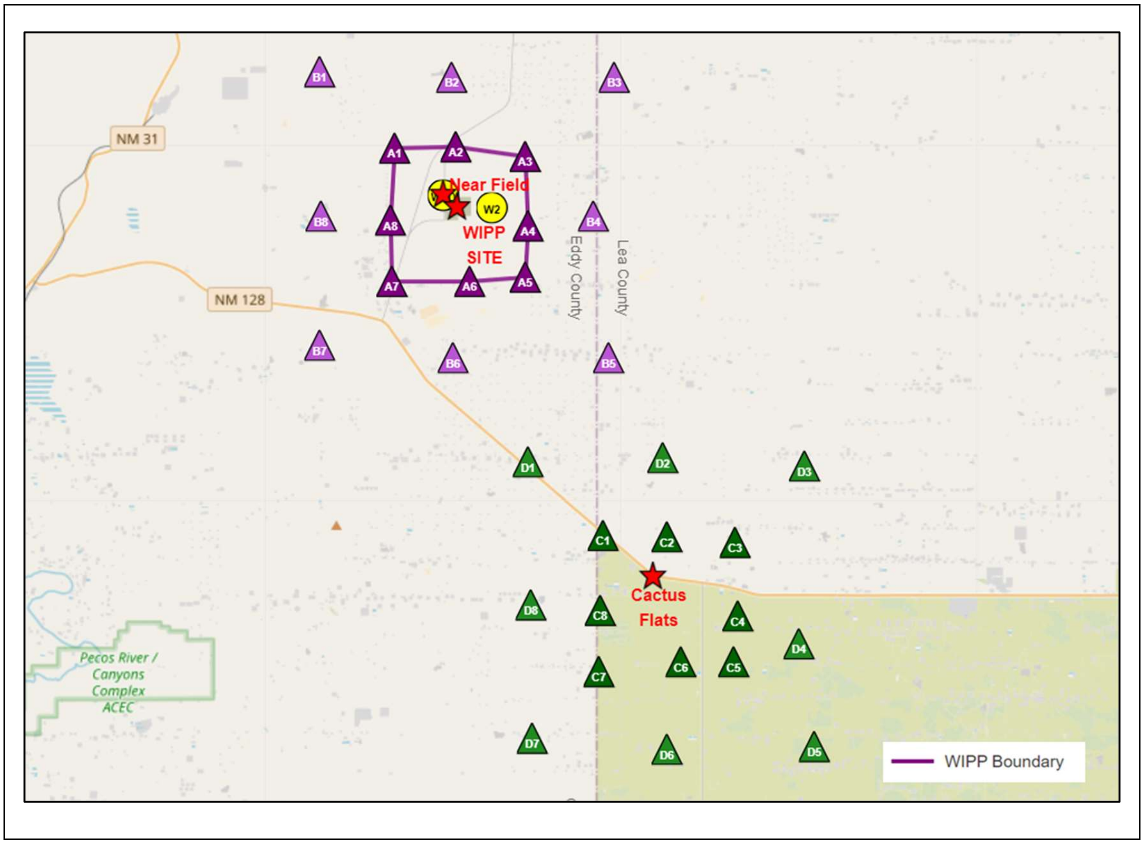
The U.S. Department of Energy (DOE) provides guidance for environmental monitoring, emphasizing the importance of sampling soil to assess the long-term accumulation of radionuclides in terrestrial environments and estimate the inventories of environmental radionuclides (U.S. DOE, 1991). This guidance is particularly relevant to the CEMRC environmental monitoring program, as it aims to monitor the potential deposition of airborne contaminants from the repository into surface soils. These pollutants can serve as a continued source of contaminant exposure and uptake, through direct contact, food chain pathways, and re-suspension.

Implementing a soil monitoring program offers the most direct approach to determine the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities. In the case of the WIPP site, the main sources of transuranic radionuclides in the surrounding soil are primarily attributable to global fallout resulting from nuclear weapons testing, releases at the Gnome site near the WIPP facility, and regional fallout from above-ground nuclear weapons testing at the Nevada National Security Site (NNSS), formerly known as the Nevada Test Site (NTS). These sources exhibit characteristic radionuclide signatures or abundances that, in principle, enable their identification in soils and estimation of their concentrations.

CEMRC has been actively conducting surface soil monitoring near the WIPP site since 1998. The primary objective was to establish independent baseline data on various anthropogenic radionuclides present in WIPP soil before the commencement of operations. These baseline data are subsequently compared with data collected during the disposal phase to assess any potential increase in radioactivity resulting from WIPP operations. Currently, the monitoring program entails annual collection of soil samples from two designated locations within the established grid, namely Near Field and Cactus Flats. Each individual sample is then subjected to analysis to determine the presence and concentrations of gamma-emitting radionuclides and actinides of concern. The specific procedures for sample collection and analyses are elaborated upon in the subsequent sections.

## 4.1 Sample Collection

Soil samples were collected from the A and B grids around the WIPP site, as well as two WIPP sites (one WIPP site is collected in duplicate). Soil samples at the depth of 0-2 cm were collected at random short distances and orientations from both locations. The sampling location of soil is shown in Figure 4.1. Individual sampling sites were selected on the basis of relatively flat topography, minimum surface erosion, and minimum surface disturbance by human or livestock activity. Approximately 4 L of soil were collected from within a 50×50 cm area for radionuclide analyses. As shown in Figure 4.1, soil samples were excavated using a trowel and placed in plastic bags for transport and storage. Sampling equipment was cleaned between samples. Samples were sieved through a 2 mm mesh screen to remove rocks, roots, and other large material. The soil samples were then oven dried at 105 ˚C and ground using a shatter box grinder to a fine analytical powder.



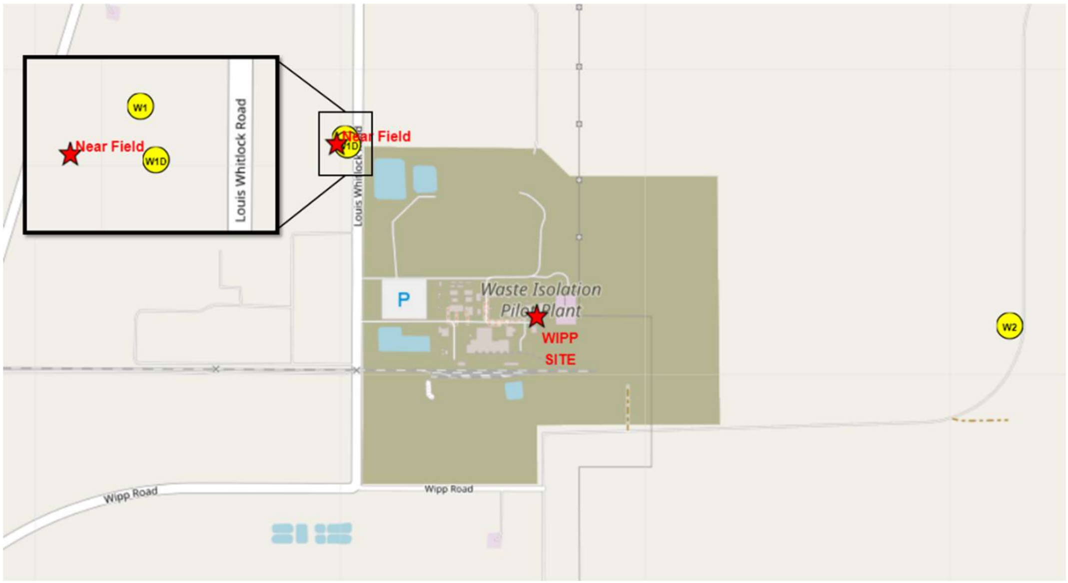


**Figure 4.1. Soil Sampling Locations and Collection**

## 4.2 Sample Preparation and Analysis

Soil samples were dried at 110 °C and blended before sampling. The samples for gamma analysis were sealed in a 300 mL paint can and stored for at least 21 days to allow radon progeny to reach equilibrium with parent radionuclides before counting. Dried and sieved soil samples were counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies). The counting containers held approximately 500 g of soil.

For actinide analyses, 4-5 g of sample were heated in a muffle furnace at 500 °C for at least 6 hours to combust organic material. Each sample was then spiked with a radioactive tracer and digested in a Teflon beaker with hydrochloric, nitric, and hydrofluoric acids. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. To remove hydrofluoric acid, the sample residues were heated with perchloric acid and boric acids. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

### 4.2.1 Radiochemical Analysis

The actinides were then separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on a second anion exchange column and the americium subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are separated and purified using strontium

(Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}$Sr is subsequently measured using liquid scintillation counting.

## 4.3 Results and Discussion

The activities of the actinides and gamma radionuclides in the soil samples are reported as activity concentrations in Bq/kg. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the soil in kilograms (kg). The activity concentrations for all samples and all isotopes are reported in Appendix C, Tables C.1 – C.4.

### 4.3.1 Actinide Concentrations in WIPP Soil

The individual concentrations of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am in the soil samples collected from the Near Field are presented in Figure 4.2 through Figure 4.4. The $^{239+240}$Pu concentrations in the Near Field ranged from 0.002 to 0.187 Bq/kg, with a mean value of 0.058 Bq/kg, while that for $^{238}$Pu was not detected in most of the soil samples except one site in grid A with concentration of 0.024 Bq/kg. The concentration is close to the minimum detectable concentration (MDC) (0.010 Bq/kg).

The $^{241}$Am radionuclide was detected in a few of the soil samples in grid B. The concentrations of these nuclides are comparable to our historical data recorded for these areas prior to the arrival of TRU wastes in the WIPP and are typical of "background soil concentrations." Historical plots of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am concentrations in soil in the vicinity of the WIPP site are shown in Figure 4.2 through Figure 4.4.

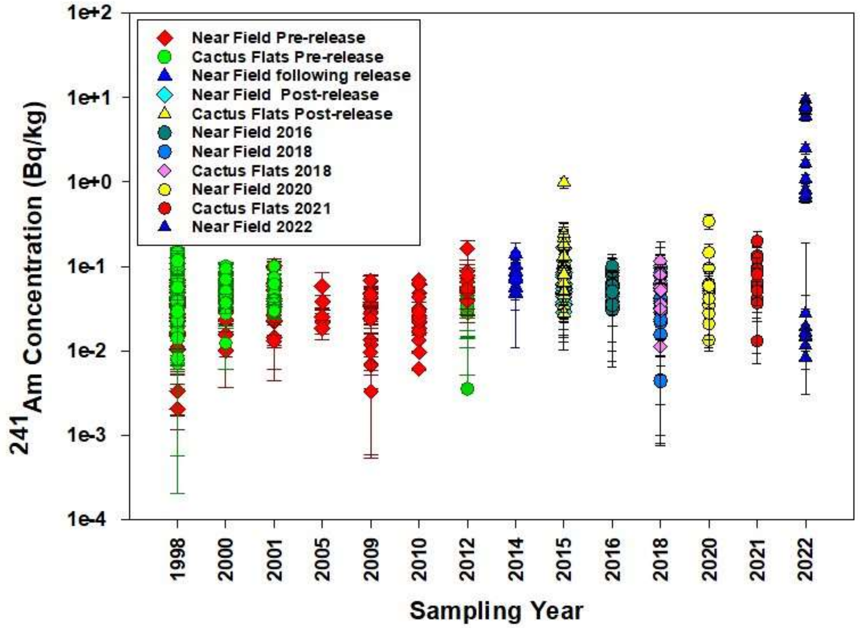


Figure 4.2. Historical Concentrations of $^{241}$Am in WIPP Soil

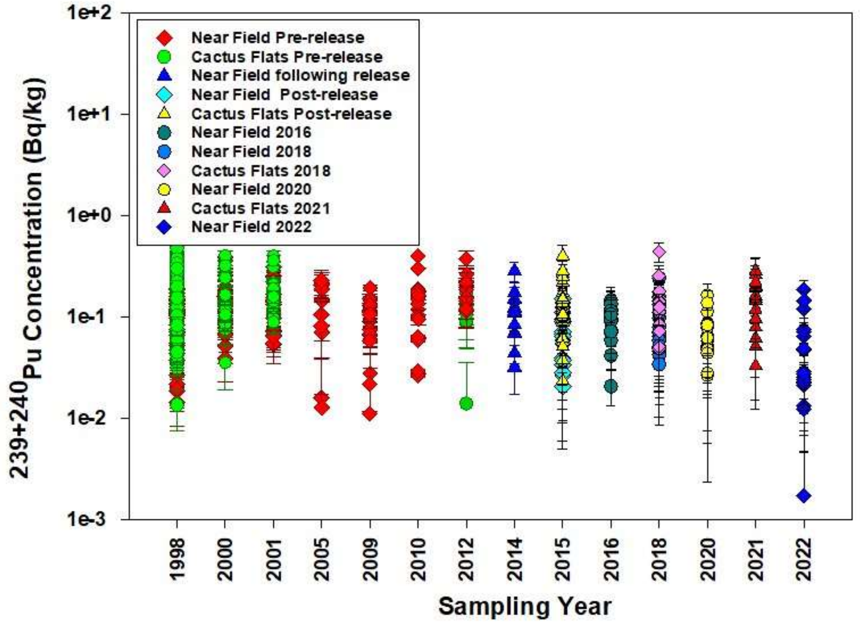


Figure 4.3. Historical Concentrations of $^{239+240}$Pu in WIPP Soil

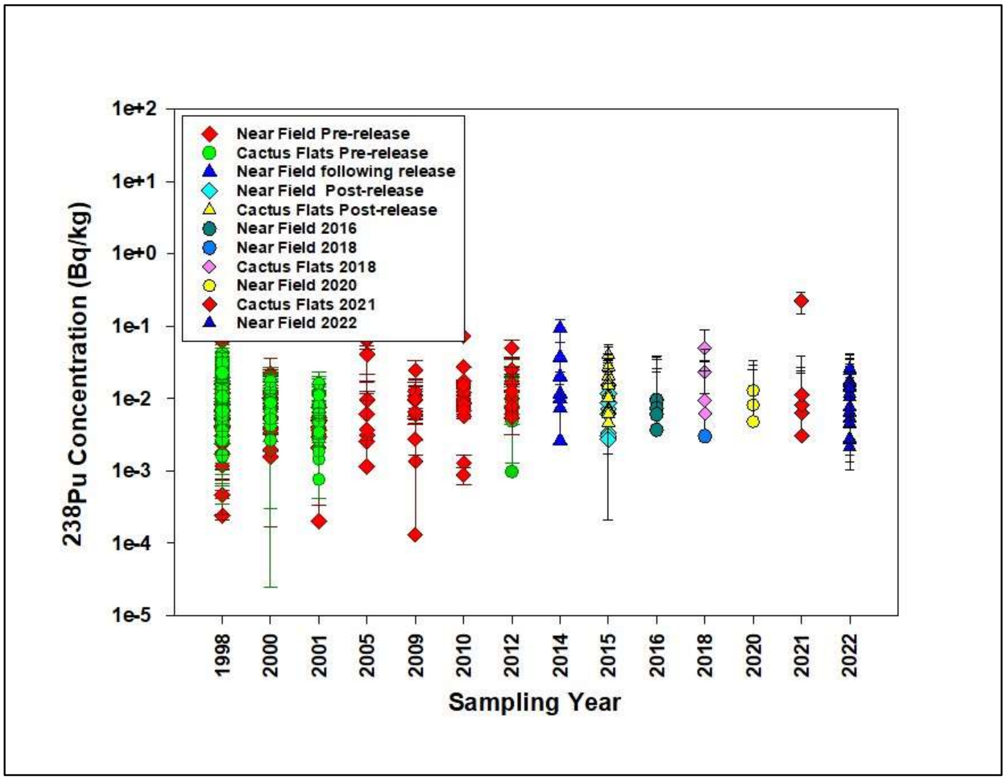


**Figure 4.4. Historical Concentrations of $^{238}$Pu in WIPP Soil**

## 4.3.2 Uranium concentrations in WIPP Soil

The naturally occurring isotopes of U were detected in most soil samples. The uranium concentration data for individual soil samples are shown in Figure 4.5 and Figure 4.6. The $^{234}$U concentrations in the Near Field ranged from 0.80 to 9.61 Bq/kg, with a mean value of 4.38 Bq/kg, while that for $^{238}$U ranged from 0.79 to 7.57 Bq/kg, with a mean value of 4.30 Bq/kg. These values are consistent with the values measured previously from the Near Field. Figure 4.4 shows the historical concentrations of $^{234}$U and $^{238}$U in WIPP soil since 1998. The uranium concentration in soil varies widely but typically contains about 74 Bq/kg (3 ppm). The calculated $^{234}$U/$^{238}$U activity ratio in the vicinity of WIPP soil varied between 0.92 and 1.52 with an average value of 1.02±0.18 for the Near Field soils. Figure 4.6 shows the variation in the $^{234}$U/$^{238}$U ratio in the soil samples collected from the Near Field grid during 2015-2018 and the Cactus Flats grid during 2015 and 2018. The $^{234}$U/$^{238}$U activity ratio obtained indicated that these two uranium isotopes are in the state of secular radioactive equilibrium.

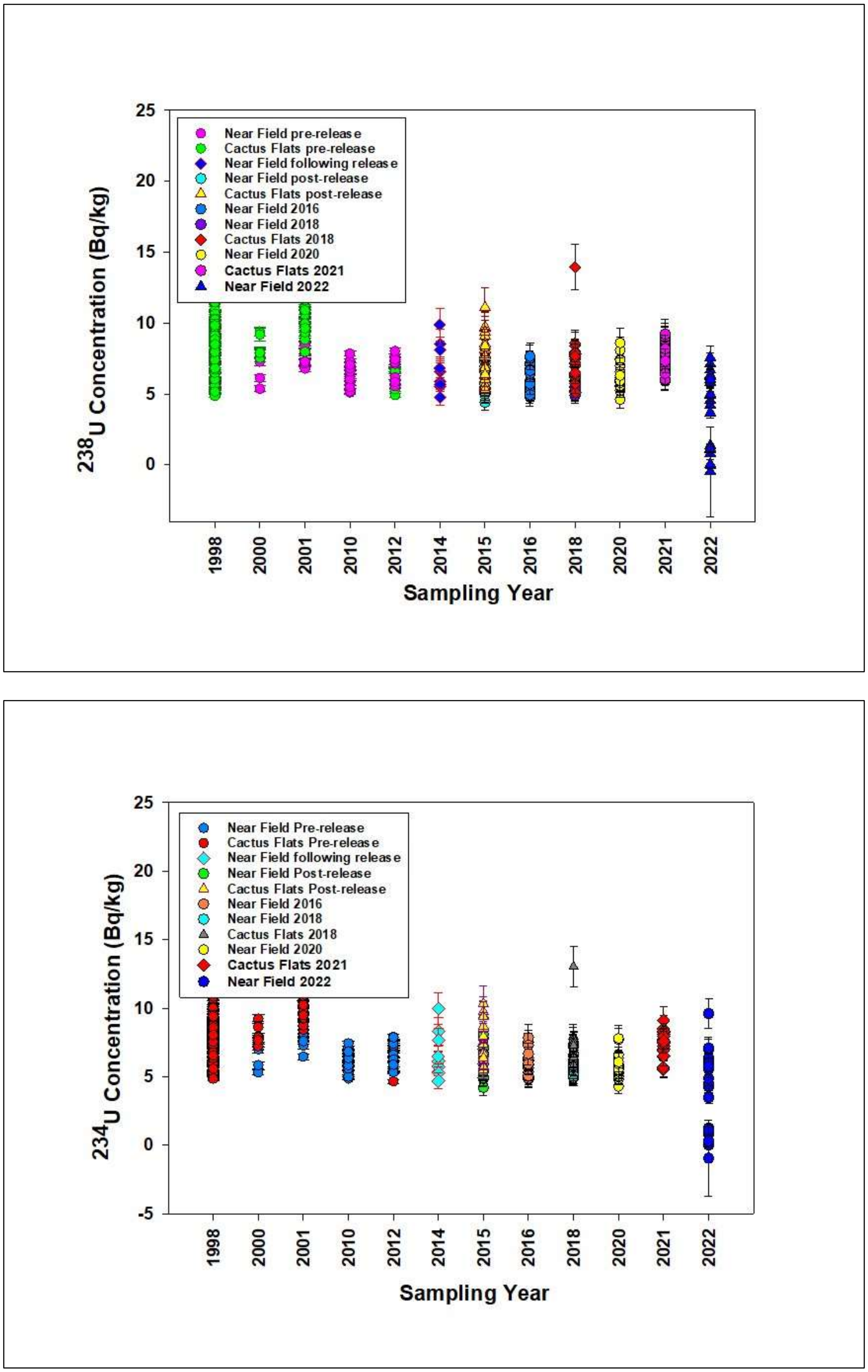
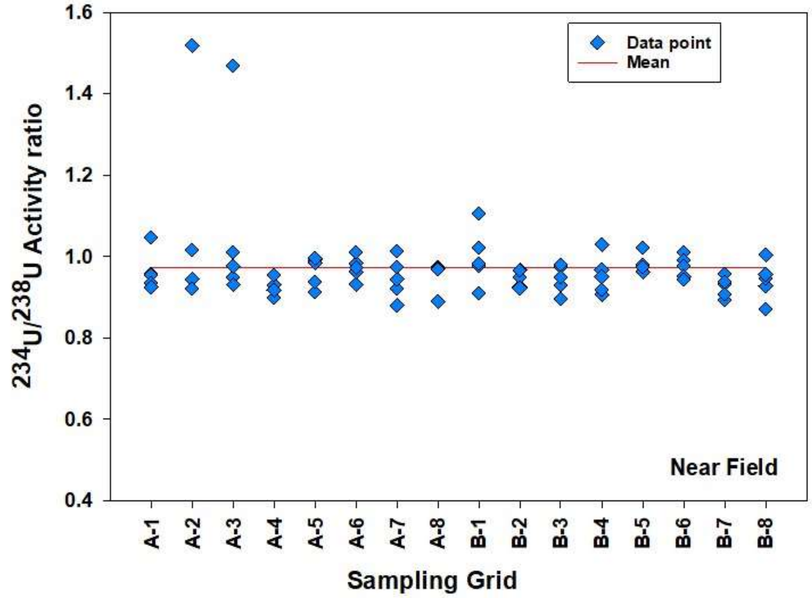


**Figure 4.5. Historical Concentrations of $^{238}$U and $^{234}$U in WIPP Soil**



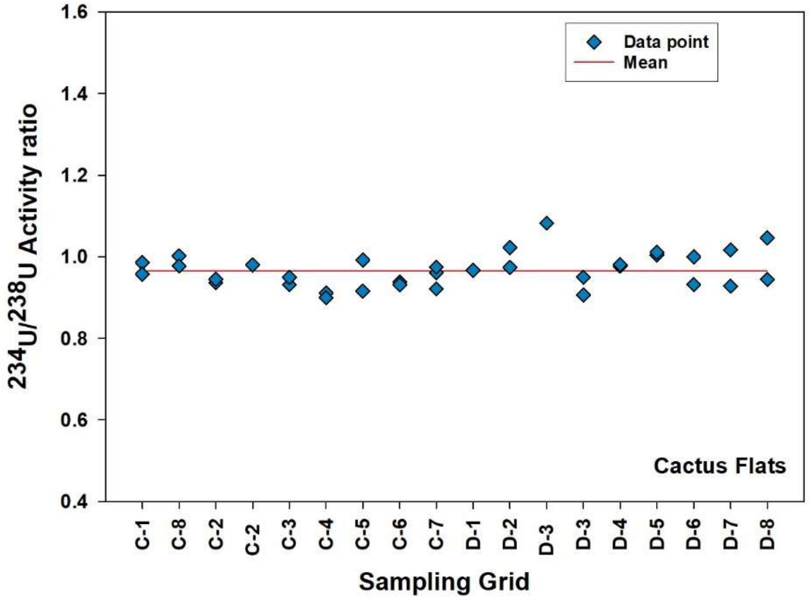
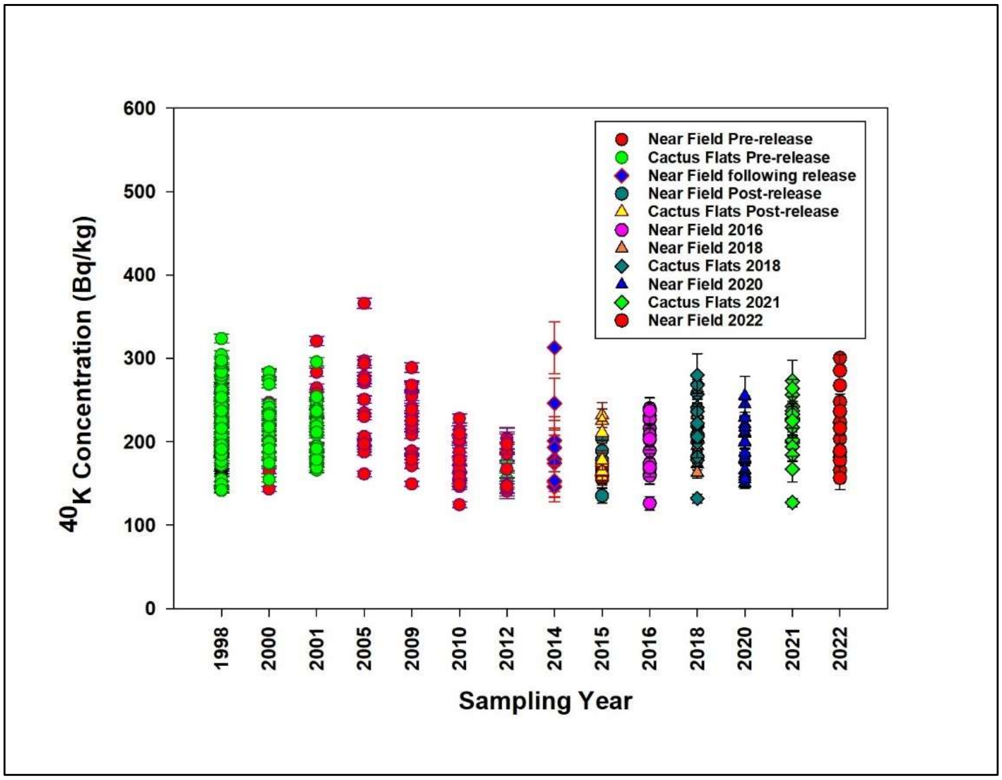


Figure 4.6. The $^{234}U/^{238}U$ Activity Ratio in WIPP Soil During 2015-2021

### 4.3.3 Gamma Radionuclide Concentrations in WIPP Soil

The concentrations of gamma-radiation-emitting radionuclides in the WIPP soil are presented in Figure 4.7 . The isotope $^{137}$Cs was detected in all soil samples except for one site in grid A and one site in grid B. The concentration of $^{137}$Cs in the Near Field soil ranged from -2.57 to 361 Bq/kg, with a mean value of 18.9 Bq/kg. Except for one site in grid B with a concentration of 361 Bq/kg, the variability in the $^{137}$Cs concentrations was not very significant in the other samples and with the exception of that single soil sample, the maximum concentration was 5.46 Bq/kg. Although $^{137}$Cs is a fission product, it is ubiquitous in soils because of global fallout from atmospheric weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). The $^{40}$K isotope was detected in all soil samples. The $^{40}$K concentrations in the Near Field soil ranged from 156 to 392 Bq/kg, with a mean value of 237 Bq/kg. Like $^{137}$Cs, the $^{40}$K is a naturally occurring gamma-radiation-emitting radionuclide and is ubiquitous in soils. There was no significant difference between concentrations of $^{137}$Cs and $^{40}$K among sampling locations, and the values fell within the range of concentrations previously observed in WIPP soils.

The $^{60}$Co isotope was not detected at any sampling locations. Historical plots of $^{40}$K and $^{137}$Cs concentrations in WIPP soil are shown in Figure 4.7. The concentrations have remained relatively constant over the past 10+ years and generally indicate worldwide fallout. Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected.



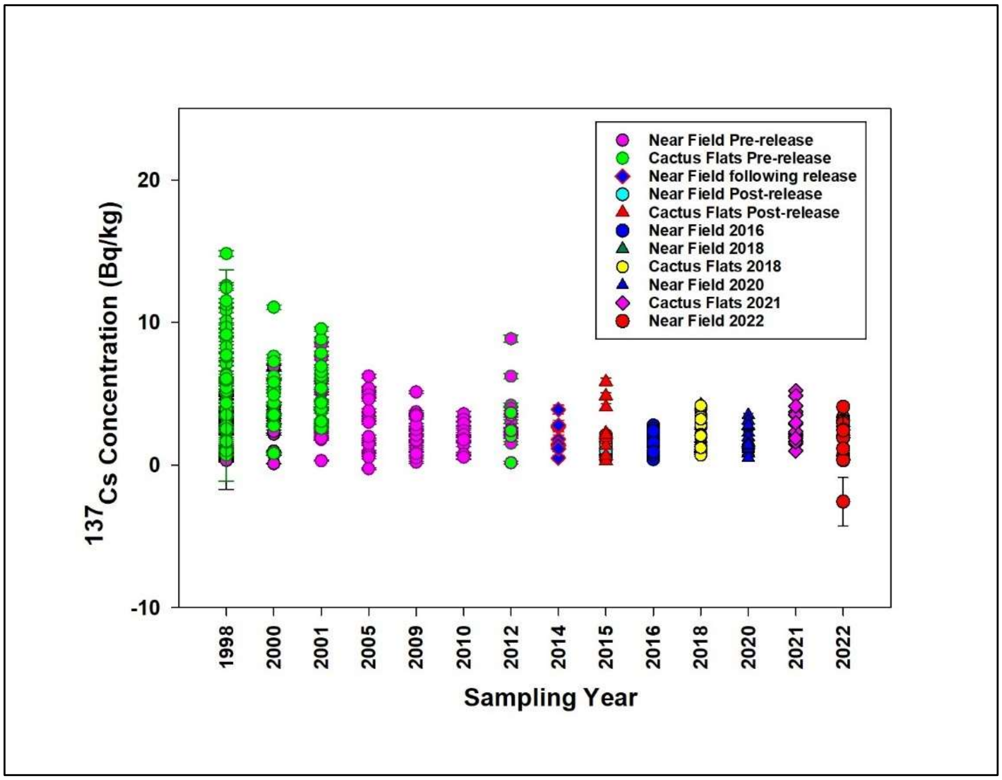


**Figure 4.7. Historical Concentrations of $^{40}$K and $^{137}$Cs in WIPP Soil**

### 4.3.4 Strontium Concentrations in WIPP Soil

The beta-radiation-emitting radionuclide $^{90}$Sr was not detected in any of the soil samples except for two sites in grid A and one WIPP site with concentration of 76.9, 73.5, and 90.7 Bq/kg, respectively.

## 4.4 Conclusions

This chapter summarizes the results of the soil-monitoring program for the calendar year 2022. The $^{239+240}$Pu concentration in the Near Field ranged from 0.002 to 0.187 Bq/kg. Isotopes of uranium were also detected in all soil samples with $^{234}$U/$^{238}$U ratio close to unity (1.0) at both locations, indicating these two uranium isotopes are in secular equilibrium. The $^{241}$Am isotope was detected in only a few of the grid B soil samples. The isotope $^{238}$Pu and the beta-radiation-emitting radionuclide $^{90}$Sr were not detected in most of the soil samples.

The gamma-radiation-emitting radionuclide $^{137}$Cs was detected in most soil samples, and $^{40}$K was detected in all soil samples. The radionuclide concentrations in the Near Field location ranged from -2.57 to 361 Bq/kg for $^{137}$Cs and 156 to 392 Bq/kg for $^{40}$K. Furthermore, there is no apparent difference between the concentrations of the radionuclides in soil collected before and after WIPP started receiving TRU waste. The monitoring results indicate no evidence of an increase in soil radionuclide concentrations that can be attributed to the 2014 radiation release event at the WIPP or the normal operations of the WIPP.

# CHAPTER 5 - SURFACE WATER MONITORING

The term "surface water" refers to water found in watercourses, lakes, or wetlands, including water that has naturally precipitated or risen to the surface from underground sources (groundwater). Examples of surface water include rivers, lakes, streams, ponds, wetlands, and oceans. The retention of radionuclide fallout by catchment soils, as well as sediments in rivers and lakes, plays a significant role in determining the subsequent transport of radioactive substances in aquatic systems. In the case of rivers and small lakes, radioactive contamination primarily arises from the erosion of surface soil layers within the watershed that then run off into the water bodies. Additionally, deposition of radioactive materials can also occur on water surfaces. The fraction of a radionuclide that adsorbs to suspended particles, which can vary considerably in surface waters, strongly influences both its transport and bioaccumulation.

Routine collection and analysis of surface water samples have been carried out in the vicinity of the WIPP site since the inception of WIPP's environmental monitoring program to assess any potential impacts of WIPP operations on the aquatic environment. The current monitoring efforts require annual collection of surface water samples from three regional reservoirs located along the Pecos River, situated at a considerable distance from the WIPP site. These reservoirs include Brantley Lake, approximately 55 km (34 miles) north-northwest of the WIPP site; Red Bluff Lake on the Pecos River, with the upstream end located approximately 48 km (30 miles) southwest of the WIPP site, and Lake Carlsbad, situated in the center of Carlsbad, approximately 40 km (25 miles) northwest of the WIPP site. The Pecos River is the primary surface water body in the vicinity of the WIPP site and is used for various recreational activities, such as fishing, boating, water skiing, and swimming. In addition to these large bodies of water, samples are also collected from three small tanks that are used by livestock. These tanks might vary from year to year. Radiological analyses are conducted to quantify gamma-emitting radionuclides and actinides of concern. Further details regarding sample collection and analyses are described in subsequent sections. This chapter presents the results of radiological analyses conducted on surface water samples collected in 2022.

## 5.1 Sample Collection

Surface water samples were collected from the three public water reservoirs in the area, Lake Carlsbad, Brantley Lake, and Red Bluff Lake as shown in Figure 5.1. At each sampling location, one sample was collected from the surface (~ 0.5 to 1 m depth) and a second sample from approximately 0.5 to 1 m above the sediment bed. In addition, water samples were collected from three tanks that are used as sources of water for livestock, namely Hill, Noya, and Lost Tanks. Surface water from each sampling location was collected in 5-gallon plastic water bottle jugs. Water from each sampling location was used to rinse containers at least three times prior to taking the sample. Approximately 8 L of surface water was collected from each location as shown in Figure 5.2.

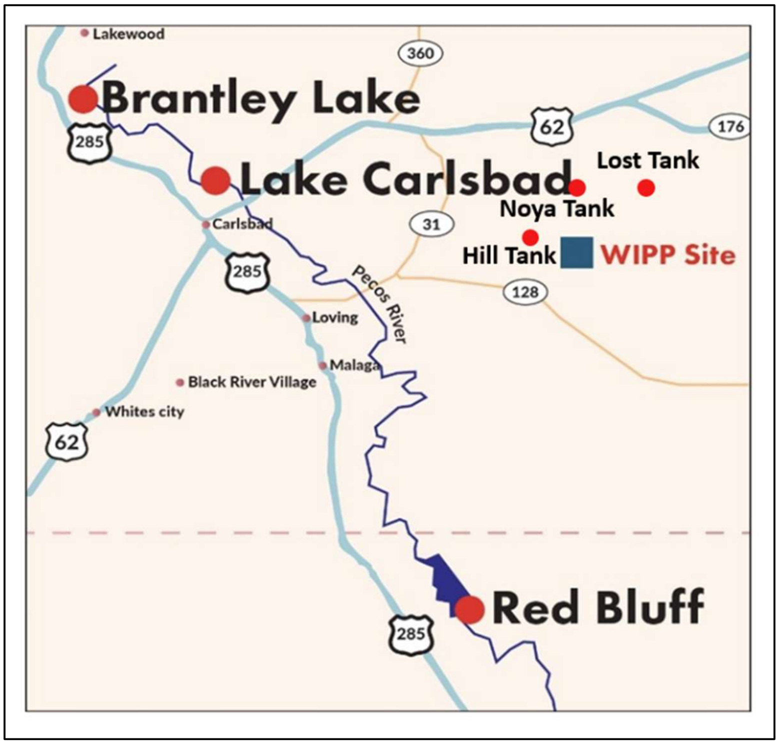


**Figure 5.1. Surface Water Sampling Locations in the Vicinity of the WIPP Site**

**Figure 5.2. Surface Water Sample Collection from the Brantley Lake by CEMRC Personnel**

## 5.2 Sample Preparation and Analysis

In the laboratory, surface water samples collected for radiological analyses were acidified with nitric acid ($HNO_3$) to a pH < 2 and the sample containers were shaken to distribute suspended material evenly. One 2 L portion was used for gamma spectroscopy and another 1 L portion was used for sequential analysis of the uranium/transuranic isotopes.

## 5.3 Determination of Individual Radionuclides

The first aliquot was transferred to 2 L Marinelli beakers for the measurement of the gamma-emitting radionuclides potassium ($^{40}$K), cobalt ($^{60}$Co), and cesium ($^{137}$Cs) by gamma spectroscopy using a high purity germanium (HPGe) detector. Before collecting the measurements, the gamma system was calibrated for energy and efficiency to enable both qualitative and quantitative analysis of the water samples. The energy and efficiency calibrations were carried out using a mixed standards material from Eckert & Ziegler Analytics Inc (Atlanta, GA) in the energy range between 60 to 2000 keV for a 2 L Marinelli geometry. The counting time for each sample was 48 hours.

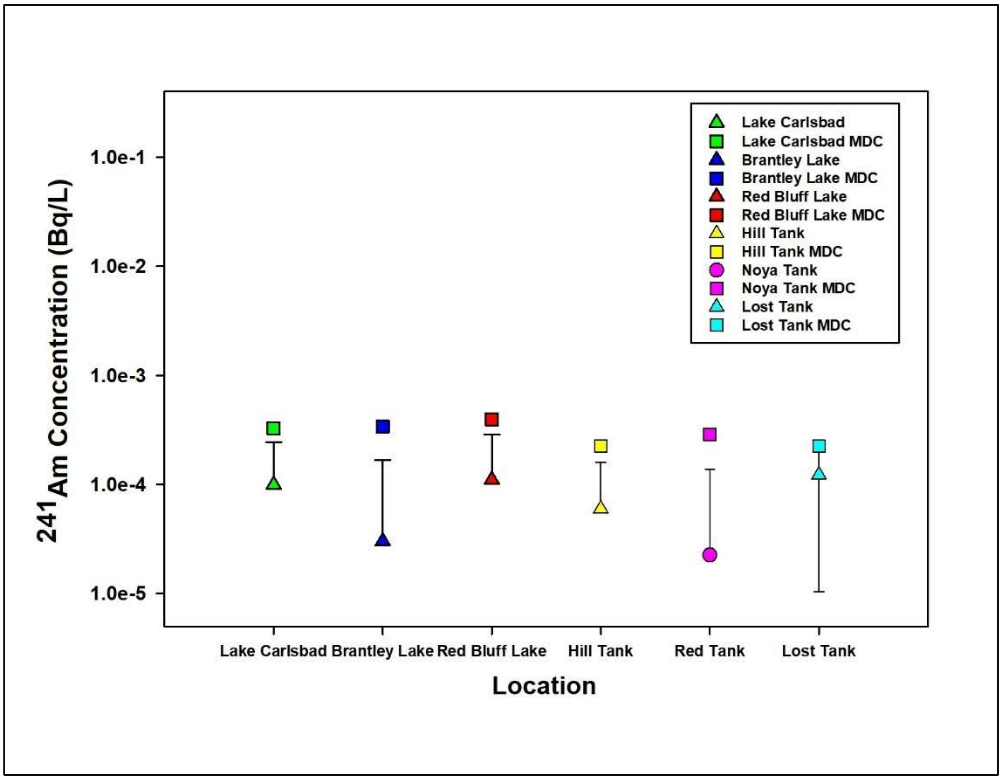
The second, 1 L aliquot, was used for actinide analyses. Tracers consisting of uranium, americium, and plutonium ($^{232}$U, $^{243}$Am, and $^{242}$Pu) were added to the samples and the samples were digested using concentrated nitric acid and 30% hydrogen peroxide ($H_2O_2$) on a hot plate until sample volume was reduced to 100-150 mL. The actinides are separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. The oxidation state of plutonium was adjusted by adding 1 mL of 1.0 M ammonium iodide ($NH_4I$) with a 10 min wait step, followed by 2 mL of 2 M sodium nitrite ($NaNO_2$). Plutonium isotopes were then separated and purified using a two-column anion exchange resin (Dowex 1-× 8, 100-200 mesh), while TRU chromatography columns were used for the separation of Am and U. The samples were then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for 5 days. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}$Sr is subsequently measured using liquid scintillation counting.

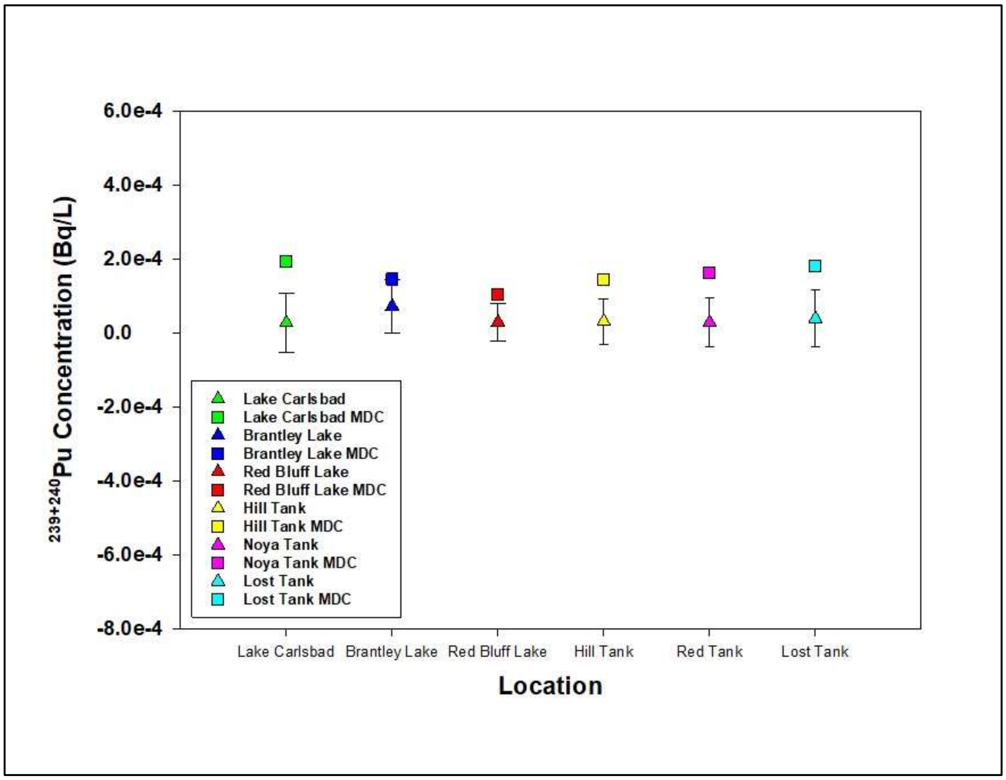
## 5.4 Results and Discussion

The activities of the actinides and gamma-radiation-emitting radionuclides were reported as activity concentration in Bq/L. Activity concentration is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by volume of the surface water in liters (L).

### 5.4.1 Actinide Concentrations in Surface Water

The concentrations of $^{241}$Am, $^{238}$Pu, and $^{239+240}$Pu in regional surface water samples in 2022 are listed in Appendix D, Table D.1. The alpha-radiation-emitting radionuclides $^{241}$Am, $^{238}$Pu, and $^{239+240}$Pu were not detected in any of the surface water samples in 2022, which is consistent with the results of the previous years. The individual concentrations of $^{241}$Am, $^{238}$Pu, and $^{239+240}$Pu measured in the three reservoirs are shown in Figure 5.3. These results are consistent with no measurable impact of WIPP-related activities to the regional reservoirs or other sources of water.


Lake Carlsbad
Lake Carlsbad MDC
Brantley Lake
Brantley Lake MDC
Red Bluff Lake
Red Bluff Lake MDC
Hill Tank
Hill Tank MDC
Noya Tank
Noya Tank MDC
Lost Tank
Lost Tank MDC
1.0e-1
1.0e-2
1.0e-3
1.0e-4
1.0e-5
241Am Concentration (Bq/L)
Lake Carlsbad
Brantley Lake
Red Bluff Lake
Hill Tank
Red Tank
Lost Tank
Location


6.0e-4
4.0e-4
2.0e-4
0.0
-2.0e-4
-4.0e-4
-6.0e-4
-8.0e-4
239+240Pu Concentration (Bq/L)
Lake Carlsbad
Lake Carlsbad MDC
Brantley Lake
Brantley Lake MDC
Red Bluff Lake
Red Bluff Lake MDC
Hill Tank
Hill Tank MDC
Noya Tank
Noya Tank MDC
Lost Tank
Lost Tank MDC
Lake Carlsbad
Brantley Lake
Red Bluff Lake
Hill Tank
Red Tank
Lost Tank
Location

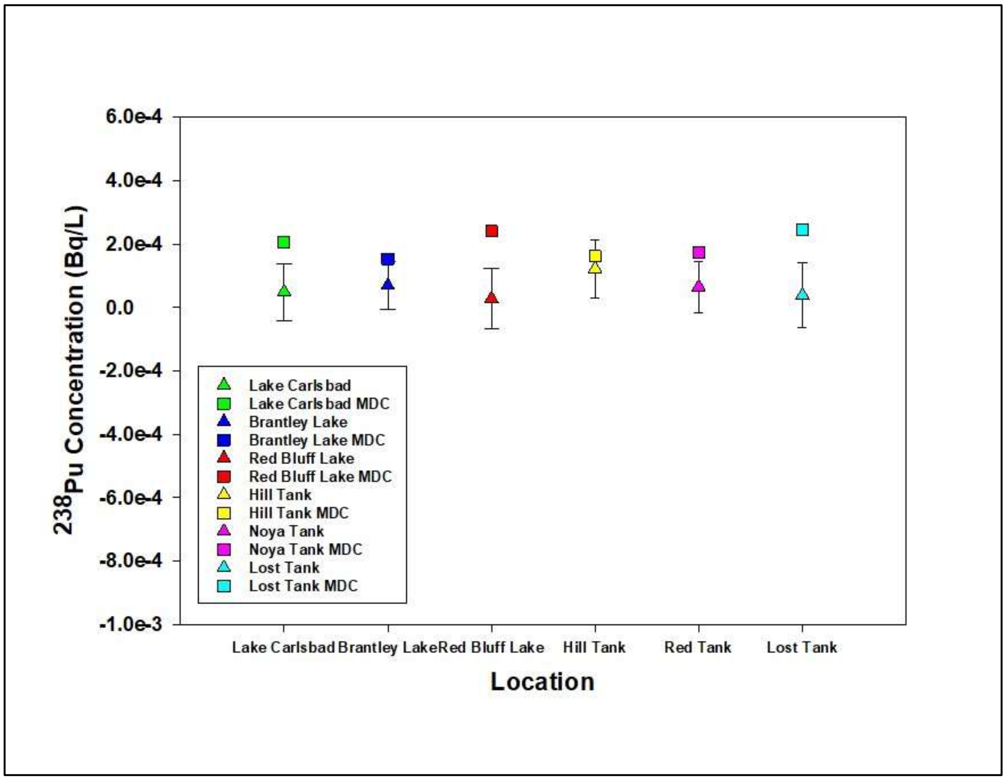


**Figure 5.3.** $^{241}$**Am (top),** $^{239+240}$**Pu (middle), and** $^{238}$**Pu (bottom) Concentrations in Surface Water Samples in Three Regional Reservoirs and Three Regional Tanks in 2022**

## 5.4.2 Uranium Concentrations in Surface Water

Isotopes of naturally occurring uranium were detected in all the surface water samples in 2022, except Red Bluff deep surface water sample for $^{234}$U. Uranium concentrations measured in the three regional reservoirs and the three tanks near the WIPP site were in the range of 3.43-41.9 mBq/L for $^{238}$U, 0.17-2.32 mBq/L for $^{235}$U, and 4.45-84.0 mBq/L for $^{234}$U. The individual concentrations of these radionuclides measured in the three reservoirs and three tanks in 2022 are listed in Appendix D, Table D.2. The concentration ranges for these isotopes showed no significant difference between baseline and monitoring phases (CEMRC Report, 1998). The concentrations of the uranium isotopes were also compared between 2015 and 2017 and between sampling locations. There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2015, 2017 and 2022. These observations further support our conclusion that there is no evidence of increases in radiological contaminants in the region that could be attributed to releases from WIPP. No significant difference between the baseline and monitoring phase concentrations was observed.

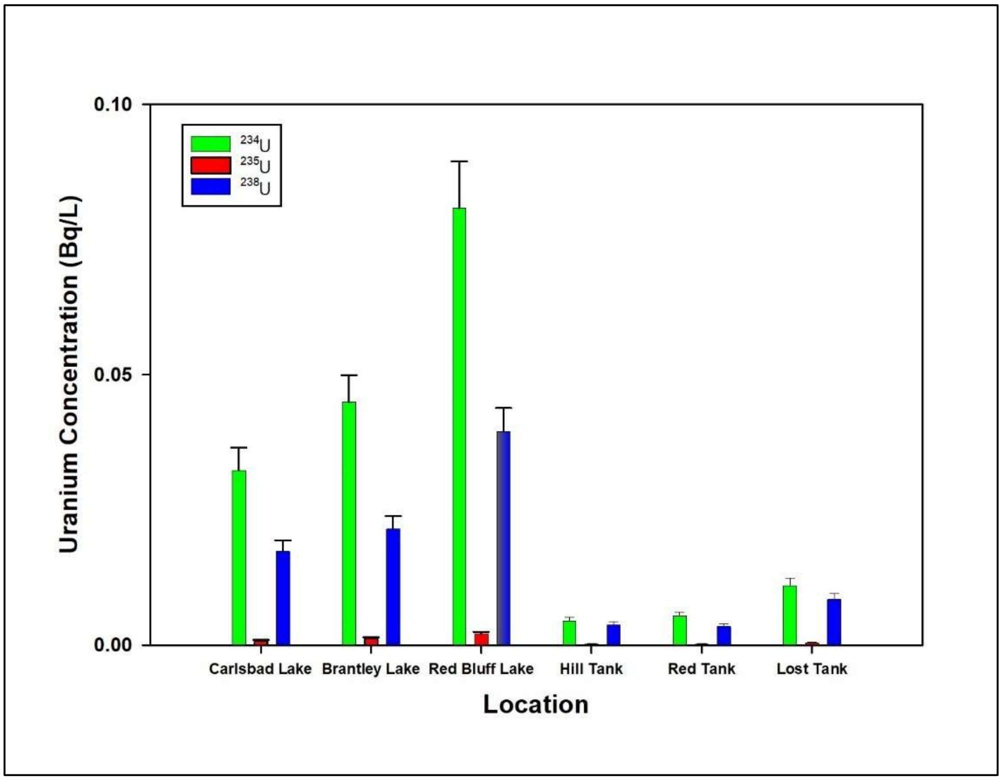


**Figure 5.4. Uranium Concentrations in Surface Water Samples in Three Regional Reservoirs and Three Tanks in 2022**

The average $^{234}U/^{238}U$ isotopic ratios were similar for these three reservoirs. The reservoirs appeared to be slightly enriched in $^{234}U$ compared to $^{238}U$, with the average activity ratios ranging from 1.87 (Lake Carlsbad) to 2.10 (Brantley Lake), while the isotopic ratios were lower in the three tanks, ranging from 1.19 in the Hill Tank to 1.56 in the Red Tank (Figure 5.5). In natural bodies of water these isotopes do not occur in equilibrium, and, with a few exceptions, waters typically contain more $^{234}U$ than $^{238}U$ (Cothern et al. 1983; Skwarzec et al. 2002). Higher activity of $^{234}U$ in water is the result of the $^{234}U$ atom displacement from the crystal lattice. The recoil atom, $^{234}U$, is liable to be oxidized to the hexavalent stage and can be leached into the water phase more easily than its parent nuclide $^{238}U$. The oxidation of U(IV) to U(VI) is an important step in leaching, because compounds containing U(VI) have a higher solubility due to the formation of strong complexes between uranyl and carbonate ions (UNSCEAR, 1977). All U(IV) compounds of uranium are practically insoluble.

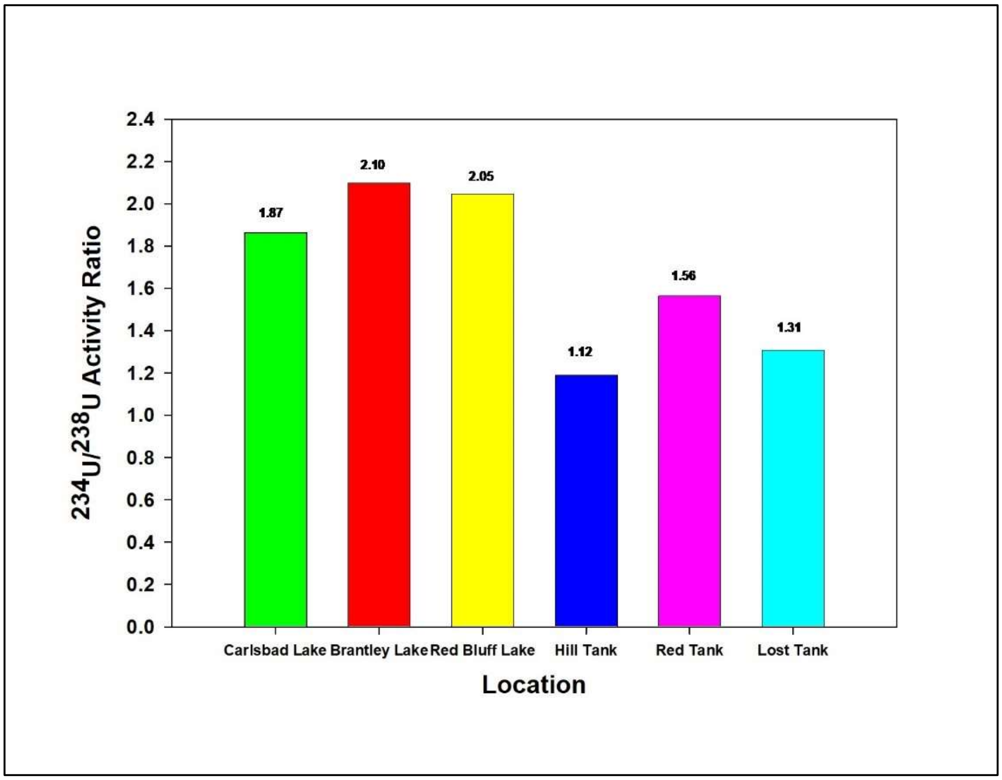


**Figure 5.5. The $^{234}U/^{238}U$ Activity Ratio in Surface Water Samples of Three Reservoirs and Three Tanks in the Vicinity of the WIPP Site**

### 5.4.3 Gamma Radionuclide Concentrations in Surface Water

The gamma-radiation-emitting radionuclides$^{137}Cs$, $^{60}Co$ , and $^{40}K$ were not detected in any of the surface water samples in 2022, as can be seen in Appendix D, Table D.3.

### 5.4.4 Strontium Concentrations in Surface Water

The beta-radiation-emitting radionuclide $^{90}Sr$ was not detected in any of the surface water samples collected in 2022, as can be seen in Table D.4.

## 5.5 Conclusions

This chapter summarizes the results of the surface water monitoring program for the calendar year 2022. It is important to note that after more than twenty years of monitoring, isotopes of plutonium ($^{238}Pu$ and $^{239+240}Pu$) and $^{241}Am$, have never been detected above MDC in all surface water samples . However, the isotopes of uranium $^{234}U$, $^{238}U$, and $^{235}U$ were detected in all surface water samples. The concentrations of uranium measured were in the range of 3.43-41.9 mBq/L for $^{238}U$, 0.17-2.32 mBq/L for $^{235}U$, and 4.45-84.0 mBq/L for $^{234}U$. The levels detected were well below the EPA recommended level of 746 mBq/L for drinking water and are within the range expected in waters from this region. The $^{234}U/^{238}U$ activity ratio indicates the U presence in surface water is most likely from natural sources. The gamma emitting radionuclides$^{137}Cs$, $^{60}Co$ , and $^{40}K$ were not detected in any of the surface water samples in

2022. In addition, the $^{90}$Sr radionuclide was not detected in any of the surface water samples in 2022. Present results, as well as the results of previous analyses of surface water, were consistent for each source across sampling periods. The 2022 monitoring results continue to show no evidence of any release from the WIPP contributing to radionuclide concentrations in the environment.

# CHAPTER 6 - DRINKING WATER MONITORING

Drinking water must be safe enough to be consumed by humans or to be used with a low risk of immediate or long-term impact on human health. For this reason, the quality of drinking water available in the area surrounding the WIPP site is routinely checked to assure the public that health and environmental standards are met and to identify any changes in water quality that might negatively impact public health or the environment. Aquifers in the region surrounding the WIPP site include Dewey Lake, the Culebra-Magenta, the Ogallala, the Dockum, the Pecos River alluvium, and the Capitan Reef (Mercer, 1983). The main Carlsbad water supply is the Sheep Draw well field, whose primary source is the Capitan Reef aquifer. The Ogallala aquifer feeds the Hobbs and WIPP (Double Eagle PRV4 formerly Double Eagle) public water supply systems. The Pecos River provides the Loving, Malaga, and Otis public water supply wells.

In 1974, the United States Congress passed the Safe Drinking Water Act. This law requires the U.S. Environmental Protection Agency (EPA) to determine safe levels of contaminants in U.S. drinking water. This safe level is called the maximum contaminant level (MCL). MCLs in drinking water have been established for a variety of radionuclides. The MCL has been set at 0.185 Bq/L (5pCi/L) for radium, while the uranium MCL has been set at 30 µg/L. The MCL for gross alpha radiation is 0.55 Bq/L (15pCi/L) (not including radon and uranium), and the maximum level for gross beta radiation is 1.85 Bq/L (50 pCi/L). It is important to note that the focus of this report is to monitor the impact of WIPP operations on the regional drinking water supplies and should not be used in assessing regulatory compliance.

CEMRC has been sampling drinking water for radiochemical analyses since 1997 and performing non-radiological analyses on drinking water since 1998. Summaries of methods, data, and results from previous samplings were reported in earlier CEMRC reports and can be found on the CEMRC website (http.//www.cemrc.org) under the annual reports tab. The scope of work requires drinking water samples to be collected annually from the six municipal water supply systems in the vicinity of the WIPP, including the City of Carlsbad (Sheep Draw and Double Eagle PRV4), Hobbs, Loving, Malaga, and Otis. These samples are subject to non-radiological and radiological analyses. Radiological analyses are used to quantify gamma-radiation-emitting radionuclides and actinides of concern. Details of the sample collection and analyses are described in the following sections. In this chapter, radiological analysis results are reported for the drinking water samples collected in 2022.

## 6.1 Sample Collection

Drinking water samples were collected from the drinking water supplies used by communities in the WIPP region. The sources included the community water supplies of Carlsbad (Sheep Draw and Double Eagle PRV4), Loving, Otis, Hobbs, and Malaga. These locations are shown in Figure 6.1.

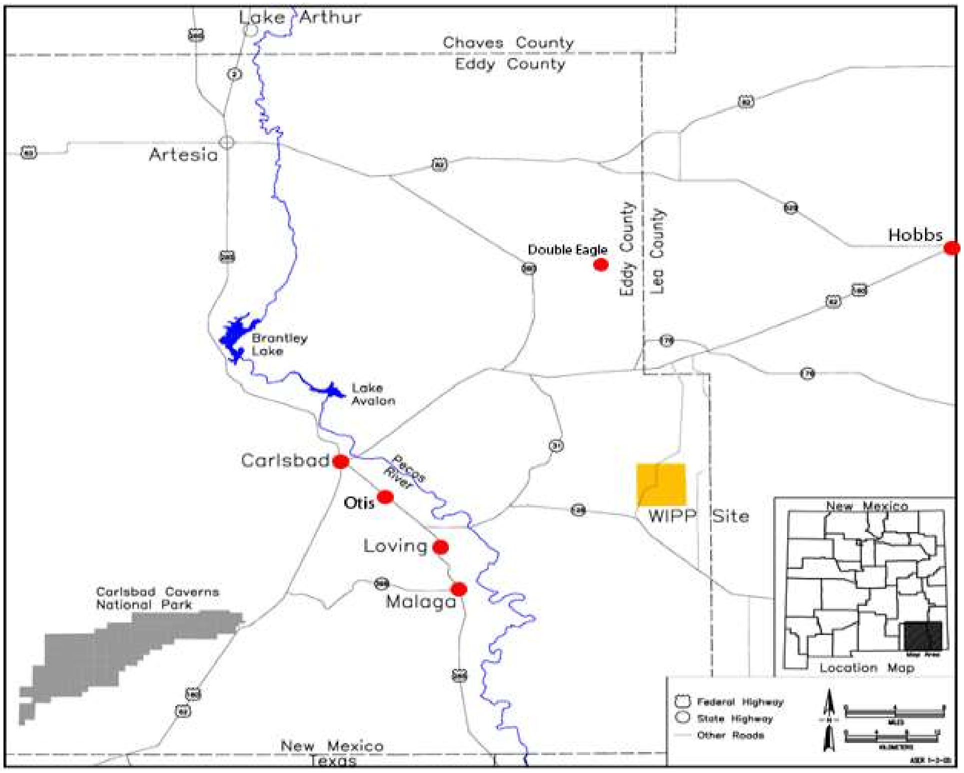


**Figure 6.1. Drinking Water Sampling Locations**

Drinking water from each sampling location was collected in a 5-gallon plastic water bottle. Water from each sampling location was also used to rinse containers at least three times prior to taking the sample. Approximately 8 L of water were collected from each location. Immediately after collection, the samples were acidified to pH ≤ 2 with concentrated nitric acid to avoid losses through microbial activity and adsorption onto the vessel walls.

## 6.2 Sample Preparation and Analysis

Drinking water sample containers were shaken and sample aliquots were measured into glass beakers - one 2 L portion for gamma analyses and another 1 L for alpha analyses. The first aliquot was transferred to 2 L Marinelli beakers to measure the gamma-emitting radionuclides by gamma spectroscopy. The second 1 L aliquot was used for the alpha analysis of uranium (U) and transuranic radionuclides by digesting the water samples with concentrated nitric and appropriate tracers on a hot plate. The samples were heated to dryness then wet-ashed using concentrated nitric acid and 30% hydrogen peroxide. Finally, the samples were heated to dryness, redissolved in 1 M HCl, and processed to separate the various isotopes.

## 6.3 Determination of Individual Radionuclides

A 2 L portion of the acidified water sample in Marinelli beakers was used directly for the gamma spectroscopy to measure the gamma-emitting radionuclides $^{40}$K, $^{60}$Co, and $^{137}$Cs using a high purity germanium (HPGe) detector (Mirion Technologies Inc.) for 48 hours. The other 1 L portion of water was prepared by co-precipitating the target radionuclides and corresponding tracers with an iron carrier, performing ion exchange and chromatographic separations of the individual radionuclides, followed by micro-precipitating the separated radionuclides onto planchets for counting. The uranium isotopes and transuranics were counted using alpha spectroscopy for five days. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}Sr$ is subsequently measured using liquid scintillation counting.

## 6.4 Results and Discussion

The actinide and gamma radionuclide activities are reported as activity concentrations in Bq/L. Activity concentrations are calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the volume of the drinking water in liters (L). All results for all samples collected in 2022 as well as historical data are included in Appendix E, Tables E.1 – E.10.

### 6.4.1 Actinide Concentrations in Drinking Water

The concentrations of $^{238}Pu$, $^{239+240}Pu$, $^{241}Am$, $^{234}U$, $^{235}U$, and $^{238}U$ in regional drinking water samples in 2022 are listed in Appendix E, Table E.1. The alpha-radiation-emitting radionuclides $^{238}Pu$, $^{239+240}Pu$, and $^{241}Am$ were not detected in the drinking water samples in 2022, which is consistent with results from previous years. The historical concentrations of $^{239+240}Pu$, $^{238}Pu$, and $^{241}Am$ measured in the drinking water from the six municipal water supply systems in the vicinity of the WIPP site are shown in Figure 6.2 through Figure 6.7.

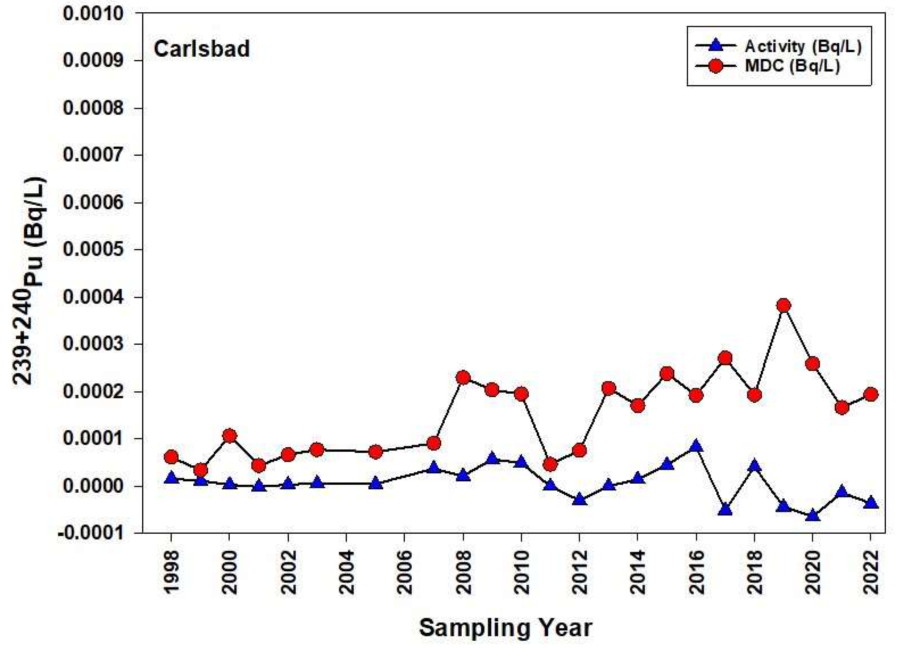
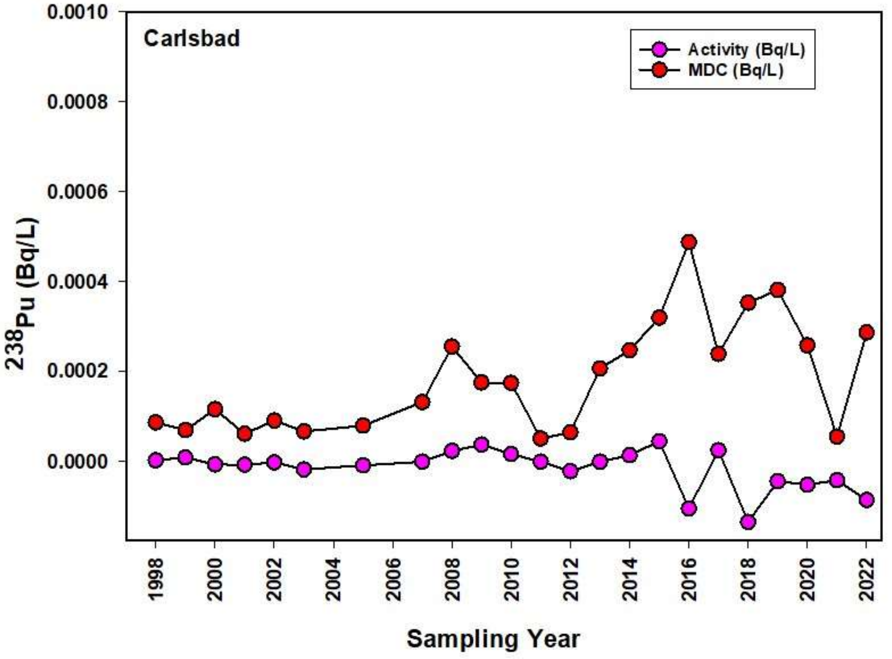


**Figure 6.2.** $^{239+240}$**Pu Concentrations in Carlsbad Drinking Water**



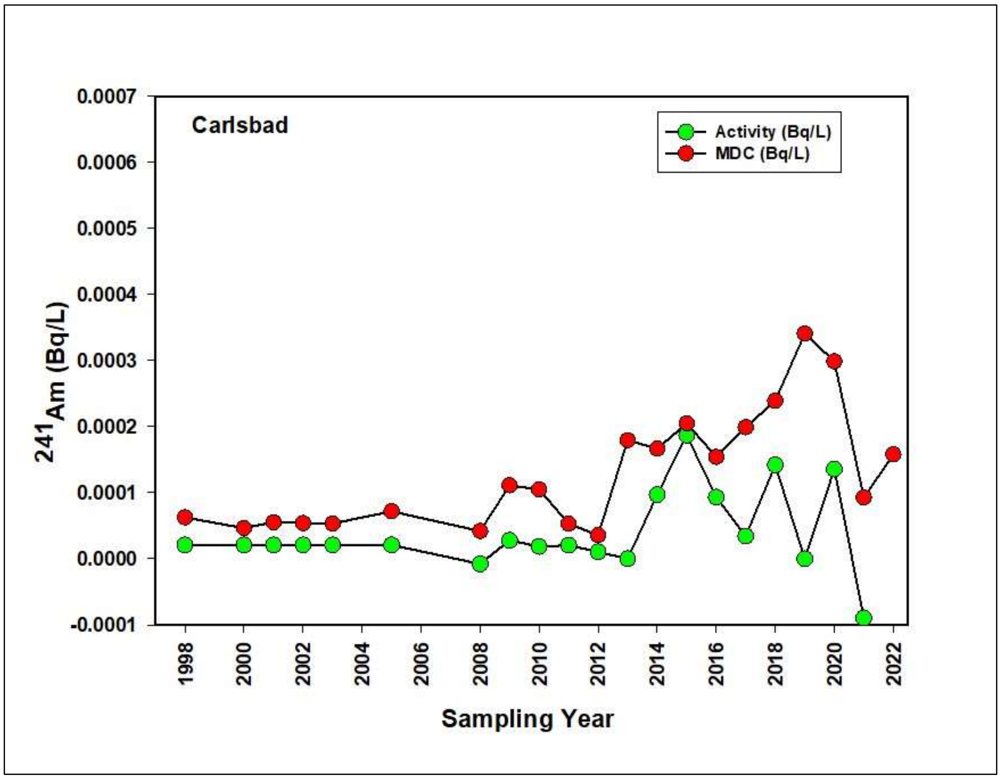
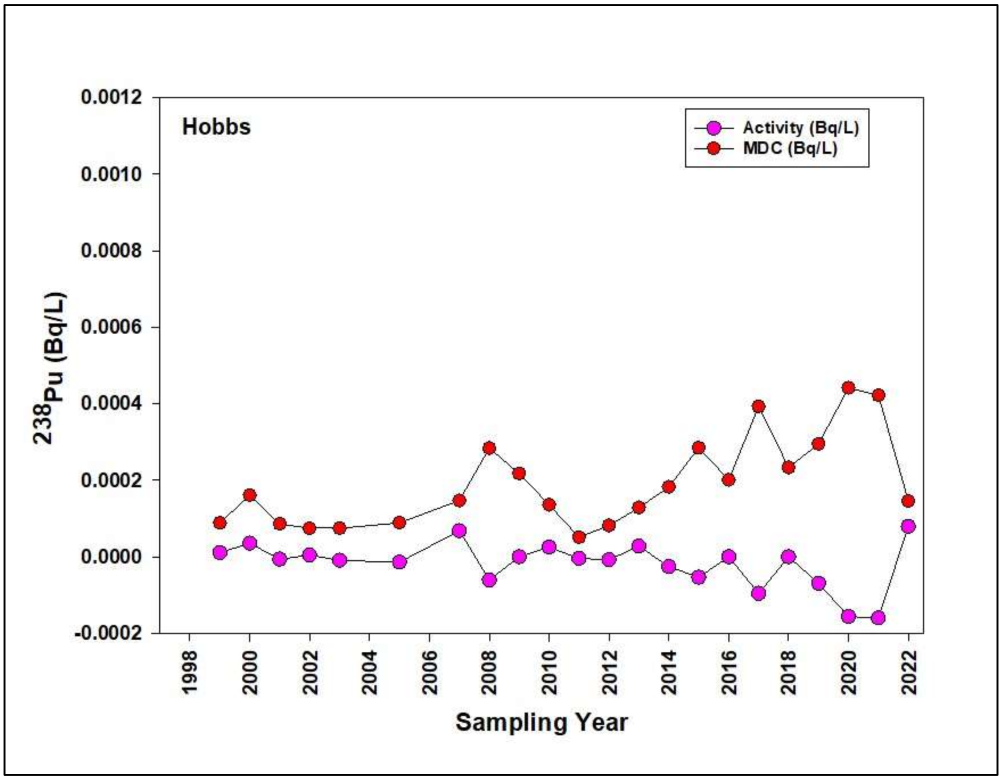


**Figure 6.3.** $^{238}$Pu and $^{241}$Am Concentrations in Carlsbad Drinking Water



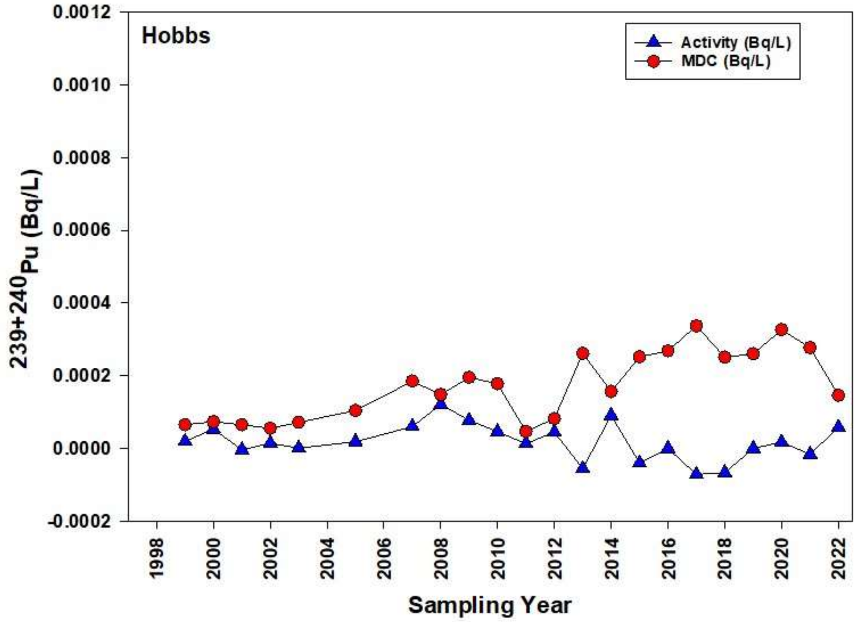
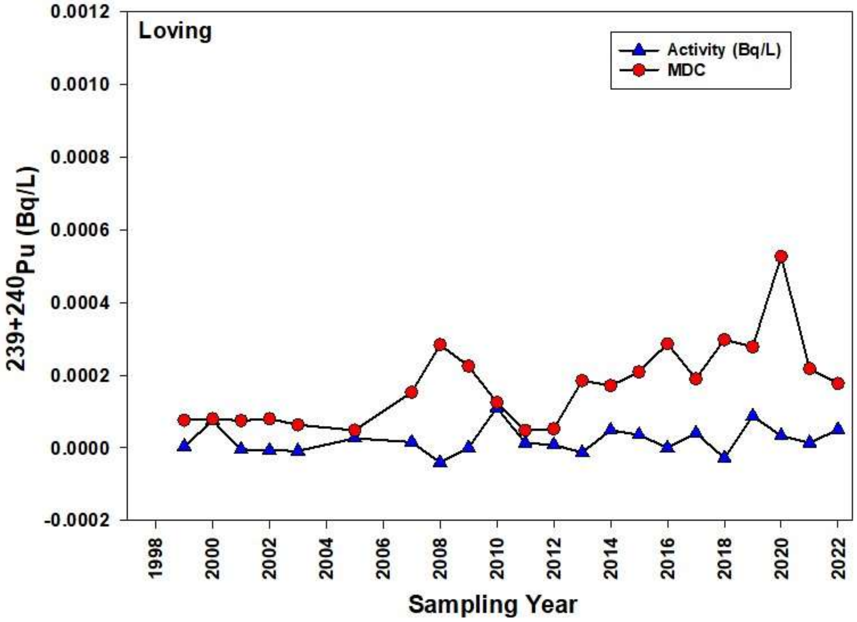


**Figure 6.4.** $^{238}$**Pu and** $^{239+240}$**Pu Concentrations in Hobbs Drinking Water**



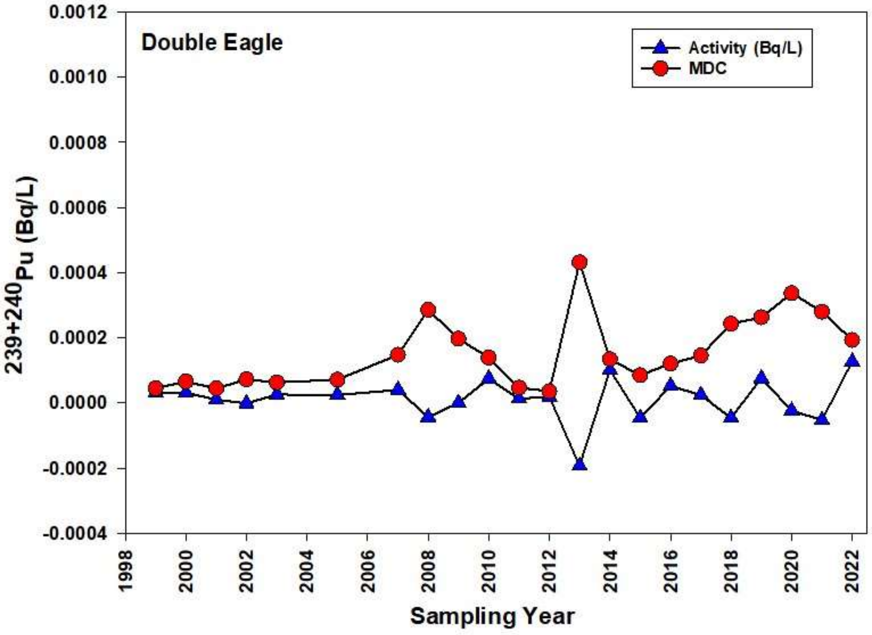
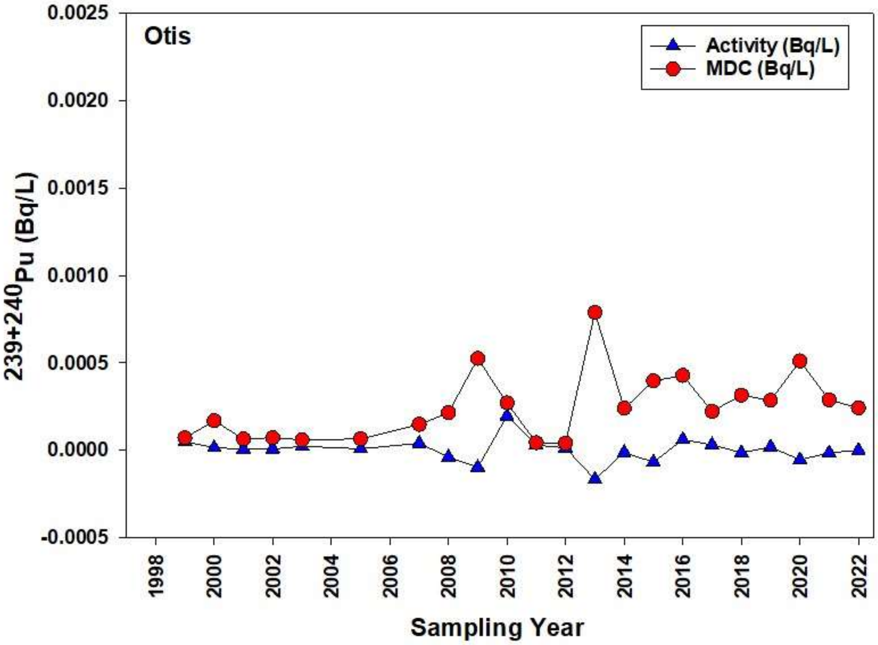


Figure 6.5. $^{239+240}$Pu Concentrations in Loving and Double Eagle Drinking Water



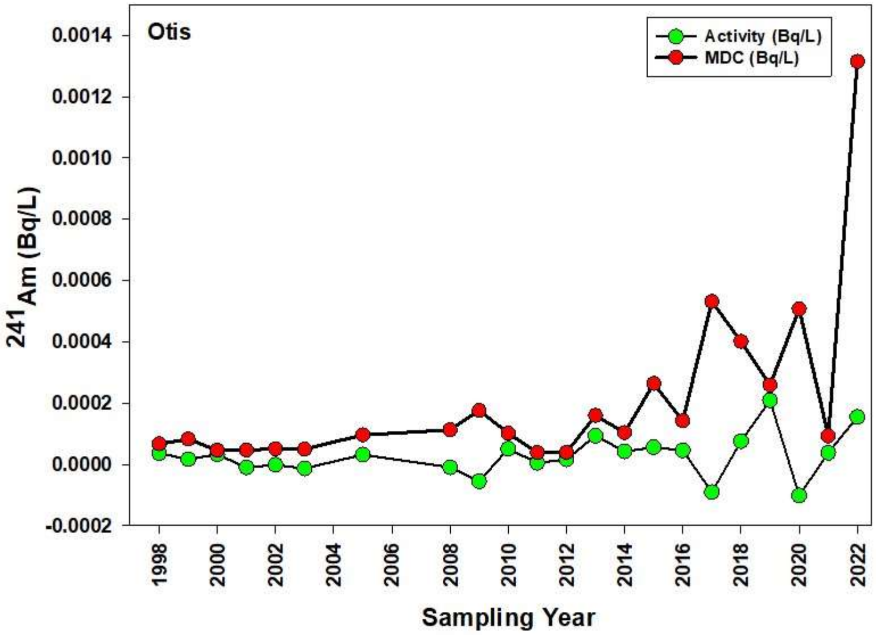
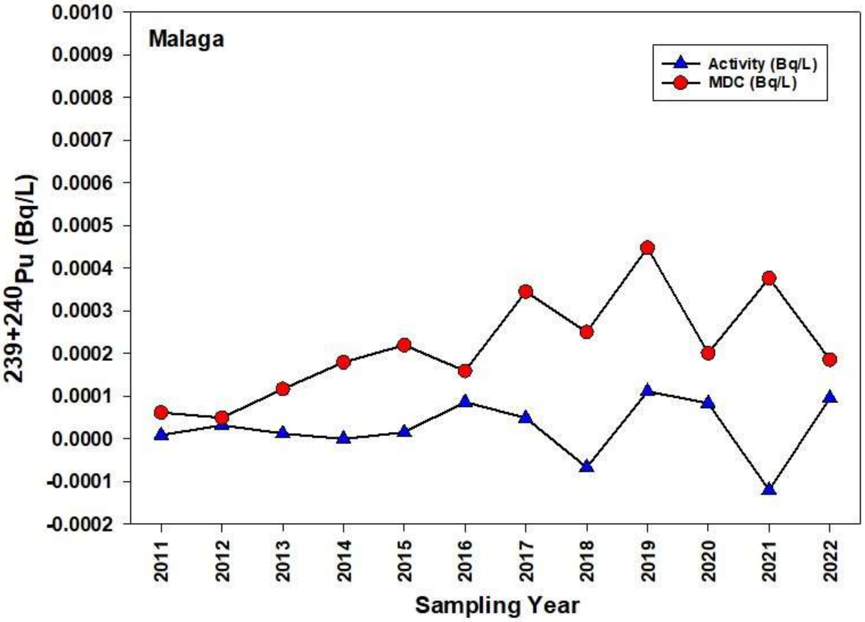


Figure 6.6. $^{239+240}$Pu and $^{241}$Am Concentrations in Otis Drinking Water



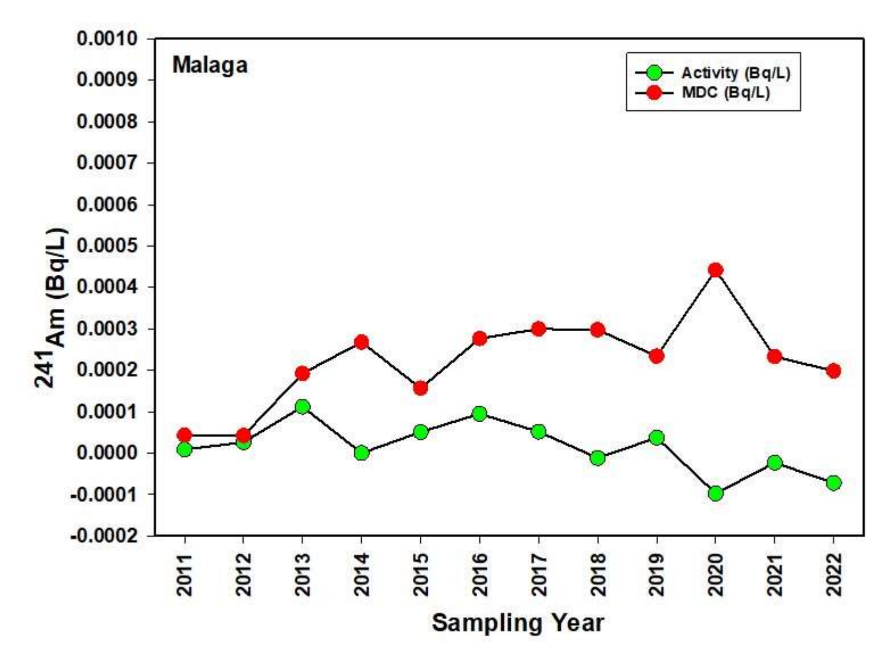


**Figure 6.7.** $^{239+240}$**Pu and** $^{241}$**Am Concentrations in Malaga Drinking Water**

## 6.4.2 Uranium Concentrations in Drinking Water

Isotopes of naturally occurring uranium were detected in all drinking water samples in 2022. Uranium concentrations measured in the communities' drinking water near the WIPP site were in the range of 4.7-46.7 mBq/L for $^{238}$U, 0.26-2.92 mBq/L for $^{235}$U, and 10.3-121.7 mBq/L for $^{234}$U as shown in Appendix E, Table E.2. These uranium activity concentrations are well below the EPA recommended level of 746 mBq/L and are within the range expected in waters from this region. According to the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2008), the $^{238}$U concentration in drinking water is about 0.5-149 mBq/L in the U.S. Cothern and Lappenbusch (1983), conducted an extensive investigation of radioactivity in drinking water in the U.S. Of the 59,812 community drinking water supplies tested in the U.S., a projected 25 to 650 exceeded a U concentration of 746 mBq/L, 100 to 2,000 exceeded 370 Bq/L, and 2,500 to 5,000 exceeded 185 mBq/L. The levels detected in the communities' drinking water sources near the WIPP site were also within the U.S.'s expected range. The concentrations of $^{234}$U, $^{235}$U, and $^{238}$U in these drinking water locations measured in 2022 are shown in Figure 6.8. The historical activity concentrations of $^{234}$U, $^{235}$U, and $^{238}$U measured at each site in the regional drinking water are summarized in Appendix E, Tables E.3 through E.8.

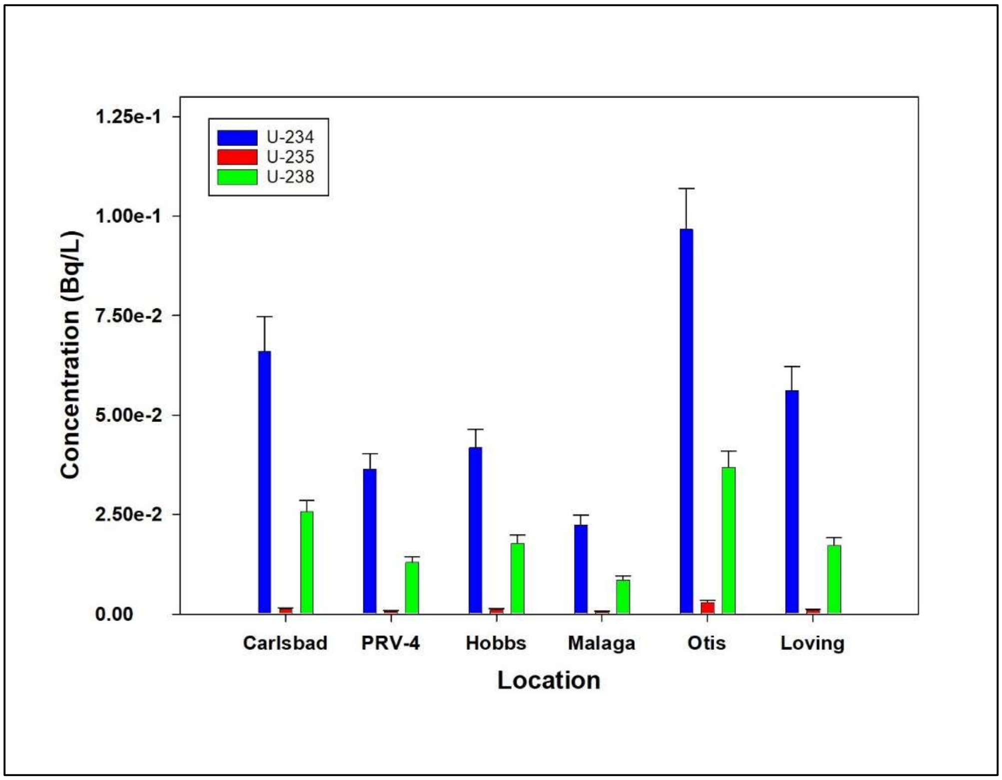


**Figure 6.8. The $^{234}$U, $^{235}$U, and $^{238}$U Concentrations (Bq/L) in Regional Drinking Water**

The low activity concentration of $^{235}$U in the water samples is consistent with the lower activity concentration of $^{235}$U in the natural environment as compared to the activity concentrations of $^{234}$U and $^{238}$U. The highest activity concentrations were found in Otis drinking waters.

Uranium in the environment occurs naturally as three radioactive isotopes. $^{238}$U (99.27%), $^{235}$U (0.72%), and $^{234}$U (0.005%). These isotopes of uranium are also found in the earth's crust, in rocks and minerals such as granite, metamorphic rocks, lignite, monazite sand, in phosphate deposits, and in uranium minerals such as uraninite, carnotite, and pitchblende. Uranium is also present as a trace element in coal, peat, asphalt, and some phosphate fertilizers at a level of about 100 µg/g or 2.5 Bq/g (Hess et al, 1985). All these sources can come in contact with water to be used for drinking purposes. Thus, it is expected that some drinking and surface water sources will contain uranium.

The natural level of uranium in water can also be enhanced because of human activity. For example, the increased concentration of natural radionuclides in water can be caused by the intensive use of phosphate fertilizers in agriculture. The average phosphate fertilizers contain about 100 µg/g (or 24.8 Bq/g), of naturally occurring uranium (Cothern and Lappenbusch, 1983) that can leach from the soil to nearby rivers and lakes (Fleischer, 1980; UNSCEAR, 1982).

The $^{234}$U/$^{238}$U activity ratio measured in regional drinking water from 1998 through 2022 is shown in Figure 6.9. Also shown in Figure 6.9 is the $^{234}$U/$^{238}$U activity ratio measured in regional drinking water for 2022 for comparison. The $^{234}$U/$^{238}$U activity ratio in these drinking water sources varies between 1.99 and 3.59 historically, which means that the two isotopes are not in radioactive equilibrium. It has been reported that the activity of uranium in natural water from $^{234}$U is higher than that of $^{238}$U, as shown in Figure 6.8. The $^{234}$U/$^{238}$U activity ratio usually ranges between 1.0 and 3.0 (Cherdynstev et al. 1971; Gilkeson et al. 1982). In radiochemical equilibrium, natural activity ratios are typically unity (1.0) for $^{234}$U/$^{238}$U and 0.045 for $^{235}$U/$^{238}$U (Pimple et al, 1992). However, many studies looking at $^{238}$U and $^{234}$U in natural bodies of water indicate that these isotopes do not occur in equilibrium and that, with a few exceptions, waters typically contain more $^{234}$U than $^{238}$U (Cothern et al. 1983; Skwarzec et al. 2002). Higher activity of $^{234}$U in water is the result of the $^{234}$U atom displacement from the crystal lattice. The recoil atom, $^{234}$U, is liable to be oxidized to the hexavalent stage and can be leached into the water phase more easily than its parent nuclide $^{238}$U. The oxidation of U(IV) to U(VI) is an important step in leaching because of the higher solubility of U(VI) compounds. All U(IV) compounds of uranium are practically insoluble. The variations in $^{234}$U/$^{238}$U activity ratio measured in regional drinking water since 1998 are shown in Figure 6.10.

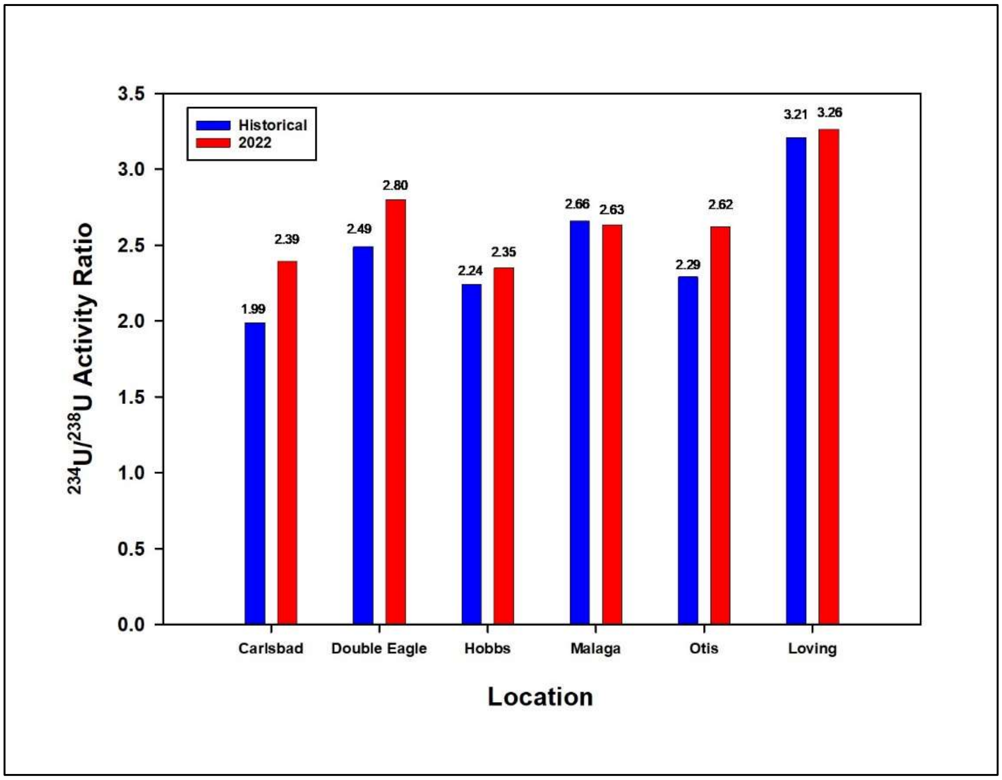


**Figure 6.9.** **$^{234}$U/$^{238}$U Activity Ratio in Regional Drinking Water from 1998-2022**

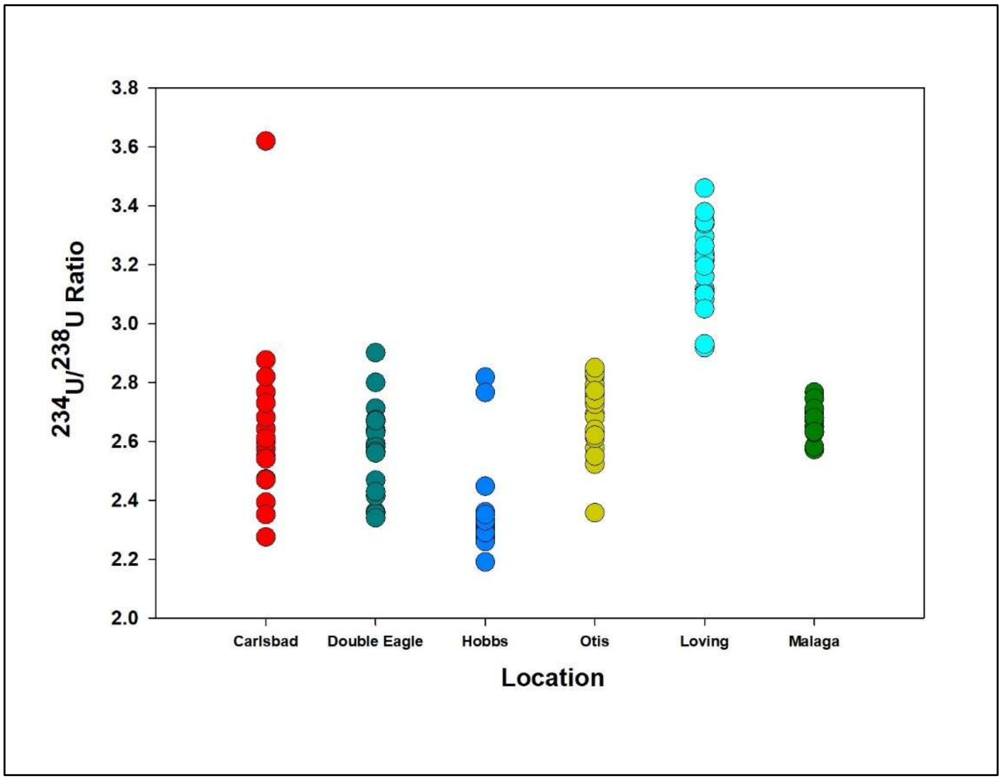


**Figure 6.10. Variation in $^{234}U/^{238}U$ Activity Ratio in Regional Drinking Water from 1998-2022**

## 6.4.3 Gamma Radionuclide Concentrations in Drinking Water

The gamma-radiation-emitting radionuclides $^{40}K$, $^{137}Cs$, and $^{60}Co$ were not detected in any of the drinking water samples in 2022. However, the naturally occurring gamma-radiation-emitting radionuclide, $^{40}K$ was detected in Hobbs drinking water sample at a level of 1.35 Bq/L in 2014. The $^{40}K$ isotope was also detected in Carlsbad, Malaga, and Otis drinking waters at a level of 1.10-1.19 Bq/L in 2013. This naturally occurring gamma-radiation-emitting radionuclide is ubiquitous in nature; therefore, an occasional detection of $^{40}K$ in drinking water is not unusual. There was no significant difference between concentrations of $^{40}K$ among sampling locations; the values also fell within the range of concentrations observed previously in these drinking water locations. The other two gamma radionuclides ($^{137}Cs$ and $^{60}Co$) were not detected in any of the drinking water samples as shown in Appendix E, Table E.9. Since these isotopes were not detected, no comparisons between years or among locations were performed.

## 6.4.4 Strontium Concentrations in Drinking Water

The $^{90}Sr$ radionuclide was not detected in any of the drinking water sources of municipalities surrounding the WIPP site. The results for all sampling locations are included in Appendix E, Table E.10.

## 6.5 Conclusions

This chapter summarizes the results of the drinking water monitoring program for the calendar year 2022. It is important to note that after more than twenty years of monitoring, isotopes of plutonium ($^{238}$Pu and $^{239+240}$Pu) and $^{241}$Am, have never been detected above MDC in any of the sampling locations in and around the WIPP. However, the isotopes of uranium $^{234}$U, $^{238}$U, and $^{235}$U were detected in all drinking water samples. The concentrations of uranium measured were in the range of 4.7-46.7 mBq/L for $^{238}$U, 0.26-2.92 mBq/L for $^{235}$U, and 10.3-121.7 mBq/L for $^{234}$U. The levels detected were well below the EPA recommended level of 746 mBq/L and are within the range expected in waters from this region. The $^{234}$U/ $^{238}$U activity ratio indicates that the presence of uranium in drinking water is most likely from natural sources. Present results, as well as the results of previous analyses of drinking water, were consistent for each source across sampling periods. In addition, the $^{90}$Sr radionuclide was not detected in any drinking water source of the region. There is no evidence of increases in radiological contaminants in the region that could be attributed to the 2014 release event at the WIPP or to WIPP-related activities.

# CHAPTER 7 - SEDIMENT MONITORING

## 7.1 Introduction

Sediments are finely divided solid materials that have settled out of a liquid stream or from standing water. The sediments accumulate radionuclides from the aqueous phase by sorption on suspended sediments and subsequent settling. CEMRC has been monitoring sediment samples from the three public reservoirs in the vicinity of WIPP, Brantley Lake, Lake Carlsbad, and Red Bluff Lake, since 1998. Many sediment samples contained the fission-product $^{137}$Cs; a few contained fission products $^{90}$Sr and $^{134}$Cs; activation-products $^{60}$Co, $^{58}$Co, $^{54}$Mn, and $^{65}$Zn; and the transuranic isotopes $^{239+240}$Pu and $^{241}$Am. These radionuclides in sediments are mainly attributed to discharges at the monitored facilities. A fraction of $^{137}$Cs, $^{90}$Sr, and $^{239}$Pu originates from fallout from atmospheric nuclear tests, which peaked in 1962-1963 and, to a minor extent, from nuclear accidents such as Chernobyl and Fukushima. Naturally occurring radionuclides uranium, thorium, and $^{40}$K were also detected. Many of the measured values were low, near the limits of detection. Assuming measured activities were high enough, the accumulation of radioactive materials in sediment could lead to human exposure through the ingestion of aquatic species, sediment re-suspension into drinking water supplies, or as an external radiation source (U.S. Department of Energy 1991).

To evaluate current conditions, CEMRC sampled sediment in the vicinity of the WIPP site in June 2022. The scope of work requires sediment samples to be collected annually from the same three public water reservoirs situated along the Pecos River. These locations include Brantley Lake, approximately 55 km (34 miles) north-northwest of the WIPP site, Red Bluff Lake on the Pecos River, the upstream end of which is the nearest standing water body approximately 48 km (30 miles) southwest of the WIPP site, and Lake Carlsbad in the center of Carlsbad about 40 km (25 miles) northwest from the WIPP site (Figure 7.1). Radiological analyses were performed to evaluate current radionuclide trends, especially Pu and Am, in the vicinity of the WIPP site. Details of the sample collection and analyses are described in the following sections. In this chapter, radiological analyses results are reported for the sediment samples collected in 2022.

### 7.1.1 Sample Collection

Sediment samples were collected at randomly selected locations within the deep basins of each reservoir. Deep basins were chosen for sampling to minimize the disturbance and particle mixing effects of current and wave action that occur at shallower depths. Also, many of the analytes of interest tend to concentrate on the fine sediments that settle in the deep reservoir basins; thus, measurements from these areas would typically represent the highest levels that might be expected for a given reservoir.

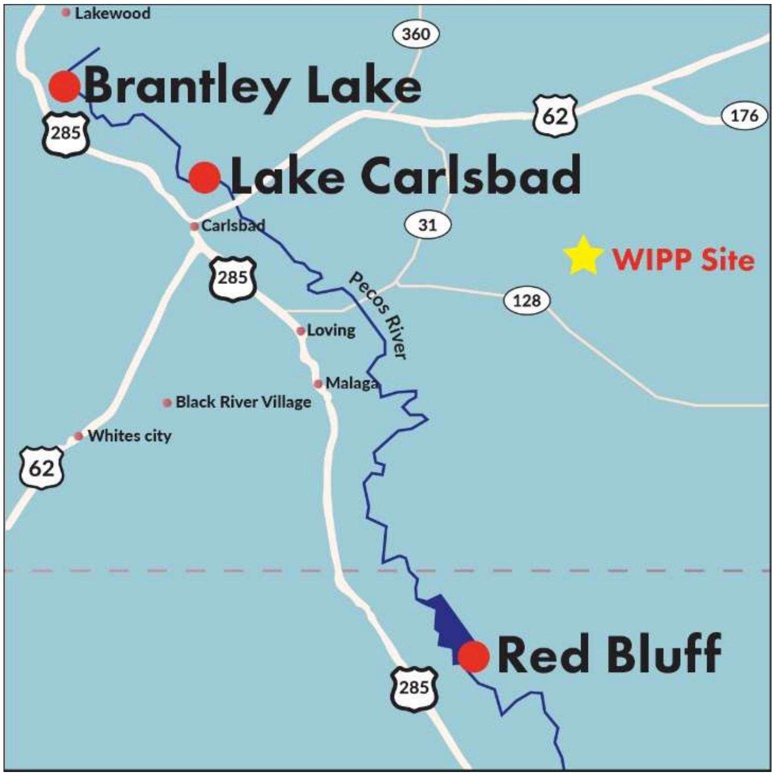


Figure 7.1. Sediment Sampling Locations

Sediment samples were collected at depths of 5-10 cm, using a grab sampler or Eckman dredge, to obtain approximately 5 L of sediment at each sampling site, as shown in Figure 7.2. Excess water was decanted from the sediment upon collection. The wet sediment was sealed in a pre-cleaned plastic bucket in the field and transported to the CEMRC laboratory for preparation before radiological analyses.

Figure 7.2. Sediment Sample Collection by CEMRC Personnel

## 7.2 Sample Preparation and Analysis

Sediment samples were dried at 105 °C for at least 12 hours and blended before sampling in the laboratory. The samples for gamma analysis were sealed in a 300 mL paint can and stored for at least 21 days to allow radon progeny to reach equilibrium with parent radionuclides before counting. Dried and sieved soil samples were counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies). The counting containers held approximately 500 g of sediments.

Samples for actinide analyses were dried at 105 ˚C and ground using a shatter box grinder to a fine analytical powder. For radiochemical analyses, 4-5 g of sample were heated in a muffle furnace at 500 ˚C for at least six hours to combust organic material. Each sample was then spiked with a radioactive tracer and digested in a Teflon beaker with hydrochloric, nitric, and hydrofluoric acids. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. To remove hydrofluoric acid, the sample residues were heated with perchloric acid and boric acids. Finally, the residues were dissolved in nitric acid for processing the individual radionuclide concentrations.

### 7.2.1 Radiochemical Analysis

The actinides were then separated as a group by co-precipitation on ferric hydroxide, $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on the second anion exchange column, and the americium was subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}$Sr is subsequently measured using liquid scintillation counting.

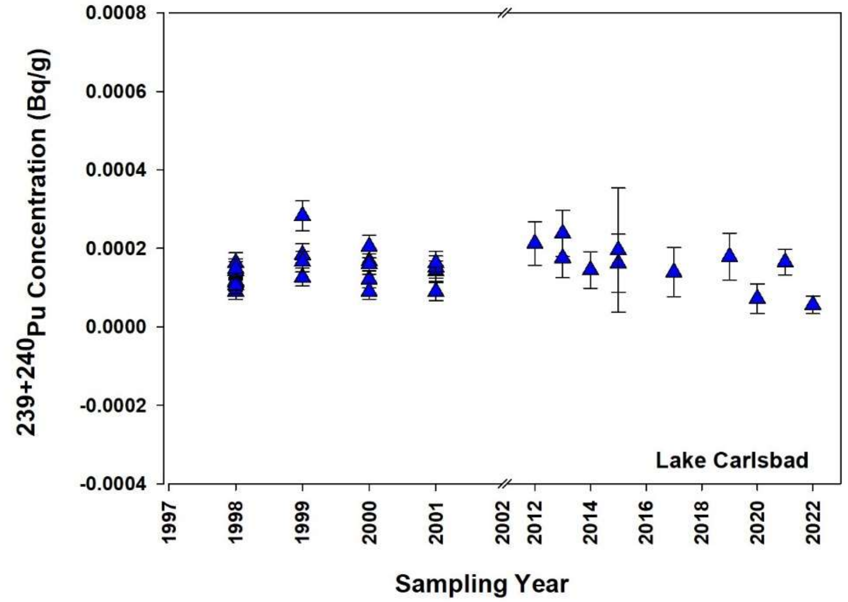
## 7.3 Results and Discussion

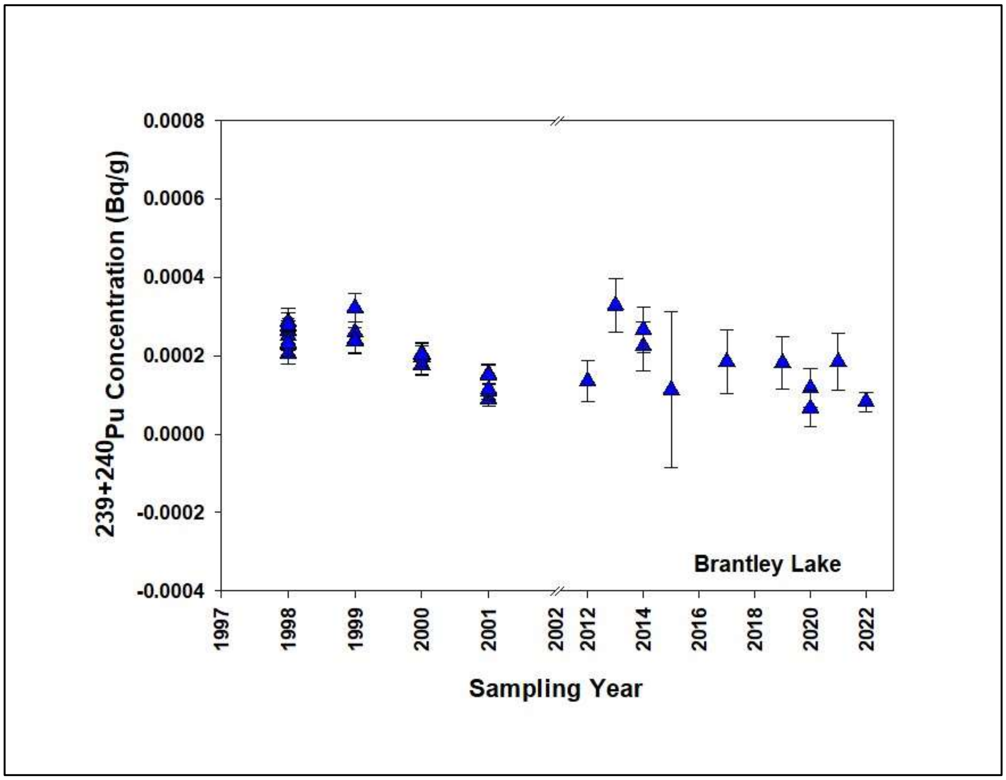
The activities of the actinides and gamma radionuclides in the sediment samples are reported as activity concentrations in Bq/g. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the sediment in grams (g). The results of all sample analyses are included in Appendix F, Tables F.1 – F.4.

### 7.3.1 Actinide Concentrations in Sediments

The individual concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the sediment samples collected from three regional reservoirs are summarized in Table F.1 (Appendix F). The $^{239+240}$Pu isotope was detected in Lake Carlsbad, Brantley Lake, and Red Bluff duplicate sediment samples at concentrations slightly greater than the MDC. The $^{241}$Am isotope was only detected in Red Bluff but not in its duplicate sample, and $^{238}$Pu was only detected in Brantley Lake sediment sample collected in 2022. The baseline concentrations of $^{239+240}$Pu ranged from 0.07 to 0.41 mBq/g with mean values of 0.13±0.03 mBq/g for Lake Carlsbad, 0.26±0.02 mBq/g for Brantley Lake, and 0.36±0.07 mBq/g for Red Bluff Lake (CEMRC, 1998). The activity concentrations of $^{239+240}$Pu in Lake Carlsbad and Brantley Lake varied between 0.06 and 0.08 mBq/g. Therefore, the concentrations of $^{239+240}$Pu measured in the sediment samples in 2022 were within the range of the 1998 baseline phase data.

In the case of soil, levels of radionuclides in the sediment samples from the aforementioned three reservoirs in 2022 showed no detectable increases above those typical of previously measured natural variation. The $^{239+240}$Pu activities are highest in the sediment collected from Brantley Lake (0.08 mBq/g). The $^{239+240}$Pu activities are lowest in Lake Carlsbad (0.06 mBq/g). The activity concentrations of $^{241}$Am Red Bluff Lake and its duplicate sample were similar, i.e., 0.04 and 0.03 mBq/g, respectively. The activity concentrations of $^{241}$Am Red Bluff Lake was a little higher than the baseline (0.03 mBq/g). The comparison of activity concentrations of $^{239+240}$Pu and $^{238}$Pu determined that the baseline and monitoring phase activities reflect no increase in radionuclide concentrations for 2022, as shown in Figure 7.3.





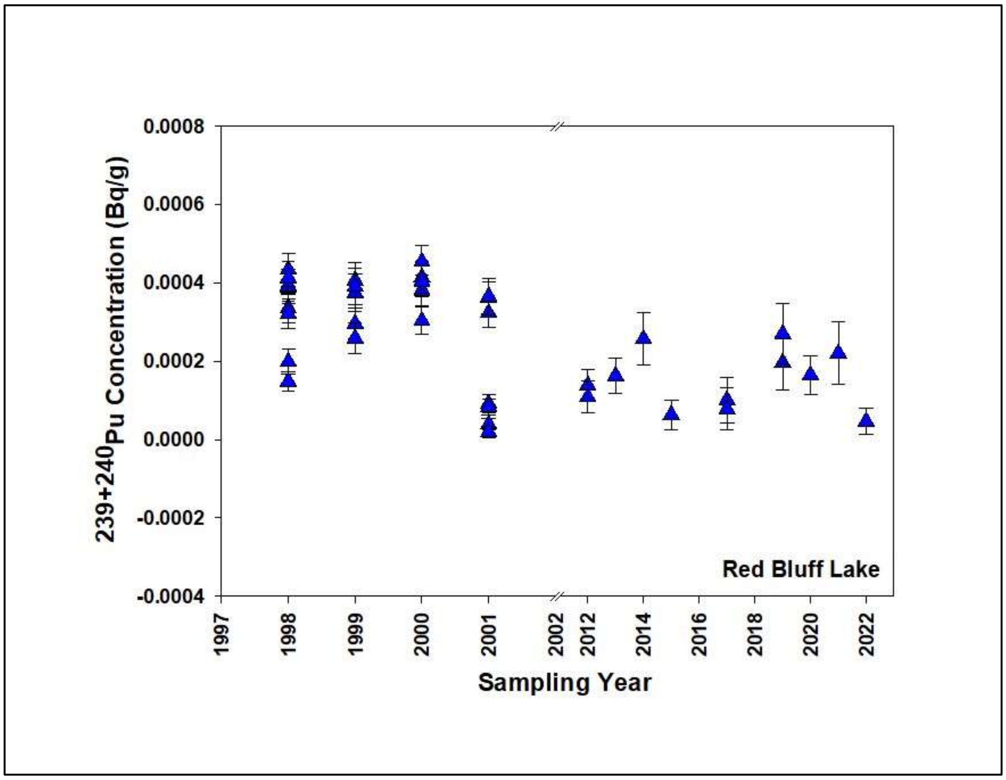
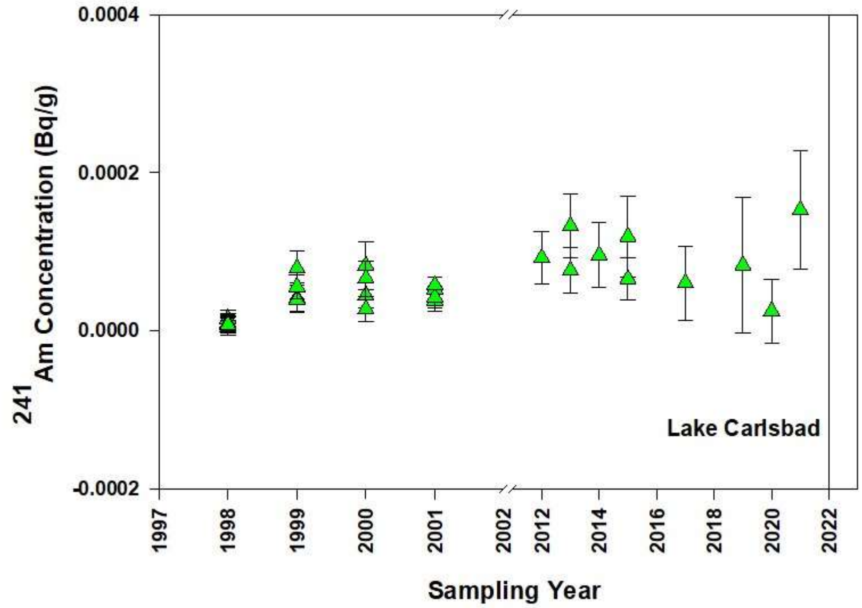
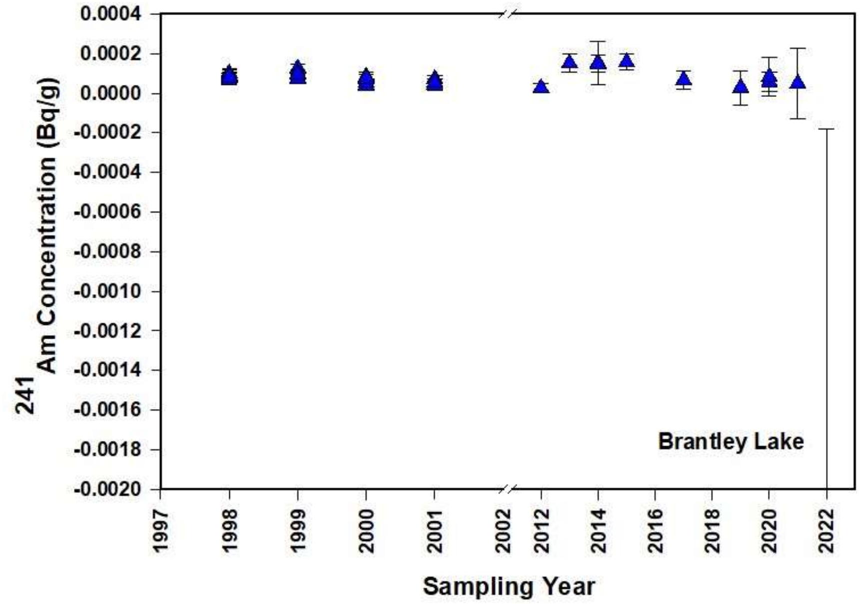


**Figure 7.3. Historical Concentrations of $^{239+240}$Pu in Regional Reservoir Sediments**



0.0004
0.0002
0.0000
-0.0002
241 Am Concentration (Bq/g)
Lake Carlsbad
1997
1998
1999
2000
2001
2002
2012
2014
2016
2018
2020
2022
Sampling Year



0.0004
0.0002
0.0000
-0.0002
-0.0004
-0.0006
-0.0008
-0.0010
-0.0012
-0.0014
-0.0016
-0.0018
-0.0020
241 Am Concentration (Bq/g)
Brantley Lake
1997
1998
1999
2000
2001
2002
2012
2014
2016
2018
2020
2022
Sampling Year

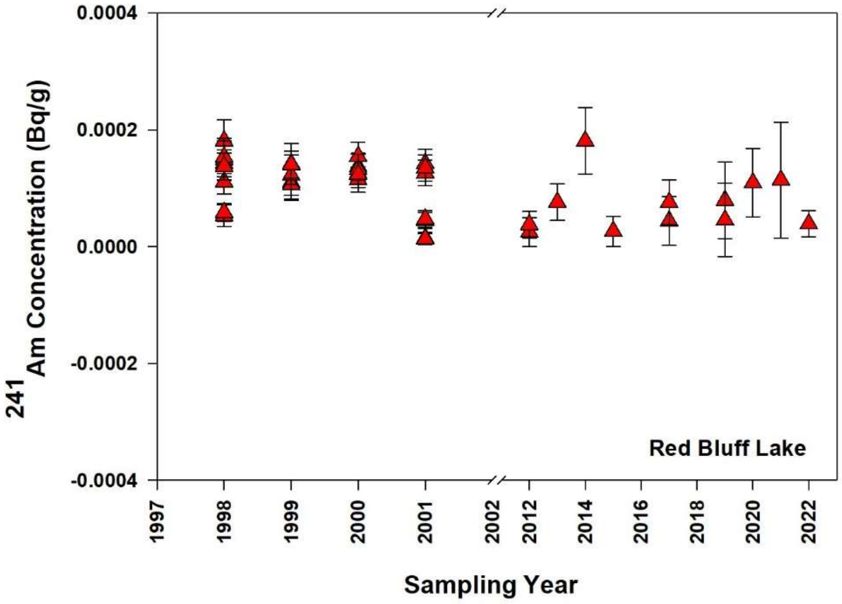


Figure 7.4. Historical Concentrations of 241$^{Am}$ in Regional Reservoir Sediments

### 7.3.2 Uranium Concentrations in Sediments

Uranium isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) were detected in all the sediment samples collected in 2022. The concentrations of uranium isotopes measured in the sediment samples are presented in Table F.2 (Appendix F). The concentration ranges of uranium isotopes measured in the sediment samples collected from all three reservoirs in 2022 are shown in Figure 7.5. The concentrations of $^{238}$U were highest in Lake Carlsbad and lowest in Red Bluff Lake duplicate sample, and that of $^{234}$U were highest in Lake Carlsbad and lowest in Brantley Lake.

Although the sediment concentrations of uranium isotopes were variable between reservoirs, the isotopic ratios were very similar between Lake Carlsbad and Red Bluff Lake. The sediments appeared to be slightly enriched in $^{234}$U compared to $^{238}$U, with the activity ratios ranging from 1.24 to 1.63, as shown in Figure 7.6.

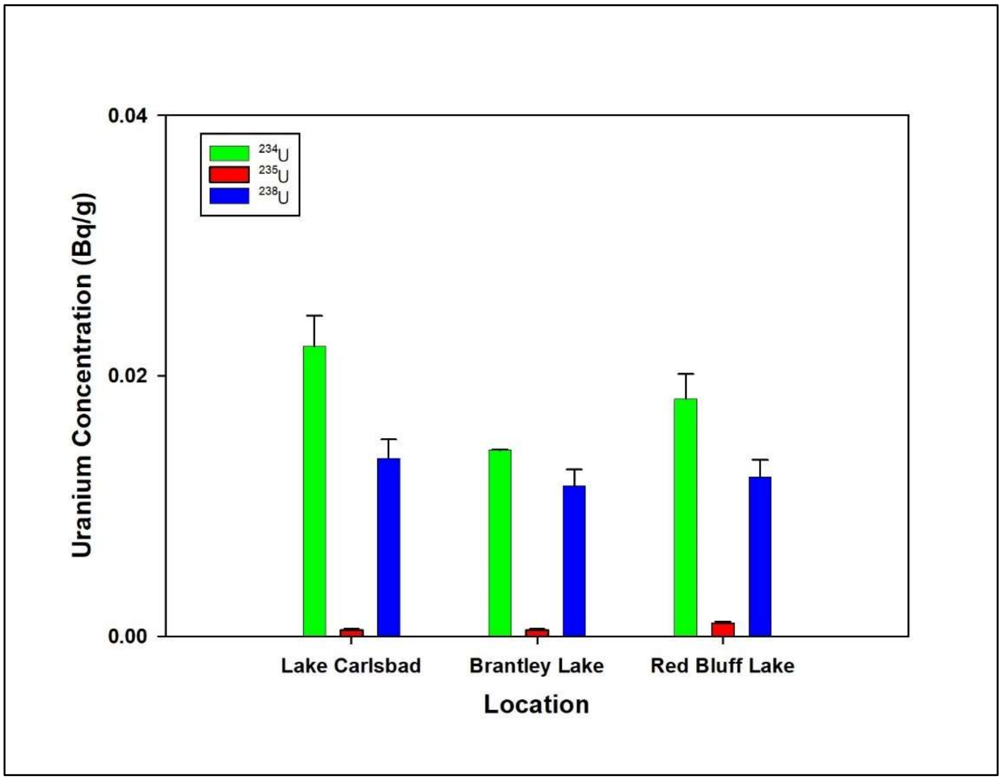


Figure 7.5. $^{234}$U and $^{238}$U Concentrations in Sediment Samples in Three Regional Reservoirs in 2021

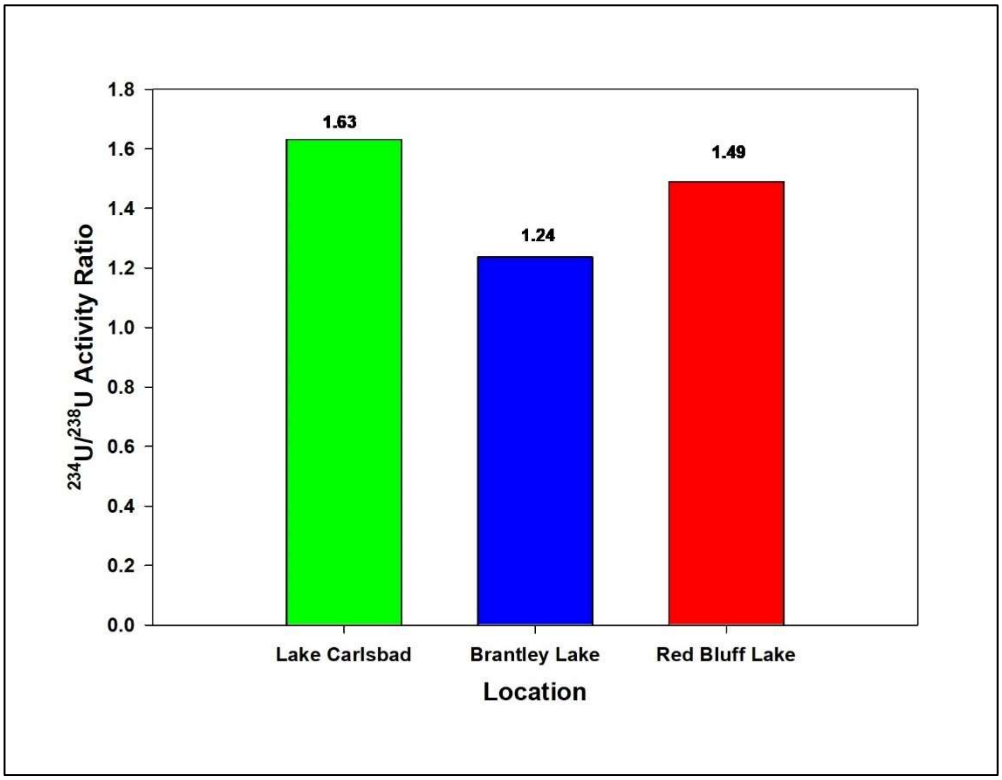
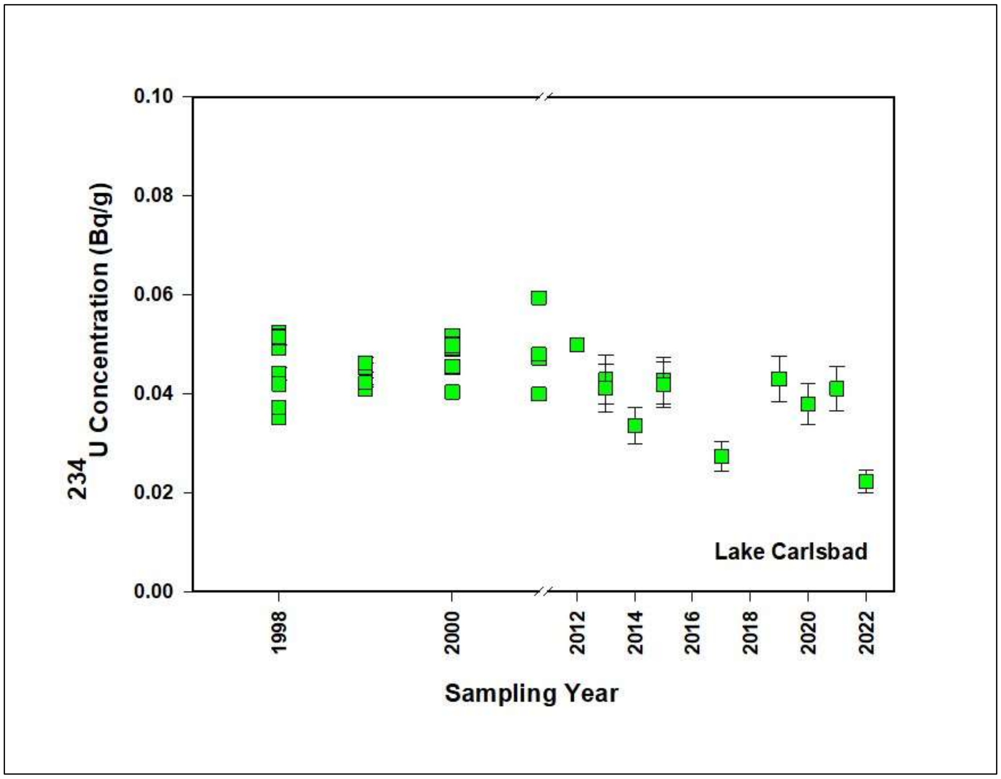
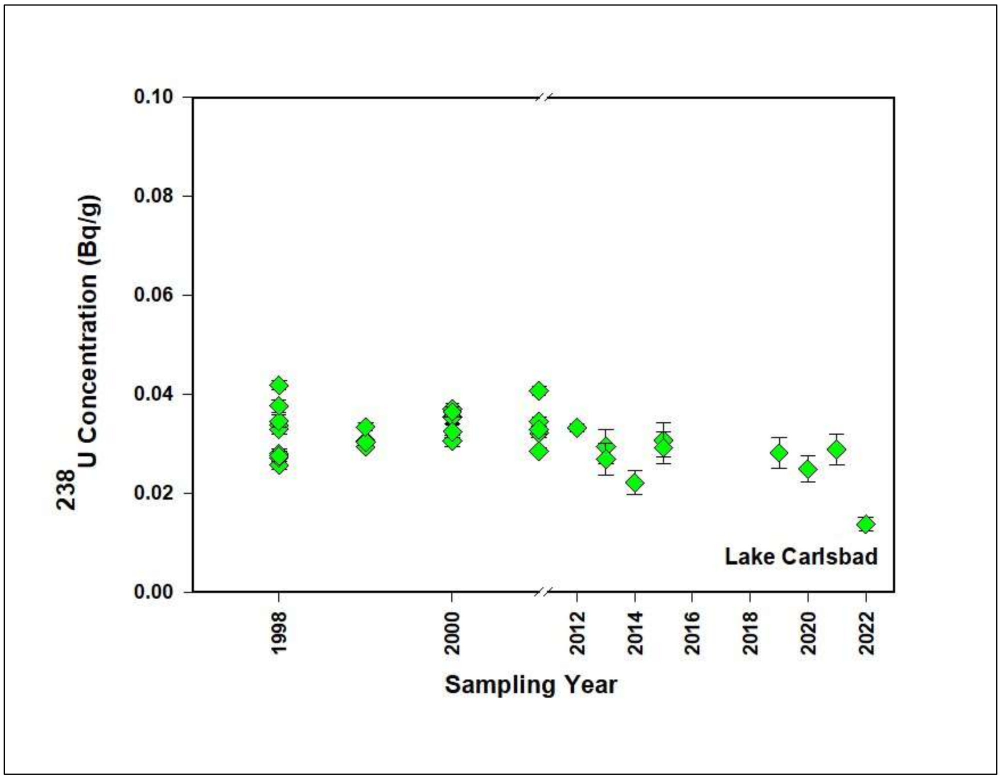
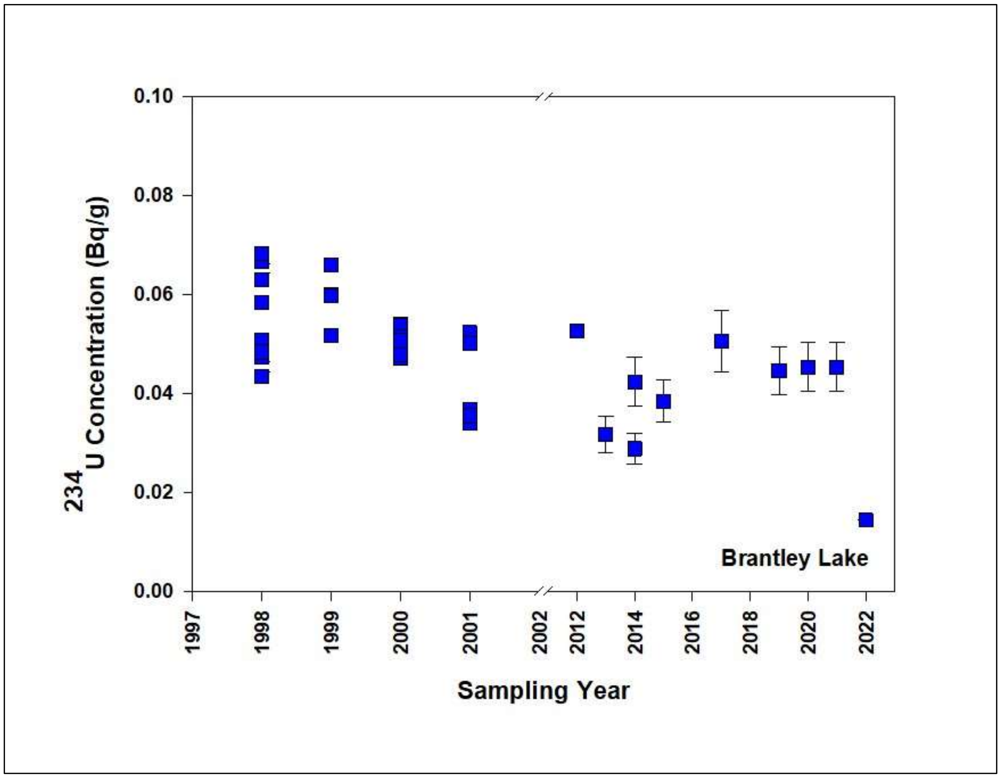


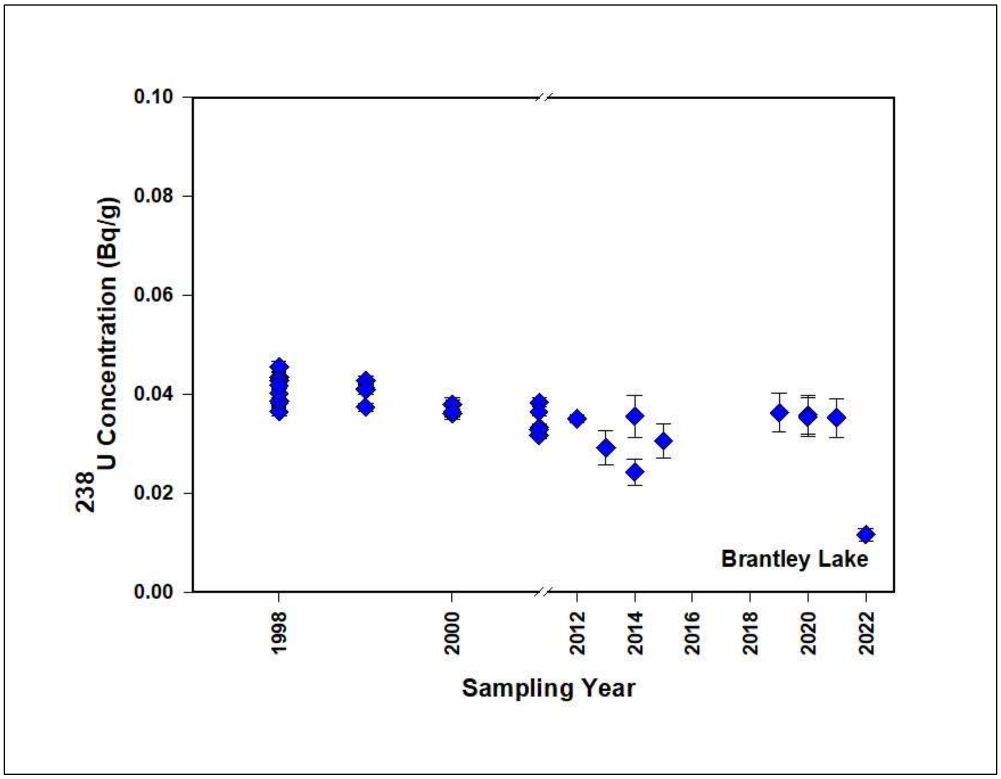
Figure 7.6. The $^{234}$U/$^{238}$U Activity Ratio in Sediment Samples in Three Regional Reservoirs in 2021

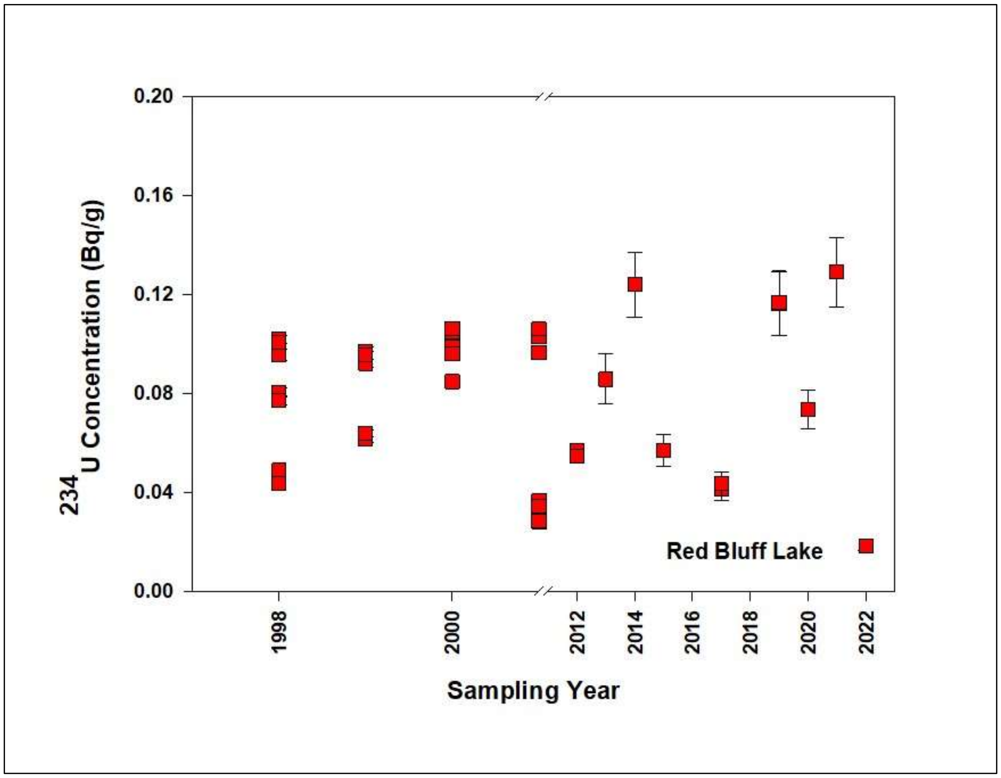
The historical concentrations of uranium isotopes measured in the sediment samples collected from the three reservoirs are shown in Figure 7.7. The activity concentration ranges for these isotopes showed no significant difference between baseline and monitoring phases, considering the 95% confidence intervals of the radio-analytical uncertainty.




238U Concentration (Bq/g)
0.10
0.08
0.06
0.04
0.02
0.00
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year
Lake Carlsbad


234U Concentration (Bq/g)
0.10
0.08
0.06
0.04
0.02
0.00
1997
1998
1999
2000
2001
2002
2012
2014
2016
2018
2020
2022
Sampling Year
Brantley Lake


0.10
0.08
0.06
0.04
0.02
0.00
238U Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.20
0.16
0.12
0.08
0.04
0.00
234U Concentration (Bq/g)
Red Bluff Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year

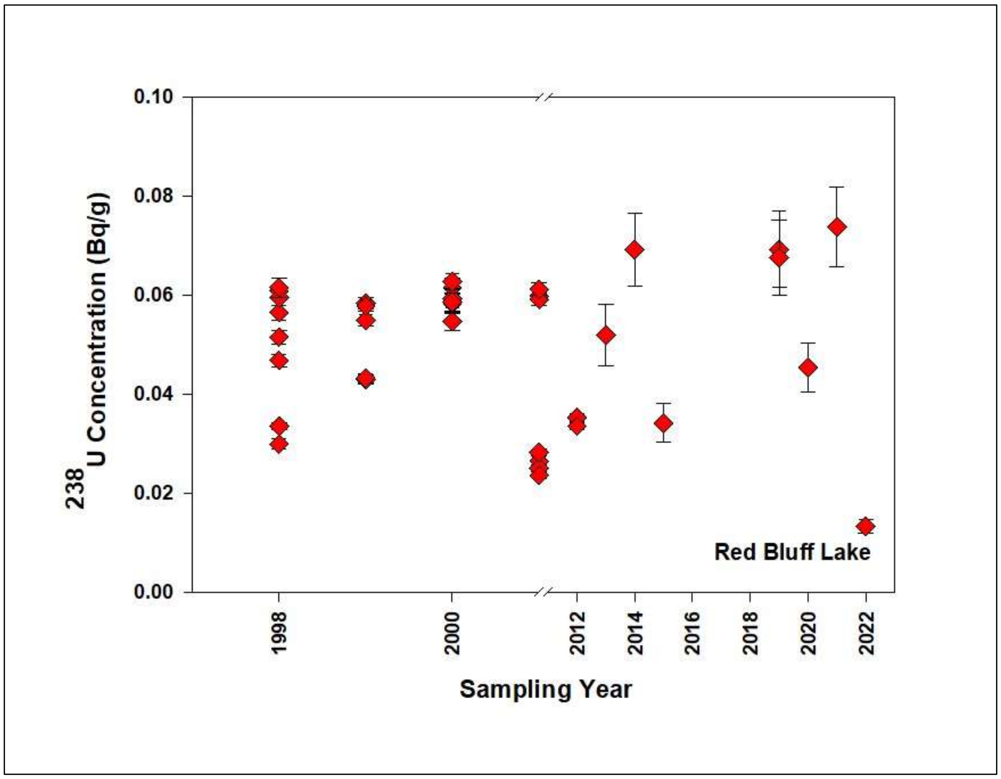
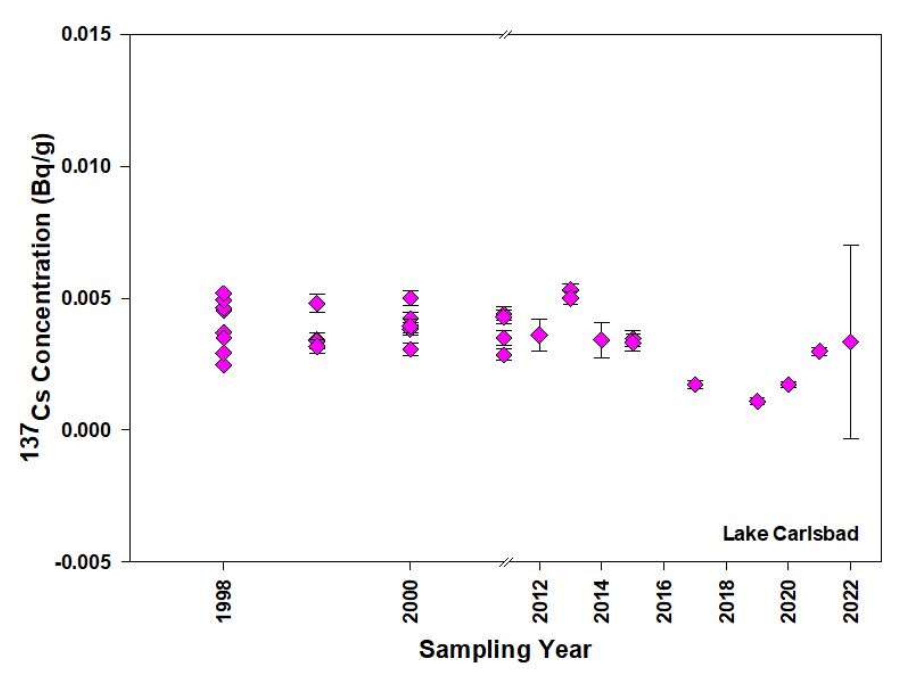


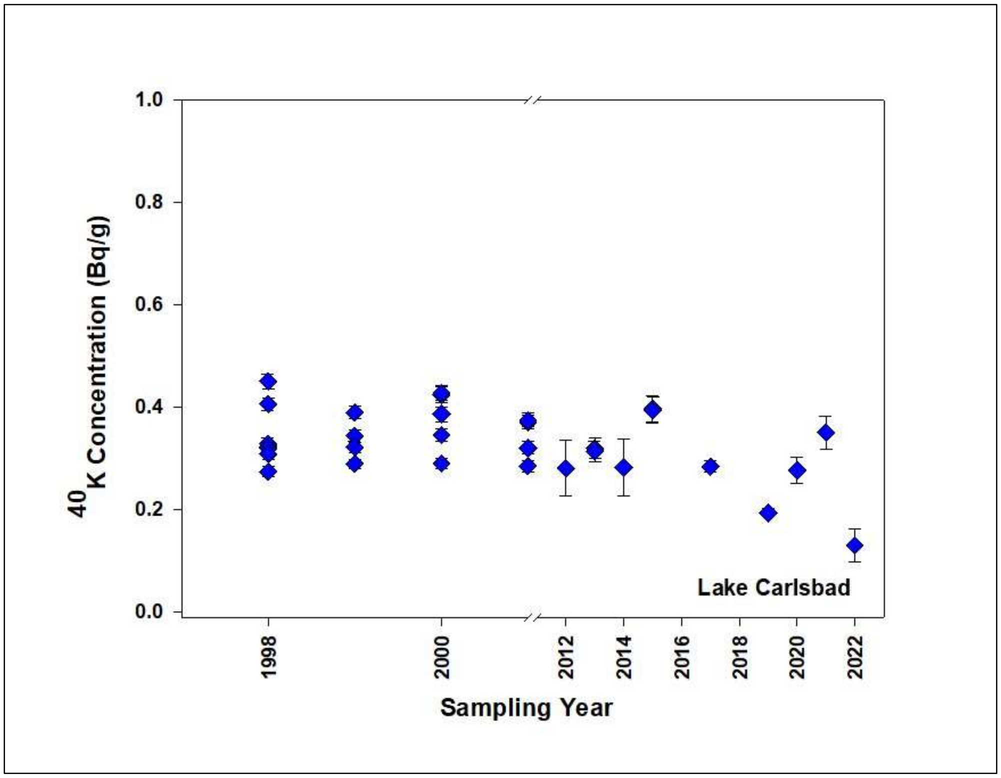
**Figure 7.7. Historical Concentration of Uranium in Sediment Samples in Three Regional Reservoirs**

### 7.3.3 Gamma Radionuclide Concentrations in Sediments

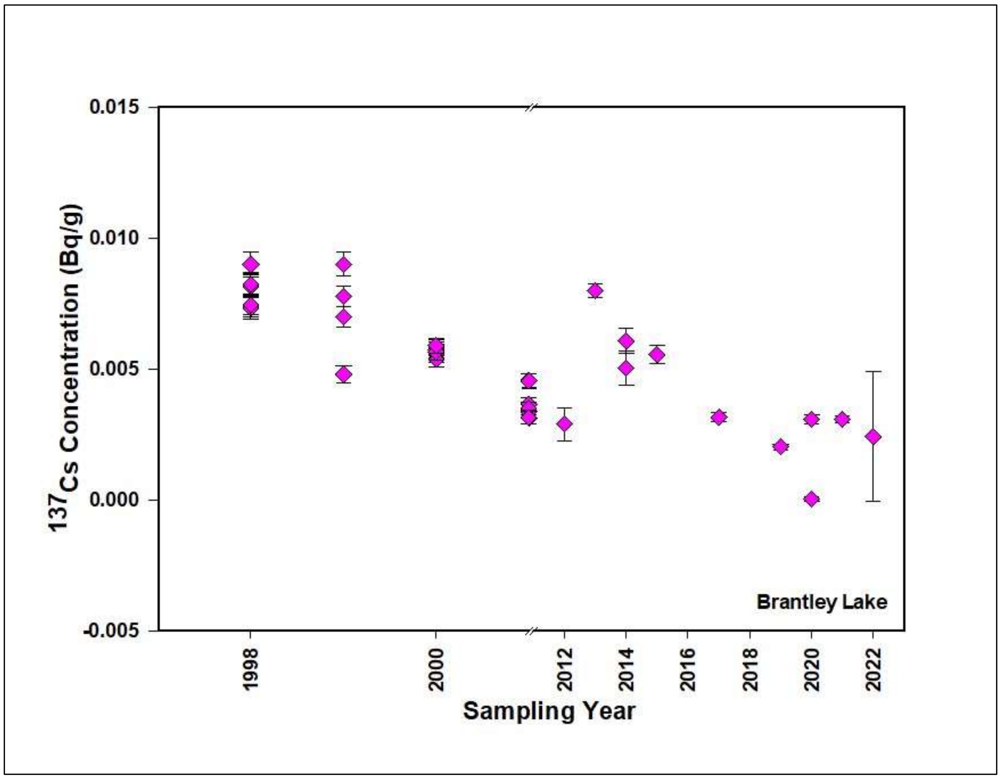
The concentrations of gamma-radiation-emitting radionuclides in sediment samples are presented in Table F.3 (Appendix F). The $^{137}$Cs and $^{60}$Co isotopes were not detected in any sediment sample. The $^{40}$K isotope was detected in every sediment sample. This naturally occurring gamma-radiation-emitting radionuclide is ubiquitous in sediments. There was no significant difference between concentrations of $^{40}$K among sampling locations and the values fell within the range of concentrations observed previously in sediment samples in three regional reservoirs around the WIPP site. The activity concentration of $^{40}$K compared to that of the baseline and monitoring phase activities reflects no increase in radionuclide concentrations for 2022. Historical plots of $^{40}$K concentrations in sediment samples collected from three public reservoirs are shown in Figure 7.8. The concentrations have remained relatively constant over the past 10+ years and generally are indicative of worldwide fallout. Some degree of variability is always associated with collecting and analyzing environmental samples; therefore, variations in sample concentrations from year to year are expected.

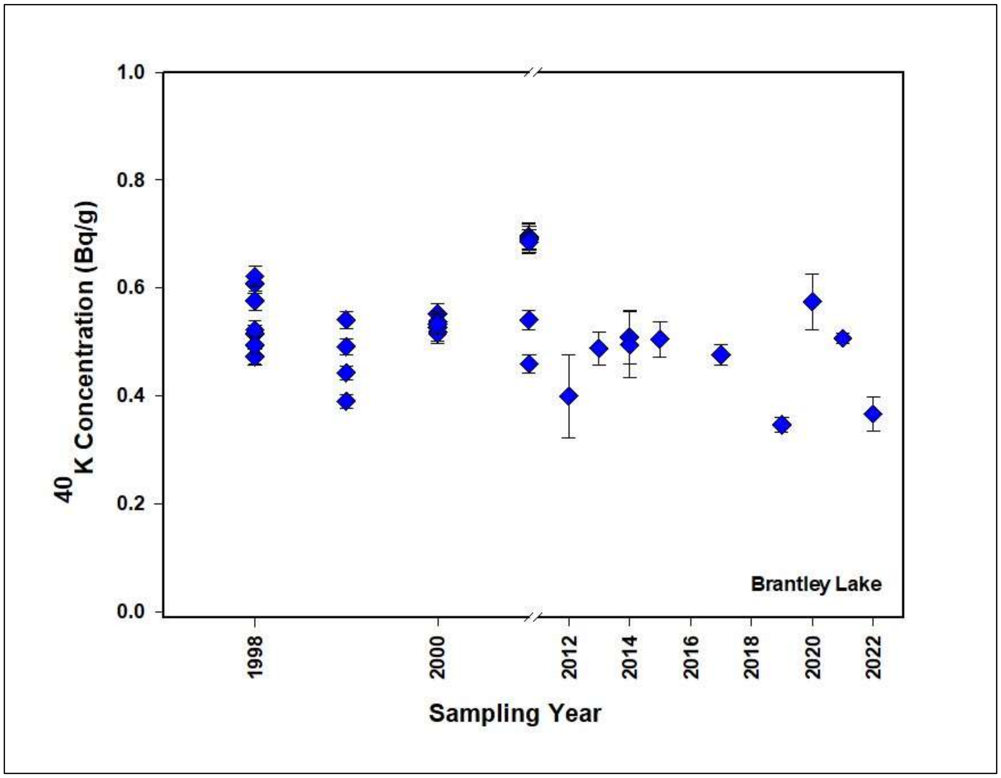


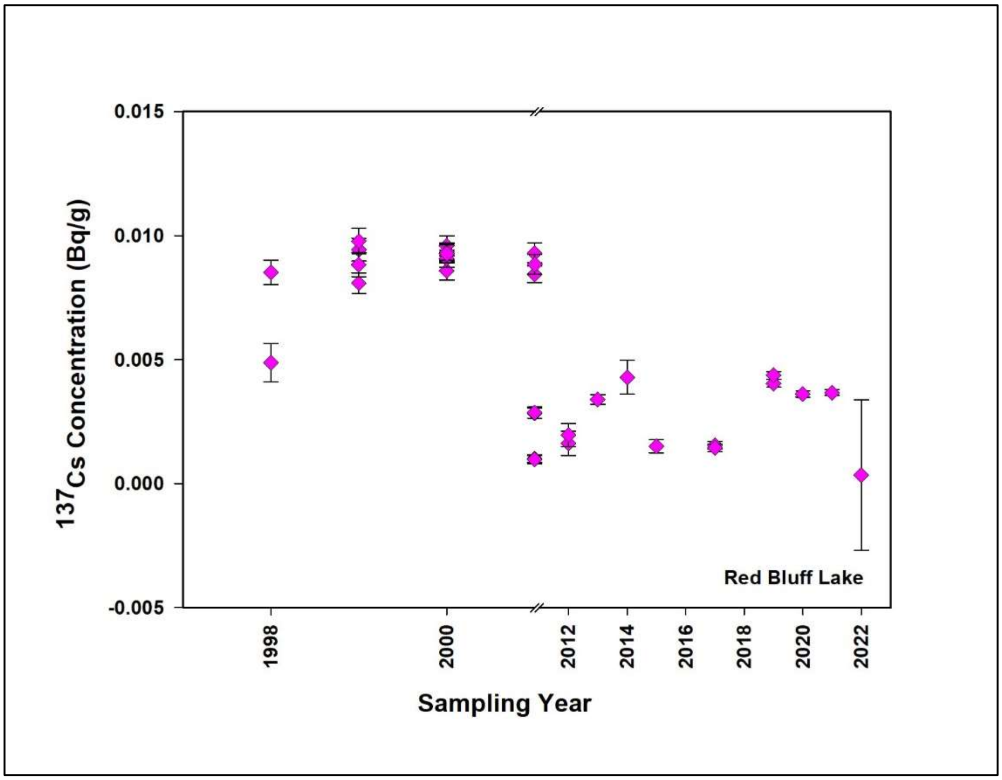
0.015
0.010
0.005
0.000
-0.005
$^{137}$Cs Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year



1.0
0.8
0.6
0.4
0.2
0.0
$^{40}$K Concentration (Bq/g)
Lake Carlsbad
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


0.015
0.010
0.005
0.000
-0.005
137Cs Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year


1.0
0.8
0.6
0.4
0.2
0.0
40K Concentration (Bq/g)
Brantley Lake
1998
2000
2012
2014
2016
2018
2020
2022
Sampling Year



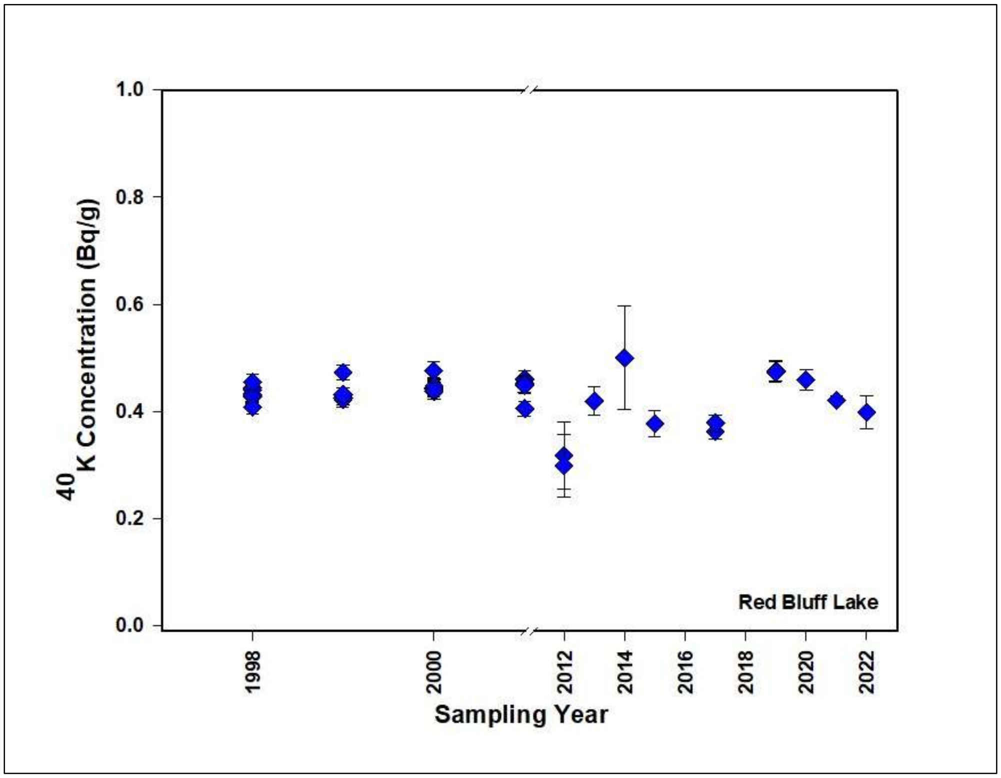


**Figure 7.8. Historical Concentration of $^{137}$Cs and $^{40}$K in Sediment Samples in Three Regional Reservoirs**

### 7.3.4 Strontium Concentrations in Sediments

The beta-radiation-emitting radionuclide $^{90}$Sr was not detected in sediment samples of the region's bodies of water except in Red Bluff sediment with the concentration of 154 Bq/kg. Note that it was not detected in the duplicate sample collected from Red Bluff. All $^{90}$Sr measured concentrations are included in Table F.4 (Appendix F).

## 7.4 Conclusions

This chapter summarizes the results of the sediment-monitoring program for the calendar year 2022. The $^{239+240}$Pu isotope was detected in the three sediment samples, whereas $^{241}$Am and $^{238}$Pu were only detected in one sediment sample in 2022. The concentration of $^{239+240}$Pu varied in the range of 0.06 to 0.08 mBq/g. Isotopes of uranium were also detected in all the sediment samples. Although the sediment concentrations of uranium isotopes were variable between reservoirs, the isotopic ratios were very similar between Lake Carlsbad and Red Bluff Lake. The sediments appeared to be slightly enriched in $^{234}$U compared to $^{238}$U, with the activity ratios ranging from 1.24 to 1.63. Finally, the $^{90}$Sr isotope was only detected in Red Bluff sediments with a concentration of 154 Bq/kg. Present results, as well as the results of previous analyses of sediment samples in the area are consistent for each source across sampling periods. There is no apparent difference between the concentration of the radionuclides collected before and after WIPP started receiving TRU waste. The monitoring results indicate that there is no evidence of increase in sediment radionuclide concentrations that can be attributed to the normal operations of the WIPP.

# CHAPTER 8 - VEGETATION MONITORING

## 8.1 Introduction

Vegetation sampling is a quantitative and adaptable method for sampling specific vegetation types in the field, which can be used for monitoring as a site-specific application. The bioavailable radionuclides from surrounding environments can be accumulated and transported in plants.

To evaluate current conditions, CEMRC sampled vegetation in the vicinity of the WIPP site in 2022. The scope of work requires vegetation samples to be collected annually. Radiological analyses were performed to evaluate current radionuclide trends, especially Pu and Am, in the vicinity of the WIPP site. Details of the sample collection and analyses are described in the following sections.

### 8.1.1 Sample Collection

Vegetation samples were collected from 5 sites (site 107: Near Field; site 108: Cactus Flats; site 111: Loving; site 112: Carlsbad, CEMRC; site 113: East Tower) which correspond to the aerosol sampling towers. Note that vegetation samples were collected from Loving site in duplicate. Aerosol sampling tower 106 (Onsite) was not used, because the surrounding area at the WIPP site is entirely paved. Vegetation samples were collected at random short distances and orientations from each tower location. A vegetation sampling location is shown in Figure 8.1. Individual sampling sites were selected on the basis of relatively flat topography, minimum surface erosion, and minimum surface disturbance by human or livestock activity. Samples were obtained using vegetation pruning clippers and plants were cut at least 1 inch above the soil surface. Vegetation preferred by livestock is of particular interest; however, any leafy vegetation is acceptable. Approximately 300-500 g of vegetation were collected. Samples were transferred to the radiochemistry group upon returning to CEMRC.

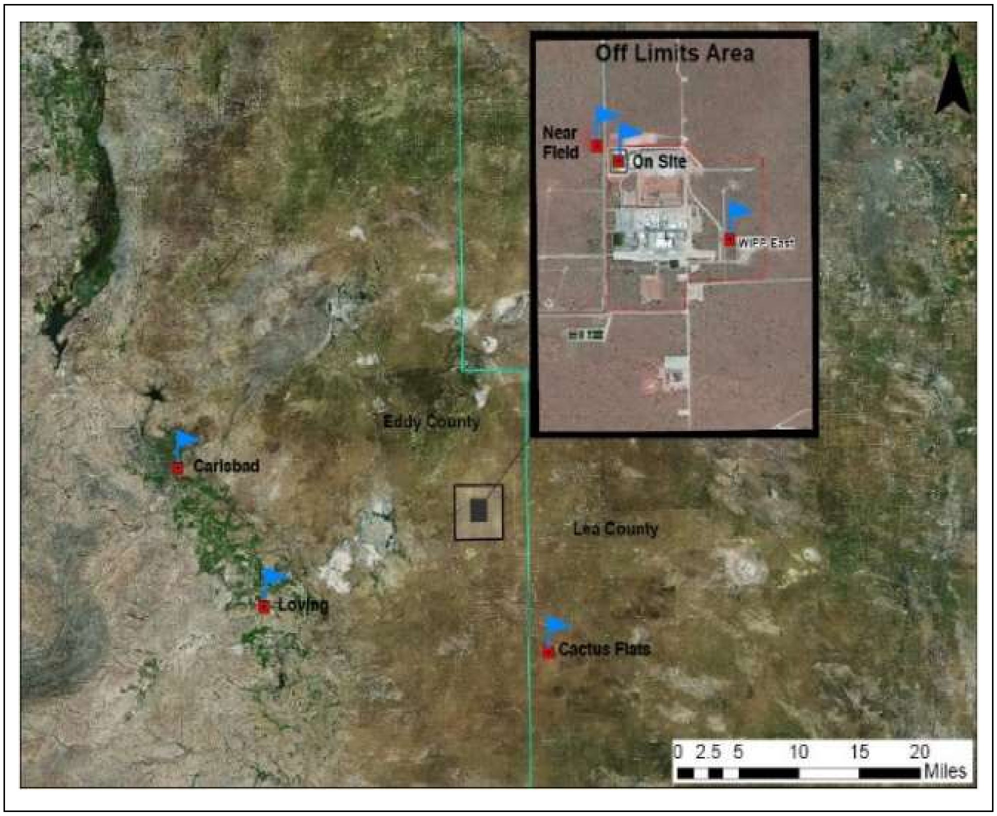


Figure 8.1. Vegetation Sampling Locations

## 8.1.2 Sample Preparation and Analysis

Vegetation samples were allowed to dry and were ground in ball mill jars overnight until enough fine analytical powders were obtained. Then, the vegetation sample (5 g) was digested in a Teflon beaker with nitric acid. The completely digested solution was counted for 48 h in a high purity germanium detector, HpGe (Mirion Technologies).

For actinide analyses, 4-5 g of each sample was spiked with a radioactive tracer and digested in a Teflon beaker with nitric acid. The actinides were then separated as a group by co-precipitation on $Fe(OH)_3$. Plutonium was separated from americium and uranium using an anion exchange column, while uranium was separated from americium on a TRU chromatography column. After separation, plutonium and uranium fractions were purified on the second anion exchange column, and the americium was subsequently purified from lanthanides on TEVA. Finally, Pu, Am, and U were micro co-precipitated on stainless steel planchettes for alpha spectrometry (Mirion Technologies) and counted for five days as per CEMRC's standard counting protocol. Portions of digested solutions containing strontium are separated and purified using strontium (Sr) resin. The strontium is then precipitated as strontium carbonate ($SrCO_3$), converted to strontium nitrate ($Sr(NO_3)_2$), and heated to dryness. The residue is dissolved in 10 mL of deionized water and mixed with 10 mL of liquid scintillation counting cocktail. The beta-radiation-emitting isotope $^{90}Sr$ is subsequently measured using liquid scintillation counting.

## 8.2 Results and Discussion

The activities of the actinides and gamma radionuclides in the vegetation samples are reported as activity concentrations in Bq/g. The activity concentration is calculated as the activity of radionuclides reported in Becquerel (Bq) divided by the mass of the vegetation in grams (g). All results are included in Appendix G, Tables G.1 – G.4.

### 8.2.1 Actinide Concentrations in Vegetation Samples

The $^{241}$Am, $^{239+240}$Pu, $^{238}$Pu, and $^{235}$U isotopes were detected in some vegetation samples collected in 2022. However, $^{234}$U and $^{238}$U concentrations were higher than MDC in all vegetation samples. The concentrations of americium, plutonium, and uranium isotopes measured in the vegetation samples are presented in Table G.2 (Appendix G). The activity concentrations of $^{241}$Am in vegetation samples collected from Loving (duplicate sample) and WIPP East Tower were $5.35\times10^{-5}$ and $7.89\times10^{-5}$ Bq/g, respectively. The $^{238}$Pu isotope was detected in vegetation samples collected from Near Field, Carlsbad, Loving (duplicate sample), and WIPP East Tower and concentrations varied between $4.83\times10^{-5}$ and $6.71\times10^{-4}$ Bq/g. The $^{239+240}$Pu isotope was detected in vegetation samples collected from Near Field, Loving, Loving (duplicate sample), and Carlsbad and the concentrations varied between $5.00\times10^{-5}$ and $5.45\times10^{-4}$ Bq/g. The concentrations of $^{239+240}$Pu in vegetation samples collected in Loving were the lowest, while the highest $^{239+240}$Pu was measured in the samples collected from WIPP East Tower. The $^{234}$U isotope was detected in all vegetation samples and the concentrations varied between $5.37\times10^{-4}$ and $6.44\times10^{-3}$ Bq/g. The concentrations of $^{234}$U in vegetation samples were lowest in the samples collected from Carlsbad and highest in those collected from Near Field. The $^{235}$U isotope was only detected in vegetation samples collected from Near Filed, Cactus Flats, Loving, and WIPP East Tower and the concentrations varied between $5.30\times10^{-5}$ and $4.58\times10^{-4}$ Bq/g. The concentrations of $^{235}$U in vegetation samples collected in WIPP East Tower were the lowest, while the highest $^{235}$U was measured in the samples collected from Near Field. The $^{238}$U isotope was detected in all vegetation samples and the concentrations varied between $5.37\times10^{-4}$ and $7.70\times10^{-3}$ Bq/g. The concentrations of $^{238}$U in vegetation samples collected in Carlsbad were the lowest, while the highest $^{238}$U was measured in the samples collected from Near Field.

### 8.2.2 Gamma Radionuclide Concentrations in Vegetation Samples

The $^{137}$Cs and $^{60}$Co isotopes were not detected in any vegetation samples. The $^{40}$K isotope was detected in all vegetation samples and the concentrations varied between 198 and 501 Bq/kg. The concentrations of $^{40}$K in vegetation samples collected from Cactus Flats were the lowest, while the highest $^{40}$K were measured in the duplicate sample collected from Loving. The results are shown in Table G.3 (Appendix G).

### 8.2.3 Strontium Concentrations in Vegetation Samples

The $^{90}$Sr isotope was detected in all vegetation samples except Loving (duplicate sample) and the concentrations varied between $1.90\times10^{-1}$ and $2.24\times10^{-1}$ Bq/g. The concentrations of

$^{90}$Sr in vegetation samples collected from Carlsbad were the lowest, while the highest $^{90}$Sr were measured in vegetation samples collected from Near Field.

## 8.3 Conclusions

This chapter summarizes the results of the vegetation-monitoring program for the calendar year 2022. The $^{137}$Cs, or $^{60}$Co isotopes were not detected in any of the vegetation samples. The $^{241}$Am, $^{238}$Pu, $^{239+240}$Pu, $^{234}$U, $^{235}$U, $^{238}$U, $^{40}$K, and $^{90}$Sr isotopes were detected in some vegetation samples. The concentration of $^{241}$Am varied in the range of $5.35\times10^{-5}$ and $7.89\times10^{-5}$ Bq/g. The $^{238}$Pu concentration varied between $4.83\times10^{-5}$ and $6.71\times10^{-4}$ Bq/g. The $^{239+240}$Pu concentration varied between $5.00\times10^{-5}$ and $5.45\times10^{-4}$ Bq/g. The $^{234}$U concentration varied between $5.37\times10^{-4}$ and $6.44\times10^{-3}$ Bq/g. The $^{235}$U concentration varied between $5.30\times10^{-5}$ and $4.58\times10^{-4}$ Bq/g. The concentration of $^{238}$U varied in the range of $5.37\times10^{-4}$ to $7.70\times10^{-3}$ Bq/g. The $^{40}$K concentration varied between 198 and 501 Bq/kg. The $^{90}$Sr concentration varied between $1.90\times10^{-1}$ and $2.24\times10^{-1}$ Bq/g.

# CHAPTER 9 - IN-VIVO MONITORING

The *in vivo* (or direct) radiobioassay is a measurement of the human body to determine the amount of radioactive material in the body. CEMRC's Internal Dosimetry (ID) Laboratory has been performing *in-vivo* radiobioassay measurements for radiological and radiation control workers. Additionally, CEMRC's ID Laboratory provides free radiobioassay service to the public residing within a 100-mile radius of the WIPP site through a program called "Lie Down and Be Counted" (LDBC) since 1997. The LDBC program is the most public aspect of CEMRC and is open to adult residents and children aged 13 and older living within a 100-mile radius of the WIPP site. The purpose of the LDBC program was to establish a baseline of "normal" or "background" radiation present in adults living in the region of the WIPP prior to the emplacement of radioactive waste in the WIPP. Further, once disposal operations began at the WIPP site, the LDBC program allows for the continued monitoring of public citizens to determine if WIPP-related disposal activities have any observable impact on area residents' health. Concerned citizens are encouraged to have the *In vivo* radiobioassay to see what radiation might exist in their lungs and whole body. The data collected prior to the operation of the WIPP TRU waste management serves as a baseline for comparisons with periodic follow-up measurements that are slated to continue through the operational phase of the WIPP.

The LDBC program uses a state-of-the-art lung and whole-body counting system that can measure the body's burden of radioactive elements at extremely low levels. The CEMRC ID laboratory has unique capabilities to detect internal deposited radionuclides in the body. The procedure is non-intrusive; participants are asked to follow a small number of steps before lying down on a bed inside of a counting room for 30 minutes, allowing for measurements to be taken. Participants will then go over their results with a CEMRC scientist. Each participant contributes to scientific research conducted by the center. Since 1997, whole-body counting has been performed at CEMRC.

The current scope of work requires CEMRC's ID laboratory to perform whole-body measurements for the Department of Energy-Carlsbad Field Office (DOE-CBFO), DOE contractors, radiological and radiation workers, and the public residing within a 100-mile radius of the WIPP site. In the event of an incident or accidental release, *in vivo* measurements will be performed for DOE clients and contractor staff within the first two days after the event. In the event of a scheduling conflict, the DOE and contractor staff's *in vivo* measurements will receive priority over non-DOE clients and members of the public. The results of in vivo measurements for members of the public will be reported in an aggregated form and all necessary precautions will be taken to ensure confidentiality and to avoid the release of individualized data. Unexpected positive results from any *in vivo* measurement will trigger an automatic recount. Details of the *in vivo* counting facility, bioassay methodologies, and demographic characteristics counting method are described in the following sections. This chapter provides an overview of the ongoing public radiobioassay measurements through December 31, 2022.

## 9.1 *In vivo* Counting Facility

The *in-vivo* counting facility consists of a large, shielded counting chamber made from pre-1945 cast iron to limit the background radiation and an instrument control workstation in the adjacent room. Radiobioassay operations are performed from the instrument control workstation. The operations room is also equipped with a video display terminal and intercom that are used to monitor subjects during the measurement. The counting chamber, as shown in Figure 9.1, is equipped with high purity germanium detector *arrays designed specifically for* lung *and* whole-body counting, an oxygen monitor, a video camera, emergency backup lights, and a voice-activated intercom for the subjects to communicate with the operator at any time during the counting process. The counting facility is also equipped with a music system to help participants relax during counting. Four lung detectors are located on top of the bed and are positioned close to the counting subject's chest and four whole-body detectors are also located under the bed. The whole-body detectors face the torso and upper leg parts of the body. CEMRC's ID laboratory has met the requirements and recommendations of the DOE Implementation Guide for Internal Dosimetry Programs (10 CFR 835) and the American National Standards Institute Performance Criteria for Radiobioassay (ANSI/HPS N13.30) (1996, 2011) and continues to meet the most current criteria for radiobioassay measurements.

**Figure 9.1. The Whole-Body counting facility at CEMRC**

During January – March 2022, the Lung and Whole-Body radiobioassay measurement system's hardware was upgraded to the Lynx digital signal analyzer(s) shown in Figure 9.2 and the software was upgraded to APEX In-vivo software based on Hewlett Packard (HP) workstation with Windows 10 operating system. This whole system, namely Lynx rack and the APEX In-vivo is referred to hereafter as APEX In-vivo system. The previous system consisted of a Compaq workstation with an ABACOS+ software operating system. The electronic units consisting of programmable high voltage units, amplifiers, analog to digital converters (ADCs), and acquisition interface modules (AIMs) were mounted on a standard nuclear instrumentation module (NIM) rack. This whole system is referred to as VMS ABACOS+ system. NIM and Lynx racks with electronic units are shown in Figure 9.2. The upgraded system passed the Department of Energy Laboratory Accreditation Program (DOELAP) performance testing for technical equivalency with the previous VMS ABACOS+ system.

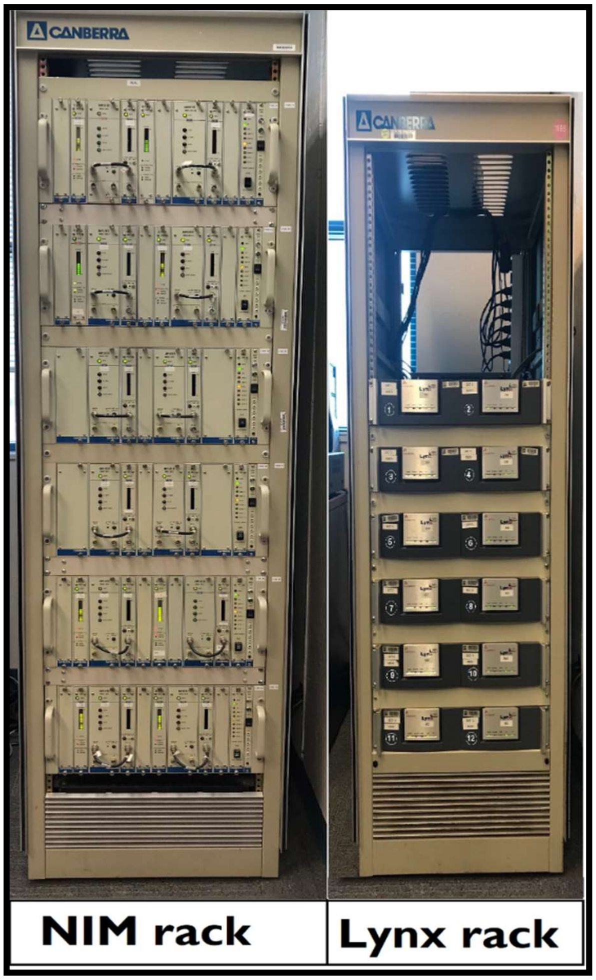


Figure 9.2. NIM and Lynx racks with electronic units

DOELAP for radiobioassay (DOE-STD-1111-2018) granted CEMRC direct radiobioassay performance qualification with valid accreditation for the operational system 1/1/2020 through 12/31/2022, with renewal valid from 1/1/2023 through 12/14/2025.

## 9.2 Minimum Detectable Activity

The minimum detectable activity or MDA is an *a priori* value used to evaluate the laboratory's ability to detect a radionuclide in a person. The MDA is defined as the amount of a radionuclide that, if present, would be detected 95% of the time under the routine operation of a facility. The MDA is used to measure the efficacy of a facility and should not be used to decide if a specific radiobioassay has or has not detected activity within a person (ANSI/HPS N13.30, 1996). To determine whether activity has been detected in a particular person, the parameter $L_C$ (decision level) is used. The $L_C$ represents the 95th percentile of a null distribution resulting from the differences of repeated, pair-wise background measurements. An individual result is assumed to be statistically greater than background if it is greater than the $L_C$. It is important to note that the use of this criterion will result in a statistically inherent 5% false positive error rate (5% of all measurements will be determined to be positive when there is no true activity in the person). Details of MDA and $L_C$ calculations can be found elsewhere (CEMRC, 1998; ANSI/HPS N13.30, 1996; Webb and Kirchner, 2000).

The details of energy and efficiency calibration of the lung and whole-body counting detectors are discussed in greater detail in a previous CEMRC Report (CEMRC, 2017). The lung detector efficiency varies with the person's chest wall thickness (CWT). Average MDA (nCi) with one standard deviation and percent variation for lung and whole-body detector systems are provided in Appendix H, Tables H.1 and H.2, respectively. One factor complicating the measurement of low-energy photon emissions from the lung is the absorption of photons in the tissue overlying the lung – adipose (fat), muscle, cartilage, and bone. The thickness of these tissues and, consequently, the attenuation can vary significantly from one individual to the next. This is particularly important for the detection of the 17 keV plutonium X-rays. At this energy, 6 mm of muscle can attenuate half of the transmitted X-rays. In the early days of lung counting, height/weight relationships had been used to estimate the CWT, but these were crude and could easily lead to errors of a factor of 2 or more (CDC, 2006, page 27). For routine *in vivo* radiobioassay measurements where no lung activity is expected, CEMRC ID uses an empirically derived prediction algorithm to estimate chest wall thickness, using easily measurable physical parameters, namely height and weight of the subject (RB-TBM-016, 2020). This prediction algorithm is based on a composite of the works by Dean (1973), Garg (1977), and Fry et al (1980) that was chosen by CDC (CDC, 2006, page 30). In cases where a precise measurement of chest wall thickness is critical (e.g., when an intake of an insoluble radionuclide is probable or suspected) CEMRC has an established ultrasonic procedure that could be used in lieu of the prediction algorithm. Ultrasonic measurements of the chest yield both thickness and composition. The arrangement for ultrasonic measurement is the responsibility of the participant.

A routine radiobioassay program should be able to detect intakes within a year that will deliver a Committed Effective Dose of 100 mrem. If this performance objective cannot be met, then a performance shortfall is said to exist. The current version of CEMRC's Lung and Whole-body Counting technical manual (RB-TBM-016, 2020) provides a detailed comparison of lung and whole-body detector system's MDAs (determined with the VMS ABACOS+ system) with annual limit of intakes. APEX In-vivo software provides the MDA for each radiobioassay measurement. The data are very limited (less than 10 observations of radiobioassay measurements of the public) to calculate the current Apex In-vivo MDA averages.

## 9.3 Volunteer Participation in the LDBC Program (1997 – 2022)

Between July 21, 1997, and March 26, 1999 (a period referred to as the “pre-operational” phase), CEMRC ID laboratory had counted 366 public volunteers. This group of 366 measurements constituted the pre-operational baseline to which subsequent results are compared. WIPP became operational on March 27, 1999. Counts performed after WIPP became operational are referred to as the “operational” phase monitoring. Between March 27, 1999, and December 31, 2022, CEMRC ID laboratory had counted 1222 public volunteers. These measurements include baseline count (individuals counted for the first time), routine count (counting of previously measured participants, counts performed on individuals at least after two years following the baseline count), and recounts (repeat counts to confirm a positive result). The total number of public volunteers who have participated in the LDBC program between July 21, 1997, and December 31, 2022, are shown in Figure 9.3.

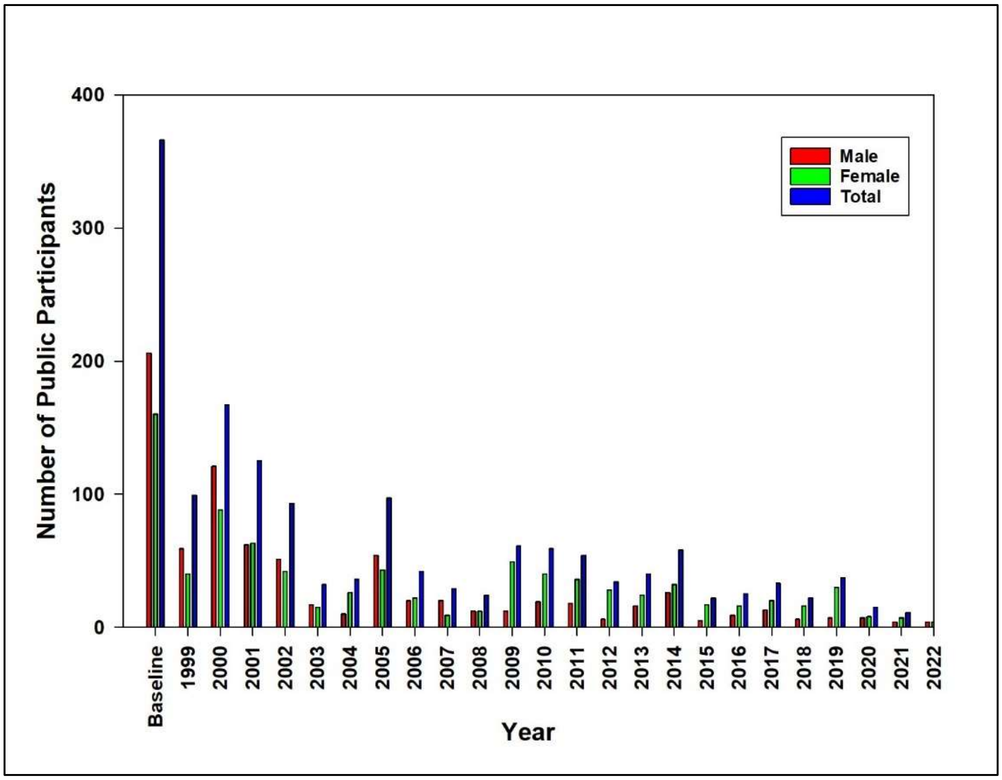


**Figure 9.3. Number of LDBC public participants from 1997-2022**

In addition to the LDBC public counts, the CEMRC ID laboratory also provides *in vivo* radiobioassay service to Waste Control Specialists (Andrews, TX), Los Alamos National Laboratory, Carlsbad Office, WIPP laboratories (located at CEMRC) and WIPP contractor personnel. The total number of radiobioassay measurements performed through December 2022 is 5965, which includes baseline (in this context baseline means the first time counted at CEMRC), routine, recounts, exit, potential intake, and any other special counts on radiological workers.

## 9.4 Demographic Characteristics

Public volunteers participating in the LDBC project are asked to complete a questionnaire to gather a demographic profile of the participants, such as age, gender, ethnicity, occupation, foreign travel, wild game consumption, smoking habits, and any nuclear medicine procedures. Appendix H, Table H.3 compares the LDBC demographic characteristics between the baseline and operational phase date. An increase of voluntary participation by Hispanics from 13.4% to 23.9% can be seen during the period between 1999 and 2022. According to the U.S. census, the percentage of the Hispanic population nationwide for this same time period increased from 12.5% to 19.1% and from 42.1% to 50.2% in the State of New Mexico. In addition, it is important to note that if the presence of a radionuclide is dependent on a subclass of interest (i.e., gender, ethnicity, etc.), valid population estimates can still be made by correcting for the proportion of under- or over-sampling for the particular subclass. Variations observed for the remainder of the demographic characteristics are also listed in Appendix H, Table H.3.

## 9.5 Results and Discussion

### 9.5.1 LDBC Results Greater Than the Decision Limits ($L_C$)

The LDBC results greater than the decision limits ($L_C$) for the baseline and operational measurements for the period 1997 - 2022 are listed in Appendix H, Table H.4. Results listed in Appendix H, Table H.4 are for the participants counted only once. For the baseline measurements (N = 366), the percentage of results greater than $L_C$ were consistent with a 5% random false-positive error rate, at the 95% confidence level (1% to 9%), for all radionuclides except $^{232}$Th via the decay of $^{212}$Pb, $^{235}$U/$^{226}$Ra, $^{60}$Co, $^{137}$Cs, $^{40}$K, $^{54}$Mn, and $^{232}$Th via the decay of $^{228}$Ac. As discussed in the 1998 report, five of these radionuclides [$^{232}$Th via $^{212}$Pb, $^{60}$Co, $^{40}$K, $^{54}$Mn ($^{228}$Ac interference), and $^{232}$Th (via $^{228}$Ac)] are part of the shield room background and positive detection is expected at low frequency. The $^{40}$K isotope is a naturally occurring isotope of an essential biological element, so detection in all individuals is expected. The $^{137}$Cs and $^{235}$U/$^{226}$Ra isotopes are not components of the shielded room background and were observed at frequencies greater than the 95% confidence interval for the false-positive error rate, discussed in more detail below.

For the operational measurement (N = 1222), the percentage of results greater than $L_C$ were consistent with the baseline at a 95% confidence level (margin of error), except for $^{60}$Co and $^{232}$Th (via $^{228}$Ac). For these radionuclides, the percentage of results greater than $L_C$ decreased relative to the baseline. This would be expected for $^{60}$Co, given that it has a relatively short half-life (5.27 years) and the content of $^{60}$Co within the shield has decreased via decay by approximately 85% since the baseline phase of monitoring. The differences in $^{232}$Th (via $^{228}$Ac) results between the baseline and operational monitoring phase were also observed in 2001 and 2002 and are likely due to the replacement of aluminum (aluminum tends to contain Th and U) in some of the detector cryostat components with those manufactured from low radiation background steel.

The percentage of results greater than $L_C$ for $^{235}U/^{226}Ra$ (11% for the baseline) is significantly higher than the distribution-free confidence interval for a 5% random false-positive error rate. These data are not nearly as compelling as those for $^{137}Cs$, but the large sample size of the current cohort tends to support the observed pattern. $^{235}U$ and $^{226}Ra$ cannot be identified separately by individual gamma energies by the current operating system. The activity result is reported together for $^{235}U$ and $^{226}Ra$ using the 186 keV gamma ray. Prior to 2022, MDA activities of $^{235}U$ and $^{226}Ra$ were calculated using their respective abundances for the 186 keV gamma ray. During the 2019 - 2020 upgrade testing of the facility, the feasibility of identification of $^{235}U$ by 185.72 keV gamma ray (57% abundance) and $^{226}Ra$ by 186.21 keV gamma ray (3.64% abundance) was considered. The system was upgraded to the APEX In-vivo operating system during 2022. The $^{235}U$ and $^{226}Ra$ results are evaluated using the radiobioassay spectra of public volunteers who participated during 2022. There were no results greater than $L_C$ for $^{235}U$ and $^{226}Ra$ for the public volunteers who participated during 2022. Investigation of the $^{235}U$ and $^{226}Ra$ results will continue as further data become available.

The $^{40}K$ results have been positive for all participants counted both before and after WIPP became operational. For the in-vivo radiobioassays performed for the public participants during the period from 7/21/1997 to 12/31/2022, the $^{40}K$ activity is in the range from 550 to 4749 Bq per person, the overall $^{40}K$ mean activity value ± standard error (SE) is 2178 ± 20 Bq per person, 2765 ± 23 Bq per person for males, and 1730 ± 13 Bq per person for females. The $^{40}K$ activity in the body of an adult person with body mass 70 kg ranges from 4,000 to 5,000 Bq (ICRP Publication 23, 1975). Such results are expected since $^{40}K$ is an essential biological element contained primarily in muscle. The amount of potassium in the body is proportionate to the muscle mass, which depends on sex, age, and physical activity level. Muscle mass also depends on human ethnicity, height, and body weight (Silva 2010, He et al., 2003). The $^{40}K$ average activity value per person for males was significantly greater than that of females because, in general, males tend to have larger body sizes and greater muscle content than females. These results are consistent with findings previously reported in the CEMRC reports and elsewhere (Webb and Kirchner, 2000). Figure 9.4 shows the number of LDBC participants with $^{40}K$ results > $L_C$, and Figure 9.5 shows the average $^{40}K$ activities among the LDBC participants during the period from 1997 to 2022.

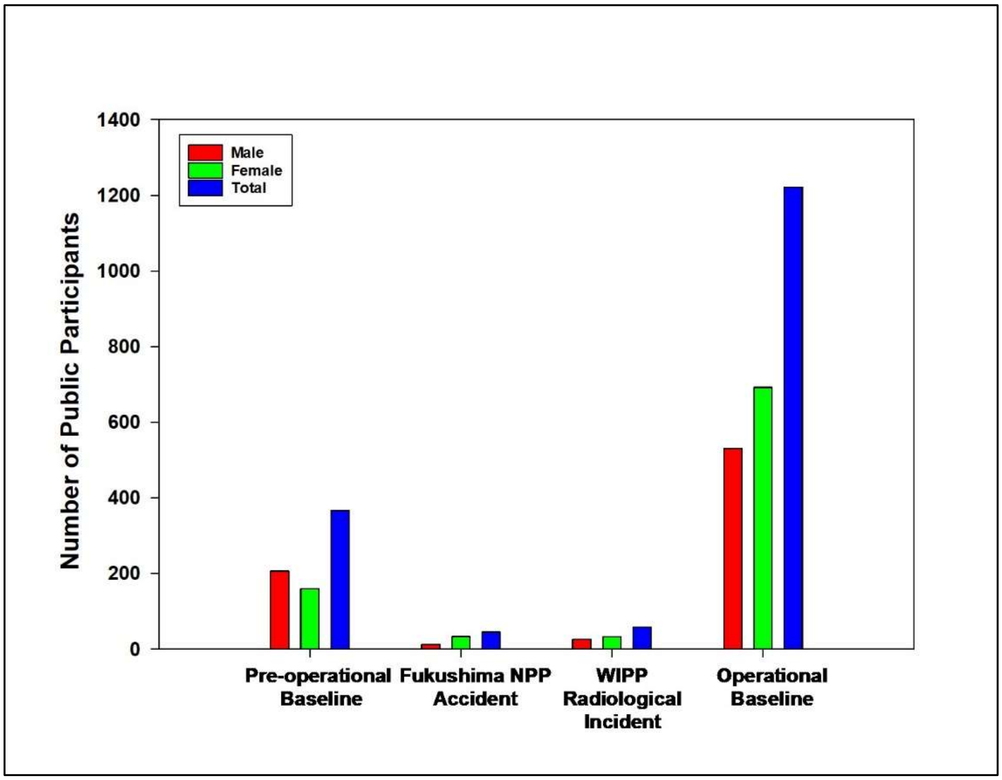


Figure 9.4. Number of participants with $^{40}K$ with results greater than $L_c$ during 1997-2022

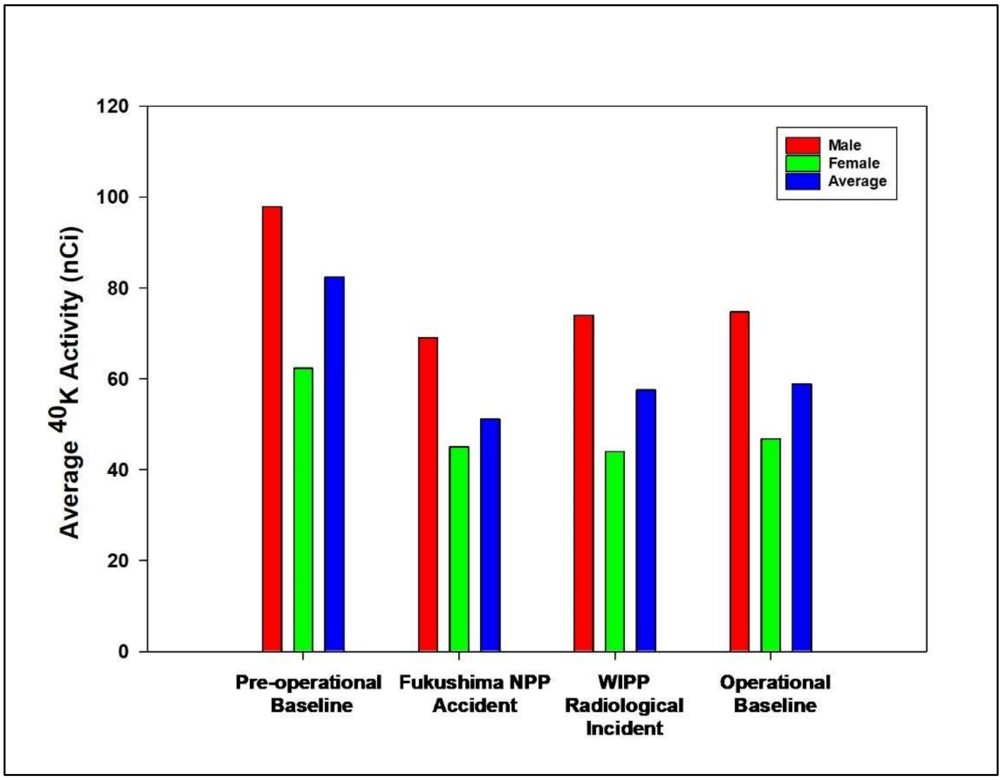


Figure 9.5. Average $^{40}K$ Activity (nCi) among LDBC participants during 1997-2022

Detectable $^{137}$Cs activity is present in about 28% (95% confidence level) for baseline, and 16.7% operational monitoring counts of residents living within a 100 mi radius of WIPP area. Results are given in Appendix H, Table H.4. These results are consistent with findings previously reported in the CEMRC reports and elsewhere (Webb and Kirchner, 2000). Detectable $^{137}$Cs body burdens ranged from 5 to 128 Bq per person with an overall activity mean activity $\pm$ SE of 11 $\pm$ 1 Bq per person. The $^{137}$Cs body burden mean activity $\pm$ SE for males was 11 $\pm$ 1 Bq per person and for females the mean activity $\pm$ SE was 11 $\pm$ 2 Bq per person. As previously reported (CERMC Reports; Webb and Kirchner, 2000) the presence of $^{137}$Cs was independent of ethnicity, age, radiation work history, consumption of wild game, nuclear medical treatments, and European travel. However, the occurrence of detectable $^{137}$Cs was associated with gender where males had a higher prevalence (65%) of $^{137}$Cs relative to females (35%). Figure 9.6 shows the number of participants with $^{137}$Cs results greater than Lc during 1997 - 2022, and Figure 9.7 shows $^{137}$Cs average activity (nCi) among LDBC participants during 1997 - 2022.

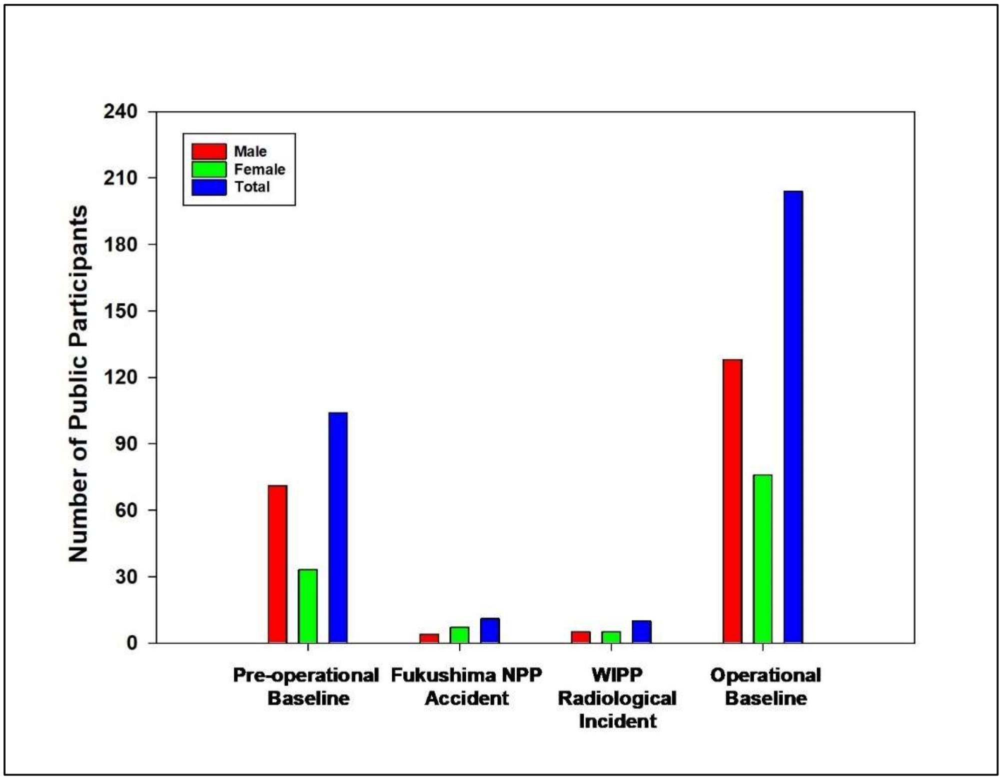


**Figure 9.6. Number of participants with $^{137}$Cs results greater than $L_c$ during 1997-2022**

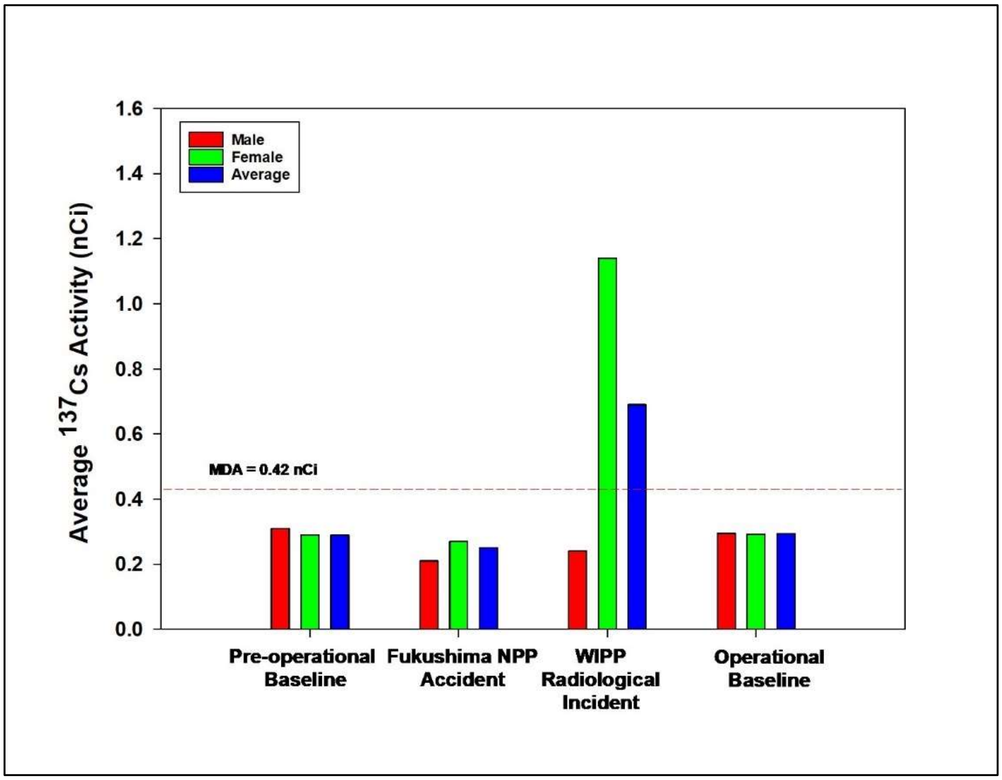


**Figure 9.7. Average $^{137}$Cs activity (nCi) among LDBC participants during 1997-2022**

Furthermore, the presence of $^{137}$Cs was associated with smoking. Smokers had a higher prevalence of detectable $^{137}$Cs (29.7%) as compared to non-smokers (24.1%) (CEMRC Report, 2005/2006). The association with gender is likely related to the tendency for a larger muscle mass in males than in females, as supported by the $^{40}$K results. The association of $^{137}$Cs with smoking could be related to the presence of fallout $^{137}$Cs in tobacco, a decreased pulmonary clearing capability in smokers, or other as yet unidentified factors.

Plutonium and americium isotopes, the main component of the WIPP's waste, were also monitored among the public. Lung counting is the primary method for determining intakes of Pu isotopes and $^{241}$Am. The lung burdens of plutonium isotopes and $^{241}$Am in public participants were measured using the 17 keV X-ray line for plutonium isotopes and the 59.5 keV gamma line for $^{241}$Am. Efficiency, and therefore the sensitivity level, varies for every count because of the effects of chest wall thickness (CWT) on the attenuation of the 17 keV x-rays and the 59.5 keV gamma ray. A typical low energy gamma spectrum of the lung counter of public count and background are shown in Figure 9.8. CWT is estimated by mass to height ratios for routine counting. However, the use of ultrasound for CWT measurement is recommended for special or positive counts. For lung counts, increases in chest wall thickness can increase the individual's MDA. In its more than 20 years of *in vivo* monitoring, CEMRC has never detected Pu isotopes or $^{241}$Am in any public volunteers.

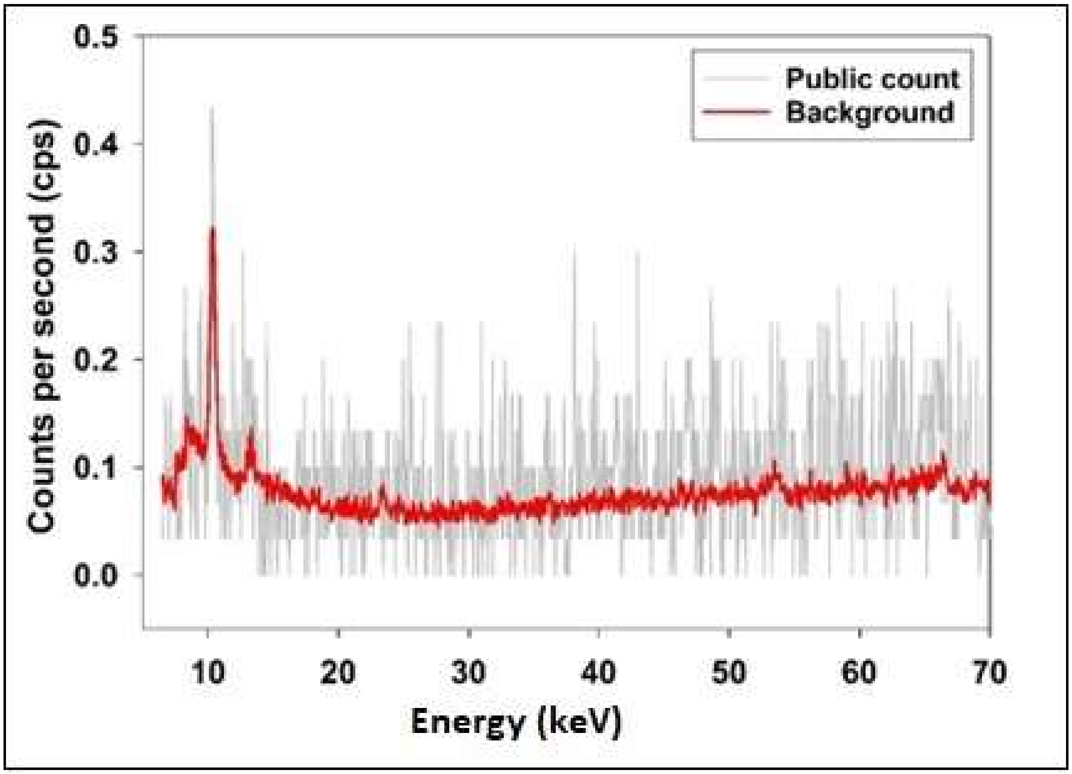


**Figure 9.8. Typical 17 keV (Pu isotopes) and $^{241}$Am (59.5 keV) energy region of Low Lung Group gamma spectrum of a public volunteer**

For most radiobioassay results, a two-step process is used to decide whether the analyte is present. In the first step, a statistical decision level ($L_C$) is used to determine if the counts in an energy region of a sample spectrum are significantly greater than in the same region in a background spectrum. This process is discussed in the 1998 CEMRC Report. The second step of the process involves a review of the spectrum by a technical expert to confirm the first step's conclusion. For example, the application of a decision level ($L_C$) to a low lung count spectrum may lead to the conclusion that no $^{241}$Am is present. In contrast, a $^{241}$Am photopeak may be visible to the technical person. In such cases, the technical expert may decide to overrule the initial decision and declare that $^{241}$Am is present. At CEMRC, the *in vivo* bioassay program attempts to perform measurements with 95% confidence level and therefore there will be a false positive rate of 5%, meaning 5% of all measurements will be determined to be positive when there is no actual activity in the person. These results, particularly the absence of detectable plutonium and americium levels, suggest that there has been no impact from WIPP's operations.

## 9.6 Conclusions

CEMRC's ID has been satisfactorily conducting the LDBC program since its inception in 1997. Comparisons of radiological activities measured between the pre-operational and operational groups revealed no significant differences, thereby indicating that waste disposal activities at WIPP showed no measurable radiological impact on local residents' health. Furthermore, the absence of detectable levels of plutonium and americium suggests that there has been no impact from WIPP operations.

Resident participation from communities other than Carlsbad, NM, has not been significant, partly because of the time and distance involved. Resident participation from Carlsbad has also been declining steadily since 2006. The main reason for this decline has been overwhelming public trust and support for the WIPP project. Local acceptance of WIPP is due partly to its robust safety record and comprehensive environmental monitoring program. Despite its recent shortcomings, there is not a great degree of concern among the local and surrounding communities about their health and safety because of WIPP's operation. Even though there was not a substantial increase in the number of citizens who take advantage of the LDBC program, the mere availability of such a service and their direct participation in CEMRC's whole-body counting program provides transparency which is key to maintaining public trust and confidence.

However, in recent years, there has been increased awareness and interest among students participating in the Early College Initiative in Carlsbad. Additionally, the ID group is also continuing to enhance the visibility of the LDBC program, by participating in the community events such as job fair, science nights during summer camps for young adults, and by interacting individually with persons living in different areas.

# CHAPTER 10 - NON-RADIOLOGICAL MONITORING

Non-radiological monitoring is a vital part of the WIPP-EM program because the activities at the WIPP site involve both radioactive and hazardous (non-radioactive) materials. The focus of the Environmental Chemistry (EC) group is to monitor the non-radiological hazard potential to the environment in, and around, the WIPP site by analyzing various sample types including airborne effluent, ambient air particulates, drinking water, and surface water. The current scope of work requires non-radiological studies for a variety of metals, inorganic anion constituents, and inorganic cation constituents, as well as characterizing some common indicator parameters of local water sources. Current methods utilized by the EC group for inorganic analyses performed on each sample type are provided in Appendix I, Table I.1. In 2022, CEMRC's non-radiological monitoring program included effluent monitoring at the FAS Stations A and B, airborne particulate monitoring surrounding the WIPP site, and annual sampling of local drinking water and surface water sources.

CEMRC has been sampling and analyzing WIPP exhaust air for inorganic constituents since December 1998. Before the 2014 event, only Station A was used for exhaust air compliance monitoring purposes. After the 2014 event, all inorganic analyses of WIPP exhaust air were halted because the filters collected were analyzed for radiological constituents to support the evaluation of the event. The CEMRC EC group resumed inorganic analyses of exhaust air in 2015 for both Station A and Station B filters.

CEMRC has also been sampling and analyzing ambient air (i.e., aerosol samples) surrounding the WIPP site since 1999. However, in 2005, the sampling process changed and all inorganic analyses were suspended. CEMRC resumed analysis and reporting results for ambient air in 2020.

In addition to air monitoring, CEMRC has also been sampling and analyzing inorganic constituents in drinking water from six community supplies and three regional surface water reservoirs since 1997. Three supplemental surface water locations were added to the list in 2021. In this chapter, inorganic results for the current drinking water and surface water sources are provided for the current year.

## 10.1 Non-Radiological Monitoring of Airborne Effluent

### 10.1.1 Sample Collection

Particulates in the exhaust air are collected on 47 mm diameter membrane filters (Versapor™ membrane filter, PALL Corporation, Port Washington, NY, USA) with the use of a cylindrical shrouded probe, commonly referred to as a Fixed Air Sampler (FAS). Typically, two sets of filters are collected from both Station A and Station B: a primary set and a secondary (backup) set. Before the 2014 accidental release event, the primary set of filters was used for the analysis of both radiological and non-radiological constituents, while the backup set of filters was archived. After the 2014 event, the primary set of filters was used for radiochemical analyses, while the backup set was used for inorganic analyses. Occasionally, both the primary and backup filter sets are needed for immediate radiochemical analyses. In such instances, inorganic analyses are not performed on this sample type.

### 10.1.2 Sample Preparation and Analysis

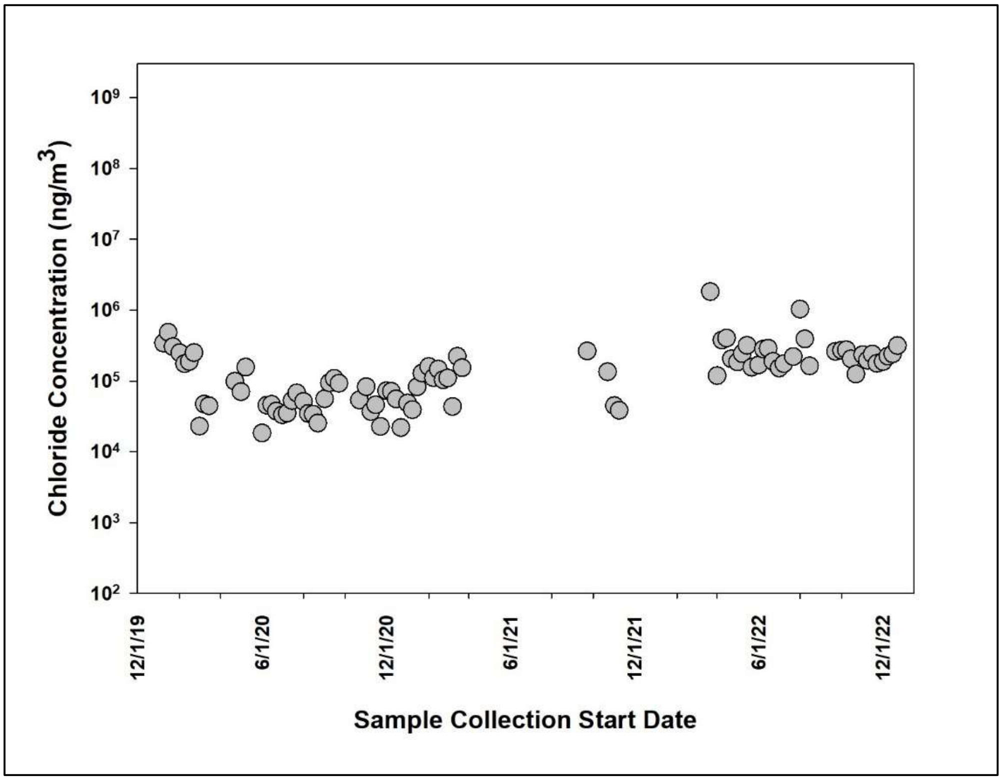
In 2020, additional analyses were requested on the FAS filters. To meet the new requirements, each FAS filter is cut in half, with one half digested for metal analysis and the other used for selected anion and cation analysis. Current methods utilized by CEMRC for inorganic analyses are summarized in Appendix I, Table I.1.

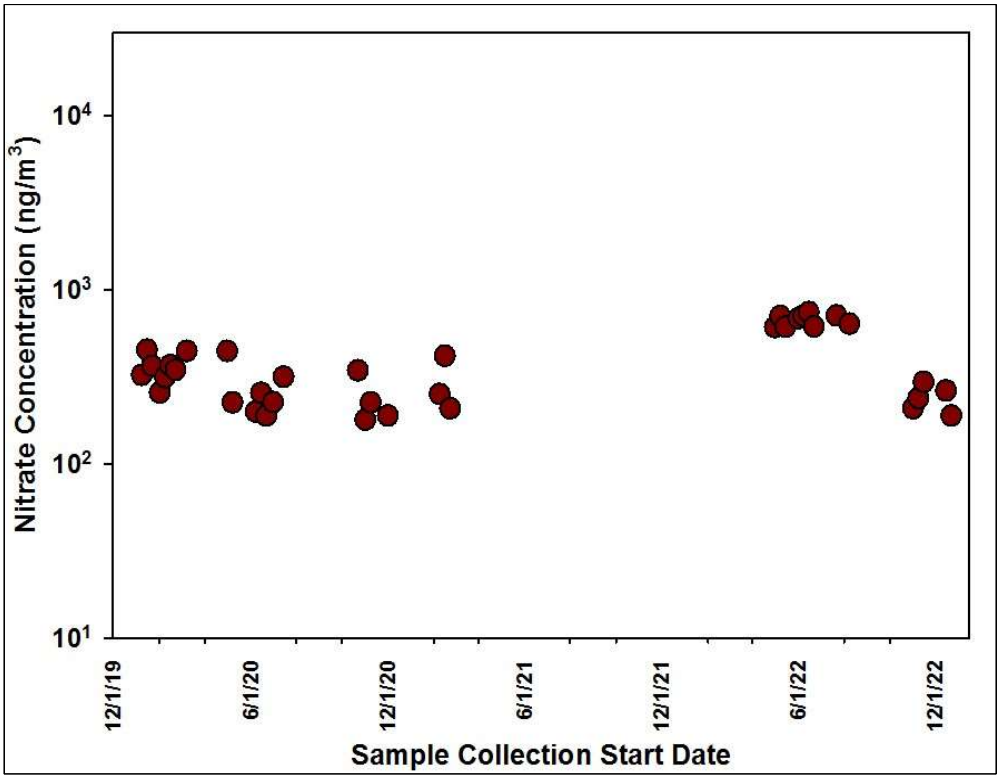
The backup filters for non-radiological metal analyses are digested in a strong acid mixture with the use of a CEM MARS Xpress™ or CEM MARS 6™ microwave unit (Charlotte, NC, USA). Individual FAS filters are placed in separate Teflon vessels and digested at 195 ˚C within an acid matrix consisting of nitric acid, hydrochloric acid, and hydrofluoric acids. A blank filter and Certified Reference Material (CRM) filter are also digested simultaneously with these FAS filters using the same method for quality control (QC) purposes. Acids used for digestions are either purchased as “trace metal” grade as noted by the manufacturer or purified in-house with a Milestone Inc. (Shelton, CT, USA) sub-boiling quartz distillation apparatus. After digestion, individual FAS filter solutions are combined into a weekly (Station A) or monthly composite (Station B), and the composite is analyzed, together with the corresponding blank and CRM filters, for selected metals by Perkin Elmer Inductively Coupled Plasma-Mass Spectrometers (ICP-MS). Metal concentrations of FAS filters from Station A and Station B are reported as the mass of metal divided by the volume of air (ng/m$^3$).

For anion and cation analyses, a water extraction using 40 mL ultrapure water is performed and the extraction solutions are combined into a weekly (Station A) or monthly composite (Station B). The composite solution is filtered prior to analysis by Ion Chromatography (IC) for selected inorganic anions and cations. Blanks and spiked blanks are also extracted in the same manner for quality control purposes. Anion and cation concentrations of FAS filters from Station A and Station B are reported as the mass of metal divided by the volume of air (ng/m$^3$).

### 10.1.3 Anion and Cation Concentrations Measured at Station A and Station B

Inorganic anion and cation analysis for Station A and Station B filters began in 2020. Selected anions include chloride, nitrate, phosphate, and sulfate and selected cations include ammonium, calcium, potassium, and magnesium. Concentration measurements for anions and cations are reported in Appendix I for Station A (Table I.2 and I.3) and Station B (Table I.4 and I.5), respectively. For Station A, chloride, nitrate, and sulfate (shown in Figure 10.1) are the only anions detected regularly above the MDC. The cations calcium, potassium, magnesium, and sodium are all regularly detected above the MDC in Station A filters as shown in Figure 10.2. For Station B, the only anion regularly detected above the MDC is chloride (Figure 10.3) and the only cations detected regularly above the MDC are sodium and calcium as shown in Figure 10.4. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis.





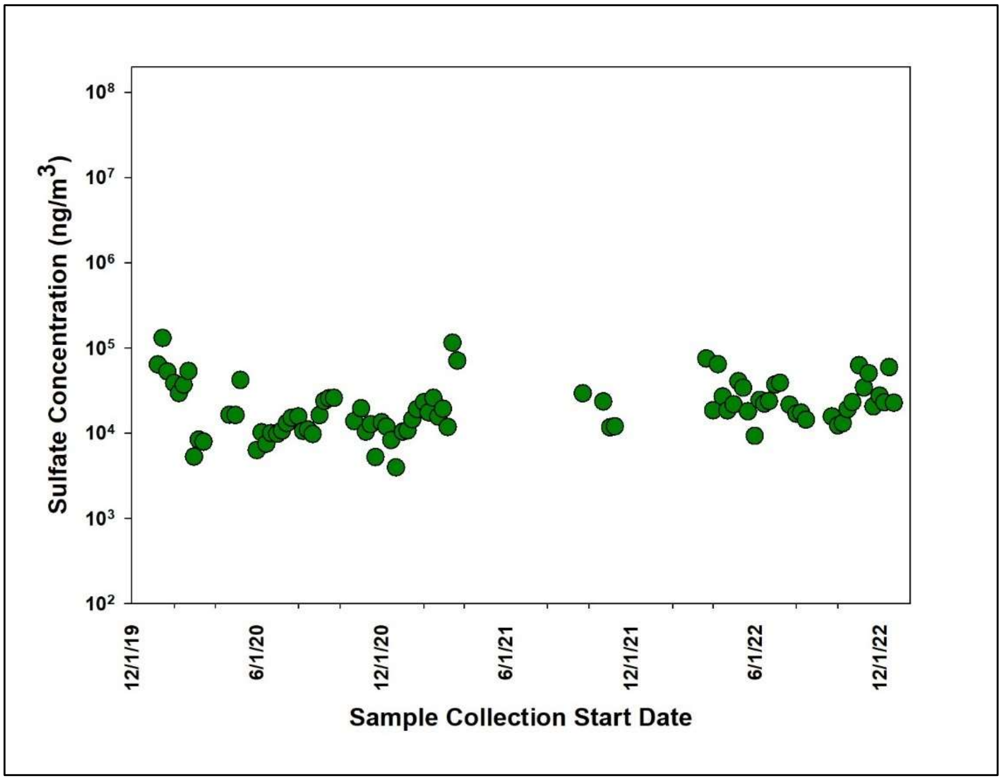
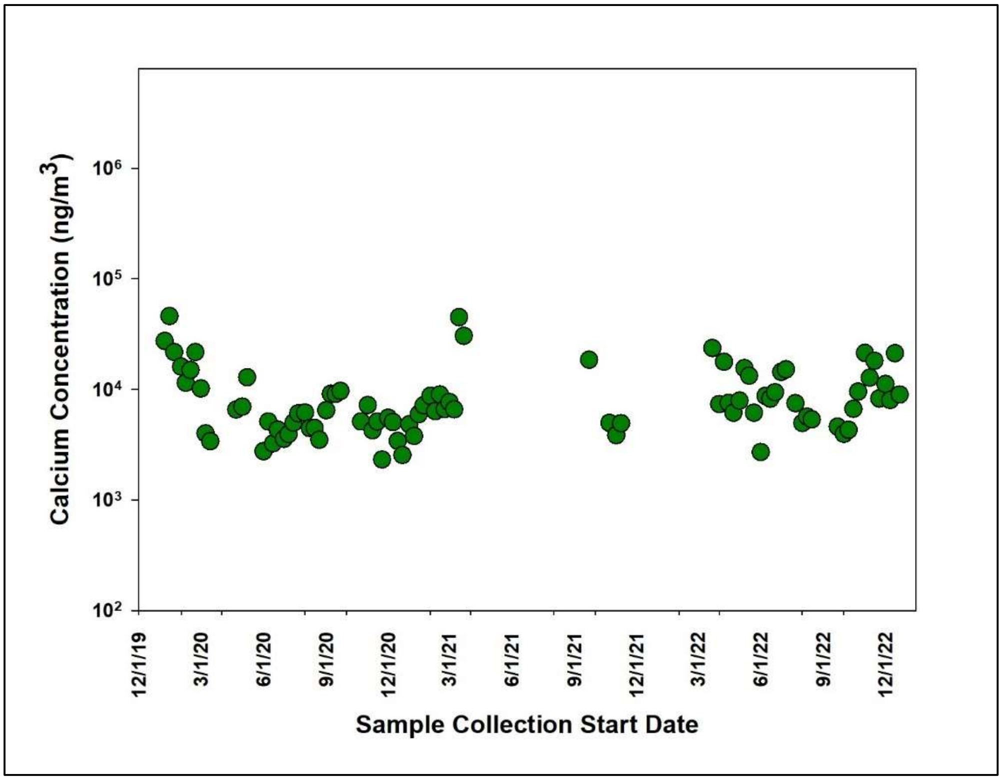
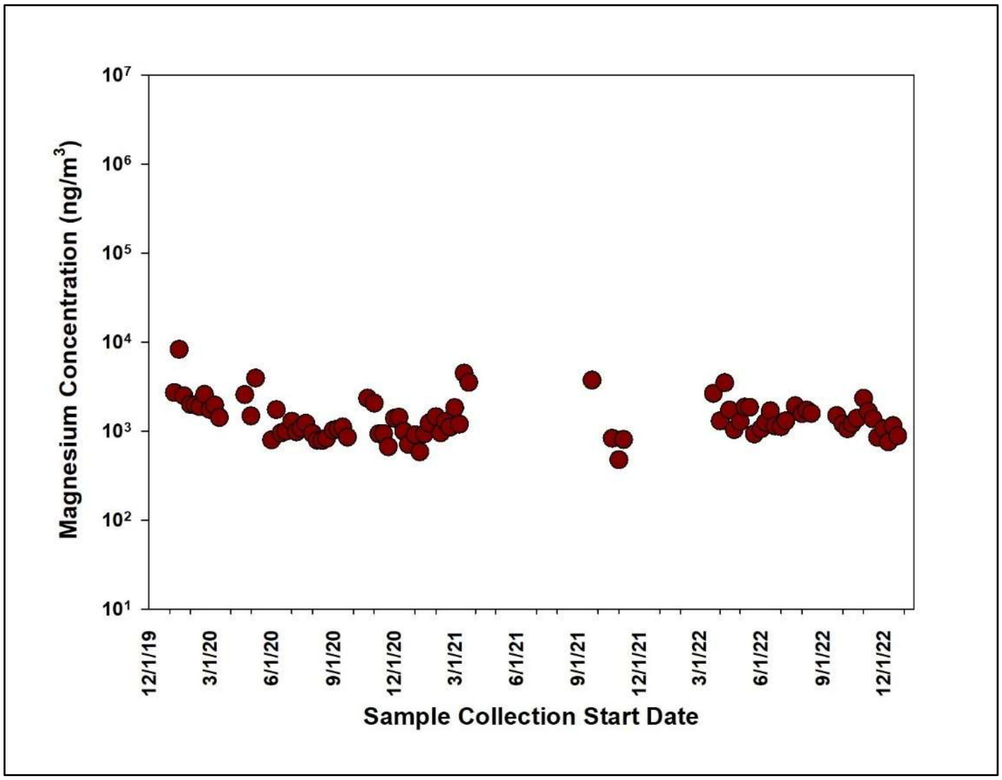
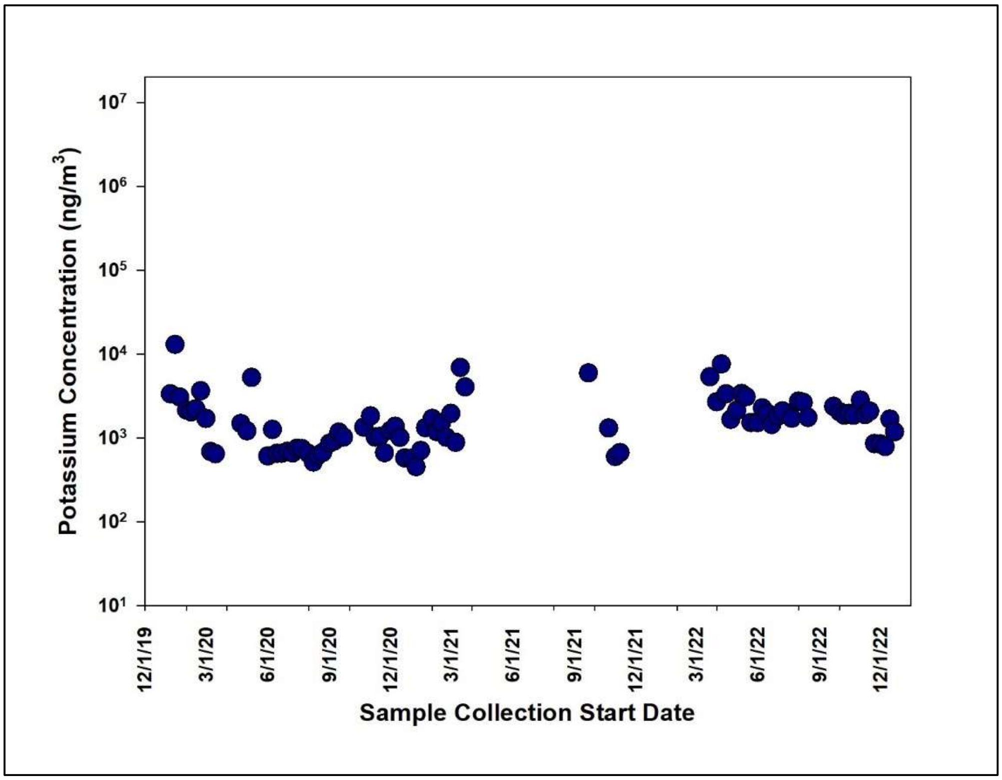


Figure 10.1. Historical Concentrations of Selected Inorganic Anions at Station A





Magnesium Concentration (ng/m$^3$)
$10^7$
$10^6$
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
6/1/22
9/1/22
12/1/22
Sample Collection Start Date



Potassium Concentration (ng/m$^3$)
$10^7$
$10^6$
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
12/1/19
3/1/20
6/1/20
9/1/20
12/1/20
3/1/21
6/1/21
9/1/21
12/1/21
3/1/22
6/1/22
9/1/22
12/1/22
Sample Collection Start Date

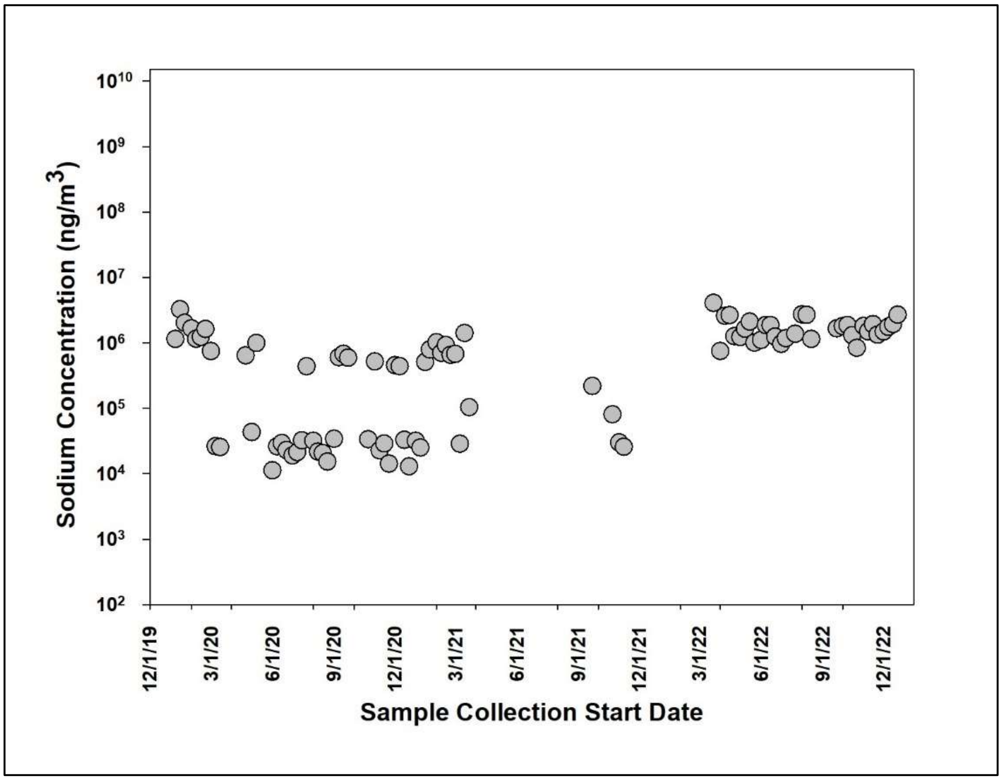


Figure 10.2. Historical Concentrations of Selected Inorganic Cations at Station A

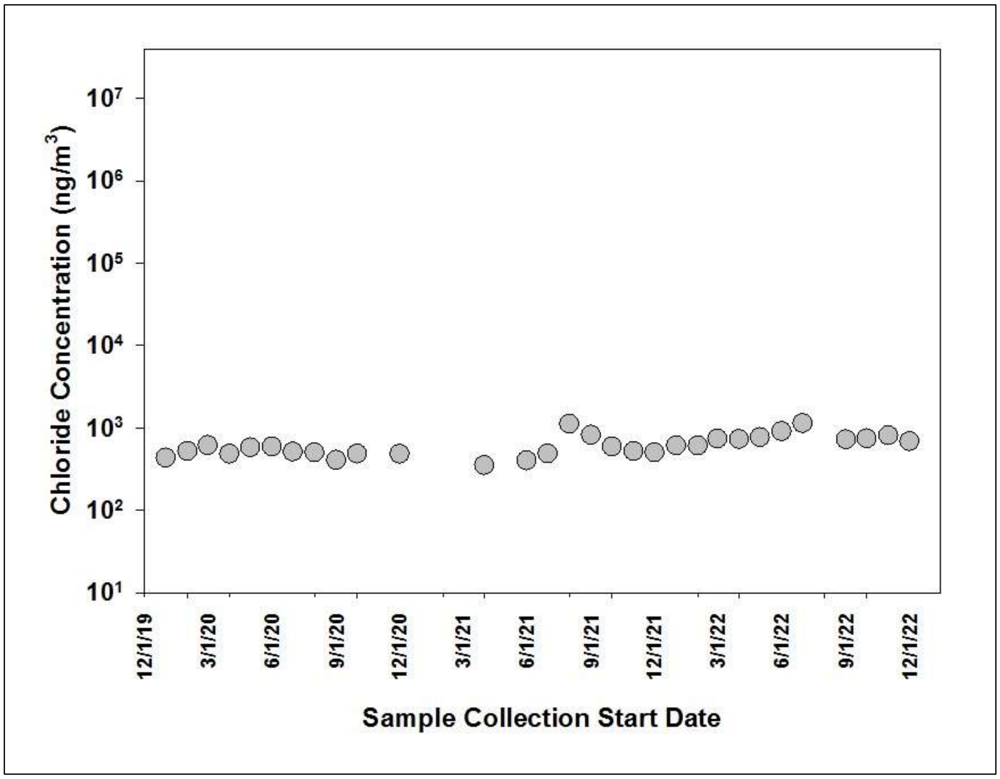
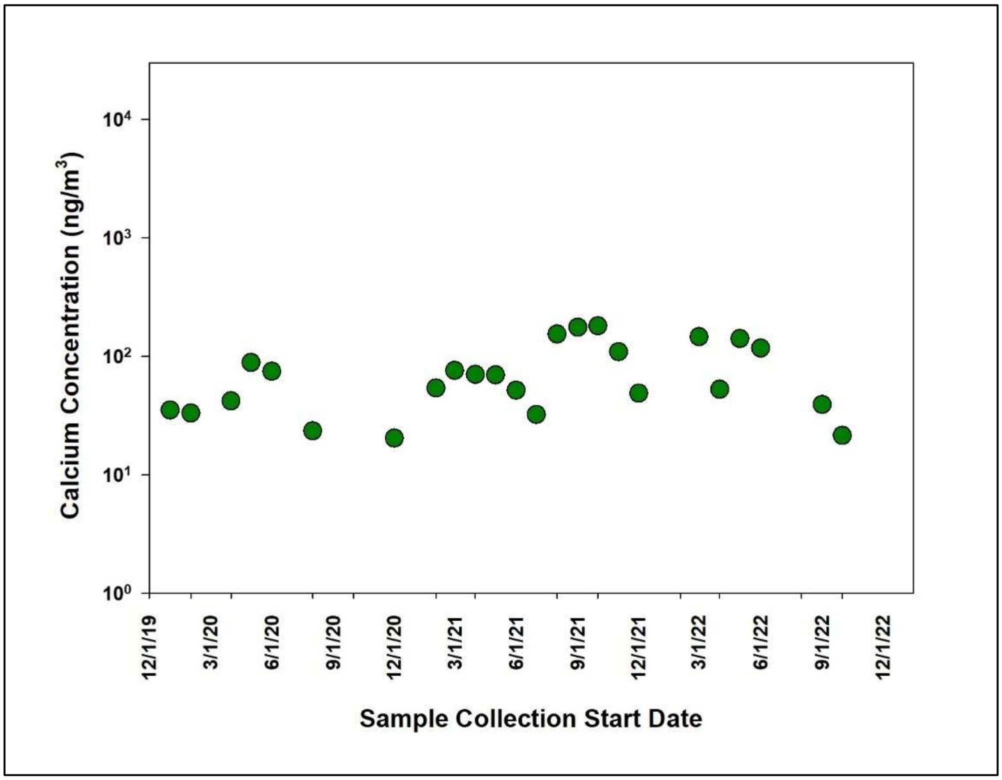


Figure 10.3. Historical Concentrations of Selected Inorganic Anions at Station B



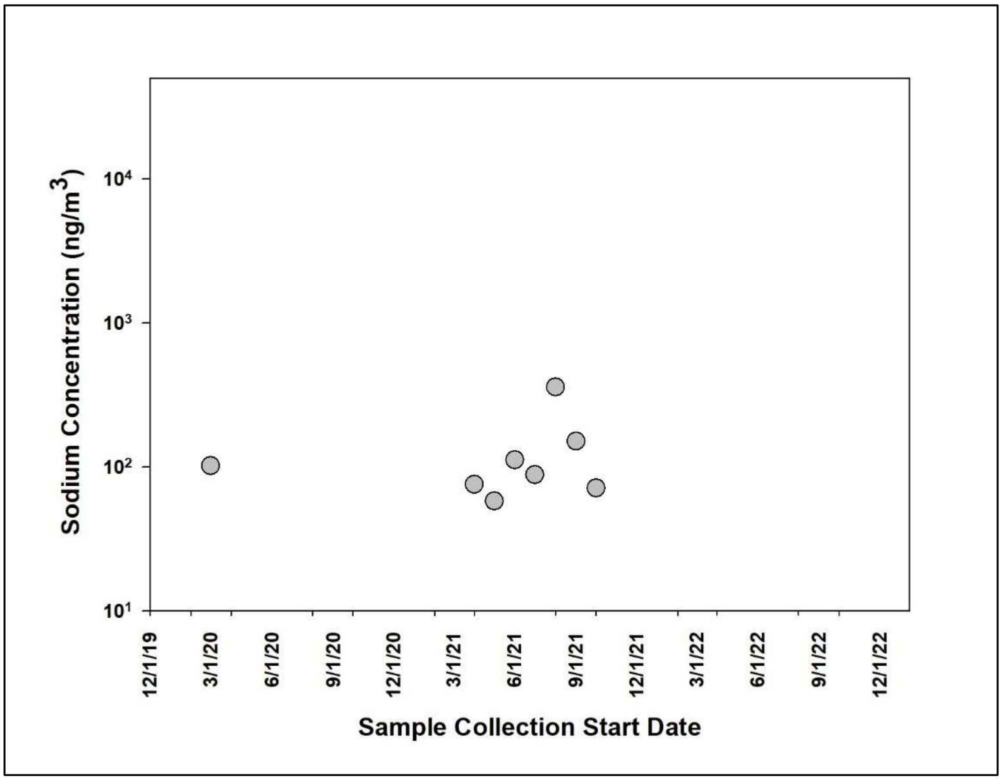


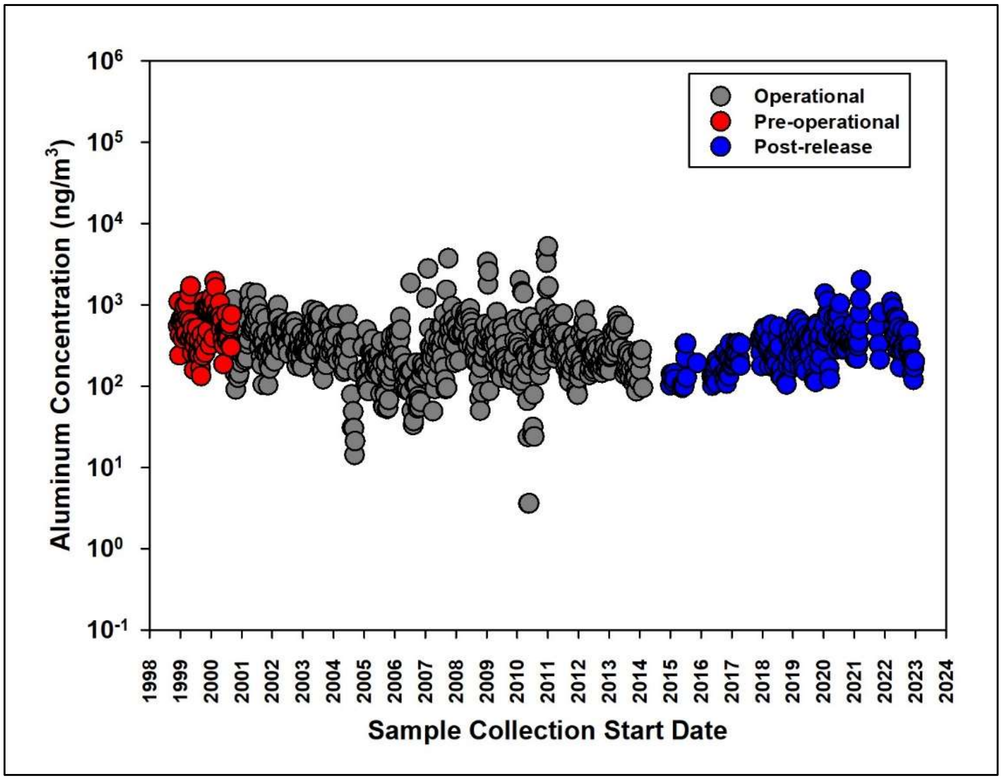
**Figure 10.4. Historical Concentrations of Selected Inorganic Cations at Station B**

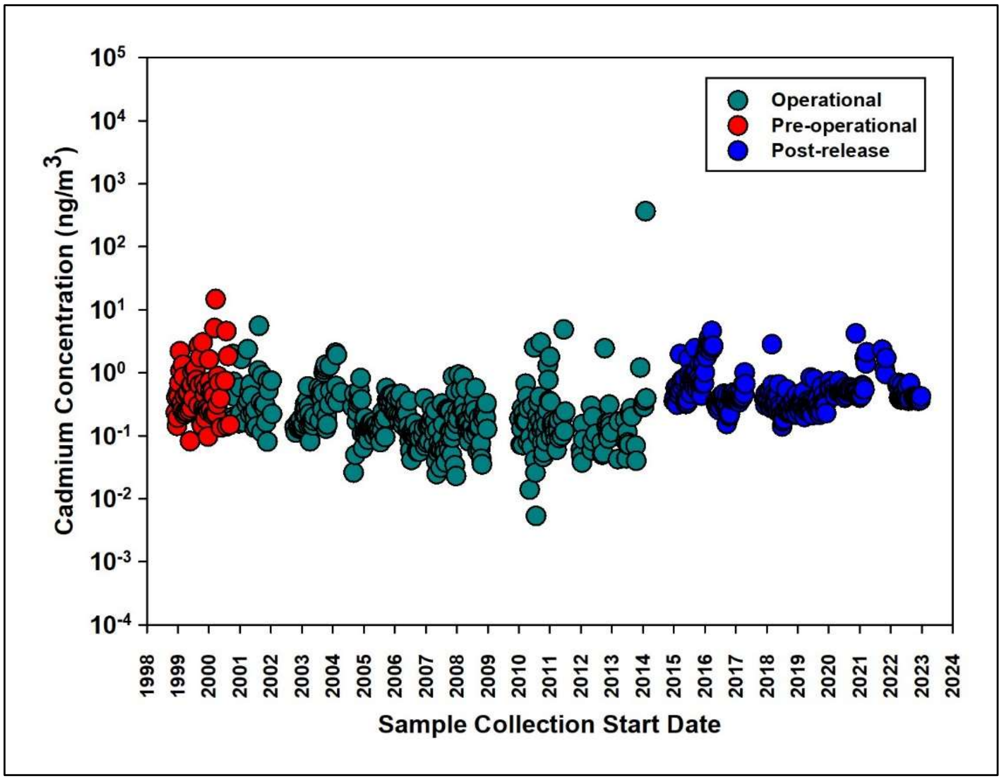
### 10.1.4 Metal Concentrations at Station A

Historical time-series plots for the following selected trace metals are shown in Figure 10.5 from 1998 through December 2022 for aluminum (Al), cadmium (Cd), lead (Pb), magnesium (Mg), silicon (Si), thorium (Th), and uranium (U). Concentrations for these trace metals on Station A filters collected in 2022 are reported in Appendix I, Table I.6. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis. In the case of silicon, analysis began in 2001 on an experimental basis only, but was discontinued in 2005. Routine reporting for this constituent began in 2015. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis.

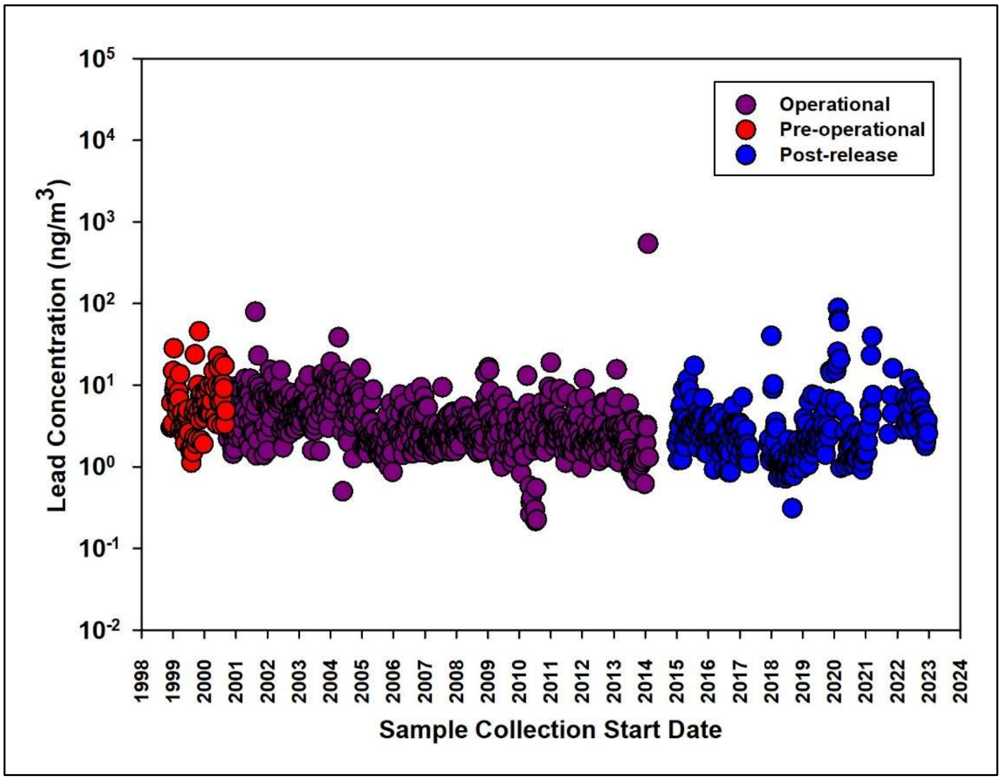
All regularly reported trace metals are detected regularly above the MDC at Station A. While variability between weekly composite results is common, long–term monitoring data show that there are no differences between the baseline, operational, and post-release data.

Aluminum concentrations are of particular interest because of the relationship observed between Al concentrations in ambient air and the $^{239+240}$Pu and $^{241}$Am activities (Arimoto et al., 2002 and 2005). Windblown dust is the main source for Al and many other elements (e.g., Fe, Mn, Sc, and the rare earth elements) in ambient air, as well as representing a source for U and some other naturally occurring radionuclides (Arimoto et al., 2005; Kirchner et.al., 2002). Special attention was also paid to magnesium as it is the primary component in the MgO backfill material that is the only engineered barrier at WIPP.

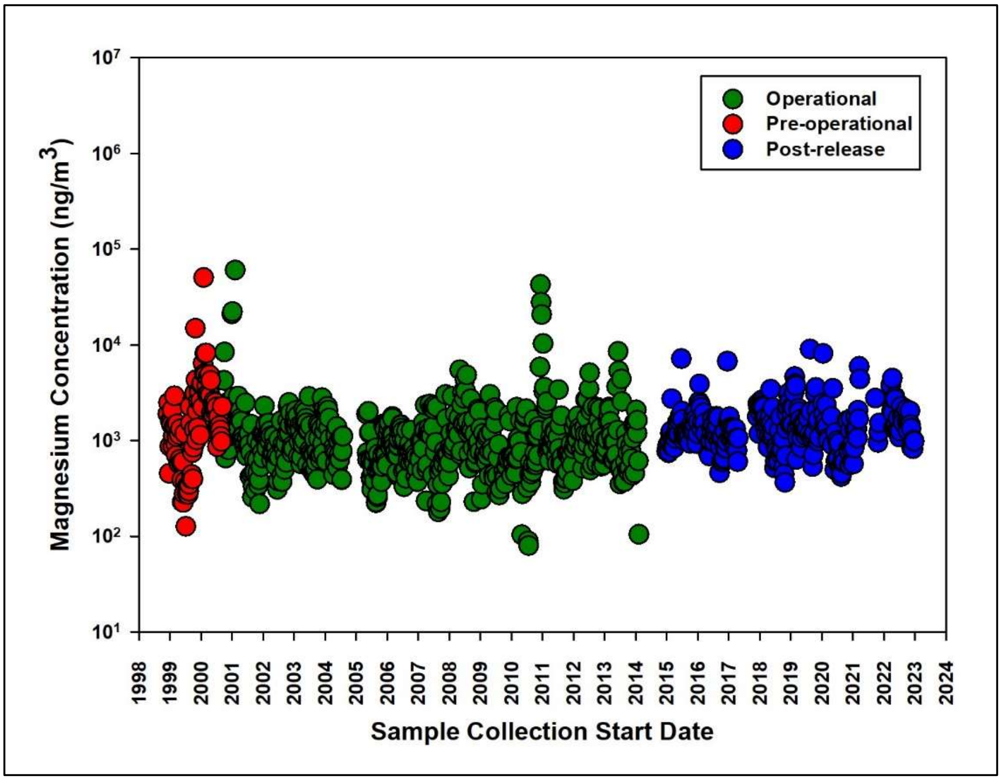


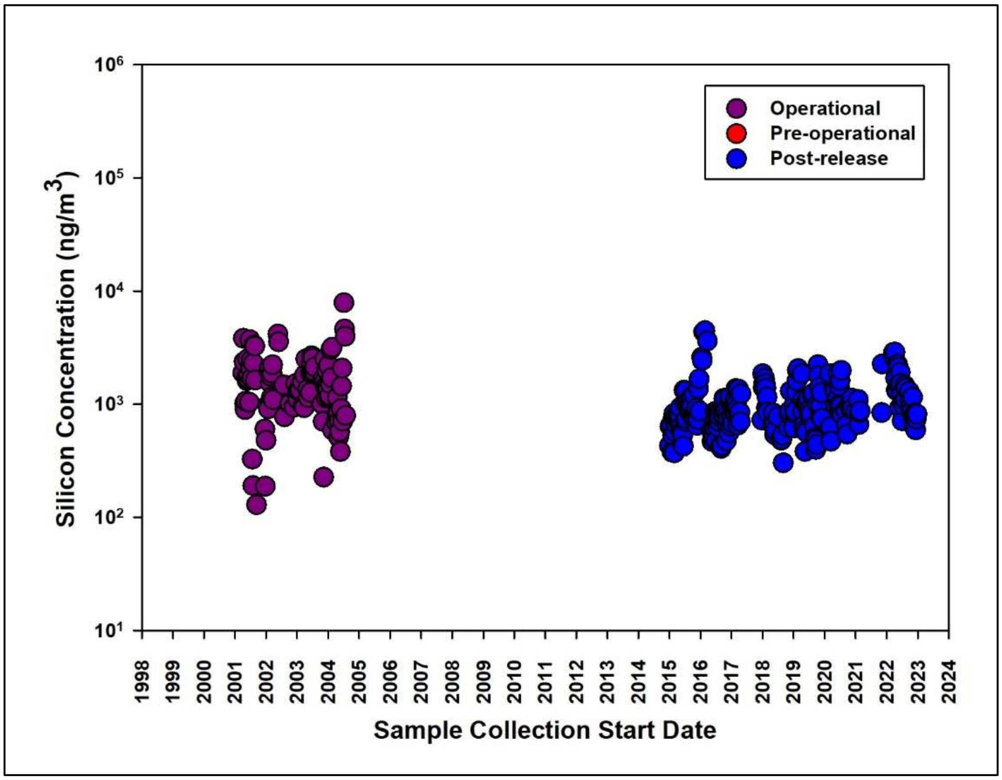


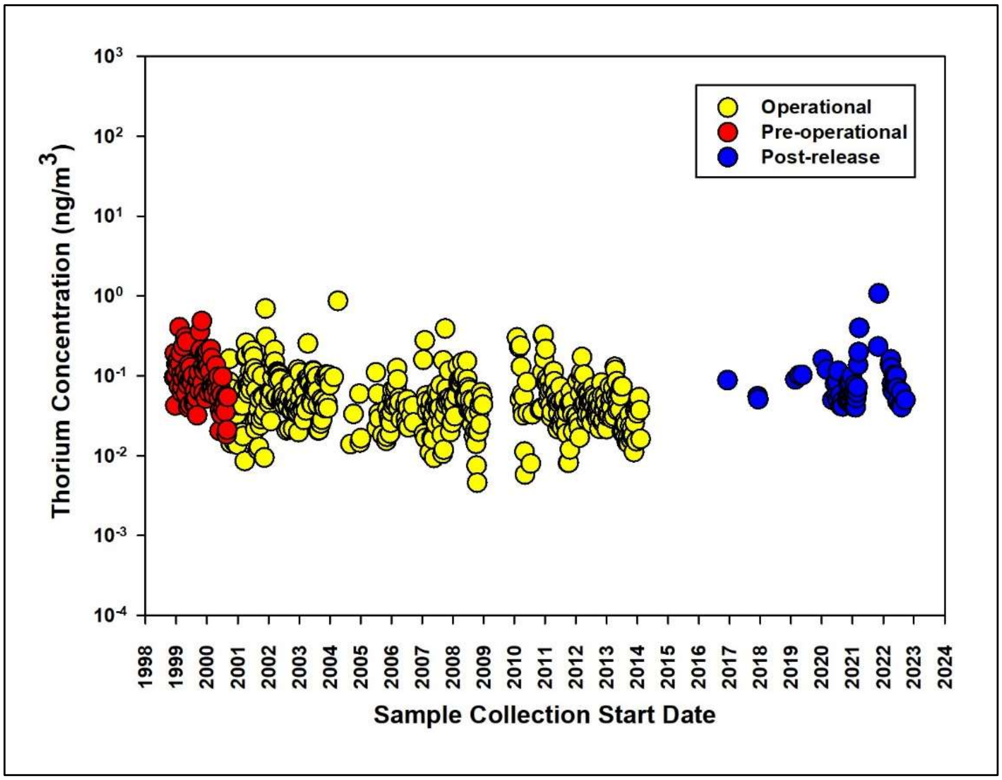
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
Cadmium Concentration (ng/m^3)
● Operational
● Pre-operational
● Post-release
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Collection Start Date



10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
Lead Concentration (ng/m^3)
● Operational
● Pre-operational
● Post-release
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Collection Start Date


Magnesium Concentration (ng/m$^3$)
$10^7$
$10^6$
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
Operational
Pre-operational
Post-release
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Collection Start Date


Silicon Concentration (ng/m$^3$)
$10^6$
$10^5$
$10^4$
$10^3$
$10^2$
$10^1$
Operational
Pre-operational
Post-release
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
Sample Collection Start Date



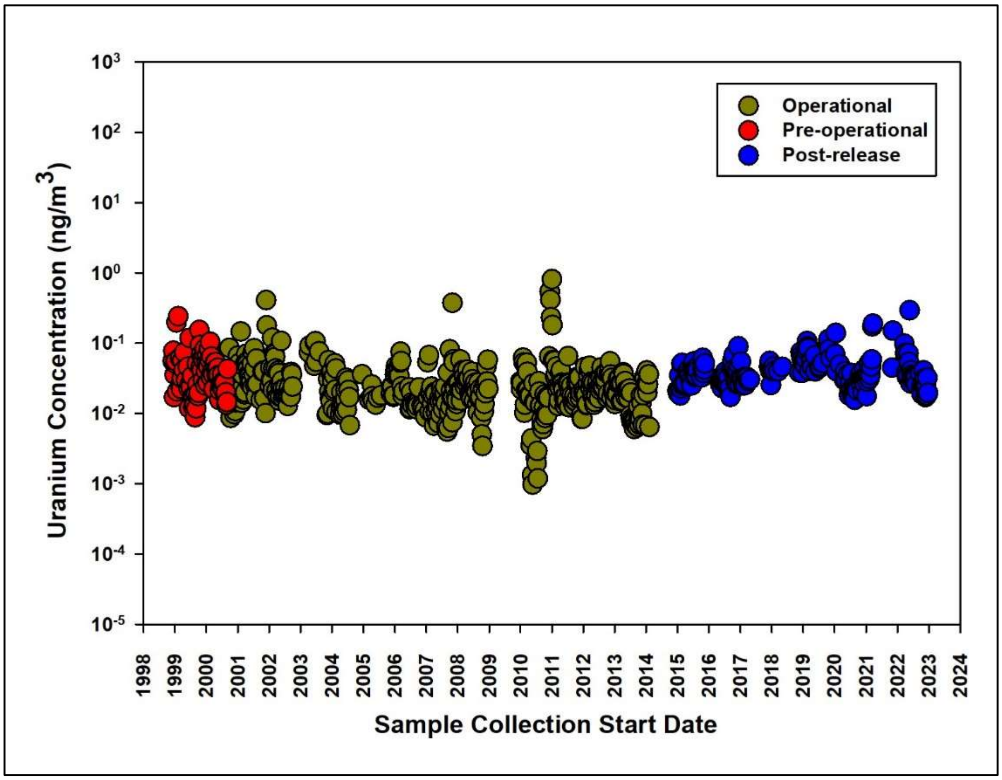
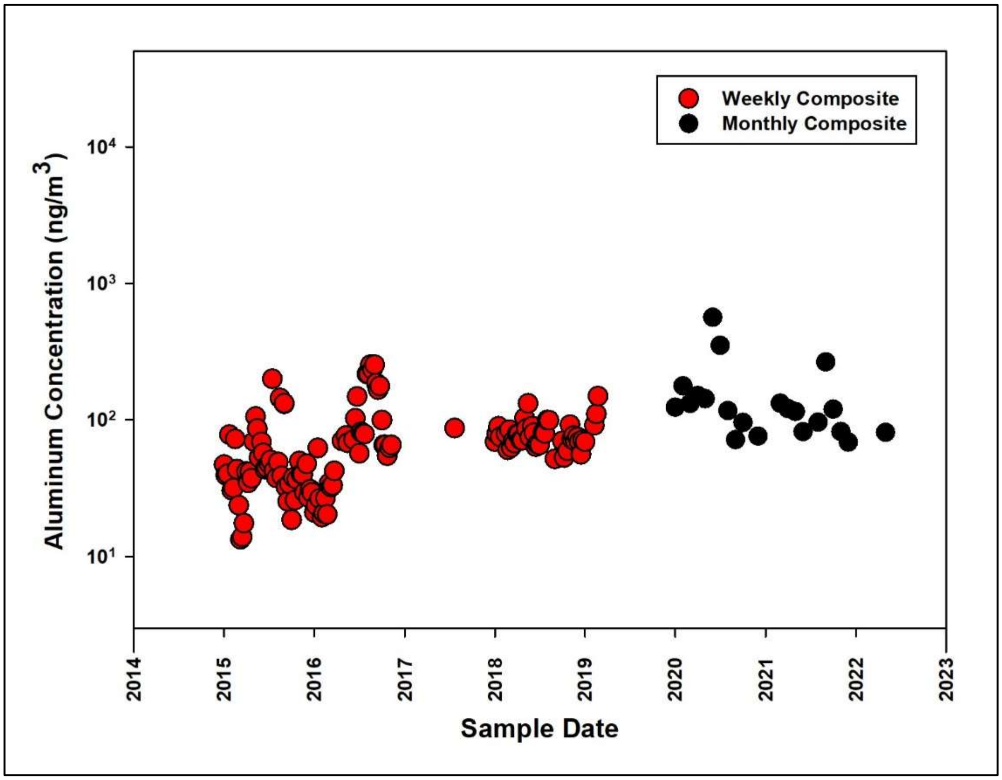
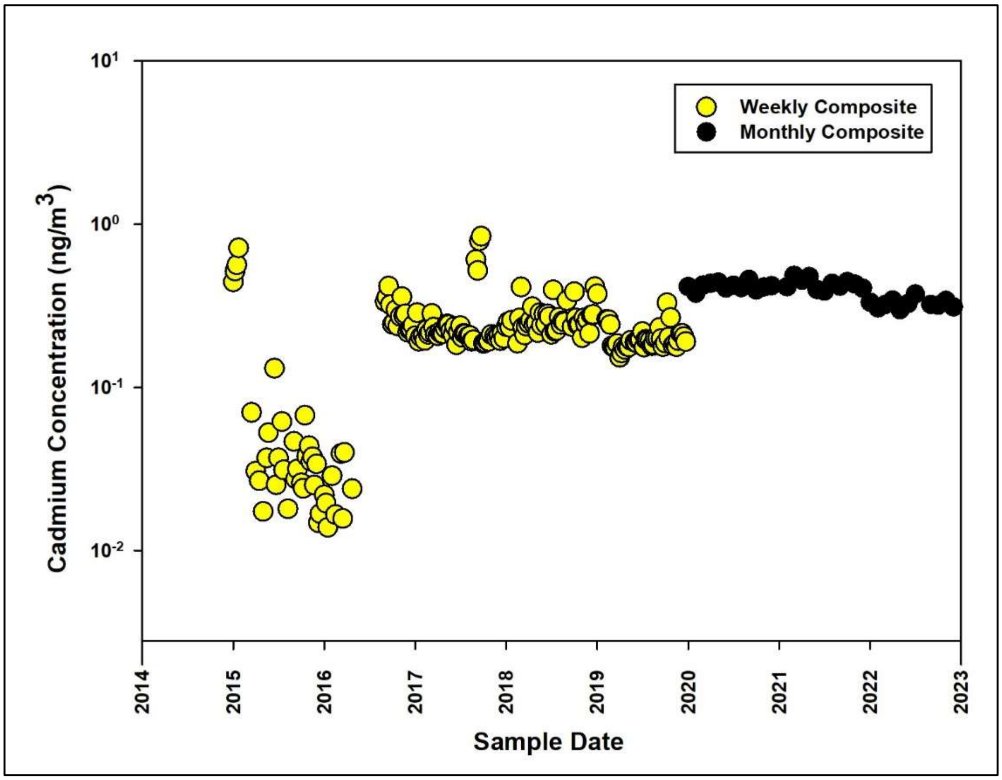


Figure 10.5. Historical Concentrations of Selected Metals at Station A

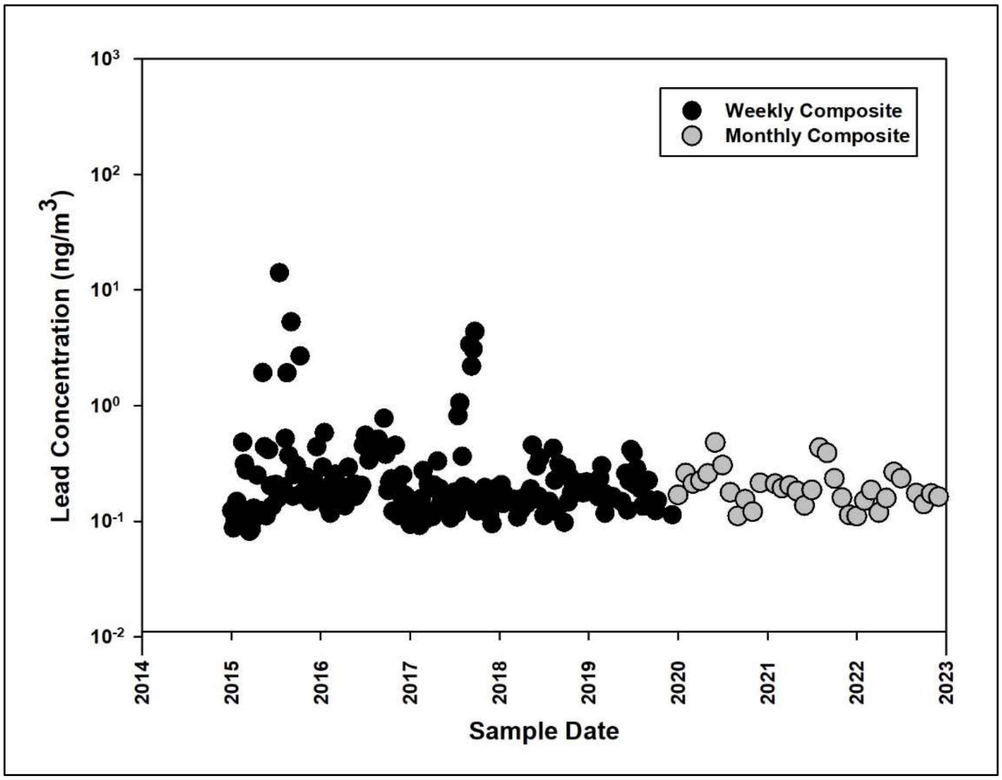
### 10.1.5 Metal Concentrations at Station B

Inorganic analyses for Station B exhaust filters began in 2015. Historical time-series plots for Station B filters are shown in Figure 10.6. Concentrations for weekly composites of Al, Mg, Cd, Pb, and Si are detected regularly above the MDC at Station B since 2015. In 2020, CEMRC switched from reporting the analysis results for weekly composites of Station B samples to monthly composites. Results of selected metals for 2022 monthly composites are reported in Appendix I, Table I.7. It is noteworthy that the concentrations of most elements detected at Station B are much lower than at Station A, which is expected, given that station B collects effluent air after HEPA filtration. It should also be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis.

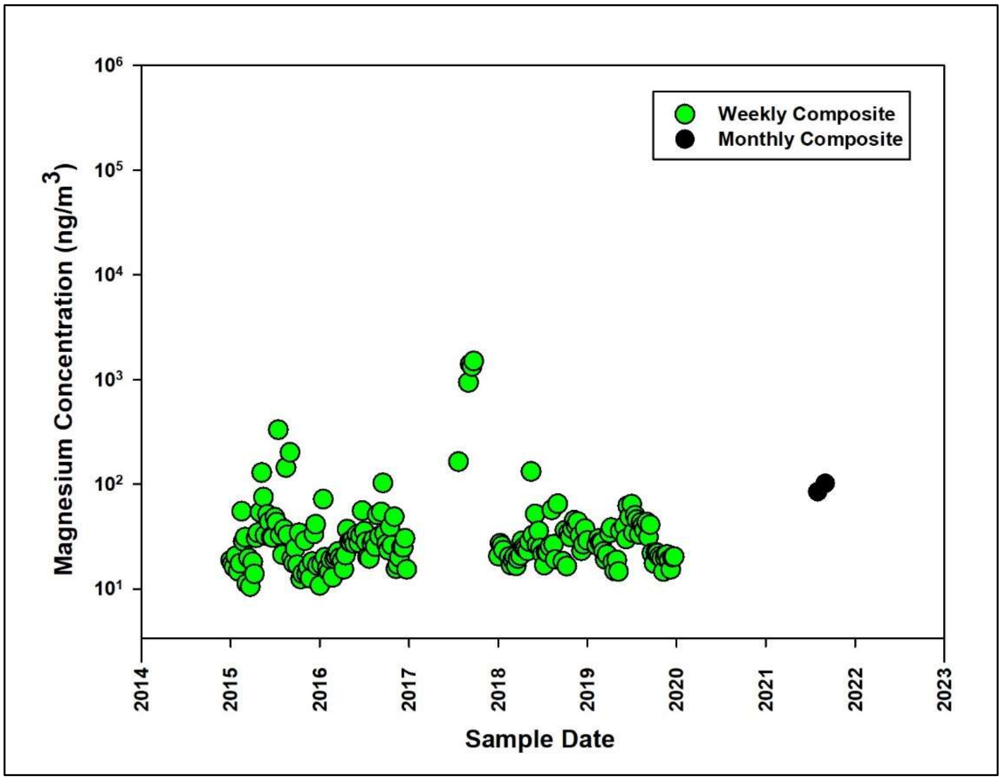




Weekly Composite
Monthly Composite
Cadmium Concentration (ng/m3)
10^1
10^0
10^-1
10^-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sample Date



Weekly Composite
Monthly Composite
Lead Concentration (ng/m3)
10^3
10^2
10^1
10^0
10^-1
10^-2
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Sample Date



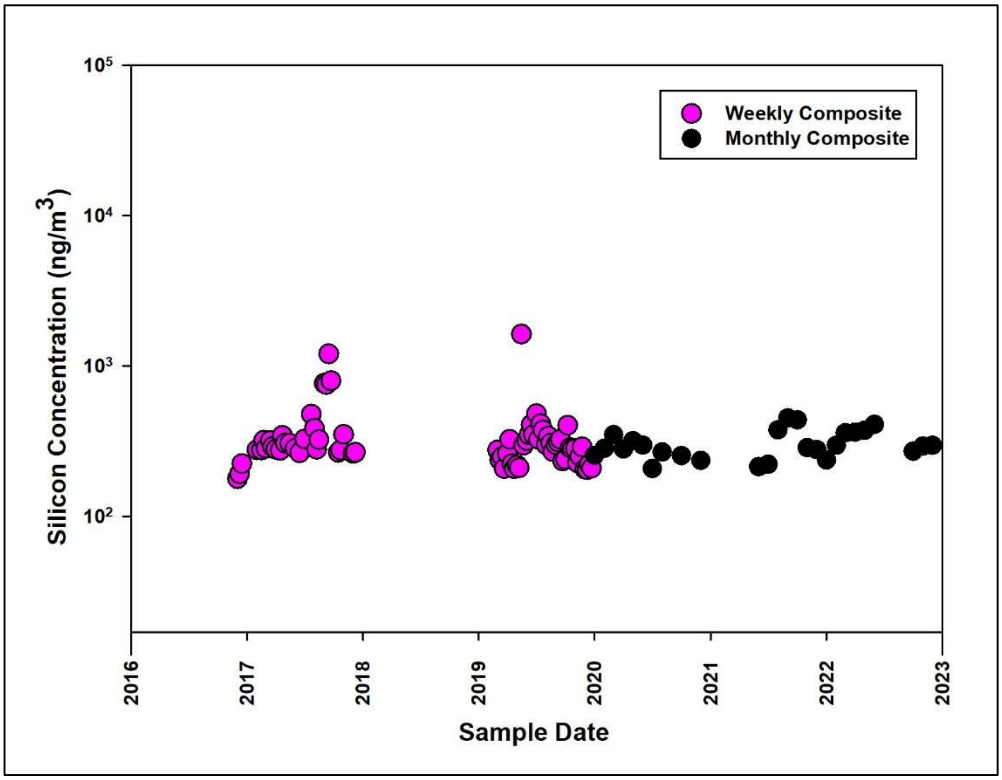


Figure 10.6. Historical Concentrations of Selected Metals at Station B

## 10.2 Non-Radiological Monitoring of Airborne Particulates

### 10.2.1 Sample Collection

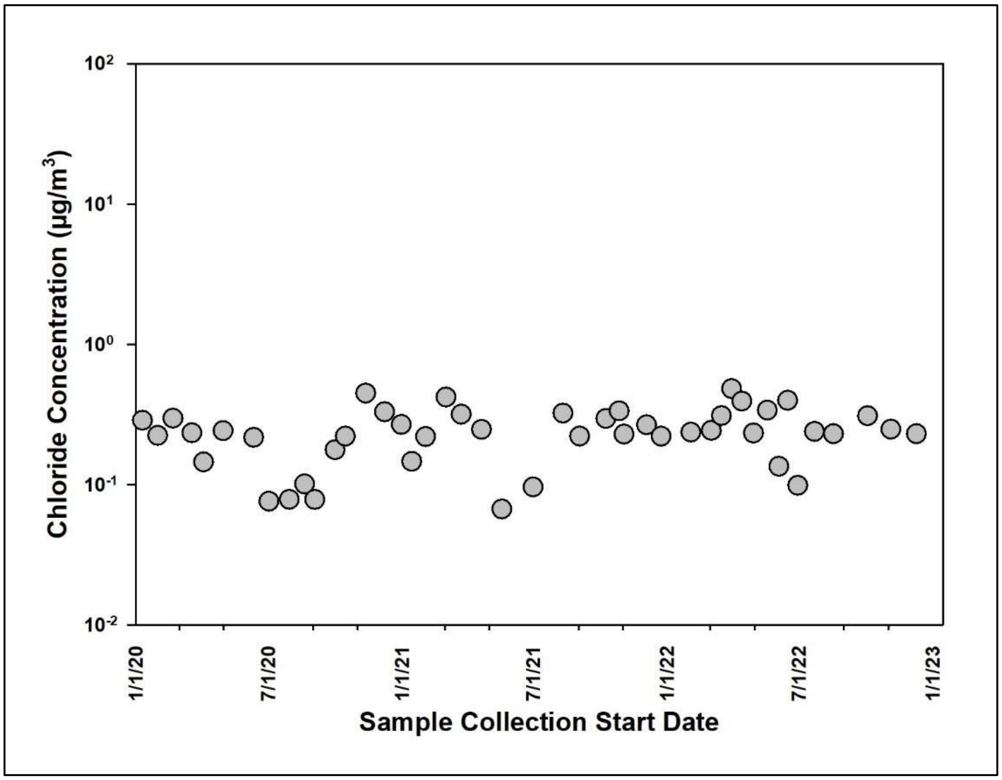
Airborne particulates in the air surrounding the WIPP site are collected on cellulose-based, Whatman 41 filters (GE Healthcare Life Sciences) in a similar way to the glass fiber filters collected above ground for radiochemical analyses. The Whatman 41 filters are only used for inorganic analyses at the following two locations: Near Field and Cactus Flats.

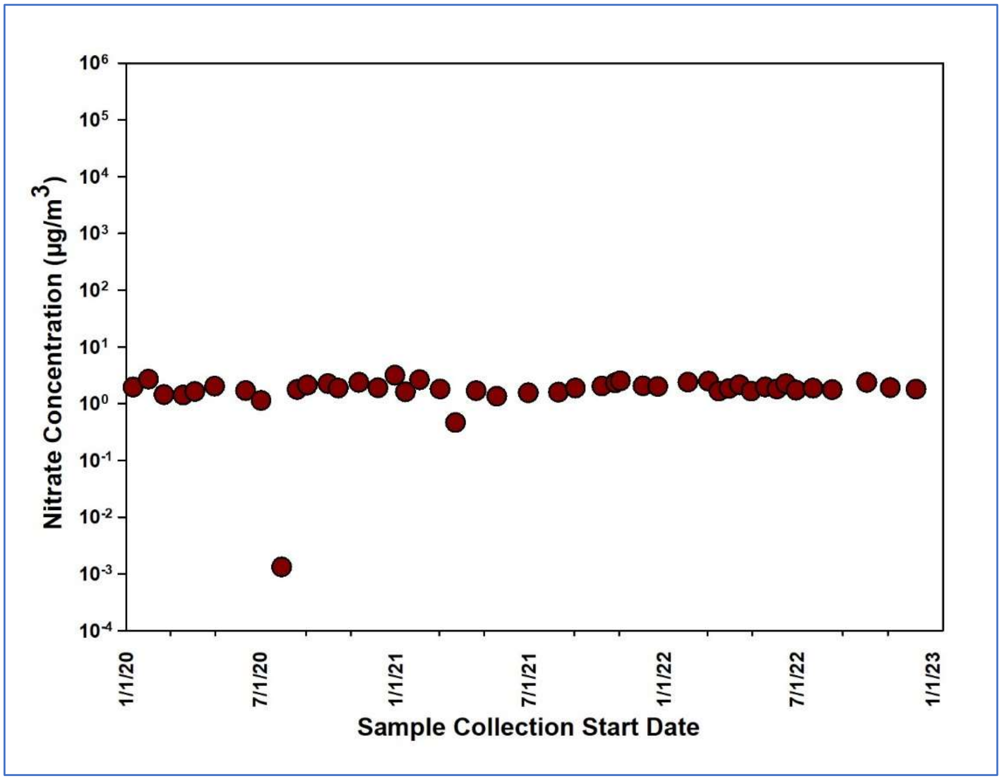
### 10.2.2 Sample Preparation and Analysis

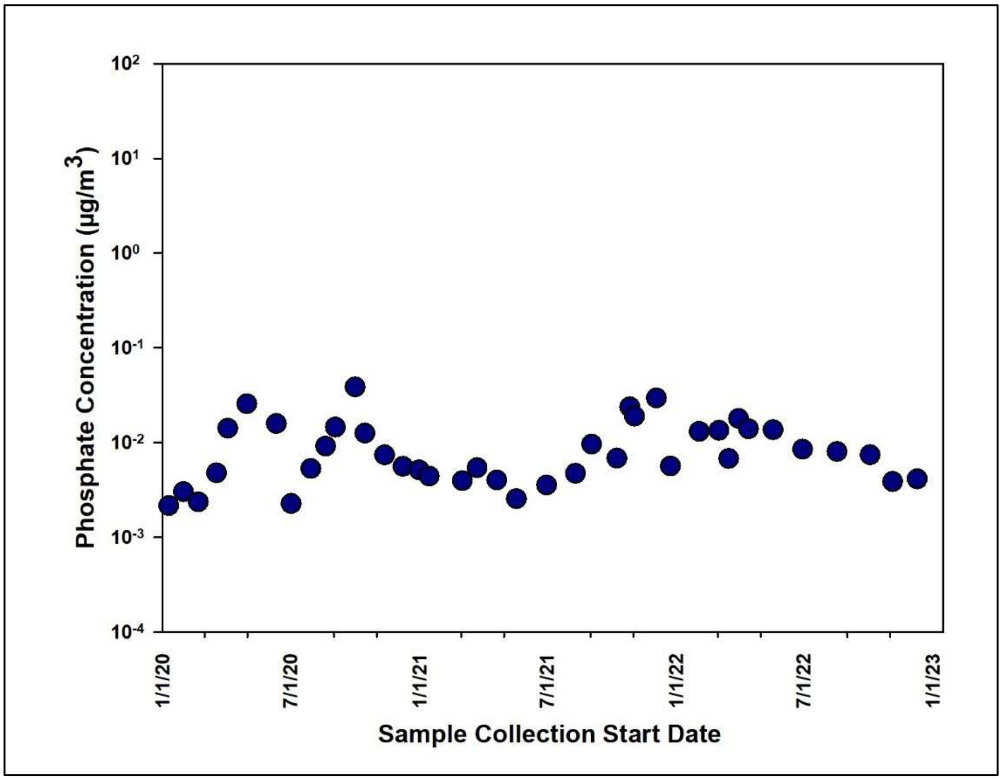
A water extraction using 40 mL ultrapure water is performed at room temperature on a ¼-sheet of each Whatman 41 filter sample. The extracted solution is filtered prior to analysis by Ion Chromatography (IC) for inorganic anions and cations. Blanks and spiked blanks are also extracted in the same manner for quality control purposes. All samples are filtered prior to analysis by Ion Chromatography (IC). Current methods utilized by CEMRC for non-radiochemical analyses performed on each sample type are summarized in Appendix I, Table I.1.

### 10.2.3 Anion and Cation Concentrations Measured at Near Field

Historical time-series plots for selected inorganic anions and cations are shown in Figure 10.7 and Figure 10.8, respectively, from January 2020 through December 2022 for samples collected at Near Field. Chloride, nitrate, phosphate, sulfate, calcium, potassium, magnesium, and sodium are all regularly detected above the MDC at the Near Field location. Concentrations of selected anions and cations for 2022 Near Field samples are reported in Appendix I, Table I.8 and I.9, respectively. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis.


Chloride Concentration (µg/m3)
10^2
10^1
10^0
10^-1
10^-2
1/1/20
7/1/20
1/1/21
7/1/21
1/1/22
7/1/22
1/1/23
Sample Collection Start Date


Nitrate Concentration (µg/m3)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
1/1/20
7/1/20
1/1/21
7/1/21
1/1/22
7/1/22
1/1/23
Sample Collection Start Date



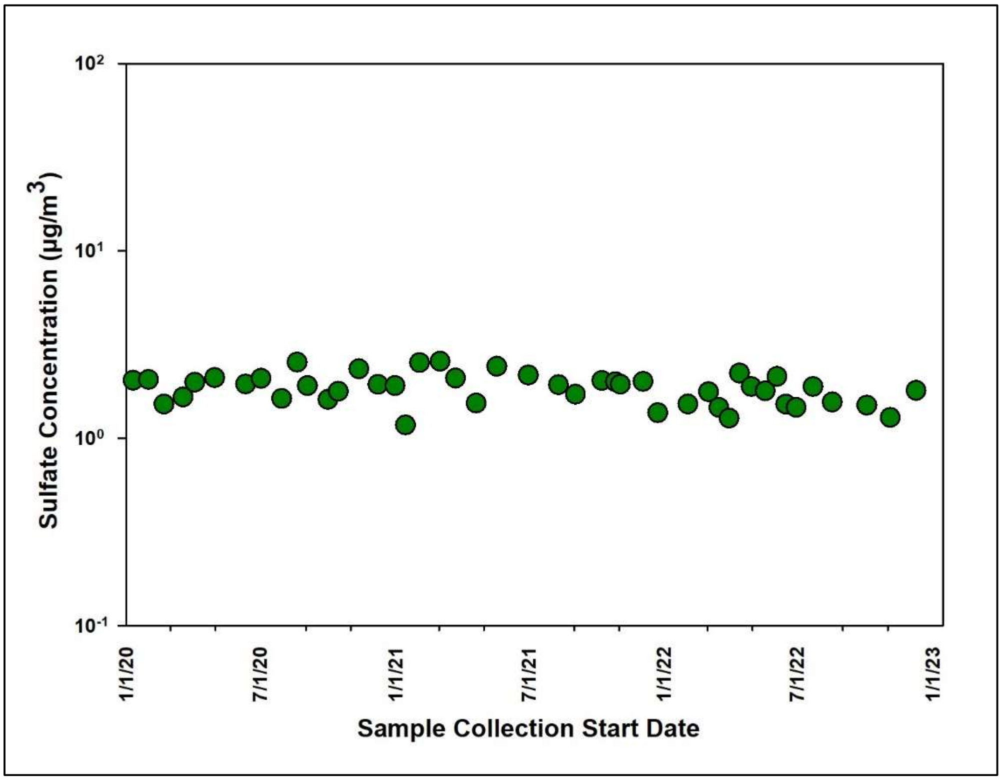
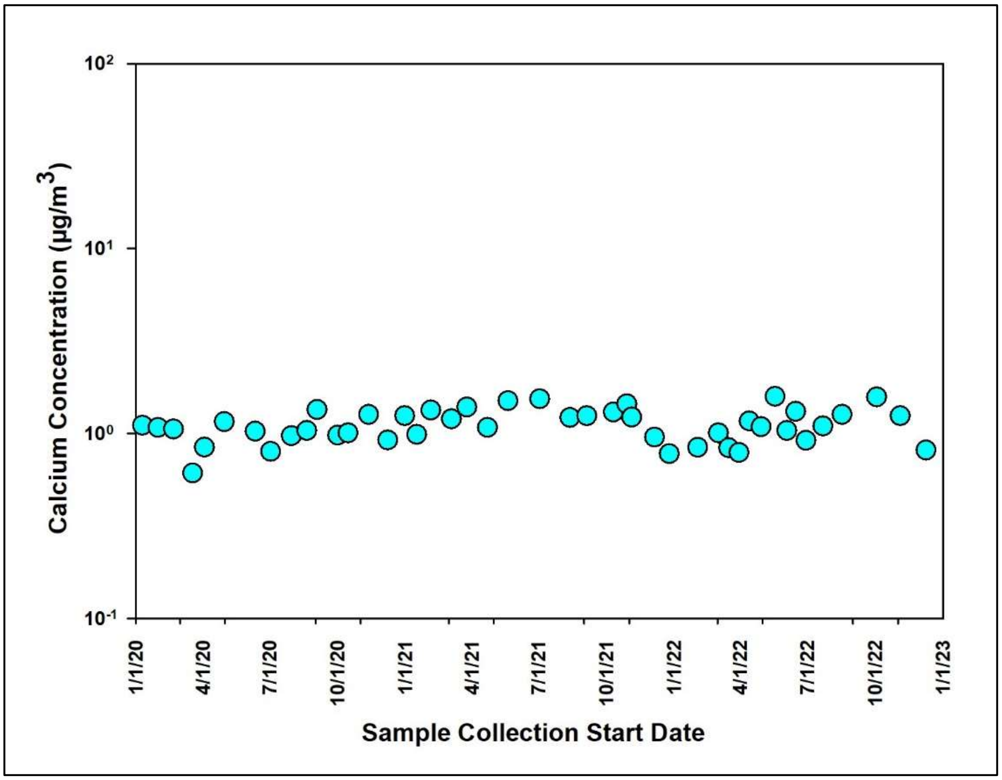
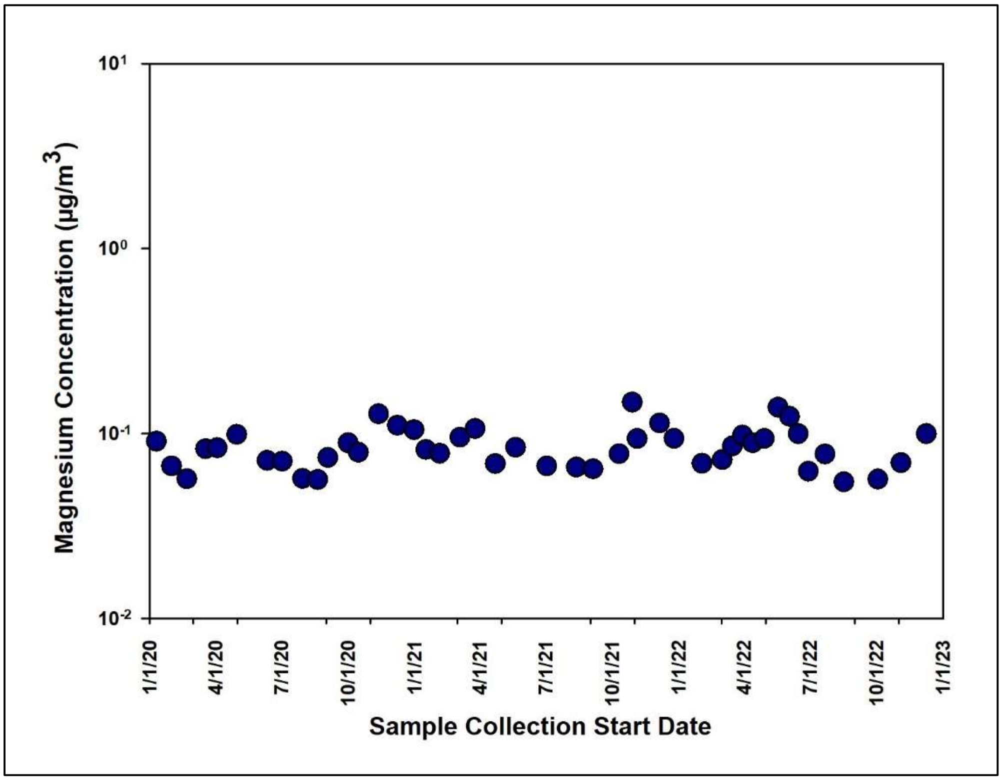


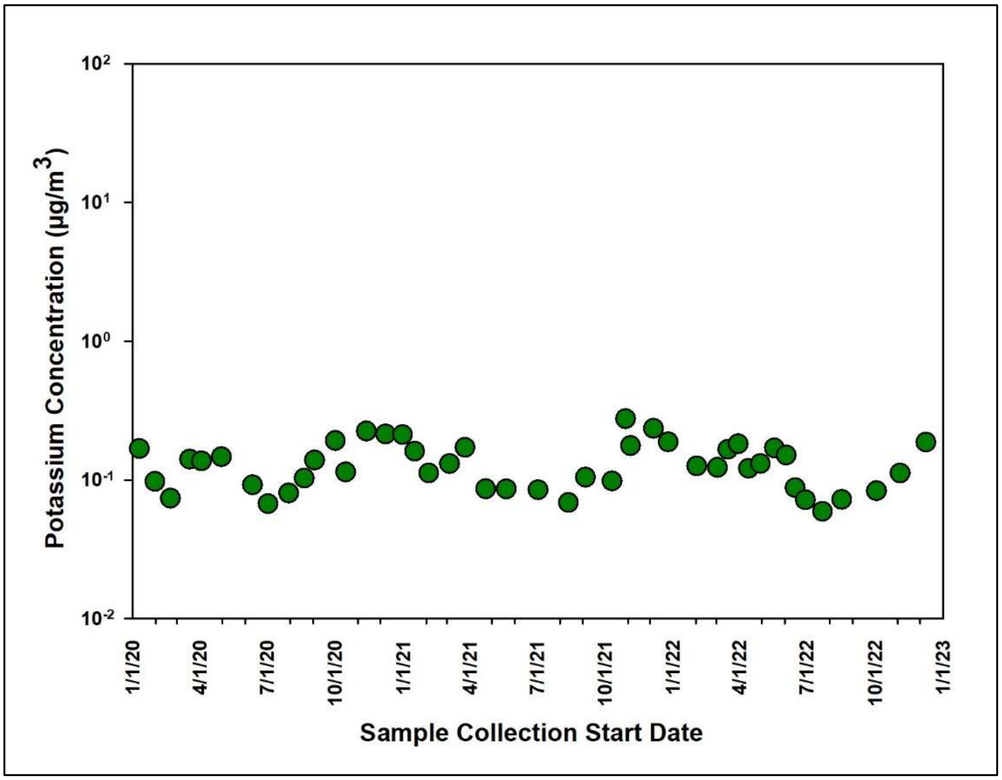
**Figure 10.7. Historical Concentrations of Selected Anions at Near Field**



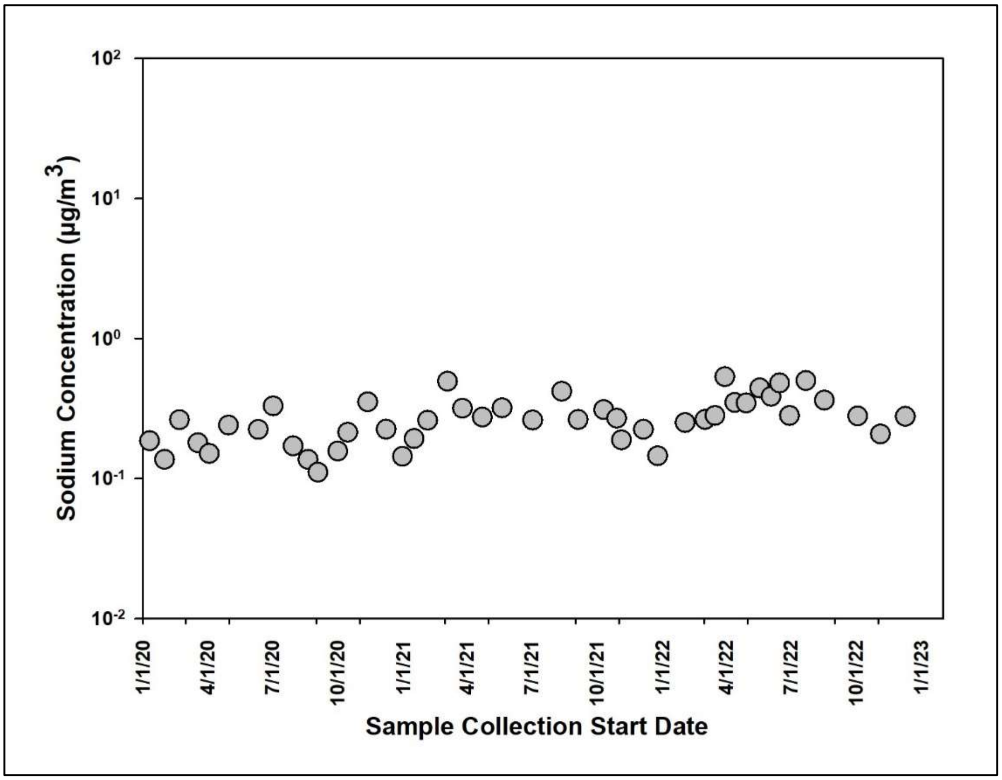
$10^2$
$10^1$
$10^0$
$10^{-1}$
Calcium Concentration (µg/m³)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date



$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
Magnesium Concentration (µg/m³)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date



$10^2$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
Potassium Concentration (µg/m$^3$)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date



$10^2$
$10^1$
$10^0$
$10^{-1}$
$10^{-2}$
Sodium Concentration (µg/m$^3$)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date

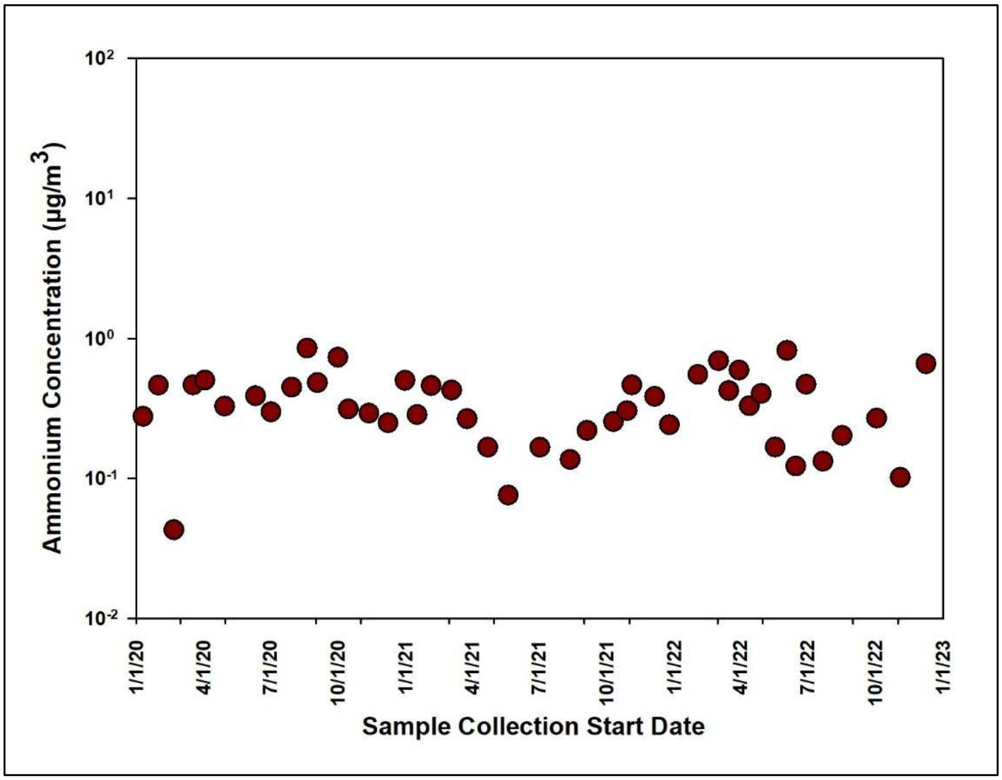
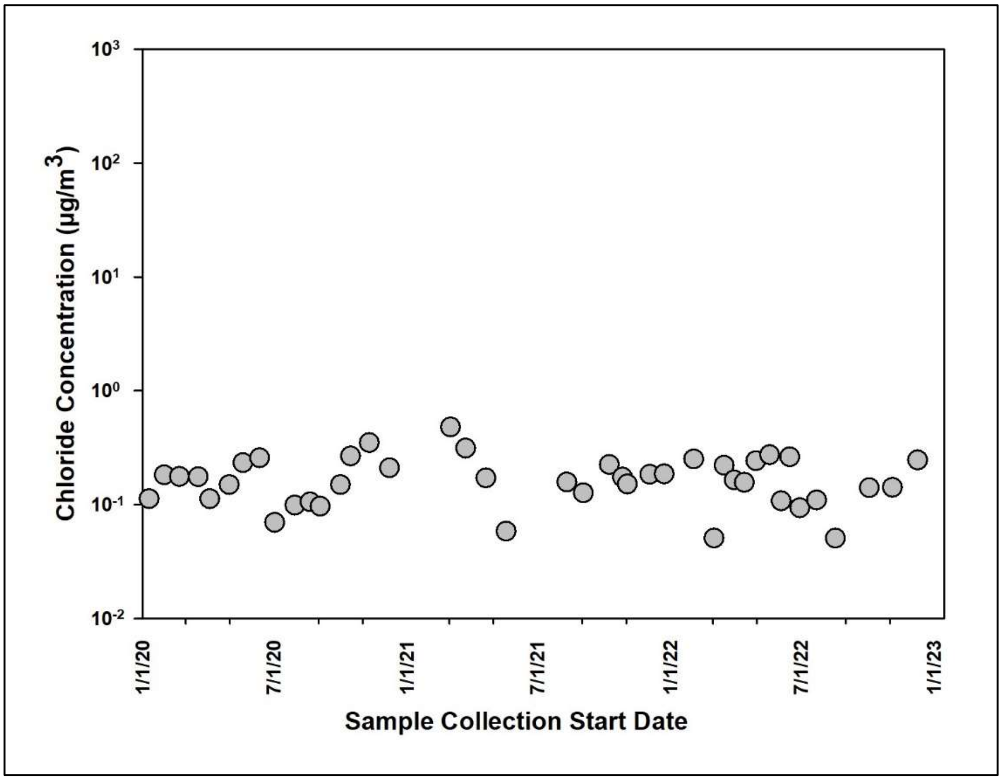
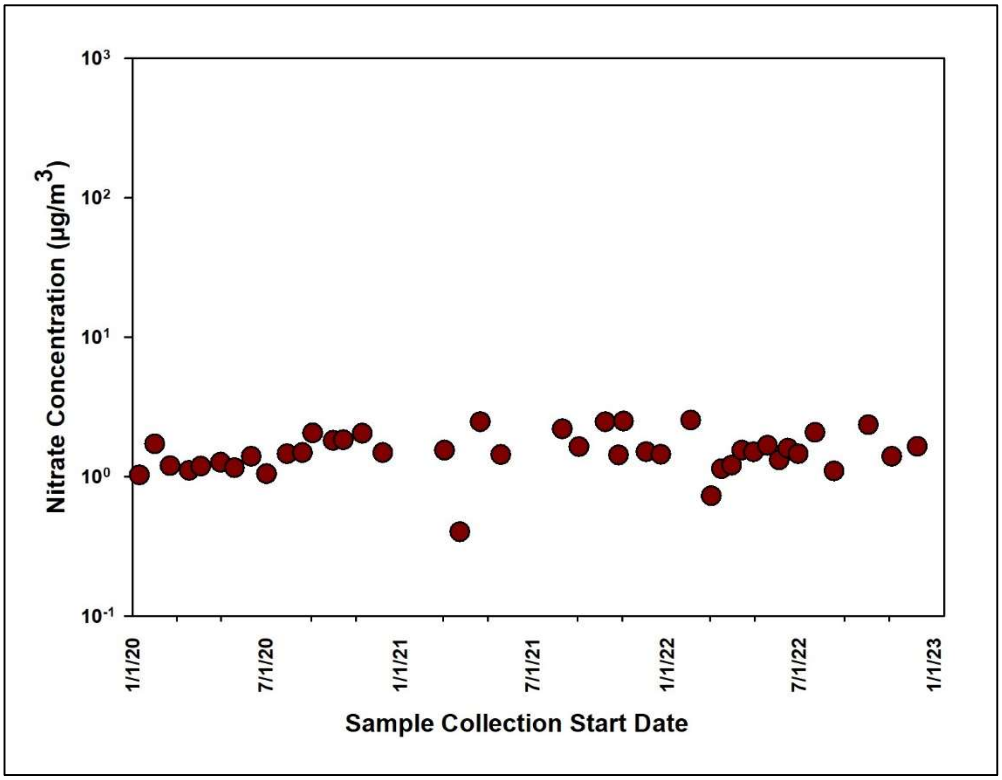


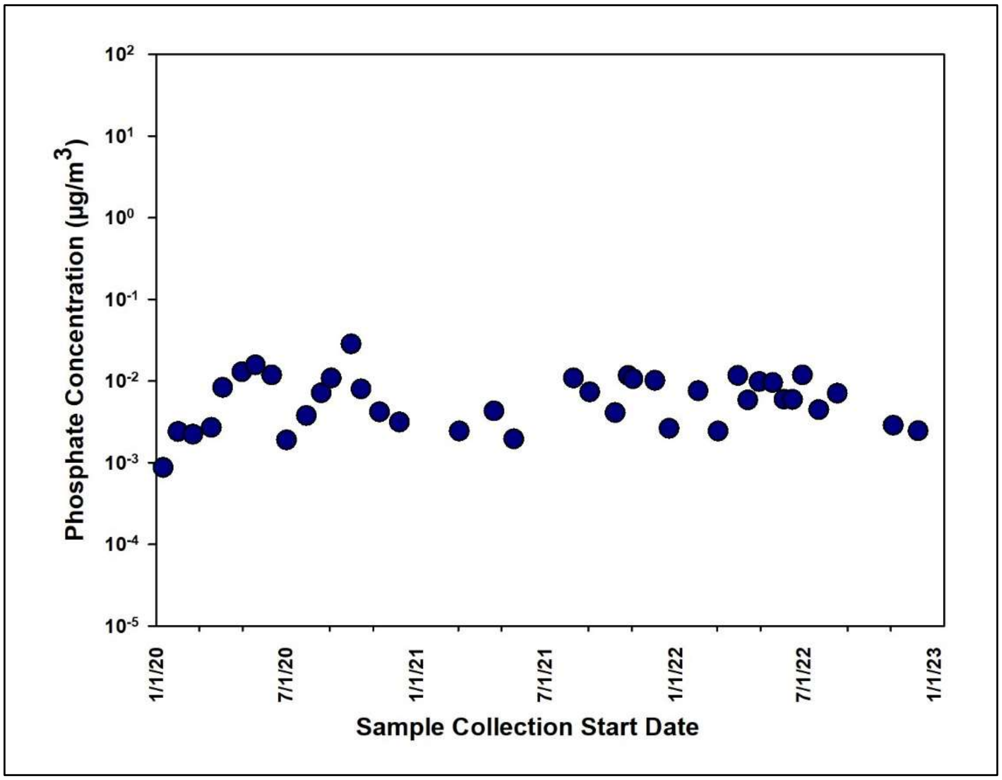
**Figure 10.8. Historical Concentrations of Selected Cations at Near Field**

### 10.2.4 Anion and Cation Concentrations Measured at Cactus Flats

Historical time-series plots for selected inorganic anions and cations are shown in Figure 10.9 and Figure 10.10, respectively, from January 2020 through December 2022 for samples collected at Cactus Flats. Chloride, nitrate, phosphate, sulfate, calcium, potassium, magnesium, and sodium are all regularly detected above the MDC at the Cactus Flats location at concentrations similar to those measured at the Near Field site. Detailed concentrations of selected anions and cations for 2022 Cactus Flats samples are reported in Appendix I, Table I.10 and I.11. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no filters were received for analysis.


10³
10²
10¹
10⁰
10⁻¹
10⁻²
Chloride Concentration (µg/m³)
1/1/20
7/1/20
1/1/21
7/1/21
1/1/22
7/1/22
1/1/23
Sample Collection Start Date


10³
10²
10¹
10⁰
10⁻¹
Nitrate Concentration (µg/m³)
1/1/20
7/1/20
1/1/21
7/1/21
1/1/22
7/1/22
1/1/23
Sample Collection Start Date



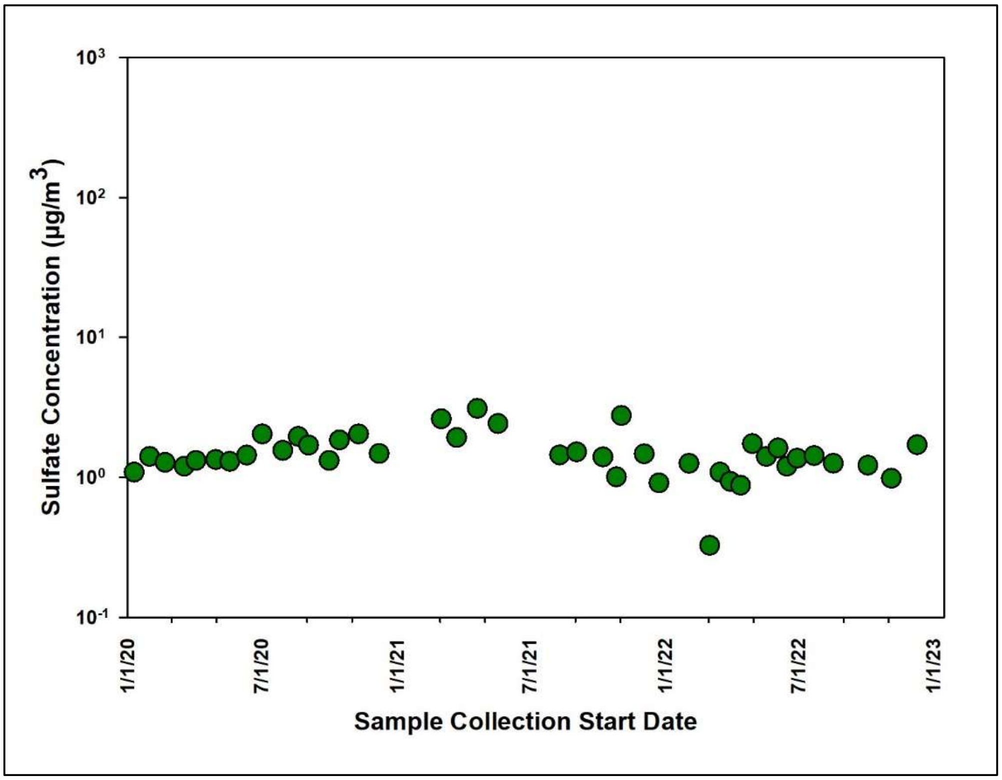
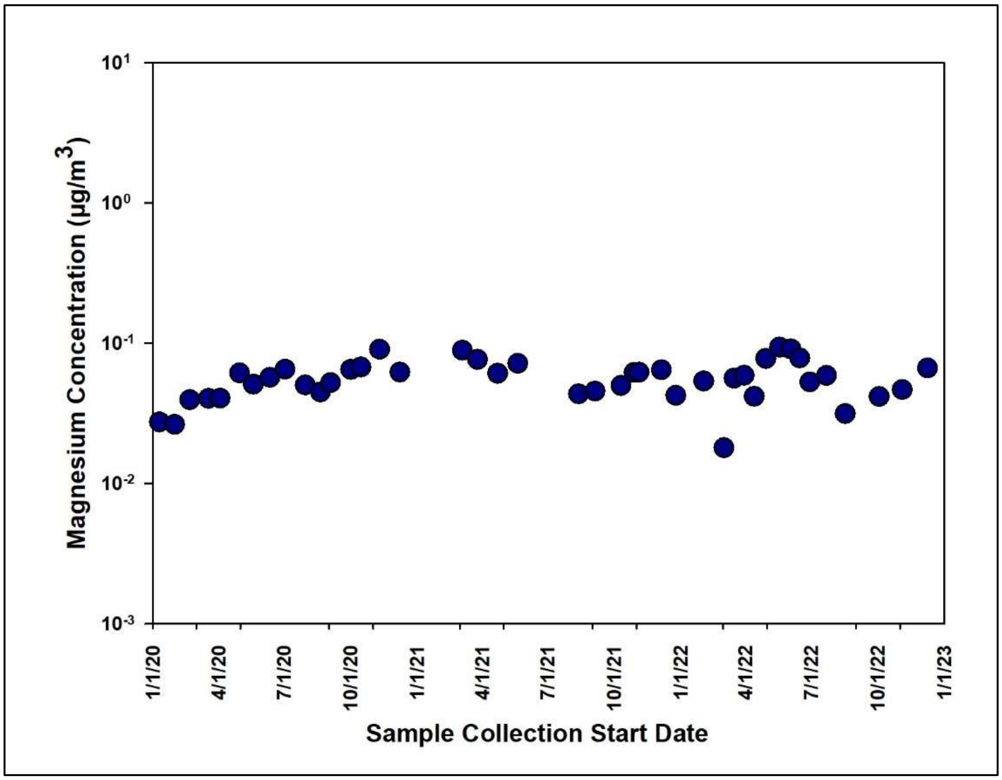
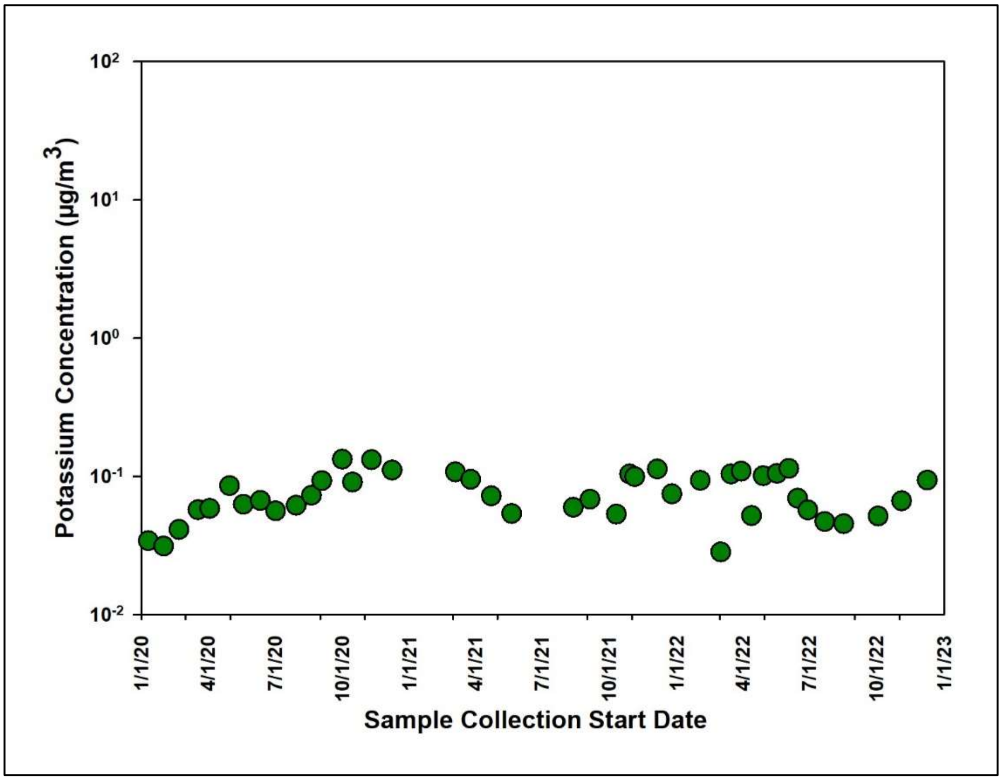


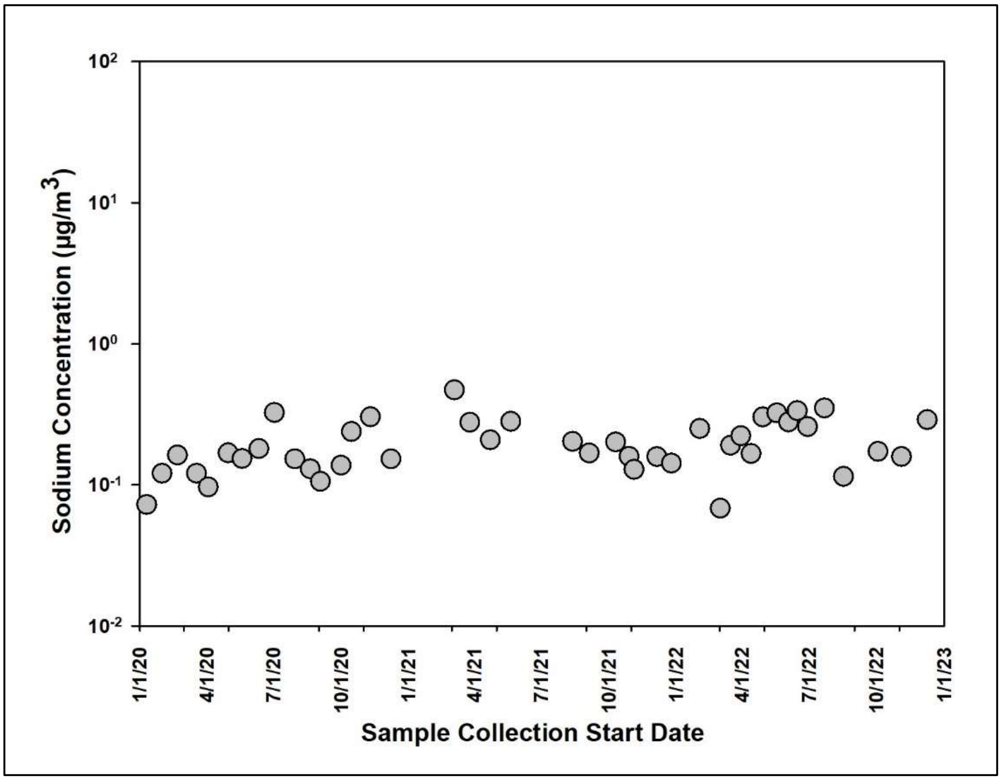
**Figure 10.9. Historical Concentrations of Selected Anions at Cactus Flats**

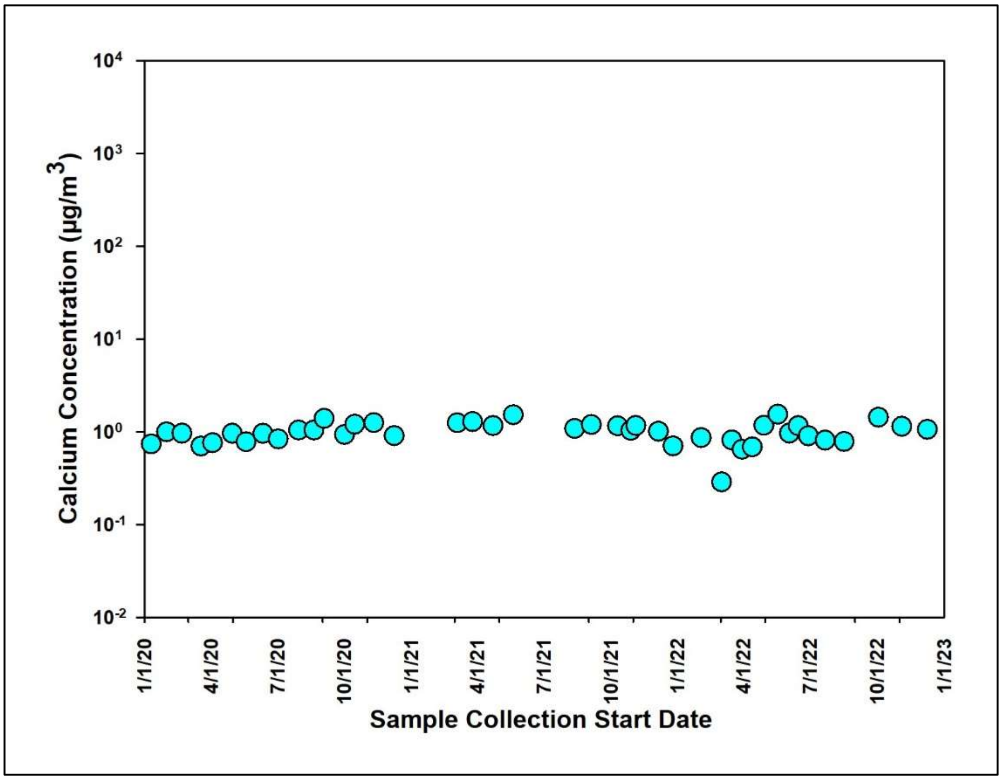


Magnesium Concentration (µg/m³)
10¹
10⁰
10⁻¹
10⁻²
10⁻³
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date



Potassium Concentration (µg/m³)
10²
10¹
10⁰
10⁻¹
10⁻²
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date


10²
10¹
10⁰
10⁻¹
10⁻²
Sodium Concentration (µg/m³)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date


10⁴
10³
10²
10¹
10⁰
10⁻¹
10⁻²
Calcium Concentration (µg/m³)
1/1/20
4/1/20
7/1/20
10/1/20
1/1/21
4/1/21
7/1/21
10/1/21
1/1/22
4/1/22
7/1/22
10/1/22
1/1/23
Sample Collection Start Date

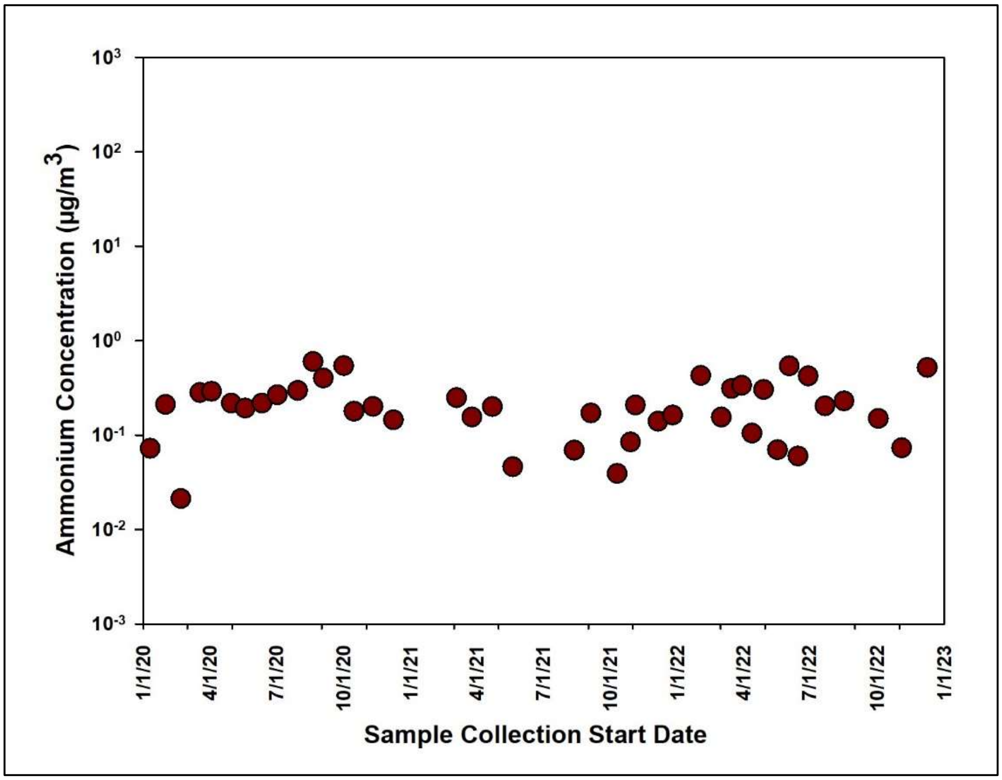


**Figure 10.10. Historical Concentrations of Selected Cations at Cactus Flats**

## 10.3 Non-Radiological Monitoring of Drinking Water

### 10.3.1 Sample Collection

Drinking water samples for non-radiological analyses were collected from six community water supplies of Carlsbad, Loving, Otis, Hobbs, Malaga, and Double Eagle. Details regarding the sampling locations and procedure for drinking water sample collection are described in Chapter 6.

### 10.3.2 Sample Preparation and Analysis

Once the water samples are received by the CEMRC facility, three aliquots are removed immediately for non-radiochemical analyses: (1) 1 L for inorganic analysis, (2) 500 mL for mercury analysis, and (3) 1 L for metal analysis. Each 1 L aliquot removed for inorganic analysis is split into two parts. The first 1 L sub-sample is immediately refrigerated and analyzed for inorganic anions within 48 hours of collection. No preservative is added to this sample. The other part of the 1 L inorganic sub-sample is preserved with a dilute nitric acid solution for inorganic cation analysis.

Because of the high salinity of the drinking water samples, both types of inorganic analyses (anions and cations) require further dilution using ultrapure water prior to analysis. For metal analysis, each aliquot is preserved with nitric acid during collection. Because of the high salinity, drinking water samples are also diluted using the same nitric acid prior to analysis.

For mercury analysis, each sample is collected in a 500 mL glass container and preserved with bromo-monochloride immediately upon arrival at CEMRC. Sample dilution is not performed for mercury analysis of water samples because mercury is rarely detected above detection limits. It should be noted that mercury analysis is performed separately from other metals in drinking water samples because of the specific requirements for sample preservation.

Metal analysis is performed using an ICP-MS, while inorganic cation and anion analyses are performed using an IC. Current methods utilized by CEMRC for non-radiochemical analyses performed on each sample type and their detection limits are summarized in Appendix I, Table I.1.

The trace metal and inorganic anion and cation concentrations measured in drinking water samples are reported in µg/L, which is calculated as the element mass in micrograms (µg) divided by volume of the drinking water in liters (L).

### 10.3.3 Metal Concentrations in Drinking Water

Analytical results for metal analysis of 2022 drinking water samples are reported in Appendix I, Table I.12. The following elemental constituents are commonly above the MDC in the drinking water samples collected from the areas surrounding the WIPP site: arsenic (As), barium (Ba), chromium (Cr), copper (Cu), lead (Pb), and antimony (Sb). Figure 10.11 through Figure 10.16 illustrate the historical concentrations of these selected metals from the six regional drinking water locations. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

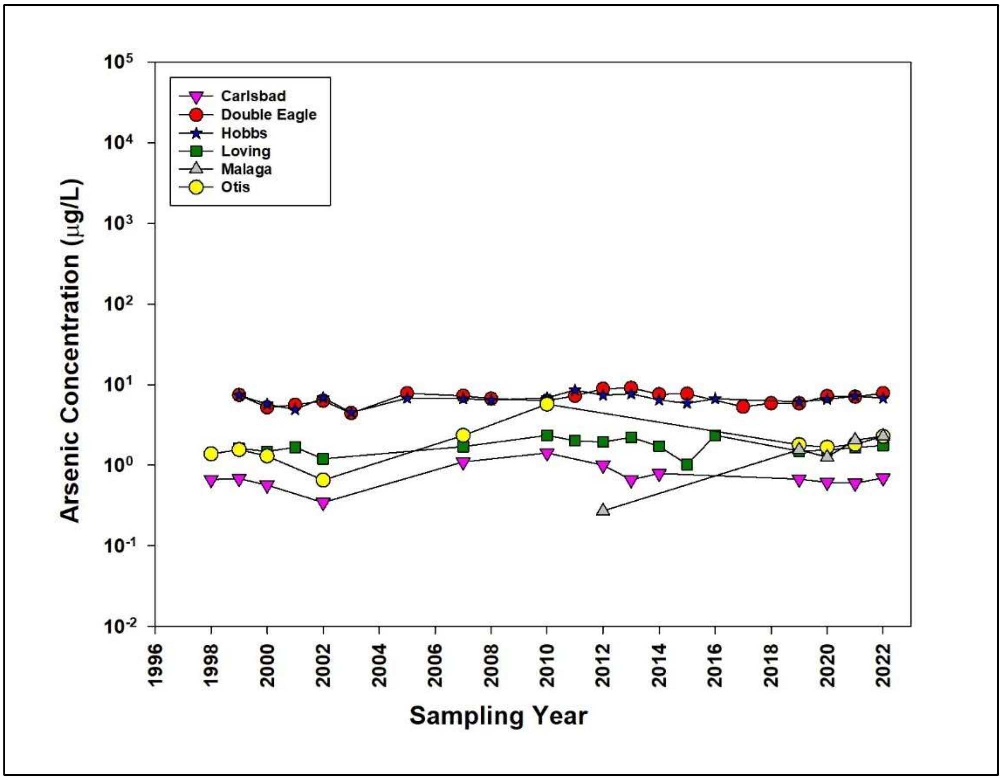


Figure 10.11. Historical Concentrations of Arsenic In Drinking Water

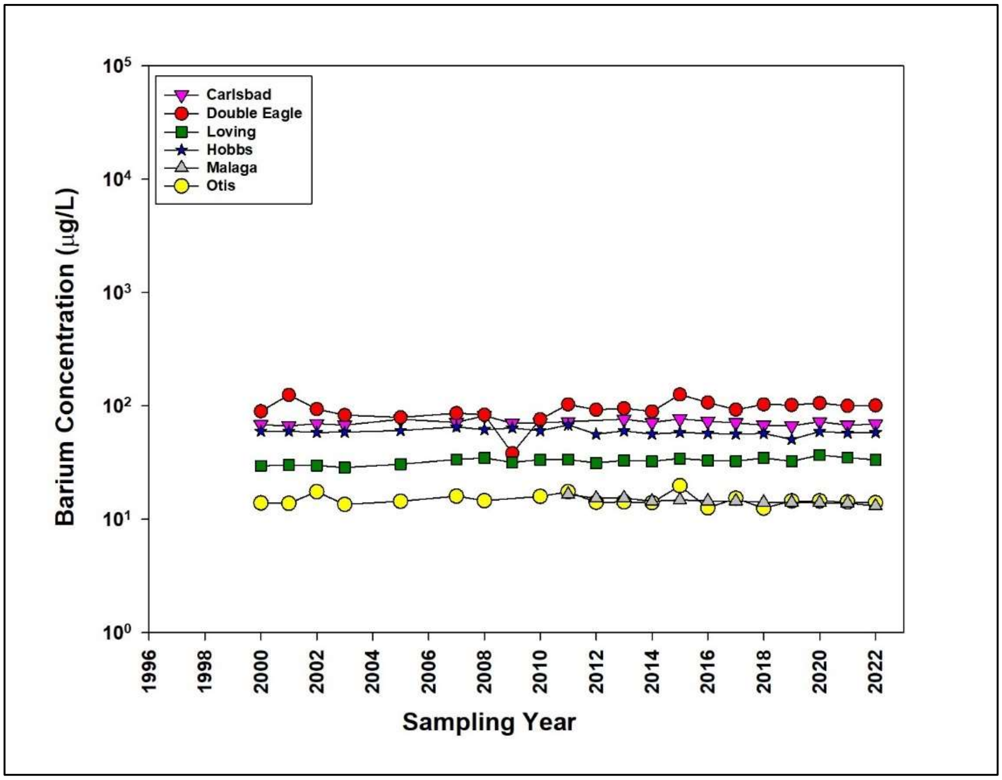


Figure 10.12. Historical Concentrations of Barium in Drinking Water

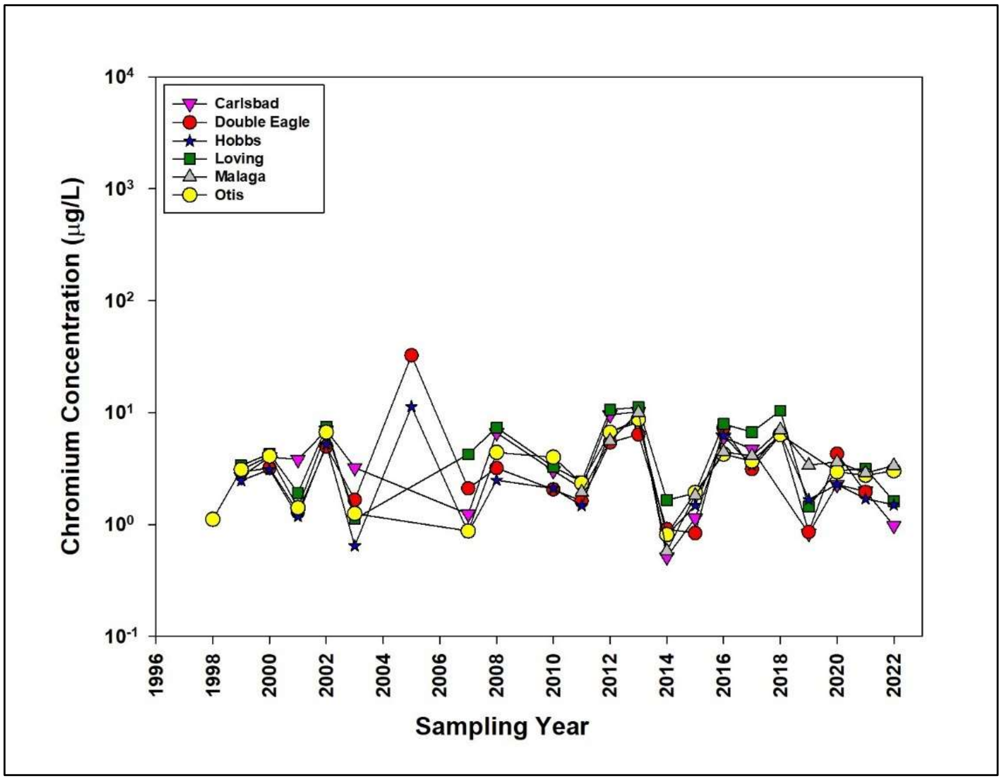


Figure 10.13. Historical Concentrations of Chromium in Drinking Water

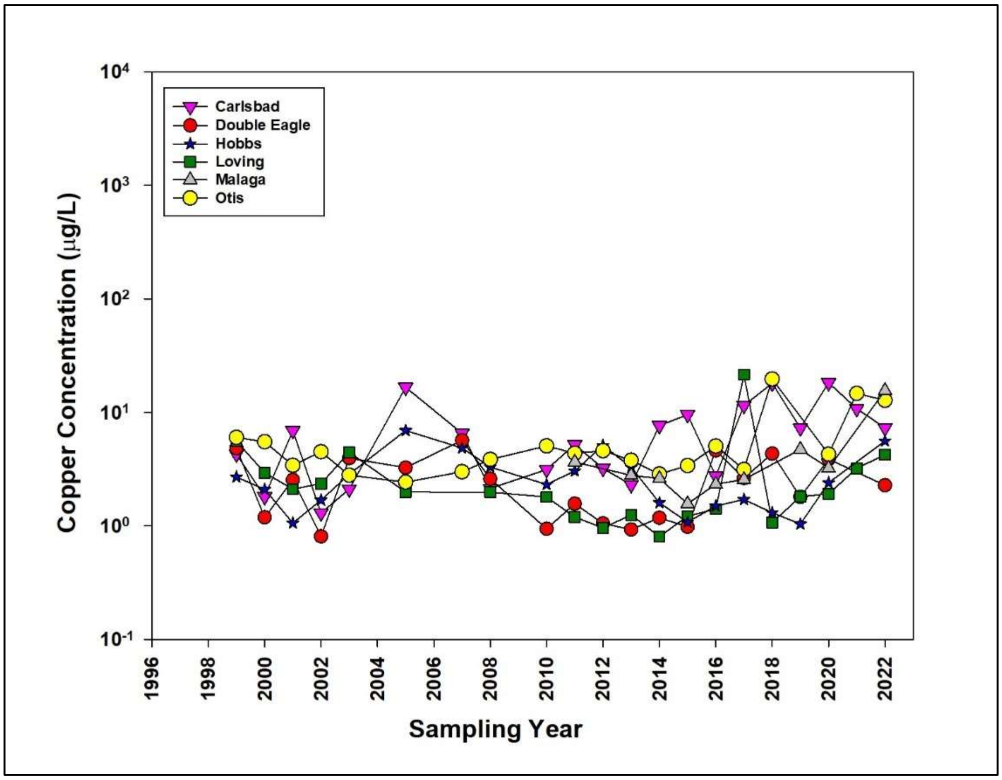


Figure 10.14. Historical Concentrations of Copper in Drinking Water

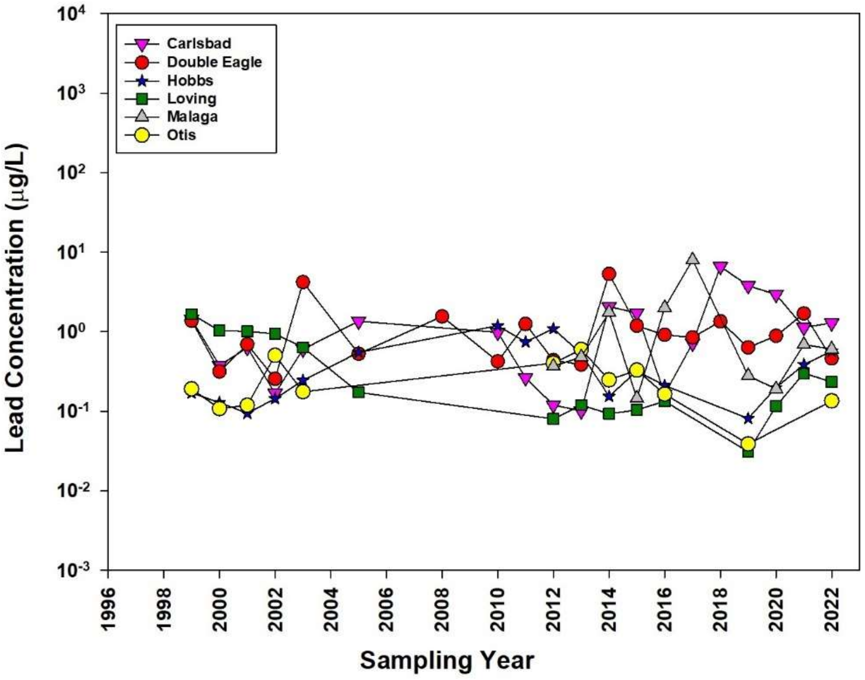


Figure 10.15. Historical Concentrations of Lead in Drinking Water

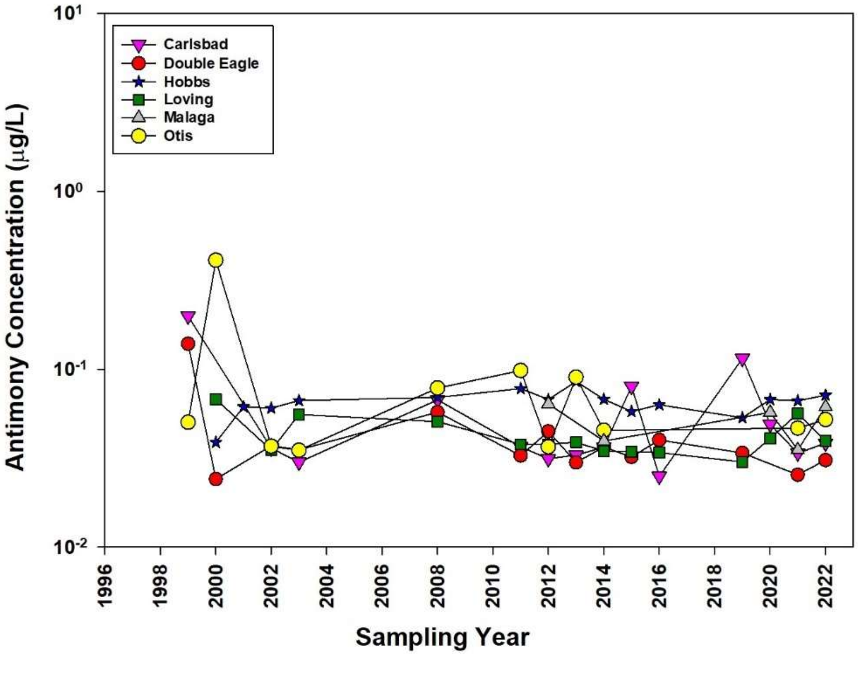


Figure 10.16. Historical Concentrations of Antimony in Drinking Water

Present results as well as the results of previous analyses of drinking water are consistent for each source across sampling periods. Furthermore, the current CEMRC results for drinking water from the Carlsbad (Sheep Draw) and WIPP (Double Eagle, PRV4) locations generally agree with the measurements for the same elements monitored by the City of Carlsbad.

### 10.3.4 Concentrations of Inorganic Anions in Drinking Water

Four inorganic anions are monitored in regional drinking water: chloride, fluoride, nitrate, and sulfate. Results for these anions are reported in Appendix I, Table I.13. All four of these anions are detected regularly above the MDC for inorganic anions. Figure 10.17 through Figure 10.20 illustrate the historical concentrations of these anions from the six regional drinking water locations. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

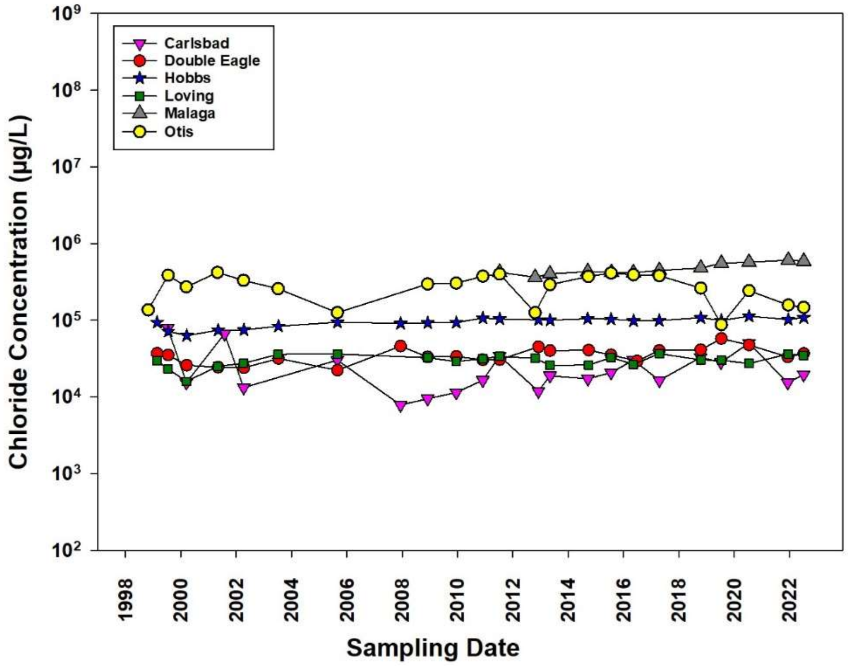


Figure 10.17. Historical Concentrations of Chloride in Drinking Water

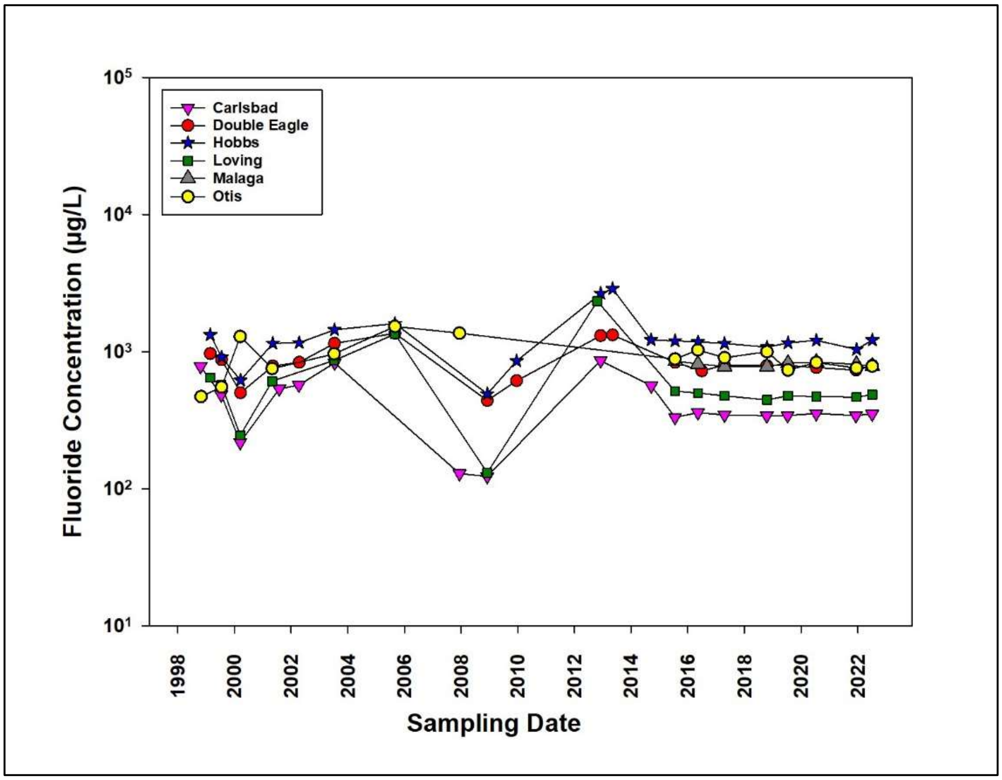


Figure 10.18. Historical Concentrations of Fluoride in Drinking Water

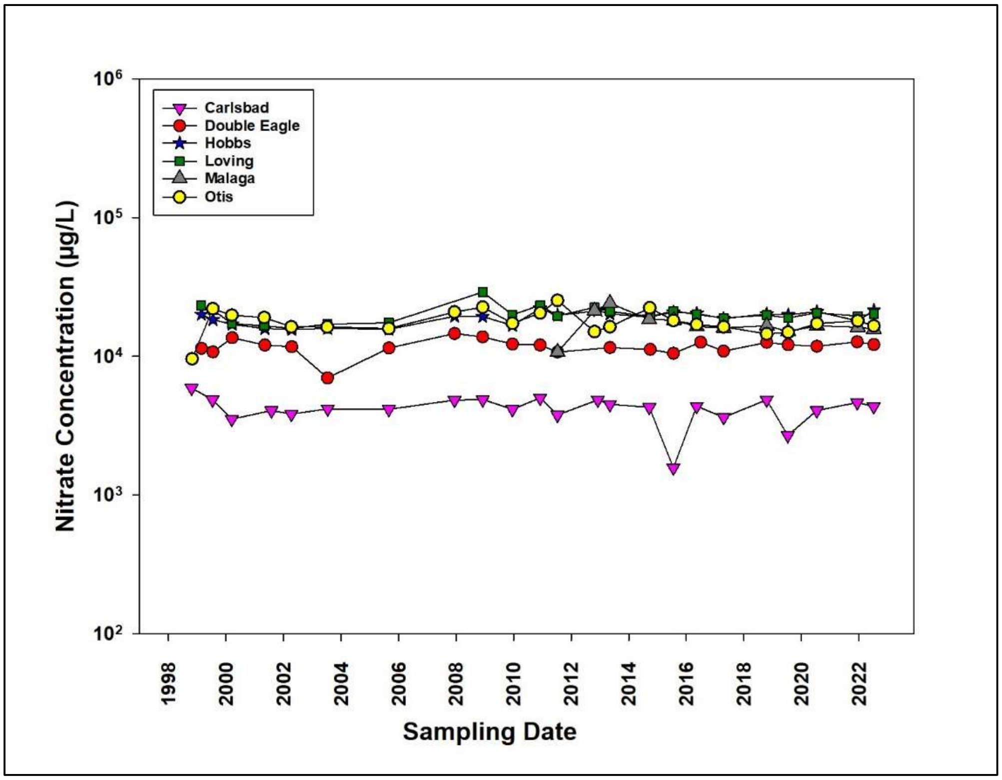


Figure 10.19. Historical Concentrations of Nitrate in Drinking Water

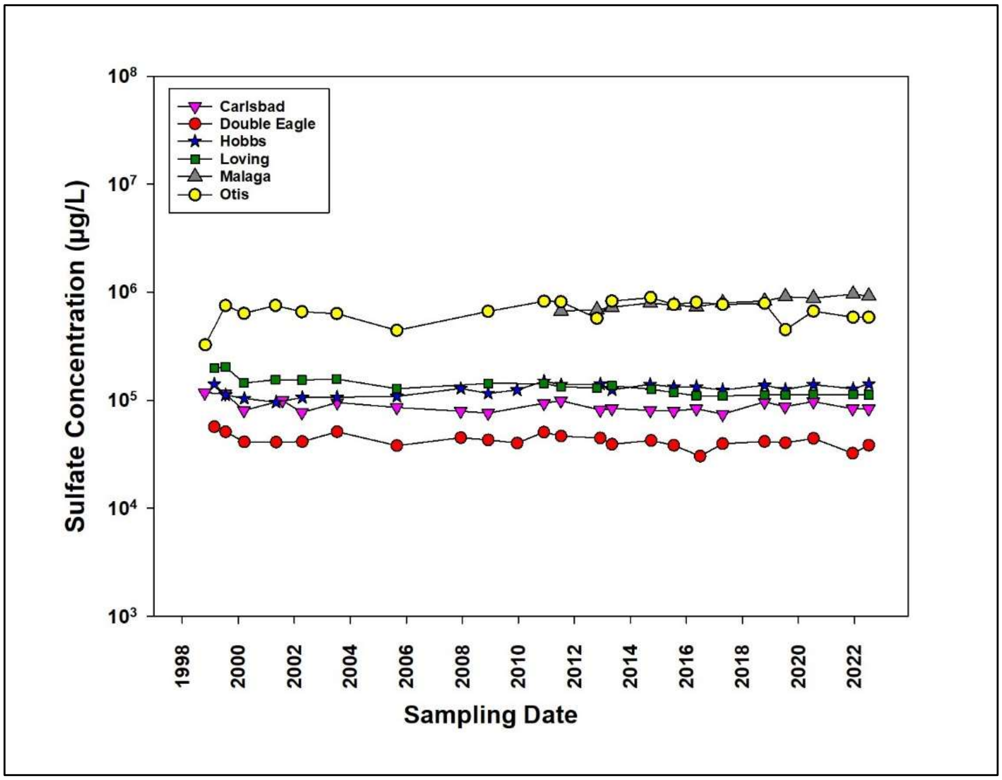


Figure 10.20. Historical Concentrations of Sulfate in Drinking Water

### 10.3.5 Concentrations of Inorganic Cations in Drinking Water

Inorganic cation analyses for regional drinking water began in 2016. Four inorganic cations are monitored: calcium, magnesium, potassium, and sodium. Results for these cations are reported in Appendix I, Table I.14. Calcium, magnesium, and sodium are detected regularly above the MDC and Figure 10.21 through Figure 10.23 illustrate the historical concentrations of these cations from the six regional drinking water locations. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

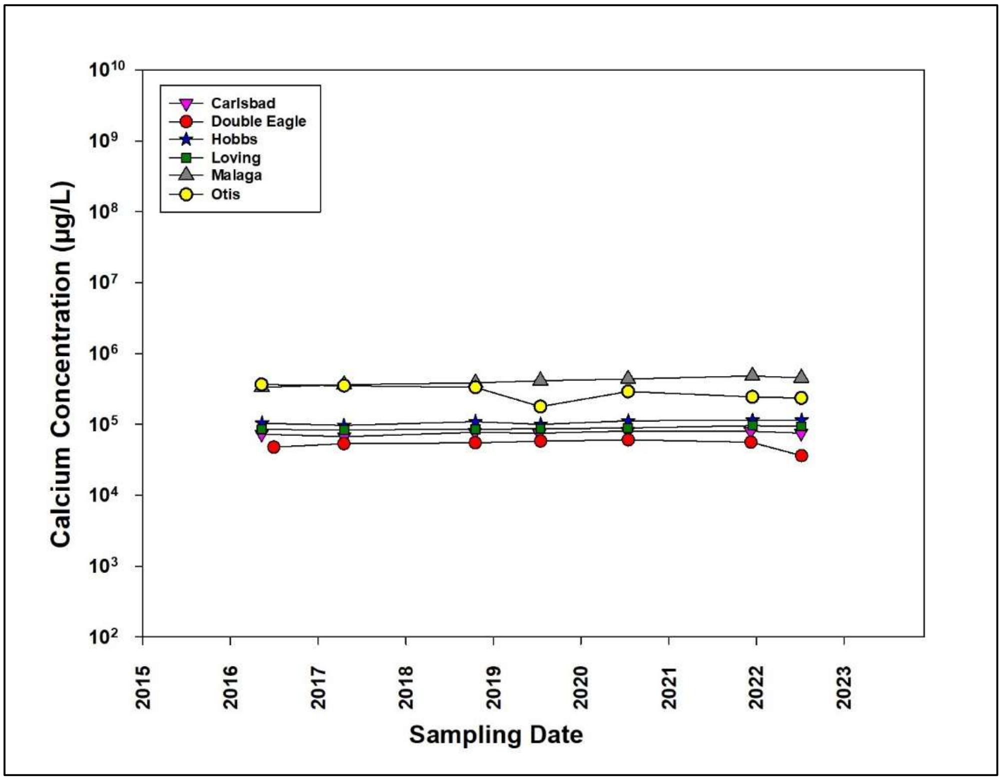


Figure 10.21. Historical Concentrations of Calcium in Drinking Water

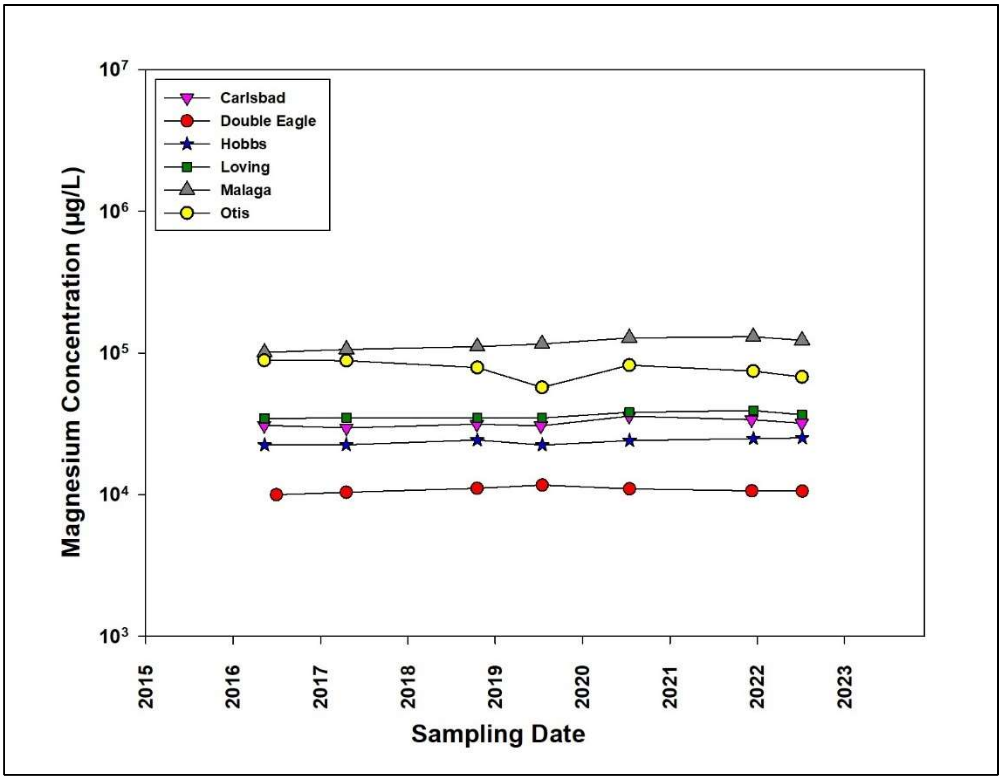


Figure 10.22. Historical Concentrations of Magnesium in Drinking Water

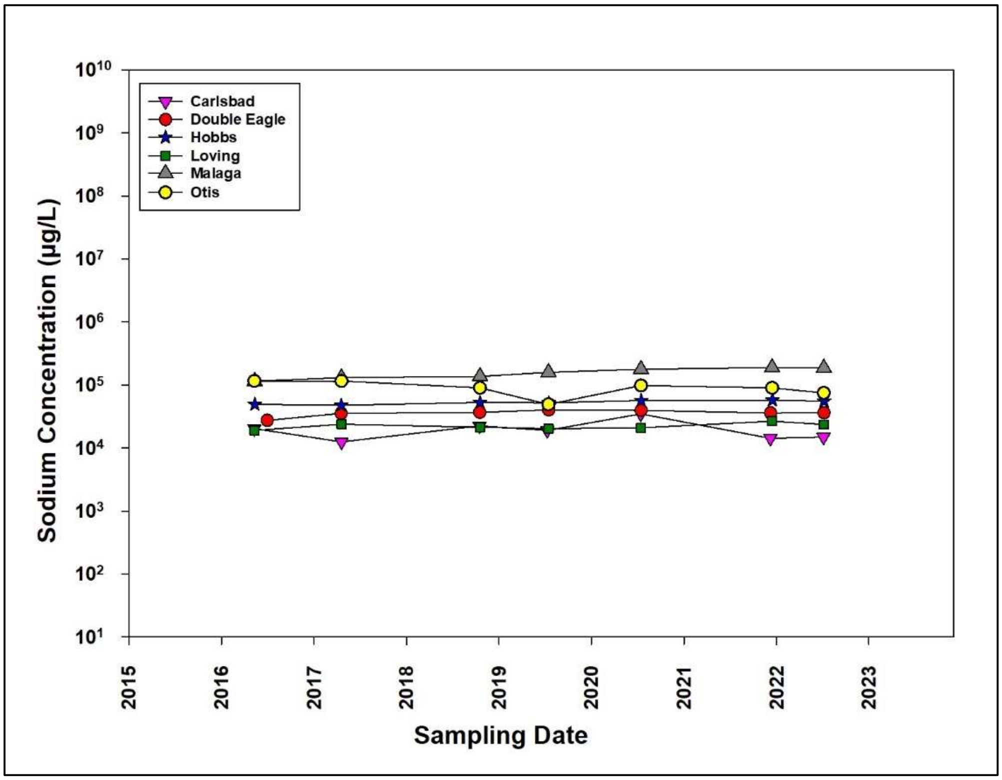


**Figure 10.23. Historical Concentrations of Sodium in Drinking Water**

## 10.3.6 Additional Analyses Performed on Drinking Water

To characterize the drinking water more comprehensively, several new types of non-radiological analyses were added in 2020. These parameters include specific gravity, pH, conductance, total organic carbon (TOC), total dissolved solids (TDS), and total suspended solids (TSS). Results of all these analyses are provided in Appendix I, Tables I.15 - I.19. Historical data are shown for pH, conductance, TOC's, and TDS in Figure 10.24 through Figure 10.27, respectively. It should be noted that TSS concentrations are rarely detected above detection limits.

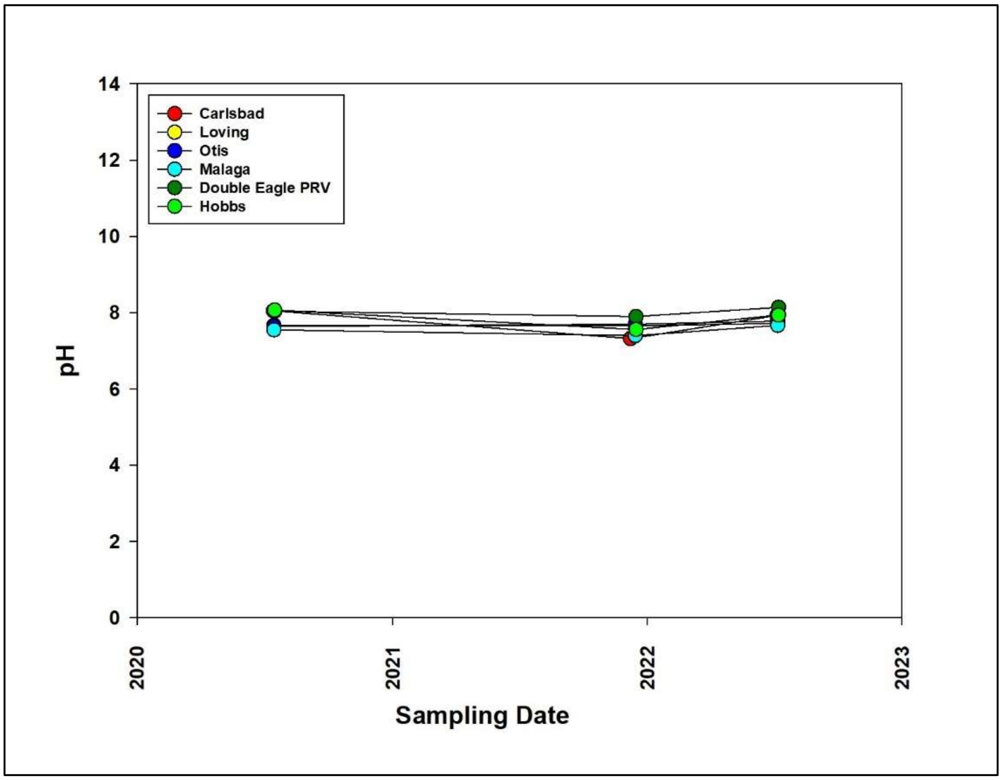


Figure 10.24. Historical pH Measurements in Drinking Water

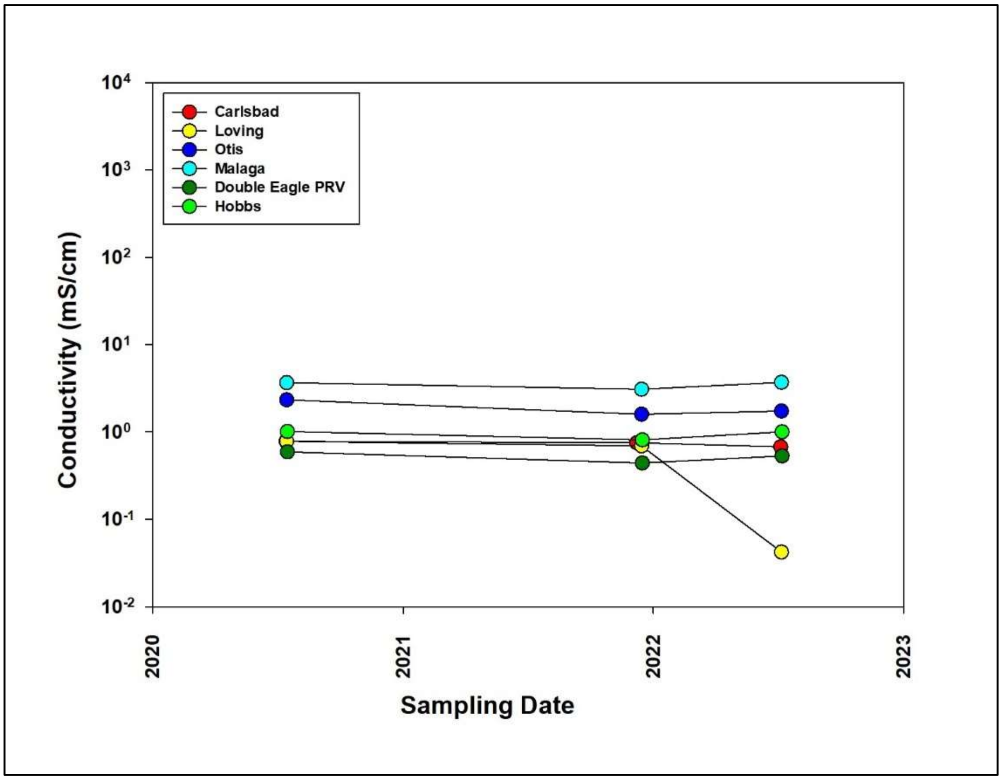


Figure 10.25. Historical Conductivity Measurements in Drinking Water

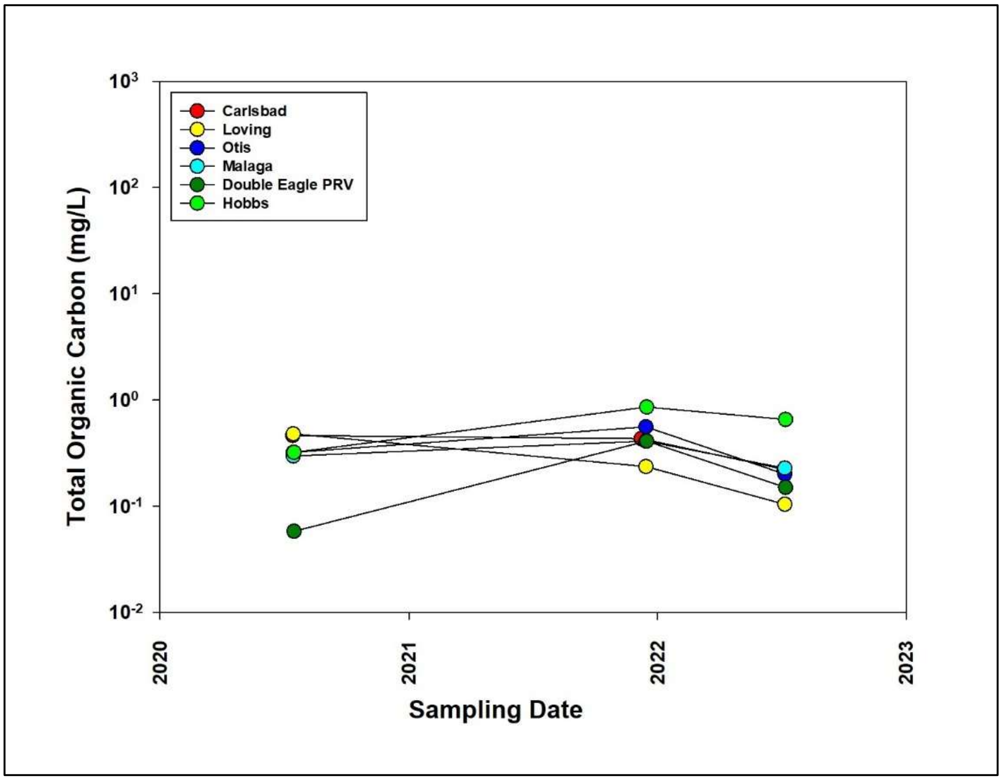


Figure 10.26. Historical Total Organic Carbon Concentrations in Drinking Water

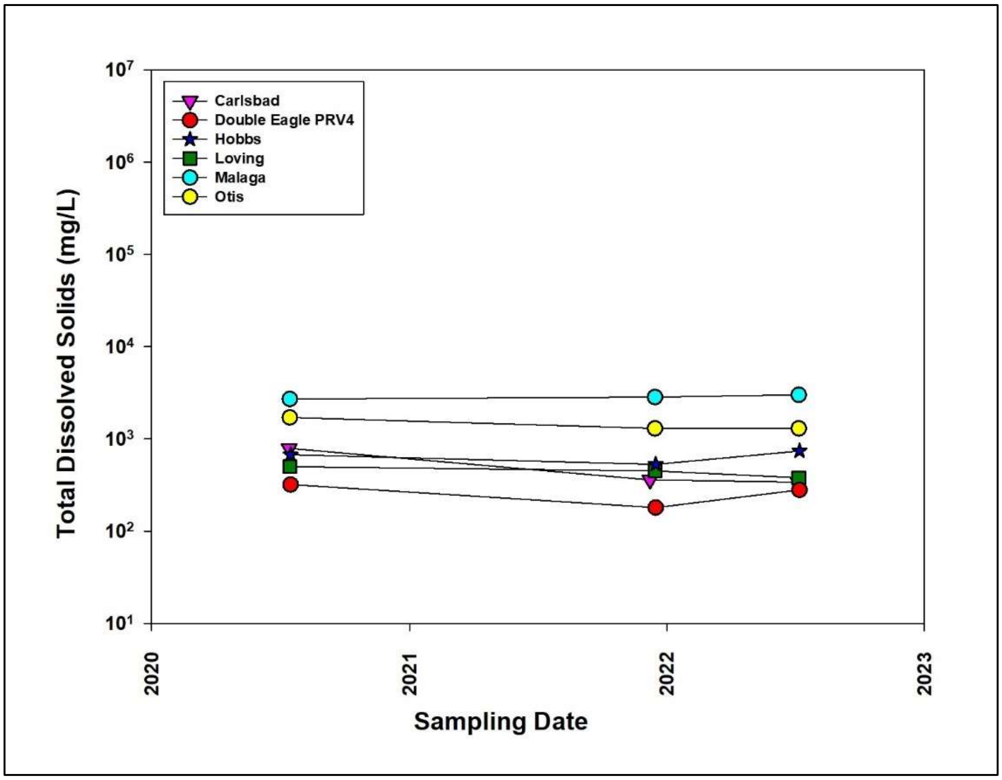


Figure 10.27. Historical Total Dissolved Solids in Drinking Water

## 10.4 Non-Radiological Monitoring of Surface Water

### 10.4.1 Sample Collection

Surface water samples for non-radiological analyses were collected from three regional reservoirs situated on the Pecos River. Sampling at the following locations began in 1999: Lake Carlsbad, Brantley Lake, and Red Bluff. A shallow and a deep sample are collected at these locations. In 2021, three supplemental locations were added to the CEMRC surface water sampling program in coordination with the WIPP sampling program. These locations are to monitor potential livestock uptake. The supplemental locations vary each year. In 2022, the supplemental sample locations were identified as “Hill Tank,” “Lost Tank,” and “Red Tank”.

### 10.4.2 Sample Preparation and Analysis

Once the surface water samples are received by the CEMRC facility, samples are divided into the same aliquots as drinking water: (1) 1L for inorganic constituent analysis, (2) 500 mL for mercury analysis and (3) 1 L for elemental analyses. Surface water samples are separated, preserved, and analyzed in the same manner as drinking water samples except that all surface water samples are filtered prior to analysis because of the high particulate content.

### 10.4.3 Metal Concentrations in Surface Water

Analytical results for metals analysis of 2022 surface water samples are reported in Appendix I, Table I.20 and I.21. Arsenic (As), barium (Ba), lead (Pb), and nickel (Ni) are metals commonly found above the MDC in the surface water samples collected from the areas surrounding the WIPP site. The amount of non-radiochemical materials in surface water is determined primarily by local geology and topography, but it can be influenced by urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, and farming. Figure 10.28 through Figure 10.31 illustrate the historical concentrations of selected metals from the 3 regional surface water locations. Since the location of the supplemental water sources changes annually, long term results do not exist. See current results for the supplemental locations sampled in 2022 in Appendix I. Present results as well as the results of previous analyses of surface water were consistent for each source across sampling periods. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

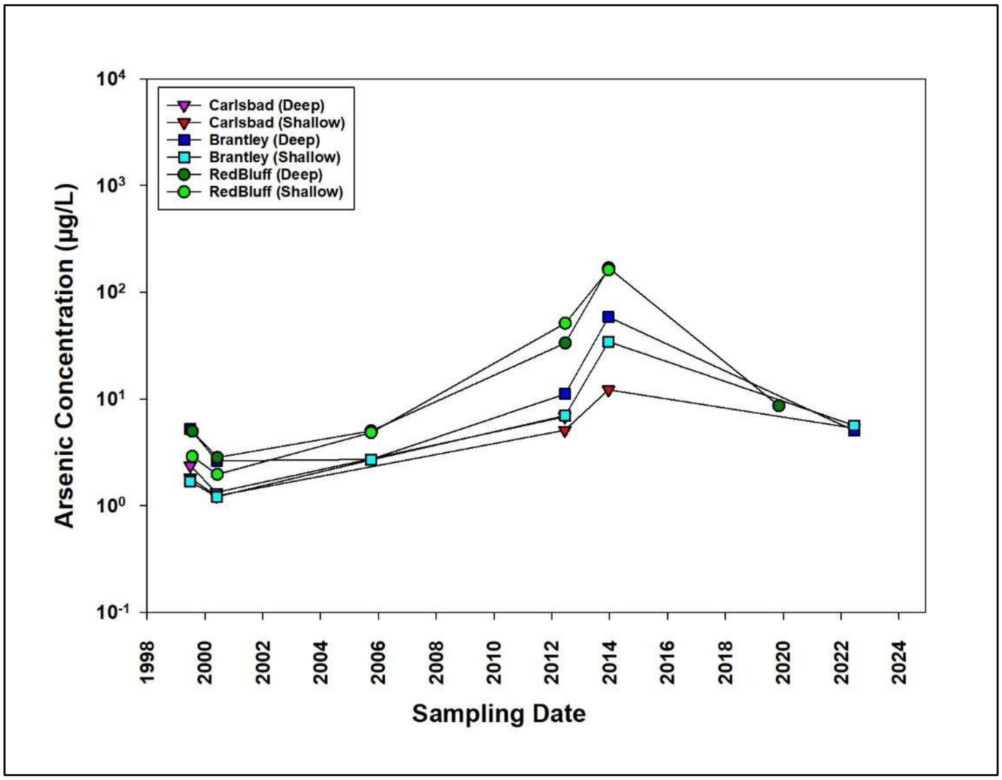


Figure 10.28. Historical Concentrations of Arsenic in Surface Water

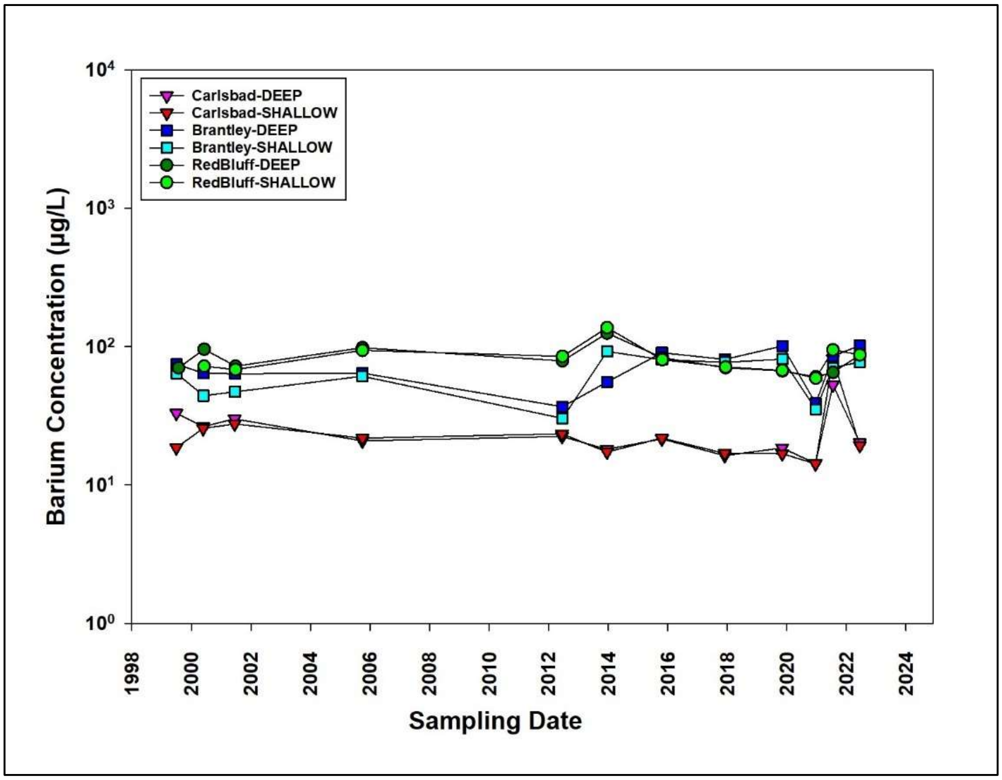
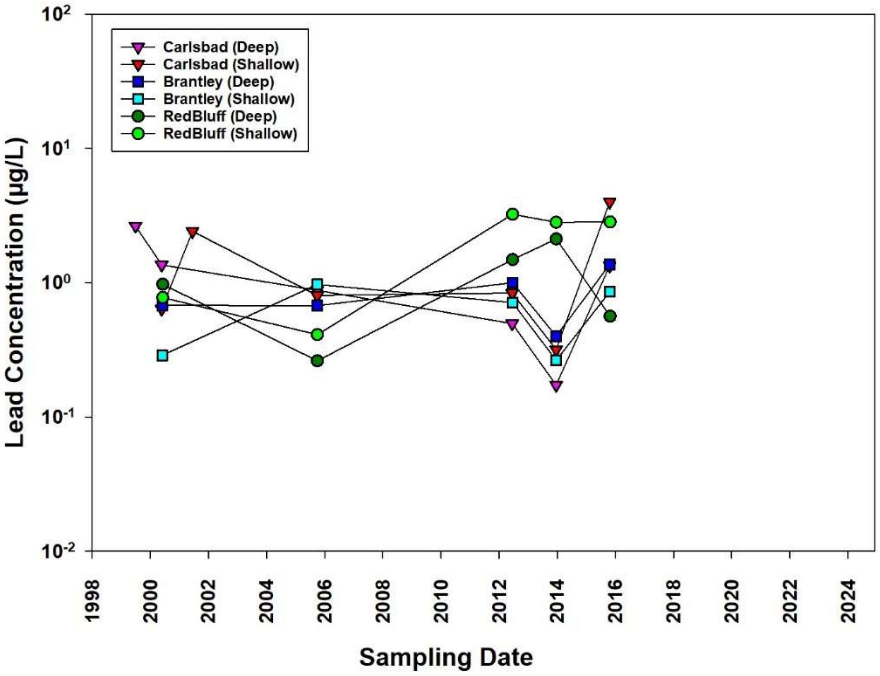


Figure 10.29. Historical Concentrations of Barium in Surface Water



*Note: Pb has not been measured above detection limits since 2016.

Figure 10.30. Historical Concentrations of Lead in Surface Water*

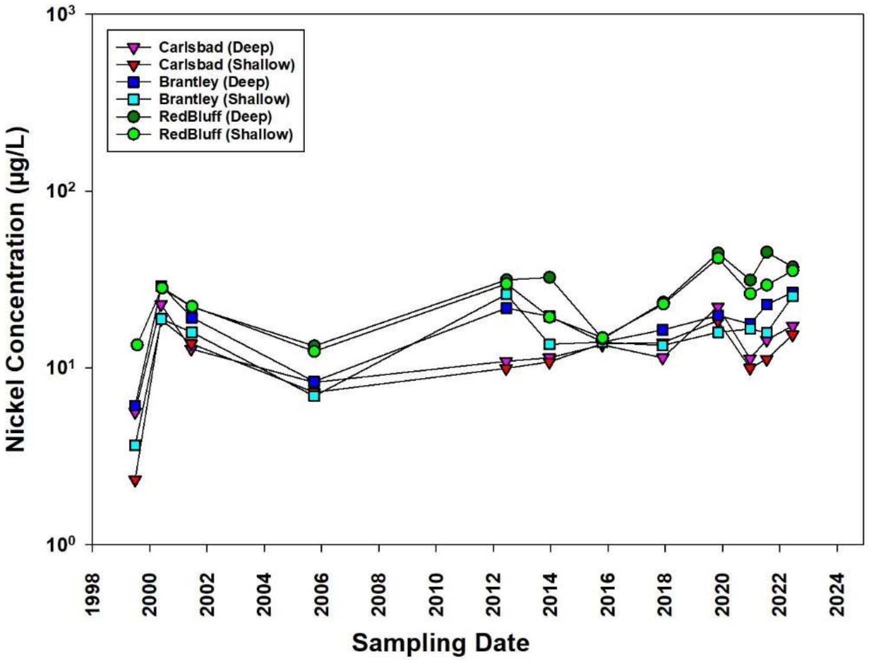


Figure 10.31. Historical Concentrations of Nickel in Surface Water

### 10.4.4 Concentrations of Inorganic Anions in Surface Water

Inorganic anion concentrations measured in regional and supplemental surface water samples are listed in Appendix I, Table I.22 and I.23. Chloride, nitrate, and sulfate are regularly detected above the MDC while phosphate is rarely detected above the detection limits. Figure 10.32 through Figure 10.34 show historical concentrations for the regional surface water samples. Because the location of the supplemental water sources changes annually, long term results do not exist. See current results for the supplemental locations sampled in 2022 in Appendix I. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

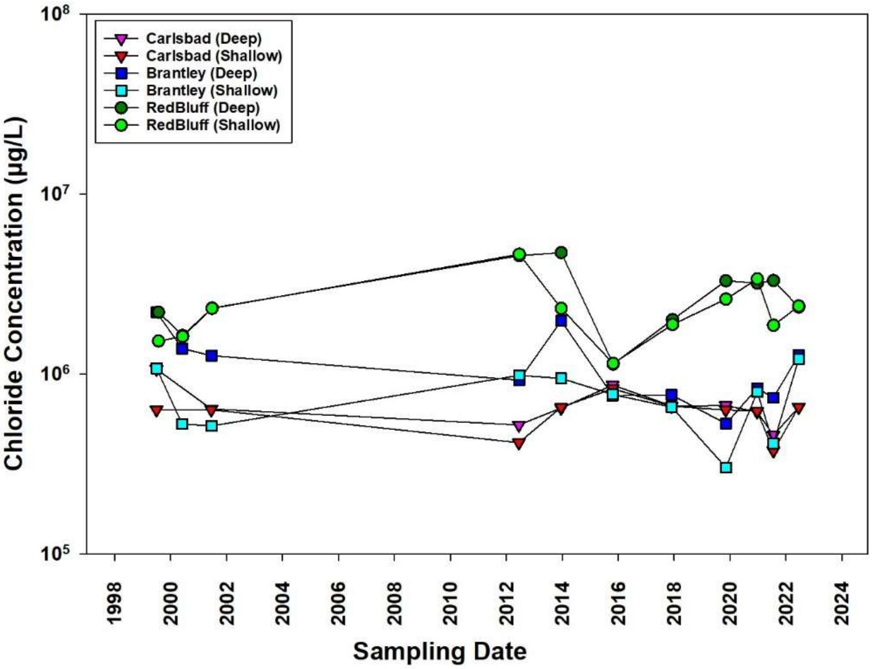


Figure 10.32. Historical Concentrations of Chloride in Surface Water

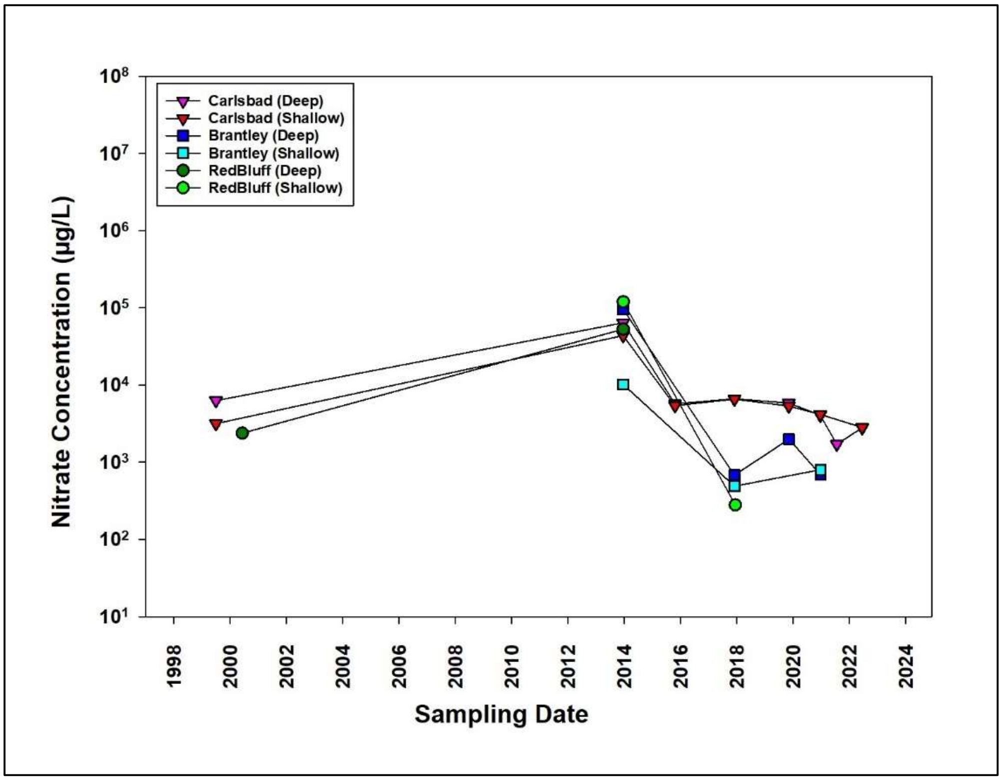


Figure 10.33. Historical Concentrations of Nitrate in Surface Water

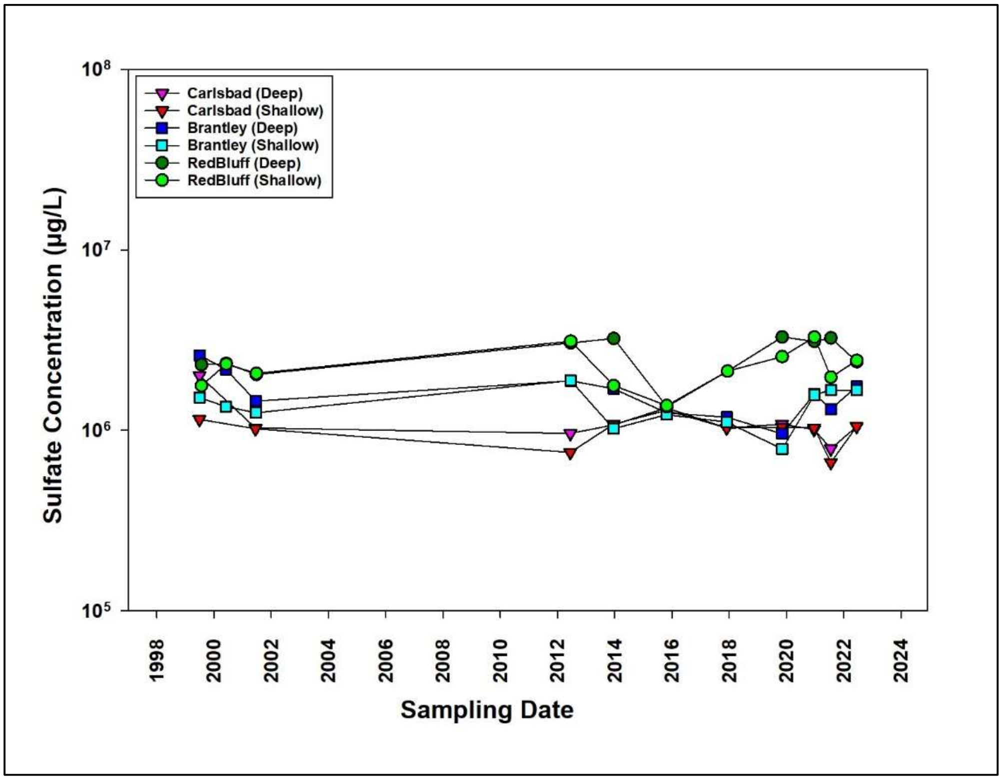


Figure 10.34. Historical Concentrations of Sulfate in Surface Water

### 10.4.5 Concentrations of Inorganic Cations in Surface Water

Inorganic cations measured in regional and supplemental surface water reservoirs are provided in Appendix I, Table I.24 and I.25. Concentrations for calcium, magnesium, potassium, and sodium have been routinely detected above the MDC since cation analysis began in 2017. Figure 10.35 through Figure 10.38 show historical concentrations for the regional surface water samples. Because the location of the supplemental water sources changes annually, long term results do not exist. See current results for the supplemental locations sampled in 2022 in Appendix I. It should be noted that any gaps in the data are either a result of concentrations measured below detection limits or no samples were received for analysis.

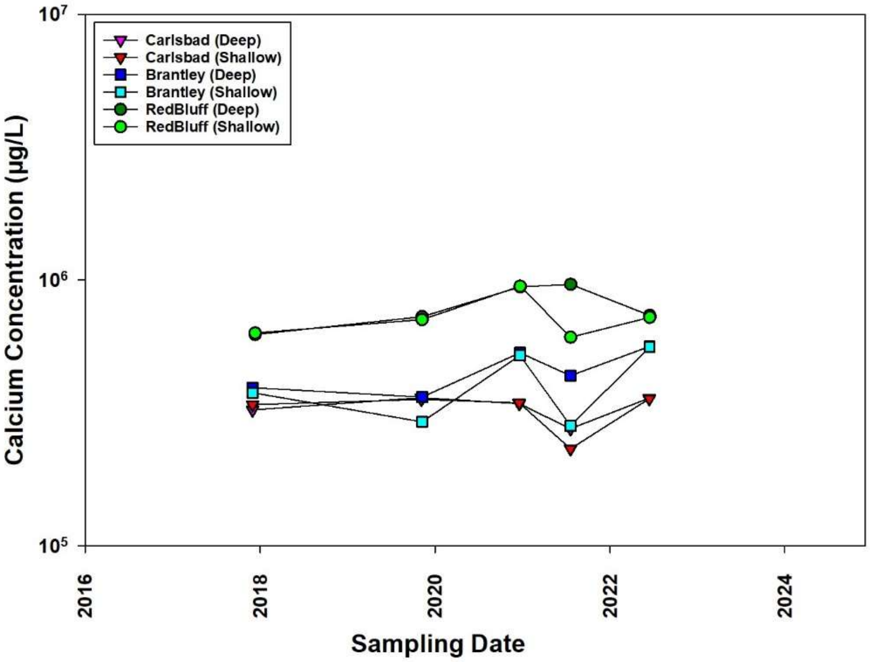


Figure 10.35. Historical Concentrations of Calcium in Surface Water

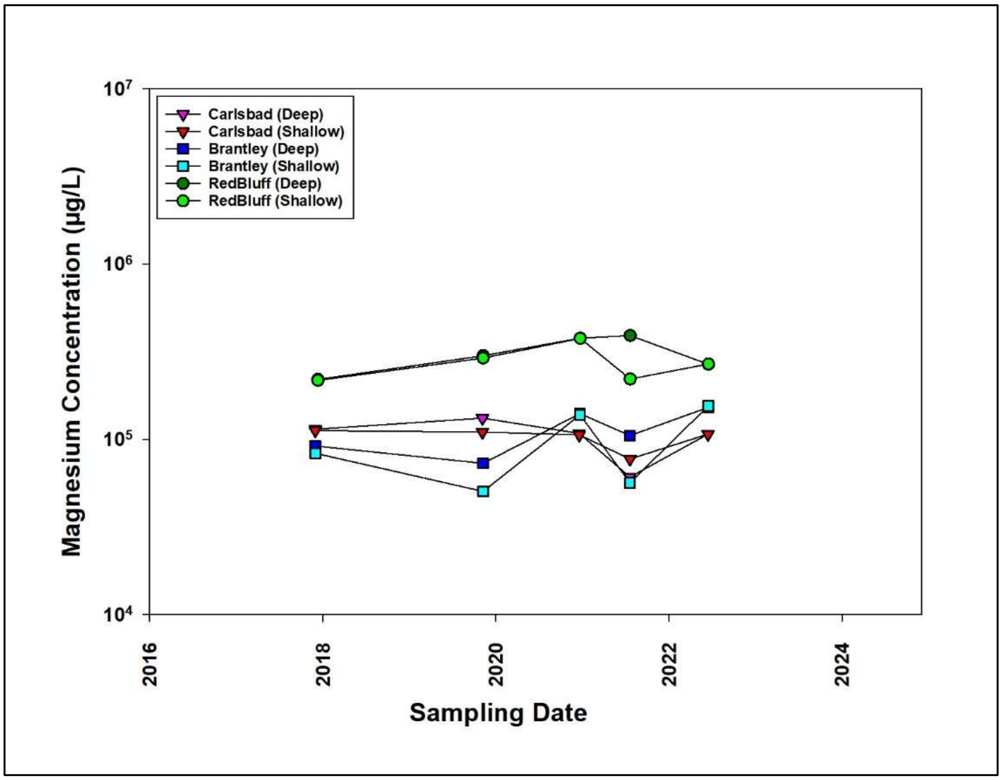


**Figure 10.36. Historical Concentrations of Magnesium in Surface Water**

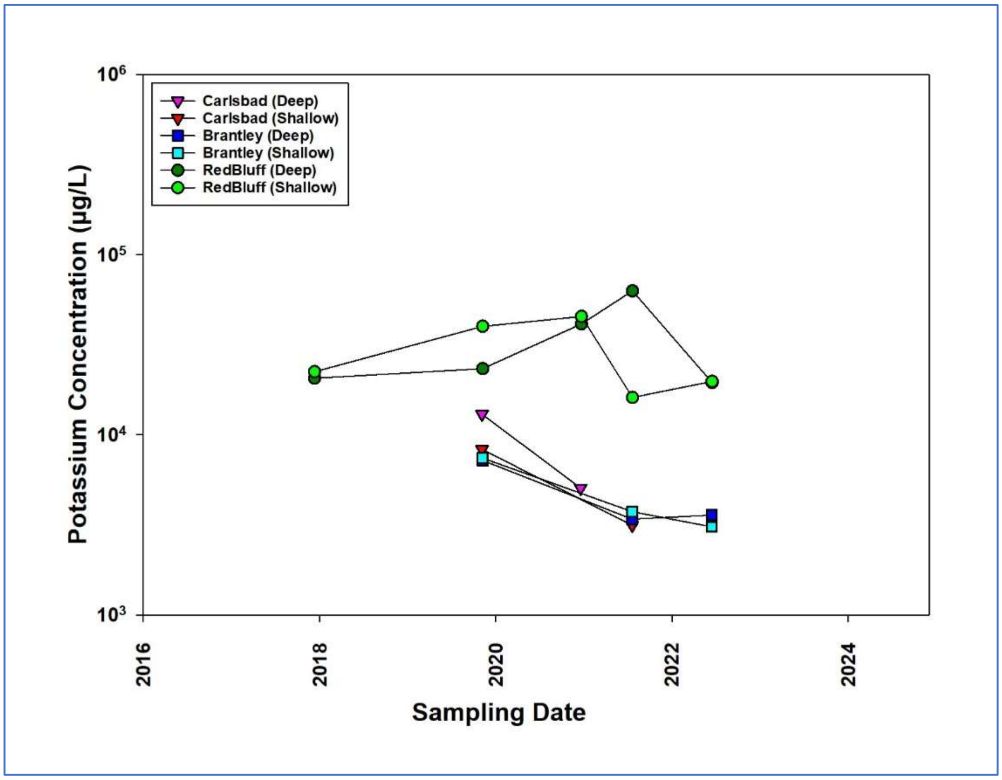


**Figure 10.37. Historical Concentrations of Potassium in Surface Water**

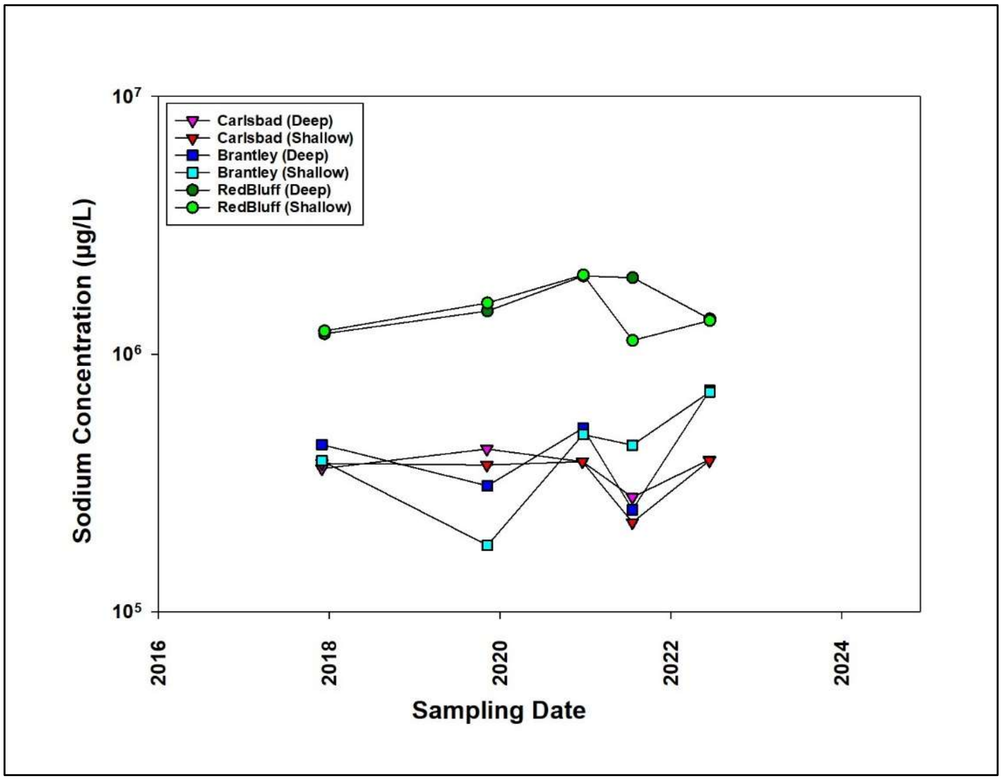


Figure 10.38. Historical Concentrations of Sodium in Surface Water

### 10.4.6 Additional Analyses Performed on Surface Water

Several additional types of non-radiological characterization were added to surface water sample processing in 2020. These parameters include the following: specific gravity, pH, conductance, total organic carbon (TOC), total dissolved solids (TDS), and total suspended solids (TSS). Results of all these analyses are provided in Appendix I. Historical data for the 3 regional locations are shown for pH, conductance, TOC, and TDS in Figure 10.39 through Figure 10.42, respectively. Because the location of the supplemental water sources changes annually, long term results do not exist. See current results for the supplemental locations sampled in 2022 in Appendix I.

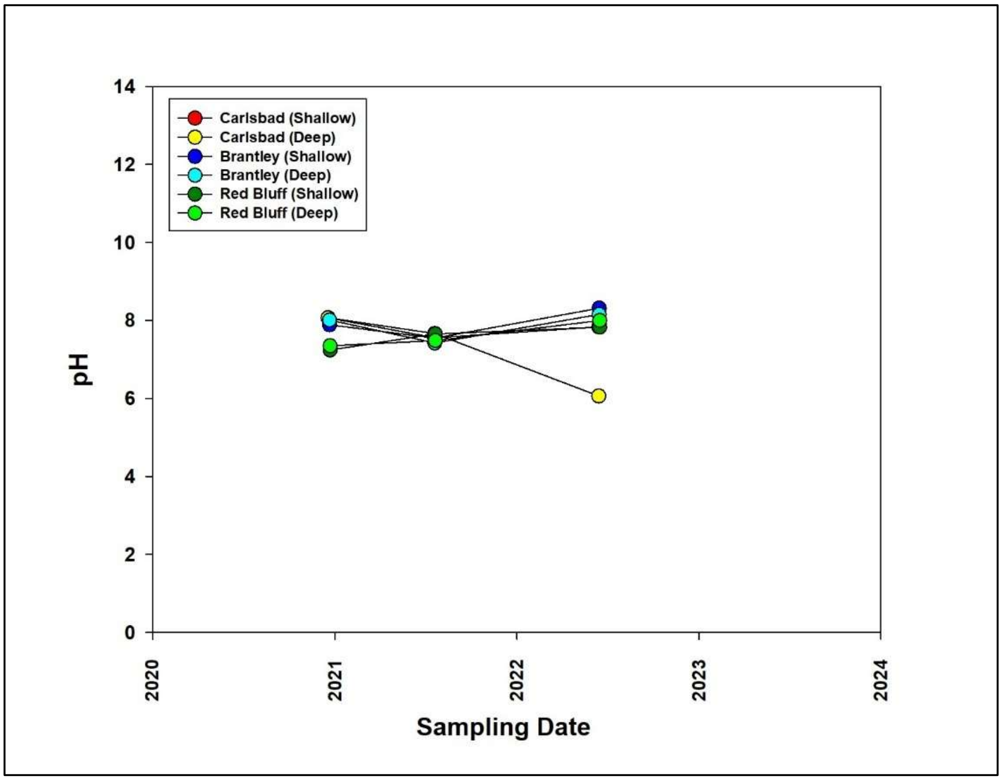


Figure 10.39. Historical pH Measurements in Surface Water

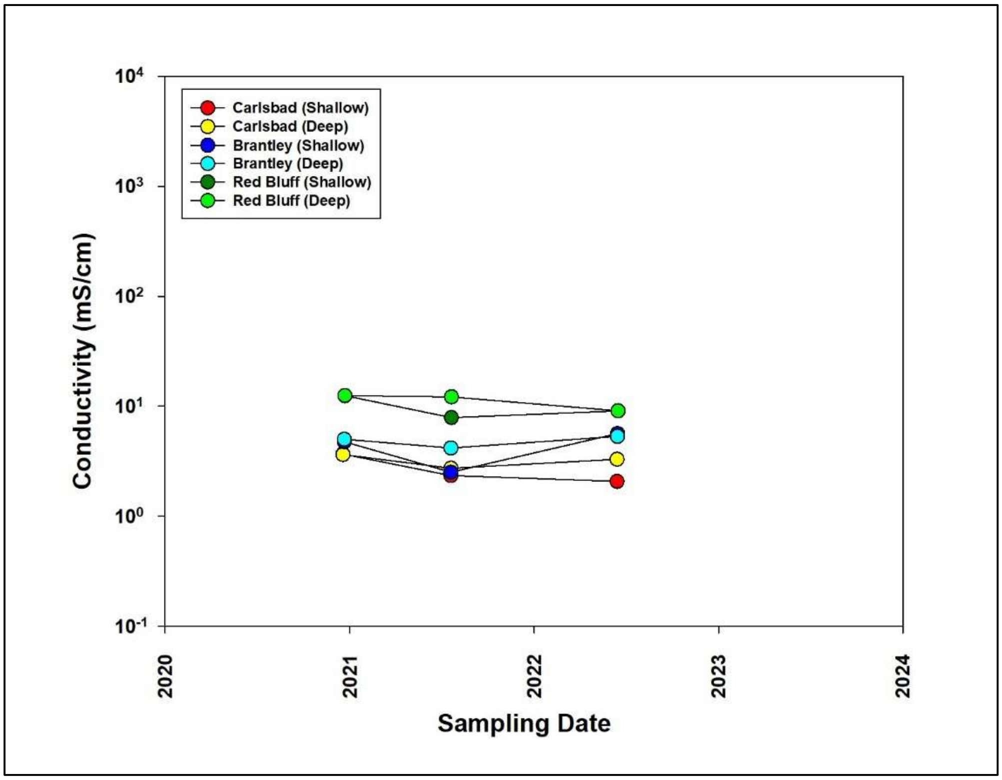


Figure 10.40. Historical Conductivity Measurements in Surface Water

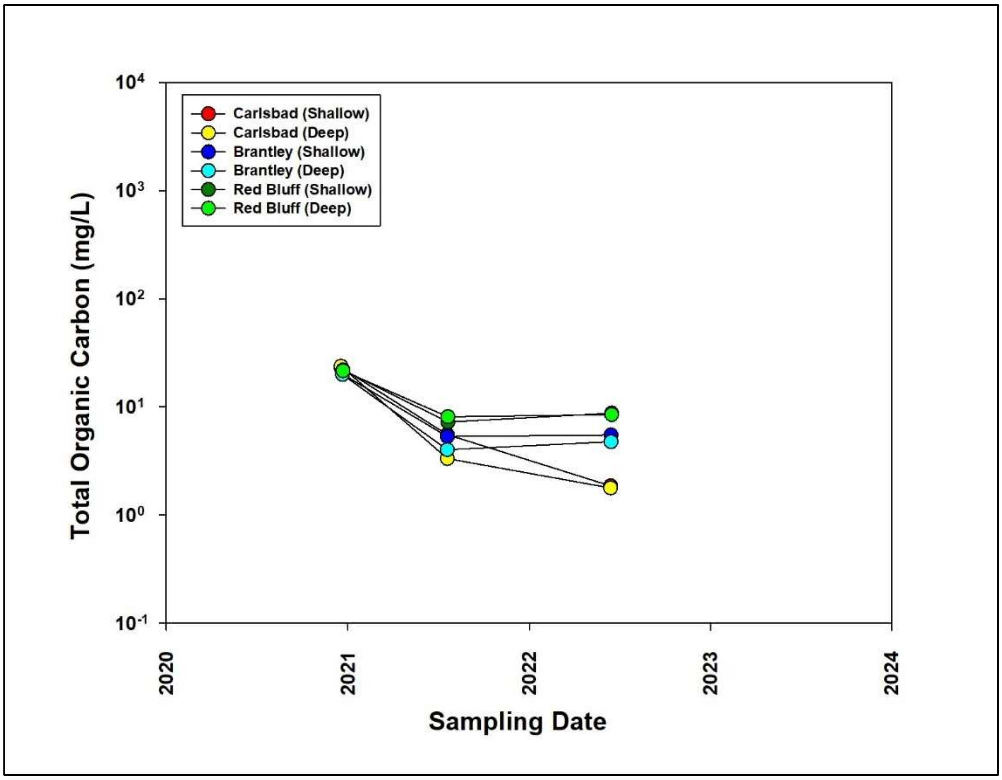


Figure 10.41. Historical Total Organic Carbon Concentrations in Surface Water

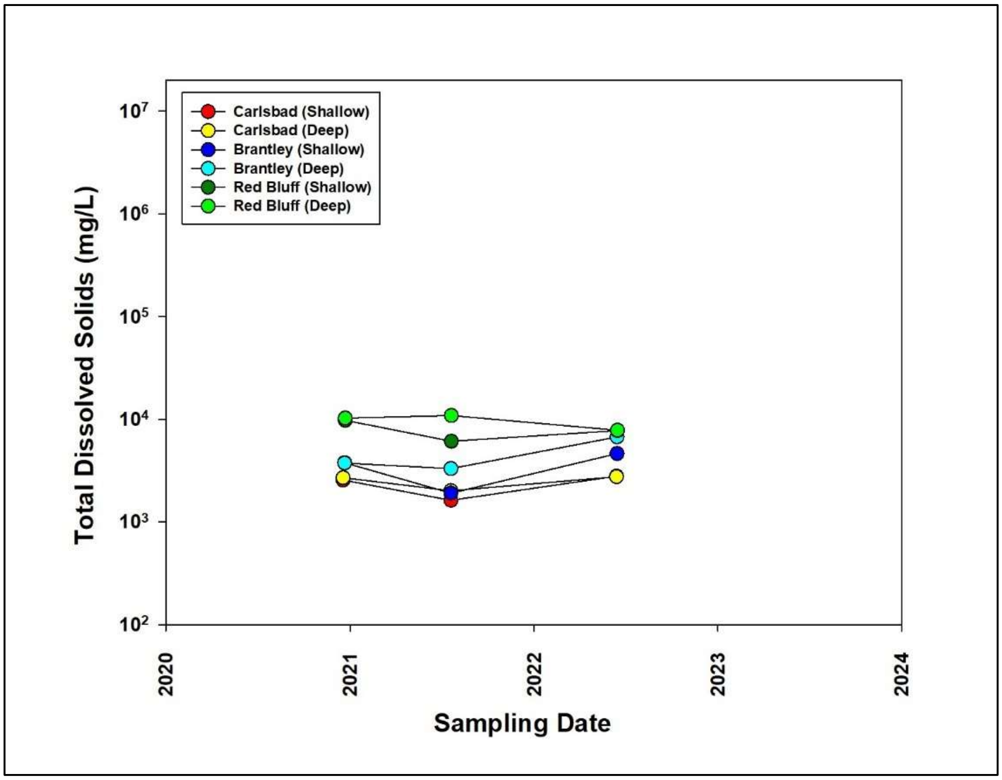


Figure 10.42. Historical Total Dissolved Solids Concentrations in Surface Water

## 10.5 Conclusions

This chapter presents the non-radiological monitoring results of a variety of environmental media including effluent air, airborne particulates, drinking water, and surface water for the calendar year 2022. While some variation is expected, no noticeable changes were observed in 2022 that could be attributed to activities at the WIPP site.

Variations in effluent air for select anions and cations measured at Station A are expected and likely a result of anthropogenic activity due to the nature of the WIPP site. Variations in select metals measured at Station A have been observed since before the WIPP site accepted the first shipment of waste and are likely related to underground activity as well. It is important to note that metal concentrations measured at Station B are significantly lower than those measured at Station A and exhibit a much smaller degree of variation. This confirms that very little inorganic material makes it past the WIPP's extensive exhaust filtration system.

Variations in inorganic concentrations observed in airborne particulates collected at both above-ground locations behaved similarly despite being over 20 miles apart. This suggests that similar events, such as weather and anthropogenic activity, were observed at both locations. Changes in concentrations are likely due to a combination of weather and local topography. Mining, oil and gas extraction, and a variety of agricultural activities are common in southeast New Mexico and are known to play an important role in the types and amounts of inorganic materials measured in airborne particulates.

High salt component concentrations, such as chloride, sodium, magnesium, and potassium, are routinely measured in regional drinking water due to the presence of natural salt deposits in the region. However, very small changes in all inorganic components as well as the additional analysis, such as pH and conductivity, are observed over time. Malaga, Otis, and Hobbs routinely have the highest concentrations of all measured inorganic materials while Carlsbad and Loving typically have the lowest concentrations. Very small changes were observed in each of the reservoirs over time suggesting that environmental changes to not have a noticeable effect on these water sources.

In general, surface water samples tend to exhibit much higher concentrations of all inorganic materials than in drinking water. The highest concentrations can be found almost always in Red Bluff, while the concentrations in Lake Carlsbad are the lowest among the three regional water sources. Virtually all the metal concentrations were very consistent over time, while anions and cations appear to fluctuate annually suggesting they are more influenced by changes in the environment. For example, during dry monsoon seasons that are characterized by low rainfall and unusually high temperatures, evaporation could be responsible for increases in salt components such as sodium, calcium, chloride, sulfate, and magnesium.

# CHAPTER 11 - VOLATILE ORGANIC COMPOUND MONITORING

The WIPP Hazardous Waste Facility Permit (HWFP), Attachment N, mandates the monitoring of volatile organic compound (VOC) emissions from mixed waste, which may be entrained in the exhaust air from the WIPP underground hazardous waste disposal units (HWDUs). The purpose of the VOC monitoring is to verify that regulated VOCs emitted by the waste are within the concentration limits specified by the HWFP. The program is designed to determine VOC concentrations attributed to open and closed panels. Currently, ten target VOCs selected for monitoring were determined to represent approximately 99% of the risk due to air emissions. These target compounds are 1,1-dichloroethylene, methylene chloride, chloroform, 1,1,1-trichloroethane, carbon tetrachloride, 1,2-dichloroethane, toluene, chlorobenzene, 1,1,2,2-tetrachloroethane, and trichloroethylene. In 2014, trichloroethylene was added to the analyte list in compliance with the NMED Administrative Order. These ten compounds and their method reporting limits for different types of samples are summarized in Appendix J, Table J.1. Compounds consistently detected in ambient air samples in the underground may be added to the list of compounds of interest.

Repository VOC monitoring was implemented in November 1999 and disposal room VOC monitoring was implemented in November 2006. CEMRC first began analyzing samples for the Confirmatory VOCs Monitoring Plan in April 2004. Originally, the samples were collected from only two stations in the WIPP underground for each filled disposal room, referred to as Repository VOC monitoring. Since 2006, each room actively receiving waste is also sampled at the exhaust side of the room, referred to as disposal room VOC monitoring. The requirements for disposal room VOC monitoring include the addition of sampling locations within active underground hazardous waste disposal units. Disposal room sampling terminates upon initiation of panel closure activities.

Before the 2014 fire and radiation release events, repository VOC sampling for target compounds was performed biweekly at two ambient air monitoring stations, VOC-A, located downstream from HWDU panel 1 in Drift E300, and VOC-B, located upstream from the active panel. As waste is placed in new panels, VOC-B will be relocated to ensure that it samples underground air before it passes the waste panels. Target compounds found in VOC-B represent background concentrations found in the underground. The VOC concentrations measured at this location are VOCs entering the mine through the air intake shaft and VOCs contributed by facility operations upstream of the waste panels. Differences measured between the two stations represent any VOC contributions from the waste panels. After the February 2014 fire event, the waste panels sampling locations for repository VOC monitoring have been changed from Stations VOC-A and VOC-B in the underground to new Stations VOC-C and VOC-D on the surface. Surface VOC sampling has been underway since February 2014.

Disposal room VOC sampling activity was suspended following the 2014 salt truck fire and radiation release event in the WIPP underground. The disposal room VOC monitoring for

Panel 7 (active waste disposal panel in 2022) was activated on December 19, 2016. Details of the sample collection and analyses are described in the following sections.

## 11.1 Sample Collection

The surface VOC samples were collected twice weekly from two air-sampling locations. These stations are located at the following locations: (1) Station VOC-C, located at the west side of Building 489, and (2) Station VOC-D, at the groundwater pad WQSP-4 for measuring background VOCs. Disposal room VOC samples were collected biweekly from Panel 7, the active disposal panel in 2022. Sample location data are identified by the source panel number, room number, and intake (I) or exhaust (E) function. For example, Panel 7 Room 6 exhaust location is coded P7R6E. Samples were collected by WIPP contractor personnel using a commercially available portable passive air canister and delivered for analysis to CEMRC in weekly batches. For the 2022 monitoring period, a total of 206 surface VOC samples and 224 disposal room VOC samples were collected.

## 11.2 Sample Preparation and Analysis

Regular VOC samples were analyzed using an Agilent 6890/5975 gas chromatography-mass spectrometry (GC-MS) system interface with an Entech 7100 pre-concentrator, while low-level VOC analyses were primarily analyzed using an Agilent 7820/5977 GCMS interface with Entech 7200/7016D pre-concentrator/auto-sampler system. Analytical procedures employed for the analyses were based on the concepts contained 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)"* (1999).

For analysis, a known volume of air sampled from the canister was directed to a pre-concentrator. The pre-concentrator captures VOCs and removes most of the water vapor and bulk gases such as oxygen, nitrogen, and carbon dioxide from the sample prior to introducing the target VOCs to the GC-MS. The VOC screening results were used to determine pre-analysis dilutions required for analysis using Entech 4600 Dynamic Diluter. Canisters were cleaned after sample analysis using the Entech 3100 Canister Cleaning system. All cleaned canisters were analyzed to assure the desired level of cleanliness has been achieved.

## 11.3 Results and Discussion

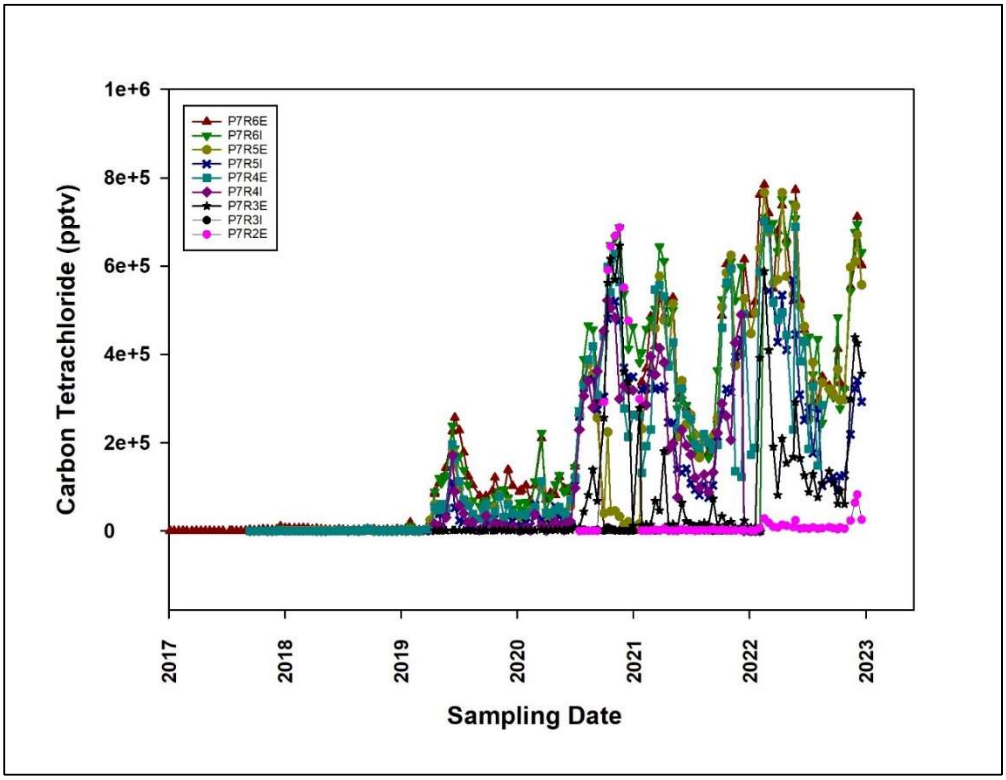
The concentrations of VOCs are reported here either in parts per billion by volume (ppbv) or parts per million by volume (ppmv). Table J.1 lists the maximum MRLs for the ten target compounds for undiluted samples. Because the samples are being diluted in the laboratory, the laboratory MRL for diluted samples is a factor of the lowest calibration level and the dilution factor. For disposal room VOC samples, the laboratory MRL varies for each sample based on the dilution factor (which is calculated based on the estimated concentration for the sample). In comparison, all surface VOC samples have a dilution factor of 2, so for example, the laboratory MRL for SIM mode analysis is 0.1 ppbv (where the lowest calibration level is 0.05 ppbv).

### 11.3.1 Disposal Room VOC Monitoring Results

Samples were collected from eleven locations in Panel 7 (P7R6E, P7R6I, P7R5E, P7R5I, P7R4E, P7R4I, P7R3E, P7R3I, P7R2E, P7R2I, and P7R1E) in 2022. Maximum sample results for the disposal room VOCs are summarized in Appendix J, Table J.2 and Table J.3. Three target VOC compounds, carbon tetrachloride, 1,1,1-trichloethane, and trichloroethylene were detected above the laboratory MRL in all nine locations. The variations of carbon tetrachloride, trichloroethylene, and 1,1,1-trichloroethane in the disposal room VOC samples over the period of 2016-2022 are shown in Figure 11.1. The maximum concentrations were 784.43 ppmv for carbon tetrachloride, 289.47 ppmv for 1,1,1-trichloroethane, and 260.34 ppmv for trichloroethylene. Chloroform was also detected above the laboratory MRL almost regularly and the maximum concentration was 33.99 ppmv.

Concentrations of other target VOC compounds, such as methylene chloride, toluene, 1,1,2,2-tetrachloroethane, and 1,1-dichloroethylene were detected at concentrations less than the method reporting limit, while concentrations of chlorobenzene and 1,2-dichloroethane were either below the method detection limit or not detected.

The levels detected were continuously below the 50% action level as listed in Appendix J, Table J.4.



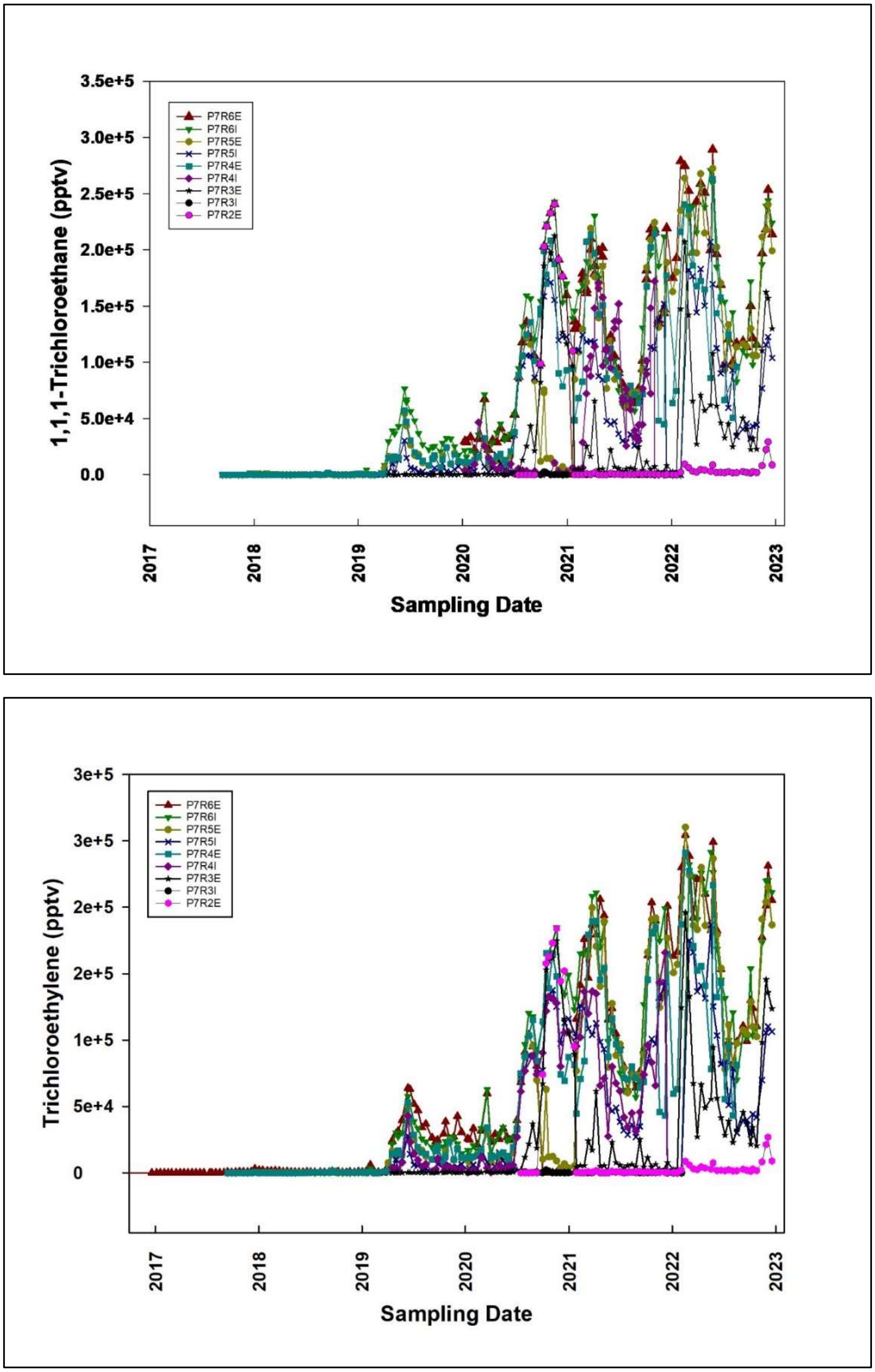
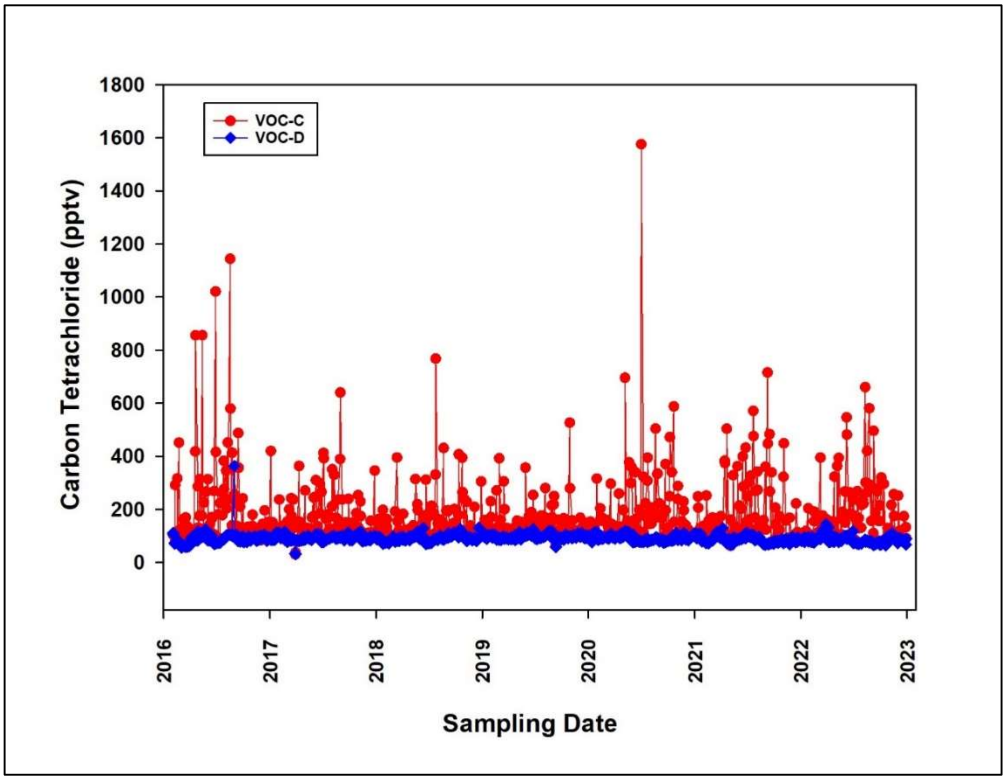
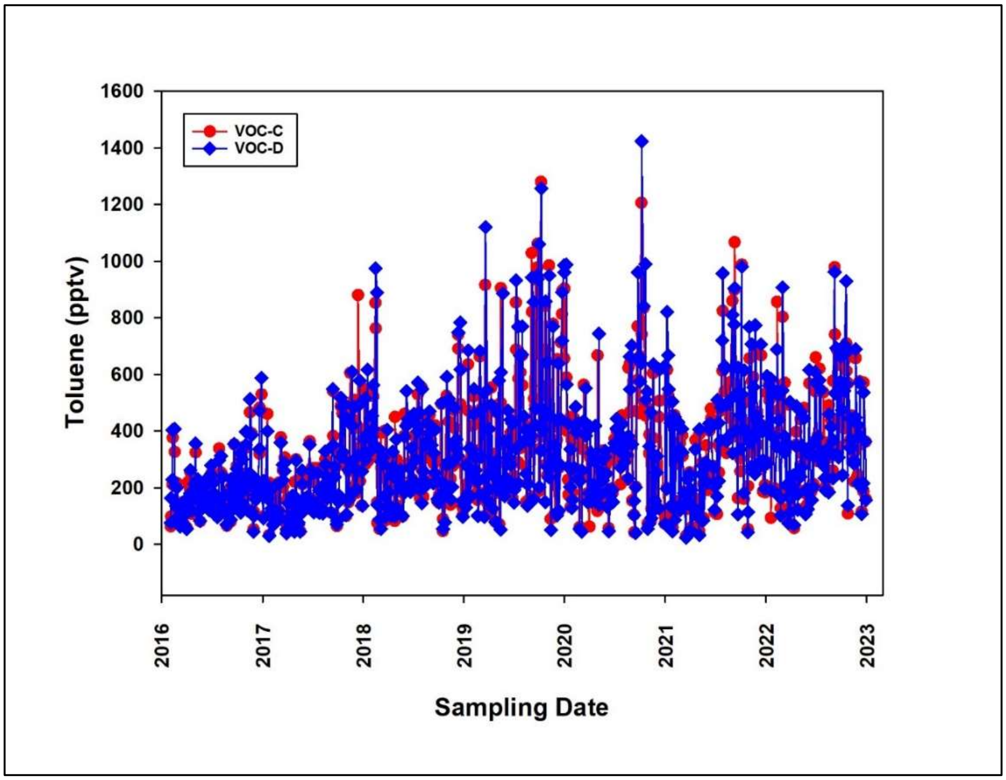


Figure 11.1. Concentrations of some Target VOC Compounds in Disposal Room VOC Samples

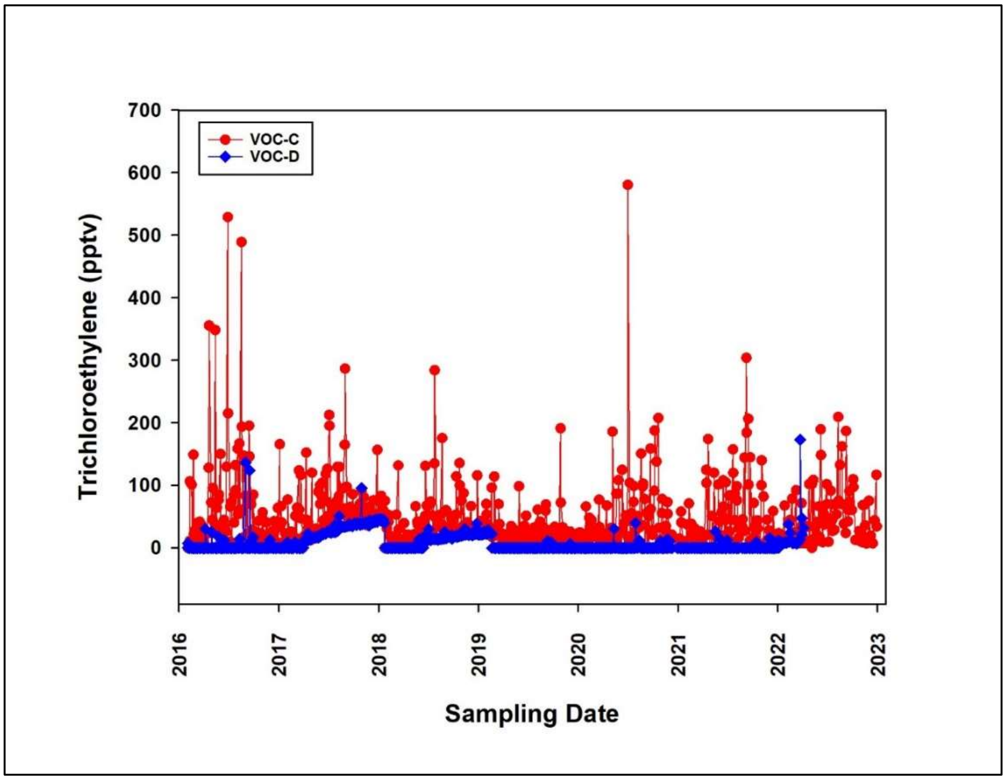
### 11.3.2 Surface VOC Monitoring Results

The concentration ranges of the target VOC compounds at sampling stations VOC-C and VOC-D are listed in Appendix J, Table J.5. Carbon tetrachloride and toluene were mostly detected above the laboratory MRL (0.1 ppbv) with very few instances below it at VOC-C sampling location. Trichloroethylene and methylene chloride were detected above the MRL occasionally with values mostly below the MRL or not detected at VOC-C location. All other compounds were below the laboratory MRL or were not detected at VOC-C location. Comparatively at VOC-D sampling station, toluene was the only compound detected mostly above the MRL regularly, whereas carbon tetrachloride concentration was typically around the MRL. Typically, concentrations of toluene and methylene chloride are mostly similar at VOC-C and VOC-D locations. All other compounds at VOC-D location were either non-detect or below the MRL. The concentrations of carbon tetrachloride, toluene, trichloroethylene, and methylene chloride for VOC-C and VOC-D sampling stations for the period of 2016-2022 are shown in Figure 11.2.





VOC-C
VOC-D
Toluene (pptv)
1600
1400
1200
1000
800
600
400
200
0
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date



VOC-C
VOC-D
Trichloroethylene (pptv)
700
600
500
400
300
200
100
0
2016
2017
2018
2019
2020
2021
2022
2023
Sampling Date

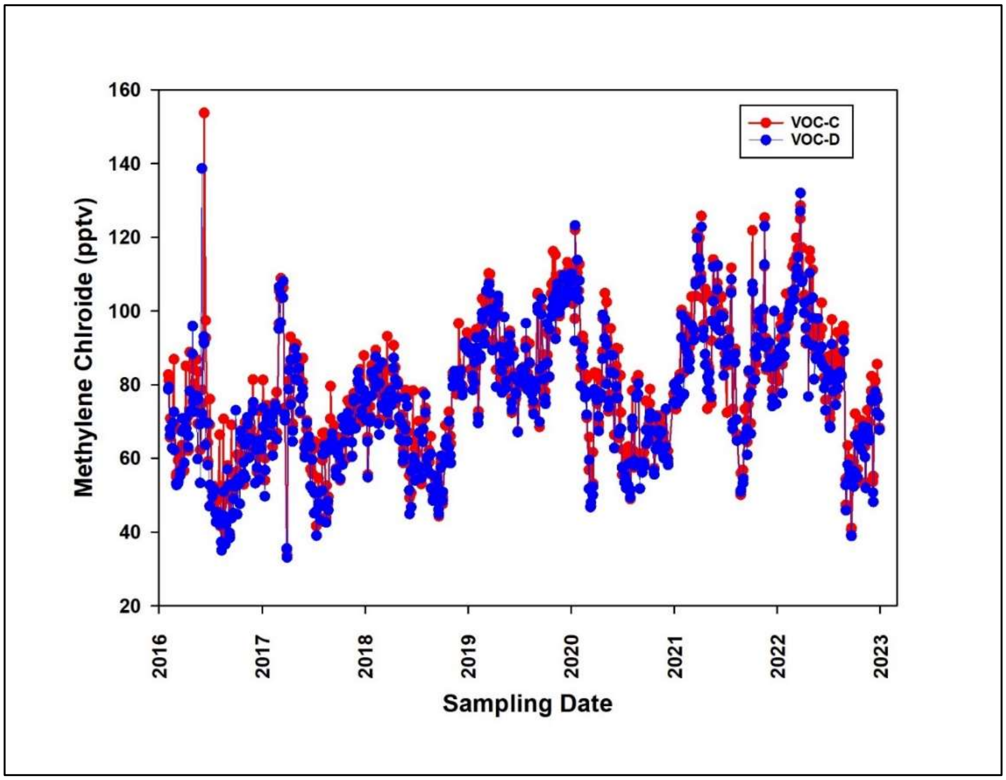


**Figure 11.2. Concentrations of Some Target VOC Compounds in Surface VOC Samples**

In 2022, the maximum concentrations of target compounds detected above the MRL at VOC-C were 0.66 ppbv for carbon tetrachloride, 0.98 ppbv for toluene, 0.21 ppbv for trichloroethylene, and 0.13 ppbv for methylene chloride. The maximum detected value for compounds detected above MRL at VOC-D were as follows: carbon tetrachloride was 0.15 ppbv, toluene was 0.96 ppbv, trichloroethylene was 0.17 ppbv, and methylene chloride was 0.13 ppbv.

CEMRC does not assess the health risks to the public and workers from the release of VOCs from the Repository or VOC in the Repository air. However, the risk evaluation studies conducted by the WIPP Contractor indicate that risk to the non-waste surface workers continues to be below action levels. Studies also reported that cancer risk and hazard Index from the release of VOC were an order of magnitude below an action level (ASER Report-2022, DOE/WIPP-21-3631 and DOE/WIPP-22-3636).

## 11.4 Conclusions

This chapter summarizes the results of the VOC monitoring program for the calendar year 2022. For disposal room VOC monitoring, 224, and for surface VOC monitoring, 206 samples were collected during 2022. Carbon tetrachloride and toluene were most regularly detected above the MRL at VOC-C sampling location. Three of the ten target compounds were regularly detected above the MRL for disposal room samples. The levels measured in 2022 were below the 50% action level as specified in Module IV of the HWFP. The VOC monitoring results indicate that risk to the non-waste surface workers continues to be below action levels.

There is no evidence of increases in VOCs in the region that could be attributed to releases from WIPP.

The more detailed results of the 2022 VOC monitoring program are reported in the Semi-Annual Volatile Organic Compound Data Summary Report (DOE/WIPP-21-3631 and DOE/WIPP-22-3636)

# CHAPTER 12 - LOW BACKGROUND RADIATION EXPERIMENT

## 12.1 Introduction

An important goal of the Low Background Radiation Experiment (LBRE) project is to document the possible benefits and costs of exposing cells and organisms to reduced radiation that are below normal levels. An additional goal that was proposed in this funding cycle is to document any evidence of ancient biosignatures present in halite inclusion fluid in the Permian age Salado formation. In this report, we 1. report the establishment of a new laboratory devoted to identify ancient life forms in WIPP halite, 2. summarize results from a new model organism, the *Aedes aegypti* mosquito, 3. present highlights from a publication on a streamlined approach in utilizing transcriptome pipeline software (Thawng and Smith, 2022) and 4. overview our patent pending on the development of the therapeutic uses of low-level radiation (Tomasi and Smith, 2022).

## 12.2 Methods

Ancient DNA Halite Disinfection Process. To ensure documenting only material from the interior of halite crystals (ancient) and not from the exterior (modern), an exhaustive disinfection procedure has been developed by Beowulf Owen as part of his MS thesis work on the topic of extracting ancient halite biosignatures.

For the *Ae. aegypti* mosquito work, we are collaborating with Dr. Immo Hansen of the NMSU Biology Department, a well-known expert in mosquito physiology. In 2021, we performed our first mosquito experiment at WIPP, but were using a strain of *Ae. aegypti* (Liverpool strain) that proved to be short-lived under the experimental conditions at WIPP. After performing multiple pilot studies at NMSU, we chose a hardier strain (from University of Georgia, the UGAL strain) for the experiment described below. Eggs were hatched at NMSU, then were sex-sorted and 200 males were distributed among 5 cages, 200 mosquitos in each. One of the cages was kept at NMSU as a trip control, and 4 cages were transported to WIPP and emplaced in Peltier incubators on the same day. The four incubators (set at 24 °C, 90% humidity, 14 hr light/dark cycles) were: 1. Above-ground in the LBRE Surface lab, 2. Underground in the LBRE steel vault, 3. Underground in a KCl-supplemented incubator, and 4. Underground in a Pozzolana-supplemented incubator. The KCl and Pozzolana-supplemented treatments were designed to mimic natural levels of radiation. After 16-days of incubation while being fed 20% sucrose and water, mosquitos were harvested for RNA and protein to perform transcriptome and proteome analyses respectively. Photos of the irradiators and mosquito apparatus are shown in Figure 12.1.

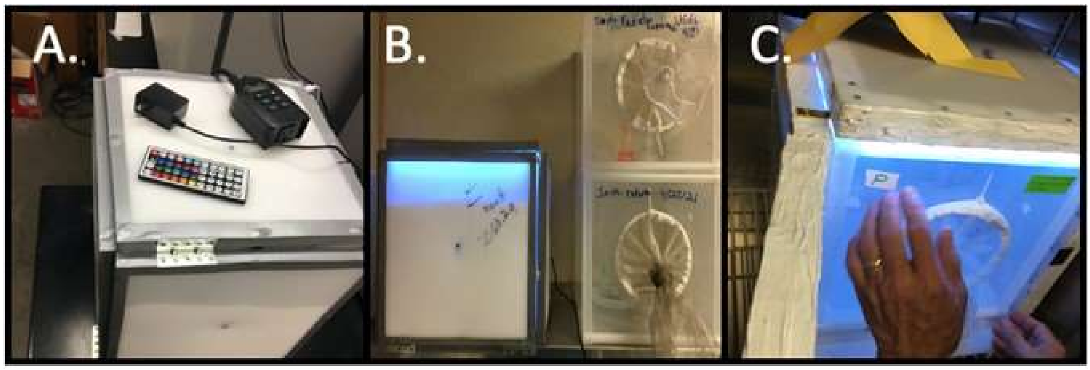


**Figure 12.1. A. An irradiator on a lab bench with light controls on top. B. An irradiator with the lights on the inside and next to it are two mosquito cages. C. An irradiator opened to show the mosquito cage inside**

For the Transcriptome analyses project, we are collaborating with Dr. John Xu in the NMSU Biology department who has developed a high-speed parallel computers laboratory for Bioinformatic Analyses. Our LBRE project personnel have been given remote access to this facility so that we can submit "jobs" and get results from our NMSU computers located elsewhere.

The idea of developing natural potassium for therapeutic use arose from a related LBRE project which funded Dr. Maurizio Tomasi in 2018 to help run a plant-based experiment at WIPP. The theoretical basis for this patent was first proposed in 2020 (Tomasi, 2020).

## 12.3 Results

Ancient DNA Laboratory Initiated at NMSU

The NMSU Biology Department has provided a 130 sq ft room that we have converted into NMSU's Ancient DNA laboratory. As part of his MS thesis, Beowulf Owen, with the help of LBRE-supported Jeremy Winder, has installed a clean room with a 0.1 μm HEPA-filtered unit, a UV sterilization chamber to sterilize materials when being introduced. Inside the clean room is a foot petal-controlled drill fitted with sterile, stainless steel drill bits of various sizes to access halite inclusions following methods published in the literature (e.g. Vreeland et al. 2000); these methods are in the process of being modified to higher quality control standards (Owen et al. NMSU MS thesis in prep). This is a project with considerable technical challenges, for example WIPP inclusion fluid is very close to saturation with numerous divalent and monovalent salts (Stein and Krumhansl, 1988) that are highly inhibitory to the Polymerase Chain Reaction (PCR), the most effective way to amplify low levels of environmental DNA.

**Figure 12.4. Graduate student Beowulf Owen in NMSU's new Ancient DNA laboratory, in front of the clean room constructed by him and Jeremy Winder. On the right is a close-up of the mylar-lined transfer chamber that is irradiated by UV lights and the 0.1 µm HEPA filter that interchanges the clean room every 10 minutes with HEPA-filtered air.**

### *Aedes aegypti* work at WIPP

On Nov. 9, 2022, Liam Goodale successfully defended his NMSU MS thesis entitled, "Less is More, Radiation Quality over Quantity: Biological Response in *Aedes aegypti* and *Escherichia coli."* After a mosquito experiment that was discontinued in 2021, Goodale completed an experiment underground at WIPP that was historic for two reasons: 1. This was the first use of the *Aedes aegypti* mosquito reported from any underground research laboratory in the world and 2. perhaps more importantly, represents a more than 9000-fold decrease in radiation comparing the underground vault (3.8 pGy/hr -- MCNP estimation by G. Esposito) compared to the WIPP surface control (35 nGy/hr (Chaio and Hayes, 2004). We are in the process of finalizing these radiation dose rate measurements in preparation for an upcoming publication (Goodale et al. manuscript in preparation).

Transcriptome analysis of the control mosquitos incubated in the LBRE surface laboratory compared to the radiation-deprived treatment underground in the steel vault showed a significant difference in gene expression response. Figure 12.5 shows a Principal Component Analysis (PCA) that demonstrates all three replicates of the minus-radiation treatment are well-separated from the control treatment. This is an important finding; it means that there is a statistically significant gene expression difference between mosquitos grown at the surface compared to the radiation-deprived treatment underground in the vault. Further analysis of the differentially expressed genes (DEGs) showed that among the downregulated genes in the minus-radiation treatment, approximately 65% of these were metabolic genes (Figure 12.6). Further analysis of these metabolic genes were associated with gene groups we have identified before (Van Voorhies et al. 2020 and Castillo et al. 2018) as involved in a stress response in the underground below background treatment. Proteome analysis is currently underway and will be reported in an upcoming publication (Goodale et al. manuscript in preparation).

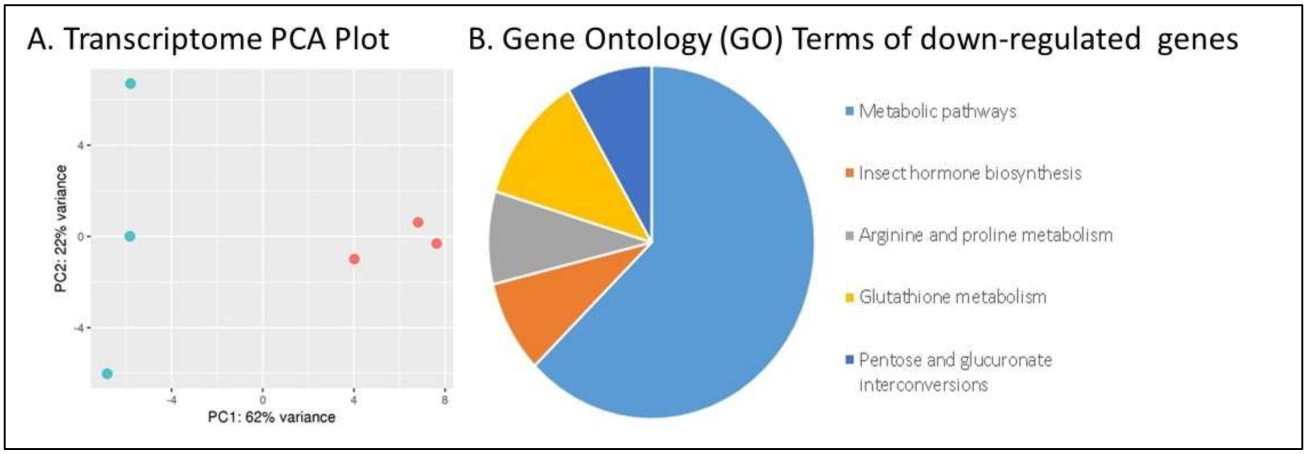


**Figure 12.5. A. Principal Component Analysis (PCA) of the surface control replicates in red vs. replicates in green from the minus radiation treatment from mosquitos grown underground at WIPP in the steel vault. B. Metabolic groups of genes ("GO" terms) that are significantly (False Discovery Rate, FDR > 0.05) downregulated in the minus radiation treatment (L. Goodale, 2022 MS thesis, manuscript in preparation)**

### New Transcriptome Software Analysis

When we report transcriptome data, we always run the analyses using at least two software programs to ensure that our results are valid (Van Voorhies et al. 2020). This past year, Drs. Thawng (the former LBRE project postdoc) and Smith wrote up our procedure and an early reviewer suggested we submit the manuscript to a high-impact journal (BioMedical Central-Genomics, https://bmcgenomics.biomedcentral.com/ ), and we were gratified that it was published in BMC-Genomics (Thawng and Smith, 2022). Briefly, we developed a flowchart showing the stages of transcriptome analyses and how three software programs used the same or different approaches (Figure 12.6). Then we tested the three software programs by submitting the same gene expression datasets from two different studies that we have run at WIPP (Figure 12.7).

Figure 12.7 shows the extent of gene expression as measured by the fold-increase or decrease relative to genes that were not affected by our radiation treatments. The three software programs yielded results that varied widely, with the CLC software showing some genes were differentially expressed by up to 936-fold, whereas another program (DNAStar-DESeq2) showed a more reasonable maximum of a 3.5-fold change in expression. We found that when we imposed a 30 read minimum cutoff (i.e., we eliminated all genes that had less than 30 copies), we decreased the expression numbers in CLC to 26.8. In the publication, we argued that this was still an unrealistically high expression level difference between our background radiation control and the minus-radiation treatment, and proposed that the DESeq-2 statistical package was the most appropriate and conservative approach to use in studies expecting low but significant gene expression differences. As a result of the reception of this article, we have been asked to write a book chapter in a volume entitled, "Current Trends in Transcriptomics" (Thawng and Smith, manuscript in preparation).

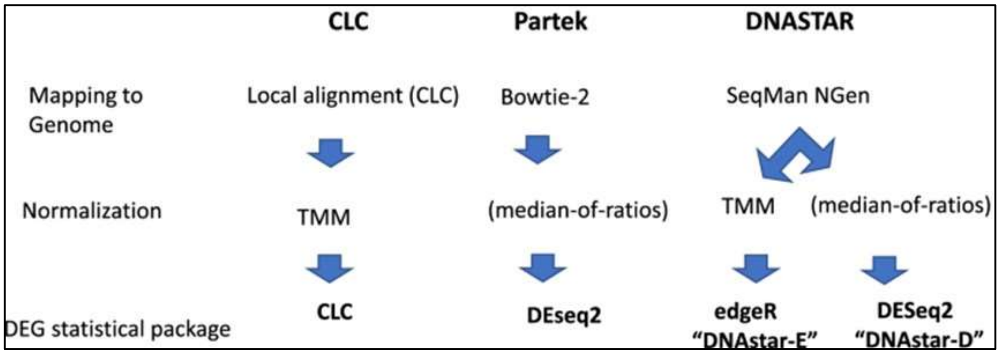


**Figure 12.6. A flowchart of the three steps in transcriptome analyses pipelines, and the steps that are shared among the three commercial software (CLC, Partek, DNAStar) tested by Thawng and Smith (2022)**

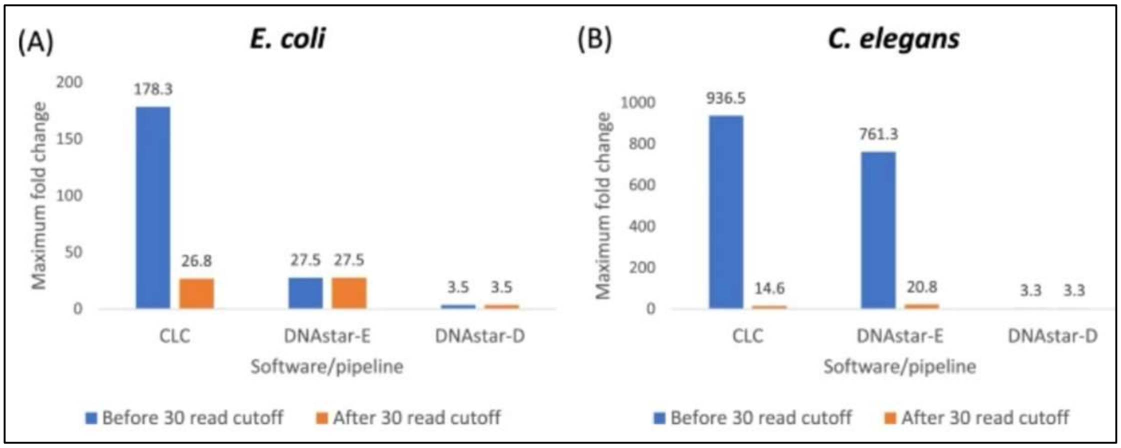


**Figure 12.7. The extent of gene expression differences between two organisms grown at WIPP showing the fold-changes in genes from RNA in organisms grown underground in the absence of normal levels of radiation (from Thawng and Smith, 2022)**

Commercial Patent – therapeutic use of auger electrons from naturally-occurring $^{40}$K

In September 2022, NMSU's Intellectual Property and Commercialization (IPAC) board recommended we apply to the U.S. Patent Office to convert our provisional patent into a commercial patent (Tomasi and Smith, 2022). If approved, this will be the first patent to come from our LBRE work at WIPP (Smith has five NMSU patents from other projects).

## 12.4 Conclusions

With an overview presentation of the LBRE project at the Carlsbad chapter of the American Nuclear Society in May 2022, the establishment of an Ancient DNA laboratory at NMSU, the proposal of a new biological model at WIPP (the *Ae. aegypti* mosquito), the publication of a new RNA Transcriptome analysis approach and a patent submitted based on some of our LBRE work, we continue to disseminate broadly our research results at WIPP.

# CHAPTER 13 - QUALITY ASSURANCE

## 13.1 General Analytical Quality Assurance

Quality assurance and quality control practices encompass all aspects of CEMRC's WIPP Environmental Monitoring Programs (WIPP-EM). The development and implementation of an independent health and environmental monitoring program has been CEMRC's primary activity. The multilayered components of the CEMRC Quality Assurance (QA) Program ensure that all analytical data reported in this report are reliable and of high quality and that, all environmental monitoring data meet quality assurance and quality control objectives.

CEMRC is subject to the policies, procedures, and guidelines adopted by NMSU, as well as state and federal laws and regulations that govern the operation of the University and radiological facilities. The management of CEMRC is committed to conducting a well-defined quality assurance program, incorporating good professional practices, and focusing on the quality of its testing and calibration in research and service to sponsors. CEMRC's technical programmatic areas in 2022 included: Environmental Chemistry, Organic Chemistry, Radiochemistry, Field Programs, and Internal Dosimetry. Since its inception, CEMRC's WIPP-EM program has been conducted as a scientific investigation, meaning that it operates without any compliance, regulatory, or oversight responsibilities. As such, there are no specific requirements for reporting data other than following good scientific practices.

## 13.2 Quality Assurance/Quality Control for Field Sampling

Samples for CEMRC's WIPP-EM Programs are collected by personnel trained following approved procedures. Established sampling locations are accurately identified and documented to ensure continuity of data. Field duplicate samples are used to assess sampling and measurement precision. Logbooks are maintained by technical staff in field operations to record locations and other specifics of the sample collection, and data on instrument identifications, performance, calibration, and maintenance. Data generated from field sampling equipment are error checked by using routine cross-checks, control charts, and graphical summaries. Most data collected in written form are also entered in electronic files and electronic copies are crossed checked against the original data forms. All electronic files are backed up daily.

Calibration and maintenance of equipment and analytical instruments are carried out on predetermined schedules coinciding with the manufacturer's specifications or modified to special project needs. Calibrations are either carried out by equipment vendors or by CEMRC personnel using certified calibration standards.

## 13.3 Quality Assurance/Quality Control for Radiochemistry

Quality control in the analytical laboratories is maintained through tracking and verification of analytical instrument performance, through the use of American Chemical Society (ACS) certified reagents, through the use of National Institute of Standards and Technology (NIST) traceable radionuclide solutions, and through verification testing of radionuclide concentrations for tracers not purchased directly from NIST or Eckert & Ziegler Analytics Inc. When making laboratory solutions, volumes and lot numbers of stock chemicals are recorded. Prior to weighing radionuclide tracers and samples, the balance being used is checked using NIST traceable weights.

Control checks are performed on all nuclear counting instrumentation each day or prior to counting a new sample. The type of instrument and methods used for performance checks were as follows: for the Protean 9604 gas-flow α/β proportional counter used for the FAS program, efficiency control charting is performed using $^{239}$Pu and $^{90}$Sr check sources along with ensuring that α/β cross-talk was within limits. Sixty-minute background counts are recorded daily. Two blanks per week for the WIPP Effluent air sampling program are counted for 20 hours and are used as a background history for calculating results.

Routine background determinations are made on the HPGe detector systems by counting blank samples; the data are used to blank correct the sample concentrations.

For the alpha spectrometer, efficiency, resolution, and centroid control charting are performed using Eckert and Ziegler Analytics check sources regularly. Before each sample count, pulser checks are performed to ensure acceptable detector resolution and centroid. Blanks counted for five days are used as a background history for calculating results. Analytical data are verified and validated as required by project-specific quality objectives before being used to support decision-making.

CEMRC also typically participates in the two national performance evaluation programs, NIST Radiochemistry Inter-Comparison Program (NIST-RIP) and the DOE-Mixed-Analyte Performance Evaluation Program (MAPEP) for soil, air filter, and water analysis. The proficiency tests help ensure the accuracy of analytical results reported to DOE and other stakeholders while also providing an efficient means for laboratories to demonstrate analytical proficiency. In 2022, CEMRC analyzed blind check samples, and the analysis results are compared with the official results measured by the MAPEP laboratory. CEMRC radio-analytical program analyzes MAPEP- air filter, water, soil, gross alpha/beta on air filters & water and unknown sample matrix. Isotopes of interest in these performance evolution programs are $^{233/234}$U, $^{238}$U, $^{238}$Pu, $^{239+240}$Pu, and $^{241}$Am, $^{244}$Cm, and gamma emitters. The analyses are carried out using CEMRC's actinide separation procedures and were treated as a regular sample set to test regular performance. CEMRC's results are consistently close to the known value. MAPEP results are presented in this annual report. Based on the number of A (Acceptable) ratings earned by CEMRC for the analysis of performance evaluation samples, the laboratory provided accurate and reliable radionuclide analysis data for WIPP environmental samples. In addition, for each sample set, reagent blank and tracer spikes are also carried through the entire separation and counting process for recovery determination and quality control. The MAPEP performance evaluation results are listed in Appendix K, Tables K.1 and K.2.

## 13.4 Quality Assurance/Quality Control for Organic Chemistry

To ensure that all procedures, processes, and deliverables are maintained and followed, two layers of assessments and audits are performed every year. A VOCs Confirmatory Monitoring Audit conducted by NWP, as part of their routine yearly program audits in compliance with contract requirements, was performed in January 2021. Additionally, CEMRC internal QA audit was conducted on the organic chemistry group in August 2018. Both audits passed and were conducted in compliance with CEMRC's QAP.

CEMRC's organic chemistry laboratory also participated in the National Air Toxics Trends Station (NATTS) proficiency test for VOC analysis thrice in 2021. For all three NATTS first tests, 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, carbon tetrachloride, chloroform, and trichloroethylene each met the acceptance criterion of ± 30 percent of the nominal spike value. Methylene chloride failed the acceptance criteria in the first and third test, while it passed in the second test when compared to the nominal spike value. In the first test, recovery of methylene chloride for referee laboratories was also high, and in the third test, methylene chloride passed the acceptance criteria when compared to the referee laboratories, so no corrective action was taken. Methylene chloride has a history of higher recoveries which may be based on canister, instrument, or spiking issues.

## 13.5 Quality Assurance/Quality Control for Environmental Chemistry

The analytical methods employed for inorganic analyses in the environmental chemistry program at CEMRC are based, when applicable, on various standard procedures (EPA/600/4-79-020, 1983; EPA/SW-846, 1997; American Public Health Association, 1981). For some matrix/analyte combinations, appropriate external standard procedures do not exist. For those cases, specialized procedures were developed to meet the need of the WIPP-EM.

Inorganic analyses were performed using Perkin Elmer Inductively Coupled Plasma Mass Spectrometry (ICP-MS), while inorganic cations and anions were measured using Ion Chromatography (IC). For ICP-MS, triplicate readings were performed on each sample, with the average result reported. Instrument performance checks shown in Appendix K, Table K.3 were run daily; the instrument was calibrated before every sample analysis. The calibration range depends on the type of sample being analyzed.

The Ion Chromatography (IC) instrument was calibrated for inorganic cation concentrations ranging from 0.25 to 10 ppm and inorganic anion concentrations ranging from 2 to 100 ppm. Currently CEMRC procedures for IC analysis only require calibrating the IC instrument once a month, but calibration checks were performed during every sample analysis as routine quality assurance.

For both ICP-MS and IC analyses, a variety of quality control samples (including blanks, spiked blanks, duplicates, and spiked samples) were prepared and run alongside every set of WIPP-EM samples during analysis. Certified reference materials were also analyzed with every sample batch. Once a year, CEMRC participated in several blind proficiency test (PT) studies coordinated by the Environmental Resource Associates (ERA). All of the reported results were within the acceptable ranges as set forth by ERA for inorganic metals, anions, and cations. The results of the blind tests are shown in Appendix K, Tables K.4 and K.5.

## 13.6 Quality Assurance/Quality Control for Internal Dosimetry

The *in vivo* bioassay program at CEMRC participates in the Department of Energy's *In- Vivo* Laboratory Accreditation Program (DOELAP) via Nuclear Waste Partnership LLC of WIPP and is currently accredited as a service laboratory to perform the following direct bioassays.

Direct radiobioassay DOELAP categories are.

- Transuranic elements via L x-rays of $^{238}$Pu
- $^{241}$Am in lung
- $^{234}$Th in lung
- $^{235}$U in lung
- Fission and activation products in the lung include $^{54}$Mn, $^{57}$Co, $^{58}$Co, and $^{60}$Co
- Fission and activation products in the total body include $^{134}$Cs and $^{137}$Cs

Under DOELAP, the *in vivo* bioassay program is subject to the performance and quality assurance requirements specified in the Department of Energy Laboratory Accreditation Program for Radiobioassay (DOE-STD-1112-98) and Performance Criteria for Radiobioassay (ANSI-N13.30). A DOELAP testing cycle was completed in 2018 that included counting phantoms representative of each of the categories listed above.

To evaluate system performance, quality control data were routinely performed throughout the year to verify that the lung and whole-body counting system was operating as it was at the time the system was calibrated. Quality control parameters that track both overall system performance and individual detector performance were measured. Quality control parameters tracked to evaluate individual detector performance, included.

- Net peak area, peak centroid and peak resolution (FWHM) across the energy range of the spectrum
- Detector background

Quality control parameters tracked to assess overall system performance included.

- Mean weighted activity of a standard source
- Summed detector background,

Efficiency calibration verification using NIST-traceable standards and phantoms.

In addition, CEMRC's Internal Dosimetry program has participated in the DOE Radiological and Environmental Sciences Laboratory (*RESL*) quarterly blind testing of Bottle Manikin Absorber (BOMAB) phantom for $^{54}$Mn, $^{60}$Co, and $^{134,\ 137}$Cs and Torso for $^{238}$Pu, $^{241}$Am, $^{235,}$

$^{238}U$, $^{57,60}Co$, $^{54}Mn$ activities deposited in the body. These bottle phantom/torso were counted on the whole-body counting system and the measured activities were reported back to RESL to compare against the known activities. CEMRC has consistently passed all performance criteria for the tests.

# References

ANSI/HPS N13.30 (1996, 2011). Performance Criteria for Radio-bioassay, Health Physics Society, McLean, VA.

Arimoto, R., J. B. Webb, & M. C. Conley. (2005). Radioactive contamination of atmospheric dust over southeastern New Mexico, Atmospheric Environment, 39. 4745-4754.

Arimoto, R., Kirchner, T. B., Webb, J. L., Conley, M. C., Stewart, B., Schoep, D. & Walthall, M. (2002). 239,240Pu and inorganic substances in aerosols from the vicinity of the Waste Isolation Pilot Plant. The importance of Resuspension. Health Physics Journal, 83.456-470.

ASER - Report - https.//www.energy.gov/ehss/policy-guidance-reports/environment-policy-guidance-reports/annual-site-environmental-reports.

ASER-2018. Waste Isolation Pilot Plant Annual Site Environmental Report for 2018. DOE/WIPP-19-3591, U.S. Department of Energy, September 2020.

Beck, H. L., Bennet, G.B. (2002). Historical overview of atmospheric nuclear weapon testing and estimates of fallout in the continental United States. Health Physics, 82.591-608.

Castillo, H., Schoderbek, D., Dulal, S., Escobar, G., Wood, J., Nelson, R., Smith, G.B. (2015). Stress induction in the bacteria *Shewanella oneidensis* and *Deinococcus radiodurans* in response to below-background ionizing radiation. International journal of radiation biology, 91(9), 749-756.

Castillo, H., Smith, G. B. (2017). Below-background ionizing radiation as an environmental cue for bacteria. Frontiers in Microbiology, Feb. 17, 2017. https.//doi.org/10.3389/fmicb.2017.00177.

Castillo, H. X. Li, F. Shilkey, Smith G.B. (2018). Transcriptome analysis reveals a stress response of *Shewanella oneidensis* deprived of background radiation levels of ionizing radiation. *PLoS ONE* May 16, 2018 1-22. https.//journals.plos.org/plosone/article?id=10.1371/journal.pone.0196472.

Castillo, Hugo, Xiaoping Li and Geoffrey B. Smith 2021a. Deinococcus radiodurans UWO298 Dependence on Background Radiation for Optimal Growth. May 2021. https://www.frontiersin.org/articles/10.3389/fgene.2021.644292/full

Castillo, Hugo, Jeremy Winder and Geoffrey Smith. 2021b. Chinese hamster V79 cells' dependence on background ionizing radiation for optimal growth Radiation and Environ. Biophysics Oct. 2021 https://doi.org/10.1007/s00411-021-00951-5

CCR-2018a -City of Carlsbad Municipal Water System 2018 Annual Consumer Report on the Quality of Your Drinking Water (*www.cityofCarlsbadnm.com)*.

CDC- Center for Disease Control & NIOSH -National Institute for Occupational Safety and Health (2006)-ORAU Team Dose Reconstruction Project for NIOSH Technical Basis Document for the Nevada Test Site – Occupational Internal Dose. ORAUT-TKBS-0008-5.

CEMRC, Carlsbad Environmental Monitoring & Research Center reports (http://www.cemrc.org/report).

CEMRC, Carlsbad Environmental Monitoring & Research Center, 1998 Report. Carlsbad, New Mexico.

CEMRC, Carlsbad Environmental Monitoring & Research Center, 2005/2006 Report. Carlsbad, New Mexico.

CEMRC, Carlsbad Environmental Monitoring & Research Center, 2011 Report. Carlsbad, New Mexico.

CEMRC, Carlsbad Environmental Monitoring & Research Center, 2017 Report. Carlsbad, New Mexico.

Cherdynstev, V.V. (1971). Uranium-234. Program for scientific translations Ltd. Keter Press, Jerusalem, p. 234.

Cothern, C.R, Lappenbusch, W.L., (1983) Occurrence of uranium in drinking water in the U.S.. Health Phys 45.89-99.

DOE/WIPP-19-3612. 2020. Semiannual VOC, Hydrogen, and Methane Data Summary Report. Reporting Period July 1, 2020 through December 31, 2020, Waste Isolation Pilot Plant, Carlsbad, NM.

EPA Compendium Method TO-15. 1999. Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analysis by Gas Chromatography/Mass Spectrometry (GC/MS). U.S. Environmental Protection Agency, Washington, D.C.

Espinosa, G., J.I. Golzarri, I. Hernández-Ibinarriaga, A. Angeles, T. Martínez and M. Navarrete. 2009. Analysis of 40K concentrations in coffees and their infusions using gamma spectrometry with HPGe detector. INCS News, 2009

Fleischer, R.L. (1980). Isotopic disequilibrium of uranium. alpha-recoil damage and preferential solution effects. Science 207.979-981.

Fratini E, Carbone C, Capece D, Esposito G, Simone G, Tabocchini MA, Tomasi, M., Belli. M., Satta L. (2015) Low-radiation environment affects the development of protection mechanisms in V79 cells. *Rad. Environ. Biophys.* 54. 183-194.

Gilkeson RH, Coward JB. A preliminary report on U-238 series disequilibrium in ground water of the Cambriam-Ordovician aquifer system of Northeastern Illinois (1992). In. Perry EC, Montgomery CW (ed) Isotope studies of hydrologic processes, Northern Illinois University Press, Dekalb. IL, pp.109-118.

Hardy, E.P., Krey, P.W., Volchok, H.L. (1973). Global inventory and distribution of fallout plutonium. Nature, 241.444-445.

Harley, J.H. (1980). Plutonium in the environment-A review. Journal of Radiation Research, 21.83-104.

He Q, Heo M, Heshka S, Wang J, Pierson RN, Albu J Jr, Albu J, Wang Z, Heymsfield SB, Gallagher D (2003). Total body potassium differs by sex and race across the adult age span. Am J Clin Nutr. 78, 72–77.

Hess, C.T., Michel, J., Norton, T.R., Prichard, H.M., Coniglio (1985). The occurrence of radioactivity in public water supplies in the United States. Health Phys 48.563-586.

ICRP-23. Task Group Report on Reference Man. Oxford: Pergamon; International Commission on Radiological Protection; Publication 23; 1975.

Kawanishi M, Okuyama K, Shiraishi K, Matsuda Y, Taniguchi R, Shiomi N, Yonezawa M, Yagi T. (2012) Growth retardation of paramecium and mouse cells by shielding them from background radiation. J. Radiat. Res. 53. 404-410.

Kelly, J. M., Bond, L. A.; Beasley, T. M. (1999). Global distribution of Pu isotopes and 237Np. Sci. Tot. Environ. 237/238.483-500.

Kenney, J.W., Downes, P.S. Gray, D.H., Ballard, S.C. (1995). Radionuclide baseline in soil near project Gnome and the Waste Isolation Pilot Plant. Environmental Evaluation Group, EEG-58.

Kirchner, T.B., Webb, J.L., Webb, S.B., Arimoto, R., Schoep, D. & B.D. Stewart. (2002). Variability in background levels of surface soil radionuclides in the vicinity of the U.S. DOE waste isolation pilot plant. J. Environ. Radioact.60. 275-291.

Krey, P.W., Beck, H.L., The distribution throughout of Utah of $^{137}$Cs and $^{239+240}$Pu from Nevada Test Site detonations. U.S. Department of Energy, Environmental Laboratory, EML-400 (1981).

Kuroda, P.K., Essien, I.O., Sandoval, D.N. (1984). Fallout of uranium isotopes from the 1980 eruption of Mount St. Helens. Journal of Radioanalytical Nuclear Chemistry, 84, 23-32. (Cited in ATSDR 1999).

Mercer J.W. (1983) Geohydrology of the proposed Waste Isolation Pilot Plant Site, Los Medanos Area, Southeastern New Mexico “Water Resources Investigations Report, 83-4016.

NRC-National Research Council (US) (1980)- Safe Drinking Water Committee. Drinking Water and Health Volume 3. Washington (DC). National Academies Press (US) 1980.

The Contribution of Drinking Water to Mineral Nutrition in Humans. Available from. https://www.ncbi.nlm.nih.gov/books/NBK216589/

Nuccetelli, C., C. Bolzan. In situ gamma spectroscopy to characterize building materials as radon and thoron sources. 2001. Sci. Tot. Environ. 272:355-360.

Pimple, M., Yoo, B., Yordanova, L. (1992) Optimization of a radioanalytical procedure for the determination of uranium isotopes in environmental samples. J. Radioanal. Nucl. Chem. Art. 161. 437-441.

Silva AM, Shen W, Heo M, Gallagher D, Wang Z, Sardinha LB, Heymsfield SB (2010) Ethnicity-related skeletal muscle differences across the lifespan. Am J Hum Biol. 22. 76–82.

Skwarzec, B.; Boryło, A., Strumin´ska, D. (2002) $^{234}$U and $^{238}$U isotopes in water and sediments of the southern Baltic. J. Environ. Radioact. 61.345-363.

Smith, G.B., Y. Grof, A. Navarette, and R.A. Guilmette (2011) Exploring the biological effects of low radiation from the other side of background. Health Physics, 100. 263-265.

Smith, G.B., M.A. Tabocchini and C. Pena-Garay. 2021. Editorial: The Biogeochemistry, Biophysics, Radiobiology, and Technical Challenges of Deep Subsurface Research. Frontiers in Earth Science, May 2021 https://www.frontiersin.org/articles/10.3389/feart.2021.678034/full

UNSCEAR (1982). Ionizing radiation. Sources and biological effects United Nations Scientific Committee on the Effects of Atomic Radiation New York. United Nations.

UNSCEAR (2000). United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation (Vol. 1).

UNSCEAR (2008). Exposures from natural radiation sources. UNSCEAR 2000 Report to the General Assembly, with scientific annexes. United Nations, New York. United Nations Scientific Committee on the Effects of Atomic Radiation.

US-DOE/EH-0173T (1991). Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.

US-EPA- 2018 Edition of the drinking water standards and health advisories. EPA 822-F-18-001, March 2018.

US-EPA Compendium Method TO-15. 1999. Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analysis by Gas Chromatography/Mass Spectrometry (GC/MS). U.S. Environmental Protection Agency, Washington, D.C.

US-EPA (1988). Aquatic Life Ambient Water Quality Criteria for Chloride. EPA 440/5-88-001.

Van Voorhies, W., Castillo, H., Thawng, C., Smith, G. (2020). Transcriptomic Response of the Caenorhabditis elegans Nematode to Background and Below-Background Radiation Levels. Frontiers of Public Health. https://doi.org/10.3389/fpubh.2020.581796

Webb, J. L., and Kirchner, T. B. (2000) An Evaluation of In Vivo Sensitivity Via Public Monitoring, Radiation Protection Dosimetry, 89 (3-4), 183-191.

# APPENDIX A - RADIONUCLIDE CONCENTRATIONS AND SPECIFIC ACTIVITIES AT STATIONS A AND B

**Table A.1. Activity concentrations of $^{241}$Am (Bq/m$^3$) at Station A**

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 1.47E-05 | 3.05E-06 | 1.83E-06 | Detected |
| 2nd week | 1.03E-05 | 1.71E-06 | 8.77E-07 | Detected |
| 3rd week | 2.44E-05 | 3.19E-06 | 8.51E-07 | Detected |
| 4th week | 2.35E-06 | 5.95E-07 | 4.54E-07 | Detected |
| **February 2022** | | | | |
| 1st week | 3.80E-06 | 1.38E-06 | 1.51E-06 | Detected |
| 2nd week | 9.21E-06 | 1.55E-06 | 1.10E-06 | Detected |
| 3rd week | 1.59E-05 | 2.35E-06 | 6.82E-07 | Detected |
| 4th week | 2.26E-05 | 3.03E-06 | 8.43E-07 | Detected |
| **March 2022** | | | | |
| 1st week | 4.80E-06 | 1.04E-06 | 7.46E-07 | Detected |
| 2nd week | 3.41E-05 | 5.74E-06 | 2.48E-06 | Detected |
| 3rd week | 3.47E-06 | 1.30E-06 | 7.99E-07 | Detected |
| 4th week | 3.80E-06 | 7.91E-07 | 6.14E-07 | Detected |
| **April 2022** | | | | |
| 1st week | 2.77E-06 | 8.45E-07 | 1.07E-06 | Detected |
| 2nd week | 2.75E-06 | 8.27E-07 | 8.13E-07 | Detected |
| 3rd week | 4.79E-06 | 1.77E-06 | 2.45E-06 | Detected |
| 4th week | 6.16E-05 | 6.85E-06 | 6.09E-07 | Detected |
| **May 2022** | | | | |
| 1st week | 3.91E-06 | 9.33E-07 | 6.60E-07 | Detected |
| 2nd week | 1.45E-03 | 1.53E-04 | 3.54E-06 | Detected |
| 3rd week | 3.51E-02 | 4.37E-06 | 6.34E-07 | Detected |
| 4th week | 1.92E-06 | 7.71E-07 | 1.08E-06 | Detected |
| **June 2022** | | | | |
| 1st week | 3.24E-06 | 9.38E-07 | 1.05E-06 | Detected |
| 2nd week | 4.76E-06 | 1.09E-06 | 7.34E-07 | Detected |
| 3rd week | 3.49E-06 | 9.19E-07 | 1.14E-06 | Detected |
| 4th week | 4.09E-06 | 8.40E-07 | 5.58E-07 | Detected |

### Table A.1. Activity concentrations of $^{241}$Am (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 1.92E-06 | 6.48E-07 | 8.27E-07 | Detected |
| 2nd week | 1.75E-06 | 6.51E-07 | 8.67E-07 | Detected |
| 3rd week | 4.80E-06 | 1.04E-06 | 7.46E-07 | Detected |
| 4th week | 2.43E-06 | 8.16E-07 | 7.57E-07 | Detected |
| **August 2022** | | | | |
| 1st week | 3.78E-06 | 9.13E-07 | 7.56E-07 | Detected |
| 2nd week | 2.05E-06 | 6.87E-07 | 7.88E-07 | Detected |
| 3rd week | 3.06E-06 | 7.43E-07 | 5.39E-07 | Detected |
| 4th week | 1.66E-06 | 5.90E-07 | 7.10E-07 | Detected |
| **September 2022** | | | | |
| 1st week | 2.11E-06 | 7.45E-07 | 9.56E-07 | Detected |
| 2nd week | 5.89E-06 | 1.05E-06 | 6.38E-07 | Detected |
| 3rd week | 5.97E-06 | 1.42E-06 | 9.87E-07 | Detected |
| 4th week | 7.92E-06 | 1.08E-06 | 5.73E-07 | Detected |
| **October 2022** | | | | |
| 1st week | 4.57E-06 | 1.17E-06 | 1.06E-06 | Detected |
| 2nd week | 6.04E-06 | 9.73E-07 | 4.94E-07 | Detected |
| 3rd week | 1.05E-05 | 1.71E-06 | 1.00E-06 | Detected |
| 4th week | 1.91E-05 | 2.52E-06 | 5.39E-07 | Detected |
| **November 2022** | | | | |
| 1st week | 7.78E-06 | 1.50E-06 | 8.98E-07 | Detected |
| 2nd week | 5.33E-06 | 1.03E-06 | 6.88E-07 | Detected |
| 3rd week | 4.10E-06 | 9.25E-07 | 8.01E-07 | Detected |
| 4th week | 3.80E-06 | 8.10E-07 | 5.34E-07 | Detected |
| **December 2022** | | | | |
| 1st week | 3.51E-06 | 1.03E-06 | 9.28E-07 | Detected |
| 2nd week | 3.03E-06 | 7.81E-07 | 6.09E-07 | Detected |
| 3rd week | 4.02E-06 | 1.11E-06 | 1.41E-06 | Detected |
| 4th week | 3.48E-06 | 1.03E-06 | 1.38E-06 | Detected |

## Table A.2. Activity concentrations of $^{239+240}Pu$ (Bq/m$^3$) at Station A

| Sample Date | $^{239+240}Pu$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 3.95E-06 | 8.90E-07 | 6.31E-07 | Detected |
| 2nd week | 9.18E-07 | 5.13E-07 | 9.29E-07 | Not Detected |
| 3rd week | 4.26E-06 | 8.88E-07 | 5.84E-07 | Detected |
| 4th week | 2.75E-07 | 2.71E-07 | 5.61E-07 | Not Detected |
| **February 2022** | | | | |
| 1st week | 9.40E-07 | 4.79E-07 | 7.12E-07 | Detected |
| 2nd week | 1.48E-06 | 4.68E-07 | 3.69E-07 | Detected |
| 3rd week | 1.93E-06 | 5.71E-07 | 5.19E-07 | Detected |
| 4th week | 2.22E-06 | 5.91E-07 | 3.81E-07 | Detected |
| **March 2022** | | | | |
| 1st week | 4.95E-07 | 3.07E-07 | 4.91E-07 | Detected |
| 2nd week | 5.43E-06 | 1.06E-06 | 6.10E-07 | Detected |
| 3rd week | 5.33E-07 | 3.44E-07 | 5.79E-07 | Not Detected |
| 4th week | 8.82E-07 | 3.15E-07 | 2.28E-07 | Detected |
| **April 2022** | | | | |
| 1st week | 3.34E-07 | 3.01E-07 | 5.82E-07 | Not Detected |
| 2nd week | 7.56E-07 | 4.21E-07 | 6.31E-07 | Detected |
| 3rd week | 9.21E-07 | 4.15E-07 | 5.41E-07 | Detected |
| 4th week | 4.01E-07 | 2.57E-07 | 4.44E-07 | Not Detected |
| **May 2022** | | | | |
| 1st week | 1.03E-05 | 1.55E-06 | 5.34E-07 | Detected |
| 2nd week | 5.21E-05 | 5.90E-06 | 4.93E-07 | Detected |
| 3rd week | 3.80E-06 | 8.17E-07 | 5.03E-07 | Detected |
| 4th week | 3.19E-07 | 2.93E-07 | 5.96E-07 | Not Detected |
| **June 2022** | | | | |
| 1st week | 1.47E-06 | 8.54E-07 | 9.74E-07 | Detected |
| 2nd week | 1.83E-06 | 1.18E-06 | 1.99E-06 | Not Detected |
| 3rd week | 1.21E-06 | 4.51E-07 | 5.39E-07 | Detected |
| 4th week | 4.30E-06 | 8.48E-07 | 5.29E-07 | Detected |

## Table A.2. Activity concentrations $^{239+240}$Pu (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{239+240}$Pu Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 3.34E-07 | 3.26E-07 | 6.46E-07 | Not Detected |
| 2nd week | 1.20E-06 | 4.77E-07 | 5.98E-07 | Detected |
| 3rd week | 5.08E-07 | 6.18E-07 | 4.48E-07 | Detected |
| 4th week | 1.01E-06 | 3.21E-07 | 3.14E-07 | Detected |
| **August 2022** | | | | |
| 1st week | 1.93E-06 | 4.80E-07 | 3.86E-07 | Detected |
| 2nd week | 1.80E-06 | 5.89E-07 | 6.28E-07 | Detected |
| 3rd week | 2.07E-06 | 5.71E-07 | 4.83E-07 | Detected |
| 4th week | 7.02E-07 | 2.77E-08 | 2.72E-07 | Detected |
| **September 2022** | | | | |
| 1st week | 2.85E-06 | 7.59E-07 | 5.58E-07 | Detected |
| 2nd week | 1.43E-06 | 4.63E-07 | 5.73E-07 | Detected |
| 3rd week | 1.78E-06 | 5.19E-07 | 2.96E-07 | Detected |
| 4th week | 4.37E-06 | 9.11E-07 | 6.14E-07 | Detected |
| **October 2022** | | | | |
| 1st week | 1.51E-06 | 5.79E-07 | 7.09E-07 | Detected |
| 2nd week | 2.87E-06 | 5.80E-07 | 2.55E-07 | Detected |
| 3rd week | 2.70E-06 | 7.15E-07 | 6.19E-07 | Detected |
| 4th week | 2.74E-06 | 6.02E-07 | 3.82E-07 | Detected |
| **November 2022** | | | | |
| 1st week | 1.05E-06 | 4.55E-07 | 6.34E-07 | Detected |
| 2nd week | 1.75E-06 | 6.26E-07 | 6.78E-07 | Detected |
| 3rd week | 1.13E-06 | 3.98E-07 | 4.27E-07 | Detected |
| 4th week | 2.99E-06 | 6.36E-07 | 3.86E-07 | Detected |
| **December 2022** | | | | |
| 1st week | 1.12E-06 | 4.41E-07 | 5.21E-07 | Detected |
| 2nd week | 1.59E-06 | 5.48E-07 | 5.74E-07 | Detected |
| 3rd week | 1.26E-06 | 5.50E-07 | 8.31E-07 | Detected |
| 4th week | 1.74E-06 | 4.68E-07 | 4.93E-07 | Detected |

### Table A.3. Activity concentrations of $^{238}$Pu (Bq/m$^3$) at Station A

| Sample Date | $^{238}$Pu Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 1.12E-05 | 1.75E-06 | 8.79E-07 | Detected |
| 2nd week | 9.29E-06 | 1.49E-06 | 5.92E-07 | Detected |
| 3rd week | 8.80E-06 | 1.47E-06 | 5.19E-07 | Detected |
| 4th week | 9.47E-06 | 1.39E-06 | 4.70E-07 | Detected |
| **February 2022** | | | | |
| 1st week | 1.04E-05 | 1.73E-06 | 8.71E-07 | Detected |
| 2nd week | 9.83E-06 | 1.50E-06 | 4.87E-07 | Detected |
| 3rd week | 1.03E-05 | 1.60E-06 | 7.69E-07 | Detected |
| 4th week | 9.39E-06 | 1.46E-06 | 4.47E-07 | Detected |
| **March 2022** | | | | |
| 1st week | 7.33E-06 | 1.24E-06 | 6.60E-07 | Detected |
| 2nd week | 8.44E-06 | 1.40E-06 | 4.94E-07 | Detected |
| 3rd week | 1.05E-05 | 1.62E-06 | 5.79E-07 | Detected |
| 4th week | 9.61E-06 | 1.38E-06 | 3.89E-07 | Detected |
| **April 2022** | | | | |
| 1st week | 5.35E-06 | 1.02E-06 | 4.71E-07 | Detected |
| 2nd week | 1.24E-05 | 1.93E-06 | 8.47E-07 | Detected |
| 3rd week | 1.16E-05 | 1.74E-06 | 4.81E-07 | Detected |
| 4th week | 1.37E-05 | 1.82E-06 | 6.01E-07 | Detected |
| **May 2022** | | | | |
| 1st week | 1.65E-05 | 2.22E-06 | 4.33E-07 | Detected |
| 2nd week | 1.40E-05 | 1.97E-06 | 6.62E-07 | Detected |
| 3rd week | 1.25E-05 | 1.81E-06 | 4.47E-07 | Detected |
| 4th week | 1.32E-05 | 1.81E-06 | 5.00E-07 | Detected |
| **June 2022** | | | | |
| 1st week | 1.21E-05 | 2.67E-06 | 1.66E-06 | Detected |
| 2nd week | 1.32E-05 | 2.95E-06 | 2.13E-06 | Detected |
| 3rd week | 1.68E-05 | 2.26E-06 | 5.83E-07 | Detected |
| 4th week | 1.21E-05 | 1.74E-06 | 7.16E-07 | Detected |

### Table A.3. Activity concentrations of $^{238}$Pu (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{238}$Pu Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 1.28E-05 | 1.94E-06 | 9.10E-07 | Detected |
| 2nd week | 1.39E-05 | 2.00E-06 | 4.84E-07 | Detected |
| 3rd week | 2.35E-06 | 6.18E-07 | 4.48E-07 | Detected |
| 4th week | 1.23E-05 | 1.62E-06 | 4.22E-07 | Detected |
| **August 2022** | | | | |
| 1st week | 1.23E-05 | 1.64E-06 | 3.86E-07 | Detected |
| 2nd week | 1.84E-05 | 2.51E-06 | 7.69E-07 | Detected |
| 3rd week | 1.53E-05 | 2.09E-06 | 4.29E-07 | Detected |
| 4th week | 1.79E-05 | 2.23E-06 | 3.19E-07 | Detected |
| **September 2022** | | | | |
| 1st week | 2.80E-05 | 3.59E-06 | 6.28E-07 | Detected |
| 2nd week | 1.21E-05 | 1.68E-06 | 5.73E-07 | Detected |
| 3rd week | 1.47E-05 | 2.03E-06 | 2.34E-07 | Detected |
| 4th week | 1.39E-05 | 2.00E-06 | 8.32E-07 | Detected |
| **October 2022** | | | | |
| 1st week | 2.12E-05 | 2.88E-06 | 5.74E-07 | Detected |
| 2nd week | 1.38E-05 | 1.78E-06 | 3.37E-07 | Detected |
| 3rd week | 1.87E-06 | 7.15E-07 | 6.19E-07 | Detected |
| 4th week | 2.15E-05 | 2.65E-06 | 5.13E-07 | Detected |
| **November 2022** | | | | |
| 1st week | 3.03E-05 | 3.75E-06 | 8.59E-07 | Detected |
| 2nd week | 3.90E-05 | 4.82E-06 | 1.01E-06 | Detected |
| 3rd week | 2.42E-05 | 2.96E-06 | 6.04E-07 | Detected |
| 4th week | 3.45E-05 | 3.99E-06 | 5.18E-07 | Detected |
| **December 2022** | | | | |
| 1st week | 4.13E-05 | 4.84E-06 | 4.63E-07 | Detected |
| 2nd week | 4.38E-05 | 5.29E-06 | 5.11E-07 | Detected |
| 3rd week | 4.01E-05 | 4.80E-06 | 6.97E-07 | Detected |
| 4th week | 4.13E-05 | 4.65E-06 | 4.13E-07 | Detected |

## Table A.4. Specific activity of $^{241}$Am (Bq/g) at Station A

| Sample Date | $^{241}$Am Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 3.43E-01 | 7.10E-02 | 4.27E-02 | Detected |
| 2nd week | 8.34E-02 | 1.39E-02 | 7.11E-03 | Detected |
| 3rd week | 1.42E-01 | 1.85E-02 | 4.93E-03 | Detected |
| 4th week | 1.72E-02 | 4.37E-03 | 3.33E-03 | Detected |
| **February 2022** | | | | |
| 1st week | 1.42E-02 | 5.14E-03 | 5.62E-03 | Detected |
| 2nd week | 3.69E-02 | 6.22E-03 | 4.41E-03 | Detected |
| 3rd week | 4.90E-02 | 7.22E-03 | 2.10E-03 | Detected |
| 4th week | 6.70E-02 | 8.98E-03 | 2.50E-03 | Detected |
| **March 2022** | | | | |
| 1st week | 4.16E-02 | 9.03E-03 | 6.47E-03 | Detected |
| 2nd week | 7.34E-02 | 1.23E-02 | 5.33E-03 | Detected |
| 3rd week | 3.64E-03 | 1.36E-03 | 8.38E-04 | Detected |
| 4th week | 4.03E-03 | 8.39E-04 | 6.51E-04 | Detected |
| **April 2022** | | | | |
| 1st week | 1.56E-02 | 4.77E-03 | 6.04E-03 | Detected |
| 2nd week | 5.13E-03 | 1.54E-03 | 1.51E-03 | Detected |
| 3rd week | 1.16E-02 | 4.31E-03 | 5.95E-03 | Detected |
| 4th week | 2.54E-01 | 2.82E-02 | 2.51E-03 | Detected |
| **May 2022** | | | | |
| 1st week | 1.64E-02 | 3.91E-03 | 2.77E-03 | Detected |
| 2nd week | 4.15E+00 | 4.37E-01 | 1.01E-02 | Detected |
| 3rd week | 8.31E+01 | 1.03E-02 | 1.50E-03 | Detected |
| 4th week | 8.54E-03 | 3.43E-03 | 4.79E-03 | Detected |
| **June 2022** | | | | |
| 1st week | 1.51E-02 | 4.38E-03 | 4.92E-03 | Detected |
| 2nd week | 1.38E-02 | 3.17E-03 | 2.13E-03 | Detected |
| 3rd week | 9.74E-03 | 2.57E-03 | 3.17E-03 | Detected |
| 4th week | 1.54E-02 | 3.15E-03 | 2.10E-03 | Detected |

### Table A.4. Specific activity of $^{241}$Am (Bq/g) at Station A (continued)

| Sample Date | $^{241}$Am Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 9.39E-03 | 3.17E-03 | 4.05E-03 | Detected |
| 2nd week | 6.34E-03 | 2.36E-03 | 3.14E-03 | Detected |
| 3rd week | 1.12E-02 | 2.44E-03 | 1.75E-03 | Detected |
| 4th week | 9.88E-03 | 3.31E-03 | 3.08E-03 | Detected |
| **August 2022** | | | | |
| 1st week | 9.37E-03 | 2.26E-03 | 1.87E-03 | Detected |
| 2nd week | 4.82E-03 | 1.61E-03 | 1.85E-03 | Detected |
| 3rd week | 1.42E-02 | 3.46E-03 | 2.51E-03 | Detected |
| 4th week | 1.05E-02 | 3.74E-03 | 4.49E-03 | Detected |
| **September 2022** | | | | |
| 1st week | 2.40E-02 | 8.47E-03 | 1.09E-02 | Detected |
| 2nd week | 5.59E-02 | 9.93E-03 | 6.06E-03 | Detected |
| 3rd week | 3.18E-02 | 7.54E-03 | 5.25E-03 | Detected |
| 4th week | 2.60E-02 | 3.53E-03 | 1.88E-03 | Detected |
| **October 2022** | | | | |
| 1st week | 1.58E-02 | 4.03E-03 | 3.65E-03 | Detected |
| 2nd week | 1.88E-02 | 3.04E-03 | 1.54E-03 | Detected |
| 3rd week | 4.55E-02 | 7.46E-03 | 4.36E-03 | Detected |
| 4th week | 1.26E-01 | 1.66E-02 | 3.55E-03 | Detected |
| **November 2022** | | | | |
| 1st week | 3.40E-02 | 6.56E-03 | 3.93E-03 | Detected |
| 2nd week | 3.09E-02 | 5.96E-03 | 3.99E-03 | Detected |
| 3rd week | 1.76E-02 | 3.96E-03 | 3.43E-03 | Detected |
| 4th week | 2.23E-02 | 4.75E-03 | 3.13E-03 | Detected |
| **December 2022** | | | | |
| 1st week | 1.97E-02 | 5.81E-03 | 5.21E-03 | Detected |
| 2nd week | 1.45E-02 | 3.73E-03 | 2.90E-03 | Detected |
| 3rd week | 1.57E-02 | 4.32E-03 | 5.53E-03 | Detected |
| 4th week | 1.14E-02 | 3.37E-03 | 4.53E-03 | Detected |

## Table A.5. Specific activity of $^{239+240}$Pu (Bq/g) at Station A

| Sample Date | $^{239+240}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 9.19E-02 | 2.07E-02 | 1.47E-02 | Detected |
| 2nd week | 7.45E-03 | 4.16E-03 | 7.54E-03 | Not Detected |
| 3rd week | 2.47E-02 | 5.14E-03 | 3.38E-03 | Detected |
| 4th week | 2.02E-03 | 1.99E-03 | 4.12E-03 | Not Detected |
| **February 2022** | | | | |
| 1st week | 3.50E-03 | 1.79E-03 | 2.65E-03 | Detected |
| 2nd week | 5.91E-03 | 1.88E-03 | 1.48E-03 | Detected |
| 3rd week | 5.93E-03 | 1.75E-03 | 1.59E-03 | Detected |
| 4th week | 6.59E-03 | 1.75E-03 | 1.13E-03 | Detected |
| **March 2022** | | | | |
| 1st week | 4.29E-03 | 2.67E-03 | 4.26E-03 | Detected |
| 2nd week | 1.17E-02 | 2.28E-03 | 1.31E-03 | Detected |
| 3rd week | 5.59E-04 | 3.61E-04 | 6.08E-04 | Not Detected |
| 4th week | 9.36E-04 | 3.35E-04 | 2.41E-04 | Detected |
| **April 2022** | | | | |
| 1st week | 1.89E-03 | 1.70E-03 | 3.29E-03 | Not Detected |
| 2nd week | 1.41E-03 | 7.84E-04 | 1.18E-03 | Detected |
| 3rd week | 2.24E-03 | 1.01E-03 | 1.31E-03 | Detected |
| 4th week | 1.65E-03 | 1.06E-03 | 1.83E-03 | Not Detected |
| **May 2022** | | | | |
| 1st week | 4.30E-02 | 6.50E-03 | 2.24E-03 | Detected |
| 2nd week | 1.49E-01 | 1.69E-02 | 1.41E-03 | Detected |
| 3rd week | 8.99E-03 | 1.93E-03 | 1.19E-03 | Detected |
| 4th week | 1.42E-03 | 1.30E-03 | 2.65E-03 | Not Detected |
| **June 2022** | | | | |
| 1st week | 6.86E-03 | 3.99E-03 | 4.55E-03 | Detected |
| 2nd week | 5.30E-03 | 3.43E-03 | 5.77E-03 | Not Detected |
| 3rd week | 3.37E-03 | 1.26E-03 | 1.51E-03 | Detected |
| 4th week | 1.61E-02 | 3.18E-03 | 1.99E-03 | Detected |

### Table A.5. Specific activity of $^{239+240}$Pu (Bq/g) at Station A (continued)

| Sample Date | $^{239+240}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 1.64E-03 | 1.59E-03 | 3.17E-03 | Not Detected |
| 2nd week | 4.36E-03 | 1.73E-03 | 2.17E-03 | Detected |
| 3rd week | 1.19E-03 | 1.45E-03 | 1.05E-03 | Detected |
| 4th week | 4.10E-03 | 1.31E-03 | 1.28E-03 | Detected |
| **August 2022** | | | | |
| 1st week | 4.79E-03 | 1.19E-03 | 9.58E-04 | Detected |
| 2nd week | 4.23E-03 | 1.38E-03 | 1.47E-03 | Detected |
| 3rd week | 9.64E-03 | 2.66E-03 | 2.25E-03 | Detected |
| 4th week | 4.44E-03 | 1.76E-04 | 1.72E-03 | Detected |
| **September 2022** | | | | |
| 1st week | 3.24E-02 | 8.63E-03 | 6.34E-03 | Detected |
| 2nd week | 1.36E-02 | 4.40E-03 | 5.44E-03 | Detected |
| 3rd week | 9.49E-03 | 2.76E-03 | 1.57E-03 | Detected |
| 4th week | 1.44E-02 | 2.99E-03 | 2.02E-03 | Detected |
| **October 2022** | | | | |
| 1st week | 5.19E-03 | 2.00E-03 | 2.44E-03 | Detected |
| 2nd week | 8.96E-03 | 1.81E-03 | 7.97E-04 | Detected |
| 3rd week | 1.18E-02 | 3.11E-03 | 2.69E-03 | Detected |
| 4th week | 1.81E-02 | 3.96E-03 | 2.51E-03 | Detected |
| **November 2022** | | | | |
| 1st week | 4.57E-03 | 1.99E-03 | 2.77E-03 | Detected |
| 2nd week | 1.02E-02 | 3.63E-03 | 3.94E-03 | Detected |
| 3rd week | 4.84E-03 | 1.70E-03 | 1.83E-03 | Detected |
| 4th week | 1.75E-02 | 3.72E-03 | 2.26E-03 | Detected |
| **December 2022** | | | | |
| 1st week | 6.27E-03 | 2.48E-03 | 2.93E-03 | Detected |
| 2nd week | 7.60E-03 | 2.61E-03 | 2.74E-03 | Detected |
| 3rd week | 4.92E-03 | 2.15E-03 | 3.25E-03 | Detected |
| 4th week | 5.68E-03 | 1.53E-03 | 1.61E-03 | Detected |

## Table A.6. Specific activity of $^{238}$Pu (Bq/g) at Station A

| Sample Date | $^{238}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 2.60E-01 | 4.08E-02 | 2.05E-02 | Detected |
| 2nd week | 7.53E-02 | 1.21E-02 | 4.81E-03 | Detected |
| 3rd week | 5.10E-02 | 8.50E-03 | 3.01E-03 | Detected |
| 4th week | 6.95E-02 | 1.02E-02 | 3.45E-03 | Detected |
| **February 2022** | | | | |
| 1st week | 3.88E-02 | 6.43E-03 | 3.25E-03 | Detected |
| 2nd week | 3.94E-02 | 6.02E-03 | 1.95E-03 | Detected |
| 3rd week | 3.17E-02 | 4.91E-03 | 2.36E-03 | Detected |
| 4th week | 2.79E-02 | 4.34E-03 | 1.33E-03 | Detected |
| **March 2022** | | | | |
| 1st week | 6.36E-02 | 1.08E-02 | 5.72E-03 | Detected |
| 2nd week | 1.81E-02 | 3.01E-03 | 1.06E-03 | Detected |
| 3rd week | 1.10E-02 | 1.70E-03 | 6.08E-04 | Detected |
| 4th week | 1.02E-02 | 1.46E-03 | 4.12E-04 | Detected |
| **April 2022** | | | | |
| 1st week | 3.02E-02 | 5.77E-03 | 2.66E-03 | Detected |
| 2nd week | 2.30E-02 | 3.59E-03 | 1.58E-03 | Detected |
| 3rd week | 2.81E-02 | 4.23E-03 | 1.17E-03 | Detected |
| 4th week | 5.63E-02 | 7.51E-03 | 2.48E-03 | Detected |
| **May 2022** | | | | |
| 1st week | 6.94E-02 | 9.32E-03 | 1.82E-03 | Detected |
| 2nd week | 4.01E-02 | 5.62E-03 | 1.89E-03 | Detected |
| 3rd week | 2.96E-02 | 4.27E-03 | 1.06E-03 | Detected |
| 4th week | 5.88E-02 | 8.06E-03 | 2.22E-03 | Detected |
| **June 2022** | | | | |
| 1st week | 5.64E-02 | 1.25E-02 | 7.77E-03 | Detected |
| 2nd week | 3.84E-02 | 8.57E-03 | 6.20E-03 | Detected |
| 3rd week | 4.70E-02 | 6.32E-03 | 1.63E-03 | Detected |
| 4th week | 4.56E-02 | 6.53E-03 | 2.69E-03 | Detected |

## Table A.6. Specific activity of $^{238}$Pu (Bq/g) at Station A (continued)

| Sample Date | $^{238}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 6.29E-02 | 9.52E-03 | 4.46E-03 | Detected |
| 2nd week | 5.03E-02 | 7.24E-03 | 1.76E-03 | Detected |
| 3rd week | 5.51E-03 | 1.45E-03 | 1.05E-03 | Detected |
| 4th week | 5.01E-02 | 6.56E-03 | 1.71E-03 | Detected |
| **August 2022** | | | | |
| 1st week | 3.05E-02 | 4.07E-03 | 9.58E-04 | Detected |
| 2nd week | 4.31E-02 | 5.89E-03 | 1.80E-03 | Detected |
| 3rd week | 7.15E-02 | 9.73E-03 | 2.00E-03 | Detected |
| 4th week | 1.13E-01 | 1.41E-02 | 2.02E-03 | Detected |
| **September 2022** | | | | |
| 1st week | 3.18E-01 | 4.08E-02 | 7.14E-03 | Detected |
| 2nd week | 1.15E-01 | 1.60E-02 | 5.44E-03 | Detected |
| 3rd week | 7.80E-02 | 1.08E-02 | 1.25E-03 | Detected |
| 4th week | 4.57E-02 | 6.58E-03 | 2.73E-03 | Detected |
| **October 2022** | | | | |
| 1st week | 7.29E-02 | 9.92E-03 | 1.98E-03 | Detected |
| 2nd week | 4.31E-02 | 5.56E-03 | 1.05E-03 | Detected |
| 3rd week | 8.15E-03 | 3.11E-03 | 2.69E-03 | Detected |
| 4th week | 1.42E-01 | 1.75E-02 | 3.37E-03 | Detected |
| **November 2022** | | | | |
| 1st week | 1.32E-01 | 1.64E-02 | 3.76E-03 | Detected |
| 2nd week | 2.27E-01 | 2.80E-02 | 5.83E-03 | Detected |
| 3rd week | 1.04E-01 | 1.27E-02 | 2.59E-03 | Detected |
| 4th week | 2.02E-01 | 2.34E-02 | 3.03E-03 | Detected |
| **December 2022** | | | | |
| 1st week | 2.32E-01 | 2.72E-02 | 2.60E-03 | Detected |
| 2nd week | 2.09E-01 | 2.52E-02 | 2.44E-03 | Detected |
| 3rd week | 1.56E-01 | 1.88E-02 | 2.72E-03 | Detected |
| 4th week | 1.35E-01 | 1.52E-02 | 1.35E-03 | Detected |

**Table A.7. Monthly activity concentrations of U isotopes at Station A**

| Radionuclide | Sample Date | Activity Bq/m³ | Unc.(2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{234}$U | January | 2.29E-06 | 6.35E-07 | 7.07E-07 | Detected |
|  | February | 1.03E-06 | 4.71E-07 | 7.45E-07 | Detected |
|  | March | 1.08E-06 | 5.01E-07 | 8.29E-07 | Detected |
|  | April | 1.11E-06 | 4.30E-07 | 5.79E-07 | Detected |
|  | May | 4.45E-06 | 1.12E-06 | 1.07E-06 | Detected |
|  | June | 1.22E-06 | 4.93E-07 | 7.71E-07 | Detected |
|  | July | 9.43E-07 | 4.15E-07 | 6.19E-07 | Detected |
|  | August | 1.60E-06 | 4.83E-07 | 5.78E-07 | Detected |
|  | September | 1.56E-06 | 5.68E-07 | 7.86E-07 | Detected |
|  | October | 2.81E-06 | 6.91E-07 | 6.11E-07 | Detected |
|  | November | 2.08E-06 | 6.19E-07 | 7.31E-07 | Detected |
|  | December | 8.32E-07 | 4.63E-07 | 8.14E-07 | Detected |
|  |  |  |  |  |  |
| $^{235}$U | January | 1.45E-06 | 5.26E-07 | 5.94E-07 | Detected |
|  | February | 2.37E-07 | 2.99E-07 | 6.25E-07 | Not Detected |
|  | March | 5.81E-07 | 3.71E-07 | 6.31E-07 | Not Detected |
|  | April | 3.92E-07 | 2.88E-07 | 4.87E-07 | Not Detected |
|  | May | 1.27E-06 | 5.98E-07 | 9.46E-07 | Detected |
|  | June | 6.48E-07 | 3.85E-07 | 6.33E-07 | Detected |
|  | July | 2.86E-07 | 2.82E-07 | 5.58E-07 | Not Detected |
|  | August | 5.35E-07 | 2.99E-07 | 4.73E-07 | Detected |
|  | September | 7.33E-07 | 4.36E-07 | 6.56E-07 | Detected |
|  | October | 1.63E-06 | 5.46E-07 | 5.74E-07 | Detected |
|  | November | 1.04E-06 | 4.43E-07 | 6.24E-07 | Detected |
|  | December | 3.51E-07 | 3.53E-07 | 7.24E-07 | Not Detected |

## Table A.7. Monthly activity concentrations of U isotopes at Station A (continued)

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}$U** | January | 1.33E-06 | 5.64E-07 | 9.39E-07 | Detected |
| | February | 5.40E-07 | 4.50E-07 | 9.27E-07 | Not Detected |
| | March | 8.15E-07 | 4.81E-07 | 8.97E-07 | Not Detected |
| | April | 9.43E-07 | 4.09E-07 | 6.22E-07 | Detected |
| | May | 2.89E-06 | 9.59E-07 | 1.27E-06 | Detected |
| | June | 6.79E-07 | 4.75E-07 | 9.41E-07 | Not Detected |
| | July | 6.33E-07 | 4.14E-07 | 7.78E-07 | Not Detected |
| | August | 7.11E-07 | 4.08E-07 | 7.48E-07 | Not Detected |
| | September | 7.53E-07 | 4.60E-07 | 7.07E-07 | Detected |
| | October | 1.70E-06 | 5.77E-07 | 7.94E-07 | Detected |
| | November | 7.72E-07 | 5.24E-07 | 9.18E-07 | Not Detected |
| | December | 2.70E-07 | 4.82E-07 | 1.14E-06 | Not Detected |

## Table A.8. Specific activity of U isotopes at Station A

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}U$ | January | 1.90E-02 | 5.28E-03 | 5.87E-03 | Detected |
| | February | 3.50E-03 | 1.60E-03 | 2.53E-03 | Detected |
| | March | 1.67E-03 | 7.72E-04 | 1.28E-03 | Detected |
| | April | 3.33E-03 | 1.29E-03 | 1.73E-03 | Detected |
| | May | 1.46E-02 | 3.67E-03 | 3.53E-03 | Detected |
| | June | 4.16E-03 | 1.68E-03 | 2.63E-03 | Detected |
| | July | 3.32E-03 | 1.46E-03 | 2.18E-03 | Detected |
| | August | 5.56E-03 | 1.68E-03 | 2.01E-03 | Detected |
| | September | 8.63E-03 | 3.15E-03 | 4.35E-03 | Detected |
| | October | 1.18E-02 | 2.89E-03 | 2.56E-03 | Detected |
| | November | 1.04E-02 | 3.11E-03 | 3.67E-03 | Detected |
| | December | 3.41E-03 | 1.90E-03 | 3.34E-03 | Detected |
| | | | | | |
| $^{235}U$ | January | 1.20E-02 | 4.38E-03 | 4.94E-03 | Detected |
| | February | 8.03E-04 | 1.01E-03 | 2.12E-03 | Not Detected |
| | March | 8.94E-04 | 5.71E-04 | 9.71E-04 | Not Detected |
| | April | 1.18E-03 | 8.64E-04 | 1.46E-03 | Not Detected |
| | May | 4.19E-03 | 1.97E-03 | 3.11E-03 | Detected |
| | June | 2.21E-03 | 1.31E-03 | 2.16E-03 | Detected |
| | July | 1.01E-03 | 9.90E-04 | 1.96E-03 | Not Detected |
| | August | 1.86E-03 | 1.04E-03 | 1.64E-03 | Detected |
| | September | 4.06E-03 | 2.41E-03 | 3.63E-03 | Detected |
| | October | 6.84E-03 | 2.29E-03 | 2.40E-03 | Detected |
| | November | 5.20E-03 | 2.22E-03 | 3.13E-03 | Detected |
| | December | 1.44E-03 | 1.45E-03 | 2.97E-03 | Not Detected |

### Table A.8. Specific activity of U isotopes at Station A (continued)

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{238}$U | January | 1.10E-02 | 4.69E-03 | 7.80E-03 | Detected |
| | February | 1.83E-03 | 1.53E-03 | 3.14E-03 | Not Detected |
| | March | 1.25E-03 | 7.40E-04 | 1.38E-03 | Not Detected |
| | April | 2.83E-03 | 1.23E-03 | 1.86E-03 | Detected |
| | May | 9.51E-03 | 3.16E-03 | 4.18E-03 | Detected |
| | June | 2.31E-03 | 1.62E-03 | 3.21E-03 | Not Detected |
| | July | 2.23E-03 | 1.45E-03 | 2.74E-03 | Not Detected |
| | August | 2.48E-03 | 1.42E-03 | 2.60E-03 | Not Detected |
| | September | 4.17E-03 | 2.55E-03 | 3.92E-03 | Detected |
| | October | 7.12E-03 | 2.42E-03 | 3.33E-03 | Detected |
| | November | 3.88E-03 | 2.63E-03 | 4.60E-03 | Not Detected |
| | December | 1.11E-03 | 1.98E-03 | 4.67E-03 | Not Detected |

### Table A.9. Activity concentrations of $^{137}$Cs (Bq/m$^3$) at Station A

| Sample Date | $^{137}$Cs Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | -1.37E-05 | 7.81E-05 | 2.62E-04 | Not Detected |
| 2nd week | 7.51E-05 | 3.41E-05 | 1.11E-04 | Not Detected |
| 3rd week | 1.08E-05 | 1.43E-04 | 4.80E-04 | Not Detected |
| 4th week | 3.32E-05 | 2.30E-05 | 7.59E-05 | Not Detected |
| **February 2022** | | | | |
| 1st week | 1.83E-05 | 5.97E-05 | 2.46E-04 | Not Detected |
| 2nd week | 3.04E-05 | 7.54E-05 | 2.52E-04 | Not Detected |
| 3rd week | 8.33E-05 | 3.25E-05 | 1.06E-04 | Not Detected |
| 4th week | 2.42E-05 | 2.18E-05 | 7.25E-05 | Not Detected |
| **March 2022** | | | | |
| 1st week | -1.08E-05 | 8.77E-05 | 2.94E-04 | Not Detected |
| 2nd week | 5.13E-05 | 2.88E-05 | 9.45E-05 | Not Detected |
| 3rd week | 5.04E-05 | 6.78E-05 | 2.25E-04 | Not Detected |
| 4th week | -2.15E-06 | 1.57E-05 | 5.33E-05 | Not Detected |
| **April 2022** | | | | |
| 1st week | -3.59E-05 | 7.27E-05 | 2.46E-04 | Not Detected |
| 2nd week | 8.16E-06 | 8.27E-05 | 2.77E-04 | Not Detected |
| 3rd week | 4.95E-05 | 2.55E-05 | 8.36E-05 | Not Detected |
| 4th week | 1.90E-05 | 5.42E+00 | 1.81E-04 | Not Detected |
| **May 2022** | | | | |
| 1st week | -7.25E-05 | 7.12E-05 | 2.42E-04 | Not Detected |
| 2nd week | -1.13E-04 | 6.50E-05 | 2.23E-04 | Not Detected |
| 3rd week | 1.14E-05 | 8.37E-05 | 2.80E-04 | Not Detected |
| 4th week | 3.84E-05 | 2.38E-05 | 7.83E-05 | Not Detected |
| **June 2022** | | | | |
| 1st week | 1.97E-05 | 2.62E-05 | 8.73E-05 | Not Detected |
| 2nd week | 3.46E-05 | 2.96E-05 | 9.81E-05 | Not Detected |
| 3rd week | 2.17E-05 | 7.28E-05 | 2.43E-04 | Not Detected |
| 4th week | -4.49E-05 | 6.50E-05 | 2.19E-04 | Not Detected |

### Table A.9. Activity concentrations of $^{137}$Cs (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{137}$Cs Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 9.01E-05 | 3.59E-05 | 1.17E-04 | Not Detected |
| 2nd week | -5.77E-05 | 7.08E-05 | 2.40E-04 | Not Detected |
| 3rd week | 2.41E-05 | 2.96E-05 | 9.85E-05 | Not Detected |
| 4th week | 6.57E-05 | 2.18E-05 | 7.03E-05 | Not Detected |
| **August 2022** | | | | |
| 1st week | 1.01E-04 | 3.17E-05 | 1.02E-04 | Not Detected |
| 2nd week | 4.80E-05 | 7.57E-05 | 2.52E-04 | Not Detected |
| 3rd week | 2.66E-06 | 7.76E-05 | 2.60E-04 | Not Detected |
| 4th week | 3.76E-06 | 5.39E-05 | 1.81E-04 | Not Detected |
| **September 2022** | | | | |
| 1st week | -8.75E-05 | 7.44E-05 | 2.53E-04 | Not Detected |
| 2nd week | 1.04E-04 | 3.26E-05 | 1.05E-04 | Not Detected |
| 3rd week | 7.65E-06 | 7.24E-05 | 2.43E-04 | Not Detected |
| 4th week | 2.32E-05 | 6.22E-05 | 2.07E-04 | Not Detected |
| **October 2022** | | | | |
| 1st week | 3.04E-06 | 8.09E-05 | 2.71E-04 | Not Detected |
| 2nd week | 6.12E-06 | 2.21E-05 | 7.44E-05 | Not Detected |
| 3rd week | 3.17E-06 | 9.11E-06 | 3.16E-05 | Not Detected |
| 4th week | 3.72E-05 | 2.05E-05 | 6.73E-05 | Not Detected |
| **November 2022** | | | | |
| 1st week | 3.89E-06 | 7.31E-05 | 2.45E-04 | Not Detected |
| 2nd week | 3.57E-05 | 2.90E-05 | 9.60E-05 | Not Detected |
| 3rd week | -5.86E-06 | 8.08E-05 | 2.71E-04 | Not Detected |
| 4th week | 0.00E+00 | 5.77E-07 | 1.56E-06 | Not Detected |
| **December 2022** | | | | |
| 1st week | 1.54E-05 | 8.08E-05 | 2.70E-04 | Not Detected |
| 2nd week | 9.90E-06 | 8.13E-05 | 2.72E-04 | Not Detected |
| 3rd week | -3.41E-06 | 2.97E-05 | 1.00E-04 | Not Detected |
| 4th week | 1.24E-05 | 1.98E-05 | 6.62E-05 | Not Detected |

## Table A.10. Activity concentrations $^{40}$K (Bq/m$^3$) at Station A

| Sample Date | $^{40}$K Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 1.01E-03 | 4.63E-04 | 1.49E-03 | Not Detected |
| 2nd week | 4.00E-04 | 4.12E-04 | 1.37E-03 | Not Detected |
| 3rd week | 5.75E-04 | 4.59E-04 | 1.53E-03 | Not Detected |
| 4th week | -9.35E-04 | 3.57E-04 | 1.23E-03 | Not Detected |
| **February 2022** | | | | |
| 1st week | 9.89E-05 | 4.48E-04 | 1.54E-03 | Not Detected |
| 2nd week | 9.96E-04 | 4.69E-04 | 1.51E-03 | Not Detected |
| 3rd week | -1.34E-03 | 4.94E-04 | 1.71E-03 | Not Detected |
| 4th week | 3.52E-04 | 5.30E-04 | 1.76E-03 | Not Detected |
| **March 2022** | | | | |
| 1st week | 2.61E-04 | 4.71E-04 | 1.60E-03 | Not Detected |
| 2nd week | -5.72E-04 | 5.36E-04 | 1.82E-03 | Not Detected |
| 3rd week | -1.55E-04 | 5.32E-04 | 1.79E-03 | Not Detected |
| 4th week | -6.69E-04 | 3.46E-04 | 1.19E-03 | Not Detected |
| **April 2022** | | | | |
| 1st week | 4.11E-04 | 4.58E-04 | 1.54E-03 | Not Detected |
| 2nd week | 8.36E-04 | 5.09E-04 | 1.67E-03 | Not Detected |
| 3rd week | -7.08E-04 | 4.71E-04 | 1.61E-03 | Not Detected |
| 4th week | -3.01E-04 | 3.36E-04 | 1.20E-03 | Not Detected |
| **May 2022** | | | | |
| 1st week | 5.54E-04 | 4.75E-04 | 1.58E-03 | Not Detected |
| 2nd week | 2.61E-04 | 4.33E-04 | 1.47E-03 | Not Detected |
| 3rd week | 9.69E-04 | 4.61E-04 | 1.49E-03 | Not Detected |
| 4th week | -3.68E-04 | 4.07E-04 | 1.38E-03 | Not Detected |
| **June 2022** | | | | |
| 1st week | -1.04E-03 | 4.92E-04 | 1.69E-03 | Not Detected |
| 2nd week | -8.14E-04 | 5.57E-04 | 1.90E-03 | Not Detected |
| 3rd week | 7.95E-04 | 4.81E-04 | 1.58E-03 | Not Detected |
| 4th week | -2.87E-04 | 3.68E-04 | 1.30E-03 | Not Detected |

## Table A.10. Activity concentrations $^{40}K$ (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | -1.07E-03 | 4.90E-04 | 1.69E-03 | Not Detected |
| 2nd week | 7.45E-04 | 4.89E-04 | 1.61E-03 | Not Detected |
| 3rd week | -1.05E-04 | 5.20E-04 | 1.75E-03 | Not Detected |
| 4th week | -4.75E-04 | 3.59E-04 | 1.22E-03 | Not Detected |
| **August 2022** | | | | |
| 1st week | -6.96E-04 | 5.21E-04 | 1.77E-03 | Not Detected |
| 2nd week | 5.49E-04 | 4.62E-04 | 1.54E-03 | Not Detected |
| 3rd week | 6.27E-04 | 4.75E-04 | 1.58E-03 | Not Detected |
| 4th week | 4.71E-04 | 3.11E-04 | 1.03E-03 | Not Detected |
| **September 2022** | | | | |
| 1st week | -8.34E-05 | 4.58E-04 | 1.59E-03 | Not Detected |
| 2nd week | -9.87E-04 | 4.80E-04 | 1.65E-03 | Not Detected |
| 3rd week | -8.06E-04 | 4.62E-04 | 1.68E-03 | Not Detected |
| 4th week | -1.90E-04 | 3.64E-04 | 1.28E-03 | Not Detected |
| **October 2022** | | | | |
| 1st week | 1.10E-03 | 4.64E-04 | 1.48E-03 | Not Detected |
| 2nd week | -6.38E-04 | 4.93E-04 | 1.68E-03 | Not Detected |
| 3rd week | -1.25E-03 | 4.23E-04 | 1.48E-03 | Not Detected |
| 4th week | -4.50E-04 | 3.43E-04 | 1.17E-03 | Not Detected |
| **November 2022** | | | | |
| 1st week | 5.25E-04 | 4.52E-04 | 1.51E-03 | Not Detected |
| 2nd week | -7.03E-04 | 5.00E-04 | 1.71E-03 | Not Detected |
| 3rd week | 8.17E-04 | 4.60E-04 | 1.50E-03 | Not Detected |
| 4th week | -1.05E-03 | 3.19E-04 | 1.12E-03 | Not Detected |
| **December 2022** | | | | |
| 1st week | 6.03E-04 | 4.31E-04 | 1.43E-03 | Not Detected |
| 2nd week | -6.18E-04 | 4.76E-04 | 1.70E-03 | Not Detected |
| 3rd week | 3.23E-05 | 5.24E-04 | 1.76E-03 | Not Detected |
| 4th week | -3.35E-04 | 3.63E-04 | 1.23E-03 | Not Detected |

## Table A.11. Activity concentrations of $^{60}Co$ (Bq/m$^3$) at Station A

| Sample Date | $^{60}Co$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 1.15E-04 | 6.00E-05 | 1.96E-04 | Not Detected |
| 2nd week | 7.21E-05 | 4.08E-05 | 1.34E-04 | Not Detected |
| 3rd week | 4.47E-03 | 2.41E-03 | 7.89E-03 | Not Detected |
| 4th week | 1.17E-05 | 2.74E-05 | 9.22E-05 | Not Detected |
| **February 2022** | | | | |
| 1st week | 2.78E-05 | 5.97E-05 | 2.03E-04 | Not Detected |
| 2nd week | 1.22E-04 | 5.93E-05 | 1.92E-04 | Not Detected |
| 3rd week | 8.71E-05 | 3.48E-05 | 1.13E-04 | Not Detected |
| 4th week | 3.38E-05 | 2.43E-05 | 8.05E-05 | Not Detected |
| **March 2022** | | | | |
| 1st week | 4.45E-05 | 5.60E-05 | 1.89E-04 | Not Detected |
| 2nd week | -1.97E-05 | 2.70E-05 | 9.37E-05 | Not Detected |
| 3rd week | 8.96E-04 | 1.07E-03 | 3.58E-03 | Not Detected |
| 4th week | 1.01E-05 | 1.72E-05 | 5.80E-05 | Not Detected |
| **April 2022** | | | | |
| 1st week | 2.43E-05 | 5.59E-05 | 1.90E-04 | Not Detected |
| 2nd week | -6.90E-06 | 6.30E-05 | 2.16E-04 | Not Detected |
| 3rd week | 4.06E-05 | 2.42E-05 | 7.94E-05 | Not Detected |
| 4th week | -8.96E-06 | 4.40E-05 | 1.53E-04 | Not Detected |
| **May 2022** | | | | |
| 1st week | -1.01E-05 | 5.80E-05 | 2.01E-04 | Not Detected |
| 2nd week | 1.21E-05 | 5.42E-05 | 1.86E-04 | Not Detected |
| 3rd week | 5.27E-05 | 5.74E-05 | 1.93E-04 | Not Detected |
| 4th week | 3.03E-06 | 1.99E-05 | 6.79E-05 | Not Detected |
| **June 2022** | | | | |
| 1st week | 4.28E-05 | 3.23E-05 | 1.07E-04 | Not Detected |
| 2nd week | 4.41E-05 | 3.97E-05 | 1.32E-04 | Not Detected |
| 3rd week | 5.18E-05 | 5.67E-05 | 1.90E-04 | Not Detected |
| 4th week | 5.37E-05 | 4.84E-05 | 1.61E-04 | Not Detected |

### Table A.11. Activity concentrations of $^{60}Co$ (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{60}Co$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 2.11E-05 | 2.60E-05 | 8.73E-05 | Not Detected |
| 2nd week | 9.05E-05 | 5.62E-05 | 1.85E-04 | Not Detected |
| 3rd week | -5.37E-06 | 2.61E-05 | 8.70E-05 | Not Detected |
| 4th week | -8.37E-06 | 2.19E-05 | 7.51E-05 | Not Detected |
| **August 2022** | | | | |
| 1st week | 2.59E-05 | 2.44E-05 | 8.13E-05 | Not Detected |
| 2nd week | 1.05E-04 | 5.68E-05 | 1.86E-04 | Not Detected |
| 3rd week | 8.83E-05 | 5.68E-05 | 1.87E-04 | Not Detected |
| 4th week | 6.51E-06 | 3.95E-05 | 1.35E-04 | Not Detected |
| **September 2022** | | | | |
| 1st week | 5.38E-05 | 5.38E-05 | 1.86E-04 | Not Detected |
| 2nd week | -9.38E-06 | 2.66E-05 | 9.19E-05 | Not Detected |
| 3rd week | 9.60E-05 | 5.63E-05 | 1.85E-04 | Not Detected |
| 4th week | 8.52E-06 | 3.93E-05 | 1.35E-04 | Not Detected |
| **October 2022** | | | | |
| 1st week | 1.55E-06 | 5.50E-05 | 1.89E-04 | Not Detected |
| 2nd week | 5.94E-06 | 2.36E-05 | 8.07E-05 | Not Detected |
| 3rd week | 9.69E-06 | 9.69E-06 | 3.31E-05 | Not Detected |
| 4th week | -1.14E-05 | 2.16E-05 | 7.40E-05 | Not Detected |
| **November 2022** | | | | |
| 1st week | 4.53E-05 | 5.20E-05 | 1.92E-04 | Not Detected |
| 2nd week | 2.55E-05 | 2.61E-05 | 8.75E-05 | Not Detected |
| 3rd week | 6.92E-05 | 5.14E-05 | 1.70E-04 | Not Detected |
| 4th week | 0.00E+00 | 8.90E-07 | 2.41E-06 | Not Detected |
| **December 2022** | | | | |
| 1st week | 3.88E-05 | 5.08E-05 | 1.72E-04 | Not Detected |
| 2nd week | 3.55E-05 | 5.29E-05 | 1.78E-04 | Not Detected |
| 3rd week | -3.42E-06 | 2.29E-05 | 7.92E-05 | Not Detected |
| 4th week | 1.87E-05 | 1.75E-05 | 5.83E-05 | Not Detected |

## Table A.12. Specific activity of $^{137}$Cs (Bq/g) at Station A

| Sample Date | $^{137}$Cs Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | -3.19E-01 | 1.82E+00 | 6.11E+00 | Not Detected |
| 2nd week | 6.09E-01 | 2.76E-01 | 9.03E-01 | Not Detected |
| 3rd week | 6.25E-02 | 8.30E-01 | 2.78E+00 | Not Detected |
| 4th week | 2.44E-01 | 1.69E-01 | 5.57E-01 | Not Detected |
| **February 2022** | | | | |
| 1st week | 6.84E-02 | 2.22E-01 | 9.16E-01 | Not Detected |
| 2nd week | 1.22E-01 | 3.02E-01 | 1.01E+00 | Not Detected |
| 3rd week | 2.56E-01 | 9.99E-02 | 3.25E-01 | Not Detected |
| 4th week | 7.19E-02 | 6.48E-02 | 2.15E-01 | Not Detected |
| **March 2022** | | | | |
| 1st week | -9.40E-02 | 7.60E-01 | 2.55E+00 | Not Detected |
| 2nd week | 1.10E-01 | 6.19E-02 | 2.03E-01 | Not Detected |
| 3rd week | 5.29E-02 | 7.11E-02 | 2.36E-01 | Not Detected |
| 4th week | -2.28E-03 | 1.67E-02 | 5.65E-02 | Not Detected |
| **April 2022** | | | | |
| 1st week | -2.03E-01 | 4.11E-01 | 1.39E+00 | Not Detected |
| 2nd week | 1.52E-02 | 1.54E-01 | 5.16E-01 | Not Detected |
| 3rd week | 1.20E-01 | 6.20E-02 | 2.03E-01 | Not Detected |
| 4th week | 7.85E-02 | 2.24E+04 | 7.48E-01 | Not Detected |
| **May 2022** | | | | |
| 1st week | -3.04E-01 | 2.99E-01 | 1.02E+00 | Not Detected |
| 2nd week | -3.22E-01 | 1.86E-01 | 6.38E-01 | Not Detected |
| 3rd week | 2.70E-02 | 1.98E-01 | 6.62E-01 | Not Detected |
| 4th week | 1.71E-01 | 1.06E-01 | 3.48E-01 | Not Detected |
| **June 2022** | | | | |
| 1st week | 9.20E-02 | 1.22E-01 | 4.08E-01 | Not Detected |
| 2nd week | 1.00E-01 | 8.61E-02 | 2.85E-01 | Not Detected |
| 3rd week | 6.07E-02 | 2.03E-01 | 6.80E-01 | Not Detected |
| 4th week | -1.69E-01 | 2.44E-01 | 8.23E-01 | Not Detected |

## Table A.12. Specific activity of $^{137}$Cs (Bq/g) at Station A (continued)

| Sample Date | $^{137}$Cs Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 4.41E-01 | 1.76E-01 | 5.72E-01 | Not Detected |
| 2nd week | -2.09E-01 | 2.57E-01 | 8.72E-01 | Not Detected |
| 3rd week | 5.65E-02 | 6.94E-02 | 2.31E-01 | Not Detected |
| 4th week | 2.67E-01 | 8.83E-02 | 2.85E-01 | Not Detected |
| **August 2022** | | | | |
| 1st week | 2.50E-01 | 7.86E-02 | 2.53E-01 | Not Detected |
| 2nd week | 1.13E-01 | 1.78E-01 | 5.92E-01 | Not Detected |
| 3rd week | 1.24E-02 | 3.62E-01 | 1.21E+00 | Not Detected |
| 4th week | 2.38E-02 | 3.41E-01 | 1.14E+00 | Not Detected |
| **September 2022** | | | | |
| 1st week | -9.94E-01 | 8.46E-01 | 2.88E+00 | Not Detected |
| 2nd week | 9.88E-01 | 3.10E-01 | 1.00E+00 | Not Detected |
| 3rd week | 4.07E-02 | 3.85E-01 | 1.29E+00 | Not Detected |
| 4th week | 7.61E-02 | 2.04E-01 | 6.81E-01 | Not Detected |
| **October 2022** | | | | |
| 1st week | 1.05E-02 | 2.79E-01 | 9.34E-01 | Not Detected |
| 2nd week | 1.91E-02 | 6.89E-02 | 2.32E-01 | Not Detected |
| 3rd week | 1.38E-02 | 3.96E-02 | 1.37E-01 | Not Detected |
| 4th week | 2.45E-01 | 1.35E-01 | 4.43E-01 | Not Detected |
| **November 2022** | | | | |
| 1st week | 1.70E-02 | 3.19E-01 | 1.07E+00 | Not Detected |
| 2nd week | 2.07E-01 | 1.68E-01 | 5.57E-01 | Not Detected |
| 3rd week | -2.51E-02 | 3.46E-01 | 1.16E+00 | Not Detected |
| 4th week | 0.00E+00 | 3.38E-03 | 9.15E-03 | Not Detected |
| **December 2022** | | | | |
| 1st week | 8.68E-02 | 4.54E-01 | 1.52E+00 | Not Detected |
| 2nd week | 4.72E-02 | 3.88E-01 | 1.30E+00 | Not Detected |
| 3rd week | -1.33E-02 | 1.16E-01 | 3.91E-01 | Not Detected |
| 4th week | 4.06E-02 | 6.50E-02 | 2.17E-01 | Not Detected |

## Table A.13. Specific activity of $^{40}K$ (Bq/g) at Station A

| Sample Date | $^{40}K$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 2.35E+01 | 1.08E+01 | 3.48E+01 | Not Detected |
| 2nd week | 3.24E+00 | 3.34E+00 | 1.11E+01 | Not Detected |
| 3rd week | 3.33E+00 | 2.66E+00 | 8.85E+00 | Not Detected |
| 4th week | -6.86E+00 | 2.62E+00 | 9.04E+00 | Not Detected |
| **February 2022** | | | | |
| 1st week | 3.68E-01 | 1.67E+00 | 5.74E+00 | Not Detected |
| 2nd week | 3.99E+00 | 1.88E+00 | 6.06E+00 | Not Detected |
| 3rd week | -4.10E+00 | 1.52E+00 | 5.25E+00 | Not Detected |
| 4th week | 1.04E+00 | 1.57E+00 | 5.23E+00 | Not Detected |
| **March 2022** | | | | |
| 1st week | 2.26E+00 | 4.08E+00 | 1.39E+01 | Not Detected |
| 2nd week | -1.23E+00 | 1.15E+00 | 3.91E+00 | Not Detected |
| 3rd week | -1.62E-01 | 5.58E-01 | 1.88E+00 | Not Detected |
| 4th week | -7.10E-01 | 3.67E-01 | 1.26E+00 | Not Detected |
| **April 2022** | | | | |
| 1st week | 2.32E+00 | 2.59E+00 | 8.71E+00 | Not Detected |
| 2nd week | 1.56E+00 | 9.49E-01 | 3.12E+00 | Not Detected |
| 3rd week | -1.72E+00 | 1.14E+00 | 3.90E+00 | Not Detected |
| 4th week | -1.24E+00 | 1.39E+00 | 4.94E+00 | Not Detected |
| **May 2022** | | | | |
| 1st week | 2.33E+00 | 1.99E+00 | 6.64E+00 | Not Detected |
| 2nd week | 7.46E-01 | 1.24E+00 | 4.20E+00 | Not Detected |
| 3rd week | 2.29E+00 | 1.09E+00 | 3.53E+00 | Not Detected |
| 4th week | -1.63E+00 | 1.81E+00 | 6.12E+00 | Not Detected |
| **June 2022** | | | | |
| 1st week | -4.87E+00 | 2.30E+00 | 7.90E+00 | Not Detected |
| 2nd week | -2.36E+00 | 1.62E+00 | 5.51E+00 | Not Detected |
| 3rd week | 2.22E+00 | 1.34E+00 | 4.41E+00 | Not Detected |
| 4th week | -1.08E+00 | 1.38E+00 | 4.88E+00 | Not Detected |

### Table A.13. Specific activity of $^{40}$K (Bq/g) at Station A (continued)

| Sample Date | $^{40}$K Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | -5.24E+00 | 2.40E+00 | 8.26E+00 | Not Detected |
| 2nd week | 2.70E+00 | 1.77E+00 | 5.85E+00 | Not Detected |
| 3rd week | -2.45E-01 | 1.22E+00 | 4.09E+00 | Not Detected |
| 4th week | -1.93E+00 | 1.46E+00 | 4.96E+00 | Not Detected |
| **August 2022** | | | | |
| 1st week | -1.72E+00 | 1.29E+00 | 4.39E+00 | Not Detected |
| 2nd week | 1.29E+00 | 1.09E+00 | 3.62E+00 | Not Detected |
| 3rd week | 2.92E+00 | 2.21E+00 | 7.34E+00 | Not Detected |
| 4th week | 2.98E+00 | 1.97E+00 | 6.49E+00 | Not Detected |
| **September 2022** | | | | |
| 1st week | -9.48E-01 | 5.21E+00 | 1.81E+01 | Not Detected |
| 2nd week | -9.37E+00 | 4.56E+00 | 1.57E+01 | Not Detected |
| 3rd week | -4.29E+00 | 2.46E+00 | 8.94E+00 | Not Detected |
| 4th week | -6.23E-01 | 1.19E+00 | 4.19E+00 | Not Detected |
| **October 2022** | | | | |
| 1st week | 3.81E+00 | 1.60E+00 | 5.12E+00 | Not Detected |
| 2nd week | -1.99E+00 | 1.54E+00 | 5.24E+00 | Not Detected |
| 3rd week | -5.44E+00 | 1.84E+00 | 6.44E+00 | Not Detected |
| 4th week | -2.96E+00 | 2.26E+00 | 7.69E+00 | Not Detected |
| **November 2022** | | | | |
| 1st week | 2.29E+00 | 1.98E+00 | 6.60E+00 | Not Detected |
| 2nd week | -4.08E+00 | 2.90E+00 | 9.90E+00 | Not Detected |
| 3rd week | 3.50E+00 | 1.97E+00 | 6.44E+00 | Not Detected |
| 4th week | -6.13E+00 | 1.87E+00 | 6.57E+00 | Not Detected |
| **December 2022** | | | | |
| 1st week | 3.39E+00 | 2.42E+00 | 8.02E+00 | Not Detected |
| 2nd week | -2.95E+00 | 2.27E+00 | 8.13E+00 | Not Detected |
| 3rd week | 1.26E-01 | 2.05E+00 | 6.86E+00 | Not Detected |
| 4th week | -1.10E+00 | 1.19E+00 | 4.03E+00 | Not Detected |

## Table A.14. Specific activity of $^{60}$Co (Bq/g) at Station A

| Sample Date | $^{60}$Co Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 2.67E+00 | 1.40E+00 | 4.56E+00 | Not Detected |
| 2nd week | 5.85E-01 | 3.31E-01 | 1.09E+00 | Not Detected |
| 3rd week | 2.59E+01 | 1.40E+01 | 4.57E+01 | Not Detected |
| 4th week | 8.62E-02 | 2.01E-01 | 6.77E-01 | Not Detected |
| **February 2022** | | | | |
| 1st week | 1.04E-01 | 2.22E-01 | 7.56E-01 | Not Detected |
| 2nd week | 4.88E-01 | 2.37E-01 | 7.70E-01 | Not Detected |
| 3rd week | 2.68E-01 | 1.07E-01 | 3.46E-01 | Not Detected |
| 4th week | 1.00E-01 | 7.22E-02 | 2.39E-01 | Not Detected |
| **March 2022** | | | | |
| 1st week | 3.86E-01 | 4.86E-01 | 1.64E+00 | Not Detected |
| 2nd week | -4.24E-02 | 5.80E-02 | 2.01E-01 | Not Detected |
| 3rd week | 9.40E-01 | 1.12E+00 | 3.75E+00 | Not Detected |
| 4th week | 1.07E-02 | 1.82E-02 | 6.15E-02 | Not Detected |
| **April 2022** | | | | |
| 1st week | 1.37E-01 | 3.16E-01 | 1.07E+00 | Not Detected |
| 2nd week | -1.29E-02 | 1.17E-01 | 4.03E-01 | Not Detected |
| 3rd week | 9.87E-02 | 5.87E-02 | 1.93E-01 | Not Detected |
| 4th week | -3.70E-02 | 1.81E-01 | 6.29E-01 | Not Detected |
| **May 2022** | | | | |
| 1st week | -4.22E-02 | 2.43E-01 | 8.43E-01 | Not Detected |
| 2nd week | 3.46E-02 | 1.55E-01 | 5.30E-01 | Not Detected |
| 3rd week | 1.25E-01 | 1.36E-01 | 4.56E-01 | Not Detected |
| 4th week | 1.34E-02 | 8.84E-02 | 3.02E-01 | Not Detected |
| **June 2022** | | | | |
| 1st week | 2.00E-01 | 1.51E-01 | 4.99E-01 | Not Detected |
| 2nd week | 1.28E-01 | 1.15E-01 | 3.83E-01 | Not Detected |
| 3rd week | 1.45E-01 | 1.59E-01 | 5.32E-01 | Not Detected |
| 4th week | 2.02E-01 | 1.82E-01 | 6.05E-01 | Not Detected |

## Table A.14. Specific activity of $^{60}$Co (Bq/g) at Station A (continued)

| Sample Date | $^{60}$Co Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 1.03E-01 | 1.27E-01 | 4.28E-01 | Not Detected |
| 2nd week | 3.28E-01 | 2.04E-01 | 6.71E-01 | Not Detected |
| 3rd week | -1.26E-02 | 6.12E-02 | 2.04E-01 | Not Detected |
| 4th week | -3.40E-02 | 8.87E-02 | 3.05E-01 | Not Detected |
| **August 2022** | | | | |
| 1st week | 6.42E-02 | 6.04E-02 | 2.02E-01 | Not Detected |
| 2nd week | 2.47E-01 | 1.33E-01 | 4.36E-01 | Not Detected |
| 3rd week | 4.12E-01 | 2.65E-01 | 8.72E-01 | Not Detected |
| 4th week | 4.12E-02 | 2.50E-01 | 8.54E-01 | Not Detected |
| **September 2022** | | | | |
| 1st week | 6.11E-01 | 6.11E-01 | 2.12E+00 | Not Detected |
| 2nd week | -8.90E-02 | 2.52E-01 | 8.72E-01 | Not Detected |
| 3rd week | 5.11E-01 | 3.00E-01 | 9.83E-01 | Not Detected |
| 4th week | 2.80E-02 | 1.29E-01 | 4.43E-01 | Not Detected |
| **October 2022** | | | | |
| 1st week | 5.34E-03 | 1.90E-01 | 6.53E-01 | Not Detected |
| 2nd week | 1.85E-02 | 7.37E-02 | 2.52E-01 | Not Detected |
| 3rd week | 4.22E-02 | 4.22E-02 | 1.44E-01 | Not Detected |
| 4th week | -7.53E-02 | 1.42E-01 | 4.87E-01 | Not Detected |
| **November 2022** | | | | |
| 1st week | 1.98E-01 | 2.27E-01 | 8.38E-01 | Not Detected |
| 2nd week | 1.48E-01 | 1.52E-01 | 5.08E-01 | Not Detected |
| 3rd week | 2.96E-01 | 2.20E-01 | 7.29E-01 | Not Detected |
| 4th week | 0.00E+00 | 5.21E-03 | 1.41E-02 | Not Detected |
| **December 2022** | | | | |
| 1st week | 2.18E-01 | 2.86E-01 | 9.65E-01 | Not Detected |
| 2nd week | 1.69E-01 | 2.52E-01 | 8.51E-01 | Not Detected |
| 3rd week | -1.34E-02 | 8.95E-02 | 3.09E-01 | Not Detected |
| 4th week | 6.11E-02 | 5.72E-02 | 1.91E-01 | Not Detected |

## Table A.15. Activity concentrations of $^{241}$Am (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | January | 2.82E-05 | 3.08E-06 | 1.55E-07 | Detected |
| | February | 1.11E-06 | 2.43E-07 | 1.75E-07 | Detected |
| | March | 1.12E-06 | 2.27E-07 | 1.48E-07 | Detected |
| | April | 1.32E-06 | 2.73E-07 | 2.33E-07 | Detected |
| | May | 3.28E-06 | 4.93E-07 | 7.12E-08 | Detected |
| | June | 1.49E-06 | 3.08E-07 | 1.77E-07 | Detected |
| | July | 1.13E-06 | 2.70E-07 | 2.56E-07 | Detected |
| | August | 1.28E-06 | 2.85E-07 | 1.96E-07 | Detected |
| | September | 5.39E-06 | 7.24E-07 | 1.68E-07 | Detected |
| | October | 1.91E-06 | 3.13E-07 | 1.82E-07 | Detected |
| | November | 1.39E-06 | 2.78E-07 | 1.52E-07 | Detected |
| | December | 5.32E-07 | 1.62E-07 | 2.23E-07 | Detected |

## Table A.16. Activity concentrations of $^{239+240}$Pu (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | $^{239+240}$Pu Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}$Pu | January | 3.76E-06 | 5.46E-07 | 1.63E-07 | Detected |
| | February | 1.16E-07 | 7.14E-08 | 9.96E-08 | Detected |
| | March | 1.60E-07 | 1.12E-07 | 2.00E-07 | Not Detected |
| | April | 2.61E-07 | 1.23E-07 | 1.75E-07 | Detected |
| | May | 1.24E-06 | 7.05E-07 | 1.21E-06 | Detected |
| | June | 3.90E-07 | 1.17E-07 | 6.96E-08 | Detected |
| | July | 7.79E-07 | 2.04E-07 | 1.74E-07 | Detected |
| | August | 8.68E-07 | 2.27E-07 | 1.91E-07 | Detected |
| | September | 9.76E-07 | 1.78E-07 | 8.41E-08 | Detected |
| | October | 6.05E-07 | 1.59E-07 | 7.92E-08 | Detected |
| | November | 7.85E-07 | 1.84E-07 | 1.27E-07 | Detected |
| | December | 4.47E-07 | 1.37E-07 | 1.62E-07 | Detected |

### Table A.17. Activity concentrations of $^{238}$Pu (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | $^{238}$Pu Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | January | 2.06E-07 | 1.07E-07 | 1.45E-07 | Detected |
| | February | 1.33E-07 | 7.90E-08 | 1.17E-07 | Detected |
| | March | 1.07E-08 | 1.07E-07 | 2.72E-07 | Not Detected |
| | April | 1.60E-07 | 9.55E-08 | 1.41E-07 | Detected |
| | May | 3.33E-06 | 1.01E-06 | 1.01E-06 | Detected |
| | June | 7.50E-08 | 6.41E-08 | 1.19E-07 | Not Detected |
| | July | 6.99E-08 | 8.73E-08 | 1.88E-07 | Not Detected |
| | August | 4.40E-08 | 1.13E-07 | 2.69E-07 | Not Detected |
| | September | 1.27E-07 | 6.83E-08 | 1.13E-07 | Detected |
| | October | 1.88E-07 | 8.41E-08 | 6.27E-08 | Detected |
| | November | 1.36E-07 | 7.81E-08 | 1.13E-07 | Detected |
| | December | 9.38E-08 | 7.28E-08 | 1.36E-07 | Not Detected |

### Table A.18. Specific activity of $^{241}$Am (Bq/g) at Station B

| Radionuclide | Sample Date | $^{241}$Am Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{241}$Am | January | 9.98E+00 | 1.09E+00 | 5.51E-02 | Detected |
| | February | 2.27E-01 | 4.94E-02 | 3.55E-02 | Detected |
| | March | 2.63E-01 | 5.33E-02 | 3.47E-02 | Detected |
| | April | 1.80E-01 | 3.72E-02 | 3.18E-02 | Detected |
| | May | 2.16E-01 | 3.24E-02 | 4.68E-03 | Detected |
| | June | 8.36E-02 | 1.73E-02 | 9.97E-03 | Detected |
| | July | 6.79E-02 | 1.62E-02 | 1.53E-02 | Detected |
| | August | 8.42E-02 | 1.87E-02 | 1.29E-02 | Detected |
| | September | 3.85E-01 | 5.17E-02 | 1.20E-02 | Detected |
| | October | 1.29E+00 | 2.12E-01 | 1.23E-01 | Detected |
| | November | 2.61E-01 | 5.21E-02 | 2.85E-02 | Detected |
| | December | 1.27E-01 | 3.86E-02 | 5.32E-02 | Detected |

## Table A.19. Specific activity of $^{239+240}$Pu (Bq/g) at Station B

| Radionuclide | Sample Date | $^{239+240}$Pu Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{239+240}$Pu | January | 1.33E+00 | 1.94E-01 | 5.79E-02 | Detected |
| | February | 2.36E-02 | 1.45E-02 | 2.03E-02 | Detected |
| | March | 3.76E-02 | 2.63E-02 | 4.71E-02 | Not Detected |
| | April | 3.55E-02 | 1.68E-02 | 2.38E-02 | Detected |
| | May | 8.14E-02 | 4.64E-02 | 7.94E-02 | Detected |
| | June | 2.19E-02 | 6.60E-03 | 3.92E-03 | Detected |
| | July | 4.67E-02 | 1.22E-02 | 1.04E-02 | Detected |
| | August | 5.69E-02 | 1.48E-02 | 1.25E-02 | Detected |
| | September | 6.97E-02 | 1.27E-02 | 6.01E-03 | Detected |
| | October | 4.10E-01 | 1.07E-01 | 5.36E-02 | Detected |
| | November | 1.47E-01 | 3.45E-02 | 2.39E-02 | Detected |
| | December | 1.07E-01 | 3.27E-02 | 3.86E-02 | Detected |

## Table A.20. Specific activity of $^{238}$Pu (Bq/g) at Station B

| Radionuclide | Sample Date | $^{238}$Pu Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | January | 7.30E-02 | 3.80E-02 | 5.14E-02 | Detected |
| | February | 2.70E-02 | 1.61E-02 | 2.38E-02 | Detected |
| | March | 2.50E-03 | 2.50E-02 | 6.38E-02 | Not Detected |
| | April | 2.19E-02 | 1.30E-02 | 1.93E-02 | Detected |
| | May | 2.19E-01 | 6.64E-02 | 6.66E-02 | Detected |
| | June | 4.22E-03 | 3.60E-03 | 6.69E-03 | Not Detected |
| | July | 4.19E-03 | 5.23E-03 | 1.13E-02 | Not Detected |
| | August | 2.88E-03 | 7.40E-03 | 1.77E-02 | Not Detected |
| | September | 9.09E-03 | 4.88E-03 | 8.07E-03 | Detected |
| | October | 1.27E-01 | 5.69E-02 | 4.25E-02 | Detected |
| | November | 2.56E-02 | 1.47E-02 | 2.12E-02 | Detected |
| | December | 2.24E-02 | 1.74E-02 | 3.24E-02 | Not Detected |

## Table A.21. Activity concentrations of U isotopes at Station B

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2$\sigma$) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | January | 2.45E-06 | 4.68E-07 | 2.57E-07 | Detected |
| | February | 6.41E-07 | 2.68E-07 | 4.27E-07 | Detected |
| | March | 7.42E-07 | 2.67E-07 | 3.25E-07 | Detected |
| | April | 1.81E-06 | 4.74E-07 | 5.10E-07 | Detected |
| | May | 2.80E-06 | 5.97E-07 | 5.68E-07 | Detected |
| | June | 1.55E-07 | 1.53E-07 | 3.11E-07 | Not Detected |
| | July | 2.80E-06 | 5.86E-07 | 4.80E-07 | Detected |
| | August | 9.58E-07 | 3.02E-07 | 3.64E-07 | Detected |
| | September | 5.23E-07 | 2.49E-07 | 4.20E-07 | Detected |
| | October | 9.03E-07 | 3.04E-07 | 4.11E-07 | Detected |
| | November | 2.04E-06 | 4.44E-07 | 4.02E-07 | Detected |
| | December | 1.87E-07 | 1.32E-07 | 2.33E-07 | Not Detected |
| | | | | | |
| $^{235}$U | January | 5.95E-07 | 2.49E-07 | 3.97E-07 | Detected |
| | February | 3.09E-07 | 1.99E-07 | 3.36E-07 | Not Detected |
| | March | 6.17E-07 | 2.67E-07 | 3.38E-07 | Detected |
| | April | 1.49E-06 | 4.39E-07 | 3.62E-07 | Detected |
| | May | 2.10E-06 | 5.12E-07 | 2.90E-07 | Detected |
| | June | 3.82E-08 | 9.37E-08 | 2.29E-07 | Not Detected |
| | July | 2.10E-06 | 5.27E-07 | 4.21E-07 | Detected |
| | August | 4.41E-07 | 2.02E-07 | 1.86E-07 | Detected |
| | September | 3.61E-07 | 2.28E-07 | 4.05E-07 | Not Detected |
| | October | 3.18E-07 | 1.90E-07 | 2.80E-07 | Detected |
| | November | 8.18E-07 | 2.99E-07 | 3.66E-07 | Detected |
| | December | 6.59E-08 | 9.34E-08 | 1.98E-07 | Not Detected |

### Table A.21. Activity concentrations of U isotopes at Station B (continued)

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$U | January | 2.50E-07 | 1.81E-07 | 3.46E-07 | Not Detected |
| | February | 3.12E-08 | 2.37E-07 | 5.84E-07 | Not Detected |
| | March | 3.43E-07 | 2.46E-07 | 4.84E-07 | Not Detected |
| | April | 1.20E-06 | 4.45E-07 | 7.23E-07 | Detected |
| | May | 2.09E-06 | 5.01E-07 | 5.15E-07 | Detected |
| | June | -4.62E-08 | 1.48E-07 | 4.07E-07 | Not Detected |
| | July | 2.16E-06 | 5.06E-07 | 4.78E-07 | Detected |
| | August | 6.31E-07 | 1.83E-07 | 3.45E-07 | Detected |
| | September | 3.07E-07 | 2.23E-07 | 4.45E-07 | Not Detected |
| | October | 5.62E-07 | 2.58E-07 | 4.24E-07 | Detected |
| | November | 1.26E-06 | 3.40E-07 | 3.69E-07 | Detected |
| | December | 6.65E-08 | 1.43E-07 | 3.39E-07 | Not Detected |

### Table A.22. Specific activity of U isotopes at Station B

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | January | 8.69E-01 | 1.66E-01 | 9.12E-02 | Detected |
| | February | 1.30E-01 | 5.46E-02 | 8.69E-02 | Detected |
| | March | 1.74E-01 | 6.28E-02 | 7.63E-02 | Detected |
| | April | 2.47E-01 | 6.47E-02 | 6.95E-02 | Detected |
| | May | 1.84E-01 | 3.93E-02 | 3.74E-02 | Detected |
| | June | 8.71E-03 | 8.58E-03 | 1.75E-02 | Not Detected |
| | July | 1.68E-01 | 3.51E-02 | 2.88E-02 | Detected |
| | August | 6.28E-02 | 1.98E-02 | 2.39E-02 | Detected |
| | September | 3.74E-02 | 1.77E-02 | 3.00E-02 | Detected |
| | October | 6.12E-01 | 2.06E-01 | 2.78E-01 | Detected |
| | November | 3.82E-01 | 8.34E-02 | 7.55E-02 | Detected |
| | December | 4.46E-02 | 3.15E-02 | 5.54E-02 | Not Detected |

**Table A.22. Specific activity of U isotopes at Station B (continued)**

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{235}$U | January | 2.11E-01 | 8.82E-02 | 1.41E-01 | Detected |
| | February | 6.28E-02 | 4.06E-02 | 6.84E-02 | Not Detected |
| | March | 1.45E-01 | 6.27E-02 | 7.93E-02 | Detected |
| | April | 2.03E-01 | 5.99E-02 | 4.93E-02 | Detected |
| | May | 1.38E-01 | 3.37E-02 | 1.91E-02 | Detected |
| | June | 2.15E-03 | 5.27E-03 | 1.29E-02 | Not Detected |
| | July | 1.26E-01 | 3.16E-02 | 2.52E-02 | Detected |
| | August | 2.89E-02 | 1.32E-02 | 1.22E-02 | Detected |
| | September | 2.58E-02 | 1.63E-02 | 2.89E-02 | Not Detected |
| | October | 2.15E-01 | 1.28E-01 | 1.90E-01 | Detected |
| | November | 1.54E-01 | 5.61E-02 | 6.88E-02 | Detected |
| | December | 1.57E-02 | 2.23E-02 | 4.72E-02 | Not Detected |
| | | | | | |
| $^{238}$U | January | 8.86E-02 | 6.41E-02 | 1.23E-01 | Not Detected |
| | February | 6.34E-03 | 4.83E-02 | 1.19E-01 | Not Detected |
| | March | 8.07E-02 | 5.77E-02 | 1.14E-01 | Not Detected |
| | April | 1.64E-01 | 6.06E-02 | 9.86E-02 | Detected |
| | May | 1.37E-01 | 3.30E-02 | 3.39E-02 | Detected |
| | June | -2.60E-03 | 8.32E-03 | 2.29E-02 | Not Detected |
| | July | 1.30E-01 | 3.03E-02 | 2.87E-02 | Detected |
| | August | 4.13E-02 | 1.20E-02 | 2.26E-02 | Detected |
| | September | 2.19E-02 | 1.60E-02 | 3.18E-02 | Not Detected |
| | October | 3.81E-01 | 1.75E-01 | 2.87E-01 | Detected |
| | November | 2.36E-01 | 6.39E-02 | 6.93E-02 | Detected |
| | December | 1.59E-02 | 3.42E-02 | 8.08E-02 | Not Detected |

### Table A.23. Activity concentrations of $^{137}$Cs (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | January | 2.40E-05 | 2.1E-05 | 6.79E-05 | Not Detected |
| | February | -3.76E-07 | 2.66E-06 | 9.34E-06 | Not Detected |
| | March | 1.46E-05 | 1.98E-05 | 6.57E-05 | Not Detected |
| | April | 1.03E-05 | 8.28E-06 | 2.74E-05 | Not Detected |
| | May | -1.17E-05 | 1.88E-05 | 6.35E-05 | Not Detected |
| | June | 9.19E-06 | 8.30E-06 | 2.75E-05 | Not Detected |
| | July | 1.42E-05 | 1.59E-05 | 5.28E-05 | Not Detected |
| | August | 6.21E-06 | 5.58E-06 | 1.85E-05 | Not Detected |
| | September | -2.77E-05 | 8.54E-06 | 2.93E-05 | Not Detected |
| | October | 1.45E-06 | 7.65E-06 | 2.56E-05 | Not Detected |
| | November | 1.30E-05 | 1.83E-05 | 6.06E-05 | Not Detected |
| | December | 7.72E-06 | 7.03E-06 | 2.33E-05 | Not Detected |

### Table A.24. Activity concentrations of $^{40}$K (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}$K | January | 1.25E-04 | 1.13E-04 | 3.78E-04 | Not Detected |
| | February | -3.04E-04 | 1.13E-04 | 3.92E-04 | Not Detected |
| | March | -6.84E-05 | 1.14E-04 | 4.02E-04 | Not Detected |
| | April | -2.10E-04 | 1.46E-04 | 4.99E-04 | Not Detected |
| | May | 1.17E-04 | 1.08E-04 | 3.60E-04 | Not Detected |
| | June | -2.51E-04 | 1.14E-04 | 3.92E-04 | Not Detected |
| | July | 4.46E-05 | 9.53E-05 | 3.25E-04 | Not Detected |
| | August | 9.39E-05 | 1.11E-04 | 3.68E-04 | Not Detected |
| | September | 5.11E-05 | 1.05E-04 | 3.51E-04 | Not Detected |
| | October | 9.85E-06 | 9.04E-05 | 3.04E-04 | Not Detected |
| | November | 4.56E-05 | 9.71E-05 | 3.31E-04 | Not Detected |
| | December | 1.38E-04 | 9.11E-05 | 3.00E-04 | Not Detected |

## Table A.25. Activity concentrations of $^{60}$Co (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{60}$Co** | January | 2.28E-05 | 1.40E-05 | 4.59E-05 | Not Detected |
| | February | -1.83E-06 | 3.39E-06 | 1.25E-05 | Not Detected |
| | March | -1.32E-05 | 1.53E-05 | 5.39E-05 | Not Detected |
| | April | 3.34E-06 | 7.07E-06 | 2.39E-05 | Not Detected |
| | May | 3.88E-05 | 1.28E-05 | 4.03E-05 | Not Detected |
| | June | 7.06E-07 | 5.62E-06 | 1.92E-05 | Not Detected |
| | July | 1.53E-06 | 1.20E-05 | 4.10E-05 | Not Detected |
| | August | 7.04E-06 | 6.65E-06 | 2.21E-05 | Not Detected |
| | September | 1.18E-05 | 7.16E-06 | 2.35E-05 | Not Detected |
| | October | 1.27E-05 | 7.15E-06 | 2.35E-05 | Not Detected |
| | November | 1.47E-05 | 1.19E-05 | 3.95E-05 | Not Detected |
| | December | 9.85E-06 | 8.14E-06 | 2.70E-05 | Not Detected |

## Table A.26. Specific activity of $^{137}$Cs (Bq/g) at Station B

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | January | 8.52E+00 | 7.28E+00 | 2.41E+01 | Not Detected |
| | February | -7.65E-02 | 5.41E-01 | 1.90E+00 | Not Detected |
| | March | 3.44E+00 | 4.65E+00 | 1.54E+01 | Not Detected |
| | April | 1.41E+00 | 1.13E+00 | 3.73E+00 | Not Detected |
| | May | -7.67E-01 | 1.24E+00 | 4.18E+00 | Not Detected |
| | June | 5.17E-01 | 4.67E-01 | 1.55E+00 | Not Detected |
| | July | 8.51E-01 | 9.55E-01 | 3.17E+00 | Not Detected |
| | August | 4.07E-01 | 3.66E-01 | 1.21E+00 | Not Detected |
| | September | -1.98E+00 | 6.10E-01 | 2.09E+00 | Not Detected |
| | October | 9.80E-01 | 5.18E+00 | 1.73E+01 | Not Detected |
| | November | 2.44E+00 | 3.43E+00 | 1.14E+01 | Not Detected |
| | December | 1.84E+00 | 1.68E+00 | 5.55E+00 | Not Detected |

### Table A.27. Specific activity of $^{40}$K (Bq/g) at Station B

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{40}$K | January | 4.44E+01 | 4.01E+01 | 1.34E+02 | Not Detected |
| | February | -6.18E+01 | 2.29E+01 | 7.97E+01 | Not Detected |
| | March | -1.61E+01 | 2.68E+01 | 9.44E+01 | Not Detected |
| | April | -2.86E+01 | 2.00E+01 | 6.80E+01 | Not Detected |
| | May | 7.67E+00 | 7.09E+00 | 2.37E+01 | Not Detected |
| | June | -1.41E+01 | 6.41E+00 | 2.20E+01 | Not Detected |
| | July | 2.67E+00 | 5.72E+00 | 1.95E+01 | Not Detected |
| | August | 6.16E+00 | 7.27E+00 | 2.41E+01 | Not Detected |
| | September | 3.65E+00 | 7.51E+00 | 2.50E+01 | Not Detected |
| | October | 6.67E+00 | 6.12E+01 | 2.06E+02 | Not Detected |
| | November | 8.57E+00 | 1.82E+01 | 6.22E+01 | Not Detected |
| | December | 3.29E+01 | 2.17E+01 | 7.16E+01 | Not Detected |

### Table A.28. Specific activity of $^{60}$Co (Bq/g) at Station B

| Radionuclide | Sample Date | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{60}$Co | January | 8.10E+00 | 4.95E+00 | 1.63E+01 | Not Detected |
| | February | -3.72E-01 | 6.90E-01 | 2.55E+00 | Not Detected |
| | March | -3.09E+00 | 3.59E+00 | 1.27E+01 | Not Detected |
| | April | 4.56E-01 | 9.64E-01 | 3.27E+00 | Not Detected |
| | May | 2.55E+00 | 8.41E-01 | 2.65E+00 | Not Detected |
| | June | 3.97E-02 | 3.16E-01 | 1.08E+00 | Not Detected |
| | July | 9.16E-02 | 7.19E-01 | 2.46E+00 | Not Detected |
| | August | 4.61E-01 | 4.36E-01 | 1.45E+00 | Not Detected |
| | September | 8.44E-01 | 5.11E-01 | 1.68E+00 | Not Detected |
| | October | 8.59E+00 | 4.84E+00 | 1.59E+01 | Not Detected |
| | November | 2.77E+00 | 2.23E+00 | 7.41E+00 | Not Detected |
| | December | 2.35E+00 | 1.94E+00 | 6.43E+00 | Not Detected |

## Table A.29. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at Station A

| Sample Date | $^{90}$Sr Activity Bq/m$^3$ | Unc. (2-sig) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 1.04E-02 | 9.74E-04 | 1.41E-02 | Not Detected |
| 2nd week | 1.31E-02 | 1.08E-03 | 1.59E-02 | Not Detected |
| 3rd week | 1.45E-02 | 1.18E-03 | 1.57E-02 | Not Detected |
| 4th week | 9.86E-03 | 7.97E-04 | 1.10E-02 | Not Detected |
| **February 2022** | | | | |
| 1st week | 1.10E-02 | 1.03E-03 | 1.42E-02 | Not Detected |
| 2nd week | 1.39E-02 | 1.18E-03 | 1.60E-02 | Not Detected |
| 3rd week | 1.46E-02 | 1.18E-03 | 1.61E-02 | Not Detected |
| 4th week | 1.53E-02 | 1.24E-03 | 1.60E-02 | Not Detected |
| **March 2022** | | | | |
| 1st week | 1.18E-02 | 1.06E-03 | 1.41E-02 | Not Detected |
| 2nd week | 1.13E-02 | 1.03E-03 | 1.42E-02 | Not Detected |
| 3rd week | 1.26E-02 | 1.11E-03 | 1.41E-02 | Not Detected |
| 4th week | 9.26E-03 | 7.96E-04 | 1.10E-02 | Not Detected |
| **April 2022** | | | | |
| 1st week | 1.23E-02 | 1.07E-03 | 1.56E-02 | Not Detected |
| 2nd week | 1.27E-02 | 1.13E-03 | 1.64E-02 | Not Detected |
| 3rd week | 1.08E-02 | 9.87E-04 | 1.36E-02 | Not Detected |
| 4th week | 1.16E-02 | 9.46E-04 | 1.24E-02 | Not Detected |
| **May 2022** | | | | |
| 1st week | 1.34E-02 | 1.17E-03 | 1.60E-02 | Not Detected |
| 2nd week | 1.42E-02 | 1.19E-03 | 1.63E-02 | Not Detected |
| 3rd week | 1.24E-02 | 1.08E-03 | 1.57E-02 | Not Detected |
| 4th week | 1.08E-02 | 9.17E-04 | 1.26E-02 | Not Detected |
| **June 2022** | | | | |
| 1st week | 1.17E-02 | 1.04E-03 | 1.59E-02 | Not Detected |
| 2nd week | 1.33E-02 | 1.15E-03 | 1.68E-02 | Not Detected |
| 3rd week | 1.29E-02 | 1.11E-03 | 1.53E-02 | Not Detected |
| 4th week | 9.18E-03 | 8.31E-04 | 1.15E-02 | Not Detected |

### Table A.29. Activity concentrations of $^{90}Sr$ (Bq/m$^3$) at Station A (continued)

| Sample Date | $^{90}Sr$ Activity Bq/m$^3$ | Unc. (2-sig) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 1.40E-02 | 1.17E-03 | 1.56E-02 | Not Detected |
| 2nd week | 1.19E-02 | 1.09E-03 | 1.49E-02 | Not Detected |
| 3rd week | 1.31E-02 | 1.17E-03 | 1.54E-02 | Not Detected |
| 4th week | 8.08E-03 | 7.30E-04 | 1.03E-02 | Not Detected |
| **August 2022** | | | | |
| 1st week | 1.21E-02 | 1.10E-03 | 1.47E-02 | Not Detected |
| 2nd week | 1.10E-02 | 1.03E-03 | 1.47E-02 | Not Detected |
| 3rd week | 1.19E-02 | 1.05E-03 | 1.48E-02 | Not Detected |
| 4th week | 8.94E-03 | 7.77E-04 | 1.10E-02 | Not Detected |
| **September 2022** | | | | |
| 1st week | 1.37E-02 | 1.18E-03 | 1.60E-02 | Not Detected |
| 2nd week | 1.41E-02 | 1.21E-03 | 1.61E-02 | Not Detected |
| 3rd week | 1.41E-02 | 1.19E-03 | 1.62E-02 | Not Detected |
| 4th week | 9.36E-03 | 8.46E-04 | 1.20E-02 | Not Detected |
| **October 2022** | | | | |
| 1st week | 1.27E-02 | 1.11E-03 | 1.56E-02 | Not Detected |
| 2nd week | 1.53E-02 | 1.26E-03 | 1.60E-02 | Not Detected |
| 3rd week | 1.29E-02 | 1.10E-03 | 1.55E-02 | Not Detected |
| 4th week | 9.39E-03 | 8.03E-04 | 1.08E-02 | Not Detected |
| **November 2022** | | | | |
| 1st week | 1.29E-02 | 1.10E-03 | 1.55E-02 | Not Detected |
| 2nd week | 1.49E-02 | 1.23E-03 | 1.15E-02 | Detected |
| 3rd week | 1.42E-02 | 1.18E-03 | 1.14E-02 | Detected |
| 4th week | 1.08E-02 | 9.01E-04 | 1.20E-02 | Not Detected |
| **December 2022** | | | | |
| 1st week | 1.29E-02 | 1.11E-03 | 1.55E-02 | Not Detected |
| 2nd week | 1.35E-02 | 1.13E-03 | 1.56E-02 | Not Detected |
| 3rd week | 1.29E-02 | 1.10E-03 | 1.55E-02 | Not Detected |
| 4th week | 8.68E-03 | 7.65E-04 | 1.09E-02 | Not Detected |

## Table A.30. Activity concentrations of $^{90}Sr$ (Bq/g) at Station A

| Sample Date | $^{90}Sr$ Activity Bq/g | Unc. (2-sig) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **January 2022** | | | | |
| 1st week | 2.43E+02 | 2.27E+01 | 3.29E+02 | Not Detected |
| 2nd week | 1.06E+02 | 8.78E+00 | 1.29E+02 | Not Detected |
| 3rd week | 8.42E+01 | 6.84E+00 | 9.07E+01 | Not Detected |
| 4th week | 7.24E+01 | 5.85E+00 | 8.10E+01 | Not Detected |
| **February 2022** | | | | |
| 1st week | 4.10E+01 | 3.85E+00 | 5.28E+01 | Not Detected |
| 2nd week | 5.57E+01 | 4.72E+00 | 6.39E+01 | Not Detected |
| 3rd week | 4.48E+01 | 3.62E+00 | 4.95E+01 | Not Detected |
| 4th week | 4.53E+01 | 3.68E+00 | 4.75E+01 | Not Detected |
| **March 2022** | | | | |
| 1st week | 1.02E+02 | 9.20E+00 | 1.22E+02 | Not Detected |
| 2nd week | 2.43E+01 | 2.22E+00 | 3.05E+01 | Not Detected |
| 3rd week | 1.32E+01 | 1.16E+00 | 1.48E+01 | Not Detected |
| 4th week | 9.82E+00 | 8.45E-01 | 1.17E+01 | Not Detected |
| **April 2022** | | | | |
| 1st week | 6.96E+01 | 6.02E+00 | 8.80E+01 | Not Detected |
| 2nd week | 2.36E+01 | 2.10E+00 | 3.05E+01 | Not Detected |
| 3rd week | 2.62E+01 | 2.40E+00 | 3.29E+01 | Not Detected |
| 4th week | 4.80E+01 | 3.90E+00 | 5.12E+01 | Not Detected |
| **May 2022** | | | | |
| 1st week | 5.62E+01 | 4.93E+00 | 6.70E+01 | Not Detected |
| 2nd week | 4.05E+01 | 3.41E+00 | 4.65E+01 | Not Detected |
| 3rd week | 2.93E+01 | 2.56E+00 | 3.71E+01 | Not Detected |
| 4th week | 4.82E+01 | 4.08E+00 | 5.60E+01 | Not Detected |
| **June 2022** | | | | |
| 1st week | 5.47E+01 | 4.87E+00 | 7.41E+01 | Not Detected |
| 2nd week | 3.87E+01 | 3.35E+00 | 4.89E+01 | Not Detected |
| 3rd week | 3.60E+01 | 3.09E+00 | 4.28E+01 | Not Detected |
| 4th week | 3.45E+01 | 3.12E+00 | 4.31E+01 | Not Detected |

## Table A.30. Specific activity of $^{90}Sr$ (Bq/g) at Station A (continued)

| Sample Date | $^{90}Sr$ Activity Bq/g | Unc. (2-sig) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| **July 2022** | | | | |
| 1st week | 6.83E+01 | 5.74E+00 | 7.65E+01 | Not Detected |
| 2nd week | 4.32E+01 | 3.96E+00 | 5.40E+01 | Not Detected |
| 3rd week | 3.07E+01 | 2.74E+00 | 3.62E+01 | Not Detected |
| 4th week | 3.28E+01 | 2.97E+00 | 4.20E+01 | Not Detected |
| **August 2022** | | | | |
| 1st week | 2.99E+01 | 2.72E+00 | 3.65E+01 | Not Detected |
| 2nd week | 2.58E+01 | 2.42E+00 | 3.46E+01 | Not Detected |
| 3rd week | 5.53E+01 | 4.92E+00 | 6.91E+01 | Not Detected |
| 4th week | 5.66E+01 | 4.92E+00 | 6.94E+01 | Not Detected |
| **September 2022** | | | | |
| 1st week | 1.55E+02 | 1.34E+01 | 1.82E+02 | Not Detected |
| 2nd week | 1.33E+02 | 1.15E+01 | 1.53E+02 | Not Detected |
| 3rd week | 7.52E+01 | 6.31E+00 | 8.64E+01 | Not Detected |
| 4th week | 3.07E+01 | 2.78E+00 | 3.94E+01 | Not Detected |
| **October 2022** | | | | |
| 1st week | 4.38E+01 | 3.83E+00 | 5.37E+01 | Not Detected |
| 2nd week | 4.77E+01 | 3.93E+00 | 4.99E+01 | Not Detected |
| 3rd week | 5.62E+01 | 4.80E+00 | 6.75E+01 | Not Detected |
| 4th week | 6.18E+01 | 5.29E+00 | 7.12E+01 | Not Detected |
| **November 2022** | | | | |
| 1st week | 5.62E+01 | 4.79E+00 | 6.76E+01 | Not Detected |
| 2nd week | 8.66E+01 | 7.15E+00 | 6.70E+01 | Detected |
| 3rd week | 6.10E+01 | 5.06E+00 | 4.89E+01 | Detected |
| 4th week | 6.34E+01 | 5.28E+00 | 7.03E+01 | Not Detected |
| **December 2022** | | | | |
| 1st week | 7.24E+01 | 6.25E+00 | 8.69E+01 | Not Detected |
| 2nd week | 6.44E+01 | 5.40E+00 | 7.42E+01 | Not Detected |
| 3rd week | 5.05E+01 | 4.28E+00 | 6.06E+01 | Not Detected |
| 4th week | 2.84E+01 | 2.50E+00 | 3.56E+01 | Not Detected |

## Table A.31. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at Station B

| Radionuclide | Sample Date | $^{90}$Sr Activity Bq/m$^3$ | Unc.(2-sig) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{90}$Sr | January | 3.83E-03 | 3.09E-04 | 4.28E-03 | Not Detected |
| | February | 3.92E-03 | 3.10E-04 | 4.25E-03 | Not Detected |
| | March | 3.57E-03 | 2.98E-04 | 4.16E-03 | Not Detected |
| | April | 4.20E-03 | 3.49E-04 | 4.63E-03 | Not Detected |
| | May | 3.65E-03 | 2.94E-04 | 4.01E-03 | Not Detected |
| | June | 3.50E-03 | 2.89E-04 | 4.12E-03 | Not Detected |
| | July | 3.45E-03 | 2.79E-04 | 3.98E-03 | Not Detected |
| | August | 3.39E-03 | 2.80E-04 | 3.99E-03 | Not Detected |
| | September | 3.50E-03 | 2.83E-04 | 3.79E-03 | Not Detected |
| | October | 3.46E-03 | 2.80E-04 | 4.00E-03 | Not Detected |
| | November | 3.44E-03 | 2.82E-04 | 3.80E-03 | Not Detected |
| | December | 3.45E-03 | 2.83E-04 | 3.68E-03 | Not Detected |

## Table A.32. Specific activity of $^{90}$Sr (Bq/g) at Station B

| Radionuclide | Sample Date | $^{90}$Sr Activity Bq/g | Unc.(2-sig) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{90}$Sr | January | 1.36E+03 | 1.09E+02 | 1.51E+03 | Not Detected |
| | February | 7.97E+02 | 6.31E+01 | 8.64E+02 | Not Detected |
| | March | 8.38E+02 | 7.00E+01 | 9.78E+02 | Not Detected |
| | April | 5.73E+02 | 4.76E+01 | 6.32E+02 | Not Detected |
| | May | 2.40E+02 | 1.93E+01 | 2.64E+02 | Not Detected |
| | June | 1.97E+02 | 1.63E+01 | 2.32E+02 | Not Detected |
| | July | 2.07E+02 | 1.67E+01 | 2.39E+02 | Not Detected |
| | August | 2.22E+02 | 1.84E+01 | 2.62E+02 | Not Detected |
| | September | 2.50E+02 | 2.02E+01 | 2.71E+02 | Not Detected |
| | October | 2.34E+03 | 1.90E+02 | 2.71E+03 | Not Detected |
| | November | 6.46E+02 | 5.29E+01 | 7.13E+02 | Not Detected |
| | December | 8.24E+02 | 6.74E+01 | 8.77E+02 | Not Detected |

# APPENDIX B - AIRBORNE PARTICULATE MONITORING

Actinide concentrations and specific activities at six monitoring stations around WIPP

Uranium concentrations and specific activities at six monitoring stations around WIPP

Gamma radionuclide concentrations and specific activities at six monitoring stations around WIPP

Strontium concentrations and specific activities at six monitoring stations around WIPP

### Table B.1. Activity concentrations of $^{239+240}Pu$ at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Feb. 2 – Mar. 2 | 1.31E-10 | 7.85E-10 | 2.08E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -9.10E-10 | 3.86E-09 | 1.07E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.80E-09 | 2.02E-09 | 4.23E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 4.14E-09 | 2.17E-09 | 3.39E-09 | Detected |
| | Apr. 13 - Apr. 29 | 2.43E-09 | 1.51E-09 | 2.49E-09 | Not Detected |
| | Apr. 29 – May 18 | 5.48E-09 | 3.40E-09 | 5.61E-09 | Not Detected |
| | May 18 – Jun. 3 | 3.91E-09 | 2.05E-09 | 2.96E-09 | Detected |
| | Jun. 3 – Jun. 15 | 6.08E-09 | 3.28E-09 | 5.20E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.92E-09 | 1.95E-09 | 3.43E-09 | Not Detected |
| | Jun. 29 – July 22 | 4.88E-09 | 2.57E-09 | 2.24E-09 | Detected |
| | July 22 -Aug. 17 | 1.55E-09 | 9.13E-10 | 1.24E-09 | Detected |
| | Aug. 17 – Oct. 3 | 1.10E-09 | 5.61E-10 | 4.77E-10 | Detected |
| | Oct. 3 – Nov. 4 | 1.55E-09 | 1.00E-09 | 1.63E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 8.45E-10 | 5.19E-10 | 7.25E-10 | Detected |
| | Dec. 9 – Jan. 6 | 8.87E-10 | 9.10E-10 | 1.89E-09 | Not Detected |

## Table B.2. Activity concentrations of $^{241}$Am at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -3.48E-09 | 3.44E-09 | 1.21E-08 | Not Detected |
|  | Mar. 2 – Mar. 16 | -8.28E-09 | 1.76E-08 | 5.08E-08 | Not Detected |
|  | Mar. 16 – Mar. 30 | -1.89E-08 | 2.69E-08 | 8.88E-08 | Not Detected |
|  | Mar. 30 - Apr. 13 | -5.48E-09 | 4.38E-09 | 1.54E-08 | Not Detected |
|  | Apr. 13 - Apr. 29 | -1.57E-08 | 1.27E-05 | 4.14E-08 | Not Detected |
|  | Apr. 29 – May 18 | -9.79E-10 | 1.55E-09 | 4.92E-09 | Not Detected |
|  | May 18 – Jun. 3 | -8.08E-09 | 6.75E-09 | 2.04E-08 | Not Detected |
|  | Jun. 3 – Jun. 15 | 7.65E-09 | 3.33E-09 | 4.64E-09 | Detected |
|  | Jun. 15 – Jun. 29 | -4.16E-10 | 3.43E-09 | 9.34E-09 | Not Detected |
|  | Jun. 29 – July 22 | -7.83E-10 | 8.01E-10 | 2.45E-09 | Not Detected |
|  | July 22 -Aug. 17 | 0.00E+00 | 2.43E-09 | 6.82E-09 | Not Detected |
|  | Aug. 17 – Oct. 3 | -4.53E-11 | 3.51E-10 | 9.65E-10 | Not Detected |
|  | Oct. 3 – Nov. 4 | 0.00E+00 | 8.13E-10 | 2.21E-09 | Not Detected |
|  | Nov. 4 – Dec. 9 | 1.40E-09 | 9.42E-10 | 1.74E-09 | Not Detected |
|  | Dec. 9 – Jan. 6 | 1.69E-09 | 9.42E-10 | 1.47E-09 | Detected |

## Table B.3. Activity concentrations of $^{238}Pu$ at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}Pu$** | Feb. 2 – Mar. 2 | 6.54E-10 | 8.71E-10 | 1.85E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.37E-09 | 3.29E-09 | 9.70E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.02E-09 | 2.26E-09 | 4.78E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 7.20E-10 | 1.61E-09 | 3.84E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.29E-09 | 1.48E-09 | 2.49E-09 | Not Detected |
| | Apr. 29 – May 18 | 6.45E-10 | 1.82E-09 | 4.55E-09 | Not Detected |
| | May 18 – Jun. 3 | 9.32E-10 | 1.79E-09 | 4.18E-09 | Not Detected |
| | Jun. 3 – Jun. 15 | 4.97E-09 | 3.86E-09 | 7.78E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.09E-09 | 1.72E-09 | 3.89E-09 | Not Detected |
| | Jun. 29 – July 22 | 4.27E-09 | 2.41E-09 | 2.24E-09 | Detected |
| | July 22 -Aug. 17 | 1.55E-09 | 1.04E-09 | 1.80E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.10E-09 | 5.76E-10 | 6.02E-10 | Detected |
| | Oct. 3 – Nov. 4 | 2.06E-10 | 9.67E-10 | 2.42E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.11E-09 | 8.21E-10 | 9.57E-10 | Detected |
| | Dec. 9 – Jan. 6 | 1.42E-09 | 9.17E-10 | 1.55E-09 | Not Detected |

### Table B.4. Activity concentrations of $^{239+240}$Pu at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | 4.83E-10 | 1.47E-09 | 3.61E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.20E-09 | 3.83E-09 | 9.38E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.41E-09 | 2.73E-09 | 4.92E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 8.66E-09 | 4.66E-09 | 7.69E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.30E-09 | 2.16E-09 | 3.90E-09 | Not Detected |
| | Apr. 29 – May 18 | 2.87E-09 | 1.65E-09 | 2.63E-09 | Detected |
| | May 18 – Jun. 3 | 4.89E-09 | 2.20E-09 | 2.87E-09 | Detected |
| | Jun. 3 – Jun. 15 | 4.87E-09 | 3.10E-09 | 5.44E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.71E-09 | 1.67E-09 | 3.32E-09 | Not Detected |
| | Jun. 29 – July 22 | 1.19E-09 | 9.00E-10 | 1.09E-09 | Detected |
| | July 22 -Aug. 17 | 2.44E-09 | 1.30E-09 | 1.63E-09 | Detected |
| | Aug. 17 – Oct. 3 | 1.18E-09 | 6.58E-10 | 9.87E-10 | Detected |
| | Oct. 3 – Nov. 4 | 4.05E-10 | 9.50E-10 | 2.27E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 6.03E-10 | 6.45E-10 | 1.35E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.69E-09 | 9.09E-10 | 1.26E-09 | Detected |

## Table B.5. Activity concentrations of $^{241}$Am at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{241}$Am** | Feb. 2 – Mar. 2 | 0.00E+00 | 3.01E-09 | 8.17E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 0.00E+00 | 1.23E-08 | 3.27E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | 4.08E-09 | 2.43E-09 | 3.94E-09 | Detected |
| | Mar. 30 - Apr. 13 | -2.60E-10 | 2.01E-09 | 5.54E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | -5.21E-09 | 1.25E-08 | 3.70E-08 | Not Detected |
| | Apr. 29 – May 18 | -4.72E-09 | 4.45E-09 | 1.45E-08 | Not Detected |
| | May 18 – Jun. 3 | 7.33E-09 | 3.03E-09 | 4.34E-09 | Detected |
| | Jun. 3 – Jun. 15 | -6.32E-09 | 1.32E-08 | 3.67E-08 | Not Detected |
| | Jun. 15 – Jun. 29 | -8.64E-09 | 6.98E-09 | 2.28E-08 | Not Detected |
| | Jun. 29 – July 22 | -3.76E-09 | 1.94E-09 | 6.50E-09 | Not Detected |
| | July 22 -Aug. 17 | -1.97E-10 | 1.31E-09 | 3.71E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | -4.79E-10 | 5.32E-10 | 1.68E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | -4.77E-10 | 5.36E-10 | 1.89E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | -6.11E-10 | 6.50E-10 | 2.30E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.07E-09 | 1.19E-09 | 1.95E-09 | Detected |

## Table B.6. Activity concentrations of $^{238}$Pu at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -3.22E-10 | 1.02E-09 | 3.03E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -3.99E-10 | 4.30E-09 | 1.12E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.55E-09 | 2.98E-09 | 6.96E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 4.33E-09 | 3.42E-09 | 6.29E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.83E-09 | 1.95E-09 | 4.11E-09 | Not Detected |
| | Apr. 29 – May 18 | 1.96E-09 | 1.64E-09 | 3.22E-09 | Not Detected |
| | May 18 – Jun. 3 | 2.17E-09 | 1.79E-09 | 3.41E-09 | Not Detected |
| | Jun. 3 – Jun. 15 | 2.98E-09 | 2.61E-09 | 5.09E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.91E-09 | 1.72E-09 | 3.32E-09 | Not Detected |
| | Jun. 29 – July 22 | 1.34E-09 | 9.96E-10 | 1.38E-09 | Not Detected |
| | July 22 -Aug. 17 | 1.76E-09 | 1.37E-09 | 2.55E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.35E-10 | 6.23E-10 | 1.40E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 0.00E+00 | 1.03E-09 | 2.67E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 7.37E-10 | 6.74E-10 | 1.35E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.03E-10 | 1.03E-09 | 2.27E-09 | Not Detected |

## Table B.7. Activity concentrations of $^{239+240}Pu$ at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{239+240}Pu$** | Feb. 2 – Mar. 2 | 1.03E-09 | 1.98E-09 | 4.62E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.06E-09 | 3.25E-09 | 7.95E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.90E-09 | 2.32E-09 | 4.18E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.45E-09 | 5.08E-09 | 7.01E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.37E-09 | 1.82E-09 | 2.79E-09 | Detected |
| | Apr. 29 – May 18 | 3.09E-09 | 1.48E-09 | 1.44E-09 | Detected |
| | May 18 – Jun. 3 | 4.92E-09 | 2.39E-09 | 3.56E-09 | Detected |
| | Jun. 3 – Jun. 15 | 4.53E-09 | 2.58E-09 | 3.40E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.50E-09 | 1.87E-09 | 3.35E-09 | Not Detected |
| | Jun. 29 – July 22 | 4.25E-09 | 5.00E-09 | 1.07E-08 | Not Detected |
| | July 22 -Aug. 17 | 3.10E-09 | 1.28E-09 | 1.07E-09 | Detected |
| | Aug. 17 – Oct. 3 | 1.14E-09 | 6.07E-10 | 7.62E-10 | Detected |
| | Oct. 3 – Nov. 4 | 2.41E-09 | 1.21E-09 | 1.45E-09 | Detected |
| | Nov. 4 – Dec. 9 | 8.81E-10 | 8.06E-10 | 1.61E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 9.45E-10 | 9.67E-10 | 1.98E-09 | Not Detected |

## Table B.8. Activity concentrations of $^{241}$Am at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{241}$Am** | Feb. 2 – Mar. 2 | -4.03E-09 | 9.90E-09 | 3.20E-08 | Not Detected |
| | Mar. 2 – Mar. 16 | -3.26E-09 | 8.42E-09 | 2.44E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | -2.04E-08 | 2.72E-08 | 8.68E-08 | Not Detected |
| | Mar. 30 - Apr. 13 | 3.62E-09 | 2.31E-09 | 2.42E-09 | Detected |
| | Apr. 13 - Apr. 29 | -9.52E-09 | 1.06E-08 | 3.34E-08 | Not Detected |
| | Apr. 29 – May 18 | 7.70E-10 | 5.55E-09 | 1.45E-08 | Not Detected |
| | May 18 – Jun. 3 | 5.01E-09 | 2.48E-09 | 3.45E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.95E-09 | 2.68E-09 | 5.94E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | -9.99E-10 | 1.73E-09 | 5.32E-09 | Not Detected |
| | Jun. 29 – July 22 | 3.71E-10 | 2.67E-09 | 6.97E-09 | Not Detected |
| | July 22 -Aug. 17 | 3.46E-10 | 2.49E-09 | 6.51E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | -3.37E-10 | 5.51E-10 | 1.58E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.25E-09 | 1.17E-09 | 2.44E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.90E-10 | 1.07E-09 | 2.57E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.35E-10 | 9.31E-10 | 1.98E-09 | Not Detected |

## Table B.9. Activity concentrations of $^{238}$Pu in the filter samples collected from Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -3.93E-16 | 1.75E-09 | 4.62E-09 | Not Detected |
|  | Mar. 2 – Mar. 16 | 1.06E-09 | 2.56E-09 | 6.17E-09 | Not Detected |
|  | Mar. 16 – Mar. 30 | 1.58E-09 | 2.24E-09 | 4.96E-09 | Not Detected |
|  | Mar. 30 - Apr. 13 | -1.49E-09 | 4.56E-09 | 1.27E-08 | Not Detected |
|  | Apr. 13 - Apr. 29 | 1.12E-09 | 2.01E-09 | 4.65E-09 | Not Detected |
|  | Apr. 29 – May 18 | 3.40E-09 | 1.52E-09 | 1.14E-09 | Detected |
|  | May 18 – Jun. 3 | 2.65E-09 | 2.53E-09 | 5.33E-09 | Not Detected |
|  | Jun. 3 – Jun. 15 | 1.98E-09 | 2.34E-09 | 4.93E-09 | Not Detected |
|  | Jun. 15 – Jun. 29 | 2.89E-09 | 2.17E-09 | 4.11E-09 | Not Detected |
|  | Jun. 29 – July 22 | 3.18E-09 | 4.52E-09 | 9.99E-09 | Not Detected |
|  | July 22 -Aug. 17 | 2.64E-09 | 1.16E-09 | 8.46E-10 | Detected |
|  | Aug. 17 – Oct. 3 | 4.44E-10 | 5.25E-10 | 1.11E-09 | Not Detected |
|  | Oct. 3 – Nov. 4 | 7.23E-10 | 1.02E-09 | 2.27E-09 | Not Detected |
|  | Nov. 4 – Dec. 9 | 3.20E-10 | 6.80E-10 | 1.55E-09 | Not Detected |
|  | Dec. 9 – Jan. 6 | 6.30E-10 | 1.15E-09 | 2.68E-09 | Not Detected |

### Table B.10. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Loving Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{241}$Am** | Feb. 2 – Mar. 2 | -7.04E-09 | 6.11E-09 | 2.14E-08 | Not Detected |
| | Mar. 2 – Mar. 16 | 0.00E+00 | 1.06E-08 | 2.82E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | -9.49E-09 | 1.98E-08 | 5.51E-08 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.68E-09 | 3.89E-09 | 7.77E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | -8.05E-09 | 1.61E-08 | 4.54E-08 | Not Detected |
| | Apr. 29 – May 18 | 1.11E-10 | 9.18E-10 | 2.37E-09 | Not Detected |
| | May 18 – Jun. 3 | 1.95E-09 | 2.42E-08 | 6.77E-08 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.27E-09 | 1.05E-08 | 2.71E-08 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.20E-08 | 1.35E-08 | 2.82E-08 | Not Detected |
| | Jun. 29 – July 22 | -5.65E-10 | 9.99E-10 | 3.28E-09 | Not Detected |
| | July 22 -Aug. 17 | -1.12E-09 | 2.10E-09 | 6.30E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 0.00E+00 | 1.43E-09 | 3.67E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | -4.21E-10 | 1.33E-09 | 3.96E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.37E-09 | 8.39E-10 | 1.53E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.31E-09 | 9.26E-10 | 1.63E-09 | Not Detected |
| | | | | | |
| **$^{239+240}$Pu** | Feb. 2 – Mar. 2 | 4.28E-10 | 1.82E-09 | 4.56E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.41E-09 | 2.44E-09 | 5.58E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 4.22E-09 | 2.74E-09 | 4.46E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 6.60E-09 | 4.86E-09 | 8.87E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.01E-09 | 2.34E-09 | 5.54E-09 | Not Detected |
| | Apr. 29 – May 18 | 3.73E-09 | 3.52E-09 | 7.02E-09 | Not Detected |
| | May 18 – Jun. 3 | 5.51E-09 | 2.28E-09 | 1.56E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.60E-09 | 1.90E-09 | 3.99E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 3.72E-09 | 2.16E-09 | 2.47E-09 | Detected |
| | Jun. 29 – July 22 | 1.58E-09 | 1.19E-09 | 2.09E-09 | Not Detected |
| | July 22 -Aug. 17 | 0.00E+00 | 6.14E-10 | 1.69E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.32E-09 | 6.50E-10 | 6.44E-10 | Detected |
| | Oct. 3 – Nov. 4 | 1.83E-09 | 9.45E-10 | 1.16E-09 | Detected |
| | Nov. 4 – Dec. 9 | 9.16E-10 | 6.53E-10 | 1.12E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.52E-09 | 8.75E-10 | 1.26E-09 | Detected |

### Table B.10. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Loving Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -2.14E-10 | 1.77E-09 | 4.80E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -2.47E-09 | 2.35E-09 | 7.90E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.45E-10 | 2.70E-09 | 6.62E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | -2.36E-09 | 4.12E-09 | 1.20E-08 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.35E-09 | 2.14E-09 | 5.89E-09 | Not Detected |
| | Apr. 29 – May 18 | 4.11E-09 | 3.90E-09 | 7.95E-09 | Not Detected |
| | May 18 – Jun. 3 | 4.66E-09 | 2.09E-09 | 1.56E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.37E-09 | 1.84E-09 | 3.99E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 3.46E-09 | 2.02E-09 | 1.96E-09 | Detected |
| | Jun. 29 – July 22 | 1.31E-09 | 1.45E-09 | 3.09E-09 | Not Detected |
| | July 22 -Aug. 17 | -3.88E-10 | 6.73E-10 | 2.07E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.32E-09 | 6.35E-10 | 5.11E-10 | Detected |
| | Oct. 3 – Nov. 4 | 2.32E-09 | 1.12E-09 | 1.53E-09 | Detected |
| | Nov. 4 – Dec. 9 | 9.16E-10 | 8.15E-10 | 1.66E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 9.87E-10 | 7.89E-10 | 1.42E-09 | Not Detected |

### Table B.11. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Carlsbad Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | 2.02E-09 | 4.16E-09 | 9.78E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.09E-08 | 7.68E-09 | 2.68E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | -7.08E-09 | 5.65E-09 | 1.99E-08 | Not Detected |
| | Mar. 30 - Apr. 13 | 0.00E+00 | 3.30E-09 | 8.86E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.46E-09 | 6.52E-09 | 2.05E-08 | Not Detected |
| | Apr. 29 – May 18 | -8.65E-10 | 8.14E-10 | 2.65E-09 | Not Detected |
| | May 18 – Jun. 3 | 2.88E-09 | 5.29E-09 | 1.23E-08 | Not Detected |
| | Jun. 3 – Jun. 15 | 0.00E+00 | 2.90E-09 | 8.13E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | -5.15E-09 | 5.08E-09 | 1.79E-08 | Not Detected |
| | Jun. 29 – July 22 | 0.00E+00 | 1.23E-09 | 3.28E-09 | Not Detected |
| | July 22 -Aug. 17 | -2.48E-09 | 1.77E-09 | 5.96E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 9.46E-10 | 7.94E-10 | 1.61E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 6.78E-09 | 5.14E-09 | 6.24E-09 | Detected |
| | Nov. 4 – Dec. 9 | 1.85E-09 | 9.70E-10 | 1.51E-09 | Detected |
| | Dec. 9 – Jan. 6 | 5.61E-10 | 1.03E-09 | 2.39E-09 | Not Detected |
| | | | | | |
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | 1.22E-09 | 1.63E-09 | 3.54E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.75E-09 | 5.35E-09 | 1.49E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | 4.55E-09 | 3.53E-09 | 6.58E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.83E-09 | 4.14E-09 | 4.78E-09 | Detected |
| | Apr. 13 - Apr. 29 | 2.45E-09 | 2.49E-09 | 5.22E-09 | Not Detected |
| | Apr. 29 – May 18 | 5.63E-09 | 4.29E-09 | 8.08E-09 | Not Detected |
| | May 18 – Jun. 3 | 3.19E-09 | 1.54E-09 | 2.11E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.60E-09 | 2.32E-09 | 5.08E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 4.73E-09 | 2.44E-09 | 2.99E-09 | Detected |
| | Jun. 29 – July 22 | 1.48E-09 | 2.84E-09 | 6.63E-09 | Not Detected |
| | July 22 -Aug. 17 | 1.26E-09 | 8.88E-10 | 1.56E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.00E-10 | 5.24E-10 | 1.21E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.84E-09 | 1.38E-09 | 2.61E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.19E-09 | 9.38E-10 | 1.81E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.58E-09 | 1.07E-09 | 1.83E-09 | Not Detected |

### Table B.11. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -1.62E-09 | 2.00E-09 | 5.89E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | -4.08E-09 | 6.08E-09 | 1.74E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | -1.05E-09 | 3.64E-09 | 9.86E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.36E-09 | 2.35E-09 | 5.38E-06 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.00E-09 | 2.23E-09 | 4.74E-09 | Not Detected |
| | Apr. 29 – May 18 | 3.21E-09 | 3.78E-09 | 8.08E-09 | Not Detected |
| | May 18 – Jun. 3 | 1.06E-09 | 1.36E-09 | 2.99E-09 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.89E-08 | 5.98E-09 | 7.19E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.74E-09 | 2.19E-09 | 3.95E-09 | Not Detected |
| | Jun. 29 – July 22 | -2.96E-10 | 2.96E-09 | 7.81E-09 | Not Detected |
| | July 22 -Aug. 17 | 1.17E-09 | 8.68E-10 | 1.56E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 9.01E-10 | 6.53E-10 | 1.21E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.47E-09 | 1.21E-09 | 2.30E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 5.09E-10 | 7.22E-10 | 1.60E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.21E-09 | 1.23E-09 | 1.98E-09 | Detected |

**Table B.12. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from East Tower Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -1.40E-09 | 6.25E-09 | 1.71E-08 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.28E-08 | 1.16E-08 | 3.61E-08 | Not Detected |
| | Mar. 16 – Mar. 30 | -1.22E-08 | 2.60E-08 | 7.49E-08 | Not Detected |
| | Mar. 30 - Apr. 13 | -6.79E-08 | 7.11E-08 | 2.28E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | -5.22E-09 | 1.05E-08 | 3.27E-08 | Not Detected |
| | Apr. 29 – May 18 | -9.89E-09 | 1.24E-08 | 3.88E-08 | Not Detected |
| | May 18 – Jun. 3 | 6.98E-09 | 2.59E-09 | 2.91E-09 | Detected |
| | Jun. 3 – Jun. 15 | 7.34E-09 | 4.12E-09 | 5.11E-09 | Detected |
| | Jun. 15 – Jun. 29 | 3.34E-09 | 6.70E-09 | 1.57E-08 | Not Detected |
| | Jun. 29 – July 22 | -9.24E-10 | 8.06E-10 | 2.71E-09 | Not Detected |
| | July 22 -Aug. 17 | -5.52E-10 | 1.61E-09 | 4.51E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | -7.61E-11 | 5.49E-10 | 1.53E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | -1.34E-09 | 2.33E-09 | 7.15E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | -5.55E-10 | 9.80E-10 | 3.22E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.03E-09 | 1.18E-09 | 7.68E-10 | Detected |
| | | | | | |
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | -3.35E-10 | 2.12E-09 | 5.51E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 9.11E-17 | 2.16E-09 | 6.06E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 4.51E-09 | 3.39E-09 | 5.96E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 6.95E-09 | 4.49E-09 | 7.56E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.76E-09 | 2.09E-09 | 4.05E-09 | Not Detected |
| | Apr. 29 – May 18 | 2.96E-09 | 2.09E-09 | 3.91E-09 | Not Detected |
| | May 18 – Jun. 3 | 3.79E-09 | 2.37E-09 | 4.26E-09 | Not Detected |
| | Jun. 3 – Jun. 15 | 6.68E-09 | 3.09E-09 | 3.49E-09 | Detected |
| | Jun. 15 – Jun. 29 | 3.67E-09 | 2.25E-09 | 3.89E-09 | Not Detected |
| | Jun. 29 – July 22 | 7.05E-09 | 4.20E-09 | 6.98E-09 | Detected |
| | July 22 -Aug. 17 | 9.04E-10 | 1.07E-09 | 2.25E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 6.03E-10 | 5.15E-10 | 9.56E-10 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.95E-10 | 8.58E-10 | 2.10E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 9.67E-10 | 6.22E-10 | 8.93E-10 | Detected |
| | Dec. 9 – Jan. 6 | 3.47E-10 | 8.34E-10 | 2.01E-09 | Not Detected |

## Table B.12. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from East Tower Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -2.18E-09 | 2.00E-09 | 5.85E-09 | Not Detected |
| | Mar. 2 – Mar. 16 | 3.82E-10 | 2.96E-09 | 7.68E-09 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.01E-09 | 3.84E-09 | 8.43E-09 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.74E-09 | 3.48E-09 | 8.17E-09 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.93E-09 | 2.38E-09 | 4.86E-09 | Not Detected |
| | Apr. 29 – May 18 | 1.57E-09 | 1.53E-09 | 3.04E-09 | Not Detected |
| | May 18 – Jun. 3 | 3.79E-10 | 2.01E-09 | 5.01E-09 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.45E-09 | 2.40E-09 | 5.46E-09 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.93E-09 | 1.90E-09 | 3.89E-09 | Not Detected |
| | Jun. 29 – July 22 | 6.31E-09 | 3.98E-09 | 6.46E-09 | Not Detected |
| | July 22 -Aug. 17 | 9.04E-10 | 1.24E-09 | 2.75E-09 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.62E-10 | 6.16E-10 | 1.42E-09 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.57E-09 | 1.02E-09 | 1.71E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 9.67E-10 | 6.89E-10 | 1.18E-09 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.50E-09 | 1.02E-09 | 1.63E-09 | Not Detected |

### Table B.13. Specific activities of $^{241}$Am in the filter samples collected from Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -4.89E-05 | 4.83E-05 | 1.70E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.23E-04 | 2.62E-04 | 7.56E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -1.84E-04 | 2.61E-04 | 8.63E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | -5.03E-05 | 4.02E-05 | 1.41E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.73E-04 | 1.40E-01 | 4.56E-04 | Not Detected |
| | Apr. 29 – May 18 | -1.12E-05 | 1.78E-05 | 5.65E-05 | Not Detected |
| | May 18 – Jun. 3 | -8.18E-05 | 6.84E-05 | 2.07E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 5.73E-05 | 2.50E-05 | 3.48E-05 | Detected |
| | Jun. 15 – Jun. 29 | -6.00E-06 | 4.94E-05 | 1.35E-04 | Not Detected |
| | Jun. 29 – July 22 | -1.23E-05 | 1.26E-05 | 3.84E-05 | Not Detected |
| | July 22 -Aug. 17 | 0.00E+00 | 3.40E-05 | 9.53E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | -8.22E-07 | 6.37E-06 | 1.75E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 0.00E+00 | 2.22E-05 | 6.03E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.99E-05 | 2.02E-05 | 3.73E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.68E-05 | 2.60E-05 | 4.07E-05 | Detected |

### Table B.14. Specific activities of $^{239+240}Pu$ in the filter samples collected from Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Feb. 2 – Mar. 2 | 1.84E-06 | 1.10E-05 | 2.92E-05 | Not Detected |
|  | Mar. 2 – Mar. 16 | -1.36E-05 | 5.75E-05 | 1.59E-04 | Not Detected |
|  | Mar. 16 – Mar. 30 | 1.75E-05 | 1.96E-05 | 4.11E-05 | Not Detected |
|  | Mar. 30 - Apr. 13 | 3.80E-05 | 1.99E-05 | 3.11E-05 | Detected |
|  | Apr. 13 - Apr. 29 | 2.68E-05 | 1.66E-05 | 2.74E-05 | Not Detected |
|  | Apr. 29 – May 18 | 6.30E-05 | 3.91E-05 | 6.45E-05 | Not Detected |
|  | May 18 – Jun. 3 | 3.97E-05 | 2.07E-05 | 3.00E-05 | Detected |
|  | Jun. 3 – Jun. 15 | 4.55E-05 | 2.46E-05 | 3.89E-05 | Detected |
|  | Jun. 15 – Jun. 29 | 4.21E-05 | 2.82E-05 | 4.95E-05 | Not Detected |
|  | Jun. 29 – July 22 | 7.64E-05 | 4.02E-05 | 3.52E-05 | Detected |
|  | July 22 -Aug. 17 | 2.16E-05 | 1.28E-05 | 1.73E-05 | Detected |
|  | Aug. 17 – Oct. 3 | 2.00E-05 | 1.02E-05 | 8.65E-06 | Detected |
|  | Oct. 3 – Nov. 4 | 4.22E-05 | 2.73E-05 | 4.46E-05 | Not Detected |
|  | Nov. 4 – Dec. 9 | 1.81E-05 | 1.11E-05 | 1.55E-05 | Detected |
|  | Dec. 9 – Jan. 6 | 2.45E-05 | 2.52E-05 | 5.23E-05 | Not Detected |

## Table B.15. Specific activities of $^{238}$Pu in the filter samples collected from Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}$Pu** | Feb. 2 – Mar. 2 | 9.20E-06 | 1.22E-05 | 2.59E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | -2.03E-05 | 4.89E-05 | 1.44E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.96E-05 | 2.19E-05 | 4.65E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 6.61E-06 | 1.48E-05 | 3.52E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.52E-05 | 1.63E-05 | 2.74E-05 | Not Detected |
| | Apr. 29 – May 18 | 7.41E-06 | 2.10E-05 | 5.22E-05 | Not Detected |
| | May 18 – Jun. 3 | 9.44E-06 | 1.81E-05 | 4.24E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 3.72E-05 | 2.89E-05 | 5.83E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.58E-05 | 2.47E-05 | 5.60E-05 | Not Detected |
| | Jun. 29 – July 22 | 6.69E-05 | 3.77E-05 | 3.52E-05 | Detected |
| | July 22 -Aug. 17 | 2.16E-05 | 1.46E-05 | 2.51E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.00E-05 | 1.05E-05 | 1.09E-05 | Detected |
| | Oct. 3 – Nov. 4 | 5.63E-06 | 2.64E-05 | 6.61E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.53E-05 | 1.76E-05 | 2.05E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.93E-05 | 2.54E-05 | 4.27E-05 | Not Detected |

### Table B.16. Specific activities of $^{241}$Am in the filter samples collected from Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | 0.00E+00 | 6.25E-05 | 1.70E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | 0.00E+00 | 1.86E-04 | 4.96E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.45E-05 | 2.06E-05 | 3.34E-05 | Detected |
| | Mar. 30 - Apr. 13 | -2.94E-06 | 2.28E-05 | 6.26E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | -7.75E-05 | 1.87E-04 | 5.50E-04 | Not Detected |
| | Apr. 29 – May 18 | -6.46E-05 | 6.09E-05 | 1.98E-04 | Not Detected |
| | May 18 – Jun. 3 | 8.82E-05 | 3.65E-05 | 5.22E-05 | Detected |
| | Jun. 3 – Jun. 15 | -6.29E-05 | 1.31E-04 | 3.65E-04 | Not Detected |
| | Jun. 15 – Jun. 29 | -2.38E-04 | 1.92E-04 | 6.28E-04 | Not Detected |
| | Jun. 29 – July 22 | -6.56E-05 | 3.38E-05 | 1.13E-04 | Not Detected |
| | July 22 -Aug. 17 | -3.56E-06 | 2.36E-05 | 6.70E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | -1.09E-05 | 1.21E-05 | 3.82E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | -1.70E-05 | 1.91E-05 | 6.76E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.11E-05 | 2.24E-05 | 7.93E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.47E-05 | 4.87E-05 | 7.97E-05 | Detected |

## Table B.17. Specific activities of $^{239+240}$Pu at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{239+240}$Pu** | Feb. 2 – Mar. 2 | 1.00E-05 | 3.07E-05 | 7.51E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.82E-05 | 5.81E-05 | 1.42E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.89E-05 | 2.31E-05 | 4.17E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.79E-05 | 5.27E-05 | 8.70E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.90E-05 | 3.22E-05 | 5.80E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.92E-05 | 2.26E-05 | 3.60E-05 | Detected |
| | May 18 – Jun. 3 | 5.89E-05 | 2.65E-05 | 3.46E-05 | Detected |
| | Jun. 3 – Jun. 15 | 4.85E-05 | 3.09E-05 | 5.42E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 4.72E-05 | 4.60E-05 | 9.13E-05 | Not Detected |
| | Jun. 29 – July 22 | 2.07E-05 | 1.57E-05 | 1.91E-05 | Detected |
| | July 22 -Aug. 17 | 4.40E-05 | 2.34E-05 | 2.94E-05 | Detected |
| | Aug. 17 – Oct. 3 | 2.69E-05 | 1.50E-05 | 2.25E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.45E-05 | 3.39E-05 | 8.11E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.08E-05 | 2.22E-05 | 4.64E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 6.94E-05 | 3.72E-05 | 5.15E-05 | Detected |

### Table B.18. Specific activities of $^{238}$Pu at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -8.38E-11 | 2.12E-05 | 6.30E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.51E-10 | 6.52E-05 | 1.71E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.32E-10 | 2.52E-05 | 5.90E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.29E-09 | 3.86E-05 | 7.10E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 6.05E-10 | 2.90E-05 | 6.11E-05 | Not Detected |
| | Apr. 29 – May 18 | 5.27E-10 | 2.24E-05 | 4.40E-05 | Not Detected |
| | May 18 – Jun. 3 | 6.02E-10 | 2.15E-05 | 4.10E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.01E-10 | 2.60E-05 | 5.07E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.33E-09 | 4.72E-05 | 9.13E-05 | Not Detected |
| | Jun. 29 – July 22 | 3.58E-10 | 1.74E-05 | 2.41E-05 | Not Detected |
| | July 22 -Aug. 17 | 4.50E-10 | 2.47E-05 | 4.60E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 7.22E-11 | 1.42E-05 | 3.18E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 0.00E+00 | 3.69E-05 | 9.55E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.24E-10 | 2.32E-05 | 4.64E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.60E-10 | 4.21E-05 | 9.30E-05 | Not Detected |

## Table B.19. Specific activities of $^{241}$Am at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -7.34E-05 | 1.80E-04 | 5.82E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | -5.36E-05 | 1.38E-04 | 4.01E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -2.52E-04 | 3.36E-04 | 1.07E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 3.82E-05 | 2.44E-05 | 2.56E-05 | Detected |
| | Apr. 13 - Apr. 29 | -1.35E-04 | 1.50E-04 | 4.72E-04 | Not Detected |
| | Apr. 29 – May 18 | 9.64E-06 | 6.95E-05 | 1.81E-04 | Not Detected |
| | May 18 – Jun. 3 | 6.08E-05 | 3.01E-05 | 4.19E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.89E-05 | 2.60E-05 | 5.77E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | -1.47E-05 | 2.54E-05 | 7.81E-05 | Not Detected |
| | Jun. 29 – July 22 | 5.98E-06 | 4.31E-05 | 1.13E-04 | Not Detected |
| | July 22 -Aug. 17 | 6.10E-06 | 4.40E-05 | 1.15E-04 | Not Detected |
| | Aug. 17 – Oct. 3 | -8.74E-06 | 1.43E-05 | 4.11E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.25E-05 | 3.05E-05 | 6.36E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.07E-05 | 2.94E-05 | 7.08E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.15E-05 | 2.40E-05 | 5.10E-05 | Not Detected |

## Table B.20. Specific activities of $^{239+240}$Pu at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{239+240}$Pu** | Feb. 2 – Mar. 2 | 1.87E-05 | 3.60E-05 | 8.41E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.75E-05 | 5.34E-05 | 1.31E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.58E-05 | 2.86E-05 | 5.17E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.99E-05 | 5.37E-05 | 7.41E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.76E-05 | 2.57E-05 | 3.95E-05 | Detected |
| | Apr. 29 – May 18 | 3.87E-05 | 1.86E-05 | 1.80E-05 | Detected |
| | May 18 – Jun. 3 | 5.97E-05 | 2.90E-05 | 4.32E-05 | Detected |
| | Jun. 3 – Jun. 15 | 4.40E-05 | 2.50E-05 | 3.30E-05 | Detected |
| | Jun. 15 – Jun. 29 | 3.67E-05 | 2.74E-05 | 4.92E-05 | Not Detected |
| | Jun. 29 – July 22 | 6.85E-05 | 8.07E-05 | 1.72E-04 | Not Detected |
| | July 22 -Aug. 17 | 5.48E-05 | 2.26E-05 | 1.88E-05 | Detected |
| | Aug. 17 – Oct. 3 | 2.97E-05 | 1.58E-05 | 1.98E-05 | Detected |
| | Oct. 3 – Nov. 4 | 6.28E-05 | 3.14E-05 | 3.77E-05 | Detected |
| | Nov. 4 – Dec. 9 | 2.42E-05 | 2.22E-05 | 4.43E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.44E-05 | 2.50E-05 | 5.10E-05 | Not Detected |

## Table B.21. Specific activities of $^{238}$Pu at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -7.15E-12 | 3.18E-05 | 8.41E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.75E-05 | 4.20E-05 | 1.01E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.95E-05 | 2.77E-05 | 6.13E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | -1.58E-05 | 4.82E-05 | 1.34E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.59E-05 | 2.83E-05 | 6.57E-05 | Not Detected |
| | Apr. 29 – May 18 | 4.26E-05 | 1.91E-05 | 1.43E-05 | Detected |
| | May 18 – Jun. 3 | 3.21E-05 | 3.07E-05 | 6.47E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.93E-05 | 2.28E-05 | 4.79E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 4.24E-05 | 3.18E-05 | 6.02E-05 | Not Detected |
| | Jun. 29 – July 22 | 5.14E-05 | 7.29E-05 | 1.61E-04 | Not Detected |
| | July 22 -Aug. 17 | 4.67E-05 | 2.05E-05 | 1.49E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.15E-05 | 1.36E-05 | 2.87E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.88E-05 | 2.67E-05 | 5.91E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 8.81E-06 | 1.87E-05 | 4.25E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.63E-05 | 2.97E-05 | 6.91E-05 | Not Detected |

## Table B.22. Specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Loving Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -9.70E-05 | 8.41E-05 | 2.95E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | 0.00E+00 | 1.31E-04 | 3.50E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -6.24E-05 | 1.30E-04 | 3.62E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | 4.53E-05 | 3.10E-05 | 6.20E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | -9.65E-05 | 1.93E-04 | 5.44E-04 | Not Detected |
| | Apr. 29 – May 18 | 1.08E-06 | 8.88E-06 | 2.29E-05 | Not Detected |
| | May 18 – Jun. 3 | 1.05E-05 | 1.31E-04 | 3.65E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.78E-06 | 8.07E-05 | 2.09E-04 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.88E-04 | 2.12E-04 | 4.43E-04 | Not Detected |
| | Jun. 29 – July 22 | -8.89E-06 | 1.57E-05 | 5.16E-05 | Not Detected |
| | July 22 -Aug. 17 | -1.79E-05 | 3.36E-05 | 1.00E-04 | Not Detected |
| | Aug. 17 – Oct. 3 | 0.00E+00 | 2.36E-05 | 6.05E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | -1.29E-05 | 4.09E-05 | 1.22E-04 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.14E-05 | 2.54E-05 | 4.62E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.03E-05 | 2.85E-05 | 5.02E-05 | Not Detected |
| | | | | | |
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | 5.90E-06 | 2.50E-05 | 6.29E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.74E-05 | 3.03E-05 | 6.91E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.78E-05 | 1.80E-05 | 2.94E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.26E-05 | 3.87E-05 | 7.07E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.21E-05 | 2.80E-05 | 6.64E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.61E-05 | 3.41E-05 | 6.80E-05 | Not Detected |
| | May 18 – Jun. 3 | 2.97E-05 | 1.23E-05 | 8.42E-06 | Detected |
| | Jun. 3 – Jun. 15 | 1.23E-05 | 1.46E-05 | 3.07E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 5.85E-05 | 3.40E-05 | 3.88E-05 | Detected |
| | Jun. 29 – July 22 | 2.48E-05 | 1.87E-05 | 3.28E-05 | Not Detected |
| | July 22 -Aug. 17 | 0.00E+00 | 9.79E-06 | 2.70E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.17E-05 | 1.07E-05 | 1.06E-05 | Detected |
| | Oct. 3 – Nov. 4 | 5.63E-05 | 2.90E-05 | 3.56E-05 | Detected |
| | Nov. 4 – Dec. 9 | 2.77E-05 | 1.97E-05 | 3.38E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.70E-05 | 2.70E-05 | 3.90E-05 | Detected |

### Table B.22. Specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Loving Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}$Pu** | Feb. 2 – Mar. 2 | -2.95E-06 | 2.43E-05 | 6.62E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | -3.05E-05 | 2.91E-05 | 9.78E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.55E-06 | 1.78E-05 | 4.35E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | -1.88E-05 | 3.28E-05 | 9.58E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.62E-05 | 2.56E-05 | 7.06E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.97E-05 | 3.78E-05 | 7.70E-05 | Not Detected |
| | May 18 – Jun. 3 | 2.52E-05 | 1.13E-05 | 8.42E-06 | Detected |
| | Jun. 3 – Jun. 15 | 1.06E-05 | 1.41E-05 | 3.07E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 5.43E-05 | 3.18E-05 | 3.07E-05 | Detected |
| | Jun. 29 – July 22 | 2.07E-05 | 2.28E-05 | 4.86E-05 | Not Detected |
| | July 22 -Aug. 17 | -6.19E-06 | 1.07E-05 | 3.30E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.17E-05 | 1.05E-05 | 8.42E-06 | Detected |
| | Oct. 3 – Nov. 4 | 7.12E-05 | 3.43E-05 | 4.70E-05 | Detected |
| | Nov. 4 – Dec. 9 | 2.77E-05 | 2.46E-05 | 5.00E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.04E-05 | 2.43E-05 | 4.38E-05 | Not Detected |

### Table B.23. Specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Carlsbad Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | 3.45E-05 | 7.10E-05 | 1.67E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.43E-04 | 1.00E-04 | 3.51E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -6.57E-05 | 5.25E-05 | 1.84E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | 0.00E+00 | 2.97E-05 | 7.99E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | -2.02E-05 | 9.03E-05 | 2.85E-04 | Not Detected |
| | Apr. 29 – May 18 | -9.98E-06 | 9.39E-06 | 3.06E-05 | Not Detected |
| | May 18 – Jun. 3 | 2.44E-05 | 4.48E-05 | 1.04E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 0.00E+00 | 2.01E-05 | 5.63E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | -8.07E-05 | 7.95E-05 | 2.81E-04 | Not Detected |
| | Jun. 29 – July 22 | 0.00E+00 | 2.16E-05 | 5.76E-05 | Not Detected |
| | July 22 -Aug. 17 | -5.36E-05 | 3.81E-05 | 1.29E-04 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.66E-05 | 2.23E-05 | 4.52E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.24E-04 | 1.70E-04 | 2.06E-04 | Detected |
| | Nov. 4 – Dec. 9 | 4.97E-05 | 2.61E-05 | 4.07E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.92E-05 | 3.53E-05 | 8.19E-05 | Not Detected |
| | | | | | |
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | 2.08E-05 | 2.78E-05 | 6.04E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | -2.29E-05 | 7.00E-05 | 1.94E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 4.22E-05 | 3.28E-05 | 6.11E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 8.86E-05 | 3.73E-05 | 4.31E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.39E-05 | 3.45E-05 | 7.24E-05 | Not Detected |
| | Apr. 29 – May 18 | 6.49E-05 | 4.95E-05 | 9.32E-05 | Not Detected |
| | May 18 – Jun. 3 | 2.71E-05 | 1.31E-05 | 1.79E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.11E-05 | 1.60E-05 | 3.52E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 7.40E-05 | 3.82E-05 | 4.68E-05 | Detected |
| | Jun. 29 – July 22 | 2.60E-05 | 4.99E-05 | 1.17E-04 | Not Detected |
| | July 22 -Aug. 17 | 2.71E-05 | 1.92E-05 | 3.37E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 8.45E-06 | 1.48E-05 | 3.40E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 6.08E-05 | 4.56E-05 | 8.64E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.20E-05 | 2.52E-05 | 4.86E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 5.41E-05 | 3.65E-05 | 6.28E-05 | Not Detected |

## Table B.23. Specific activity of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}$Pu** | Feb. 2 – Mar. 2 | -2.77E-05 | 3.41E-05 | 1.01E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | -5.34E-05 | 7.95E-05 | 2.28E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -9.74E-06 | 3.38E-05 | 9.15E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.22E-05 | 2.12E-05 | 4.85E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.77E-05 | 3.09E-05 | 6.56E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.71E-05 | 4.36E-05 | 9.32E-05 | Not Detected |
| | May 18 – Jun. 3 | 9.02E-06 | 1.15E-05 | 2.53E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.31E-04 | 4.14E-05 | 4.98E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.29E-05 | 3.43E-05 | 6.18E-05 | Not Detected |
| | Jun. 29 – July 22 | -5.20E-06 | 5.20E-05 | 1.37E-04 | Not Detected |
| | July 22 -Aug. 17 | 2.52E-05 | 1.87E-05 | 3.37E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.54E-05 | 1.84E-05 | 3.40E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 4.86E-05 | 4.00E-05 | 7.63E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.37E-05 | 1.94E-05 | 4.29E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 7.57E-05 | 4.22E-05 | 6.79E-05 | Detected |

## Table B.24. Specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from East Tower Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 2 – Mar. 2 | -2.22E-05 | 9.92E-05 | 2.72E-04 | Not Detected |
| | Mar. 2 – Mar. 16 | -1.30E-04 | 1.18E-04 | 3.67E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | -1.36E-04 | 2.89E-04 | 8.32E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | -5.80E-04 | 6.07E-04 | 1.95E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | -6.04E-05 | 1.21E-04 | 3.79E-04 | Not Detected |
| | Apr. 29 – May 18 | -1.02E-04 | 1.28E-04 | 3.99E-04 | Not Detected |
| | May 18 – Jun. 3 | 7.32E-05 | 2.72E-05 | 3.06E-05 | Detected |
| | Jun. 3 – Jun. 15 | 5.78E-05 | 3.24E-05 | 4.03E-05 | Detected |
| | Jun. 15 – Jun. 29 | 5.02E-05 | 1.01E-04 | 2.36E-04 | Not Detected |
| | Jun. 29 – July 22 | -1.51E-05 | 1.32E-05 | 4.44E-05 | Not Detected |
| | July 22 -Aug. 17 | -8.37E-06 | 2.43E-05 | 6.84E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | -1.71E-06 | 1.24E-05 | 3.45E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | -3.88E-05 | 6.74E-05 | 2.07E-04 | Not Detected |
| | Nov. 4 – Dec. 9 | -1.49E-05 | 2.63E-05 | 8.63E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.82E-05 | 3.45E-05 | 2.24E-05 | Detected |
| | | | | | |
| $^{239+240}$Pu | Feb. 2 – Mar. 2 | -5.32E-06 | 3.36E-05 | 8.73E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 9.25E-13 | 2.20E-05 | 6.16E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.01E-05 | 3.77E-05 | 6.62E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.93E-05 | 3.84E-05 | 6.46E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 3.19E-05 | 2.42E-05 | 4.69E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.05E-05 | 2.15E-05 | 4.03E-05 | Not Detected |
| | May 18 – Jun. 3 | 3.98E-05 | 2.49E-05 | 4.47E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 5.26E-05 | 2.44E-05 | 2.75E-05 | Detected |
| | Jun. 15 – Jun. 29 | 5.52E-05 | 3.39E-05 | 5.84E-05 | Not Detected |
| | Jun. 29 – July 22 | 1.15E-04 | 6.88E-05 | 1.14E-04 | Detected |
| | July 22 -Aug. 17 | 1.37E-05 | 1.62E-05 | 3.41E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.36E-05 | 1.16E-05 | 2.15E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 8.55E-06 | 2.49E-05 | 6.07E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.59E-05 | 1.67E-05 | 2.40E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.01E-05 | 2.43E-05 | 5.87E-05 | Not Detected |

## Table B.24. Specific activities of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu in the filter samples collected from East Tower Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Feb. 2 – Mar. 2 | -5.32E-06 | 3.36E-05 | 8.73E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 9.25E-13 | 2.20E-05 | 6.16E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.01E-05 | 3.77E-05 | 6.62E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.93E-05 | 3.84E-05 | 6.46E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 3.19E-05 | 2.42E-05 | 4.69E-05 | Not Detected |
| | Apr. 29 – May 18 | 3.05E-05 | 2.15E-05 | 4.03E-05 | Not Detected |
| | May 18 – Jun. 3 | 3.98E-05 | 2.49E-05 | 4.47E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 5.26E-05 | 2.44E-05 | 2.75E-05 | Detected |
| | Jun. 15 – Jun. 29 | 5.52E-05 | 3.39E-05 | 5.84E-05 | Not Detected |
| | Jun. 29 – July 22 | 1.15E-04 | 6.88E-05 | 1.14E-04 | Detected |
| | July 22 -Aug. 17 | 1.37E-05 | 1.62E-05 | 3.41E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.36E-05 | 1.16E-05 | 2.15E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 8.55E-06 | 2.49E-05 | 6.07E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.59E-05 | 1.67E-05 | 2.40E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.01E-05 | 2.43E-05 | 5.87E-05 | Not Detected |

### Table B.25. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 1.70E-07 | 2.12E-08 | 3.95E-09 | Detected |
|  | Mar. 2 – Mar. 16 | 2.91E-07 | 3.49E-08 | 6.69E-09 | Detected |
|  | Mar. 16 – Mar. 30 | 3.78E-07 | 4.39E-08 | 6.23E-09 | Detected |
|  | Mar. 30 - Apr. 13 | 3.20E-07 | 3.77E-08 | 5.13E-09 | Detected |
|  | Apr. 13 - Apr. 29 | 3.46E-07 | 3.99E-08 | 3.68E-09 | Detected |
|  | Apr. 29 – May 18 | 3.35E-07 | 4.02E-08 | 5.91E-09 | Detected |
|  | May 18 – Jun. 3 | 3.18E-07 | 3.64E-08 | 3.15E-09 | Detected |
|  | Jun. 3 – Jun. 15 | 2.96E-07 | 3.33E-08 | 3.79E-09 | Detected |
|  | Jun. 15 – Jun. 29 | 3.00E-07 | 3.62E-08 | 5.93E-09 | Detected |
|  | Jun. 29 – July 22 | 2.16E-07 | 2.59E-08 | 3.85E-09 | Detected |
|  | July 22 -Aug. 17 | 1.07E-07 | 1.33E-08 | 2.03E-09 | Detected |
|  | Aug. 17 – Oct. 3 | 6.42E-08 | 7.85E-09 | 1.30E-09 | Detected |
|  | Oct. 3 – Nov. 4 | 6.13E-08 | 8.49E-09 | 2.81E-09 | Detected |
|  | Nov. 4 – Dec. 9 | 6.95E-08 | 8.76E-09 | 1.93E-09 | Detected |
|  | Dec. 9 – Jan. 6 | 1.33E-07 | 1.59E-08 | 2.55E-09 | Detected |
|  |  |  |  |  |  |
| $^{235}$U | Feb. 2 – Mar. 2 | 6.17E-09 | 2.63E-09 | 3.46E-09 | Detected |
|  | Mar. 2 – Mar. 16 | 1.21E-08 | 4.45E-09 | 5.26E-09 | Detected |
|  | Mar. 16 – Mar. 30 | 1.63E-08 | 5.14E-09 | 6.00E-09 | Detected |
|  | Mar. 30 - Apr. 13 | 1.70E-08 | 4.80E-09 | 4.10E-09 | Detected |
|  | Apr. 13 - Apr. 29 | 1.94E-08 | 4.83E-09 | 3.58E-09 | Detected |
|  | Apr. 29 – May 18 | 1.72E-08 | 5.18E-09 | 4.71E-09 | Detected |
|  | May 18 – Jun. 3 | 1.42E-08 | 3.91E-09 | 3.27E-09 | Detected |
|  | Jun. 3 – Jun. 15 | 1.52E-08 | 3.87E-09 | 3.19E-09 | Detected |
|  | Jun. 15 – Jun. 29 | 1.46E-08 | 4.84E-09 | 5.20E-09 | Detected |
|  | Jun. 29 – July 22 | 7.37E-09 | 2.74E-09 | 3.07E-09 | Detected |
|  | July 22 -Aug. 17 | 4.75E-09 | 1.82E-09 | 1.73E-09 | Detected |
|  | Aug. 17 – Oct. 3 | 2.96E-09 | 1.12E-09 | 1.27E-09 | Detected |
|  | Oct. 3 – Nov. 4 | 2.12E-09 | 1.43E-09 | 2.46E-09 | Not Detected |
|  | Nov. 4 – Dec. 9 | 3.44E-09 | 1.27E-09 | 9.38E-10 | Detected |
|  | Dec. 9 – Jan. 6 | 4.75E-09 | 1.75E-09 | 1.81E-09 | Detected |

### Table B.25. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) at Onsite Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 1.45E-07 | 1.84E-08 | 3.94E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.62E-07 | 3.19E-08 | 9.15E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.37E-07 | 3.96E-08 | 6.59E-09 | Detected |
| | Mar. 30 - Apr. 13 | 2.94E-07 | 3.49E-08 | 6.38E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.09E-07 | 3.61E-08 | 5.28E-09 | Detected |
| | Apr. 29 – May 18 | 2.83E-07 | 3.48E-08 | 7.16E-09 | Detected |
| | May 18 – Jun. 3 | 2.94E-07 | 3.39E-08 | 4.69E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.63E-07 | 3.00E-08 | 4.75E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.77E-07 | 3.37E-08 | 7.56E-09 | Detected |
| | Jun. 29 – July 22 | 2.09E-07 | 2.51E-08 | 4.67E-09 | Detected |
| | July 22 -Aug. 17 | 1.03E-07 | 1.29E-08 | 2.73E-09 | Detected |
| | Aug. 17 – Oct. 3 | 5.88E-08 | 7.30E-09 | 1.87E-09 | Detected |
| | Oct. 3 – Nov. 4 | 5.99E-08 | 8.37E-09 | 3.58E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.12E-08 | 7.90E-09 | 2.43E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.20E-07 | 1.45E-08 | 3.62E-09 | Detected |

### Table B.26. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 1.89E-07 | 2.39E-08 | 4.99E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.74E-07 | 3.23E-08 | 5.30E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.58E-07 | 4.14E-08 | 5.40E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.91E-07 | 4.69E-08 | 6.64E-09 | Detected |
| | Apr. 13 - Apr. 29 | 2.93E-07 | 3.43E-08 | 5.09E-09 | Detected |
| | Apr. 29 – May 18 | 3.01E-07 | 3.54E-08 | 4.27E-09 | Detected |
| | May 18 – Jun. 3 | 3.40E-07 | 3.97E-08 | 5.17E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.47E-07 | 3.05E-08 | 1.50E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.82E-07 | 3.44E-08 | 5.20E-09 | Detected |
| | Jun. 29 – July 22 | 2.26E-07 | 2.63E-08 | 2.77E-09 | Detected |
| | July 22 -Aug. 17 | 1.86E-07 | 2.17E-08 | 2.57E-08 | Detected |
| | Aug. 17 – Oct. 3 | 5.45E-08 | 6.92E-09 | 1.60E-09 | Detected |
| | Oct. 3 – Nov. 4 | 5.88E-08 | 8.46E-09 | 2.76E-09 | Detected |
| | Nov. 4 – Dec. 9 | 5.47E-08 | 7.36E-09 | 2.18E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.06E-07 | 1.30E-08 | 2.29E-09 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 7.97E-09 | 3.06E-09 | 2.90E-09 | Detected |
| | Mar. 2 – Mar. 16 | 1.33E-08 | 4.29E-09 | 4.23E-09 | Detected |
| | Mar. 16 – Mar. 30 | 1.57E-08 | 4.72E-09 | 4.91E-09 | Detected |
| | Mar. 30 - Apr. 13 | 1.99E-08 | 5.76E-09 | 3.24E-09 | Detected |
| | Apr. 13 - Apr. 29 | 1.45E-08 | 4.22E-09 | 4.01E-09 | Detected |
| | Apr. 29 – May 18 | 1.17E-08 | 3.63E-09 | 3.16E-09 | Detected |
| | May 18 – Jun. 3 | 1.48E-08 | 4.42E-09 | 3.67E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.23E-08 | 3.80E-09 | 1.85E-09 | Detected |
| | Jun. 15 – Jun. 29 | 1.56E-08 | 5.09E-09 | 5.06E-09 | Detected |
| | Jun. 29 – July 22 | 1.04E-08 | 2.94E-09 | 2.04E-09 | Detected |
| | July 22 -Aug. 17 | 7.87E-09 | 2.46E-09 | 1.89E-09 | Detected |
| | Aug. 17 – Oct. 3 | 2.78E-09 | 1.09E-09 | 1.19E-09 | Detected |
| | Oct. 3 – Nov. 4 | 2.72E-09 | 1.42E-09 | 1.48E-09 | Detected |
| | Nov. 4 – Dec. 9 | 1.98E-09 | 1.18E-09 | 1.91E-09 | Detected |
| | Dec. 9 – Jan. 6 | 3.66E-09 | 1.54E-09 | 1.78E-09 | Detected |

## Table B.26. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) at Near Field Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 1.74E-07 | 2.23E-08 | 6.12E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.54E-07 | 3.02E-08 | 5.68E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.23E-07 | 3.76E-08 | 4.95E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.83E-07 | 4.61E-08 | 8.39E-09 | Detected |
| | Apr. 13 - Apr. 29 | 2.80E-07 | 3.29E-08 | 5.97E-09 | Detected |
| | Apr. 29 – May 18 | 2.77E-07 | 3.28E-08 | 4.78E-09 | Detected |
| | May 18 – Jun. 3 | 3.19E-07 | 3.75E-08 | 7.34E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.48E-07 | 3.05E-08 | 1.49E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.80E-07 | 3.42E-08 | 7.47E-09 | Detected |
| | Jun. 29 – July 22 | 2.02E-07 | 2.38E-08 | 3.74E-09 | Detected |
| | July 22 -Aug. 17 | 1.71E-07 | 2.02E-08 | 3.47E-09 | Detected |
| | Aug. 17 – Oct. 3 | 5.69E-08 | 7.18E-09 | 1.80E-09 | Detected |
| | Oct. 3 – Nov. 4 | 5.35E-08 | 7.89E-09 | 3.16E-09 | Detected |
| | Nov. 4 – Dec. 9 | 5.39E-08 | 7.30E-09 | 2.78E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.03E-07 | 1.27E-08 | 2.87E-09 | Detected |

### Table B.27. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 1.70E-07 | 4.57E-08 | 2.03E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.64E-07 | 3.14E-08 | 4.77E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.80E-07 | 4.42E-08 | 4.04E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.94E-07 | 4.62E-08 | 5.97E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.19E-07 | 3.73E-08 | 5.45E-09 | Detected |
| | Apr. 29 – May 18 | 3.00E-07 | 3.52E-08 | 4.42E-09 | Detected |
| | May 18 – Jun. 3 | 3.55E-07 | 4.12E-08 | 4.72E-09 | Detected |
| | Jun. 3 – Jun. 15 | 3.42E-07 | 3.70E-08 | 7.79E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.94E-07 | 3.64E-08 | 6.63E-09 | Detected |
| | Jun. 29 – July 22 | 2.40E-07 | 2.91E-08 | 4.88E-09 | Detected |
| | July 22 -Aug. 17 | 1.92E-07 | 2.24E-08 | 3.10E-09 | Detected |
| | Aug. 17 – Oct. 3 | -7.04E-07 | 2.70E-06 | 3.45E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | 5.94E-08 | 7.88E-09 | 1.91E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.73E-08 | 8.74E-09 | 2.55E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.47E-07 | 1.76E-08 | 2.51E-09 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.06E-08 | 2.52E-09 | 1.77E-09 | Detected |
| | Mar. 2 – Mar. 16 | 1.13E-08 | 3.69E-09 | 3.38E-09 | Detected |
| | Mar. 16 – Mar. 30 | 1.69E-08 | 4.88E-09 | 3.44E-09 | Detected |
| | Mar. 30 - Apr. 13 | 1.53E-08 | 4.76E-09 | 2.91E-09 | Detected |
| | Apr. 13 - Apr. 29 | 1.08E-08 | 3.80E-09 | 4.29E-09 | Detected |
| | Apr. 29 – May 18 | 1.40E-08 | 4.03E-09 | 3.53E-09 | Detected |
| | May 18 – Jun. 3 | 1.50E-08 | 4.44E-09 | 3.66E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.43E-08 | 4.84E-09 | 6.18E-09 | Detected |
| | Jun. 15 – Jun. 29 | 1.50E-08 | 5.13E-09 | 4.91E-09 | Detected |
| | Jun. 29 – July 22 | 1.28E-08 | 4.02E-09 | 4.11E-09 | Detected |
| | July 22 -Aug. 17 | 7.97E-09 | 2.50E-09 | 2.20E-09 | Detected |
| | Aug. 17 – Oct. 3 | 1.74E-09 | 1.20E-06 | 2.75E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.40E-09 | 1.39E-09 | 1.41E-09 | Detected |
| | Nov. 4 – Dec. 9 | 2.19E-09 | 1.26E-09 | 2.01E-09 | Detected |
| | Dec. 9 – Jan. 6 | 6.53E-09 | 2.26E-09 | 2.53E-09 | Detected |

## Table B.27. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) at Cactus Flats Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 1.53E-07 | 1.76E-08 | 2.38E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.49E-07 | 2.99E-08 | 6.76E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.48E-07 | 4.08E-08 | 5.88E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.67E-07 | 4.33E-08 | 7.54E-09 | Detected |
| | Apr. 13 - Apr. 29 | 2.74E-07 | 3.25E-08 | 7.46E-09 | Detected |
| | Apr. 29 – May 18 | 2.85E-07 | 3.35E-08 | 5.35E-09 | Detected |
| | May 18 – Jun. 3 | 3.17E-07 | 3.72E-08 | 5.90E-09 | Detected |
| | Jun. 3 – Jun. 15 | 3.17E-07 | 3.73E-08 | 7.61E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.84E-07 | 3.53E-08 | 7.42E-09 | Detected |
| | Jun. 29 – July 22 | 2.18E-07 | 2.67E-08 | 6.13E-09 | Detected |
| | July 22 -Aug. 17 | 1.85E-07 | 2.16E-08 | 3.09E-09 | Detected |
| | Aug. 17 – Oct. 3 | -1.40E-07 | 1.68E-06 | 4.18E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | 5.54E-08 | 7.45E-09 | 2.12E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.23E-08 | 8.26E-09 | 3.49E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.40E-07 | 1.68E-08 | 3.30E-09 | Detected |

### Table B.28. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Loving Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. ($2\sigma$) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 2.20E-07 | 2.85E-08 | 5.96E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.86E-07 | 3.38E-08 | 4.79E-09 | Detected |
| | Mar. 16 – Mar. 30 | 4.21E-07 | 4.89E-08 | 4.40E-09 | Detected |
| | Mar. 30 - Apr. 13 | 5.13E-07 | 6.12E-08 | 1.16E-08 | Detected |
| | Apr. 13 - Apr. 29 | 3.30E-07 | 3.78E-08 | 4.31E-09 | Detected |
| | Apr. 29 – May 18 | 4.25E-07 | 5.02E-08 | 5.12E-09 | Detected |
| | May 18 – Jun. 3 | 5.27E-07 | 5.91E-08 | 4.40E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.87E-07 | 3.49E-08 | 1.40E-09 | Detected |
| | Jun. 15 – Jun. 29 | 3.21E-07 | 4.08E-08 | 9.34E-09 | Detected |
| | Jun. 29 – July 22 | 2.17E-07 | 2.53E-08 | 3.61E-09 | Detected |
| | July 22 -Aug. 17 | 9.14E-08 | 1.15E-08 | 2.86E-09 | Detected |
| | Aug. 17 – Oct. 3 | 7.54E-08 | 9.20E-09 | 1.89E-09 | Detected |
| | Oct. 3 – Nov. 4 | 5.11E-08 | 7.35E-09 | 2.79E-09 | Detected |
| | Nov. 4 – Dec. 9 | 4.73E-08 | 6.37E-09 | 1.96E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.22E-07 | 1.48E-08 | 2.92E-09 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.18E-08 | 4.24E-09 | 3.04E-09 | Detected |
| | Mar. 2 – Mar. 16 | 1.55E-08 | 4.54E-09 | 3.71E-09 | Detected |
| | Mar. 16 – Mar. 30 | 1.92E-08 | 5.57E-09 | 4.91E-09 | Detected |
| | Mar. 30 - Apr. 13 | 2.16E-08 | 7.26E-09 | 9.17E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.37E-09 | 3.66E-09 | 3.44E-09 | Not Detected |
| | Apr. 29 – May 18 | 1.48E-08 | 4.92E-09 | 4.98E-09 | Detected |
| | May 18 – Jun. 3 | 2.44E-08 | 5.83E-09 | 4.43E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.39E-08 | 3.95E-09 | 1.73E-09 | Detected |
| | Jun. 15 – Jun. 29 | 1.55E-08 | 6.24E-09 | 7.46E-09 | Detected |
| | Jun. 29 – July 22 | 1.09E-08 | 3.07E-09 | 2.10E-09 | Detected |
| | July 22 -Aug. 17 | 4.67E-09 | 1.74E-09 | 1.60E-09 | Detected |
| | Aug. 17 – Oct. 3 | 4.39E-09 | 1.47E-09 | 1.59E-09 | Detected |
| | Oct. 3 – Nov. 4 | 2.39E-09 | 1.43E-09 | 2.23E-09 | Detected |
| | Nov. 4 – Dec. 9 | 2.57E-09 | 1.18E-09 | 1.57E-09 | Detected |
| | Dec. 9 – Jan. 6 | 3.96E-09 | 1.84E-09 | 2.81E-09 | Detected |

## Table B.28. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from Loving Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 1.95E-07 | 2.57E-08 | 5.64E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.63E-07 | 3.14E-08 | 5.98E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.91E-07 | 4.56E-08 | 5.03E-09 | Detected |
| | Mar. 30 - Apr. 13 | 4.62E-07 | 5.56E-08 | 1.13E-08 | Detected |
| | Apr. 13 - Apr. 29 | 3.05E-07 | 3.52E-08 | 4.63E-09 | Detected |
| | Apr. 29 – May 18 | 4.07E-07 | 4.83E-08 | 7.35E-09 | Detected |
| | May 18 – Jun. 3 | 4.58E-07 | 5.19E-08 | 5.79E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.71E-07 | 3.32E-08 | 1.76E-09 | Detected |
| | Jun. 15 – Jun. 29 | 3.10E-07 | 3.97E-08 | 1.13E-08 | Detected |
| | Jun. 29 – July 22 | 2.20E-07 | 2.56E-08 | 3.86E-09 | Detected |
| | July 22 -Aug. 17 | 8.79E-08 | 1.11E-08 | 2.94E-09 | Detected |
| | Aug. 17 – Oct. 3 | 7.79E-08 | 9.49E-09 | 2.37E-09 | Detected |
| | Oct. 3 – Nov. 4 | 4.20E-08 | 6.40E-09 | 3.47E-09 | Detected |
| | Nov. 4 – Dec. 9 | 4.63E-08 | 6.26E-09 | 2.11E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.17E-07 | 1.42E-08 | 3.09E-09 | Detected |

**Table B.29. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Carlsbad Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 2.23E-07 | 2.55E-08 | 2.33E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.92E-07 | 3.50E-08 | 5.33E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.67E-07 | 4.33E-08 | 4.68E-09 | Detected |
| | Mar. 30 - Apr. 13 | 5.56E-07 | 6.65E-08 | 8.74E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.46E-07 | 4.07E-08 | 6.80E-09 | Detected |
| | Apr. 29 – May 18 | 3.48E-07 | 4.27E-08 | 7.10E-09 | Detected |
| | May 18 – Jun. 3 | 4.09E-07 | 4.75E-08 | 6.61E-09 | Detected |
| | Jun. 3 – Jun. 15 | 3.33E-07 | 4.01E-08 | 5.59E-09 | Detected |
| | Jun. 15 – Jun. 29 | 3.05E-07 | 3.75E-08 | 7.64E-09 | Detected |
| | Jun. 29 – July 22 | 1.71E-07 | 2.03E-08 | 3.15E-09 | Detected |
| | July 22 -Aug. 17 | 1.97E-07 | 2.27E-08 | 3.88E-09 | Detected |
| | Aug. 17 – Oct. 3 | 4.90E-08 | 6.20E-09 | 1.46E-09 | Detected |
| | Oct. 3 – Nov. 4 | 6.31E-08 | 9.00E-09 | 2.72E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.78E-08 | 8.75E-09 | 1.78E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.20E-07 | 1.47E-08 | 2.03E-09 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.19E-08 | 3.09E-09 | 2.42E-09 | Detected |
| | Mar. 2 – Mar. 16 | 1.48E-08 | 4.95E-09 | 5.37E-09 | Detected |
| | Mar. 16 – Mar. 30 | 1.72E-08 | 5.28E-09 | 3.98E-09 | Detected |
| | Mar. 30 - Apr. 13 | 2.59E-08 | 7.83E-09 | 5.77E-09 | Detected |
| | Apr. 13 - Apr. 29 | 1.36E-08 | 4.37E-09 | 3.47E-09 | Detected |
| | Apr. 29 – May 18 | 1.83E-08 | 5.86E-09 | 5.25E-09 | Detected |
| | May 18 – Jun. 3 | 1.79E-08 | 5.54E-09 | 6.37E-09 | Detected |
| | Jun. 3 – Jun. 15 | 1.49E-08 | 4.39E-09 | 3.14E-09 | Detected |
| | Jun. 15 – Jun. 29 | 1.48E-08 | 5.46E-09 | 6.44E-09 | Detected |
| | Jun. 29 – July 22 | 6.33E-09 | 2.29E-09 | 2.51E-09 | Detected |
| | July 22 -Aug. 17 | 6.58E-09 | 2.33E-09 | 3.08E-09 | Detected |
| | Aug. 17 – Oct. 3 | 2.65E-09 | 1.04E-09 | 1.28E-09 | Detected |
| | Oct. 3 – Nov. 4 | 4.00E-09 | 1.93E-09 | 2.64E-09 | Detected |
| | Nov. 4 – Dec. 9 | 3.27E-09 | 1.44E-09 | 1.85E-09 | Detected |
| | Dec. 9 – Jan. 6 | 6.77E-09 | 2.25E-09 | 2.28E-09 | Detected |

## Table B.29. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 2.12E-07 | 2.43E-08 | 3.47E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.85E-07 | 3.42E-08 | 7.02E-09 | Detected |
| | Mar. 16 – Mar. 30 | 3.46E-07 | 4.12E-08 | 6.29E-09 | Detected |
| | Mar. 30 - Apr. 13 | 5.32E-07 | 6.40E-08 | 9.51E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.20E-07 | 3.80E-08 | 6.17E-09 | Detected |
| | Apr. 29 – May 18 | 3.56E-07 | 4.36E-08 | 7.95E-09 | Detected |
| | May 18 – Jun. 3 | 4.12E-07 | 4.79E-08 | 7.00E-09 | Detected |
| | Jun. 3 – Jun. 15 | 3.01E-07 | 3.65E-08 | 5.57E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.97E-07 | 3.68E-08 | 9.59E-09 | Detected |
| | Jun. 29 – July 22 | 1.58E-07 | 1.89E-08 | 3.91E-09 | Detected |
| | July 22 -Aug. 17 | 9.34E-08 | 1.18E-08 | 3.79E-09 | Detected |
| | Aug. 17 – Oct. 3 | 4.29E-08 | 5.56E-09 | 1.87E-09 | Detected |
| | Oct. 3 – Nov. 4 | 6.29E-08 | 9.05E-09 | 3.90E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.73E-08 | 8.73E-09 | 2.66E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.11E-07 | 1.37E-08 | 2.34E-09 | Detected |

## Table B.30. Activity concentrations of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from East Tower Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. ($2\sigma$) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{234}$U** | Feb. 2 – Mar. 2 | 1.83E-07 | 2.15E-08 | 2.93E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.62E-07 | 3.14E-08 | 6.03E-09 | Detected |
| | Mar. 16 – Mar. 30 | 2.32E-07 | 2.66E-08 | 3.53E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.18E-07 | 3.55E-08 | 5.07E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.25E-07 | 3.79E-08 | 4.79E-09 | Detected |
| | Apr. 29 – May 18 | 3.49E-07 | 4.04E-08 | 4.54E-09 | Detected |
| | May 18 – Jun. 3 | 3.80E-07 | 4.37E-08 | 5.32E-09 | Detected |
| | Jun. 3 – Jun. 15 | 4.00E-07 | 4.68E-08 | 6.46E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.90E-07 | 3.52E-08 | 6.42E-09 | Detected |
| | Jun. 29 – July 22 | 2.30E-07 | 2.80E-08 | 4.09E-09 | Detected |
| | July 22 -Aug. 17 | 9.91E-08 | 1.26E-08 | 2.88E-09 | Detected |
| | Aug. 17 – Oct. 3 | 5.13E-08 | 6.63E-09 | 1.52E-09 | Detected |
| | Oct. 3 – Nov. 4 | 6.15E-08 | 8.54E-09 | 2.06E-09 | Detected |
| | Nov. 4 – Dec. 9 | 6.84E-08 | 8.90E-09 | 2.37E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.32E-07 | 1.62E-08 | 2.28E-09 | Detected |
| | | | | | |
| **$^{235}$U** | Feb. 2 – Mar. 2 | 9.72E-09 | 2.74E-09 | 2.34E-09 | Detected |
| | Mar. 2 – Mar. 16 | 9.53E-09 | 4.01E-09 | 5.80E-09 | Detected |
| | Mar. 16 – Mar. 30 | 1.42E-08 | 3.57E-09 | 2.13E-09 | Detected |
| | Mar. 30 - Apr. 13 | 1.48E-08 | 3.91E-09 | 4.01E-09 | Detected |
| | Apr. 13 - Apr. 29 | 1.43E-08 | 4.21E-09 | 3.02E-09 | Detected |
| | Apr. 29 – May 18 | 1.30E-08 | 3.99E-09 | 3.98E-09 | Detected |
| | May 18 – Jun. 3 | 1.62E-08 | 4.78E-09 | 4.85E-09 | Detected |
| | Jun. 3 – Jun. 15 | 2.08E-08 | 5.93E-09 | 5.16E-09 | Detected |
| | Jun. 15 – Jun. 29 | 7.76E-09 | 3.86E-09 | 5.63E-09 | Detected |
| | Jun. 29 – July 22 | 1.07E-08 | 3.44E-09 | 2.20E-09 | Detected |
| | July 22 -Aug. 17 | 5.85E-09 | 2.12E-09 | 1.90E-09 | Detected |
| | Aug. 17 – Oct. 3 | 2.72E-09 | 1.05E-09 | 8.15E-10 | Detected |
| | Oct. 3 – Nov. 4 | 1.75E-09 | 1.25E-09 | 2.06E-09 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.56E-09 | 1.52E-09 | 2.00E-09 | Detected |
| | Dec. 9 – Jan. 6 | 5.16E-09 | 2.01E-09 | 1.94E-09 | Detected |

### Table B.30. Activity concentrations of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from East Tower Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{238}U$** | Feb. 2 – Mar. 2 | 1.68E-07 | 1.99E-08 | 3.64E-09 | Detected |
| | Mar. 2 – Mar. 16 | 2.60E-07 | 3.13E-08 | 6.37E-09 | Detected |
| | Mar. 16 – Mar. 30 | 2.18E-07 | 2.52E-08 | 3.21E-09 | Detected |
| | Mar. 30 - Apr. 13 | 3.01E-07 | 3.36E-08 | 4.94E-09 | Detected |
| | Apr. 13 - Apr. 29 | 3.14E-07 | 3.68E-08 | 6.21E-09 | Detected |
| | Apr. 29 – May 18 | 3.25E-07 | 3.78E-08 | 4.52E-09 | Detected |
| | May 18 – Jun. 3 | 3.58E-07 | 4.14E-08 | 4.89E-09 | Detected |
| | Jun. 3 – Jun. 15 | 3.92E-07 | 4.59E-08 | 8.03E-09 | Detected |
| | Jun. 15 – Jun. 29 | 2.72E-07 | 3.34E-08 | 8.19E-09 | Detected |
| | Jun. 29 – July 22 | 2.20E-07 | 2.69E-08 | 4.69E-09 | Detected |
| | July 22 -Aug. 17 | 9.68E-08 | 1.24E-08 | 3.13E-09 | Detected |
| | Aug. 17 – Oct. 3 | 4.80E-08 | 6.28E-09 | 1.74E-09 | Detected |
| | Oct. 3 – Nov. 4 | 5.17E-08 | 7.48E-09 | 3.12E-09 | Detected |
| | Nov. 4 – Dec. 9 | 7.14E-08 | 9.26E-09 | 2.98E-09 | Detected |
| | Dec. 9 – Jan. 6 | 1.29E-07 | 1.58E-08 | 3.06E-09 | Detected |

### Table B.31. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 2.39E-03 | 2.97E-04 | 5.56E-05 | Detected |
| | Mar. 2 – Mar. 16 | 4.34E-03 | 5.20E-04 | 9.96E-05 | Detected |
| | Mar. 16 – Mar. 30 | 3.67E-03 | 4.27E-04 | 6.06E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.94E-03 | 3.46E-04 | 4.72E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.81E-03 | 4.40E-04 | 4.05E-05 | Detected |
| | Apr. 29 – May 18 | 3.85E-03 | 4.62E-04 | 6.79E-05 | Detected |
| | May 18 – Jun. 3 | 3.22E-03 | 3.69E-04 | 3.19E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.22E-03 | 2.50E-04 | 2.84E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.33E-03 | 5.21E-04 | 8.55E-05 | Detected |
| | Jun. 29 – July 22 | 3.39E-03 | 4.05E-04 | 6.04E-05 | Detected |
| | July 22 -Aug. 17 | 1.50E-03 | 1.86E-04 | 2.84E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.17E-03 | 1.43E-04 | 2.36E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.67E-03 | 2.32E-04 | 7.67E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.49E-03 | 1.88E-04 | 4.13E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.68E-03 | 4.40E-04 | 7.05E-05 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 8.66E-05 | 3.70E-05 | 4.87E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.80E-04 | 6.63E-05 | 7.83E-05 | Detected |
| | Mar. 16 – Mar. 30 | 1.59E-04 | 5.00E-05 | 5.83E-05 | Detected |
| | Mar. 30 - Apr. 13 | 1.57E-04 | 4.40E-05 | 3.76E-05 | Detected |
| | Apr. 13 - Apr. 29 | 2.14E-04 | 5.32E-05 | 3.94E-05 | Detected |
| | Apr. 29 – May 18 | 1.98E-04 | 5.95E-05 | 5.42E-05 | Detected |
| | May 18 – Jun. 3 | 1.44E-04 | 3.97E-05 | 3.32E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.14E-04 | 2.90E-05 | 2.39E-05 | Detected |
| | Jun. 15 – Jun. 29 | 2.11E-04 | 6.98E-05 | 7.49E-05 | Detected |
| | Jun. 29 – July 22 | 1.15E-04 | 4.30E-05 | 4.82E-05 | Detected |
| | July 22 -Aug. 17 | 6.64E-05 | 2.55E-05 | 2.42E-05 | Detected |
| | Aug. 17 – Oct. 3 | 5.37E-05 | 2.02E-05 | 2.30E-05 | Detected |
| | Oct. 3 – Nov. 4 | 5.79E-05 | 3.91E-05 | 6.72E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 7.37E-05 | 2.71E-05 | 2.01E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.31E-04 | 4.85E-05 | 5.00E-05 | Detected |

### Table B.31. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) at Onsite Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 2.04E-03 | 2.59E-04 | 5.53E-05 | Detected |
| | Mar. 2 – Mar. 16 | 3.90E-03 | 4.75E-04 | 1.36E-04 | Detected |
| | Mar. 16 – Mar. 30 | 3.27E-03 | 3.85E-04 | 6.41E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.70E-03 | 3.21E-04 | 5.86E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.40E-03 | 3.97E-04 | 5.82E-05 | Detected |
| | Apr. 29 – May 18 | 3.25E-03 | 4.00E-04 | 8.22E-05 | Detected |
| | May 18 – Jun. 3 | 2.98E-03 | 3.44E-04 | 4.75E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.97E-03 | 2.24E-04 | 3.56E-05 | Detected |
| | Jun. 15 – Jun. 29 | 3.99E-03 | 4.85E-04 | 1.09E-04 | Detected |
| | Jun. 29 – July 22 | 3.28E-03 | 3.93E-04 | 7.31E-05 | Detected |
| | July 22 -Aug. 17 | 1.44E-03 | 1.80E-04 | 3.82E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.07E-03 | 1.33E-04 | 3.40E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.64E-03 | 2.29E-04 | 9.77E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.31E-03 | 1.69E-04 | 5.22E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.31E-03 | 4.01E-04 | 1.00E-04 | Detected |

**Table B.32. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Near Field Station**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 3.93E-03 | 4.96E-04 | 1.04E-04 | Detected |
| | Mar. 2 – Mar. 16 | 4.16E-03 | 4.90E-04 | 8.04E-05 | Detected |
| | Mar. 16 – Mar. 30 | 3.04E-03 | 3.51E-04 | 4.57E-05 | Detected |
| | Mar. 30 - Apr. 13 | 4.42E-03 | 5.30E-04 | 7.51E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.35E-03 | 5.10E-04 | 7.57E-05 | Detected |
| | Apr. 29 – May 18 | 4.12E-03 | 4.84E-04 | 5.84E-05 | Detected |
| | May 18 – Jun. 3 | 4.10E-03 | 4.78E-04 | 6.23E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.46E-03 | 3.04E-04 | 1.49E-05 | Detected |
| | Jun. 15 – Jun. 29 | 7.77E-03 | 9.47E-04 | 1.43E-04 | Detected |
| | Jun. 29 – July 22 | 3.94E-03 | 4.59E-04 | 4.83E-05 | Detected |
| | July 22 -Aug. 17 | 3.36E-03 | 3.92E-04 | 4.63E-04 | Detected |
| | Aug. 17 – Oct. 3 | 1.24E-03 | 1.58E-04 | 3.66E-05 | Detected |
| | Oct. 3 – Nov. 4 | 2.10E-03 | 3.02E-04 | 9.86E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.88E-03 | 2.54E-04 | 7.53E-05 | Detected |
| | Dec. 9 – Jan. 6 | 4.34E-03 | 5.30E-04 | 9.39E-05 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.66E-04 | 6.37E-05 | 6.03E-05 | Detected |
| | Mar. 2 – Mar. 16 | 2.02E-04 | 6.50E-05 | 6.41E-05 | Detected |
| | Mar. 16 – Mar. 30 | 1.33E-04 | 4.00E-05 | 4.17E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.25E-04 | 6.51E-05 | 3.66E-05 | Detected |
| | Apr. 13 - Apr. 29 | 2.16E-04 | 6.27E-05 | 5.96E-05 | Detected |
| | Apr. 29 – May 18 | 1.60E-04 | 4.97E-05 | 4.33E-05 | Detected |
| | May 18 – Jun. 3 | 1.79E-04 | 5.32E-05 | 4.42E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.23E-04 | 3.78E-05 | 1.84E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.30E-04 | 1.40E-04 | 1.39E-04 | Detected |
| | Jun. 29 – July 22 | 1.81E-04 | 5.14E-05 | 3.56E-05 | Detected |
| | July 22 -Aug. 17 | 1.42E-04 | 4.43E-05 | 3.41E-05 | Detected |
| | Aug. 17 – Oct. 3 | 6.33E-05 | 2.49E-05 | 2.71E-05 | Detected |
| | Oct. 3 – Nov. 4 | 9.70E-05 | 5.08E-05 | 5.30E-05 | Detected |
| | Nov. 4 – Dec. 9 | 6.82E-05 | 4.07E-05 | 6.59E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.50E-04 | 6.31E-05 | 7.28E-05 | Detected |

### Table B.32. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Near Field Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{238}$U** | Feb. 2 – Mar. 2 | 3.63E-03 | 4.64E-04 | 1.27E-04 | Detected |
|  | Mar. 2 – Mar. 16 | 3.85E-03 | 4.58E-04 | 8.62E-05 | Detected |
|  | Mar. 16 – Mar. 30 | 2.73E-03 | 3.19E-04 | 4.20E-05 | Detected |
|  | Mar. 30 - Apr. 13 | 4.33E-03 | 5.21E-04 | 9.48E-05 | Detected |
|  | Apr. 13 - Apr. 29 | 4.16E-03 | 4.90E-04 | 8.87E-05 | Detected |
|  | Apr. 29 – May 18 | 3.80E-03 | 4.49E-04 | 6.54E-05 | Detected |
|  | May 18 – Jun. 3 | 3.84E-03 | 4.51E-04 | 8.83E-05 | Detected |
|  | Jun. 3 – Jun. 15 | 2.47E-03 | 3.04E-04 | 1.49E-05 | Detected |
|  | Jun. 15 – Jun. 29 | 7.70E-03 | 9.41E-04 | 2.06E-04 | Detected |
|  | Jun. 29 – July 22 | 3.52E-03 | 4.15E-04 | 6.53E-05 | Detected |
|  | July 22 -Aug. 17 | 3.08E-03 | 3.64E-04 | 6.27E-05 | Detected |
|  | Aug. 17 – Oct. 3 | 1.30E-03 | 1.64E-04 | 4.09E-05 | Detected |
|  | Oct. 3 – Nov. 4 | 1.91E-03 | 2.82E-04 | 1.13E-04 | Detected |
|  | Nov. 4 – Dec. 9 | 1.86E-03 | 2.52E-04 | 9.59E-05 | Detected |
|  | Dec. 9 – Jan. 6 | 4.22E-03 | 5.19E-04 | 1.17E-04 | Detected |

### Table B.33. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 3.10E-03 | 8.31E-04 | 3.69E-05 | Detected |
| | Mar. 2 – Mar. 16 | 4.34E-03 | 5.15E-04 | 7.83E-05 | Detected |
| | Mar. 16 – Mar. 30 | 4.70E-03 | 5.47E-04 | 4.99E-05 | Detected |
| | Mar. 30 - Apr. 13 | 4.17E-03 | 4.88E-04 | 6.31E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.51E-03 | 5.27E-04 | 7.71E-05 | Detected |
| | Apr. 29 – May 18 | 3.76E-03 | 4.41E-04 | 5.54E-05 | Detected |
| | May 18 – Jun. 3 | 4.31E-03 | 5.00E-04 | 5.73E-05 | Detected |
| | Jun. 3 – Jun. 15 | 3.32E-03 | 3.60E-04 | 7.57E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.31E-03 | 5.33E-04 | 9.73E-05 | Detected |
| | Jun. 29 – July 22 | 3.88E-03 | 4.69E-04 | 7.88E-05 | Detected |
| | July 22 -Aug. 17 | 3.39E-03 | 3.95E-04 | 5.48E-05 | Detected |
| | Aug. 17 – Oct. 3 | -1.83E-02 | 7.01E-02 | 8.96E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.55E-03 | 2.05E-04 | 4.98E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.85E-03 | 2.40E-04 | 7.01E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.79E-03 | 4.53E-04 | 6.47E-05 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.93E-04 | 4.58E-05 | 3.22E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.85E-04 | 6.06E-05 | 5.56E-05 | Detected |
| | Mar. 16 – Mar. 30 | 2.09E-04 | 6.03E-05 | 4.25E-05 | Detected |
| | Mar. 30 - Apr. 13 | 1.62E-04 | 5.03E-05 | 3.07E-05 | Detected |
| | Apr. 13 - Apr. 29 | 1.53E-04 | 5.36E-05 | 6.06E-05 | Detected |
| | Apr. 29 – May 18 | 1.76E-04 | 5.05E-05 | 4.42E-05 | Detected |
| | May 18 – Jun. 3 | 1.83E-04 | 5.39E-05 | 4.44E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.39E-04 | 4.70E-05 | 6.00E-05 | Detected |
| | Jun. 15 – Jun. 29 | 2.20E-04 | 7.52E-05 | 7.20E-05 | Detected |
| | Jun. 29 – July 22 | 2.06E-04 | 6.49E-05 | 6.64E-05 | Detected |
| | July 22 -Aug. 17 | 1.41E-04 | 4.42E-05 | 3.89E-05 | Detected |
| | Aug. 17 – Oct. 3 | 4.51E-05 | 3.13E-02 | 7.15E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 8.86E-05 | 3.63E-05 | 3.67E-05 | Detected |
| | Nov. 4 – Dec. 9 | 6.02E-05 | 3.47E-05 | 5.52E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.69E-04 | 5.83E-05 | 6.53E-05 | Detected |

## Table B.33. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from Cactus Flats Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{238}U$** | Feb. 2 – Mar. 2 | 2.79E-03 | 3.20E-04 | 4.33E-05 | Detected |
| | Mar. 2 – Mar. 16 | 4.10E-03 | 4.91E-04 | 1.11E-04 | Detected |
| | Mar. 16 – Mar. 30 | 4.30E-03 | 5.04E-04 | 7.27E-05 | Detected |
| | Mar. 30 - Apr. 13 | 3.88E-03 | 4.57E-04 | 7.97E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.87E-03 | 4.59E-04 | 1.05E-04 | Detected |
| | Apr. 29 – May 18 | 3.57E-03 | 4.20E-04 | 6.71E-05 | Detected |
| | May 18 – Jun. 3 | 3.85E-03 | 4.51E-04 | 7.16E-05 | Detected |
| | Jun. 3 – Jun. 15 | 3.08E-03 | 3.62E-04 | 7.39E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.17E-03 | 5.18E-04 | 1.09E-04 | Detected |
| | Jun. 29 – July 22 | 3.51E-03 | 4.31E-04 | 9.89E-05 | Detected |
| | July 22 -Aug. 17 | 3.27E-03 | 3.82E-04 | 5.46E-05 | Detected |
| | Aug. 17 – Oct. 3 | -3.64E-03 | 4.37E-02 | 1.09E-01 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.44E-03 | 1.94E-04 | 5.54E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.71E-03 | 2.27E-04 | 9.59E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.61E-03 | 4.34E-04 | 8.52E-05 | Detected |

**Table B.34. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Loving Station**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 3.03E-03 | 3.93E-04 | 8.21E-05 | Detected |
| | Mar. 2 – Mar. 16 | 3.54E-03 | 4.19E-04 | 5.93E-05 | Detected |
| | Mar. 16 – Mar. 30 | 2.77E-03 | 3.21E-04 | 2.89E-05 | Detected |
| | Mar. 30 - Apr. 13 | 4.09E-03 | 4.88E-04 | 9.22E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.95E-03 | 4.54E-04 | 5.17E-05 | Detected |
| | Apr. 29 – May 18 | 4.11E-03 | 4.86E-04 | 4.95E-05 | Detected |
| | May 18 – Jun. 3 | 2.84E-03 | 3.19E-04 | 2.37E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.20E-03 | 2.69E-04 | 1.08E-05 | Detected |
| | Jun. 15 – Jun. 29 | 5.04E-03 | 6.40E-04 | 1.47E-04 | Detected |
| | Jun. 29 – July 22 | 3.41E-03 | 3.98E-04 | 5.68E-05 | Detected |
| | July 22 -Aug. 17 | 1.46E-03 | 1.83E-04 | 4.56E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.24E-03 | 1.52E-04 | 3.12E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.57E-03 | 2.26E-04 | 8.57E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.43E-03 | 1.93E-04 | 5.93E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.76E-03 | 4.55E-04 | 9.01E-05 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 1.63E-04 | 5.84E-05 | 4.19E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.92E-04 | 5.62E-05 | 4.59E-05 | Detected |
| | Mar. 16 – Mar. 30 | 1.26E-04 | 3.66E-05 | 3.23E-05 | Detected |
| | Mar. 30 - Apr. 13 | 1.73E-04 | 5.79E-05 | 7.31E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.04E-05 | 4.39E-05 | 4.13E-05 | Not Detected |
| | Apr. 29 – May 18 | 1.43E-04 | 4.76E-05 | 4.82E-05 | Detected |
| | May 18 – Jun. 3 | 1.32E-04 | 3.15E-05 | 2.39E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.07E-04 | 3.03E-05 | 1.33E-05 | Detected |
| | Jun. 15 – Jun. 29 | 2.44E-04 | 9.80E-05 | 1.17E-04 | Detected |
| | Jun. 29 – July 22 | 1.71E-04 | 4.82E-05 | 3.31E-05 | Detected |
| | July 22 -Aug. 17 | 7.45E-05 | 2.77E-05 | 2.56E-05 | Detected |
| | Aug. 17 – Oct. 3 | 7.24E-05 | 2.42E-05 | 2.63E-05 | Detected |
| | Oct. 3 – Nov. 4 | 7.33E-05 | 4.38E-05 | 6.84E-05 | Detected |
| | Nov. 4 – Dec. 9 | 7.76E-05 | 3.58E-05 | 4.73E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.22E-04 | 5.67E-05 | 8.67E-05 | Detected |

**Table B.34. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from Loving Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 2.68E-03 | 3.54E-04 | 7.77E-05 | Detected |
| | Mar. 2 – Mar. 16 | 3.26E-03 | 3.89E-04 | 7.41E-05 | Detected |
| | Mar. 16 – Mar. 30 | 2.57E-03 | 3.00E-04 | 3.31E-05 | Detected |
| | Mar. 30 - Apr. 13 | 3.68E-03 | 4.43E-04 | 9.00E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.66E-03 | 4.22E-04 | 5.55E-05 | Detected |
| | Apr. 29 – May 18 | 3.94E-03 | 4.68E-04 | 7.11E-05 | Detected |
| | May 18 – Jun. 3 | 2.47E-03 | 2.80E-04 | 3.12E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.09E-03 | 2.55E-04 | 1.35E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.87E-03 | 6.23E-04 | 1.78E-04 | Detected |
| | Jun. 29 – July 22 | 3.46E-03 | 4.03E-04 | 6.08E-05 | Detected |
| | July 22 -Aug. 17 | 1.40E-03 | 1.77E-04 | 4.69E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.28E-03 | 1.56E-04 | 3.91E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.29E-03 | 1.97E-04 | 1.07E-04 | Detected |
| | Nov. 4 – Dec. 9 | 1.40E-03 | 1.89E-04 | 6.36E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.61E-03 | 4.38E-04 | 9.53E-05 | Detected |

### Table B.35. Specific activities of U isotopes ($^{234}$U, $^{235}$U, and $^{238}$U) in the filter samples collected from Carlsbad Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}$U | Feb. 2 – Mar. 2 | 3.80E-03 | 4.36E-04 | 3.97E-05 | Detected |
| | Mar. 2 – Mar. 16 | 3.82E-03 | 4.58E-04 | 6.97E-05 | Detected |
| | Mar. 16 – Mar. 30 | 3.40E-03 | 4.02E-04 | 4.35E-05 | Detected |
| | Mar. 30 - Apr. 13 | 5.01E-03 | 6.00E-04 | 7.87E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.80E-03 | 5.64E-04 | 9.43E-05 | Detected |
| | Apr. 29 – May 18 | 4.02E-03 | 4.93E-04 | 8.19E-05 | Detected |
| | May 18 – Jun. 3 | 3.47E-03 | 4.03E-04 | 5.61E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.31E-03 | 2.78E-04 | 3.87E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.77E-03 | 5.88E-04 | 1.20E-04 | Detected |
| | Jun. 29 – July 22 | 3.00E-03 | 3.56E-04 | 5.53E-05 | Detected |
| | July 22 -Aug. 17 | 4.25E-03 | 4.90E-04 | 8.38E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.38E-03 | 1.74E-04 | 4.12E-05 | Detected |
| | Oct. 3 – Nov. 4 | 2.09E-03 | 2.98E-04 | 8.99E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.82E-03 | 2.35E-04 | 4.80E-05 | Detected |
| | Dec. 9 – Jan. 6 | 4.13E-03 | 5.03E-04 | 6.96E-05 | Detected |
| | | | | | |
| $^{235}$U | Feb. 2 – Mar. 2 | 2.03E-04 | 5.27E-05 | 4.13E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.94E-04 | 6.47E-05 | 7.03E-05 | Detected |
| | Mar. 16 – Mar. 30 | 1.60E-04 | 4.90E-05 | 3.70E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.34E-04 | 7.05E-05 | 5.20E-05 | Detected |
| | Apr. 13 - Apr. 29 | 1.88E-04 | 6.06E-05 | 4.81E-05 | Detected |
| | Apr. 29 – May 18 | 2.11E-04 | 6.76E-05 | 6.06E-05 | Detected |
| | May 18 – Jun. 3 | 1.52E-04 | 4.70E-05 | 5.40E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.03E-04 | 3.04E-05 | 2.17E-05 | Detected |
| | Jun. 15 – Jun. 29 | 2.32E-04 | 8.54E-05 | 1.01E-04 | Detected |
| | Jun. 29 – July 22 | 1.11E-04 | 4.03E-05 | 4.41E-05 | Detected |
| | July 22 -Aug. 17 | 1.42E-04 | 5.04E-05 | 6.64E-05 | Detected |
| | Aug. 17 – Oct. 3 | 7.47E-05 | 2.92E-05 | 3.61E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.32E-04 | 6.40E-05 | 8.74E-05 | Detected |
| | Nov. 4 – Dec. 9 | 8.80E-05 | 3.88E-05 | 4.99E-05 | Detected |
| | Dec. 9 – Jan. 6 | 2.32E-04 | 7.70E-05 | 7.82E-05 | Detected |

### Table B.35. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{238}U$** | Feb. 2 – Mar. 2 | 3.61E-03 | 4.15E-04 | 5.92E-05 | Detected |
| | Mar. 2 – Mar. 16 | 3.72E-03 | 4.48E-04 | 9.17E-05 | Detected |
| | Mar. 16 – Mar. 30 | 3.21E-03 | 3.82E-04 | 5.84E-05 | Detected |
| | Mar. 30 - Apr. 13 | 4.80E-03 | 5.77E-04 | 8.57E-05 | Detected |
| | Apr. 13 - Apr. 29 | 4.43E-03 | 5.26E-04 | 8.55E-05 | Detected |
| | Apr. 29 – May 18 | 4.11E-03 | 5.03E-04 | 9.16E-05 | Detected |
| | May 18 – Jun. 3 | 3.49E-03 | 4.06E-04 | 5.93E-05 | Detected |
| | Jun. 3 – Jun. 15 | 2.08E-03 | 2.53E-04 | 3.86E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.65E-03 | 5.76E-04 | 1.50E-04 | Detected |
| | Jun. 29 – July 22 | 2.77E-03 | 3.32E-04 | 6.87E-05 | Detected |
| | July 22 -Aug. 17 | 2.02E-03 | 2.55E-04 | 8.18E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.21E-03 | 1.57E-04 | 5.25E-05 | Detected |
| | Oct. 3 – Nov. 4 | 2.08E-03 | 2.99E-04 | 1.29E-04 | Detected |
| | Nov. 4 – Dec. 9 | 1.81E-03 | 2.35E-04 | 7.15E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.80E-03 | 4.69E-04 | 8.00E-05 | Detected |

### Table B.36. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from East Tower Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{234}U$ | Feb. 2 – Mar. 2 | 2.90E-03 | 3.41E-04 | 4.65E-05 | Detected |
| | Mar. 2 – Mar. 16 | 2.66E-03 | 3.19E-04 | 6.12E-05 | Detected |
| | Mar. 16 – Mar. 30 | 2.57E-03 | 2.95E-04 | 3.92E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.71E-03 | 3.03E-04 | 4.33E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.77E-03 | 4.39E-04 | 5.55E-05 | Detected |
| | Apr. 29 – May 18 | 3.59E-03 | 4.16E-04 | 4.67E-05 | Detected |
| | May 18 – Jun. 3 | 3.99E-03 | 4.59E-04 | 5.59E-05 | Detected |
| | Jun. 3 – Jun. 15 | 3.16E-03 | 3.69E-04 | 5.09E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.35E-03 | 5.29E-04 | 9.65E-05 | Detected |
| | Jun. 29 – July 22 | 3.77E-03 | 4.58E-04 | 6.69E-05 | Detected |
| | July 22 -Aug. 17 | 1.50E-03 | 1.92E-04 | 4.36E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.15E-03 | 1.49E-04 | 3.42E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.78E-03 | 2.47E-04 | 5.97E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.83E-03 | 2.39E-04 | 6.36E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.85E-03 | 4.71E-04 | 6.63E-05 | Detected |
| | | | | | |
| $^{235}U$ | Feb. 2 – Mar. 2 | 1.54E-04 | 4.34E-05 | 3.71E-05 | Detected |
| | Mar. 2 – Mar. 16 | 9.67E-05 | 4.08E-05 | 5.89E-05 | Detected |
| | Mar. 16 – Mar. 30 | 1.58E-04 | 3.96E-05 | 2.37E-05 | Detected |
| | Mar. 30 - Apr. 13 | 1.27E-04 | 3.34E-05 | 3.43E-05 | Detected |
| | Apr. 13 - Apr. 29 | 1.66E-04 | 4.87E-05 | 3.50E-05 | Detected |
| | Apr. 29 – May 18 | 1.34E-04 | 4.10E-05 | 4.09E-05 | Detected |
| | May 18 – Jun. 3 | 1.70E-04 | 5.02E-05 | 5.09E-05 | Detected |
| | Jun. 3 – Jun. 15 | 1.64E-04 | 4.67E-05 | 4.06E-05 | Detected |
| | Jun. 15 – Jun. 29 | 1.17E-04 | 5.79E-05 | 8.46E-05 | Detected |
| | Jun. 29 – July 22 | 1.74E-04 | 5.63E-05 | 3.60E-05 | Detected |
| | July 22 -Aug. 17 | 8.88E-05 | 3.21E-05 | 2.88E-05 | Detected |
| | Aug. 17 – Oct. 3 | 6.13E-05 | 2.36E-05 | 1.84E-05 | Detected |
| | Oct. 3 – Nov. 4 | 5.08E-05 | 3.63E-05 | 5.97E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 9.54E-05 | 4.07E-05 | 5.36E-05 | Detected |
| | Dec. 9 – Jan. 6 | 1.50E-04 | 5.86E-05 | 5.64E-05 | Detected |

## Table B.36. Specific activities of U isotopes ($^{234}U$, $^{235}U$, and $^{238}U$) in the filter samples collected from East Tower Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Feb. 2 – Mar. 2 | 2.66E-03 | 3.16E-04 | 5.77E-05 | Detected |
| | Mar. 2 – Mar. 16 | 2.64E-03 | 3.18E-04 | 6.47E-05 | Detected |
| | Mar. 16 – Mar. 30 | 2.42E-03 | 2.80E-04 | 3.57E-05 | Detected |
| | Mar. 30 - Apr. 13 | 2.57E-03 | 2.87E-04 | 4.22E-05 | Detected |
| | Apr. 13 - Apr. 29 | 3.64E-03 | 4.26E-04 | 7.20E-05 | Detected |
| | Apr. 29 – May 18 | 3.34E-03 | 3.89E-04 | 4.65E-05 | Detected |
| | May 18 – Jun. 3 | 3.76E-03 | 4.34E-04 | 5.13E-05 | Detected |
| | Jun. 3 – Jun. 15 | 3.09E-03 | 3.61E-04 | 6.33E-05 | Detected |
| | Jun. 15 – Jun. 29 | 4.08E-03 | 5.01E-04 | 1.23E-04 | Detected |
| | Jun. 29 – July 22 | 3.60E-03 | 4.39E-04 | 7.67E-05 | Detected |
| | July 22 -Aug. 17 | 1.47E-03 | 1.88E-04 | 4.75E-05 | Detected |
| | Aug. 17 – Oct. 3 | 1.08E-03 | 1.41E-04 | 3.91E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.50E-03 | 2.17E-04 | 9.02E-05 | Detected |
| | Nov. 4 – Dec. 9 | 1.92E-03 | 2.48E-04 | 7.98E-05 | Detected |
| | Dec. 9 – Jan. 6 | 3.75E-03 | 4.61E-04 | 8.91E-05 | Detected |

**Table B.37. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Onsite Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Feb. 2 – Mar. 2 | -3.53E-07 | 1.94E-07 | 6.70E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 5.33E-07 | 2.52E-07 | 8.24E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 7.03E-07 | 2.15E-07 | 6.91E-07 | Detected |
| | Mar. 30 - Apr. 13 | 1.57E-07 | 2.07E-07 | 6.87E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.99E-07 | 1.70E-07 | 5.62E-07 | Not Detected |
| | Apr. 29 – May 18 | -2.59E-07 | 1.80E-07 | 6.06E-07 | Not Detected |
| | May 18 – Jun. 3 | 3.86E-07 | 1.99E-07 | 6.53E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 3.23E-07 | 5.40E-07 | 1.80E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.24E-07 | 1.94E-07 | 6.48E-07 | Not Detected |
| | Jun. 29 – July 22 | -4.03E-07 | 1.43E-07 | 4.86E-07 | Not Detected |
| | July 22 -Aug. 17 | -3.35E-07 | 1.23E-07 | 4.23E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.51E-07 | 1.68E-07 | 5.55E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.91E-07 | 7.88E-08 | 2.56E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -9.55E-08 | 1.90E-07 | 6.42E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | -3.00E-07 | 1.24E-07 | 4.20E-07 | Not Detected |
| | | | | | |
| $^{60}$Co | Feb. 2 – Mar. 2 | 1.62E-07 | 1.84E-07 | 6.18E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.33E-07 | 2.45E-07 | 8.19E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 7.16E-07 | 2.44E-07 | 7.84E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 6.15E-07 | 2.34E-07 | 7.57E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 3.93E-07 | 2.01E-07 | 6.58E-07 | Not Detected |
| | Apr. 29 – May 18 | 3.79E-07 | 1.53E-07 | 4.93E-07 | Not Detected |
| | May 18 – Jun. 3 | 2.33E-07 | 1.95E-07 | 6.45E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.00E-06 | 4.50E-07 | 1.45E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | 3.02E-07 | 2.51E-07 | 8.30E-07 | Not Detected |
| | Jun. 29 – July 22 | 2.61E-07 | 1.18E-07 | 3.85E-07 | Not Detected |
| | July 22 -Aug. 17 | 4.15E-07 | 1.12E-07 | 3.53E-07 | Detected |
| | Aug. 17 – Oct. 3 | 5.73E-08 | 1.15E-07 | 3.89E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.52E-08 | 6.55E-08 | 2.22E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.78E-07 | 1.58E-07 | 5.02E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.49E-07 | 1.13E-07 | 3.63E-07 | Not Detected |

**Table B.37. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Onsite Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}$K | Feb. 2 – Mar. 2 | 2.87E-06 | 1.43E-06 | 4.65E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 3.43E-06 | 4.19E-06 | 1.39E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.48E-05 | 3.08E-06 | 9.65E-06 | Detected |
| | Mar. 30 - Apr. 13 | 1.02E-05 | 2.97E-06 | 9.49E-06 | Detected |
| | Apr. 13 - Apr. 29 | 7.84E-06 | 2.41E-06 | 7.76E-06 | Detected |
| | Apr. 29 – May 18 | 3.97E-06 | 2.18E-06 | 7.11E-06 | Not Detected |
| | May 18 – Jun. 3 | 7.77E-06 | 2.41E-06 | 7.77E-06 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.50E-06 | 3.36E-06 | 1.15E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.38E-05 | 3.02E-06 | 9.52E-06 | Detected |
| | Jun. 29 – July 22 | 5.79E-07 | 1.68E-06 | 5.64E-06 | Not Detected |
| | July 22 -Aug. 17 | 1.46E-06 | 1.55E-06 | 5.15E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.40E-06 | 9.40E-07 | 3.01E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | -2.10E-06 | 1.39E-06 | 4.74E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.00E-06 | 1.28E-06 | 4.02E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.94E-07 | 1.40E-06 | 4.68E-06 | Not Detected |

**Table B.38. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Near Field Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -1.22E-07 | 1.55E-07 | 5.23E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.82E-07 | 4.87E-07 | 1.62E-06 | Not Detected |
| | Mar. 16 – Mar. 30 | -9.92E-07 | 2.65E-07 | 9.14E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.06E-07 | 2.80E-07 | 9.21E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 8.45E-08 | 4.65E-07 | 1.56E-06 | Not Detected |
| | Apr. 29 – May 18 | 3.14E-07 | 1.89E-07 | 6.22E-07 | Not Detected |
| | May 18 – Jun. 3 | 5.24E-07 | 5.01E-07 | 1.66E-06 | Not Detected |
| | Jun. 3 – Jun. 15 | -8.66E-07 | 3.16E-07 | 1.08E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | -3.34E-07 | 4.68E-07 | 1.59E-06 | Not Detected |
| | Jun. 29 – July 22 | 1.14E-07 | 3.05E-07 | 1.02E-06 | Not Detected |
| | July 22 -Aug. 17 | 3.10E-07 | 1.54E-07 | 5.05E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.89E-08 | 4.81E-08 | 1.62E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.29E-07 | 8.59E-08 | 2.83E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.00E-07 | 9.51E-08 | 3.23E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.45E-07 | 9.62E-08 | 3.13E-07 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 2.12E-07 | 1.22E-07 | 4.02E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 8.48E-08 | 4.02E-07 | 1.38E-06 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.81E-07 | 2.70E-07 | 8.63E-07 | Detected |
| | Mar. 30 - Apr. 13 | 3.61E-07 | 2.43E-07 | 8.02E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 5.02E-07 | 3.84E-07 | 1.27E-06 | Not Detected |
| | Apr. 29 – May 18 | 3.32E-08 | 1.65E-07 | 5.63E-07 | Not Detected |
| | May 18 – Jun. 3 | 2.16E-07 | 3.63E-07 | 1.23E-06 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.24E-06 | 2.78E-07 | 8.66E-07 | Detected |
| | Jun. 15 – Jun. 29 | 2.04E-07 | 4.04E-07 | 1.37E-06 | Not Detected |
| | Jun. 29 – July 22 | 3.50E-07 | 2.42E-07 | 7.99E-07 | Not Detected |
| | July 22 -Aug. 17 | -1.20E-07 | 1.10E-07 | 3.82E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 6.54E-08 | 9.68E-08 | 3.23E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 7.68E-08 | 6.84E-08 | 2.28E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.66E-07 | 7.15E-08 | 2.32E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.20E-07 | 8.43E-08 | 2.69E-07 | Not Detected |

**Table B.38. Activity concentrations of gamma emitting isotopes ($^{137}Cs$, $^{60}Co$, and $^{40}K$) in the filter samples collected from Near Field Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}K$ | Feb. 2 – Mar. 2 | 2.42E-06 | 1.58E-06 | 5.20E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 5.99E-06 | 3.17E-06 | 1.03E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 6.44E-06 | 3.36E-06 | 1.10E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.12E-06 | 4.22E-06 | 1.39E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.00E-05 | 3.00E-06 | 9.36E-06 | Detected |
| | Apr. 29 – May 18 | 9.67E-06 | 3.12E-06 | 1.01E-05 | Not Detected |
| | May 18 – Jun. 3 | 6.10E-06 | 2.99E-06 | 9.73E-06 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.54E-06 | 4.16E-06 | 1.36E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 2.65E-07 | 3.36E-06 | 1.16E-05 | Not Detected |
| | Jun. 29 – July 22 | 2.79E-06 | 1.99E-06 | 6.59E-06 | Not Detected |
| | July 22 -Aug. 17 | -2.15E-07 | 2.04E-06 | 6.92E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | -3.54E-07 | 1.12E-06 | 3.76E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | -2.40E-06 | 1.33E-06 | 4.56E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.01E-06 | 1.09E-06 | 3.64E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.76E-06 | 1.59E-06 | 5.17E-06 | Not Detected |

**Table B.39. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Cactus Flats Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Feb. 2 – Mar. 2 | 1.79E-07 | 9.79E-08 | 3.21E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | -5.05E-07 | 2.68E-07 | 9.06E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 7.20E-07 | 2.46E-07 | 7.98E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.80E-07 | 2.22E-07 | 7.19E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | -7.44E-07 | 2.59E-07 | 8.83E-07 | Not Detected |
| | Apr. 29 – May 18 | 8.37E-07 | 2.45E-07 | 7.90E-07 | Detected |
| | May 18 – Jun. 3 | -6.51E-07 | 2.50E-07 | 8.49E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.16E-06 | 3.15E-07 | 1.01E-06 | Detected |
| | Jun. 15 – Jun. 29 | -8.53E-07 | 2.61E-07 | 8.94E-07 | Not Detected |
| | Jun. 29 – July 22 | 4.15E-07 | 1.90E-07 | 6.22E-07 | Not Detected |
| | July 22 -Aug. 17 | 2.62E-07 | 1.28E-07 | 4.10E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | -3.01E-08 | 1.62E-07 | 5.44E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.40E-07 | 2.26E-07 | 7.53E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.03E-07 | 8.63E-08 | 2.77E-07 | Detected |
| | Dec. 9 – Jan. 6 | 1.71E-07 | 1.03E-07 | 3.39E-07 | Not Detected |
| | | | | | |
| $^{60}$Co | Feb. 2 – Mar. 2 | 1.37E-07 | 1.11E-07 | 3.67E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 6.29E-07 | 2.11E-07 | 6.78E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.66E-07 | 2.22E-07 | 7.37E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.02E-07 | 2.71E-07 | 8.60E-07 | Detected |
| | Apr. 13 - Apr. 29 | 5.88E-07 | 2.16E-07 | 6.97E-07 | Not Detected |
| | Apr. 29 – May 18 | 3.39E-07 | 1.88E-07 | 6.18E-07 | Not Detected |
| | May 18 – Jun. 3 | 8.04E-07 | 2.43E-07 | 7.71E-07 | Detected |
| | Jun. 3 – Jun. 15 | 7.30E-08 | 2.46E-07 | 8.35E-07 | Not Detected |
| | Jun. 15 – Jun. 29 | 9.09E-07 | 2.73E-07 | 8.73E-07 | Detected |
| | Jun. 29 – July 22 | 3.60E-07 | 1.52E-07 | 4.91E-07 | Not Detected |
| | July 22 -Aug. 17 | 1.49E-07 | 1.37E-07 | 4.55E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.45E-07 | 1.08E-07 | 3.50E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.44E-07 | 1.58E-07 | 5.19E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.23E-07 | 9.87E-08 | 3.27E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.15E-07 | 1.12E-07 | 3.59E-07 | Not Detected |

## Table B.39. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Cactus Flats Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}$K | Feb. 2 – Mar. 2 | 4.06E-06 | 1.87E-06 | 6.11E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 6.22E-06 | 2.81E-06 | 9.17E-06 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.38E-06 | 3.81E-06 | 1.25E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 8.12E-06 | 3.22E-06 | 1.05E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 7.42E-06 | 2.97E-06 | 9.68E-06 | Not Detected |
| | Apr. 29 – May 18 | 6.72E-06 | 2.45E-06 | 7.94E-06 | Not Detected |
| | May 18 – Jun. 3 | -4.36E-08 | 3.04E-06 | 1.02E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.48E-05 | 4.86E-06 | 1.57E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.07E-05 | 3.57E-06 | 1.16E-05 | Not Detected |
| | Jun. 29 – July 22 | 3.54E-06 | 2.35E-06 | 7.76E-06 | Not Detected |
| | July 22 -Aug. 17 | 3.54E-06 | 2.17E-06 | 7.13E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.37E-06 | 1.01E-06 | 3.14E-06 | Detected |
| | Oct. 3 – Nov. 4 | 2.65E-06 | 1.41E-06 | 4.62E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | -8.22E-07 | 1.48E-06 | 4.98E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.20E-06 | 1.56E-06 | 5.08E-06 | Not Detected |

**Table B.40. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Loving Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | 1.81E-07 | 1.22E-07 | 4.01E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 3.69E-07 | 1.93E-07 | 6.31E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.78E-07 | 2.76E-07 | 8.99E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | -8.93E-07 | 5.43E-07 | 1.85E-06 | Not Detected |
| | Apr. 13 - Apr. 29 | 3.42E-07 | 1.92E-07 | 6.31E-07 | Not Detected |
| | Apr. 29 – May 18 | -1.81E-07 | 3.92E-07 | 1.32E-06 | Not Detected |
| | May 18 – Jun. 3 | 6.43E-08 | 1.56E-07 | 5.23E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 6.10E-07 | 2.76E-07 | 9.00E-07 | Not Detected |
| | Jun. 15 – Jun. 29 | 2.97E-07 | 2.58E-07 | 8.54E-07 | Not Detected |
| | Jun. 29 – July 22 | -4.98E-07 | 1.65E-07 | 5.66E-07 | Not Detected |
| | July 22 -Aug. 17 | 2.04E-07 | 1.34E-07 | 4.42E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | -5.16E-08 | 1.80E-07 | 6.06E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.04E-07 | 8.37E-08 | 2.77E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.62E-07 | 2.04E-07 | 6.92E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.30E-07 | 9.57E-08 | 3.16E-07 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 1.48E-07 | 1.30E-07 | 4.33E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.06E-07 | 2.03E-07 | 6.77E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.53E-07 | 2.59E-07 | 8.57E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | -3.65E-07 | 4.53E-07 | 1.57E-06 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.18E-07 | 1.89E-07 | 6.27E-07 | Not Detected |
| | Apr. 29 – May 18 | 8.30E-09 | 3.04E-07 | 1.05E-06 | Not Detected |
| | May 18 – Jun. 3 | 2.86E-07 | 2.10E-07 | 6.95E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 2.58E-07 | 2.75E-07 | 9.17E-07 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.06E-06 | 3.44E-07 | 1.11E-06 | Not Detected |
| | Jun. 29 – July 22 | 2.59E-07 | 1.70E-07 | 5.61E-07 | Not Detected |
| | July 22 -Aug. 17 | 5.22E-08 | 1.25E-07 | 4.20E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.08E-08 | 1.25E-07 | 4.31E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.35E-07 | 6.64E-08 | 2.16E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.27E-07 | 1.29E-07 | 4.70E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.06E-07 | 9.13E-08 | 3.03E-07 | Not Detected |

**Table B.40. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Loving Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}$K | Feb. 2 – Mar. 2 | 4.86E-06 | 1.65E-06 | 5.34E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 9.29E-06 | 3.74E-06 | 1.22E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.70E-05 | 3.64E-06 | 1.14E-05 | Detected |
| | Mar. 30 - Apr. 13 | -2.84E-06 | 3.19E-06 | 1.13E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 8.19E-06 | 3.29E-06 | 1.07E-05 | Not Detected |
| | Apr. 29 – May 18 | 1.46E-06 | 2.32E-06 | 7.86E-06 | Not Detected |
| | May 18 – Jun. 3 | 9.18E-06 | 3.59E-06 | 1.17E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 3.89E-06 | 3.29E-06 | 1.09E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.79E-05 | 5.10E-06 | 1.64E-05 | Detected |
| | Jun. 29 – July 22 | 3.01E-06 | 2.02E-06 | 6.63E-06 | Not Detected |
| | July 22 -Aug. 17 | 3.66E-06 | 1.66E-06 | 5.42E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.25E-06 | 1.15E-06 | 3.86E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | 9.03E-08 | 1.53E-06 | 5.11E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.70E-06 | 1.30E-06 | 4.13E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.52E-06 | 1.70E-06 | 5.57E-06 | Not Detected |

**Table B.41. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Carlsbad Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -4.34E-07 | 2.98E-07 | 1.01E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.03E-07 | 2.67E-07 | 8.91E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | -9.45E-07 | 5.31E-07 | 1.82E-06 | Not Detected |
| | Mar. 30 - Apr. 13 | -6.71E-07 | 3.56E-07 | 1.21E-06 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.52E-07 | 2.21E-07 | 7.37E-07 | Not Detected |
| | Apr. 29 – May 18 | -6.74E-07 | 2.49E-07 | 8.53E-07 | Not Detected |
| | May 18 – Jun. 3 | 1.13E-06 | 3.06E-07 | 9.85E-07 | Detected |
| | Jun. 3 – Jun. 15 | 6.21E-07 | 7.62E-07 | 2.53E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | 5.44E-08 | 3.19E-07 | 1.07E-06 | Not Detected |
| | Jun. 29 – July 22 | 8.61E-08 | 1.13E-07 | 3.75E-07 | Not Detected |
| | July 22 -Aug. 17 | -3.67E-07 | 2.58E-07 | 8.82E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 8.55E-08 | 5.04E-08 | 1.66E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 8.70E-08 | 2.41E-07 | 8.04E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -4.60E-07 | 1.94E-07 | 6.74E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.69E-07 | 1.32E-07 | 4.31E-07 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 1.75E-07 | 2.40E-07 | 8.04E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 5.40E-07 | 3.03E-07 | 9.91E-07 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.18E-07 | 4.86E-07 | 1.65E-06 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.65E-07 | 2.24E-07 | 7.22E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 6.20E-07 | 2.58E-07 | 8.34E-07 | Not Detected |
| | Apr. 29 – May 18 | 3.00E-07 | 2.05E-07 | 6.77E-07 | Not Detected |
| | May 18 – Jun. 3 | 8.77E-08 | 2.08E-07 | 7.01E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.84E-07 | 5.93E-07 | 1.95E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | 5.81E-07 | 2.77E-07 | 9.00E-07 | Not Detected |
| | Jun. 29 – July 22 | 9.27E-08 | 1.27E-07 | 4.25E-07 | Not Detected |
| | July 22 -Aug. 17 | 2.58E-07 | 1.91E-07 | 6.33E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | -1.29E-08 | 4.52E-08 | 1.57E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.14E-07 | 1.37E-07 | 4.43E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 9.41E-08 | 1.54E-07 | 5.21E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.09E-07 | 1.17E-07 | 3.71E-07 | Detected |

### Table B.41. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{40}$K** | Feb. 2 – Mar. 2 | -4.19E-07 | 1.93E-06 | 6.72E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.11E-05 | 3.54E-06 | 1.14E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 9.63E-06 | 3.89E-06 | 1.24E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 4.38E-06 | 3.99E-06 | 1.32E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.51E-05 | 3.62E-06 | 1.15E-05 | Detected |
| | Apr. 29 – May 18 | 6.63E-07 | 2.84E-06 | 9.49E-06 | Not Detected |
| | May 18 – Jun. 3 | 6.53E-06 | 3.72E-06 | 1.21E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.03E-05 | 4.83E-06 | 1.56E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.44E-05 | 3.74E-06 | 1.19E-05 | Detected |
| | Jun. 29 – July 22 | 7.79E-06 | 1.79E-06 | 5.64E-06 | Detected |
| | July 22 -Aug. 17 | 4.93E-07 | 1.67E-06 | 5.72E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | -1.98E-07 | 1.02E-06 | 3.41E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.52E-06 | 1.67E-06 | 5.53E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.56E-06 | 1.52E-06 | 4.99E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.27E-06 | 1.58E-06 | 5.13E-06 | Not Detected |

**Table B.42. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from East Tower Station**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -4.01E-07 | 1.64E-07 | 5.56E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.08E-07 | 5.01E-07 | 1.67E-06 | Not Detected |
| | Mar. 16 – Mar. 30 | -6.20E-07 | 2.91E-07 | 9.90E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 3.50E-07 | 2.38E-07 | 7.85E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.12E-07 | 4.83E-07 | 1.61E-06 | Not Detected |
| | Apr. 29 – May 18 | 3.91E-07 | 2.08E-07 | 6.80E-07 | Not Detected |
| | May 18 – Jun. 3 | 3.76E-07 | 2.04E-07 | 6.68E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | -5.88E-07 | 3.74E-07 | 1.26E-06 | Not Detected |
| | Jun. 15 – Jun. 29 | -8.11E-07 | 4.56E-07 | 1.57E-06 | Not Detected |
| | Jun. 29 – July 22 | 3.15E-08 | 3.29E-07 | 1.10E-06 | Not Detected |
| | July 22 -Aug. 17 | -1.76E-07 | 2.76E-07 | 9.33E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.14E-08 | 1.75E-07 | 5.85E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.18E-08 | 8.30E-08 | 2.78E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | -3.01E-07 | 1.87E-07 | 6.40E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | -1.16E-07 | 2.66E-07 | 8.94E-07 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 3.09E-07 | 1.48E-07 | 4.81E-07 | Not Detected |
| | Mar. 2 – Mar. 16 | 7.63E-07 | 3.86E-07 | 1.26E-06 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.98E-07 | 2.64E-07 | 8.57E-07 | Not Detected |
| | Mar. 30 - Apr. 13 | 3.02E-07 | 2.22E-07 | 7.35E-07 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.29E-07 | 3.51E-07 | 1.22E-06 | Not Detected |
| | Apr. 29 – May 18 | 4.58E-08 | 1.95E-07 | 6.56E-07 | Not Detected |
| | May 18 – Jun. 3 | 2.27E-07 | 2.32E-07 | 7.73E-07 | Not Detected |
| | Jun. 3 – Jun. 15 | 8.24E-07 | 2.76E-07 | 8.80E-07 | Not Detected |
| | Jun. 15 – Jun. 29 | 5.10E-09 | 4.15E-07 | 1.43E-06 | Not Detected |
| | Jun. 29 – July 22 | 2.62E-07 | 2.46E-07 | 8.24E-07 | Not Detected |
| | July 22 -Aug. 17 | 3.72E-07 | 2.37E-07 | 7.79E-07 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.38E-07 | 1.20E-07 | 3.99E-07 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.00E-07 | 6.96E-08 | 2.30E-07 | Not Detected |
| | Nov. 4 – Dec. 9 | 5.05E-08 | 1.39E-07 | 4.72E-07 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.07E-07 | 2.21E-07 | 7.38E-07 | Not Detected |

**Table B.42. Activity concentrations of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from East Tower Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}$K | Feb. 2 – Mar. 2 | 4.20E-06 | 1.69E-06 | 5.52E-06 | Not Detected |
| | Mar. 2 – Mar. 16 | 6.16E-06 | 3.22E-06 | 1.05E-05 | Not Detected |
| | Mar. 16 – Mar. 30 | 7.86E-06 | 3.45E-06 | 1.13E-05 | Not Detected |
| | Mar. 30 - Apr. 13 | 2.59E-06 | 4.05E-06 | 1.35E-05 | Not Detected |
| | Apr. 13 - Apr. 29 | 7.28E-06 | 3.17E-06 | 1.02E-05 | Not Detected |
| | Apr. 29 – May 18 | 6.78E-07 | 2.76E-06 | 9.18E-06 | Not Detected |
| | May 18 – Jun. 3 | 8.00E-06 | 3.09E-06 | 1.00E-05 | Not Detected |
| | Jun. 3 – Jun. 15 | 6.98E-06 | 3.93E-06 | 1.29E-05 | Not Detected |
| | Jun. 15 – Jun. 29 | 7.96E-06 | 3.55E-06 | 1.15E-05 | Not Detected |
| | Jun. 29 – July 22 | 3.71E-06 | 2.06E-06 | 6.73E-06 | Not Detected |
| | July 22 -Aug. 17 | 2.87E-07 | 1.91E-06 | 6.53E-06 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.07E-06 | 1.05E-06 | 3.41E-06 | Not Detected |
| | Oct. 3 – Nov. 4 | -3.04E-06 | 1.48E-06 | 5.09E-06 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.54E-06 | 1.22E-06 | 3.83E-06 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.69E-06 | 1.81E-06 | 5.96E-06 | Not Detected |

### Table B.43. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -4.96E-03 | 2.73E-03 | 9.41E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 7.93E-03 | 3.75E-03 | 1.23E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 6.84E-03 | 2.09E-03 | 6.72E-03 | Detected |
| | Mar. 30 - Apr. 13 | 1.44E-03 | 1.90E-03 | 6.31E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.20E-03 | 1.87E-03 | 6.19E-03 | Not Detected |
| | Apr. 29 – May 18 | -2.97E-03 | 2.07E-03 | 6.97E-03 | Not Detected |
| | May 18 – Jun. 3 | 3.92E-03 | 2.02E-03 | 6.62E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 2.42E-03 | 4.05E-03 | 1.35E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.79E-03 | 2.80E-03 | 9.33E-03 | Not Detected |
| | Jun. 29 – July 22 | -6.31E-03 | 2.24E-03 | 7.62E-03 | Not Detected |
| | July 22 -Aug. 17 | -4.68E-03 | 1.72E-03 | 5.92E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.56E-03 | 3.06E-03 | 1.01E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 5.23E-03 | 2.15E-03 | 7.00E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.05E-03 | 4.08E-03 | 1.38E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | -8.29E-03 | 3.43E-03 | 1.16E-02 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 2.28E-03 | 2.59E-03 | 8.68E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 3.48E-03 | 3.64E-03 | 1.22E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 6.96E-03 | 2.37E-03 | 7.62E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.65E-03 | 2.15E-03 | 6.95E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | 4.33E-03 | 2.22E-03 | 7.25E-03 | Not Detected |
| | Apr. 29 – May 18 | 4.35E-03 | 1.75E-03 | 5.67E-03 | Not Detected |
| | May 18 – Jun. 3 | 2.36E-03 | 1.97E-03 | 6.54E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 7.52E-03 | 3.37E-03 | 1.09E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 4.35E-03 | 3.62E-03 | 1.20E-02 | Not Detected |
| | Jun. 29 – July 22 | 4.09E-03 | 1.86E-03 | 6.04E-03 | Not Detected |
| | July 22 -Aug. 17 | 5.80E-03 | 1.56E-03 | 4.94E-03 | Detected |
| | Aug. 17 – Oct. 3 | 1.04E-03 | 2.08E-03 | 7.05E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 9.60E-04 | 1.79E-03 | 6.06E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.03E-02 | 3.38E-03 | 1.08E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 9.66E-03 | 3.11E-03 | 1.00E-02 | Not Detected |

### Table B.43. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Onsite Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{40}$K** | Feb. 2 – Mar. 2 | 4.03E-02 | 2.01E-02 | 6.54E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 5.10E-02 | 6.24E-02 | 2.07E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.44E-01 | 2.99E-02 | 9.38E-02 | Detected |
| | Mar. 30 - Apr. 13 | 9.36E-02 | 2.73E-02 | 8.72E-02 | Detected |
| | Apr. 13 - Apr. 29 | 8.63E-02 | 2.66E-02 | 8.54E-02 | Detected |
| | Apr. 29 – May 18 | 4.57E-02 | 2.50E-02 | 8.17E-02 | Not Detected |
| | May 18 – Jun. 3 | 7.87E-02 | 2.44E-02 | 7.87E-02 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.12E-02 | 2.52E-02 | 8.61E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.99E-01 | 4.35E-02 | 1.37E-01 | Detected |
| | Jun. 29 – July 22 | 9.08E-03 | 2.64E-02 | 8.84E-02 | Not Detected |
| | July 22 -Aug. 17 | 2.05E-02 | 2.17E-02 | 7.19E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.35E-02 | 1.71E-02 | 5.46E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | -5.72E-02 | 3.80E-02 | 1.30E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | 8.57E-02 | 2.74E-02 | 8.61E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.13E-03 | 3.86E-02 | 1.30E-01 | Not Detected |

### Table B.44. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -2.55E-03 | 3.23E-03 | 1.09E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.76E-03 | 7.38E-03 | 2.46E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | -8.41E-03 | 2.25E-03 | 7.74E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.72E-03 | 3.16E-03 | 1.04E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.26E-03 | 6.91E-03 | 2.31E-02 | Not Detected |
| | Apr. 29 – May 18 | 4.30E-03 | 2.59E-03 | 8.51E-03 | Not Detected |
| | May 18 – Jun. 3 | 6.31E-03 | 6.03E-03 | 2.00E-02 | Not Detected |
| | Jun. 3 – Jun. 15 | -8.62E-03 | 3.15E-03 | 1.07E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | -9.18E-03 | 1.29E-02 | 4.36E-02 | Not Detected |
| | Jun. 29 – July 22 | 1.99E-03 | 5.32E-03 | 1.77E-02 | Not Detected |
| | July 22 -Aug. 17 | 5.60E-03 | 2.79E-03 | 9.12E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.31E-04 | 1.10E-03 | 3.68E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 4.61E-03 | 3.07E-03 | 1.01E-02 | Not Detected |
| | Nov. 4 – Dec. 9 | -6.89E-03 | 3.28E-03 | 1.11E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.00E-02 | 3.94E-03 | 1.28E-02 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 5.52E-08 | 2.55E-03 | 8.36E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 3.21E-08 | 6.10E-03 | 2.09E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.88E-07 | 2.29E-03 | 7.32E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.08E-07 | 2.74E-03 | 9.06E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.66E-07 | 5.72E-03 | 1.89E-02 | Not Detected |
| | Apr. 29 – May 18 | 8.90E-09 | 2.26E-03 | 7.71E-03 | Not Detected |
| | May 18 – Jun. 3 | 5.97E-08 | 4.37E-03 | 1.48E-02 | Not Detected |
| | Jun. 3 – Jun. 15 | 3.76E-07 | 2.77E-03 | 8.62E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.42E-07 | 1.11E-02 | 3.77E-02 | Not Detected |
| | Jun. 29 – July 22 | 9.35E-08 | 4.23E-03 | 1.39E-02 | Not Detected |
| | July 22 -Aug. 17 | -3.07E-08 | 1.98E-03 | 6.90E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.09E-08 | 2.21E-03 | 7.35E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.64E-08 | 2.44E-03 | 8.15E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | 5.05E-08 | 2.47E-03 | 7.98E-03 | Not Detected |
| | Dec. 9 – Jan. 6 | 5.40E-08 | 3.45E-03 | 1.10E-02 | Not Detected |

## Table B.44. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Near Field Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{40}$K** | Feb. 2 – Mar. 2 | 5.03E-02 | 3.28E-02 | 1.08E-01 | Not Detected |
| | Mar. 2 – Mar. 16 | 9.09E-02 | 4.81E-02 | 1.57E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 5.46E-02 | 2.85E-02 | 9.35E-02 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.78E-02 | 4.77E-02 | 1.57E-01 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.49E-01 | 4.46E-02 | 1.39E-01 | Detected |
| | Apr. 29 – May 18 | 1.32E-01 | 4.27E-02 | 1.38E-01 | Not Detected |
| | May 18 – Jun. 3 | 7.34E-02 | 3.60E-02 | 1.17E-01 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.50E-02 | 4.15E-02 | 1.36E-01 | Not Detected |
| | Jun. 15 – Jun. 29 | 7.31E-03 | 9.25E-02 | 3.18E-01 | Not Detected |
| | Jun. 29 – July 22 | 4.87E-02 | 3.48E-02 | 1.15E-01 | Not Detected |
| | July 22 -Aug. 17 | -3.88E-03 | 3.68E-02 | 1.25E-01 | Not Detected |
| | Aug. 17 – Oct. 3 | -8.07E-03 | 2.56E-02 | 8.56E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | -8.56E-02 | 4.74E-02 | 1.63E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.49E-02 | 3.76E-02 | 1.25E-01 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.54E-01 | 6.50E-02 | 2.11E-01 | Not Detected |

**Table B.45. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Cactus Flats Station**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Feb. 2 – Mar. 2 | 3.26E-03 | 1.78E-03 | 5.84E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | -8.30E-03 | 4.40E-03 | 1.49E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.90E-03 | 3.04E-03 | 9.86E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 6.13E-03 | 2.34E-03 | 7.59E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.05E-02 | 3.66E-03 | 1.25E-02 | Not Detected |
| | Apr. 29 – May 18 | 1.05E-02 | 3.07E-03 | 9.90E-03 | Detected |
| | May 18 – Jun. 3 | -7.90E-03 | 3.03E-03 | 1.03E-02 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.13E-02 | 3.06E-03 | 9.85E-03 | Detected |
| | Jun. 15 – Jun. 29 | -1.25E-02 | 3.83E-03 | 1.31E-02 | Not Detected |
| | Jun. 29 – July 22 | 6.71E-03 | 3.06E-03 | 1.00E-02 | Not Detected |
| | July 22 -Aug. 17 | 4.63E-03 | 2.25E-03 | 7.23E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | -7.82E-04 | 4.21E-03 | 1.41E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.65E-03 | 5.90E-03 | 1.96E-02 | Not Detected |
| | Nov. 4 – Dec. 9 | 8.34E-03 | 2.37E-03 | 7.62E-03 | Detected |
| | Dec. 9 – Jan. 6 | 4.41E-03 | 2.66E-03 | 8.76E-03 | Not Detected |
| | | | | | |
| $^{60}$Co | Feb. 2 – Mar. 2 | 2.49E-03 | 2.01E-03 | 6.68E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.03E-02 | 3.47E-03 | 1.11E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.29E-03 | 2.74E-03 | 9.12E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.53E-03 | 2.87E-03 | 9.08E-03 | Detected |
| | Apr. 13 - Apr. 29 | 8.31E-03 | 3.06E-03 | 9.85E-03 | Not Detected |
| | Apr. 29 – May 18 | 4.25E-03 | 2.36E-03 | 7.74E-03 | Not Detected |
| | May 18 – Jun. 3 | 9.76E-03 | 2.95E-03 | 9.36E-03 | Detected |
| | Jun. 3 – Jun. 15 | 7.09E-04 | 2.39E-03 | 8.11E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.33E-02 | 4.01E-03 | 1.28E-02 | Detected |
| | Jun. 29 – July 22 | 5.81E-03 | 2.45E-03 | 7.93E-03 | Not Detected |
| | July 22 -Aug. 17 | 2.63E-03 | 2.42E-03 | 8.04E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | 6.35E-03 | 2.81E-03 | 9.09E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 6.36E-03 | 4.11E-03 | 1.35E-02 | Not Detected |
| | Nov. 4 – Dec. 9 | 3.39E-03 | 2.71E-03 | 8.98E-03 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.14E-03 | 2.89E-03 | 9.26E-03 | Not Detected |

**Table B.45. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Cactus Flats Station (continued)**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{40}$K** | Feb. 2 – Mar. 2 | 7.39E-02 | 3.40E-02 | 1.11E-01 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.02E-01 | 4.62E-02 | 1.51E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.04E-01 | 4.71E-02 | 1.54E-01 | Not Detected |
| | Mar. 30 - Apr. 13 | 8.58E-02 | 3.40E-02 | 1.11E-01 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.05E-01 | 4.20E-02 | 1.37E-01 | Not Detected |
| | Apr. 29 – May 18 | 8.42E-02 | 3.07E-02 | 9.95E-02 | Not Detected |
| | May 18 – Jun. 3 | -5.30E-04 | 3.69E-02 | 1.24E-01 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.44E-01 | 4.72E-02 | 1.53E-01 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.57E-01 | 5.24E-02 | 1.70E-01 | Not Detected |
| | Jun. 29 – July 22 | 5.71E-02 | 3.80E-02 | 1.25E-01 | Not Detected |
| | July 22 -Aug. 17 | 6.24E-02 | 3.82E-02 | 1.26E-01 | Not Detected |
| | Aug. 17 – Oct. 3 | 8.75E-02 | 2.63E-02 | 8.17E-02 | Detected |
| | Oct. 3 – Nov. 4 | 6.90E-02 | 3.68E-02 | 1.20E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | -2.26E-02 | 4.06E-02 | 1.37E-01 | Not Detected |
| | Dec. 9 – Jan. 6 | 8.27E-02 | 4.02E-02 | 1.31E-01 | Not Detected |

### Table B.46. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Loving Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | 2.49E-03 | 1.68E-03 | 5.52E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 4.57E-03 | 2.39E-03 | 7.81E-03 | Not Detected |
| | Mar. 16 – Mar. 30 | 3.80E-03 | 1.81E-03 | 5.92E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | -7.12E-03 | 4.33E-03 | 1.48E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 4.10E-03 | 2.31E-03 | 7.57E-03 | Not Detected |
| | Apr. 29 – May 18 | -1.76E-03 | 3.79E-03 | 1.28E-02 | Not Detected |
| | May 18 – Jun. 3 | 3.47E-04 | 8.42E-04 | 2.82E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 4.69E-03 | 2.12E-03 | 6.92E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | 4.67E-03 | 4.06E-03 | 1.34E-02 | Not Detected |
| | Jun. 29 – July 22 | -7.84E-03 | 2.60E-03 | 8.91E-03 | Not Detected |
| | July 22 -Aug. 17 | 3.25E-03 | 2.14E-03 | 7.05E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | -8.51E-04 | 2.97E-03 | 9.99E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 3.21E-03 | 2.57E-03 | 8.52E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | -7.90E-03 | 6.16E-03 | 2.09E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 4.01E-03 | 2.95E-03 | 9.75E-03 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 2.04E-03 | 1.79E-03 | 5.97E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.55E-03 | 2.51E-03 | 8.38E-03 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.32E-03 | 1.70E-03 | 5.63E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | -2.91E-03 | 3.61E-03 | 1.25E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.62E-03 | 2.26E-03 | 7.51E-03 | Not Detected |
| | Apr. 29 – May 18 | 8.03E-05 | 2.94E-03 | 1.01E-02 | Not Detected |
| | May 18 – Jun. 3 | 1.54E-03 | 1.13E-03 | 3.75E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.98E-03 | 2.11E-03 | 7.05E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.67E-02 | 5.41E-03 | 1.74E-02 | Not Detected |
| | Jun. 29 – July 22 | 4.07E-03 | 2.67E-03 | 8.83E-03 | Not Detected |
| | July 22 -Aug. 17 | 8.33E-04 | 1.99E-03 | 6.70E-03 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.77E-04 | 2.06E-03 | 7.11E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 4.14E-03 | 2.04E-03 | 6.63E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | -6.87E-03 | 3.91E-03 | 1.42E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 3.27E-03 | 2.81E-03 | 9.34E-03 | Not Detected |

### Table B.46. Specific activities of gamma emitting isotopes ($^{137}Cs$, $^{60}Co$, and $^{40}K$) in the filter samples collected from Loving Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{40}$K | Feb. 2 – Mar. 2 | 6.69E-02 | 2.28E-02 | 7.35E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.15E-01 | 4.63E-02 | 1.51E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.12E-01 | 2.39E-02 | 7.52E-02 | Detected |
| | Mar. 30 - Apr. 13 | -2.27E-02 | 2.55E-02 | 9.02E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 9.82E-02 | 3.95E-02 | 1.28E-01 | Not Detected |
| | Apr. 29 – May 18 | 1.41E-02 | 2.25E-02 | 7.60E-02 | Not Detected |
| | May 18 – Jun. 3 | 4.95E-02 | 1.94E-02 | 6.30E-02 | Not Detected |
| | Jun. 3 – Jun. 15 | 2.99E-02 | 2.53E-02 | 8.36E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 2.80E-01 | 8.01E-02 | 2.58E-01 | Detected |
| | Jun. 29 – July 22 | 4.73E-02 | 3.18E-02 | 1.04E-01 | Not Detected |
| | July 22 -Aug. 17 | 5.85E-02 | 2.65E-02 | 8.65E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.06E-02 | 1.90E-02 | 6.36E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.77E-03 | 4.71E-02 | 1.57E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.12E-01 | 3.94E-02 | 1.25E-01 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.09E-01 | 5.23E-02 | 1.72E-01 | Not Detected |

**Table B.47. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from Carlsbad Station**

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -7.41E-03 | 5.08E-03 | 1.73E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.35E-03 | 3.49E-03 | 1.16E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | -8.77E-03 | 4.93E-03 | 1.69E-02 | Not Detected |
| | Mar. 30 - Apr. 13 | -6.04E-03 | 3.21E-03 | 1.09E-02 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.10E-03 | 3.06E-03 | 1.02E-02 | Not Detected |
| | Apr. 29 – May 18 | -7.78E-03 | 2.87E-03 | 9.83E-03 | Not Detected |
| | May 18 – Jun. 3 | 9.54E-03 | 2.59E-03 | 8.35E-03 | Detected |
| | Jun. 3 – Jun. 15 | 4.30E-03 | 5.27E-03 | 1.75E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 8.51E-04 | 5.00E-03 | 1.68E-02 | Not Detected |
| | Jun. 29 – July 22 | 1.51E-03 | 1.98E-03 | 6.60E-03 | Not Detected |
| | July 22 -Aug. 17 | -7.93E-03 | 5.57E-03 | 1.90E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 2.41E-03 | 1.42E-03 | 4.66E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.88E-03 | 7.98E-03 | 2.66E-02 | Not Detected |
| | Nov. 4 – Dec. 9 | -1.24E-02 | 5.22E-03 | 1.81E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 9.20E-03 | 4.51E-03 | 1.47E-02 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 2.99E-03 | 4.09E-03 | 1.37E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 7.06E-03 | 3.96E-03 | 1.30E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 2.02E-03 | 4.51E-03 | 1.54E-02 | Not Detected |
| | Mar. 30 - Apr. 13 | 5.09E-03 | 2.02E-03 | 6.51E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | 8.60E-03 | 3.57E-03 | 1.16E-02 | Not Detected |
| | Apr. 29 – May 18 | 3.45E-03 | 2.36E-03 | 7.80E-03 | Not Detected |
| | May 18 – Jun. 3 | 7.44E-04 | 1.76E-03 | 5.94E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 6.81E-03 | 4.10E-03 | 1.35E-02 | Not Detected |
| | Jun. 15 – Jun. 29 | 9.10E-03 | 4.33E-03 | 1.41E-02 | Not Detected |
| | Jun. 29 – July 22 | 1.63E-03 | 2.23E-03 | 7.47E-03 | Not Detected |
| | July 22 -Aug. 17 | 5.57E-03 | 4.12E-03 | 1.37E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | -3.62E-04 | 1.27E-03 | 4.41E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.04E-02 | 4.55E-03 | 1.47E-02 | Not Detected |
| | Nov. 4 – Dec. 9 | 2.53E-03 | 4.14E-03 | 1.40E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.40E-02 | 4.01E-03 | 1.27E-02 | Detected |

## Table B.47. Specific activities of gamma emitting isotopes ($^{137}Cs$, $^{60}Co$, and $^{40}K$) in the filter samples collected from Carlsbad Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{40}K$** | Feb. 2 – Mar. 2 | -7.15E-03 | 3.30E-02 | 1.15E-01 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.45E-01 | 4.63E-02 | 1.49E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.94E-02 | 3.61E-02 | 1.15E-01 | Not Detected |
| | Mar. 30 - Apr. 13 | 3.95E-02 | 3.59E-02 | 1.19E-01 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.09E-01 | 5.01E-02 | 1.59E-01 | Detected |
| | Apr. 29 – May 18 | 7.65E-03 | 3.27E-02 | 1.09E-01 | Not Detected |
| | May 18 – Jun. 3 | 5.54E-02 | 3.15E-02 | 1.03E-01 | Not Detected |
| | Jun. 3 – Jun. 15 | 7.15E-02 | 3.35E-02 | 1.08E-01 | Not Detected |
| | Jun. 15 – Jun. 29 | 2.26E-01 | 5.85E-02 | 1.86E-01 | Detected |
| | Jun. 29 – July 22 | 1.37E-01 | 3.14E-02 | 9.91E-02 | Detected |
| | July 22 -Aug. 17 | 1.06E-02 | 3.60E-02 | 1.23E-01 | Not Detected |
| | Aug. 17 – Oct. 3 | -5.57E-03 | 2.86E-02 | 9.61E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 8.33E-02 | 5.53E-02 | 1.83E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | 6.88E-02 | 4.08E-02 | 1.34E-01 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.46E-01 | 5.42E-02 | 1.76E-01 | Not Detected |

## Table B.48. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from East Tower Station

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{137}$Cs** | Feb. 2 – Mar. 2 | -6.37E-03 | 2.60E-03 | 8.82E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.11E-03 | 5.09E-03 | 1.70E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | -6.89E-03 | 3.23E-03 | 1.10E-02 | Not Detected |
| | Mar. 30 - Apr. 13 | 2.99E-03 | 2.04E-03 | 6.70E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | 2.46E-03 | 5.59E-03 | 1.86E-02 | Not Detected |
| | Apr. 29 – May 18 | 4.02E-03 | 2.14E-03 | 7.00E-03 | Not Detected |
| | May 18 – Jun. 3 | 3.95E-03 | 2.14E-03 | 7.01E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | -4.63E-03 | 2.95E-03 | 9.93E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | -1.22E-02 | 6.85E-03 | 2.35E-02 | Not Detected |
| | Jun. 29 – July 22 | 5.16E-04 | 5.39E-03 | 1.80E-02 | Not Detected |
| | July 22 -Aug. 17 | -2.66E-03 | 4.19E-03 | 1.42E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 7.06E-04 | 3.93E-03 | 1.32E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | 9.21E-04 | 2.40E-03 | 8.04E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | -8.07E-03 | 5.02E-03 | 1.72E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | -3.37E-03 | 7.75E-03 | 2.61E-02 | Not Detected |
| | | | | | |
| **$^{60}$Co** | Feb. 2 – Mar. 2 | 4.91E-03 | 2.35E-03 | 7.63E-03 | Not Detected |
| | Mar. 2 – Mar. 16 | 7.75E-03 | 3.92E-03 | 1.28E-02 | Not Detected |
| | Mar. 16 – Mar. 30 | 6.65E-03 | 2.93E-03 | 9.52E-03 | Not Detected |
| | Mar. 30 - Apr. 13 | 2.58E-03 | 1.90E-03 | 6.28E-03 | Not Detected |
| | Apr. 13 - Apr. 29 | -1.49E-03 | 4.07E-03 | 1.41E-02 | Not Detected |
| | Apr. 29 – May 18 | 4.71E-04 | 2.00E-03 | 6.76E-03 | Not Detected |
| | May 18 – Jun. 3 | 2.38E-03 | 2.43E-03 | 8.12E-03 | Not Detected |
| | Jun. 3 – Jun. 15 | 6.49E-03 | 2.18E-03 | 6.94E-03 | Not Detected |
| | Jun. 15 – Jun. 29 | 7.66E-05 | 6.23E-03 | 2.14E-02 | Not Detected |
| | Jun. 29 – July 22 | 4.29E-03 | 4.03E-03 | 1.35E-02 | Not Detected |
| | July 22 -Aug. 17 | 5.64E-03 | 3.60E-03 | 1.18E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.11E-03 | 2.70E-03 | 9.00E-03 | Not Detected |
| | Oct. 3 – Nov. 4 | 2.90E-03 | 2.01E-03 | 6.66E-03 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.35E-03 | 3.72E-03 | 1.27E-02 | Not Detected |
| | Dec. 9 – Jan. 6 | 6.03E-03 | 6.44E-03 | 2.15E-02 | Not Detected |

### Table B.48. Specific activities of gamma emitting isotopes ($^{137}$Cs, $^{60}$Co, and $^{40}$K) in the filter samples collected from East Tower Station (continued)

| Radionuclide | Sample Date 2022 | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{40}$K** | Feb. 2 – Mar. 2 | 6.66E-02 | 2.69E-02 | 8.76E-02 | Not Detected |
| | Mar. 2 – Mar. 16 | 6.25E-02 | 3.27E-02 | 1.07E-01 | Not Detected |
| | Mar. 16 – Mar. 30 | 8.73E-02 | 3.84E-02 | 1.25E-01 | Not Detected |
| | Mar. 30 - Apr. 13 | 2.21E-02 | 3.46E-02 | 1.15E-01 | Not Detected |
| | Apr. 13 - Apr. 29 | 8.43E-02 | 3.68E-02 | 1.18E-01 | Not Detected |
| | Apr. 29 – May 18 | 6.98E-03 | 2.84E-02 | 9.45E-02 | Not Detected |
| | May 18 – Jun. 3 | 8.40E-02 | 3.24E-02 | 1.05E-01 | Not Detected |
| | Jun. 3 – Jun. 15 | 5.50E-02 | 3.10E-02 | 1.02E-01 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.20E-01 | 5.34E-02 | 1.73E-01 | Not Detected |
| | Jun. 29 – July 22 | 6.07E-02 | 3.38E-02 | 1.10E-01 | Not Detected |
| | July 22 -Aug. 17 | 4.35E-03 | 2.89E-02 | 9.90E-02 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.65E-02 | 2.36E-02 | 7.68E-02 | Not Detected |
| | Oct. 3 – Nov. 4 | -8.81E-02 | 4.30E-02 | 1.47E-01 | Not Detected |
| | Nov. 4 – Dec. 9 | 9.50E-02 | 3.26E-02 | 1.03E-01 | Not Detected |
| | Dec. 9 – Jan. 6 | 7.83E-02 | 5.29E-02 | 1.74E-01 | Not Detected |

## Table B.49. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at Onsite Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 5.63E-05 | 4.59E-06 | 5.73E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.41E-04 | 1.16E-05 | 1.46E-04 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.43E-04 | 1.09E-05 | 1.26E-04 | Detected |
| | Mar. 30 - Apr. 13 | 1.19E-04 | 9.53E-06 | 1.21E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.06E-04 | 8.49E-06 | 1.03E-04 | Detected |
| | Apr. 29 – May 18 | 7.94E-05 | 6.76E-06 | 8.91E-05 | Not Detected |
| | May 18 – Jun. 3 | 9.93E-05 | 8.08E-06 | 1.02E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.32E-04 | 1.07E-05 | 1.37E-04 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.15E-04 | 9.20E-06 | 1.18E-04 | Not Detected |
| | Jun. 29 – July 22 | 6.60E-05 | 5.26E-06 | 7.01E-05 | Not Detected |
| | July 22 -Aug. 17 | 6.13E-05 | 5.04E-06 | 6.51E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.11E-05 | 2.53E-06 | 3.55E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 5.00E-05 | 3.90E-06 | 4.99E-05 | Detected |
| | Nov. 4 – Dec. 9 | 4.70E-05 | 3.80E-06 | 4.56E-05 | Detected |
| | Dec. 9 – Jan. 6 | 4.92E-05 | 4.21E-06 | 5.54E-05 | Not Detected |

## Table B.50. Specific activities of $^{90}Sr$ (Bq/g) at Onsite Station

| Radionuclide | Sample Date 2022 | $^{90}Sr$ Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{90}Sr$** | Feb. 2 – Mar. 2 | 7.92E-01 | 6.45E-02 | 8.05E-01 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.10E+00 | 1.72E-01 | 2.18E+00 | Not Detected |
| | Mar. 16 – Mar. 30 | 1.39E+00 | 1.06E-01 | 1.22E+00 | Detected |
| | Mar. 30 - Apr. 13 | 1.09E+00 | 8.75E-02 | 1.11E+00 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.17E+00 | 9.35E-02 | 1.13E+00 | Detected |
| | Apr. 29 – May 18 | 9.12E-01 | 7.77E-02 | 1.02E+00 | Not Detected |
| | May 18 – Jun. 3 | 1.01E+00 | 8.19E-02 | 1.03E+00 | Not Detected |
| | Jun. 3 – Jun. 15 | 9.88E-01 | 8.03E-02 | 1.02E+00 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.66E+00 | 1.33E-01 | 1.70E+00 | Not Detected |
| | Jun. 29 – July 22 | 1.03E+00 | 8.25E-02 | 1.10E+00 | Not Detected |
| | July 22 -Aug. 17 | 8.57E-01 | 7.04E-02 | 9.10E-01 | Not Detected |
| | Aug. 17 – Oct. 3 | 5.65E-01 | 4.58E-02 | 6.44E-01 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.36E+00 | 1.06E-01 | 1.36E+00 | Detected |
| | Nov. 4 – Dec. 9 | 1.01E+00 | 8.15E-02 | 9.79E-01 | Detected |
| | Dec. 9 – Jan. 6 | 1.36E+00 | 1.17E-01 | 1.53E+00 | Not Detected |

### Table B.51. Activity concentrations of $^{90}Sr$ (Bq/m$^3$) at Near Field Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}Sr$** | Feb. 2 – Mar. 2 | 6.79E-05 | 8.67E-08 | 6.46E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.42E-04 | 1.65E-07 | 1.29E-04 | Detected |
| | Mar. 16 – Mar. 30 | 1.24E-04 | 1.82E-07 | 1.30E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.22E-04 | 1.94E-07 | 1.37E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.09E-04 | 1.59E-07 | 1.15E-04 | Not Detected |
| | Apr. 29 – May 18 | 1.03E-04 | 1.36E-07 | 1.01E-04 | Detected |
| | May 18 – Jun. 3 | 1.15E-04 | 1.64E-07 | 1.18E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.62E-04 | 2.12E-07 | 1.57E-04 | Detected |
| | Jun. 15 – Jun. 29 | 1.24E-04 | 1.78E-07 | 1.33E-04 | Not Detected |
| | Jun. 29 – July 22 | 7.11E-05 | 1.12E-07 | 8.05E-05 | Not Detected |
| | July 22 -Aug. 17 | 7.18E-05 | 9.85E-08 | 7.49E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.57E-05 | 5.13E-08 | 3.85E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 4.71E-05 | 6.93E-08 | 4.92E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.70E-05 | 6.08E-08 | 4.54E-05 | Detected |
| | Dec. 9 – Jan. 6 | 4.98E-05 | 7.96E-08 | 5.39E-05 | Not Detected |

### Table B.52. Specific activities of $^{90}$Sr (Bq/g) at Near Field Station

| Radionuclide | Sample Date 2022 | $^{90}$Sr Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{90}$Sr | Feb. 2 – Mar. 2 | 1.41E+00 | 1.80E-03 | 1.34E+00 | Detected |
| | Mar. 2 – Mar. 16 | 2.15E+00 | 2.51E-03 | 1.95E+00 | Detected |
| | Mar. 16 – Mar. 30 | 1.05E+00 | 1.55E-03 | 1.10E+00 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.38E+00 | 2.19E-03 | 1.55E+00 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.62E+00 | 2.37E-03 | 1.70E+00 | Not Detected |
| | Apr. 29 – May 18 | 1.41E+00 | 1.87E-03 | 1.38E+00 | Detected |
| | May 18 – Jun. 3 | 1.38E+00 | 1.98E-03 | 1.42E+00 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.61E+00 | 2.11E-03 | 1.56E+00 | Detected |
| | Jun. 15 – Jun. 29 | 3.41E+00 | 4.91E-03 | 3.65E+00 | Not Detected |
| | Jun. 29 – July 22 | 1.24E+00 | 1.96E-03 | 1.40E+00 | Not Detected |
| | July 22 -Aug. 17 | 1.30E+00 | 1.78E-03 | 1.35E+00 | Not Detected |
| | Aug. 17 – Oct. 3 | 8.13E-01 | 1.17E-03 | 8.78E-01 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.68E+00 | 2.47E-03 | 1.76E+00 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.62E+00 | 2.09E-03 | 1.56E+00 | Detected |
| | Dec. 9 – Jan. 6 | 2.04E+00 | 3.26E-03 | 2.21E+00 | Not Detected |

### Table B.53. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at Cactus Flats Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 6.14E-05 | 9.08E-08 | 6.47E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.18E-04 | 1.54E-07 | 1.14E-04 | Detected |
| | Mar. 16 – Mar. 30 | 1.14E-04 | 1.82E-07 | 1.29E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.14E-04 | 2.00E-07 | 1.38E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.13E-04 | 1.56E-07 | 1.15E-04 | Not Detected |
| | Apr. 29 – May 18 | 1.09E-04 | 1.37E-07 | 1.03E-04 | Detected |
| | May 18 – Jun. 3 | 1.13E-04 | 1.68E-07 | 1.21E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.57E-04 | 2.21E-07 | 1.60E-04 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.24E-04 | 1.78E-07 | 1.29E-04 | Not Detected |
| | Jun. 29 – July 22 | 7.18E-05 | 1.14E-07 | 8.22E-05 | Not Detected |
| | July 22 -Aug. 17 | 7.09E-05 | 1.06E-07 | 7.80E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.48E-05 | 4.86E-08 | 3.70E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 5.17E-05 | 7.24E-08 | 5.30E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.42E-05 | 7.54E-08 | 4.98E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 6.36E-05 | 9.02E-08 | 6.28E-05 | Detected |

## Table B.54. Specific activities of $^{90}$Sr (Bq/g) at Cactus Flats Station

| Radionuclide | Sample Date 2022 | $^{90}$Sr Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 1.12E+00 | 1.65E-03 | 1.18E+00 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.94E+00 | 2.54E-03 | 1.88E+00 | Detected |
| | Mar. 16 – Mar. 30 | 1.41E+00 | 2.26E-03 | 1.60E+00 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.21E+00 | 2.12E-03 | 1.46E+00 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.60E+00 | 2.20E-03 | 1.63E+00 | Not Detected |
| | Apr. 29 – May 18 | 1.36E+00 | 1.72E-03 | 1.30E+00 | Detected |
| | May 18 – Jun. 3 | 1.38E+00 | 2.04E-03 | 1.46E+00 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.52E+00 | 2.15E-03 | 1.55E+00 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.82E+00 | 2.61E-03 | 1.90E+00 | Not Detected |
| | Jun. 29 – July 22 | 1.16E+00 | 1.84E-03 | 1.33E+00 | Not Detected |
| | July 22 -Aug. 17 | 1.25E+00 | 1.87E-03 | 1.38E+00 | Not Detected |
| | Aug. 17 – Oct. 3 | 9.05E-01 | 1.26E-03 | 9.60E-01 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.35E+00 | 1.89E-03 | 1.38E+00 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.22E+00 | 2.07E-03 | 1.37E+00 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.64E+00 | 2.33E-03 | 1.62E+00 | Detected |

### Table B.55. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at Loving Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 6.83E-05 | 8.99E-08 | 6.71E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.32E-04 | 1.63E-07 | 1.25E-04 | Detected |
| | Mar. 16 – Mar. 30 | 1.29E-04 | 1.91E-07 | 1.38E-04 | Not Detected |
| | Mar. 30 - Apr. 13 | 1.17E-04 | 1.78E-07 | 1.31E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.16E-04 | 1.45E-07 | 1.10E-04 | Detected |
| | Apr. 29 – May 18 | 8.74E-05 | 1.39E-07 | 1.00E-04 | Not Detected |
| | May 18 – Jun. 3 | 1.23E-04 | 1.63E-07 | 1.20E-04 | Detected |
| | Jun. 3 – Jun. 15 | 1.44E-04 | 1.99E-07 | 1.46E-04 | Not Detected |
| | Jun. 15 – Jun. 29 | 1.68E-04 | 2.34E-07 | 1.73E-04 | Not Detected |
| | Jun. 29 – July 22 | 7.22E-05 | 1.21E-07 | 8.49E-05 | Not Detected |
| | July 22 -Aug. 17 | 7.16E-05 | 8.78E-08 | 6.87E-05 | Detected |
| | Aug. 17 – Oct. 3 | 3.89E-05 | 6.16E-08 | 4.44E-05 | Not Detected |
| | Oct. 3 – Nov. 4 | 4.44E-05 | 7.24E-08 | 4.98E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.13E-05 | 6.30E-08 | 4.31E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 5.65E-05 | 7.66E-08 | 5.39E-05 | Detected |

### Table B.56. Specific activities of $^{90}$Sr (Bq/g) at Loving Station

| Radionuclide | Sample Date 2022 | $^{90}$Sr Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 9.41E-01 | 1.24E-03 | 9.25E-01 | Detected |
| | Mar. 2 – Mar. 16 | 1.63E+00 | 2.02E-03 | 1.55E+00 | Detected |
| | Mar. 16 – Mar. 30 | 8.47E-01 | 1.26E-03 | 9.08E-01 | Not Detected |
| | Mar. 30 - Apr. 13 | 9.29E-01 | 1.42E-03 | 1.04E+00 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.39E+00 | 1.74E-03 | 1.32E+00 | Detected |
| | Apr. 29 – May 18 | 8.45E-01 | 1.34E-03 | 9.67E-01 | Not Detected |
| | May 18 – Jun. 3 | 6.64E-01 | 8.81E-04 | 6.47E-01 | Detected |
| | Jun. 3 – Jun. 15 | 1.11E+00 | 1.53E-03 | 1.13E+00 | Not Detected |
| | Jun. 15 – Jun. 29 | 2.64E+00 | 3.68E-03 | 2.71E+00 | Not Detected |
| | Jun. 29 – July 22 | 1.13E+00 | 1.90E-03 | 1.34E+00 | Not Detected |
| | July 22 -Aug. 17 | 1.14E+00 | 1.40E-03 | 1.10E+00 | Detected |
| | Aug. 17 – Oct. 3 | 6.42E-01 | 1.02E-03 | 7.33E-01 | Not Detected |
| | Oct. 3 – Nov. 4 | 1.36E+00 | 2.23E-03 | 1.53E+00 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.25E+00 | 1.90E-03 | 1.30E+00 | Not Detected |
| | Dec. 9 – Jan. 6 | 1.74E+00 | 2.36E-03 | 1.66E+00 | Detected |

### Table B.57. Activity concentrations of $^{90}Sr$ (Bq/m$^3$) at Carlsbad Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}Sr$** | Feb. 2 – Mar. 2 | 7.46E-05 | 1.05E-07 | 7.72E-05 | Not Detected |
| | Mar. 2 – Mar. 16 | 1.77E-04 | 1.85E-07 | 1.47E-04 | Detected |
| | Mar. 16 – Mar. 30 | 1.56E-04 | 2.10E-07 | 1.56E-04 | Detected |
| | Mar. 30 - Apr. 13 | 1.53E-04 | 2.11E-07 | 1.57E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.36E-04 | 1.84E-07 | 1.36E-04 | Detected |
| | Apr. 29 – May 18 | 1.00E-04 | 1.69E-07 | 1.19E-04 | Not Detected |
| | May 18 – Jun. 3 | 1.31E-04 | 1.87E-07 | 1.35E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.85E-04 | 2.45E-07 | 1.82E-04 | Detected |
| | Jun. 15 – Jun. 29 | 1.28E-04 | 2.14E-07 | 1.47E-04 | Not Detected |
| | Jun. 29 – July 22 | 6.37E-05 | 1.01E-07 | 7.15E-05 | Not Detected |
| | July 22 -Aug. 17 | 5.64E-05 | 8.98E-08 | 6.43E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 3.89E-05 | 4.47E-08 | 3.56E-05 | Detected |
| | Oct. 3 – Nov. 4 | 4.90E-05 | 7.62E-08 | 5.40E-05 | Not Detected |
| | Nov. 4 – Dec. 9 | 4.55E-05 | 7.93E-08 | 5.22E-05 | Not Detected |
| | Dec. 9 – Jan. 6 | 5.87E-05 | 9.08E-08 | 6.24E-05 | Not Detected |

## Table B.58. Specific activities of $^{90}$Sr (Bq/g) at Carlsbad Station

| Radionuclide | Sample Date 2022 | $^{90}$Sr Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 1.27E+00 | 1.79E-03 | 1.32E+00 | Not Detected |
| | Mar. 2 – Mar. 16 | 2.32E+00 | 2.42E-03 | 1.93E+00 | Detected |
| | Mar. 16 – Mar. 30 | 1.45E+00 | 1.95E-03 | 1.45E+00 | Detected |
| | Mar. 30 - Apr. 13 | 1.38E+00 | 1.90E-03 | 1.42E+00 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.89E+00 | 2.55E-03 | 1.89E+00 | Detected |
| | Apr. 29 – May 18 | 1.15E+00 | 1.95E-03 | 1.37E+00 | Not Detected |
| | May 18 – Jun. 3 | 1.11E+00 | 1.59E-03 | 1.14E+00 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.28E+00 | 1.70E-03 | 1.26E+00 | Detected |
| | Jun. 15 – Jun. 29 | 2.01E+00 | 3.35E-03 | 2.30E+00 | Not Detected |
| | Jun. 29 – July 22 | 1.12E+00 | 1.78E-03 | 1.26E+00 | Not Detected |
| | July 22 -Aug. 17 | 1.22E+00 | 1.94E-03 | 1.39E+00 | Not Detected |
| | Aug. 17 – Oct. 3 | 1.09E+00 | 1.26E-03 | 1.00E+00 | Detected |
| | Oct. 3 – Nov. 4 | 1.62E+00 | 2.52E-03 | 1.79E+00 | Not Detected |
| | Nov. 4 – Dec. 9 | 1.22E+00 | 2.13E-03 | 1.40E+00 | Not Detected |
| | Dec. 9 – Jan. 6 | 2.01E+00 | 3.11E-03 | 2.14E+00 | Not Detected |

## Table B.59. Activity concentrations of $^{90}$Sr (Bq/m$^3$) at East Tower Station

| Radionuclide | Sample Date 2022 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 7.11E-05 | 9.28E-08 | 6.88E-05 | Detected |
| | Mar. 2 – Mar. 16 | 1.66E-04 | 1.53E-07 | 1.29E-04 | Detected |
| | Mar. 16 – Mar. 30 | 1.59E-04 | 1.79E-07 | 1.40E-04 | Detected |
| | Mar. 30 - Apr. 13 | 1.29E-04 | 2.00E-07 | 1.44E-04 | Not Detected |
| | Apr. 13 - Apr. 29 | 1.55E-04 | 1.41E-07 | 1.17E-04 | Detected |
| | Apr. 29 – May 18 | 1.35E-04 | 1.23E-07 | 1.02E-04 | Detected |
| | May 18 – Jun. 3 | 1.21E-04 | 1.67E-07 | 1.22E-04 | Not Detected |
| | Jun. 3 – Jun. 15 | 1.62E-04 | 2.22E-07 | 1.62E-04 | Detected |
| | Jun. 15 – Jun. 29 | 1.24E-04 | 1.85E-07 | 1.32E-04 | Not Detected |
| | Jun. 29 – July 22 | 8.67E-05 | 1.08E-07 | 8.32E-05 | Detected |
| | July 22 -Aug. 17 | 7.22E-05 | 1.08E-07 | 7.94E-05 | Not Detected |
| | Aug. 17 – Oct. 3 | 4.32E-05 | 5.07E-08 | 4.02E-05 | Detected |
| | Oct. 3 – Nov. 4 | 1.38E-03 | 1.65E-08 | 5.42E-05 | Detected |
| | Nov. 4 – Dec. 9 | 6.06E-05 | 6.31E-08 | 5.10E-05 | Detected |
| | Dec. 9 – Jan. 6 | 6.27E-05 | 1.04E-07 | 6.92E-05 | Not Detected |

### Table B.60. Specific activities of $^{90}$Sr (Bq/g) at East Tower Station

| Radionuclide | Sample Date 2022 | $^{90}$Sr Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Feb. 2 – Mar. 2 | 1.13E+00 | 1.47E-03 | 1.09E+00 | Detected |
|  | Mar. 2 – Mar. 16 | 1.68E+00 | 1.56E-03 | 1.31E+00 | Detected |
|  | Mar. 16 – Mar. 30 | 1.77E+00 | 1.99E-03 | 1.56E+00 | Detected |
|  | Mar. 30 - Apr. 13 | 1.10E+00 | 1.71E-03 | 1.23E+00 | Not Detected |
|  | Apr. 13 - Apr. 29 | 1.79E+00 | 1.63E-03 | 1.35E+00 | Detected |
|  | Apr. 29 – May 18 | 1.39E+00 | 1.27E-03 | 1.05E+00 | Detected |
|  | May 18 – Jun. 3 | 1.28E+00 | 1.75E-03 | 1.29E+00 | Not Detected |
|  | Jun. 3 – Jun. 15 | 1.28E+00 | 1.75E-03 | 1.28E+00 | Detected |
|  | Jun. 15 – Jun. 29 | 1.86E+00 | 2.78E-03 | 1.98E+00 | Not Detected |
|  | Jun. 29 – July 22 | 1.42E+00 | 1.77E-03 | 1.36E+00 | Detected |
|  | July 22 -Aug. 17 | 1.09E+00 | 1.64E-03 | 1.20E+00 | Not Detected |
|  | Aug. 17 – Oct. 3 | 9.72E-01 | 1.14E-03 | 9.05E-01 | Detected |
|  | Oct. 3 – Nov. 4 | 3.98E+01 | 4.78E-04 | 1.57E+00 | Detected |
|  | Nov. 4 – Dec. 9 | 1.62E+00 | 1.69E-03 | 1.37E+00 | Detected |
|  | Dec. 9 – Jan. 6 | 1.83E+00 | 3.03E-03 | 2.02E+00 | Not Detected |

# APPENDIX C - RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

### Table C.1. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | A-1 | 3/23/2022 | 8.34E-03 | 1.19E-02 | 2.67E-02 | Not Detected |
| | A-2 | 3/24/2022 | 1.92E-02 | 1.17E-02 | 2.14E-02 | Not Detected |
| | A-3 | 3/24/2022 | 1.66E-02 | 1.06E-02 | 1.83E-02 | Not Detected |
| | A-4 | 3/24/2022 | 1.45E-02 | 1.15E-02 | 2.21E-02 | Not Detected |
| | A-5 | 3/22/2022 | 1.49E-02 | 1.73E-01 | 4.37E-01 | Not Detected |
| | A-6 | 3/22/2022 | -9.09E-02 | 1.01E-01 | 3.18E-01 | Not Detected |
| | *A-7* | *3/24/2022* | 6.05E+00 | 8.32E-01 | 1.46E-01 | Detected |
| | *A-7-Dup* | *3/24/2022* | 8.13E+00 | 1.31E+00 | 2.01E-01 | Detected |
| | *A-8* | *3/23/2023* | 6.91E+00 | 9.99E-01 | 1.32E-01 | Detected |
| | *B-1* | *3/22/2022* | 9.48E+00 | 1.31E+00 | 1.74E-01 | Detected |
| | *B-2* | *3/23/2023* | 2.50E+00 | 3.37E-01 | 6.03E-02 | Detected |
| | *B-3* | *3/22/2022* | 8.15E+00 | 1.11E+00 | 1.00E-01 | Detected |
| | *B-4* | *3/22/2022* | 7.84E+00 | 1.20E+00 | 1.95E-01 | Detected |
| | B-5 | 3/25/2022 | 6.51E-01 | 8.60E-02 | 2.72E-02 | Detected |
| | B-5-Dup | 3/25/2022 | 8.05E-01 | 1.04E-01 | 2.99E-02 | Detected |
| | B-6 | 3/25/2022 | 7.08E-01 | 9.35E-02 | 3.36E-02 | Detected |
| | B-7 | 3/24/2022 | 1.66E+00 | 1.97E-01 | 3.27E-02 | Detected |
| | B-8 | 3/25/2022 | 1.09E+00 | 1.30E-01 | 2.78E-02 | Detected |
| | WIPP-1 | 4/7/2022 | 1.15E-02 | 1.77E-02 | 4.02E-02 | Not Detected |
| | WIPP-1-Dup | 4/7/2022 | 2.76E-02 | 1.77E-02 | 3.38E-02 | Not Detected |
| | *WIPP-2* | *4/7/2022* | *2.78E-01* | *2.30E-01* | *2.92E-01* | *Not Detected* |
| | | | | | | |
| $^{239+240}$Pu | A-1 | 3/23/2022 | 2.31E-02 | 1.21E-02 | 1.26E-02 | Detected |
| | A-2 | 3/24/2022 | 2.90E-02 | 1.35E-02 | 1.52E-02 | Detected |
| | A-3 | 3/24/2022 | 2.14E-02 | 1.23E-02 | 1.89E-02 | Detected |
| | A-4 | 3/24/2022 | 2.73E-02 | 2.06E-02 | 3.28E-02 | Not Detected |
| | A-5 | 3/22/2022 | 2.54E-02 | 1.63E-02 | 3.21E-02 | Not Detected |
| | A-6 | 3/22/2022 | 1.33E-02 | 8.60E-03 | 1.40E-02 | Not Detected |
| | A-7 | 3/24/2022 | 2.55E-02 | 9.97E-03 | 1.24E-02 | Detected |
| | A-7-Dup | 3/24/2022 | 1.22E-02 | 7.55E-03 | 1.25E-02 | Not Detected |
| | A-8 | 3/23/2023 | 2.25E-02 | 8.89E-03 | 1.05E-02 | Detected |

### Table C.1. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site (continued)

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{239+240}$Pu | B-1 | 3/22/2022 | 1.87E-01 | 4.09E-02 | 3.50E-02 | Detected |
| | B-2 | 3/23/2023 | 4.74E-02 | 1.62E-02 | 2.08E-02 | Detected |
| | B-3 | 3/22/2022 | 7.21E-02 | 1.64E-02 | 1.43E-02 | Detected |
| | B-4 | 3/22/2022 | 7.60E-02 | 2.24E-02 | 2.85E-02 | Detected |
| | B-5 | 3/25/2022 | 2.42E-02 | 2.45E-02 | 5.24E-02 | Not Detected |
| | B-5-Dup | 3/25/2022 | 1.70E-03 | 5.89E-03 | 1.44E-02 | Not Detected |
| | B-6 | 3/25/2022 | 6.39E-02 | 1.85E-02 | 1.95E-02 | Detected |
| | B-7 | 3/24/2022 | 1.44E-01 | 3.24E-02 | 2.13E-02 | Detected |
| | B-8 | 3/25/2022 | 4.88E-02 | 1.65E-02 | 2.04E-02 | Detected |
| | WIPP-1 | 4/7/2022 | 2.75E-02 | 1.55E-02 | 2.70E-02 | Detected |
| | WIPP-1-Dup | 4/7/2022 | 1.19E-01 | 3.73E-02 | 3.29E-02 | Detected |
| | WIPP-2 | 4/7/2022 | 1.46E-01 | 3.14E-02 | 2.79E-02 | Detected |
| | | | | | | |
| $^{238}$Pu | A-1 | 3/23/2022 | 2.44E-02 | 1.21E-02 | 9.98E-03 | Detected |
| | A-2 | 3/24/2022 | 1.77E-02 | 1.20E-02 | 2.00E-02 | Not Detected |
| | A-3 | 3/24/2022 | -4.76E-03 | 9.53E-03 | 2.80E-02 | Not Detected |
| | A-4 | 3/24/2022 | 1.64E-02 | 1.90E-02 | 3.85E-02 | Not Detected |
| | A-5 | 3/22/2022 | -1.27E-02 | 1.16E-02 | 3.41E-02 | Not Detected |
| | A-6 | 3/22/2022 | 2.65E-03 | 7.72E-03 | 1.89E-02 | Not Detected |
| | A-7 | 3/24/2022 | 2.13E-03 | 5.50E-03 | 1.33E-02 | Not Detected |
| | A-7-Dup | 3/24/2022 | 6.55E-03 | 5.24E-03 | 9.45E-03 | Not Detected |
| | A-8 | 3/23/2023 | 5.37E-03 | 6.60E-03 | 1.43E-02 | Not Detected |
| | B-1 | 3/22/2022 | 4.46E-03 | 1.71E-02 | 4.19E-02 | Not Detected |
| | B-2 | 3/23/2023 | 2.79E-03 | 6.70E-03 | 1.62E-02 | Not Detected |
| | B-3 | 3/22/2022 | 6.47E-03 | 6.88E-03 | 1.45E-02 | Not Detected |
| | B-4 | 3/22/2022 | 1.04E-02 | 9.38E-03 | 1.81E-02 | Not Detected |
| | B-5 | 3/25/2022 | -3.72E-03 | 9.12E-03 | 2.95E-02 | Not Detected |
| | B-5-Dup | 3/25/2022 | 4.53E-03 | 7.36E-03 | 1.69E-02 | Not Detected |
| | B-6 | 3/25/2022 | 1.16E-02 | 9.94E-03 | 1.95E-02 | Not Detected |
| | B-7 | 3/24/2022 | 1.48E-02 | 1.50E-02 | 3.16E-02 | Not Detected |
| | B-8 | 3/25/2022 | 7.66E-03 | 8.60E-03 | 1.80E-02 | Not Detected |
| | WIPP-1 | 4/7/2022 | 1.69E-02 | 1.09E-02 | 1.84E-02 | Not Detected |
| | WIPP-1-Dup | 4/7/2022 | 1.40E-02 | 2.56E-02 | 5.95E-02 | Not Detected |
| | WIPP-2 | 4/7/2022 | 2.59E-02 | 1.64E-02 | 3.14E-02 | Not Detected |

*The results in italics correspond to actinide isotope tracer recovery rates below 30%. The samples are being re-analyzed.

**Table C.2. Activity concentrations of $^{234}$U, $^{235}$U, and $^{238}$U (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site**

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{234}$U | A-1 | 3/23/2022 | 1.26E+00 | 1.50E-01 | 1.82E-02 | Detected |
| | A-2 | 3/24/2022 | 9.61E+00 | 1.05E+00 | 3.38E-02 | Detected |
| | A-3 | 3/24/2022 | 6.18E+00 | 6.87E-01 | 1.95E-02 | Detected |
| | A-4 | 3/24/2022 | 1.24E+00 | 1.45E-01 | 1.75E-02 | Detected |
| | A-5 | 3/22/2022 | 4.26E+00 | 4.54E-01 | 1.71E-02 | Detected |
| | A-6 | 3/22/2022 | 8.01E-01 | 1.00E-01 | 1.94E-02 | Detected |
| | A-7 | 3/24/2022 | 1.08E+00 | 1.29E-01 | 2.45E-02 | Detected |
| | A-7-Dup | 3/24/2022 | 1.20E+00 | 1.43E-01 | 1.17E-02 | Detected |
| | A-8 | 3/23/2023 | 1.10E+00 | 1.35E-01 | 3.57E-02 | Detected |
| | B-1 | 3/22/2022 | 7.00E+00 | 7.60E-01 | 3.63E-02 | Detected |
| | B-2 | 3/23/2023 | 4.51E+00 | 4.92E-01 | 2.26E-02 | Detected |
| | B-3 | 3/22/2022 | 6.35E+00 | 6.91E-01 | 2.14E-02 | Detected |
| | B-4 | 3/22/2022 | 5.74E+00 | 6.07E-01 | 2.88E-02 | Detected |
| | B-5 | 3/25/2022 | 4.87E+00 | 5.27E-01 | 2.76E-02 | Detected |
| | B-5-Dup | 3/25/2022 | 5.54E+00 | 6.10E-01 | 2.10E-02 | Detected |
| | B-6 | 3/25/2022 | 3.47E+00 | 3.88E-01 | 1.84E-02 | Detected |
| | B-7 | 3/24/2022 | 7.10E+00 | 7.63E-01 | 1.90E-02 | Detected |
| | B-8 | 3/25/2022 | 6.01E+00 | 6.54E-01 | 2.72E-02 | Detected |
| | WIPP-1 | 4/7/2022 | 4.27E+00 | 5.04E-01 | 8.08E-02 | Detected |
| | WIPP-1-Dup | 4/7/2022 | 4.59E+00 | 5.40E-01 | 7.58E-02 | Detected |
| | WIPP-2 | 4/7/2022 | 5.74E+00 | 6.16E-01 | 2.91E-02 | Detected |
| | | | | | | |
| $^{235}$U | A-1 | 3/23/2022 | 9.14E-02 | 2.43E-02 | 1.55E-02 | Detected |
| | A-2 | 3/24/2022 | 3.71E-01 | 6.51E-02 | 1.65E-02 | Detected |
| | A-3 | 3/24/2022 | 4.68E-01 | 7.56E-02 | 1.58E-02 | Detected |
| | A-4 | 3/24/2022 | 7.48E-02 | 1.93E-02 | 9.38E-03 | Detected |
| | A-5 | 3/22/2022 | 2.12E-01 | 3.51E-02 | 1.36E-02 | Detected |
| | A-6 | 3/22/2022 | 4.41E-02 | 1.59E-02 | 1.43E-02 | Detected |
| | A-7 | 3/24/2022 | 5.61E-02 | 1.77E-02 | 1.37E-02 | Detected |
| | A-7-Dup | 3/24/2022 | 8.03E-02 | 2.16E-02 | 1.11E-02 | Detected |
| | A-8 | 3/23/2023 | 9.72E-02 | 2.66E-02 | 2.83E-02 | Detected |

**Table C.2. Activity concentrations of $^{234}$U, $^{235}$U, and $^{238}$U (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site (continued)**

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. ($2\sigma$) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{235}$U | B-1 | 3/22/2022 | 3.58E-01 | 6.40E-02 | 2.57E-02 | Detected |
| | B-2 | 3/23/2023 | 2.05E-01 | 3.89E-02 | 1.75E-02 | Detected |
| | B-3 | 3/22/2022 | 3.07E-01 | 5.13E-02 | 2.16E-02 | Detected |
| | B-4 | 3/22/2022 | 2.98E-01 | 5.09E-02 | 2.77E-02 | Detected |
| | B-5 | 3/25/2022 | 2.29E-01 | 4.33E-02 | 2.51E-02 | Detected |
| | B-5-Dup | 3/25/2022 | 2.66E-01 | 4.91E-02 | 1.78E-02 | Detected |
| | B-6 | 3/25/2022 | 1.67E-01 | 3.52E-02 | 2.07E-02 | Detected |
| | B-7 | 3/24/2022 | 3.98E-01 | 6.25E-02 | 1.62E-02 | Detected |
| | B-8 | 3/25/2022 | 2.64E-01 | 4.79E-02 | 1.32E-02 | Detected |
| | WIPP-1 | 4/7/2022 | 2.03E-01 | 6.44E-02 | 5.73E-02 | Detected |
| | WIPP-1-Dup | 4/7/2022 | 2.13E-01 | 6.67E-02 | 5.88E-02 | Detected |
| | WIPP-2 | 4/7/2022 | 2.85E-01 | 4.94E-02 | 2.29E-02 | Detected |
| | | | | | | |
| $^{238}$U | A-1 | 3/23/2022 | 1.36E+00 | 1.61E-01 | 1.96E-02 | Detected |
| | A-2 | 3/24/2022 | 6.33E+00 | 7.02E-01 | 4.71E-02 | Detected |
| | A-3 | 3/24/2022 | 4.21E+00 | 4.75E-01 | 2.76E-02 | Detected |
| | A-4 | 3/24/2022 | 1.31E+00 | 1.52E-01 | 2.00E-02 | Detected |
| | A-5 | 3/22/2022 | 4.55E+00 | 4.83E-01 | 1.83E-02 | Detected |
| | A-6 | 3/22/2022 | 7.92E-01 | 9.95E-02 | 2.63E-02 | Detected |
| | A-7 | 3/24/2022 | 1.06E+00 | 1.27E-01 | 2.52E-02 | Detected |
| | A-7-Dup | 3/24/2022 | 1.11E+00 | 1.34E-01 | 8.98E-03 | Detected |
| | A-8 | 3/23/2023 | 1.14E+00 | 1.38E-01 | 3.49E-02 | Detected |
| | B-1 | 3/22/2022 | 7.12E+00 | 7.75E-01 | 5.15E-02 | Detected |
| | B-2 | 3/23/2023 | 4.89E+00 | 5.31E-01 | 2.82E-02 | Detected |
| | B-3 | 3/22/2022 | 6.69E+00 | 7.26E-01 | 2.82E-02 | Detected |
| | B-4 | 3/22/2022 | 6.25E+00 | 6.60E-01 | 3.05E-02 | Detected |
| | B-5 | 3/25/2022 | 5.00E+00 | 5.40E-01 | 2.53E-02 | Detected |
| | B-5-Dup | 3/25/2022 | 5.83E+00 | 6.41E-01 | 3.06E-02 | Detected |
| | B-6 | 3/25/2022 | 3.68E+00 | 4.10E-01 | 2.12E-02 | Detected |
| | B-7 | 3/24/2022 | 7.57E+00 | 8.12E-01 | 2.55E-02 | Detected |
| | B-8 | 3/25/2022 | 6.28E+00 | 6.83E-01 | 3.78E-02 | Detected |

## Table C.2. Activity concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site (continued)

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{238}U$ | WIPP-1 | 4/7/2022 | 4.33E+00 | 5.11E-01 | 1.14E-01 | Detected |
| | WIPP-1-Dup | 4/7/2022 | 4.79E+00 | 5.62E-01 | 9.48E-02 | Detected |
| | WIPP-2 | 4/7/2022 | 6.03E+00 | 6.46E-01 | 3.97E-02 | Detected |

**Table C.3. Activity concentrations of $^{137}Cs$, $^{40}K$, and $^{60}Co$ (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site**

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{137}Cs$ | A-1 | 3/23/2022 | 4.07E-01 | 5.09E-02 | 1.52E-01 | Detected |
|  | A-2 | 3/24/2022 | 2.06E+00 | 1.33E-01 | 3.97E-01 | Detected |
|  | A-3 | 3/24/2022 | 1.89E+00 | 9.10E-02 | 2.60E-01 | Detected |
|  | A-4 | 3/24/2022 | 3.34E+00 | 1.26E-01 | 3.23E-01 | Detected |
|  | A-5 | 3/22/2022 | -2.57E+00 | 1.69E+00 | 5.81E+00 | Not Detected |
|  | A-6 | 3/22/2022 | 3.25E-01 | 4.87E-02 | 1.49E-01 | Detected |
|  | A-7 | 3/24/2022 | 3.11E+00 | 1.25E-01 | 3.28E-01 | Detected |
|  | A-7-Dup | 3/24/2022 | 6.57E-01 | 1.10E-01 | 3.50E-01 | Detected |
|  | A-8 | 3/23/2023 | 4.07E+00 | 1.18E-01 | 3.11E-01 | Detected |
|  | B-1 | 3/22/2022 | 2.70E+00 | 1.26E-01 | 1.84E-01 | Detected |
|  | B-2 | 3/23/2023 | 1.16E+00 | 7.01E-02 | 1.54E-01 | Detected |
|  | B-3 | 3/22/2022 | 2.94E+00 | 1.34E-01 | 3.79E-01 | Detected |
|  | B-4 | 3/22/2022 | 3.61E+02 | 9.92E-01 | 3.19E+00 | Detected |
|  | B-5 | 3/25/2022 | 2.46E+00 | 1.02E+00 | 3.33E+00 | Not Detected |
|  | B-5-Dup | 3/25/2022 | 3.58E-01 | 8.09E-02 | 2.60E-01 | Detected |
|  | B-6 | 3/25/2022 | 1.92E+00 | 9.65E-02 | 1.65E-01 | Detected |
|  | B-7 | 3/24/2022 | 2.42E+00 | 1.50E-01 | 4.47E-01 | Detected |
|  | B-8 | 3/25/2022 | 1.14E+00 | 1.05E-01 | 3.21E-01 | Detected |
|  | WIPP-1 | 4/7/2022 | 6.07E-01 | 5.86E-02 | 1.78E-01 | Detected |
|  | WIPP-1-Dup | 4/7/2022 | 1.19E+00 | 7.29E-02 | 1.63E-01 | Detected |
|  | WIPP-2 | 4/7/2022 | 5.46E+00 | 1.58E-01 | 3.56E-01 | Detected |
|  |  |  |  |  |  |  |
| $^{40}K$ | A-1 | 3/23/2022 | 2.03E+02 | 1.85E+01 | 1.96E+00 | Detected |
|  | A-2 | 3/24/2022 | 1.81E+02 | 4.14E+00 | 4.06E+00 | Detected |
|  | A-3 | 3/24/2022 | 2.48E+02 | 4.13E+00 | 2.74E+00 | Detected |
|  | A-4 | 3/24/2022 | 3.00E+02 | 5.23E+00 | 3.09E+00 | Detected |
|  | A-5 | 3/22/2022 | 1.87E+02 | 2.06E+01 | 5.68E+01 | Detected |
|  | A-6 | 3/22/2022 | 1.66E+02 | 1.50E+01 | 1.94E+00 | Detected |
|  | A-7 | 3/24/2022 | 3.37E+02 | 5.80E+00 | 3.03E+00 | Detected |
|  | A-7-Dup | 3/24/2022 | 2.22E+02 | 4.93E+00 | 4.21E+00 | Detected |
|  | A-8 | 3/23/2023 | 3.82E+02 | 6.10E+00 | 3.03E+00 | Detected |

**Table C.3. Activity concentrations of $^{137}$Cs, $^{40}$K, and $^{60}$Co (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site (continued)**

| Radionuclide | Grid Node | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{40}$K | B-1 | 3/22/2022 | 2.36E+02 | 2.14E+01 | 1.95E+00 | Detected |
| | B-2 | 3/23/2023 | 1.77E+02 | 1.61E+01 | 1.89E+00 | Detected |
| | B-3 | 3/22/2022 | 2.23E+02 | 4.88E+00 | 3.64E+00 | Detected |
| | B-4 | 3/22/2022 | 2.85E+02 | 1.94E+01 | 5.40E+01 | Detected |
| | B-5 | 3/25/2022 | 2.16E+02 | 1.79E+01 | 4.94E+01 | Detected |
| | B-5-Dup | 3/25/2022 | 2.68E+02 | 4.75E+00 | 3.27E+00 | Detected |
| | B-6 | 3/25/2022 | 1.56E+02 | 1.42E+01 | 1.78E+00 | Detected |
| | B-7 | 3/24/2022 | 2.37E+02 | 5.23E+00 | 4.52E+00 | Detected |
| | B-8 | 3/25/2022 | 1.89E+02 | 4.23E+00 | 3.43E+00 | Detected |
| | WIPP-1 | 4/7/2022 | 1.66E+02 | 6.60E+00 | 1.67E+00 | Detected |
| | WIPP-1-Dup | 4/7/2022 | 2.06E+02 | 1.87E+01 | 2.05E+01 | Detected |
| | WIPP-2 | 4/7/2022 | 3.92E+02 | 6.67E+00 | 3.23E+00 | Detected |
| | | | | | | |
| $^{60}$Co | A-1 | 3/23/2022 | 4.63E-02 | 4.62E-02 | 1.53E-01 | Not Detected |
| | A-2 | 3/24/2022 | 5.57E-02 | 7.89E-02 | 2.63E-01 | Not Detected |
| | A-3 | 3/24/2022 | 1.70E-01 | 7.15E-02 | 2.33E-01 | Not Detected |
| | A-4 | 3/24/2022 | 1.98E-01 | 8.62E-02 | 2.81E-01 | Not Detected |
| | A-5 | 3/22/2022 | 3.90E+00 | 1.66E+00 | 5.36E+00 | Not Detected |
| | A-6 | 3/22/2022 | 9.31E-03 | 4.14E-02 | 1.39E-01 | Not Detected |
| | A-7 | 3/24/2022 | -2.46E-02 | 8.48E-02 | 2.85E-01 | Not Detected |
| | A-7-Dup | 3/24/2022 | 1.11E-01 | 8.29E-02 | 2.74E-01 | Not Detected |
| | A-8 | 3/23/2023 | 1.34E-01 | 6.91E-02 | 2.27E-01 | Not Detected |
| | B-1 | 3/22/2022 | 4.89E-02 | 4.52E-02 | 1.49E-01 | Not Detected |
| | B-2 | 3/23/2023 | 3.82E-02 | 3.82E-02 | 1.27E-01 | Not Detected |
| | B-3 | 3/22/2022 | 1.97E-02 | 7.75E-02 | 2.60E-01 | Not Detected |
| | B-4 | 3/22/2022 | 1.12E+00 | 7.95E-01 | 2.63E+00 | Not Detected |
| | B-5 | 3/25/2022 | 1.99E+00 | 1.10E+00 | 3.61E+00 | Not Detected |
| | B-5-Dup | 3/25/2022 | 2.47E-01 | 9.42E-02 | 3.07E-01 | Not Detected |
| | B-6 | 3/25/2022 | 1.12E-01 | 4.15E-02 | 1.34E-01 | Not Detected |
| | B-7 | 3/24/2022 | 1.50E-01 | 8.23E-02 | 2.70E-01 | Not Detected |
| | B-8 | 3/25/2022 | 6.36E-02 | 7.46E-02 | 2.48E-01 | Not Detected |
| | WIPP-1 | 4/7/2022 | 1.10E-01 | 4.63E-02 | 1.51E-01 | Not Detected |
| | WIPP-1-Dup | 4/7/2022 | 6.27E-02 | 5.44E-02 | 1.80E-01 | Not Detected |
| | WIPP-2 | 4/7/2022 | -6.12E-03 | 7.99E-02 | 2.68E-01 | Not Detected |

**Table C.4. Activity concentration of $^{90}$Sr (Bq/kg) in soil samples collected from Near Field in the vicinity of the WIPP site**

| Radionuclide | Grid Node | Sample Date | $^{90}$Sr Activity Bq/kg | Unc.(2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{90}$Sr | A-1 | 3/23/2022 | 7.69E+01 | 4.52E+00 | 6.96E+01 | Detected |
| | A-2 | 3/24/2022 | 7.35E+01 | 4.48E+00 | 7.15E+01 | Detected |
| | A-3 | 3/24/2022 | 6.62E+01 | 4.12E+00 | 6.63E+01 | Not Detected |
| | A-4 | 3/24/2022 | 6.17E+01 | 3.98E+00 | 6.70E+01 | Not Detected |
| | A-5 | 3/22/2022 | 6.32E+01 | 5.04E+00 | 7.01E+01 | Not Detected |
| | A-6 | 3/22/2022 | 4.87E+01 | 3.62E+00 | 6.43E+01 | Not Detected |
| | A-7 | 3/24/2022 | 4.54E+01 | 3.51E+00 | 6.42E+01 | Not Detected |
| | A-7-Dup | 3/24/2022 | 4.75E+01 | 3.55E+00 | 6.27E+01 | Not Detected |
| | A-8 | 3/23/2023 | 4.26E+01 | 3.41E+00 | 6.49E+01 | Not Detected |
| | B-1 | 3/22/2022 | 6.41E+01 | 5.08E+00 | 6.98E+01 | Not Detected |
| | B-2 | 3/23/2023 | 5.64E+01 | 4.60E+00 | 6.71E+01 | Not Detected |
| | B-3 | 3/22/2022 | 6.33E+01 | 5.04E+00 | 6.90E+01 | Not Detected |
| | B-4 | 3/22/2022 | 5.68E+01 | 4.77E+00 | 7.02E+01 | Not Detected |
| | B-5 | 3/25/2022 | 5.77E+01 | 4.68E+00 | 7.00E+01 | Not Detected |
| | B-5-Dup | 3/25/2022 | 6.11E+01 | 4.84E+00 | 7.01E+01 | Not Detected |
| | B-6 | 3/25/2022 | 6.00E+01 | 4.82E+00 | 7.01E+01 | Not Detected |
| | B-7 | 3/24/2022 | 5.89E+01 | 4.76E+00 | 7.01E+01 | Not Detected |
| | B-8 | 3/25/2022 | 5.52E+01 | 4.58E+00 | 6.82E+01 | Not Detected |
| | WIPP-1 | 4/7/2022 | 5.02E+01 | 4.37E+00 | 7.01E+01 | Not Detected |
| | WIPP-1-Dup | 4/7/2022 | 5.78E+01 | 4.72E+00 | 7.00E+01 | Not Detected |
| | WIPP-2 | 4/7/2022 | 9.07E+01 | 5.90E+00 | 7.02E+01 | Detected |

# APPENDIX D - RADIONUCLIDE CONCENTRATIONS IN SURFACE WATER SAMPLES

Actinide concentrations in surface water

Uranium concentrations in surface water

Gamma radionuclide concentrations in surface water

Strontium concentrations in surface water

## Table D.1. Actinide concentrations in surface water

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Trip Blank | 2.06E-05 | 1.01E-04 | 2.52E-04 | Not Detected |
| | Lake Carlsbad (Shallow) | 3.82E-05 | 8.53E-05 | 2.04E-04 | Not Detected |
| | Lake Carlsbad (Deep) | 1.61E-04 | 2.06E-04 | 4.51E-04 | Not Detected |
| | Brantley Lake (Shallow) | -5.14E-02 | 1.74E-01 | 3.73E-01 | Not Detected |
| | Brantley Lake (Deep) | -4.13E-05 | 1.85E-04 | 5.07E-04 | Not Detected |
| | Lost Tank | 1.23E-04 | 1.12E-04 | 2.24E-04 | Not Detected |
| | Hill Tank (bottom) | 6.00E-05 | 9.91E-05 | 2.26E-04 | Not Detected |
| | Red Tank | 2.26E-05 | 1.15E-04 | 2.87E-04 | Not Detected |
| | Red Bluff (Shallow) | 2.06E-05 | 1.01E-04 | 2.52E-04 | Not Detected |
| | Red Bluff (Deep) | 2.00E-04 | 2.50E-04 | 5.38E-04 | Not Detected |
| | Red Bluff (Shallow, Dup) | 1.36E-04 | 9.17E-05 | 1.58E-04 | Not Detected |
| | Red Bluff (Deep,Dup) | 4.35E-05 | 9.73E-05 | 2.32E-04 | Not Detected |
| | | | | | |
| $^{239+240}$Pu | Trip Blank | -1.26E-04 | 8.84E-05 | 2.76E-04 | Not Detected |
| | Lake Carlsbad (Shallow) | 1.43E-11 | 6.72E-05 | 1.77E-04 | Not Detected |
| | Lake Carlsbad (Deep) | 5.38E-05 | 9.16E-05 | 2.11E-04 | Not Detected |
| | Brantley Lake (Shallow) | 6.31E-05 | 8.07E-05 | 1.77E-04 | Not Detected |
| | Brantley Lake (Deep) | 7.90E-05 | 6.32E-05 | 1.14E-04 | Not Detected |
| | Lost Tank | 3.84E-05 | 7.68E-05 | 1.81E-04 | Not Detected |
| | Hill Tank (bottom) | 3.06E-05 | 6.12E-05 | 1.44E-04 | Not Detected |
| | Red Tank | 2.79E-05 | 6.71E-05 | 1.62E-04 | Not Detected |
| | Red Bluff (Shallow) | -1.38E-05 | 6.18E-05 | 1.95E-04 | Not Detected |
| | Red Bluff (Deep) | -1.43E-05 | 7.59E-05 | 2.02E-04 | Not Detected |
| | Red Bluff (Shallow, Dup) | 2.84E-05 | 4.93E-05 | 1.05E-04 | Not Detected |
| | Red Bluff (Deep,Dup) | 1.48E-04 | 1.13E-04 | 2.13E-04 | Not Detected |

## Table D.1. Actinide Concentrations in Surface Water (continued)

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{238}$Pu | Trip Blank | -1.09E-04 | 1.00E-04 | 2.94E-04 | Not Detected |
| | Lake Carlsbad (Shallow) | 5.26E-05 | 7.23E-05 | 1.60E-04 | Not Detected |
| | Lake Carlsbad (Deep) | 4.48E-05 | 1.06E-04 | 2.53E-04 | Not Detected |
| | Brantley Lake (Shallow) | 1.03E-04 | 7.63E-05 | 1.37E-04 | Not Detected |
| | Brantley Lake (Deep) | 3.59E-05 | 7.19E-05 | 1.69E-04 | Not Detected |
| | Lost Tank | 3.84E-05 | 1.02E-04 | 2.44E-04 | Not Detected |
| | Hill Tank (bottom) | 1.22E-04 | 9.20E-05 | 1.62E-04 | Not Detected |
| | Red Tank | 6.50E-05 | 8.13E-05 | 1.75E-04 | Not Detected |
| | Red Bluff (Shallow) | 2.76E-05 | 9.57E-05 | 2.41E-04 | Not Detected |
| | Red Bluff (Deep) | -3.59E-05 | 8.73E-05 | 2.36E-04 | Not Detected |
| | Red Bluff (Shallow, Dup) | 1.42E-05 | 4.93E-05 | 1.32E-04 | Not Detected |
| | Red Bluff (Deep,Dup) | 5.29E-05 | 9.24E-05 | 2.22E-04 | Not Detected |

## Table D.2. Uranium concentrations in surface water

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{234}$U | Trip Blank | 7.44E-04 | 2.29E-04 | 2.99E-04 | Detected |
| | Lake Carlsbad (Shallow) | 2.82E-02 | 4.19E-03 | 3.28E-04 | Detected |
| | Lake Carlsbad (Deep) | 3.64E-02 | 4.25E-03 | 3.89E-04 | Detected |
| | Brantley Lake (Shallow) | 4.53E-02 | 5.00E-03 | 2.66E-04 | Detected |
| | Brantley Lake (Deep) | 4.47E-02 | 4.83E-03 | 2.32E-04 | Detected |
| | Lost Tank | 1.10E-02 | 1.38E-03 | 2.36E-04 | Detected |
| | Hill Tank (bottom) | 4.45E-03 | 6.69E-04 | 2.72E-04 | Detected |
| | Red Tank | 5.37E-03 | 7.37E-04 | 2.30E-04 | Detected |
| | Red Bluff (Shallow) | 8.25E-02 | 8.94E-03 | 2.82E-04 | Detected |
| | Red Bluff (Deep) | 8.40E-02 | 8.92E-03 | 1.69E-01 | Not Detected |
| | Red Bluff (Shallow, Dup) | 1.53E-02 | 2.03E-02 | 0.00E+00 | Detected |
| | Red Bluff (Deep,Dup) | 8.20E-02 | 8.78E-03 | 2.32E-04 | Detected |
| | | | | | |
| $^{235}$U | Trip Blank | -2.70E-05 | 7.64E-05 | 2.35E-04 | Not Detected |
| | Lake Carlsbad (Shallow) | 9.18E-04 | 2.54E-04 | 2.53E-04 | Detected |
| | Lake Carlsbad (Deep) | 5.46E-04 | 2.15E-04 | 2.33E-04 | Detected |
| | Brantley Lake (Shallow) | 1.08E-03 | 2.53E-04 | 1.36E-04 | Detected |
| | Brantley Lake (Deep) | 1.25E-03 | 2.81E-04 | 2.11E-04 | Detected |
| | Lost Tank | 3.83E-04 | 1.69E-04 | 2.17E-04 | Detected |
| | Hill Tank (bottom) | 1.71E-04 | 1.08E-04 | 1.32E-04 | Detected |
| | Red Tank | 1.81E-04 | 1.02E-04 | 1.12E-04 | Detected |
| | Red Bluff (Shallow) | 2.32E-03 | 4.45E-04 | 2.25E-04 | Detected |
| | Red Bluff (Deep) | 2.05E-03 | 3.82E-04 | 1.44E-04 | Detected |
| | Red Bluff (Shallow, Dup) | 1.26E-02 | 2.17E-02 | 0.00E+00 | Detected |
| | Red Bluff (Deep,Dup) | 1.97E-03 | 3.67E-04 | 1.58E-04 | Detected |

### Table D.2. Uranium concentrations in Surface Water (continued)

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{238}$U | Trip Blank | 3.27E-04 | 1.86E-04 | 3.50E-04 | Not Detected |
| | Lake Carlsbad (Shallow) | 1.70E-02 | 2.00E-03 | 2.77E-04 | Detected |
| | Lake Carlsbad (Deep) | 1.76E-02 | 2.18E-03 | 4.76E-04 | Detected |
| | Brantley Lake (Shallow) | 2.15E-02 | 2.46E-03 | 2.41E-04 | Detected |
| | Brantley Lake (Deep) | 2.14E-02 | 2.40E-03 | 2.13E-04 | Detected |
| | Lost Tank | 8.40E-03 | 1.10E-03 | 2.91E-04 | Detected |
| | Hill Tank (bottom) | 3.74E-03 | 5.94E-04 | 3.43E-04 | Detected |
| | Red Tank | 3.43E-03 | 5.32E-04 | 3.20E-04 | Detected |
| | Red Bluff (Shallow) | 4.01E-02 | 4.45E-03 | 3.50E-04 | Detected |
| | Red Bluff (Deep) | 4.19E-02 | 4.54E-03 | 2.47E-04 | Detected |
| | Red Bluff (Shallow, Dup) | 7.60E-02 | 4.05E-02 | 0.00E+00 | Detected |
| | Red Bluff (Deep,Dup) | 4.03E-02 | 4.40E-03 | 2.39E-04 | Detected |

## Table D.3. Gamma emitting radionuclides in surface water

| Radionuclide | Location | Activity Bq/L | Unc ($2\sigma$) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Trip Blank | 2.33E-01 | 3.10E-01 | 1.03E+00 | Not Detected |
| | Lake Carlsbad (Shallow) | -8.66E-02 | 1.76E-01 | 5.89E-01 | Not Detected |
| | Lake Carlsbad (Deep) | 1.92E-01 | 1.17E-01 | 3.84E-01 | Not Detected |
| | Brantley Lake (Shallow) | -4.42E-01 | 1.40E-01 | 4.80E-01 | Not Detected |
| | Brantley Lake (Deep) | 2.83E-01 | 1.26E-01 | 4.10E-01 | Not Detected |
| | Lost Tank | -1.68E-01 | 1.63E-01 | 5.48E-01 | Not Detected |
| | Hill Tank (bottom) | 1.26E-01 | 1.32E-01 | 4.37E-01 | Not Detected |
| | Red Tank | -4.76E-01 | 2.71E-01 | 9.29E-01 | Not Detected |
| | Red Bluff (Shallow) | -4.35E-01 | 1.60E-01 | 5.46E-01 | Not Detected |
| | Red Bluff (Deep) | 1.68E-01 | 2.86E-01 | 9.52E+04 | Not Detected |
| | Red Bluff (Shallow, Dup) | -3.97E-01 | 1.56E-01 | 5.31E-01 | Not Detected |
| | Red Bluff (Deep,Dup) | 1.80E-01 | 1.17E-01 | 3.86E-01 | Not Detected |
| | | | | | |
| $^{60}$Co | Trip Blank | 5.81E-02 | 2.23E-01 | 7.61E-01 | Not Detected |
| | Lake Carlsbad (Shallow) | 4.84E-01 | 1.75E-01 | 5.65E-01 | Not Detected |
| | Lake Carlsbad (Deep) | 1.27E-01 | 1.23E-01 | 4.11E-01 | Not Detected |
| | Brantley Lake (Shallow) | 2.97E-01 | 1.28E-01 | 4.14E-01 | Not Detected |
| | Brantley Lake (Deep) | 1.89E-01 | 1.11E-01 | 3.65E-01 | Not Detected |
| | Lost Tank | 2.84E-01 | 1.14E-01 | 3.66E-01 | Not Detected |
| | Hill Tank (bottom) | 2.23E-01 | 1.14E-01 | 3.71E-01 | Not Detected |
| | Red Tank | 4.10E-01 | 2.15E-01 | 7.01E-01 | Not Detected |
| | Red Bluff (Shallow) | 2.89E-01 | 1.25E-01 | 4.07E-01 | Not Detected |
| | Red Bluff (Deep) | 1.11E-01 | 2.16E-01 | 7.31E-01 | Not Detected |
| | Red Bluff (Shallow, Dup) | 3.52E-01 | 1.32E-01 | 4.25E-01 | Not Detected |
| | Red Bluff (Deep,Dup) | 2.27E-01 | 1.39E-01 | 4.56E-01 | Not Detected |

### Table D.3. Gamma emitting radionuclides in surface water (continued)

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{40}$K | Trip Blank | 4.21E+00 | 1.74E+00 | 5.57E+00 | Not Detected |
| | Lake Carlsbad (Shallow) | 1.28E+00 | 1.87E+00 | 6.21E+00 | Not Detected |
| | Lake Carlsbad (Deep) | 1.77E+00 | 2.12E+00 | 7.02E+00 | Not Detected |
| | Brantley Lake (Shallow) | -1.38E-01 | 1.75E+00 | 5.89E+00 | Not Detected |
| | Brantley Lake (Deep) | 6.36E-01 | 1.99E+00 | 6.64E+00 | Not Detected |
| | Lost Tank | 1.53E+00 | 1.77E+00 | 5.87E+00 | Not Detected |
| | Hill Tank (bottom) | 2.21E+00 | 2.09E+00 | 6.93E+00 | Not Detected |
| | Red Tank | 2.38E+00 | 1.80E+00 | 5.99E+00 | Not Detected |
| | Red Bluff (Shallow) | 8.68E-01 | 1.79E+00 | 5.98E+00 | Not Detected |
| | Red Bluff (Deep) | 1.10E-01 | 1.84E+00 | 6.35E+00 | Not Detected |
| | Red Bluff (Shallow, Dup) | 2.01E+00 | 1.80E+00 | 5.94E+00 | Not Detected |
| | Red Bluff (Deep,Dup) | 4.78E+00 | 1.79E+00 | 5.80E+00 | Not Detected |

### Table D.4. Strontium concentration in surface water

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{90}$Sr | Trip Blank | 2.13E+01 | 1.69E+00 | 2.34E+01 | Not Detected |
| | Lake Carlsbad (Shallow) | 2.17E+01 | 1.72E+00 | 2.34E+01 | Not Detected |
| | Lake Carlsbad (Deep) | 1.86E+01 | 1.56E+00 | 2.34E+01 | Not Detected |
| | Brantley Lake (Shallow) | 2.01E+01 | 1.66E+00 | 2.34E+01 | Not Detected |
| | Brantley Lake (Deep) | 1.98E+01 | 1.53E+00 | 2.34E+01 | Not Detected |
| | Lost Tank | 2.24E+01 | 1.74E+00 | 2.34E+01 | Not Detected |
| | Hill Tank (bottom) | 2.01E+01 | 1.65E+00 | 2.34E+01 | Not Detected |
| | Red Tank | 1.86E+01 | 1.59E+00 | 2.34E+01 | Not Detected |
| | Red Bluff (Shallow) | 2.21E+01 | 1.73E+00 | 2.34E+01 | Not Detected |
| | Red Bluff (Deep) | 1.79E+01 | 1.56E+00 | 2.34E+01 | Not Detected |
| | Red Bluff (Shallow, Dup) | 2.05E+01 | 1.69E+00 | 2.34E+01 | Not Detected |
| | Red Bluff (Deep,Dup) | 1.94E+01 | 1.61E+00 | 2.34E+01 | Not Detected |

# APPENDIX E - RADIONUCLIDE CONCENTRATIONS IN DRINKING WATER

Actinide concentrations in drinking water

Uranium concentrations in drinking water

Gamma radionuclide concentrations in drinking water

Strontium concentrations in drinking water

## Table E.1. Actinide concentrations in drinking water

| Radionuclide | Location | Activity Bq/L | Unc (2σ) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Sheep Draw | -2.22E-04 | 1.58E-04 | 5.53E-04 | Not Detected |
| | Sheep Draw-Dup | 2.27E-04 | 1.76E-04 | 3.28E-04 | Not Detected |
| | Malaga | -7.21E-05 | 1.98E-04 | 5.65E-04 | Not Detected |
| | Loving | 9.28E-05 | 8.36E-05 | 1.62E-04 | Not Detected |
| | Otis | 1.55E-04 | 5.36E-04 | 1.32E-04 | Not Detected |
| | Trip Blank | 9.45E-05 | 7.63E-05 | 1.33E-04 | Not Detected |
| | Hobbs | -1.23E-04 | 1.84E-04 | 5.43E-04 | Not Detected |
| | PRV-4 | 7.34E-05 | 8.24E-05 | 1.73E-04 | Not Detected |
| | | | | | |
| $^{239+240}$Pu | Sheep Draw | -3.67E-05 | 5.48E-05 | 1.94E-04 | Not Detected |
| | Sheep Draw-Dup | 1.12E-04 | 8.96E-05 | 1.30E-04 | Not Detected |
| | Malaga | 9.60E-05 | 9.35E-05 | 1.86E-04 | Not Detected |
| | Loving | 5.08E-05 | 7.89E-05 | 1.77E-04 | Not Detected |
| | Otis | -9.08E-12 | 9.32E-05 | 2.43E-04 | Not Detected |
| | Trip Blank | 7.67E-05 | 7.71E-05 | 1.52E-04 | Not Detected |
| | Hobbs | 5.81E-05 | 6.84E-05 | 1.46E-04 | Not Detected |
| | PRV-4 | 1.27E-04 | 1.00E-04 | 1.93E-04 | Not Detected |
| | | | | | |
| $^{238}$Pu | Sheep Draw | -8.55E-05 | 8.86E-05 | 2.87E-04 | Not Detected |
| | Sheep Draw-Dup | 1.69E-04 | 1.27E-04 | 2.23E-04 | Not Detected |
| | Malaga | 1.49E-04 | 1.10E-04 | 2.01E-04 | Not Detected |
| | Loving | 1.02E-04 | 1.15E-04 | 2.49E-04 | Not Detected |
| | Otis | 8.57E-05 | 1.25E-04 | 2.84E-04 | Not Detected |
| | Trip Blank | 8.62E-05 | 9.23E-05 | 1.93E-04 | Not Detected |
| | Hobbs | 7.99E-05 | 7.31E-05 | 1.46E-04 | Not Detected |
| | PRV-4 | 5.44E-05 | 8.90E-05 | 2.03E-04 | Not Detected |

### Table E.2. Uranium concentrations in drinking water

| Radionuclide | Location | Activity Bq/L | Unc ($2\sigma$) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{234}U$ | Sheep Draw | 1.03E-02 | 4.47E-03 | 1.27E-04 | Detected |
| | Sheep Draw-Dup | 1.22E-01 | 1.29E-02 | 1.47E-04 | Detected |
| | Malaga | 2.23E-02 | 2.53E-03 | 2.73E-04 | Detected |
| | Loving | 5.62E-02 | 6.00E-03 | 2.21E-04 | Detected |
| | Otis | 9.67E-02 | 1.03E-02 | 1.62E-04 | Detected |
| | Trip Blank | 2.95E-04 | 1.54E-04 | 2.51E-04 | Detected |
| | Hobbs | 4.18E-02 | 4.62E-03 | 2.74E-04 | Detected |
| | PRV-4 | 3.64E-02 | 3.87E-03 | 1.56E-04 | Detected |
| | | | | | |
| $^{235}U$ | Sheep Draw | 2.62E-04 | 1.46E-04 | 2.28E-04 | Detected |
| | Sheep Draw-Dup | 2.36E-03 | 3.94E-04 | 1.53E-04 | Detected |
| | Malaga | 5.06E-04 | 1.94E-04 | 2.63E-04 | Detected |
| | Loving | 9.07E-04 | 2.30E-04 | 2.01E-04 | Detected |
| | Otis | 2.92E-03 | 4.78E-04 | 1.38E-04 | Detected |
| | Trip Blank | 2.91E-05 | 9.20E-05 | 2.31E-04 | Not Detected |
| | Hobbs | 1.05E-03 | 2.72E-04 | 2.63E-04 | Detected |
| | PRV-4 | 6.97E-04 | 1.69E-04 | 7.62E-05 | Detected |
| | | | | | |
| $^{238}U$ | Sheep Draw | 4.73E-03 | 6.78E-04 | 2.98E-04 | Detected |
| | Sheep Draw-Dup | 4.67E-02 | 5.02E-03 | 2.19E-04 | Detected |
| | Malaga | 8.48E-03 | 1.07E-03 | 2.89E-04 | Detected |
| | Loving | 1.72E-02 | 1.95E-03 | 2.03E-04 | Detected |
| | Otis | 3.69E-02 | 4.04E-03 | 2.36E-04 | Detected |
| | Trip Blank | 8.21E-05 | 1.35E-04 | 3.10E-04 | Not Detected |
| | Hobbs | 1.78E-02 | 2.07E-03 | 2.89E-04 | Detected |
| | PRV-4 | 1.30E-02 | 1.46E-03 | 1.97E-04 | Detected |

**Table E.3. Historical concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ (Bq/L) in Carlsbad drinking water**

| Year | $^{234}U$ (Bq/L) | $^{235}U$ (Bq/L) | $^{238}U$ (Bq/L) |
|---|---|---|---|
| 1998 | 3.34E-02 | 7.52E-04 | 1.35E-02 |
| 1999 | 2.94E-02 | 6.99E-04 | 1.14E-02 |
| 2000 | 2.81E-02 | 8.12E-04 | 1.08E-02 |
| 2001 | 3.15E-02 | 9.68E-04 | 1.21E-02 |
| 2002 | 3.02E-02 | 7.97E-04 | 1.26E-02 |
| 2003 | 2.90E-02 | 5.52E-04 | 1.05E-02 |
| 2005 | 2.75E-02 | 1.54E-03 | 1.11E-02 |
| 2007 | NR | NR | NR |
| 2008 | 7.73E-02 | 3.09E-03 | 3.18E-02 |
| 2009 | 2.48E-02 | 3.57E-04 | 9.24E-03 |
| 2010 | 2.99E-02 | 5.64E-04 | 1.17E-02 |
| 2011 | 2.83E-02 | 7.83E-03 | 1.09E-02 |
| 2012 | 9.20E-03 | 1.85E-04 | 3.26E-03 |
| 2013 | 2.47E-02 | 3.80E-04 | 9.35E-03 |
| 2014 | 2.85E-02 | 5.83E-04 | 1.06E-02 |
| 2015 | 2.09E-02 | 3.39E-04 | 7.80E-03 |
| 2016 | 3.34E-02 | 9.90E-04 | 1.23E-02 |
| 2017 | 3.02E-02 | 5.41E-04 | 8.36E-02 |
| 2018 | 2.80E-02 | 5.87E-04 | 1.10E-02 |
| 2019 | 1.00E-01 | 2.35E-03 | 4.42E-02 |
| 2020 | 2.79E-02 | 6.77E-04 | 1.07E-02 |
| 2021 | 2.73E-02 | 1.14E-03 | 1.00E-02 |
| 2022 | 1.03E-02 | 2.62E-04 | 4.73E-03 |

**Table E.4. Historical concentrations of $^{234}$U, $^{235}$U, and $^{238}$U (Bq/L) in Double Eagle**

| Year | $^{234}$U (Bq/L) | $^{235}$U (Bq/L) | $^{238}$U(Bq/L) |
|---|---|---|---|
| 1998 | NR | NR | NR |
| 1999 | 6.19E-02 | 1.35E-04 | 2.32E-02 |
| 2000 | 5.40E-02 | 1.38E-04 | 2.19E-02 |
| 2001 | 4.10E-02 | 1.22E-04 | 1.74E-02 |
| 2002 | 4.16E-02 | 1.01E-04 | 1.77E-02 |
| 2003 | 4.25E-02 | 8.89E-05 | 1.61E-02 |
| 2005 | 5.83E-02 | 1.43E-04 | 2.48E-02 |
| 2007 | NR | NR | NR |
| 2008 | 1.86E-01 | 4.31E-04 | 7.94E-02 |
| 2009 | 6.97E-02 | 7.55E-04 | 2.89E-02 |
| 2010 | 4.89E-02 | 1.36E-04 | 2.01E-02 |
| 2011 | 4.80E-02 | 8.45E-05 | 1.86E-02 |
| 2012 | 8.75E-03 | 3.55E-04 | 3.22E-03 |
| 2013 | 4.69E-02 | 4.90E-03 | 1.81E-02 |
| 2014 | 4.94E-02 | 6.12E-04 | 1.85E-02 |
| 2015 | 4.55E-02 | 9.19E-04 | 1.57E-02 |
| 2016 | 5.14E-02 | 1.19E-03 | 1.96E-02 |
| 2017 | 9.65E-02 | 2.36E-03 | 4.13E-02 |
| 2018 | 6.56E-02 | 1.85E-03 | 2.54E-02 |
| 2019 | 8.22E-02 | 1.57E-03 | 3.20E-02 |
| 2020 | 4.96E-02 | 1.02E-03 | 1.94E-02 |
| 2021 | 4.56E-02 | 1.57E-03 | 2.08E-02 |
| 2022 | 3.64E-02 | 6.97E-04 | 1.30E-02 |

### Table E.5. Historical concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ in Hobbs drinking water

| Year | $^{234}U$ (Bq/L) | $^{235}U$ (Bq/L) | $^{238}U$ (Bq/L) |
|---|---|---|---|
| 1998 | NR | NR | NR |
| 1999 | 8.81E-02 | 2.46E-03 | 3.86E-02 |
| 2000 | 9.06E-02 | 2.34E-03 | 3.99E-02 |
| 2001 | 7.52E-02 | 2.59E-03 | 3.32E-02 |
| 2002 | 9.40E-02 | 2.37E-03 | 4.05E-02 |
| 2003 | 1.30E-01 | 2.51E-03 | 4.61E-02 |
| 2005 | 9.82E-02 | 2.68E-03 | 4.27E-02 |
| 2007 | NR | NR | NR |
| 2008 | 2.87E-01 | 1.18E-02 | 1.31E-01 |
| 2009 | 8.94E-02 | 1.99E-03 | 3.86E-02 |
| 2010 | 1.04E-01 | 2.23E-03 | 4.59E-02 |
| 2011 | 1.04E-01 | 2.60E-03 | 4.50E-02 |
| 2012 | 1.61E-02 | 4.31E-04 | 5.82E-03 |
| 2013 | 9.25E-02 | 2.18E-03 | 3.97E-02 |
| 2014 | 9.82E-02 | 1.89E-03 | 4.01E-02 |
| 2015 | 9.67E-02 | 2.17E-03 | 4.17E-02 |
| 2016 | 1.05E-01 | 2.48E-03 | 4.44E-02 |
| 2017 | 4.82E-02 | 2.37E-03 | 5.08E-02 |
| 2018 | 9.82E-02 | 2.54E-03 | 4.49E-02 |
| 2019 | 9.96E-02 | 2.30E-03 | 4.35E-02 |
| 2020 | 1.07E-01 | 3.25E-03 | 4.55E-02 |
| 2021 | 9.28E-02 | 2.61E-03 | 3.98E-02 |
| 2022 | 4.18E-02 | 1.05E-03 | 1.78E-02 |

## Table E.6. Historical concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ in Otis drinking water

| Year | $^{234}U$ (Bq/L) | $^{235}U$ (Bq/L) | $^{238}U$ (Bq/L) |
|---|---|---|---|
| 1998 | 1.29E-01 | 2.73E-03 | 4.67E-02 |
| 1999 | 1.50E-01 | 2.85E-03 | 5.30E-02 |
| 2000 | 1.44E-01 | 2.97E-03 | 5.16E-02 |
| 2001 | 1.62E-01 | 3.30E-03 | 6.01E-02 |
| 2002 | 1.47E-01 | 3.34E-03 | 5.34E-02 |
| 2003 | 1.34E-01 | 2.56E-03 | 4.81E-02 |
| 2005 | 1.17E-01 | 2.60E-03 | 4.36E-02 |
| 2007 | NR | NR | NR |
| 2008 | 3.89E-01 | 1.35E-02 | 1.53E-01 |
| 2009 | 1.47E-01 | 3.80E-03 | 5.35E-02 |
| 2010 | 1.54E-01 | 2.66E-03 | 5.41E-02 |
| 2011 | 1.54E-01 | 1.19E-02 | 2.39E-01 |
| 2012 | 3.94E-02 | 1.00E-03 | 1.39E-02 |
| 2013 | 1.51E-01 | 3.17E-03 | 5.45E-02 |
| 2014 | 1.71E-01 | 3.46E-03 | 7.24E-02 |
| 2015 | 1.70E-01 | 2.95E-03 | 6.61E-02 |
| 2016 | 2.70E-02 | 1.44E-03 | 1.13E-02 |
| 2017 | 1.68E-01 | 2.86E-03 | 6.59E-02 |
| 2018 | 1.71E-01 | 3.36E-03 | 6.54E-02 |
| 2019 | 1.15E-01 | 2.01E-03 | 4.02E-02 |
| 2020 | 1.46E-01 | 3.50E-03 | 5.56E-02 |
| 2021 | 1.24E-01 | 2.50E-03 | 4.69E-02 |
| 2022 | 9.67E-02 | 2.92E-03 | 3.69E-02 |

### Table E.7. Historical concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ in Loving drinking water

| Year | $^{234}U$ (Bq/L) | $^{235}U$ (Bq/L) | $^{238}U$ (Bq/L) |
|---|---|---|---|
| 1998 | NR | NR | NR |
| 1999 | 8.15E-02 | 1.66E-03 | 2.63E-02 |
| 2000 | 8.38E-02 | 1.63E-03 | 2.59E-02 |
| 2001 | 8.05E-02 | 1.61E-03 | 2.48E-02 |
| 2002 | 8.82E-02 | 1.63E-03 | 2.83E-02 |
| 2003 | 7.91E-02 | 1.35E-03 | 2.40E-02 |
| 2005 | 8.13E-02 | 1.42E-03 | 2.64E-02 |
| 2007 | NR | NR | NR |
| 2008 | 2.56E-01 | 5.15E-03 | 7.71E-02 |
| 2009 | 7.42E-02 | 1.26E-03 | 2.22E-02 |
| 2010 | 8.00E-02 | 1.20E-03 | 2.49E-02 |
| 2011 | 7.50E-02 | 3.90E-02 | 2.57E-02 |
| 2012 | 2.53E-02 | 4.93E-04 | 7.58E-03 |
| 2013 | 7.17E-02 | 1.20E-03 | 2.31E-02 |
| 2014 | 7.57E-02 | 1.63E-03 | 2.24E-02 |
| 2015 | 7.42E-02 | 1.26E-03 | 2.30E-02 |
| 2016 | 7.05E-02 | 1.23E-03 | 2.23E-02 |
| 2017 | 7.48E-02 | 1.01E-03 | 2.16E-02 |
| 2018 | 7.31E-02 | 1.35E-03 | 2.35E-02 |
| 2019 | 8.18E-02 | 1.42E-03 | 2.56E-02 |
| 2020 | 7.43E-02 | 1.42E-03 | 2.43E-02 |
| 2021 | 7.19E-02 | 3.94E-03 | 2.46E-02 |
| 2022 | 5.62E-02 | 9.07E-04 | 1.72E-02 |

**Table E.8. Historical concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ (Bq/L) in Malaga drinking water**

| Year | $^{234}U$ (Bq/L) | $^{235}U$ (Bq/L) | $^{238}U$ (Bq/L) |
|---|---|---|---|
| 2011 | 1.38E-01 | 2.56E-03 | 5.34E-02 |
| 2012 | 1.33E-01 | 1.92E-03 | 4.83E-02 |
| 2013 | 1.40E-01 | 3.33E-03 | 5.46E-02 |
| 2014 | 1.67E-01 | 4.59E-03 | 6.19E-02 |
| 2015 | 1.57E-01 | 4.99E-03 | 6.07E-02 |
| 2016 | 1.47E-01 | 2.36E-03 | 5.43E-02 |
| 2017 | 1.65E-01 | 3.24E-03 | 6.24E-02 |
| 2018 | 1.61E-01 | 3.41E-03 | 6.01E-02 |
| 2019 | 1.81E-01 | 4.09E-03 | 6.67E-02 |
| 2020 | 1.86E-01 | 3.32E-03 | 6.93E-02 |
| 2021 | 1.73E-01 | 3.99E-03 | 6.58E-02 |
| 2022 | 2.23E-02 | 5.06E-04 | 8.48E-03 |

*Collection started in 2011

## Table E.9. Gamma emitting radionuclides in drinking water

| Radionuclide | Location | Activity Bq/L | Unc(2$\sigma$) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Sheep Draw | 1.79E-01 | 1.15E-01 | 3.79E-01 | Not Detected |
| | Sheep Draw-Dup | -3.60E-02 | 1.00E-01 | 3.40E-01 | Not Detected |
| | Malaga | 2.03E-01 | 1.16E+04 | 3.80E-01 | Not Detected |
| | Loving | -4.32E-01 | 2.78E-01 | 9.49E-01 | Not Detected |
| | Otis | -3.61E-01 | 1.71E-01 | 5.80E-01 | Not Detected |
| | Trip Blank | 4.52E-01 | 1.39E-01 | 4.53E-01 | Not Detected |
| | Hobbs | 2.02E-01 | 1.05E-01 | 3.43E-01 | Not Detected |
| | PRV-4 | -1.36E-01 | 2.52E-01 | 8.54E-01 | Not Detected |
| | | | | | |
| $^{60}$Co | Sheep Draw | 3.87E-02 | 1.09E-01 | 3.68E-01 | Not Detected |
| | Sheep Draw-Dup | 2.31E-01 | 1.06E-01 | 3.43E-01 | Not Detected |
| | Malaga | 2.69E-01 | 1.33E-01 | 4.36E-01 | Not Detected |
| | Loving | 5.16E-02 | 2.05E-01 | 7.01E-01 | Not Detected |
| | Otis | 4.03E-01 | 1.33E-01 | 4.26E-01 | Not Detected |
| | Trip Blank | 2.44E-01 | 1.10E-01 | 3.58E-01 | Not Detected |
| | Hobbs | 2.15E-01 | 1.20E-01 | 3.93E-01 | Not Detected |
| | PRV-4 | 1.38E-01 | 2.14E-01 | 7.24E-01 | Not Detected |
| | | | | | |
| $^{40}$K | Sheep Draw | 2.93E+00 | 2.11E+00 | 6.96E+00 | Not Detected |
| | Sheep Draw-Dup | 1.95E+00 | 2.24E+00 | 7.41E+00 | Not Detected |
| | Malaga | 2.42E+00 | 1.71E+00 | 5.65E+00 | Not Detected |
| | Loving | 1.24E+00 | 1.69E+00 | 5.73E+00 | Not Detected |
| | Otis | -1.53E+00 | 1.61E+00 | 5.48E+00 | Not Detected |
| | Trip Blank | 1.06E-01 | 2.01E+00 | 6.74E+00 | Not Detected |
| | Hobbs | 1.48E+00 | 1.57E+00 | 5.22E+00 | Not Detected |
| | PRV-4 | 1.05E+00 | 1.78E+00 | 6.04E+00 | Not Detected |

### Table E.10.  Sr concentrations in drinking water

| Radionuclide | Location | Activity Bq/L | Unc($2\sigma$) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| **$^{90}$Sr** | Sheep Draw | 2.16E+01 | 1.89E+00 | 2.84E+01 | Not Detected |
| | Sheep Draw-Dup | 2.30E+01 | 1.98E+00 | 2.65E+01 | Not Detected |
| | Malaga | 2.49E+01 | 2.05E+00 | 2.65E+01 | Not Detected |
| | Loving | 2.30E+01 | 1.98E+00 | 2.65E+01 | Not Detected |
| | Otis | 2.35E+01 | 1.99E+00 | 2.65E+01 | Not Detected |
| | Trip Blank | 2.62E+01 | 2.14E+00 | 2.65E+01 | Not Detected |
| | Hobbs | 2.44E+01 | 2.06E+00 | 2.84E+01 | Not Detected |
| | PRV-4 | 2.16E+01 | 1.91E+00 | 2.65E+01 | Not Detected |

# APPENDIX F - RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES

Actinide concentrations in sediment samples

Uranium concentrations in sediment samples

Gamma radionuclide concentrations in sediment samples

Strontium concentrations in sediment samples

**Table F.1. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site**

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | Lake Carlsbad | 6/14/2022 | -2.16E-03 | 2.72E-03 | 8.06E-03 | Not Detected |
| | Brantley | 6/15/2022 | -4.09E-03 | 3.91E-03 | 1.08E-02 | Not Detected |
| | Red Bluff | 6/16/2022 | 3.89E-05 | 2.24E-05 | 3.43E-05 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 2.72E-05 | 2.00E-05 | 4.06E-05 | Not Detected |
| | | | | | | |
| $^{239+240}$Pu | Lake Carlsbad | 6/14/2022 | 5.58E-05 | 2.23E-05 | 3.03E-05 | Detected |
| | Brantley | 6/15/2022 | 8.30E-05 | 2.45E-05 | 2.72E-05 | Detected |
| | Red Bluff | 6/16/2022 | 5.18E-05 | 3.50E-05 | 6.02E-05 | Not Detected |
| | Red Bluff-Dup | 6/16/2022 | 4.66E-05 | 3.33E-05 | 6.21E-05 | Not Detected |
| | | | | | | |
| $^{238}$Pu | Lake Carlsbad | 6/14/2022 | 1.36E-05 | 1.39E-05 | 2.84E-05 | Not Detected |
| | Brantley | 6/15/2022 | 2.81E-05 | 1.52E-05 | 2.40E-05 | Detected |
| | Red Bluff | 6/16/2022 | 4.49E-05 | 3.35E-05 | 6.02E-05 | Not Detected |
| | Red Bluff-Dup | 6/16/2022 | 3.32E-05 | 2.78E-05 | 5.45E-05 | Not Detected |

Dup = duplicate

### Table F.2. Activity concentrations of $^{234}U$, $^{235}U$, and $^{238}U$ (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{234}U$ | Lake Carlsbad | 6/14/2022 | 2.23E-02 | 2.35E-03 | 3.78E-05 | Detected |
| | Brantley | 6/15/2022 | 1.43E-02 | 4.93E-05 | 4.93E-05 | Detected |
| | Red Bluff | 6/16/2022 | 1.97E-02 | 2.07E-03 | 4.33E-05 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 1.68E-02 | 1.78E-03 | 3.88E-05 | Detected |
| | | | | | | |
| $^{235}U$ | Lake Carlsbad | 6/14/2022 | 4.76E-04 | 8.40E-05 | 4.78E-05 | Detected |
| | Brantley | 6/15/2022 | 4.72E-04 | 8.32E-05 | 4.74E-05 | Detected |
| | Red Bluff | 6/16/2022 | 1.24E-03 | 1.66E-04 | 2.11E-05 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 7.55E-04 | 1.11E-04 | 1.89E-05 | Detected |
| | | | | | | |
| $^{238}U$ | Lake Carlsbad | 6/14/2022 | 1.37E-02 | 1.45E-03 | 4.97E-05 | Detected |
| | Brantley | 6/15/2022 | 1.16E-02 | 1.24E-03 | 5.21E-05 | Detected |
| | Red Bluff | 6/16/2022 | 1.33E-02 | 1.41E-03 | 5.47E-05 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 1.12E-02 | 1.20E-03 | 5.40E-05 | Detected |

Dup = duplicate

### Table F.3. Activity concentrations of $^{137}Cs$, $^{40}K$, and $^{60}Co$ (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{137}Cs$ | Lake Carlsbad | 6/14/2022 | 3.35E-03 | 3.67E-03 | 1.22E-02 | Not Detected |
| | Brantley | 6/15/2022 | 2.42E-03 | 2.49E-03 | 8.24E-03 | Not Detected |
| | Red Bluff | 6/16/2022 | 3.23E-03 | 3.99E-03 | 1.33E-02 | Not Detected |
| | Red Bluff-Dup | 6/16/2022 | -2.55E-03 | 2.05E-03 | 6.93E-03 | Not Detected |
| | | | | | | |
| $^{40}K$ | Lake Carlsbad | 6/14/2022 | 1.30E-01 | 3.23E-02 | 1.00E-01 | Detected |
| | Brantley | 6/15/2022 | 3.67E-01 | 3.08E-02 | 8.86E-02 | Detected |
| | Red Bluff | 6/16/2022 | 4.19E-01 | 4.44E-02 | 1.23E-01 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 3.99E-01 | 3.16E-02 | 8.97E-02 | Detected |
| | | | | | | |
| $^{60}Co$ | Lake Carlsbad | 6/14/2022 | 1.52E-03 | 2.90E-03 | 9.83E-03 | Not Detected |
| | Brantley | 6/15/2022 | 4.97E-03 | 1.78E-03 | 5.73E-03 | Not Detected |
| | Red Bluff | 6/16/2022 | 4.46E-03 | 2.93E-03 | 9.68E-03 | Not Detected |
| | Red Bluff-Dup | 6/16/2022 | 5.88E-03 | 1.91E-03 | 6.12E-03 | Not Detected |

Dup = duplicate

**Table F.4. Activity concentrations of $^{90}$Sr (Bq/kg) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site**

| Radionuclide | Location | Sample Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{90}$Sr | Lake Carlsbad | 6/14/2022 | 1.06E+02 | 9.08E+00 | 1.34E+02 | Not Detected |
| | Brantley | 6/15/2022 | 1.15E+02 | 9.51E+00 | 1.35E+02 | Not Detected |
| | Red Bluff | 6/16/2022 | 1.54E+02 | 9.21E+00 | 1.43E+02 | Detected |
| | Red Bluff-Dup | 6/16/2022 | 1.21E+02 | 8.04E+00 | 1.39E+02 | Not Detected |

# APPENDIX G - RADIONUCLIDE CONCENTRATIONS IN VEGETATION SAMPLES

**Table G.1. Activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu (Bq/g) in vegetation samples**

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | Near Field | 8/9/2022 | 5.82E-05 | 3.74E-05 | 6.45E-05 | Not Detected |
| | Cactus Flats | 8/9/2022 | 4.59E-05 | 3.34E-05 | 6.50E-05 | Not Detected |
| | Loving | 8/9/2022 | 1.59E-05 | 3.44E-05 | 8.11E-05 | Not Detected |
| | East Tower | 8/9/2022 | 7.89E-05 | 3.51E-05 | 5.25E-05 | Detected |
| | Loving-Dup | 8/9/2022 | 5.35E-05 | 3.03E-05 | 5.22E-05 | Detected |
| | Carlsbad | 9/23/2022 | 3.08E-05 | 2.09E-05 | 3.48E-05 | Not Detected |
| | | | | | | |
| $^{239+240}$Pu | Near Field | 8/9/2022 | 2.54E-04 | 8.18E-05 | 1.00E-04 | Detected |
| | Cactus Flats | 8/9/2022 | 4.98E-05 | 3.23E-05 | 5.26E-05 | Not Detected |
| | Loving | 8/9/2022 | 5.00E-05 | 2.79E-05 | 4.18E-05 | Detected |
| | East Tower | 8/9/2022 | 5.45E-04 | 2.11E-04 | 2.81E-04 | Detected |
| | Loving-Dup | 8/9/2022 | 2.87E-04 | 7.72E-05 | 7.11E-05 | Detected |
| | Carlsbad | 9/23/2022 | 2.90E-05 | 1.96E-05 | 3.37E-05 | Not Detected |
| | | | | | | |
| $^{238}$Pu | Near Field | 8/9/2022 | 2.23E-04 | 7.72E-05 | 1.00E-04 | Detected |
| | Cactus Flats | 8/9/2022 | 3.65E-05 | 3.60E-05 | 7.45E-05 | Not Detected |
| | Loving | 8/9/2022 | 3.95E-05 | 3.14E-05 | 6.19E-05 | Not Detected |
| | East Tower | 8/9/2022 | 6.71E-04 | 2.28E-04 | 2.63E-04 | Detected |
| | Loving-Dup | 8/9/2022 | 2.42E-04 | 7.23E-05 | 8.05E-05 | Detected |
| | Carlsbad | 9/23/2022 | 4.83E-05 | 2.34E-05 | 3.37E-05 | Detected |

Dup = duplicate

### Table G.2. Activity concentrations of $^{234}$U, $^{235}$U, and $^{238}$U (Bq/g) in vegetation samples

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{234}$U | Near Field | 8/9/2022 | 6.44E-03 | 8.11E-04 | 1.06E-04 | Detected |
|  | Cactus Flats | 8/9/2022 | 2.41E-03 | 3.17E-04 | 5.89E-05 | Detected |
|  | Loving | 8/9/2022 | 1.23E-03 | 1.80E-04 | 5.36E-05 | Detected |
|  | East Tower | 8/9/2022 | 8.72E-04 | 1.34E-04 | 6.20E-05 | Detected |
|  | Loving-Dup | 8/9/2022 | 8.65E-04 | 1.32E-04 | 5.07E-05 | Detected |
|  | Carlsbad | 9/23/2022 | 5.37E-04 | 9.30E-05 | 5.85E-05 | Detected |
|  |  |  |  |  |  |  |
| $^{235}$U | Near Field | 8/9/2022 | 4.58E-04 | 1.31E-04 | 9.02E-05 | Detected |
|  | Cactus Flats | 8/9/2022 | 2.38E-04 | 7.19E-05 | 6.61E-05 | Detected |
|  | Loving | 8/9/2022 | 9.12E-05 | 4.13E-05 | 4.56E-05 | Detected |
|  | East Tower | 8/9/2022 | 5.30E-05 | 3.17E-05 | 4.94E-05 | Detected |
|  | Loving-Dup | 8/9/2022 | 1.87E-05 | 2.16E-05 | 4.39E-05 | Not Detected |
|  | Carlsbad | 9/23/2022 | 3.11E-05 | 2.62E-05 | 4.93E-05 | Not Detected |
|  |  |  |  |  |  |  |
| $^{238}$U | Near Field | 8/9/2022 | 7.70E-03 | 9.52E-04 | 1.55E-04 | Detected |
|  | Cactus Flats | 8/9/2022 | 2.54E-03 | 3.35E-04 | 6.77E-05 | Detected |
|  | Loving | 8/9/2022 | 9.17E-04 | 1.46E-04 | 7.21E-05 | Detected |
|  | East Tower | 8/9/2022 | 5.94E-04 | 1.04E-04 | 7.70E-05 | Detected |
|  | Loving-Dup | 8/9/2022 | 1.15E-03 | 1.65E-04 | 5.63E-05 | Detected |
|  | Carlsbad | 9/23/2022 | 5.37E-04 | 9.47E-05 | 7.34E-05 | Detected |

Dup = duplicate

### Table G.3. Activity concentrations of $^{137}$Cs, $^{40}$K, and $^{60}$Co (Bq/kg) in vegetation samples

| Radionuclides | Location | Sample Date | Activity Bq/kg | Unc. ($2\sigma$) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|
| $^{137}$Cs | Near Field | 8/9/2022 | 5.80E+00 | 1.89E+00 | 6.10E+00 | Not Detected |
| | Cactus Flats | 8/9/2022 | 2.76E-01 | 1.62E+00 | 5.42E+00 | Not Detected |
| | Loving | 8/9/2022 | 3.01E+00 | 4.09E+00 | 1.36E+01 | Not Detected |
| | East Tower | 8/9/2022 | -7.32E+00 | 2.01E+00 | 6.94E+00 | Not Detected |
| | Loving-Dup | 8/9/2022 | -3.77E+00 | 3.84E+00 | 1.30E+01 | Not Detected |
| | Carlsbad | 9/23/2022 | -5.94E+00 | 1.94E+00 | 6.66E+00 | Not Detected |
| | | | | | | |
| $^{40}$K | Near Field | 8/9/2022 | 3.93E+02 | 3.50E+01 | 1.02E+02 | Detected |
| | Cactus Flats | 8/9/2022 | 1.98E+02 | 2.83E+01 | 8.63E+01 | Detected |
| | Loving | 8/9/2022 | 2.55E+02 | 3.99E+01 | 1.18E+02 | Detected |
| | East Tower | 8/9/2022 | 3.54E+02 | 3.00E+01 | 8.60E+01 | Detected |
| | Loving-Dup | 8/9/2022 | 5.01E+02 | 4.63E+01 | 1.24E+02 | Detected |
| | Carlsbad | 9/23/2022 | 4.18E+02 | 3.12E+01 | 8.77E+01 | Detected |
| | | | | | | |
| $^{60}$Co | Near Field | 8/9/2022 | 2.42E+00 | 1.92E+00 | 6.34E+00 | Not Detected |
| | Cactus Flats | 8/9/2022 | 2.61E+00 | 1.78E+00 | 5.89E+00 | Not Detected |
| | Loving | 8/9/2022 | 4.22E+00 | 2.95E+00 | 9.77E+00 | Not Detected |
| | East Tower | 8/9/2022 | 4.65E+00 | 1.65E+00 | 5.28E+00 | Not Detected |
| | Loving-Dup | 8/9/2022 | 4.53E-01 | 3.39E+00 | 1.15E+01 | Not Detected |
| | Carlsbad | 9/23/2022 | 4.57E+00 | 1.69E+00 | 5.44E+00 | Not Detected |

Dup = duplicate

### Table G.4. Activity concentrations of $^{90}$Sr (Bq/g) in vegetation samples

| Radionuclide | Location | Sample Date | Activity Bq/g | Unc. ($2\sigma$) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{90}$Sr | Near Field | 8/9/2022 | 2.24E-01 | 1.37E-02 | 1.81E-01 | Detected |
| | Cactus Flats | 8/9/2022 | 2.20E-01 | 1.36E-02 | 1.78E-01 | Detected |
| | Loving | 8/9/2022 | 2.01E-01 | 1.29E-02 | 1.78E-01 | Detected |
| | East Tower | 8/9/2022 | 1.97E-01 | 1.25E-02 | 1.71E-01 | Detected |
| | Loving-Dup | 8/9/2022 | 1.82E-01 | 1.23E-02 | 1.82E-01 | Not Detected |
| | Carlsbad | 9/23/2022 | 1.90E-01 | 1.24E-02 | 1.75E-01 | Detected |

Dup = duplicate

# APPENDIX H - IN-VIVO RESULTS

Average MDA of Lung Detector through December 2022

Average MDA of Whole-Body counting detector December 2022

Demographic Characteristics of the LDBC population through December 2022

LDBC results greater than the decision limits ($L_C$) through December 2022

## Table H.1: 2022 Apex In-vivo System’s Average MDAs (nCi) of Lung detector group
## MDA averages are determined from 10 radiobioassay measurements

| Radionuclide | Energy (keV) | MDA (nCi) as a function of Chest Wall Thickness (CWT in cm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1.6 cm | | 3.33 cm | | 5.10 cm | | 6.0 cm | | 7.5 cm | |
| | | Avg | 1-Stdev | Avg | 1 Stdev | Avg | 1 Stdev | Avg | 1 Stdev | Avg | 1 Stdev |
| $^{241}$Am | 59.5 | 0.16 | 0.05 | 0.3 | 0.1 | 0.6 | 0.2 | 0.8 | 0.2 | 1.4 | 0.4 |
| $^{144}$Ce | 133.5 | 0.56 | 0.16 | 0.9 | 0.3 | 1.6 | 0.5 | 2.1 | 0.6 | 3.2 | 0.9 |
| $^{252}$Cf | 19.2 | 19 | 5 | 123 | 34 | 827 | 228 | 2184 | 601 | 10518 | 2986 |
| $^{244}$Cm | 18.1 | 19 | 6 | 150 | 44 | 1224 | 356 | 3565 | 1038 | 20230 | 6417 |
| $^{155}$Eu | 105.3 | 0.27 | 0.08 | 0.5 | 0.1 | 0.8 | 0.2 | 1.1 | 0.3 | 1.9 | 0.5 |
| $^{237}$Np | 86.5 | 0.45 | 0.14 | 0.8 | 0.3 | 1.6 | 0.5 | 2.1 | 0.6 | 3.5 | 1.0 |
| $^{238}$Pu | 17.1 | 21 | 6 | 203 | 58 | 2.09 | 0.6 | 6.86 | 2.0 | 47 | 14 |
| $^{239}$Pu | 17.1 | 51 | 15 | 505 | 145 | 5.21 | 1.5 | 17.07 | 4.9 | 117 | 34 |
| $^{240}$Pu | 17.1 | 20 | 6 | 1255 | 360 | 13 | 4 | 42 | 12 | 291 | 84 |
| $^{242}$Pu | 17.1 | 24 | 7 | 3123 | 895 | 32 | 9 | 106 | 30 | 724 | 210 |
| $^{226}$Ra | 186.1 | 2.0 | 0.6 | 3.2 | 0.9 | 5.05 | 1.5 | 6.41 | 1.8 | 9 | 2.7 |
| $^{232}$Th via $^{212}$Pb | 238.6 | 0.123 | 0.002 | 0.196 | 0.003 | 0.5 | 0.1 | 0.6 | 0.2 | 0.9 | 0.2 |
| $^{232}$Th | 59 | 21 | 2 | 39 | 5 | 76 | 9 | 106 | 12 | 184 | 21 |
| $^{232}$Th via $^{228}$Th[a] | 84.3 | 3.1 | 0.2 | 5.7 | 0.3 | 11 | 1 | 15 | 1 | 25 | 1 |
| $^{233}$U | 440.3 | 0.65 | 0.08 | 1.0 | 0.1 | 1.5 | 0.2 | 1.7 | 0.2 | 2.1 | 0.3 |
| $^{235}$U[b] | 185.7 | 0.12 | 0.04 | 0.20 | 0.06 | 0.31 | 0.09 | 0.40 | 0.11 | 0.6 | 0.2 |
| Nat U via $^{234}$Th[c] | 63.3 | 1.6 | 0.5 | 2.9 | 0.9 | 6 | 2 | 8 | 2 | 13 | 4 |

[a] Radionuclide used to indicate natural thorium.

[b] Radionuclide used to indicate enriched uranium.

[c] Radionuclide used to indicate natural uranium or depleted uranium.

**Table H.2: 2022 Apex In-vivo System's Average MDAs (nCi) of Whole-Body detector group**

**MDA averages are determined from 10 radiobioassay measurements**

| Radionuclide | Energy (keV) | Average MDA (nCi) | 1-stdev (nCi) |
|---|---|---|---|
| Ba-133 | 356 | 0.77 | 0.21 |
| Ba-140 | 537 | 1.47 | 0.45 |
| Ce-141 | 145 | 1.08 | 0.31 |
| Co-58 | 811 | 0.38 | 0.10 |
| Co-60 | 1333 | 0.36 | 0.10 |
| Cr-51 | 320 | 4.31 | 1.22 |
| Cs-134 | 604 | 0.49 | 0.14 |
| Cs-137 | 662 | 0.42 | 0.12 |
| Eu-152 | 344 | 1.58 | 0.46 |
| Eu-154 | 1275 | 1.13 | 0.34 |
| Eu-155 | 105 | 2.59 | 0.73 |
| Fe-59 | 1099 | 0.72 | 0.20 |
| I-131 | 365 | 0.52 | 0.14 |
| I-133 | 530 | 0.42 | 0.11 |
| Ir-192 | 317 | 0.52 | 0.15 |
| Mn-54 | 835 | 0.38 | 0.11 |
| Ru-103 | 497 | 0.43 | 0.12 |
| Ru-106 | 622 | 3.73 | 1.08 |
| Sb-125 | 428 | 1.36 | 0.39 |
| Th-I(AC) | 911 | 1.30 | 0.35 |
| Y-88 | 898 | 0.40 | 0.11 |
| Zn-65 | 1116 | 0.92 | 0.27 |
| Zr-95 | 757 | 0.66 | 0.19 |

### Table H.3: Demographic Characteristics of the LDBC population during 1997-2022

| Characteristic | | Voluntary Participants | | 2000[a] | | 2022[b] Estimates | |
|---|---|---|---|---|---|---|---|
| | | Baseline | Operational | NM | US | NM | US |
| Gender | Male | 56.2%<br>(52.2% to 61.9%)[C] | 43.4%<br>(40.6% to 46.2%) | 49.2% | 49.1% | 49.8% | 49.6% |
| | Female | 43.8%<br>(38.6% to 48.3%) | 56.6%<br>(53.8% to 59.4%) | 50.8% | 50.9% | 50.2% | 50.4% |
| Ethnicity | Hispanic | 13.4%<br>(9.5% to 16.3%) | 23.9%<br>(21.5% to 26. 3%) | 42.1% | 12.5% | 50.2% | 19.1% |
| | All others | 86.6%<br>(83.3% to 90.9%) | 76.1%<br>(73.7% to78.5 %) | 57.9% | 87.5% | 49.8% | 80.9% |
| Age 65 years or over | | 16.70%[d] | 35.5%<br>(32.8% to 38.2%) | 11.7% | 12.4% | 19.1% | 17.3% |
| Currently or previously classified as a radiation worker | | 4.0%[d] | 9.7%<br>(8.1% to 11.4%) | NA | NA | NA | NA |
| Consumption of wild game within 3 months prior to count | | 16.4%[d] | 22.01%<br>(19.7% to 24.3%) | NA | NA | NA | NA |
| Medical treatment other than X-rays using radionuclides | | 9%[d] | 5.7%<br>(4.4% to 7.0%) | NA | NA | NA | NA |
| European/Japan travel within 2 years prior to the count | | 4%[d] | 4.7%<br>(3.5% to 5.8%) | NA | NA | NA | NA |
| Current smoker | | 13.9%[d] | 13.2%<br>(11.3% to 15.1%) | N/A | N/A | 14% - 16.4%[e] | 10.1%-13.0%[f] |

[a] 2000 Census data for US and NM
https://www2.census.gov/library/publications/2001/dec/2kh00.pdf (accessed on 10/17/2022).
https://usa.ipums.org/usa/resources/voliii/pubdocs/2000/c2kprof00-nm.pdf (accessed on 10/17/2022).

[b] 2022 Census data for US and NM
https://www.census.gov/quickfacts/fact/table/US/PST04521 (accessed on 8/01/2023).
https://www.census.gov/quickfacts/fact/table/NM (accessed on 8/01/2023).

[c] Values in parentheses are margin of error (margin of error represents the 95% confidence interval of the observed percentage

[d] Margin of error cannot be quoted due to small sample size.

[e] % Adult smoking in NM
https://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm
(Page last reviewed: May 4, 2023, accessed on 8/01/2023)

[f] % Adult smoking in US
https://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/index.htm#nation
(Page last reviewed: May 4, 2023, accessed on 8/01/2023)

**Table H.4: LDBC results greater than the decision limits ($L_C$) through December 2022**

| Radionuclides | *In-Vivo* count type | Baseline counts (N = 366) % of results ≥ $L_C$[a] | Operational counts (N = 1222) % of results ≥$L_C$[a] |
|---|---|---|---|
| $^{241}$Am | Lung | 5.2 (4.0 to 6.4) | 4.3 (3.1 to 5.4) |
| $^{144}$Ce | Lung | 4.6 (3.5 to 5.7) | 4.7 (3.6 to 5.9) |
| $^{252}$Cf | Lung | 4.1 (3.1 to 5.1) | 5.9 (4.6 to 7.2) |
| $^{244}$Cm | Lung | 5.7 (4.5 to 7.0) | 4.7 (3.6 to 5.9) |
| $^{155}$Eu | Lung | 7.1 (5.8 to 8.4) | 5.1 (3.8 to 6.3) |
| $^{237}$Np | Lung | 3.6 (2.6 to 4.5) | 3.8 (2.8 to 4.9) |
| $^{210}$Pb | Lung | 4.4 (3.3 to 5.4) | 6 (4.6 to 7.3) |
| Pu-Isotopes [c] | Lung | 5.7 (4.5 to 7.0) | 5 (3.8 to 6.2) |
| $^{232}$Th via $^{212}$Pb [d] | Lung | 34.2 (31.7 to 36.6) | 31.5 (28.9 to 34.1) |
| $^{232}$Th | Lung | 4.9 (3.8 to 6.0) | 5.6 (4.3 to 6.9) |
| $^{232}$Th via $^{228}$Th | Lung | 4.1 (3.1 to 5.1) | 4.7 (3.6 to 5.9) |
| $^{233}$U | Lung | 5.7 (4.5 to 7.0) | 8.9 (7.3 to 10.5) |
| $^{235}$U_$^{226}$Ra [e] | Lung | 10.7 (9.0 to 12.3) | 10.9 (9.1 to 12.6) |
| $^{238}$U | Lung | 5.2 (4.0 to 6.4) | 5.3 (4.1 to 6.6) |
| $^{133}$Ba | Whole Body | 3.6 (2.6 to 4.5) | 3.4 (2.4 to 4.5) |
| $^{140}$Ba | Whole Body | 5.2 (4.0 to 6.4) | 3.9 (2.8 to 5) |
| $^{141}$Ce | Whole Body | 3.6 (2.6 to 4.5) | 4.9 (3.7 to 6.1) |
| $^{58}$Co | Whole Body | 4.4 (3.3 to 5.4) | 3.8 (2.7 to 4.8) |
| $^{60}$Co [d] | Whole Body | 54.6 (52.0 to 57.2) | 21.2 (18.9 to 23.5) |
| $^{51}$Cr | Whole Body | 5.7 (4.5 to 7.0) | 4.4 (3.3 to 5.6) |
| $^{134}$Cs | Whole Body | 1.6 (1.0 to 2.3) | 3.1 (2.1 to 4.1) |
| $^{137}$Cs | Whole Body | 28.4 (26.1 to 30.8) | 16.7 (14.6 to 18.8) |
| $^{152}$Eu | Whole Body | 7.4 (6.0 to 8.7) | 5.6 (4.3 to 6.9) |
| $^{154}$Eu | Whole Body | 3.8 (2.8 to 4.8) | 3.5 (2.5 to 4.6) |
| $^{155}$Eu | Whole Body | 3.8 (2.8 to 4.8) | 3.4 (2.4 to 4.5) |
| $^{59}$Fe | Whole Body | 3.8 (2.8 to 4.8) | 5.7 (4.4 to 7) |
| $^{131}$I | Whole Body | 5.2 (4.0 to 6.4) | 4.6 (3.4 to 5.8) |
| $^{133}$I | Whole Body | 3.3 (2.3 to 4.2) | 4.1 (3 to 5.2) |
| $^{192}$Ir | Whole Body | 4.1 (3.1 to 5.1) | 4.3 (3.1 to 5.4) |
| $^{40}$K | Whole Body | 100.0 (100.0 to 100.0) | 100.0 (100.0 to 100.0) |
| [d] $^{54}$Mn | Whole Body | 12.3 (10.6 to 14.0) | 12.5 (10.7 to 14.4) |
| $^{103}$Ru | Whole Body | 2.2 (1.4 to 3.0) | 1.9 (1.1 to 2.6) |
| $^{106}$Ru | Whole Body | 4.4 (3.3 to 5.4) | 4.5 (3.3 to 5.7) |
| $^{125}$Sb | Whole Body | 5.2 (4.0 to 6.4) | 4.5 (3.3 to 5.7) |
| $^{232}$Th via $^{228}$Ac | Whole Body | 34.7 (32.2 to 37.2) | 26.5 (24 to 29) |
| $^{88}$Y | Whole Body | 7.7 (6.3 to 9.0) | 6.6 (5.2 to 8) |
| $^{95}$Zr | Whole Body | 6.6 (5.3 to 7.9) | 3.8 (2.7 to 4.8) |

[a] N = number of individuals. Baseline counts include only the initial counts during this baseline period.

[b] Margin of error represents the 95% confidence interval of the observed percentage.

[c] $^{238-240,\ 242}$ Pu isotopes are identified as a group, denoted as Pu-Isotopes by the software.

[d] These radionuclides are present in the shield background, so they are expected to be detected periodically.

[e] $^{235}U$ and $^{226}Ra$ have gamma ray energies 185.72 keV and 186.21 keV, respectively. Software (VMS ABACOS+) identified both with the same 186 keV gamma ray energy, calculated the individual activity using the corresponding yields. The upgraded software (in 2022) identifies 185.72 keV and 186.21, calculates the individual activity using the corresponding yields.

# APPENDIX I - NON-RADIOLOGICAL MONITORING

Detection limits of different methods

Weekly composite concentrations of selected anions (ng/m$^3$) at Station A
Weekly composite concentrations of selected cations (ng/m$^3$) at Station A

Monthly composite concentrations of selected anions (ng/m$^3$) at Station B
Monthly composite concentrations of selected cations (ng/m$^3$) at Station B

Weekly composite concentrations of selected metals (ng/m$^3$) at Station A
Monthly composite concentrations of selected metals (ng/m$^3$) at Station B

Concentrations of selected anion concentrations (ng/m$^3$) in ambient air at Near Field
Concentrations of selected cation concentrations (ng/m$^3$) in ambient air at Near Field

Concentrations of selected anion concentrations (ng/m$^3$) in ambient air at Cactus Flats
Concentrations of selected cation concentrations (ng/m$^3$) in ambient air at Cactus Flats

Summary of metal concentrations in drinking water samples
Selected anion concentrations in drinking water samples
Selected cation concentrations in drinking water samples
Summaries of other analyses performed on drinking water samples

Summary of metal concentrations in surface water samples
Selected anion concentrations in surface water samples
Selected cation concentrations in surface water samples
Summaries of other analyses performed on surface water samples

## Table I.1. Summary of sample type, analytes, methods, and detection limits used for non-radioactive analyses in 2022

| Sample Type | Detection method | Method/ Parameters | Analytes of Interest | Detection Limits* (µg/L) |
|---|---|---|---|---|
| Drinking Water | ICP-MS | Metals analysis (EPA 200.8) | Ag, As, Ba, Be, Cd, Cr, Ni, Pb, Sb, Se, Tl, V | Varies by element** |
| Drinking Water | ICP-MS | Mercury (EPA 200.8) | Hg | 0.13 |
| Drinking Water | IC | Anions (EPA 300.0) | $Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$ | 2.2 – 12.3 |
| Drinking Water | IC | Cations (ASTM Standard D6919-09) | $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$ | 1.6 - 68 |
| Surface Water | ICP-MS | Metals analysis (EPA 200.8) | Ag, As, Ba, Be, Cd, Cr, Ni, Pb, Sb, Se, Tl, V | Varies by element** |
| Surface Water | ICP-MS | Mercury (EPA 200.8) | Hg | 0.19 |
| Surface Water | IC | Anions (EPA 300.0) | $Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$ | 3.1 – 18.2 |
| Surface Water | IC | Cations (ASTM Standard D6919-09) | $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$ | 2.5 - 47 |
| Station A and B filters | ICP-MS | Metals analysis (EPA 200.8) | Al<br>Cd<br>Mg<br>Pb<br>Si<br>Th<br>U | 261<br>0.33<br>259<br>0.12<br>778<br>0.12<br>0.042 |
| Station A and B filters | IC | Anions (EPA 300.0) | $Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$ | 3.3 - 851 |
| Station A and B filters | IC | Cations (ASTM Standard D6919-09) | $NH_4^+$, $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$ | 48 - 130 |
| Whatman 41 filters | IC | Anions (EPA 300.0) | $Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$ | 4.0 - 1821 |
| Whatman 41 filters | IC | Cations (ASTM Standard D6919-09) | $Ca^{2+}$, $Mg^{2+}$, $K^+$, $Na^+$ | 5.8 - 430 |

* Detection limits are determined/updated annually.

** Current MDC values for individual metals are included in the results section of this chapter.

**Table I.2. Concentrations of selected anions (ng/m$^3$) in 2022 weekly composites from Station A**

| Sample Start Date | Chloride | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|
| 03/01/22 | N/A | N/A | N/A | N/A |
| 03/08/22 | N/A | N/A | N/A | N/A |
| 03/15/22 | N/A | N/A | N/A | N/A |
| 03/22/22 | 1820000 | <MDL | <MDL | 75200 |
| 04/01/22 | 119000 | <MDL | <MDL | 18500 |
| 04/08/22 | 377000 | <MDL | <MDL | 64500 |
| 04/15/22 | 403000 | <MDL | <MDL | 26900 |
| 04/22/22 | 205000 | <MDL | <MDL | 18500 |
| 05/01/22 | 185000 | 608 | <MDL | 21800 |
| 05/08/22 | 243000 | 704 | <MDL | 40700 |
| 05/15/22 | 318000 | 611 | <MDL | 34200 |
| 05/22/22 | 156000 | <MDL | 4390 | 18000 |
| 06/01/22 | 168000 | 683 | <MDL | 9290 |
| 06/08/22 | 282000 | 707 | <MDL | 24500 |
| 06/15/22 | 289000 | 742 | <MDL | 22200 |
| 06/22/22 | 189000 | 615 | <MDL | 23800 |
| 07/01/22 | 152000 | <MDL | <MDL | 37200 |
| 07/08/22 | 175000 | <MDL | <MDL | 39000 |
| 07/15/22 | N/A | N/A | N/A | N/A |
| 07/22/22 | 221000 | 710 | <MDL | 21500 |
| 08/01/22 | 1030000 | <MDL | <MDL | 16900 |
| 08/08/22 | 393000 | 637 | <MDL | 17400 |
| 08/15/22 | 163000 | <MDL | <MDL | 14400 |
| 08/22/22 | N/A | N/A | N/A | N/A |
| 09/01/22 | N/A | N/A | N/A | N/A |
| 09/08/22 | N/A | N/A | N/A | N/A |
| 09/15/22 | N/A | N/A | N/A | N/A |
| 09/22/22 | 261000 | <MDL | <MDL | 15700 |
| 10/01/22 | 271000 | <MDL | <MDL | 12300 |
| 10/08/22 | 275000 | <MDL | <MDL | 13100 |
| 10/15/22 | 205000 | <MDL | <MDL | 19100 |

### Table I.2. Concentrations of selected anions (ng/m$^3$) in 2022 weekly composites from Station A (continued)

| Sample Start Date | Chloride | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|
| 10/22/22 | 125000 | <MDL | <MDL | 23100 |
| 11/01/22 | 235000 | 208 | <MDL | 62700 |
| 11/08/22 | 196000 | 238 | <MDL | 34300 |
| 11/15/22 | 240000 | 295 | <MDL | 50600 |
| 11/22/22 | 177000 | <MDL | <MDL | 20600 |
| 12/01/22 | 188000 | <MDL | <MDL | 27500 |
| 12/08/22 | 224000 | <MDL | <MDL | 23000 |
| 12/15/22 | 241000 | 263 | <MDL | 59600 |
| 12/22/22 | 316000 | 189 | <MDL | 22700 |

*NOTE: In 2022, no filters were received in January and February. A few weeks of filters were not received in March, July, August and September as well.*

**Table I.3. Concentrations of selected cations (ng/m$^3$) in 2022 weekly composites from Station A**

| Sample Date | Sodium | Ammonium | Magnesium | Potassium | Calcium |
|---|---|---|---|---|---|
| 03/01/22 | N/A | N/A | N/A | N/A | N/A |
| 03/08/22 | N/A | N/A | N/A | N/A | N/A |
| 03/15/22 | N/A | N/A | N/A | N/A | N/A |
| 03/22/22 | 4110000 | <MDL | 2650 | 5350 | 23700 |
| 04/01/22 | 754000 | <MDL | 1300 | 2680 | 7360 |
| 04/08/22 | 2600000 | <MDL | 3500 | 7610 | 17800 |
| 04/15/22 | 2660000 | <MDL | 1720 | 3340 | 7550 |
| 04/22/22 | 1270000 | <MDL | 1040 | 1660 | 6150 |
| 05/01/22 | 1230000 | <MDL | 1280 | 2130 | 7900 |
| 05/08/22 | 1650000 | <MDL | 1860 | 3370 | 15600 |
| 05/15/22 | 2120000 | <MDL | 1850 | 3080 | 13300 |
| 05/22/22 | 1010000 | 3950 | 926 | 1520 | 6140 |
| 06/01/22 | 1110000 | <MDL | 1060 | 1520 | 2710 |
| 06/08/22 | 1880000 | <MDL | 1250 | 2270 | 8730 |
| 06/15/22 | 1880000 | <MDL | 1680 | 1970 | 8260 |
| 06/22/22 | 1250000 | <MDL | 1140 | 1440 | 9410 |
| 07/01/22 | 970000 | <MDL | 1120 | 1810 | 14400 |
| 07/08/22 | 1180000 | <MDL | 1300 | 2090 | 15200 |
| 07/15/22 | N/A | N/A | N/A | N/A | N/A |
| 07/22/22 | 1380000 | <MDL | 1920 | 1710 | 7500 |
| 08/01/22 | 2730000 | <MDL | 1570 | 2730 | 4960 |
| 08/08/22 | 2700000 | <MDL | 1720 | 2640 | 5680 |
| 08/15/22 | 1150000 | <MDL | 1580 | 1750 | 5360 |
| 08/22/22 | N/A | N/A | N/A | N/A | N/A |
| 09/01/22 | N/A | N/A | N/A | N/A | N/A |
| 09/08/22 | N/A | N/A | N/A | N/A | N/A |
| 09/15/22 | N/A | N/A | N/A | N/A | N/A |
| 09/22/22 | 1670000 | <MDL | 1490 | 2370 | 4600 |

## Table I.3. Concentrations of selected cations (ng/m$^3$) in 2022 weekly composites from Station A (continued)

| Sample Date | Sodium | Ammonium | Magnesium | Potassium | Calcium |
|---|---|---|---|---|---|
| 10/01/22 | 1810000 | <MDL | 1200 | 2040 | 3960 |
| 10/08/22 | 1880000 | <MDL | 1060 | 1860 | 4310 |
| 10/15/22 | 1310000 | <MDL | 1210 | 1950 | 6680 |
| 10/22/22 | 844000 | <MDL | 1390 | 1860 | 9560 |
| 11/01/22 | 1820000 | <MDL | 2330 | 2820 | 21400 |
| 11/08/22 | 1500000 | <MDL | 1660 | 1890 | 12800 |
| 11/15/22 | 1930000 | <MDL | 1370 | 2080 | 18200 |
| 11/22/22 | 1340000 | <MDL | 850 | 854 | 8270 |
| 12/01/22 | 1500000 | <MDL | 1060 | 844 | 11200 |
| 12/08/22 | 1760000 | <MDL | 754 | 786 | 8010 |
| 12/15/22 | 1940000 | <MDL | 1150 | 1670 | 21300 |
| 12/22/22 | 2710000 | <MDL | 884 | 1180 | 8990 |

*NOTE: In 2022, no filters were received in January and February. A few weeks of filters were not received in March, July, August and September as well.*

**Table I.4. Concentrations of selected anions (ng/m$^3$) in 2022 monthly composites from Station B**

| Sample Date | Chloride ng/m$^3$ | Nitrate ng/m$^3$ | Phosphate ng/m$^3$ | Sulfate ng/m$^3$ |
|---|---|---|---|---|
| January | 614 | <MDL | <MDL | <MDL |
| February | 612 | <MDL | <MDL | 212 |
| March | 743 | <MDL | <MDL | <MDL |
| April | 733 | <MDL | <MDL | 254 |
| May | 773 | <MDL | <MDL | <MDL |
| June | 911 | <MDL | <MDL | 325 |
| July | 1140 | <MDL | <MDL | 232 |
| August | N/A | N/A | N/A | N/A |
| September | 727 | <MDL | <MDL | 251 |
| October | 748 | <MDL | <MDL | <MDL |
| November | 811 | <MDL | <MDL | <MDL |
| December | 687 | <MDL | <MDL | 251 |
| *NOTE: In 2022, no filters were received in August.* | | | | |

**Table I.5. Concentrations of selected cations (ng/m$^3$) in 2022 monthly composites from Station B**

| Sample Start Date | Sodium | Ammonium | Magnesium | Potassium | Calcium |
|---|---|---|---|---|---|
| January | <MDL | <MDL | <MDL | <MDL | <MDL |
| February | <MDL | <MDL | <MDL | <MDL | <MDL |
| March | <MDL | <MDL | 33 | <MDL | 147 |
| April | <MDL | <MDL | <MDL | <MDL | 53 |
| May | <MDL | <MDL | <MDL | <MDL | 142 |
| June | <MDL | <MDL | <MDL | <MDL | 118 |
| July | <MDL | <MDL | <MDL | <MDL | <MDL |
| August | N/A | N/A | N/A | N/A | N/A |
| September | <MDL | <MDL | <MDL | <MDL | 39 |
| October | <MDL | <MDL | <MDL | <MDL | 22 |
| November | <MDL | <MDL | <MDL | <MDL | <MDL |
| December | <MDL | <MDL | <MDL | <MDL | <MDL |
| *NOTE: In 2022, no filters were received in August.* | | | | | |

### Table I.6. Concentrations of selected metals (ng/m$^3$) in weekly composites from Station A in 2022

| Sample Date | Aluminum | Cadmium | Lead | Magnesium | Silica | Thorium | Uranium |
|---|---|---|---|---|---|---|---|
| 03/01/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 03/08/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 03/15/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 03/22/22 | 1087 | 0.63 | 2.87 | 3818 | 2876 | 0.14 | 0.098 |
| 04/01/22 | 875 | 0.69 | 6.96 | 2064 | 2573 | 0.16 | 0.072 |
| 04/08/22 | 919 | 0.40 | 3.40 | 4490 | 2888 | 0.13 | 0.073 |
| 04/15/22 | 553 | 0.53 | 3.56 | 1950 | 1699 | 0.081 | 0.038 |
| 04/22/22 | 424 | 0.38 | 3.55 | 1364 | 1334 | 0.067 | 0.033 |
| 05/01/22 | 426 | 0.37 | 3.46 | 1397 | 1306 | 0.063 | 0.035 |
| 05/08/22 | 702 | 0.64 | 6.01 | 2863 | 2253 | 0.10 | 0.072 |
| 05/15/22 | 695 | 0.47 | 5.40 | 2692 | 2118 | 0.093 | 0.054 |
| 05/22/22 | 463 | 0.39 | 11.9 | 1447 | 1483 | 0.074 | 0.29 |
| 06/01/22 | 283 | 0.48 | 2.84 | 1253 | 930 | <MDL | 0.027 |
| 06/08/22 | 666 | 0.41 | 3.81 | 1221 | 1913 | 0.010 | 0.041 |
| 06/15/22 | 528 | 0.41 | 7.11 | 1716 | 1524 | 0.071 | 0.035 |
| 06/22/22 | 340 | 0.37 | 4.14 | 1287 | 1213 | 0.047 | 0.030 |
| 07/01/22 | 171 | 0.40 | 5.74 | 1085 | 714 | <MDL | 0.033 |
| 07/08/22 | 272 | 0.62 | 9.46 | 1252 | 1041 | <MDL | 0.031 |
| 07/15/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 07/22/22 | 301 | 0.38 | 8.45 | 2282 | 967 | 0.043 | 0.032 |
| 08/01/22 | 489 | 0.36 | 7.05 | 1800 | 1466 | 0.063 | 0.032 |
| 08/08/22 | 298 | 0.38 | 7.04 | 1716 | 1094 | 0.040 | 0.026 |
| 08/15/22 | 267 | 0.68 | 2.89 | 1552 | 1383 | <MDL | <MDL |
| 08/22/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 09/01/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 09/08/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 09/15/22 | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| 09/22/22 | 435 | 0.42 | 7.02 | 2115 | 1296 | 0.050 | 0.037 |
| 10/01/22 | 277 | 0.39 | 5.03 | 1581 | 1088 | <MDL | 0.023 |
| 10/08/22 | 473 | 0.38 | 3.57 | 1278 | 940 | <MDL | 0.019 |
| 10/15/22 | 253 | 0.40 | 4.23 | 1649 | 958 | <MDL | 0.026 |

## Table I.6. Concentrations of selected metals (ng/m$^3$) in weekly composites from Station A in 2022 (continued)

| Sample Date | Aluminum | Cadmium | Lead | Magnesium | Silica | Thorium | Uranium |
|---|---|---|---|---|---|---|---|
| 10/22/22 | 235 | 0.38 | 2.09 | 1537 | 858 | <MDL | 0.026 |
| 11/01/22 | 321 | 0.40 | 4.22 | 2041 | 1154 | <MDL | 0.041 |
| 11/08/22 | 213 | 0.38 | 4.24 | 1466 | 780 | <MDL | 0.027 |
| 11/15/22 | 197 | 0.37 | 3.67 | 1342 | 781 | <MDL | 0.032 |
| 11/22/22 | 142 | 0.36 | 1.80 | 844 | 626 | <MDL | 0.017 |
| 12/01/22 | 211 | 0.37 | 2.04 | 930 | 836 | <MDL | 0.025 |
| 12/08/22 | 119 | 0.40 | 2.98 | 821 | 592 | <MDL | 0.018 |
| 12/15/22 | 170 | 0.37 | 3.65 | 1009 | 739 | <MDL | 0.032 |
| 12/22/22 | 201 | 0.42 | 2.56 | 985 | 819 | <MDL | 0.020 |

*NOTE: In 2022, no filters were received in January and February. A few weeks of filters were not received in March, July, August and September as well.*

## Table I.7. Concentrations of selected metals (ng/m$^3$) in 2022 monthly composites from Station B

| Sample Date | Aluminum | Cadmium | Lead | Magnesium | Silica | Thorium | Uranium |
|---|---|---|---|---|---|---|---|
| January | <MDC | 0.33 | 0.11 | <MDC | 237 | <MDC | <MDC |
| February | <MDC | 0.31 | 0.15 | <MDC | 298 | <MDC | <MDC |
| March | <MDC | 0.32 | 0.19 | <MDC | 360 | <MDC | <MDC |
| April | <MDC | 0.34 | 0.12 | <MDC | 363 | <MDC | <MDC |
| May | 81 | 0.30 | 0.16 | <MDC | 373 | <MDC | <MDC |
| June | <MDC | 0.33 | 0.27 | <MDC | 409 | <MDC | <MDC |
| July | <MDC | 0.37 | 0.24 | <MDC | <MDC | <MDC | <MDC |
| August | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| September | <MDC | 0.32 | 0.17 | <MDC | <MDC | <MDC | <MDC |
| October | <MDC | 0.32 | 0.14 | <MDC | 271 | <MDC | <MDC |
| November | <MDC | 0.34 | 0.17 | <MDC | 294 | <MDC | <MDC |
| December | <MDC | 0.31 | 0.16 | <MDC | 297 | <MDC | <MDC |

*NOTE: In 2022, no filters were received in August.*

### Table I.8. Concentrations of anions in ambient air (µg/m$^3$) at Near Field

| Start Date | Chloride | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|
| 2/2/2022 | 0.24 | 2.40 | 0.013 | 1.52 |
| 3/2/2022 | 0.24 | 2.49 | 0.014 | 1.77 |
| 3/16/2022 | 0.31 | 1.66 | 0.0068 | 1.46 |
| 3/30/2022 | 0.48 | 1.85 | 0.018 | 1.28 |
| 4/13/2022 | 0.39 | 2.15 | 0.014 | 2.23 |
| 4/29/2022 | 0.23 | 1.66 | <MDL | 1.89 |
| 5/18/2022 | 0.34 | 1.97 | 0.01374 | 1.79 |
| 6/3/2022 | 0.13 | 1.81 | <MDL | 2.14 |
| 6/15/2022 | 0.40 | 2.26 | <MDL | 1.52 |
| 6/29/2022 | 0.099 | 1.73 | 0.0085 | 1.46 |
| 7/22/2022 | 0.24 | 1.88 | <MDL | 1.89 |
| 8/17/2022 | 0.23 | 1.76 | 0.0081 | 1.56 |
| 10/3/2022 | 0.31 | 2.37 | 0.0075 | 1.50 |
| 11/4/2022 | 0.25 | 1.92 | 0.0039 | 1.29 |
| 12/09/2022 | 0.23 | 1.80 | 0.0042 | 1.80 |

### Table I.9. Concentrations of cations in ambient air (µg/m$^3$) at Near Field

| Start Date | Sodium | Magnesium | Potassium | Calcium |
|---|---|---|---|---|
| 2/2/2022 | 0.25 | 0.069 | 0.13 | 0.84 |
| 3/2/2022 | 0.26 | 0.072 | 0.12 | 1.01 |
| 3/16/2022 | 0.28 | 0.086 | 0.17 | 0.84 |
| 3/30/2022 | 0.53 | 0.098 | 0.18 | 0.79 |
| 4/13/2022 | 0.35 | 0.089 | 0.12 | 1.17 |
| 4/29/2022 | 0.35 | 0.094 | 0.13 | 1.09 |
| 5/18/2022 | 0.44 | 0.14 | 0.17 | 1.59 |
| 6/3/2022 | 0.39 | 0.12 | 0.15 | 1.04 |
| 6/15/2022 | 0.48 | 0.10 | 0.088 | 1.32 |
| 6/29/2022 | 0.28 | 0.063 | 0.072 | 0.92 |
| 7/22/2022 | 0.50 | 0.078 | 0.059 | 1.10 |
| 8/17/2022 | 0.36 | 0.055 | 0.072 | 1.27 |
| 10/3/2022 | 0.28 | 0.057 | 0.084 | 1.58 |
| 11/4/2022 | 0.21 | 0.070 | 0.11 | 1.25 |
| 12/09/2022 | 0.28 | 0.10 | 0.19 | 0.82 |

### Table I.10. Concentrations of anions in ambient air (μg/m$^3$) at Cactus Flats

| Start Date | Chloride | Nitrate | Phosphate | Sulfate |
|---|---|---|---|---|
| 2/2/2022 | 0.25 | 2.55 | 0.0076 | 1.26 |
| 3/2/2022 | 0.051 | 0.73 | 0.0024 | 0.33 |
| 3/16/2022 | 0.22 | 1.14 | <MDL | 1.09 |
| 3/30/2022 | 0.16 | 1.21 | 0.012 | 0.94 |
| 4/13/2022 | 0.16 | 1.55 | 0.0059 | 0.88 |
| 4/29/2022 | 0.24 | 1.51 | 0.0099 | 1.74 |
| 5/18/2022 | 0.28 | 1.68 | 0.0096 | 1.41 |
| 6/3/2022 | 0.11 | 1.32 | 0.0060 | 1.62 |
| 6/15/2022 | 0.26 | 1.60 | 0.0056 | 1.20 |
| 6/29/2022 | 0.094 | 1.46 | 0.012 | 1.37 |
| 7/22/2022 | 0.11 | 2.08 | 0.0045 | 1.43 |
| 8/17/2022 | 0.051 | 1.10 | 0.0071 | 1.26 |
| 10/3/2022 | 0.14 | 2.36 | <MDL | 1.22 |
| 11/4/2022 | 0.14 | 1.40 | 0.0029 | 0.98 |
| 12/9/2022 | 0.25 | 1.65 | 0.0025 | 1.71 |

### Table I.11. Concentrations of cations in ambient air (μg/m$^3$) at Cactus Flats

| Start Date | Sodium | Magnesium | Potassium | Calcium |
|---|---|---|---|---|
| 2/2/2022 | 0.25 | 0.054 | 0.094 | 0.86 |
| 3/2/2022 | 0.068 | 0.018 | 0.028 | 0.29 |
| 3/16/2022 | 0.19 | 0.056 | 0.10 | 0.81 |
| 3/30/2022 | 0.22 | 0.059 | 0.11 | 0.65 |
| 4/13/2022 | 0.17 | 0.042 | 0.052 | 0.68 |
| 4/29/2022 | 0.30 | 0.078 | 0.10 | 1.17 |
| 5/18/2022 | 0.32 | 0.094 | 0.11 | 1.54 |
| 6/3/2022 | 0.28 | 0.091 | 0.11 | 0.96 |
| 6/15/2022 | 0.34 | 0.079 | 0.070 | 1.16 |
| 6/29/2022 | 0.26 | 0.053 | 0.057 | 0.90 |
| 7/22/2022 | 0.35 | 0.059 | 0.047 | 0.81 |
| 8/17/2022 | 0.12 | 0.032 | 0.045 | 0.78 |
| 10/3/2022 | 0.17 | 0.042 | 0.052 | 1.43 |
| 11/4/2022 | 0.16 | 0.047 | 0.066 | 1.14 |
| 12/9/2022 | 0.29 | 0.067 | 0.094 | 1.06 |

## Table I.12. Summary of metal concentrations (μg/L) measured in drinking water for 2022

| Metals | Carlsbad (Sheep Draw) Conc. | Loving Conc. | Double Eagle (PRV4) Conc. | Hobbs Conc. | Otis Conc. | Malaga Conc. |
|---|---|---|---|---|---|---|
| Ag | <MDC | <MDC | <MDC | <MDC | <MDC | 1.27E-01 |
| Al | 7.61E+00 | 7.37E+00 | 1.67E+01 | 1.42E+01 | 2.14E+01 | 1.07E+01 |
| As | 6.95E-01 | 1.76E+00 | 7.82E+00 | 6.80E+00 | 2.27E+00 | 2.29E+00 |
| Ba | 6.90E+01 | 3.34E+01 | 1.01E+02 | 5.82E+01 | 1.40E+01 | 1.31E+01 |
| Be | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Ca | 6.15E+04 | 7.85E+04 | 5.06E+04 | 9.73E+04 | 2.11E+05 | 4.17E+05 |
| Cd | 1.28E-02 | 7.11E-03 | <MDC | 1.76E-02 | <MDC | <MDC |
| Ce | 5.00E-03 | 5.99E-03 | 1.39E-02 | 1.18E-02 | 1.21E-02 | <MDC |
| Co | 2.63E-01 | 3.09E-01 | <MDC | 4.66E-01 | 9.78E-01 | 1.64E+00 |
| Cr | 9.79E-01 | 1.61E+00 | <MDC | 1.50E+00 | 3.02E+00 | 3.36E+00 |
| Cu | 7.31E+00 | 4.25E+00 | 2.28E+00 | 5.60E+00 | 1.28E+01 | 1.56E+01 |
| Dy | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Er | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Eu | 2.88E-02 | 1.56E-02 | 4.22E-02 | 2.62E-02 | <MDC | <MDC |
| Fe | 6.40E+02 | 8.08E+02 | 4.59E+02 | 9.39E+02 | 2.40E+03 | 4.02E+03 |
| Gd | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Hg | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| K | 1.07E+03 | 1.96E+03 | 3.07E+03 | 2.92E+03 | 2.80E+03 | 4.08E+03 |
| La | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Li | 6.26E+00 | 1.94E+01 | 2.12E+01 | 3.64E+01 | 4.01E+01 | 5.84E+01 |
| Mg | 3.19E+04 | 3.61E+04 | 1.11E+04 | 2.54E+04 | 6.94E+04 | 1.25E+05 |
| Mn | 1.12E+00 | 5.65E-02 | 1.48E+00 | 1.05E+00 | 3.66E-01 | 2.01E-01 |
| Mo | 1.16E+00 | 1.60E+00 | 1.79E+00 | 2.61E+00 | 3.13E+00 | 4.00E+00 |
| Na | 1.45E+04 | 2.22E+04 | 3.47E+04 | 5.27E+04 | 7.25E+04 | 1.82E+05 |
| Nd | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Ni | 3.77E+00 | 4.32E+00 | 2.07E+00 | 4.74E+00 | 1.23E+01 | 1.97E+01 |
| P | <MDC | 6.86E+00 | <MDC | <MDC | <MDC | <MDC |
| Pb | 1.29E+00 | 2.34E-01 | 4.61E-01 | 5.69E-01 | 1.35E-01 | 6.04E-01 |

Conc. = concentration

### Table I.12. Summary of metal concentrations (µg/L) measured in drinking water for 2022 (continued)

| Metals | Carlsbad (Sheep Draw) Conc. | Loving Conc. | Double Eagle (PRV4) Conc. | Hobbs Conc. | Otis Conc. | Malaga Conc. |
|---|---|---|---|---|---|---|
| Pr | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Sb | 3.84E-02 | 3.95E-02 | 3.08E-02 | 7.14E-02 | 5.21E-02 | 6.14E-02 |
| Sc | 3.92E+00 | 6.06E+00 | 1.01E+01 | 1.59E+01 | 7.12E+00 | 6.89E+00 |
| Se | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Si | 5.99E+03 | 9.45E+03 | 1.64E+04 | 2.73E+04 | 1.06E+04 | 1.15E+04 |
| Sr | 3.15E+02 | 7.16E+02 | 5.19E+02 | 1.12E+03 | 2.49E+03 | 4.82E+03 |
| Th | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Tl | 1.13E-01 | <MDC | <MDC | <MDC | <MDC | <MDC |
| U | 8.32E-01 | 1.92E+00 | 1.88E+00 | 3.96E+00 | 3.78E+00 | 5.59E+00 |
| V | 3.51E+00 | 1.17E+01 | 3.05E+01 | 3.05E+01 | 1.15E+01 | 8.56E+00 |
| Zn | 1.55E+01 | <MDC | <MDC | <MDC | <MDC | <MDC |

Conc. = concentration

### Table I.13. Summary of anion concentrations (µg/L) measured in drinking water for 2022

| Anion | Carlsbad (Sheep Draw) Conc. | Loving Conc. | Double Eagle (PRV4) Conc. | Hobbs Conc. | Otis Conc. | Malaga Conc. |
|---|---|---|---|---|---|---|
| Fluoride | 3.51E+02 | 4.86E+02 | 7.95E+02 | 1.22E+03 | 7.85E+02 | 7.85E+02 |
| Chloride | 1.95E+04 | 3.47E+04 | 3.68E+04 | 1.09E+05 | 1.47E+05 | 5.90E+05 |
| Nitrate | 4.35E+03 | 2.02E+04 | 1.21E+04 | 2.15E+04 | 1.65E+04 | 1.57E+04 |
| Sulfate | 8.34E+04 | 1.13E+05 | 3.84E+04 | 1.42E+05 | 5.88E+05 | 9.24E+05 |

Conc. = concentration

### Table I.14. Summary of cation concentrations (µg/L) measured in drinking water for 2022

| Cation | Carlsbad (Sheep Draw) Conc. | Loving Conc. | Double Eagle (PRV4) Conc. | Hobbs Conc. | Otis Conc. | Malaga Conc. |
|---|---|---|---|---|---|---|
| Calcium | 7.52E+04 | 9.35E+04 | 5.35E+04 | 1.15E+05 | 2.36E+05 | 4.53E+05 |
| Magnesium | 3.19E+04 | 3.66E+04 | 1.06E+04 | 2.52E+04 | 6.79E+04 | 1.23E+05 |
| Potassium | 4.90E+02 | 1.20E+03 | 2.67E+03 | 1.15E+05 | <MDC | 1.52E+03 |
| Sodium | 1.49E+04 | 2.37E+04 | 3.61E+04 | 5.54E+04 | 7.47E+04 | 1.87E+05 |

Conc. = concentration

**Table I.15. Summary of specific gravity measured in drinking water samples for 2022**

| Location | SG $_{T/4°C}$ |
|---|---|
| Sheep Draw | 0.997 |
| Loving | 0.993 |
| Otis | 0.990 |
| Malaga | 1.000 |
| Double PRV4 | 0.990 |
| Hobbs | 0.987 |

**Table I.16. Summary of pH measurements conducted on drinking water samples for 2022**

| Location | pH @ 23°C |
|---|---|
| Sheep Draw | 7.93 |
| Loving | 7.72 |
| Otis | 7.78 |
| Malaga | 7.67 |
| Double Eagle PRV4 | 8.14 |
| Hobbs | 7.94 |

**Table I.17. Summary of conductivities measured in drinking water samples for 2022**

| Location | Conductivity (mS/cm) | Temperature (°C) |
|---|---|---|
| Sheep Draw | 0.674 | 25.9 |
| Loving | 0.042 | 25.6 |
| Otis | 1.73 | 24.9 |
| Malaga | 3.69 | 24.8 |
| Double Eagle PRV4 | 0.53 | 21.0 |
| Hobbs | 1.00 | 21.0 |

### Table I.18. Summary of total organic carbon (TOC) measured in drinking water samples for 2022

| Location | TOC mg/L |
|---|---|
| Carlsbad | 0.22 |
| Loving | 0.10 |
| Otis | 0.20 |
| Malaga | 0.23 |
| Double Eagle (PRV4) | 0.15 |
| Hobbs | 0.65 |

### Table I.19. Summary of total dissolved solids (TDS) and total suspended solids (TSS) measured in drinking water samples for 2022

| Location | TDS mg/L | TSS mg/L |
|---|---|---|
| Sheep Draw | 340 | N.D. |
| Loving | 380 | 10 |
| Otis | 1300 | 40 |
| Malaga | 3000 | 340 |
| Double Eagle PRV4 | 280 | N.D. |
| Hobbs | 740 | 20 |
| N.D. = non-detectable | | |

## Table I.20. Metal concentrations (µg/L) in regional surface water for 2022

| Metals | Lake Carlsbad (shallow) Conc. | Lake Carlsbad (deep) Conc. | Brantley Lake (shallow) Conc. | Brantley Lake (deep) Conc. | Red Bluff (shallow) Conc. | Red Bluff (deep) Conc. |
|---|---|---|---|---|---|---|
| Ag | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Al | 1.07E+02 | 1.09E+02 | 2.66E+02 | 3.89E+02 | 1.28E+02 | 1.15E+02 |
| As | 5.32E+00 | <MDC | 5.63E+00 | 5.04E+00 | <MDC | <MDC |
| Ba | 1.93E+01 | 2.02E+01 | 7.75E+01 | 1.02E+02 | 8.72E+01 | 8.71E+01 |
| Be | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Ca | 3.11E+05 | 2.99E+05 | 5.06E+05 | 5.30E+05 | 6.80E+05 | 7.03E+05 |
| Cd | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Ce | 1.33E-01 | 1.15E-01 | 2.96E-01 | 4.16E-01 | <MDC | <MDC |
| Co | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Cr | <MDC | 1.55E+01 | 1.25E+01 | 1.24E+01 | 6.76E+01 | 6.55E+01 |
| Cu | 9.95E+00 | 1.10E+01 | 1.53E+01 | 1.47E+01 | 2.94E+01 | 3.22E+01 |
| Dy | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Er | 3.32E-02 | <MDC | <MDC | 6.39E-02 | <MDC | <MDC |
| Eu | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Fe | 3.02E+03 | 3.56E+03 | 5.19E+03 | 4.99E+03 | 8.15E+03 | 7.78E+03 |
| Gd | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Hg | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| K | 6.03E+03 | 6.44E+03 | 8.90E+03 | 9.18E+03 | 3.43E+04 | 3.51E+04 |
| La | <MDC | <MDC | 1.78E-01 | 2.47E-01 | <MDC | <MDC |
| Li | 4.16E+01 | 4.26E+01 | 5.83E+01 | 5.76E+01 | 1.18E+02 | 1.15E+02 |
| Mg | 1.10E+05 | 1.13E+05 | 1.62E+05 | 1.55E+05 | 2.94E+05 | 2.91E+05 |
| Mn | 9.49E+00 | 9.67E+00 | 7.77E+01 | 2.58E+02 | 1.02E+02 | 1.55E+02 |
| Mo | 4.20E+00 | 2.92E+00 | 4.71E+00 | 5.40E+00 | 8.24E+00 | 7.71E+00 |
| Na | 3.96E+05 | 3.79E+05 | 7.30E+05 | 7.41E+05 | 1.43E+06 | 1.43E+06 |
| Nd | <MDC | <MDC | 1.48E-01 | 2.04E-01 | <MDC | <MDC |
| Ni | 1.54E+01 | 1.73E+01 | 2.55E+01 | 2.68E+01 | 3.55E+01 | 3.72E+01 |
| P | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Pb | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Pr | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Sb | 1.58E-01 | 1.41E-01 | 3.93E-01 | 4.04E-01 | 8.41E-01 | 7.48E-01 |
| Sc | 5.49E+00 | 6.80E+00 | 5.46E+00 | 5.50E+00 | <MDC | <MDC |
| Se | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |

## Table I. 20. Metal concentrations (µg/L) in regional surface water for 2022 (continued)

| | | | | | | |
|---|---|---|---|---|---|---|
| Si | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Sr | 4.36E+03 | 4.58E+03 | 7.66E+03 | 8.09E+03 | 1.06E+04 | 1.05E+04 |
| Th | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Tl | 2.11E-01 | 1.81E-01 | <MDC | <MDC | <MDC | <MDC |
| U | 3.69E+00 | 3.80E+00 | 4.71E+00 | 4.58E+00 | 9.35E+00 | 8.83E+00 |
| V | 6.72E+00 | 9.79E+00 | 7.74E+00 | 7.44E+00 | 2.00E+01 | 2.09E+01 |
| Zn | <MDC | <MDC | <MDC | <MDC | <MDC | <MDC |
| Conc. = concentration | | | | | | |

**Table I.21. Metal concentrations (µg/L) in supplemental surface water locations for 2022**

| Metals | Hill Tank Conc. | Lost Tank Conc. | Red Tank Conc. |
|---|---|---|---|
| Ag | <MDC | <MDC | <MDC |
| Al | 7.56E+03 | 1.55E+04 | 3.02E+03 |
| As | 6.73E+00 | 1.11E+01 | 4.43E+00 |
| Ba | 5.57E+02 | 5.87E+02 | 3.80E+02 |
| Be | 4.44E-01 | 1.04E+00 | 1.50E-01 |
| Ca | 6.98E+04 | 1.09E+05 | 6.02E+04 |
| Cd | 1.45E-01 | 3.04E-01 | 5.13E-02 |
| Ce | 1.20E+01 | 2.58E+01 | 3.66E+00 |
| Co | 4.85E+00 | 1.08E+01 | 2.10E+00 |
| Cr | 5.47E+00 | 1.19E+01 | 2.57E+00 |
| Cu | 7.69E+00 | 1.59E+01 | 2.96E+00 |
| Dy | 8.82E-01 | 1.88E+00 | 2.24E-01 |
| Er | 4.17E-01 | 8.80E-01 | 1.10E-01 |
| Eu | 4.25E-01 | 7.49E-01 | 1.91E-01 |
| Fe | 4.90E+03 | 1.15E+04 | 2.35E+03 |
| Gd | 1.34E+00 | 3.02E+00 | 3.65E-01 |
| Hg | <MDC | <MDC | <MDC |
| K | 1.17E+04 | 3.47E+04 | 1.10E+04 |
| La | 5.62E+00 | 1.17E+01 | 1.72E+00 |
| Li | 9.42E+00 | 1.95E+01 | 1.11E+01 |
| Mg | 7.56E+03 | 1.94E+04 | 9.33E+03 |
| Mn | 3.08E+02 | 6.86E+02 | 6.70E+01 |
| Mo | 4.98E-01 | 5.85E-01 | 9.91E-01 |
| Na | 1.43E+03 | 2.07E+03 | 1.00E+04 |
| Nd | 5.84E+00 | 1.24E+01 | 1.69E+00 |
| Ni | 1.22E+01 | 2.75E+01 | 6.76E+00 |
| P | 2.67E+02 | 6.66E+02 | 2.16E+02 |
| Pb | 5.07E+00 | 1.16E+01 | 1.58E+00 |
| Pr | 1.56E+00 | 3.22E+00 | 4.63E-01 |
| Sb | 3.06E-01 | 4.05E-01 | 4.11E-01 |
| Sc | 1.53E+01 | 2.44E+01 | 1.03E+01 |
| Se | <MDC | <MDC | <MDC |

**Table I.21. Metal concentrations (µg/L) in supplemental surface water locations for 2022 (continued)**

| Metals | Hill Tank Conc. | Lost Tank Conc. | Red Tank Conc. |
|---|---|---|---|
| Si | 2.53E+04 | 4.12E+04 | 1.60E+04 |
| Sr | 2.66E+02 | 3.29E+02 | 3.33E+02 |
| Th | 2.20E-01 | 3.63E-01 | 1.23E-01 |
| Tl | 7.51E-02 | 1.49E-01 | 3.20E-02 |
| U | 6.38E-01 | 1.56E+00 | 7.84E-01 |
| V | 2.41E+01 | 2.32E+01 | 2.79E+01 |
| Zn | <MDC | 5.21E+01 | <MDC |

Conc. = concentration

**Table I.22. Selected anion concentrations (µg/L) in regional surface water for 2022**

| Anion | Lake Carlsbad (shallow) Conc. | Lake Carlsbad (deep) Conc. | Brantley Lake (shallow) Conc. | Brantley Lake (deep) Conc. | Red Bluff (shallow) Conc. | Red Bluff (deep) Conc. |
|---|---|---|---|---|---|---|
| **Fluoride** | 7.05E+02 | 6.95E+02 | 9.00E+02 | 8.70E+02 | 8.80E+02 | 8.60E+02 |
| **Chloride** | 6.53E+05 | 6.51E+05 | 1.21E+06 | 1.27E+06 | 2.38E+06 | 2.35E+06 |
| **Nitrate** | 2.82E+03 | 2.79E+03 | <MDC | <MDC | <MDC | <MDC |
| **Sulfate** | 1.05E+06 | 1.05E+06 | 1.67E+06 | 1.75E+06 | 2.44E+06 | 2.40E+06 |

Conc. = concentration

**Table I.23. Selected anion concentrations (µg/L) in supplemental surface water locations for 2022**

| Anion | Hill Tank Conc. | Lost Tank Conc. | Red Tank Conc. |
|---|---|---|---|
| **Fluoride** | 2.78E+02 | 1.65E+02 | 5.49E+02 |
| **Chloride** | 2.43E+03 | 8.40E+03 | 1.34E+04 |
| **Nitrate** | 3.20E+01 | 3.40E+01 | 1.35E+02 |
| **Sulfate** | 8.36E+03 | 3.24E+03 | 3.16E+04 |

Conc. = concentration

### Table I.24. Selected cation concentrations (µg/L) in regional surface water for 2022

| Cation | Lake Carlsbad (shallow) Conc. | Lake Carlsbad (deep) Conc. | Brantley Lake (shallow) Conc. | Brantley Lake (deep) Conc. | Red Bluff (shallow) Conc. | Red Bluff (deep) Conc. |
|---|---|---|---|---|---|---|
| **Calcium** | 3.58E+05 | 3.60E+05 | 5.60E+05 | 5.63E+05 | 7.25E+05 | 7.37E+05 |
| **Magnesium** | 1.07E+05 | 1.07E+05 | 1.55E+05 | 1.52E+05 | 2.69E+05 | 2.68E+05 |
| **Potassium** | <MDC | <MDC | 3.08E+03 | 3.58E+03 | 1.98E+04 | 1.95E+04 |
| **Sodium** | 3.86E+05 | 3.89E+05 | 7.12E+05 | 7.22E+05 | 1.35E+06 | 1.37E+06 |

Conc. = concentration

### Table I.25. Selected cation concentrations (µg/L) in supplemental surface water locations for 2022

| Cation | Hill Tank Conc. | Lost Tank Conc. | Red Tank Conc. |
|---|---|---|---|
| **Calcium** | 7.61E+04 | 1.07E+05 | 6.49E+04 |
| **Magnesium** | 4.37E+03 | 1.10E+04 | 6.85E+03 |
| **Potassium** | 8.88E+03 | 2.58E+04 | 9.39E+03 |
| **Sodium** | 1.27E+03 | 1.74E+03 | 9.90E+03 |

Conc. = concentration

### Table I.26. Summary of specific gravity measured in surface water samples for 2022

| Location | SG $_{T/4°C}$ |
|---|---|
| Lake Carlsbad, shallow | 0.979 |
| Lake Carlsbad, deep | 0.982 |
| Brantley Lake, shallow | 0.984 |
| Brantley Lake, deep | 0.984 |
| Red Bluff, shallow | 0.987 |
| Red Bluff, deep | 0.984 |
| Hill Tank | 0.980 |
| Red Tank | 0.984 |
| Lost Tank | 0.974 |

**Table I.27. Summary of pH measurements conducted on surface water samples for 2022**

| Location | pH @ 23°C |
|---|---|
| Lake Carlsbad, shallow | 7.835 |
| Lake Carlsbad, deep | 6.06 |
| Brantley Lake, shallow | 8.32 |
| Brantley Lake, deep | 8.16 |
| Red Bluff, shallow | 7.83 |
| Red Bluff, deep | 8.00 |
| Hill tank | 8.50 |
| Red tank | 8.45 |
| Lost tank | 8.36 |

**Table I.28. Summary of conductivities measured in surface water samples for 2022**

| Location | Conductivity mS/cm | Temperature (°C) |
|---|---|---|
| Lake Carlsbad (Shallow) | 2.07 | 25.1 |
| Lake Carlsbad (Deep) | 3.29 | 25.1 |
| Brantley Lake (Shallow) | 5.64 | 23.9 |
| Brantley Lake (Deep) | 5.32 | 24.6 |
| Red Bluff (Shallow) | 9.06 | 20.2 |
| Red Bluff (Deep) | 9.07 | 20.3 |
| Hill Tank | 0.297 | 23.4 |
| Red Tank | 0.374 | 23.4 |
| Lost Tank | 0.535 | 23.4 |

### Table I.29. Summary of total organic carbon (TOC) in surface water samples for 2022

| Location | TOC mg/L |
|---|---|
| Lake Carlsbad (shallow) | 1.86 |
| Lake Carlsbad (deep) | 1.78 |
| Brantley Lake (shallow) | 5.49 |
| Brantley Lake (deep) | 4.76 |
| Red Bluff (shallow) | 8.75 |
| Red Bluff (deep) | 8.48 |
| Hill Tank | 19.54 |
| Red Tank | 9.80 |
| Lost Tank | 46.20 |

### Table I.30. Summary of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) in surface water samples for 2022

| Location | TDS mg/L | TSS mg/L |
|---|---|---|
| Lake Carlsbad (Shallow) | 2780 | N.D. |
| Lake Carlsbad (Deep) | 2750 | N.D. |
| Brantley Lake (Shallow) | 4610 | N.D. |
| Brantley Lake (Deep) | 6710 | N.D. |
| Red Bluff (shallow) | 7730 | 70 |
| Red Bluff (deep) | 7790 | 20 |
| Lost Tank | 310 | 910 |
| Hill Tank | 260 | 300 |
| Red Tank | 360 | 100 |
| N.D. = Not-detect | | |

# APPENDIX J - VOC COMPOUNDS AND CONCENTRATIONS OF DISPOSAL AND SURFACE RESULTS

Target Compounds for WIPP confirmatory VOC

Concentrations of concern for VOC

Disposal room VOC monitoring results for Panel 7

Surface VOC results

## Table J.1. Target compounds for WIPP confirmatory VOC monitoring program and the maximum MRLs for undiluted repository and disposal room VOCs

| Target Compound | MRL (ppbv) for Repository air VOC in SIM mode | MRL (ppbv) for repository air VOC in SCAN mode | MRL (ppbv) for Disposal Room VOC |
|---|---|---|---|
| 1,1-Dichloroethylene | 0.1 | 0.2 | 500 |
| Carbon tetrachloride | 0.1 | 0.2 | 500 |
| Methylene chloride | 0.1 | 0.2 | 500 |
| Chloroform | 0.1 | 0.2 | 500 |
| 1,1,2,2-Tetrachloroethane | 0.1 | 0.2 | 500 |
| 1,1,1-Trichloroethane | 0.1 | 0.2 | 500 |
| Chlorobenzene | 0.1 | 0.2 | 500 |
| 1,2-Dichloroethane | 0.1 | 0.2 | 500 |
| Toluene | 0.1 | 0.2 | 500 |
| Trichloroethylene | 0.1 | 0.2 | 500 |

ppbv- Parts per billion by volume
MRL – Maximum Method Reporting Limit for undiluted samples.
SIM- Selected Ion Monitoring

## Table J.2. Disposal room VOC monitoring maximum results for Panel 7

| Target Compound | P7R6E (ppmv) | P7R6I (ppmv) | P7R5E (ppmv) | P7R5I (ppmv) | P7R4E (ppmv) |
|---|---|---|---|---|---|
| Carbon tetrachloride | 784.43 | 751.76 | 766.32 | 568.97 | 701.11 |
| Chlorobenzene | U | U | U | U | U |
| Chloroform | 33.99 | 32.71 | 32.54 | 25.63 | 30.57 |
| 1,2-Dichloroethane | U | U | U | U | U |
| 1,1-Dichloroethylene | U | U | U | 0.26 J | U |
| Methylene chloride | 2.89 J | 2.89 J | 2.76 J | 1.92 J | 2.62 J |
| 1,1,2,2-Tetrachloroethane | U | 0.00 J | U | U | U |
| Toluene | 1.97 J | 1.97 J | 1.97 J | 0.98 J | U |
| 1,1,1-Trichloroethane | 289.47 | 270.84 | 272.54 | 207.15 | 262.96 |
| Trichloroethylene | 254.44 | 241.36 | 260.34 | 186.77 | 241.05 |

ppmv-Parts per million by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit
* –

### Table J.3. Disposal room VOC monitoring maximum results for Panel 7

| Target Compound | P7R4I (ppmv) | P7R3E (ppmv) | P7R3I (ppmv) | P7R2E (ppmv) | P7R2I (ppmv) | P7R1E (ppmv) |
|---|---|---|---|---|---|---|
| Carbon tetrachloride | 0.05 | 588.26 | 0.06 | 82.09 | 1.72 | 14.03 |
| Chlorobenzene | U | U | U | U | U | U |
| Chloroform | 0.00 J | 25.98 | 0.00 J | 4.26 | 0.07 | 0.71 |
| 1,2-Dichloroethane | U | U | U | U | U | U |
| 1,1-Dichloroethylene | U | 0.26 J | U | 0.02 J | 0.00 J | 0.00 J |
| Methylene chloride | 0.00 J | 2.36 J | U | 0.55 J | 0.01 J | 0.09 J |
| 1,1,2,2-Tetrachloroethane | U | U | U | U | U | U |
| Toluene | 0.00 J | 1.05 J | 0.00 J | 0.22 J | 0.01 J | 0.04 J |
| 1,1,1-Trichloroethane | 0.02 | 207.20 | 0.02 | 29.29 | 0.7 | 4.99 |
| Trichloroethylene | 0.03 | 196.17 | 0.04 | 26.88 | 0.53 | 4.46 |

ppmv-Parts per million by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit
* − Operated for only part of 2022

### Table J.4. Concentrations of concern for VOC, from Module IV of the Hazardous Waste Facility Permit (No. NM4890139088-TSDF)

| Target Compound | 50% Action Level (ppmv) | 95% Action Level (ppmv) | Room based Limits (ppmv) |
|---|---|---|---|
| 1,1-Dichloroethylene | 2,745 | 5,215 | 5,490 |
| Carbon tetrachloride | 4,813 | 9,145 | 9,625 |
| Methylene Chloride | 50,000 | 95,000 | 100,000 |
| Chloroform | 4,965 | 9,433 | 9,930 |
| 1,1,2,2-Tetrachloroethane | 1,480 | 2,812 | 2,960 |
| 1,1,1-Trichloroethane | 16,850 | 32,015 | 33,700 |
| Chlorobenzene | 6500 | 12350 | 13000 |
| 1,2-Dichloroethane | 1,200 | 2,280 | 2,400 |
| Toluene | 5,500 | 10,450 | 11,000 |
| Trichloroethylene | 24,000 | 45,600 | 48,000 |

**Table J.5. Surface VOC results for stations VOC-C and VOC-D**

| Target Compounds | VOC-C (ppbv) | VOC-D (ppbv) |
|---|---|---|
| Carbon Tetrachloride | 0.075 J - 0.661 | 0.065 J - 0.145 |
| Chlorobenzene | U - 0.071 J | U - 0.027 J |
| Chloroform | 0.01 J - 0.039 J | U - 0.017 J |
| 1,2-Dichloroethane | 0.007 J - 0.03 J | 0.007 J - 0.033 J |
| 1,1-Dichloroethylene | U | U |
| Methylene chloride | 0.041 J - 0.129 | 0.039 J - 0.132 |
| 1,1,2,2-Tetrachloroethane | U - 0.034 J | U - 0.012 J |
| Toluene | 0.057 J - 0.978 | 0.068 J - 0.961 |
| 1,1,1-Trichloroethane | U - 0.24 J | U - 0.018 J |
| Trichloroethylene | U - 0.209 | U - 0.173 |

ppbv-Parts per billion by volume
U – Not-Detected (ND) or below Method Detection Limit
J – Estimated value, below laboratory Method Reporting Limit

# APPENDIX K - RADIOCHEMISTRY INTERCOMPARISON, ICP-MS PERFORMANCE, ENVIRONMENTAL CHEMISTRY PROFICIENCY

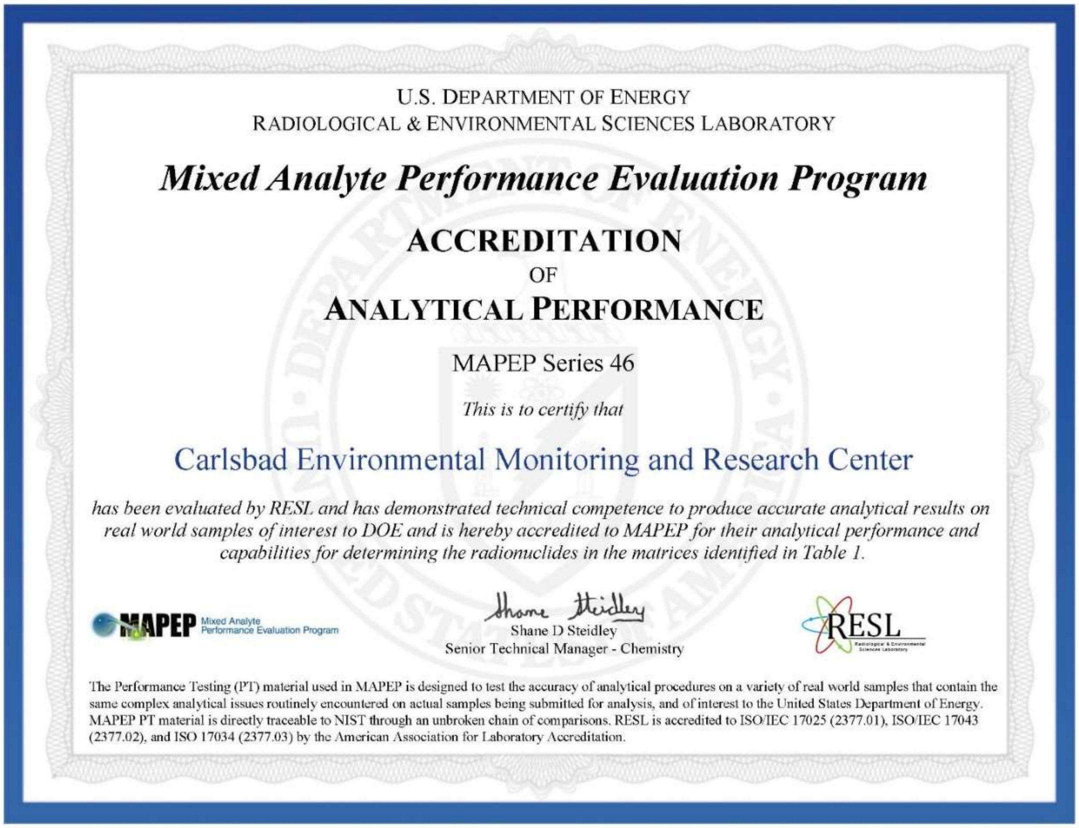
NIST radiochemistry intercomparison program test results

MAPEP radiochemistry intercomparison program test results

Daily performance tests for ICP-MS

Environmental chemistry proficiency test results for metal analyses, mercury, inorganic anions, and cations

**Table K.1. Radiochemistry MAPEP 2022 certificate**



U.S. DEPARTMENT OF ENERGY
RADIOLOGICAL & ENVIRONMENTAL SCIENCES LABORATORY

*Mixed Analyte Performance Evaluation Program*

**ACCREDITATION**
OF
**ANALYTICAL PERFORMANCE**

MAPEP Series 46

*This is to certify that*

Carlsbad Environmental Monitoring and Research Center

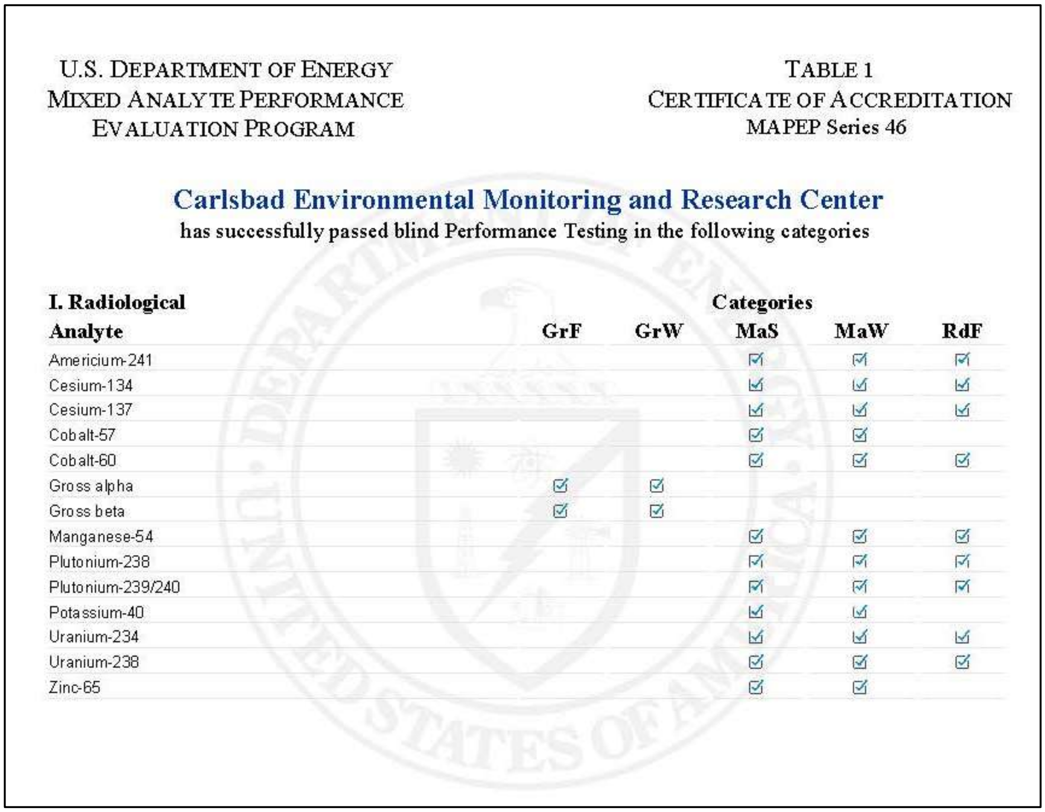
*has been evaluated by RESL and has demonstrated technical competence to produce accurate analytical results on real world samples of interest to DOE and is hereby accredited to MAPEP for their analytical performance and capabilities for determining the radionuclides in the matrices identified in Table 1.*

MAPEP Mixed Analyte Performance Evaluation Program

Shane Steidley
Shane D Steidley
Senior Technical Manager - Chemistry

RESL Radiological & Environmental Sciences Laboratory

The Performance Testing (PT) material used in MAPEP is designed to test the accuracy of analytical procedures on a variety of real world samples that contain the same complex analytical issues routinely encountered on actual samples being submitted for analysis, and of interest to the United States Department of Energy. MAPEP PT material is directly traceable to NIST through an unbroken chain of comparisons. RESL is accredited to ISO/IEC 17025 (2377.01), ISO/IEC 17043 (2377.02), and ISO 17034 (2377.03) by the American Association for Laboratory Accreditation.



U.S. DEPARTMENT OF ENERGY
MIXED ANALYTE PERFORMANCE
EVALUATION PROGRAM

TABLE 1
CERTIFICATE OF ACCREDITATION
MAPEP Series 46

**Carlsbad Environmental Monitoring and Research Center**
**has successfully passed blind Performance Testing in the following categories**

| **I. Radiological** | | | **Categories** | | |
|---|---|---|---|---|---|
| **Analyte** | **GrF** | **GrW** | **MaS** | **MaW** | **RdF** |
| Americium-241 | | | ☑ | ☑ | ☑ |
| Cesium-134 | | | ☑ | ☑ | ☑ |
| Cesium-137 | | | ☑ | ☑ | ☑ |
| Cobalt-57 | | | ☑ | ☑ | |
| Cobalt-60 | | | ☑ | ☑ | ☑ |
| Gross alpha | ☑ | ☑ | | | |
| Gross beta | ☑ | ☑ | | | |
| Manganese-54 | | | ☑ | ☑ | ☑ |
| Plutonium-238 | | | ☑ | ☑ | ☑ |
| Plutonium-239/240 | | | ☑ | ☑ | ☑ |
| Potassium-40 | | | ☑ | ☑ | |
| Uranium-234 | | | ☑ | ☑ | ☑ |
| Uranium-238 | | | ☑ | ☑ | ☑ |
| Zinc-65 | | | ☑ | ☑ | |

# Table K.2. Radiochemistry MAPEP 2022 Results

**MAPEP** Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP Series 46*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

## MAPEP-22-GrF46: Gross alpha/beta air filter

Radiological — Units: (Bq/sample)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Gross alpha | 0.665 | 1.20 | A |  | -44.6 | 0.36 - 2.04 | 0.015 | A |
| Gross beta | 0.778 | 0.681 | A |  | 14.2 | 0.341 - 1.022 | 0.010 | N |

*Radiological Reference Date: February 1, 2022*

## MAPEP-22-GrW46: Gross alpha/beta water

Radiological — Units: (Bq/L)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Gross alpha | 0.828 | 0.574 | A |  | 44.3 | 0.172 - 0.976 | 0.246 | W |
| Gross beta | 7.697 | 7.25 | A |  | 6.2 | 3.63 - 10.88 | 0.708 | A |

*Radiological Reference Date: February 1, 2022*

## MAPEP-22-MaS46: Radiological and inorganic combined soil standard

Inorganic — Units: (mg/kg)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Antimony | NR | 0.16 |  |  |  | Sensitivity Evaluation |  |  |
| Arsenic | NR | 35.2 |  |  |  | 24.6 - 45.8 |  |  |
| Barium | NR | 341 |  |  |  | 239 - 443 |  |  |
| Beryllium | NR | 59.1 |  |  |  | 41.4 - 76.8 |  |  |
| Cadmium | NR | 11.7 |  |  |  | 8.2 - 15.2 |  |  |
| Chromium | NR | 110 |  |  |  | 77 - 143 |  |  |
| Cobalt | NR | 245 |  |  |  | 172 - 319 |  |  |
| Copper | NR | 195 |  |  |  | 137 - 254 |  |  |
| Lead | NR | 72.8 |  |  |  | 51.0 - 94.6 |  |  |
| Mercury | NR | 0.322 |  |  |  | 0.225 - 0.419 |  |  |
| Nickel | NR | 347 |  |  |  | 243 - 451 |  |  |
| Selenium | NR | 0.36 |  |  |  | Sensitivity Evaluation |  |  |
| Silver | NR | 10.6 |  |  |  | 7.4 - 13.8 |  |  |
| Technetium-99 | NR | 0.00123 |  |  |  | 0.00086 - 0.00160 |  |  |
| Thallium | NR | 75.0 |  |  |  | 52.5 - 97.5 |  |  |
| Uranium-235 | NR | 0.0330 |  |  |  | 0.0231 - 0.0429 |  |  |
| Uranium-238 | NR | 9.9 |  |  |  | 6.9 - 12.9 |  |  |
| Uranium-Total | NR | 9.9 |  |  |  | 6.9 - 12.9 |  |  |
| Vanadium | NR | 215 |  |  |  | 151 - 280 |  |  |

## Table K. 2. Radiochemistry MAPEP 2022 Results (continued)

**Inorganic** Units: (mg/kg)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Zinc | NR | 288 | | | | 202 - 374 | | |

**Radiological** Units: (Bq/kg)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Americium-241 | 62.59 | 72.0 | A | | -13.1 | 50.4 - 93.6 | 4.32 | A |
| Cesium-134 | 823.04 | 890 | A | | -7.5 | 623 - 1157 | 19.89 | A |
| Cesium-137 | 407.60 | 365 | A | | 11.7 | 256 - 475 | 8.14 | N |
| Cobalt-57 | 1124.50 | 1400 | A | | -19.7 | 980 - 1820 | 104.29 | A |
| Cobalt-60 | 374.22 | 443 | A | | -15.5 | 310 - 576 | 7.47 | N |
| Iron-55 | NR | 1100 | | | | 770 - 1430 | | |
| Manganese-54 | 1134.57 | 1140 | A | | -0.5 | 798 - 1482 | 24.50 | A |
| Nickel-63 | NR | 780 | | | | 546 - 1014 | | |
| Plutonium-238 | 51.72 | 56.0 | A | | -7.6 | 39.2 - 72.8 | 3.46 | A |
| Plutonium-239/240 | 37.64 | 41.0 | A | | -8.2 | 28.7 - 53.3 | 2.55 | A |
| Potassium-40 | 447.50 | 596 | W | | -24.9 | 417 - 775 | 20.86 | A |
| Strontium-90 | NR | 677 | | | | 474 - 880 | | |
| Technetium-99 | NR | 778 | | | | 545 - 1011 | | |
| Thorium-228 | NR | 43 | | | | 30 - 56 | | |
| Thorium-230 | NR | 38 | | | | 27 - 49 | | |
| Thorium-232 | NR | 42 | | | | 29 - 55 | | |
| Uranium-234 | 39.53 | 44.0 | A | | -10.2 | 30.8 - 57.2 | 2.58 | A |
| Uranium-238 | 114.59 | 123 | A | | -6.8 | 86 - 160 | 7.26 | A |
| Zinc-65 | 1.21 | | A | | | False Positive Test | 0.53 | |

*Radiological Reference Date: February 1, 2022*

### MAPEP-22-MaW46: Radiological and inorganic combined water standard

**Inorganic** Units: (mg/L)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Antimony | NR | 10.22 | | | | 7.15 - 13.29 | | |
| Arsenic | NR | 3.37 | | | | 2.36 - 4.38 | | |
| Barium | NR | 0.041 | | | | Sensitivity Evaluation | | |
| Beryllium | NR | 1.95 | | | | 1.37 - 2.54 | | |
| Cadmium | NR | | | | | False Positive Test | | |
| Chromium | NR | 3.29 | | | | 2.30 - 4.28 | | |
| Cobalt | NR | 12.5 | | | | 8.8 - 16.3 | | |
| Copper | NR | 15.3 | | | | 10.7 - 19.9 | | |
| Lead | NR | 1.57 | | | | 1.10 - 2.04 | | |
| Mercury | NR | 0.152 | | | | 0.106 - 0.198 | | |
| Nickel | NR | 8.22 | | | | 5.75 - 10.69 | | |
| Selenium | NR | 0.81 | | | | 0.57 - 1.05 | | |
| Technetium-99 | NR | 1.26E-5 | | | | 8.80E-6 - 1.64E-5 | | |
| Thallium | NR | 1.04 | | | | 0.73 - 1.35 | | |
| Uranium-235 | NR | 9.1E-4 | | | | 6.37E-4 - 1.18E-3 | | |
| Uranium-238 | NR | 0.124 | | | | 0.087 - 0.161 | | |

# Table K. 2. Radiochemistry MAPEP 2022 Results (continued)

### Inorganic

Units: (mg/L)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Uranium-Total | NR | 0.125 | | | | 0.088 - 0.163 | | |
| Vanadium | NR | 4.9 | | | | 3.4 - 6.4 | | |
| Zinc | NR | 10.2 | | | | 7.1 - 13.3 | | |

### Radiological

Units: (Bq/L)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Americium-241 | 0.32 | 0.355 | A | | -9.9 | 0.249 - 0.462 | 0.02 | A |
| Cesium-134 | 0.01 | | A | | | False Positive Test | 0.18 | |
| Cesium-137 | 7.90 | 7.64 | A | | 3.4 | 5.35 - 9.93 | 0.60 | A |
| Cobalt-57 | 35.38 | 36.0 | A | | -1.7 | 25.2 - 46.8 | 0.88 | A |
| Cobalt-60 | 8.83 | 9.3 | A | | -5.1 | 6.5 - 12.1 | 0.49 | A |
| Hydrogen-3 | NR | 300 | | | | 210 - 390 | | |
| Iron-55 | NR | 15.2 | | | | 10.6 - 19.8 | | |
| Manganese-54 | 18.48 | 18.9 | A | | -2.2 | 13.2 - 24.6 | 0.85 | A |
| Nickel-63 | NR | 34.0 | | | | 23.8 - 44.2 | | |
| Plutonium-238 | 0.98 | 1.07 | A | | -8.4 | 0.75 - 1.39 | 0.06 | A |
| Plutonium-239/240 | 1.09 | 1.19 | A | | -8.4 | 0.83 - 1.55 | 0.07 | A |
| Potassium-40 | 4.67 | | A | | | False Positive Test | 2.76 | |
| Radium-226 | NR | 0.8 | | | | 0.6 - 1.0 | | |
| Strontium-90 | NR | 12.9 | | | | 9.0 - 16.8 | | |
| Technetium-99 | NR | 7.9 | | | | 5.5 - 10.3 | | |
| Uranium-234 | 1.51 | 1.5 | A | | 0.7 | 1.1 - 2.0 | 0.11 | A |
| Uranium-238 | 1.52 | 1.54 | A | | -1.3 | 1.08 - 2.00 | 0.11 | A |
| Zinc-65 | 28.33 | 26.2 | A | | 8.1 | 18.3 - 34.1 | 1.73 | A |

*Radiological Reference Date: February 1, 2022*

## MAPEP-22-RdF46: Radiological air filter

### Inorganic

Units: (ug/sample)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Uranium-235 | NR | 0.041 | | | | 0.029 - 0.053 | | |
| Uranium-238 | NR | 5.35 | | | | 3.75 - 6.96 | | |
| Uranium-Total | NR | 5.4 | | | | 3.8 - 7.0 | | |

### Radiological

Units: (Bq/sample)

| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
|---|---|---|---|---|---|---|---|---|
| Americium-241 | 0.044 | 0.0439 | A | | 0.2 | 0.0307 - 0.0571 | 0.003 | A |
| Cesium-134 | 0.756 | 0.93 | A | | -18.7 | 0.65 - 1.21 | 0.030 | A |
| Cesium-137 | 0.737 | 0.726 | A | | 1.5 | 0.508 - 0.944 | 0.038 | A |
| Cobalt-57 | 0.838 | | N | (1) | | False Positive Test | 0.029 | |
| Cobalt-60 | 0.532 | 0.72 | W | | -26.1 | 0.50 - 0.94 | 0.029 | A |
| Manganese-54 | 0.009 | | A | | | False Positive Test | 0.023 | |
| Plutonium-238 | 0.021 | 0.0221 | A | | -5.0 | 0.0155 - 0.0287 | 0.002 | A |
| Plutonium-239/240 | 0.015 | 0.0141 | A | | 6.4 | 0.0099 - 0.0183 | 0.001 | A |

## Table K. 2. Radiochemistry MAPEP 2022 Results (continued)

| Radiological | | | | | | | | Units: (Bq/sample) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Strontium-90 | NR | 0.54 | | | | 0.38 - 0.70 | | |
| Uranium-234 | 0.065 | 0.064 | A | | 1.6 | 0.045 - 0.083 | 0.005 | A |
| Uranium-238 | 0.064 | 0.067 | A | | -4.5 | 0.047 - 0.087 | 0.005 | A |
| Zinc-65 | 0.774 | | N | (1) | | False Positive Test | 0.088 | |

*Radiological Reference Date: February 1, 2022*

**Notes:**

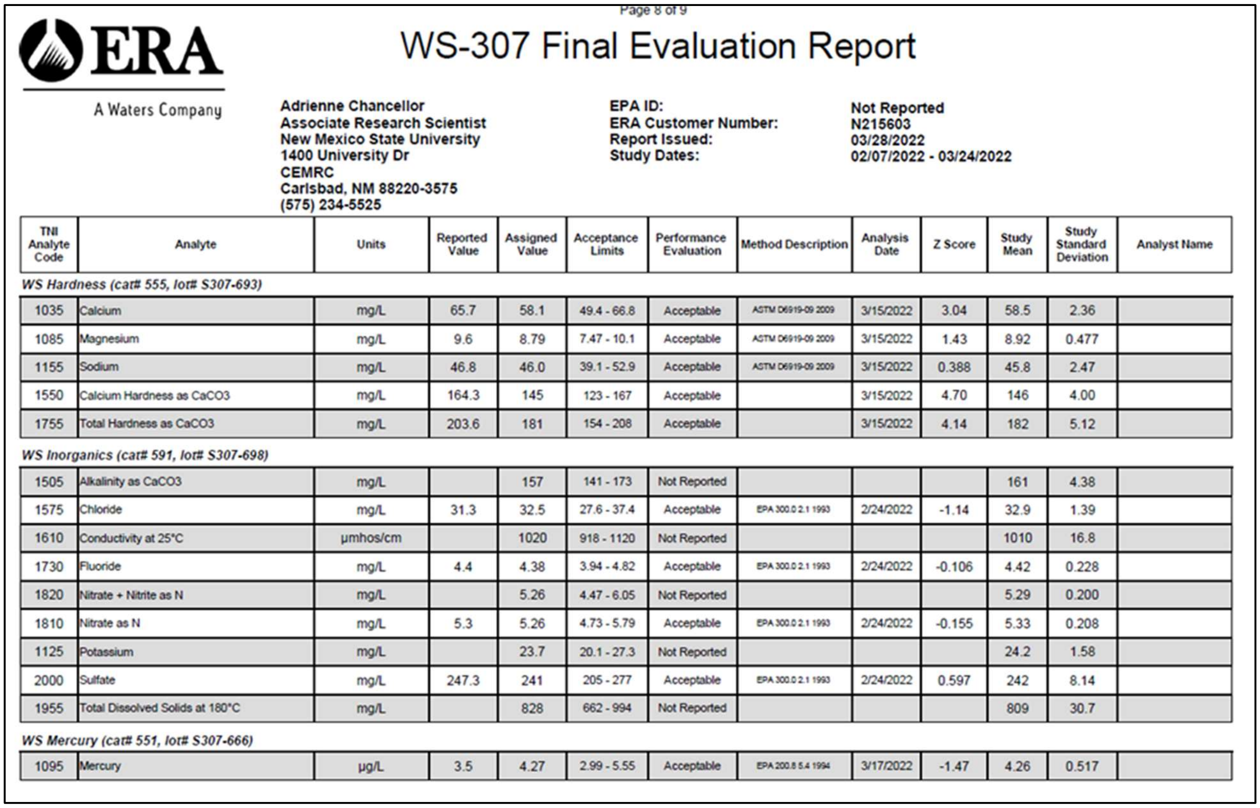
(1) = False Positive

### Table K.3. Daily performance tests (ICP-MS)

| | Acceptable Ranges | 01/11/2022 | | | 11/18/2022 | | |
|---|---|---|---|---|---|---|---|
| | Criteria for Net Intensity Mean of 3 replicate readings | Measured Intensity Mean | RSD | Performance Evaluation | Measured Mean Intensity | RSD | Performance Evaluation |
| Be | >4,500 | 7508.0 | 2.7 | Acceptable | 7,867.9 | 2.3 | Acceptable |
| In | >80,000 | 130,728.3 | 2.2 | Acceptable | 111,947.1 | 2.8 | Acceptable |
| U | >60,000 | 134,068.6 | 2.6 | Acceptable | 105,828.0 | 1.4 | Acceptable |
| CeO | ≤3% | 2.5% | N/A | Acceptable | 2.1% | N/A | Acceptable |
| Ce++ | ≤3% | 1.5% | N/A | Acceptable | 1.6% | N/A | Acceptable |
| Bkgd | ≤3 | 0.13 | N/A | Acceptable | 0.10 | N/A | Acceptable |

RSD = Relative Standard Deviation

### Table K.4. Environmental chemistry proficiency test results for mercury, cations, and inorganic anions



Page 8 of 9

ERA
A Waters Company

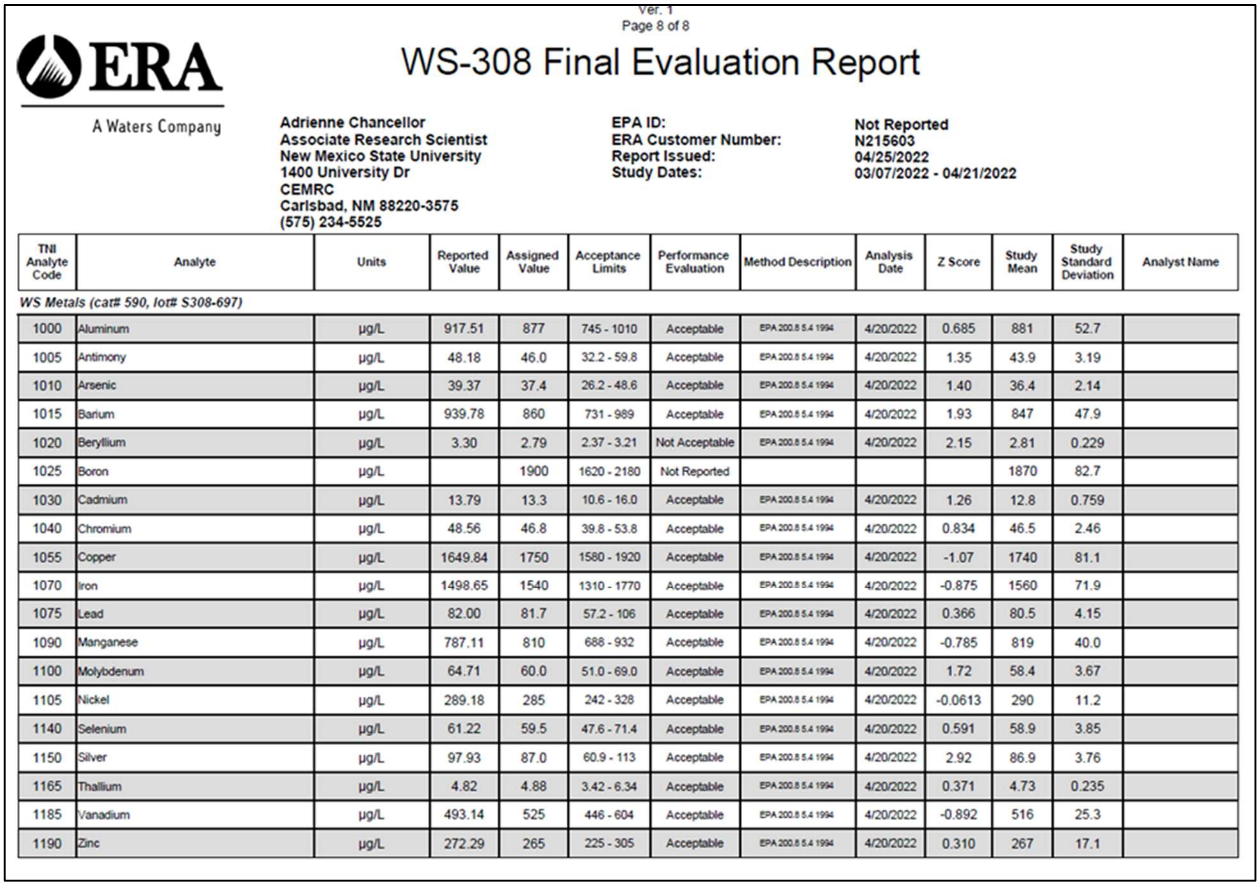
## WS-307 Final Evaluation Report

Adrienne Chancellor
Associate Research Scientist
New Mexico State University
1400 University Dr
CEMRC
Carlsbad, NM 88220-3575
(575) 234-5525

EPA ID: Not Reported
ERA Customer Number: N215603
Report Issued: 03/28/2022
Study Dates: 02/07/2022 - 03/24/2022

| TNI Analyte Code | Analyte | Units | Reported Value | Assigned Value | Acceptance Limits | Performance Evaluation | Method Description | Analysis Date | Z Score | Study Mean | Study Standard Deviation | Analyst Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *WS Hardness (cat# 555, lot# S307-693)* | | | | | | | | | | | | |
| 1035 | Calcium | mg/L | 65.7 | 58.1 | 49.4 - 66.8 | Acceptable | ASTM D6919-09 2009 | 3/15/2022 | 3.04 | 58.5 | 2.36 | |
| 1085 | Magnesium | mg/L | 9.6 | 8.79 | 7.47 - 10.1 | Acceptable | ASTM D6919-09 2009 | 3/15/2022 | 1.43 | 8.92 | 0.477 | |
| 1155 | Sodium | mg/L | 46.8 | 46.0 | 39.1 - 52.9 | Acceptable | ASTM D6919-09 2009 | 3/15/2022 | 0.388 | 45.8 | 2.47 | |
| 1550 | Calcium Hardness as CaCO3 | mg/L | 164.3 | 145 | 123 - 167 | Acceptable | | 3/15/2022 | 4.70 | 146 | 4.00 | |
| 1755 | Total Hardness as CaCO3 | mg/L | 203.6 | 181 | 154 - 208 | Acceptable | | 3/15/2022 | 4.14 | 182 | 5.12 | |
| *WS Inorganics (cat# 591, lot# S307-698)* | | | | | | | | | | | | |
| 1505 | Alkalinity as CaCO3 | mg/L | | 157 | 141 - 173 | Not Reported | | | | 161 | 4.38 | |
| 1575 | Chloride | mg/L | 31.3 | 32.5 | 27.6 - 37.4 | Acceptable | EPA 300.0 2.1 1993 | 2/24/2022 | -1.14 | 32.9 | 1.39 | |
| 1610 | Conductivity at 25°C | µmhos/cm | | 1020 | 918 - 1120 | Not Reported | | | | 1010 | 16.8 | |
| 1730 | Fluoride | mg/L | 4.4 | 4.38 | 3.94 - 4.82 | Acceptable | EPA 300.0 2.1 1993 | 2/24/2022 | -0.106 | 4.42 | 0.228 | |
| 1820 | Nitrate + Nitrite as N | mg/L | | 5.26 | 4.47 - 6.05 | Not Reported | | | | 5.29 | 0.200 | |
| 1810 | Nitrate as N | mg/L | 5.3 | 5.26 | 4.73 - 5.79 | Acceptable | EPA 300.0 2.1 1993 | 2/24/2022 | -0.155 | 5.33 | 0.208 | |
| 1125 | Potassium | mg/L | | 23.7 | 20.1 - 27.3 | Not Reported | | | | 24.2 | 1.58 | |
| 2000 | Sulfate | mg/L | 247.3 | 241 | 205 - 277 | Acceptable | EPA 300.0 2.1 1993 | 2/24/2022 | 0.597 | 242 | 8.14 | |
| 1955 | Total Dissolved Solids at 180°C | mg/L | | 828 | 662 - 994 | Not Reported | | | | 809 | 30.7 | |
| *WS Mercury (cat# 551, lot# S307-666)* | | | | | | | | | | | | |
| 1095 | Mercury | µg/L | 3.5 | 4.27 | 2.99 - 5.55 | Acceptable | EPA 200.8 5.4 1994 | 3/17/2022 | -1.47 | 4.26 | 0.517 | |

## Table K.5. Environmental chemistry proficiency test results for metal analyses



Ver. 1
Page 8 of 8

ERA
A Waters Company

### WS-308 Final Evaluation Report

**Adrienne Chancellor**
**Associate Research Scientist**
**New Mexico State University**
**1400 University Dr**
**CEMRC**
**Carlsbad, NM 88220-3575**
**(575) 234-5525**

| | |
|---|---|
| **EPA ID:** | **Not Reported** |
| **ERA Customer Number:** | **N215603** |
| **Report Issued:** | **04/25/2022** |
| **Study Dates:** | **03/07/2022 - 04/21/2022** |

*WS Metals (cat# 590, lot# S308-697)*

| TNI Analyte Code | Analyte | Units | Reported Value | Assigned Value | Acceptance Limits | Performance Evaluation | Method Description | Analysis Date | Z Score | Study Mean | Study Standard Deviation | Analyst Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000 | Aluminum | µg/L | 917.51 | 877 | 745 - 1010 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.685 | 881 | 52.7 | |
| 1005 | Antimony | µg/L | 48.18 | 46.0 | 32.2 - 59.8 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 1.35 | 43.9 | 3.19 | |
| 1010 | Arsenic | µg/L | 39.37 | 37.4 | 26.2 - 48.6 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 1.40 | 36.4 | 2.14 | |
| 1015 | Barium | µg/L | 939.78 | 860 | 731 - 989 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 1.93 | 847 | 47.9 | |
| 1020 | Beryllium | µg/L | 3.30 | 2.79 | 2.37 - 3.21 | Not Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 2.15 | 2.81 | 0.229 | |
| 1025 | Boron | µg/L | | 1900 | 1620 - 2180 | Not Reported | | | | 1870 | 82.7 | |
| 1030 | Cadmium | µg/L | 13.79 | 13.3 | 10.6 - 16.0 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 1.26 | 12.8 | 0.759 | |
| 1040 | Chromium | µg/L | 48.56 | 46.8 | 39.8 - 53.8 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.834 | 46.5 | 2.46 | |
| 1055 | Copper | µg/L | 1649.84 | 1750 | 1580 - 1920 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | -1.07 | 1740 | 81.1 | |
| 1070 | Iron | µg/L | 1498.65 | 1540 | 1310 - 1770 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | -0.875 | 1560 | 71.9 | |
| 1075 | Lead | µg/L | 82.00 | 81.7 | 57.2 - 106 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.366 | 80.5 | 4.15 | |
| 1090 | Manganese | µg/L | 787.11 | 810 | 688 - 932 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | -0.785 | 819 | 40.0 | |
| 1100 | Molybdenum | µg/L | 64.71 | 60.0 | 51.0 - 69.0 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 1.72 | 58.4 | 3.67 | |
| 1105 | Nickel | µg/L | 289.18 | 285 | 242 - 328 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | -0.0613 | 290 | 11.2 | |
| 1140 | Selenium | µg/L | 61.22 | 59.5 | 47.6 - 71.4 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.591 | 58.9 | 3.85 | |
| 1150 | Silver | µg/L | 97.93 | 87.0 | 60.9 - 113 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 2.92 | 86.9 | 3.76 | |
| 1165 | Thallium | µg/L | 4.82 | 4.88 | 3.42 - 6.34 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.371 | 4.73 | 0.235 | |
| 1185 | Vanadium | µg/L | 493.14 | 525 | 446 - 604 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | -0.892 | 516 | 25.3 | |
| 1190 | Zinc | µg/L | 272.29 | 265 | 225 - 305 | Acceptable | EPA 200.8 5.4 1994 | 4/20/2022 | 0.310 | 267 | 17.1 | |