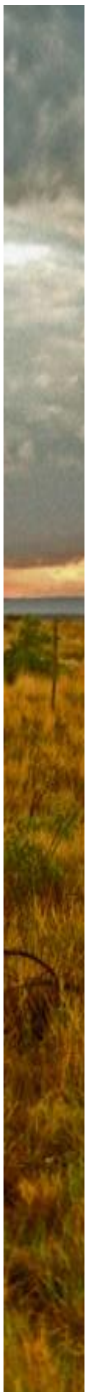
# Carlsbad Environmental Monitoring & Research Center



2014 Annual Report

# Executive Summary

The Carlsbad Environmental Monitoring and Research Center (CEMRC), an entity of the New Mexico State University, has measured the levels of radiological and non-radiological constituents in samples of the WIPP exhaust air, ambient air, soil, sediment, surface and drinking water collected at and in the vicinity of the U.S. DOE's Waste Isolation Pilot Plant (WIPP) during calendar year 2014. The WIPP is a U.S. Department of Energy (DOE) mined geologic repository that has been in operation since March, 1999. Since that time, over 86,000 cubic meters of waste in various vented payload containers have been emplaced in the repository. Over its lifetime, WIPP is expected to dispose of approximately 175,000 cubic meters of TRU waste from various DOE sites. The WIPP is about half full in terms of its legally defined capacity. The primary radionuclides within the disposed waste are $^{239+240}$Pu and $^{241}$Am, which account for more than 99% of the total TRU radioactivity disposed and/or scheduled for disposal in the repository. For the first time in its fifteen years of operation, there was an airborne radiation release from the WIPP.

In February, 2014, two isolated incidents took place at the WIPP that caused concern for the WIPP workforce and the DOE, as well as with other interested parties such as WIPP regulators and the local populace. As a result of these incidents, the WIPP facility has been closed with respect to waste handling/waste disposal operations for the foreseeable future. The first incident occurred on February 5, 2014 a truck used to remove salt from an active mining location to the salt hoist caught on fire in the northern part of the underground facility. All workers were safely evacuated and the underground portion of the WIPP was shut down. Although several workers were treated for smoke inhalation, no radioactive waste was impacted by this fire, as the fire occurred at a considerable distance from the waste panels. However, nine days later, at approximately 11:30 PM Mountain Standard Time (MST) on Friday, February 14, 2014 a second unrelated event occurred, which resulted in the release of americium and plutonium isotopes from at least one TRU waste container into the underground environment. The release was detected by an underground CAM (Continuous Air Monitor) located near panel 7 where waste had most recently been emplaced. As soon as this CAM alarmed on the night of February 14, 2014 the WIPP ventilation system automatically switched to filtration mode, reducing the flow of air within the repository, and rerouting the exhaust air stream through a set of surface-mounted HEPA filter banks. Independent analytical results of air filters from sampling stations on and near the WIPP facility were compiled and released by the Carlsbad Environmental Monitoring and Research Center (CEMRC), confirming the presence of trace amounts of $^{241}$Am and $^{239+240}$Pu, at ratios reflecting the suspect waste stream, in both WIPP exhaust air and ambient air near the WIPP facility. These concentrations of radiological contaminants in the air samples collected were deemed to be very small, localized, and well below any level of public-health or environmental concern.

In response to this incident, CEMRC began an intensified WIPP underground air sampling campaign and accelerated its radiochemical analyses of samples obtained in and around the WIPP site. Rapid analyses were also performed on ambient air samples and on environmental samples from the vicinity of the WIPP site immediately after the event's occurrence. However, as airborne concentrations have receded, the CEMRC monitoring

activities have once again returned to a “normal” collection, analysis, and reporting process effective July, 2014.

This annual report summarizes the environmental samples collected and analyzed by CEMRC during the calendar Year 2014 including the monitoring results associated with the two isolated events that occurred at the WIPP in February, 2014. The monitoring results collected immediately after the fire and radiation release events were reported to the public by CEMRC as they were obtained through analyses. The data collected following the February fire and radiation release events at the WIPP have been compared to the similar data collected during the monitoring phase of the WIPP to assess the radiological and ecological impacts, if any, of radiation on workers and on the general public living and working near the WIPP. Based on the analyses conducted by the CEMRC scientific staff, measured releases were determined to be low and localized, and no negative radiation-related health effects among local workers or the public are to be expected.

## CHAPTER 1 | INTRODUCTION

This section describes an overview of the WIPP site and the CEMRC’s major environmental programs. The Waste Isolation Pilot Plant (WIPP), is a radioactive waste repository operated by the U.S. Department of Energy (DOE) for the permanent disposal of defense-related transuranic (TRU) wastes. Located in the Chihuahuan desert of southeastern New Mexico near Carlsbad, the facility is designed to permanently dispose of transuranic (TRU) wastes that were generated from research and the production of nuclear weapons at various DOE sites.

Environmental monitoring is a key component in the development and operation of any nuclear facility. Well after the facility had been sited and constructed, but before repository operations began, the DOE and local community leaders recognized the value of having an independent environmental monitoring program. With the help of the DOE, the New Mexico State University (NMSU) created the CEMRC, which is funded annually by the DOE through a financial assistance grant process that respects its independence in carrying out and reporting the results of environmental monitoring at and near the WIPP site. The CEMRC program maintains capabilities necessary for the rapid detection of radionuclides in the event of accidental releases from the repository or from the site during waste handling and/or waste disposal operations.

## CHAPTER 2 | WIPP UNDERGROUND AIR MONITORING

This section summarizes the WIPP’s underground air monitoring results for the calendar year 2014. This section also covers the CEMRC’s monitoring efforts following the February 14, 2014 radiological event at WIPP. The WIPP facility operates three effluent air monitoring stations. These are known as Stations A, B, and C respectively. Each station is equipped with at least one fixed air sampler (FAS) collecting particulates from the effluent air stream on a Versapor filter. Station A is an above ground sampling platform, which collects particulates of unfiltered air exhausted from the repository, that is then either released directly to the environment or is directed into a HEPA filter bank designed to capture up to 99.97% of radioactive material. Activities measured at Station A reflect the level of contamination present in the exhaust air of the repository prior to being released to the environment. The Station B sampler collects particulates from the underground exhaust air after HEPA filtration and, sometimes, non-filtered air during maintenance-related activities. Therefore, following a radiological event, such as the one that occurred on February 14, 2014, the activities measured at Station B are reflective of the level of contamination that was ultimately released into the environment. Station C is used to sample the exhaust from the Waste Handling Building (WHB) where air exhausted from the WHB passes through double HEPA filters before being vented to the environment. The effluent studies at Station A and Station B are a major component of WIPP Environmental Monitoring (WIPP-EM) program. Sampling operations at Station A provide a way to monitor for releases of radionuclides and other substances in the exhaust air from the WIPP. In addition, if radioactive materials were to be released from the facility, one would expect to detect it at Station A and/or Station B before it is observed in the local population or environment. Station A is located where radioactive or hazardous materials would most likely be detected in the event of a release. The daily monitoring of the air filter samples collected from Station A indicates that the February 14, 2014 event released moderate levels of radioactivity within the WIPP repository, predominantly consisting of americium and plutonium isotopes. While results from Station B indicates that a small, but measurable amount of radioactivity eventually escaped to the surface and was detected beyond the site's property protection boundary.

## CHAPTER 3 | AMBIENT AIR MONITORING

This section summarizes the ambient air monitoring results for the calendar year 2014 levels in the vicinity of the WIPP site. A network of continuously operating samplers at three locations across the WIPP site was used to determine whether the nuclear waste handling and storage operations at the WIPP have released radionuclides into the environment. Air sampling was performed weekly at these three monitoring stations. A total of 108 air particulate filter samples have been collected and analyzed during 2014. Except for the brief detection of americium and plutonium in the nearby ambient air samples shortly after the event, there is no increase in radiological contaminants that could be attributed to the recent radiation release from the WIPP in the wider region. The CEMRC has been monitoring radionuclide concentrations in the ambient air since the inception of the WIPP-EM program in 1996. With few exceptions, fallout from atmospheric testing of nuclear weapons is the primary source of plutonium in ambient air. One of the most interesting and important findings from the prior WIPP-EM aerosol studies was that $^{239+240}$Pu in aerosols from all stations exhibited seasonal patterns and that the peak $^{239+240}$Pu activities generally occur in the March to June timeframe, which is when strong and gusty winds in the area frequently give rise to blowing dust.

## CHAPTER 4 | SOIL MONITORING

This section summarizes soil monitoring efforts conducted around the WIPP Site during the calendar year 2014. Soil samples were collected from the Near field location and analyzed to monitor the deposition of americium and plutonium, if any, following the underground radiological event at WIPP. Samples were analyzed for radionuclides expected to occur in the areas sampled. The CEMRC monitoring data indicate that concentrations of these radionuclides are comparable to the historical data recorded for these areas prior to arrival of TRU wastes in the WIPP and that, there is no persistent contamination and no lasting increase in radiological contaminants near WIPP that can be attributed to the 2014 radiation release event.

## CHAPTER 5 | SURFACE WATER AND SEDIMENT MONITORING

This section summarizes Surface water and sediment monitoring conducted at three reservoirs on the Pecos River, which is the major perennial fresh water system closest to the WIPP that has extensive human usage. The three reservoirs are (1) Brantley Lake, located approximately 55 km (34 miles) northwest of the WIPP; (2) Lake Carlsbad, located in Carlsbad and approximately 40 km (25 miles) northwest of the WIPP; and (3) Red Bluff Reservoir, located approximately 48 km (30 miles) southwest of the WIPP. As expected, the isotopes of americium and plutonium were not detected in any of the surface water samples, while the levels of radionuclides in sediment samples from the aforementioned three reservoirs in the region showed no detectable increases above those typical of previously measured natural variation, demonstrating no long-term environmental impacts of the February 14 radiation release event. As for the gamma radionuclides, $^{40}K$ was detected in all sediments and two of the surface water samples, while concentrations of all other gamma radionuclides were typically less than the minimum detectable concentrations.

## CHAPTER 6 | DRINKING WATER MONITORING

This section summarizes public drinking water monitoring results for the calendar year 2014. Public drinking water samples are routinely sampled from six drinking water sources in the region of the WIPP. These sampling locations are not likely to be affected by any WIPP-related radioactivity releases; however, because water is a primary vector in the food chain, the samples are collected and analyzed regularly. The CEMRC's drinking water monitoring program fulfills the following environmental challenges: protecting human and environmental health, assuring local residents about the quality of their drinking water, and assessing the long-term trends and environmental impacts of the WIPP on local water supply systems. As with surface water, the absence of WIPP radionuclides in drinking water samples demonstrates no adverse effect to the local and wider public or to the environment from the February 14, radiation release at the WIPP.

## CHAPTER 7 | WHOLE BODY COUNTING

In addition to the monitoring of environmental media (air, soil, drinking water, and surface water/sediment), the CEMRC also operates a Lung and Whole Body Counting (LWBC) lab that performs *in vivo* measurements of the internally-deposited radionuclides in humans and has been performing such measurements since 1997 for public volunteers living within a 100-mile radius of the WIPP facility as well as for WIPP radiation workers and other nuclear-related entities in the surrounding area. Prior to the WIPP becoming operational, the CEMRC LWBC lab performed *in vivo* measurements, also referred to as counts, on 366 public volunteers in order to establish a baseline of radiological activities in the inhabitants within the local population. The WIPP became operational in March 1999, accepting its first waste shipment from Los Alamos National Labs on March 26, 1999. During the WIPP operational phase but prior to the February 14, 2014 event, the CEMRC LWBC lab performed counts on 991 public volunteers. Following the February 14, 2014 event, the CEMRC LWBC lab performed *in vivo* measurements on 40 public volunteers. By comparing the results of the 40 individuals counted after the underground radiation event to the measurements compiled during the previous 16 years, one can conclude that there are no negative health effects on the public citizens living in the surrounding areas of the WIPP facility as a result of the February 14, 2014 underground radiation event.

## CHAPTER 8 | VOLATILE ORGANIC COMPOUND

The WIPP Hazardous Waste Treatment Facility (HWTF) permit, Attachment N, issued by the New Mexico Environment Department (NMED) under the Resource Conservation and Recovery Act (RCRA), mandates the monitoring of volatile organic compound (VOC) emissions from mixed waste that may be entrained in the ambient air from the WIPP underground hazardous waste disposal units (HWDUs) to assure that VOC concentrations do not exceed regulatory limits, during or after disposal. Currently, nine (9) target VOCs are actively monitored as they represent 99% risk to safety due to air emissions while any other compounds consistently detected in air samples may be added to the list of compounds of interest.

## CHAPTER 9 | QUALITY ASSURANCE

This section summarizes the comprehensive quality assurance programs, which include various quality control practices and methods employed to ensure data quality. The programs are implemented through quality assurance plans designed to meet requirements of the American National Standards Institute. Quality assurance plans are maintained for all activities and certified auditors verify conformance. Samples are collected and analyzed according to documented standard procedures. Analytical data quality was verified by a continuing program of internal laboratory quality control, replicate sampling and analysis are often done to assure data quality.

## CONCLUSION

After almost fifteen years of successful waste disposal operations, the WIPP repository had its first minor accident on February 14, 2014. It was the first unambiguous release at the WIPP. The accident released moderate levels of radioactivity into the underground air. A small portion of the contaminated underground air also escaped to the surface through imperfectly sealing dampers and was detected approximately one kilometer away from the facility. The radiation release was caused by a runaway chemical reaction inside a TRU waste drum which experienced a seal and lid failure, spewing radioactive materials into the repository. According to source-term estimates, the actual amount of radioactivity released from the WIPP site was less than 1.5 millicurie (mCi). The dominant radionuclides released were americium and plutonium, in a ratio that matches the content of the breached drum.

In the wake of the radiation-release incident of February 14, 2014, CEMRC began an intensified ambient air sampling campaign and accelerated its radiochemical analyses of samples obtained in and around the WIPP site, and, more importantly, notified the public through news releases and through participation in “town hall” meetings arranged by the Mayor’s Office of the City of Carlsbad in cooperation with the Carlsbad Field office of the DOE. The accelerated air monitoring campaign, which began on February 15, 2014 shows that except for the brief detection of americium and plutonium in the nearby ambient air samples, there is no increase in radiological contaminants that could be attributed to the recent radiation release from the WIPP in the wider region. The highest activities detected outside were 115.2 µBq/m$^3$ for $^{241}$Am and 10.2 µBq/m$^3$ for $^{239+240}$ Pu at a sampling station located 91 meters away from the underground air exhaust point and 81.4 µBq/m$^3$ of $^{241}$Am and 5.8 µBq/m$^3$ of $^{239+240}$Pu at a monitoring station located approximately one kilometer northwest of the WIPP facility. The levels detected were very low and localized, and no radiation-related health effects among local workers or the public would be expected. A week after the event, the airborne radioactive particulate levels at these stations had decreased by a hundred times, and two weeks later the levels at these stations were back to the pre-release levels and sometimes not even detectable, demonstrating no long-term environmental contamination. **In terms of radiological risk at or in the vicinity of the WIPP site, the increased risk from the WIPP releases is exceedingly small, approaching zero.**

The release of any radioactivity has the potential to alarm portions of the general population who do not understand the difference between actual radiological risk and perceived risk. It is not surprising that some media treatment of the WIPP radiation release event has amplified the public's perception of their risk. Following the event, there were rumors propagated in some media concerning evacuations planned or in progress, which did not help assure the public. The WIPP release incident was newsworthy, but it was not dangerous to any member of the public. To eliminate unnecessary concern surrounding fear of radiation, the monitoring data were posted on the CEMRC website as they were reviewed and verified. Graphs of the monitoring data were displayed along with information on how to interpret the graphs in order to show the decreasing trend in radiation in the ambient air with time. Information on the contaminant levels that might have been a cause for public concern, had they been found, was also posted.

Throughout the duration of the response to the February 14 release event, "town hall" meetings were held with members of the public to identify and discuss their concerns about the WIPP radiation release event. This timely dissemination of information provided the public a key element of trust and transparency. Public access to the monitoring data and their ability to directly participate in CEMRC's whole body counting provided a sense of security to concerned citizens after the event in evaluating their own safety, which has a direct relationship to their continuing acceptance of a nearby nuclear facility.

In the past, CEMRC's independence and its extensive monitoring program and constant public engagement provided a model of how to garner confidence in the local public in acceptance of a nearby nuclear facility and trust in the scientific methods employed. Following the radiation release event at WIPP, CEMRC's independent monitoring program and independent communications effort has proven its value in terms of assuring continued local acceptance of the facility. **The CEMRC independent monitoring and communications model perhaps ought to be considered as part of the infrastructure needed to assure local acceptance of planned repositories elsewhere.**

## Table of Contents

## List of Tables

## List of Figures

## Acronyms and Abbreviations

| | |
|---|---|
| μBq | MicroBecquerel |
| μm | Micrometer |
| Am | Americium |
| ANSI | American National Standards Institute |
| ASTM | American Society for Testing and Materials |
| Ba | Barium |
| Bq | Becquerel |
| C | Centigrade |
| Ca | Calcium |
| CAM | Continuous Air Monitor |
| Ce | Cerium |
| CEMRC | Carlsbad Environmental Monitoring & Research Center |
| CEMRP | Carlsbad Environmental Monitoring & Research Program |
| Cf | Californium |
| CFR | Code of Federal Regulations |
| CH | Contact-handled |
| Ci | Curie |
| cm | Centimeter |
| Cm | Curium |
| Co | Cobalt |
| Cr | Chromium |
| Cs | Cesium |
| DL | Detection Limit |
| DOE | U.S. Department of Energy |
| DOE/CBFO | U.S. Department of Energy/Carlsbad Field Office |
| EEG | Environmental Evaluation Group |
| EPA | U.S. Environmental Protection Agency |
| Eu | Europium |
| FAS | Fixed Air Samples |
| Fe | Iron |
| FP | Field Programs |
| g | Gram |
| HCl | Hydrochloric acid |
| $HClO_4$ | Perchloric acid |
| HEPA | High Efficiency Particulate Air |
| HF | Hydrofluoric acid |
| $HNO_3$ | Nitric acid |
| $H_2O_2$ | Hydrogen Peroxide |
| HPGe | High Purity Germanium |
| I | Iodine |
| ID | Internal Dosimetry |
| Ir | Iridium |
| K | Potassium |
| km | Kilometer |

| | |
|---|---|
| L | Liter |
| LANL | Los Alamos National Labs |
| LDBC | "Lie Down and Be Counted" |
| m | Meter |
| MAPEP | Mixed-Analyte Performance Evaluation Program |
| mBq | MilliBecquerel |
| MDC | Minimum Detectable Concentration |
| MDL | Method Detection Limit |
| min | Minute |
| mL | Milliliter |
| Mn | Manganese |
| MTL | Minimum Testing Level |
| MTRU | Mixed Transuranic |
| Na | Sodium |
| NaOH | Sodium Hydroxide |
| Nd | Neodymium |
| NIST | National Institute of Standards and Technology |
| NMED | New Mexico Environment Department |
| NMSU | New Mexico State University |
| Np | Neptunium |
| NRIP | National Radiochemistry Intercomparison Program |
| NWP | Nuclear Waste Partnership |
| Pb | Lead |
| Pu | Plutonium |
| QA | Quality Assurance |
| QAP | Quality Assurance Program |
| QAPD | Quality Assurance Program Document |
| QC | Quality Control |
| Ra | Radium |
| RC | Radiochemistry |
| RH | Remote-Handled |
| Ru | Ruthenium |
| Sb | Antimony |
| SNL | Sandia National Labs |
| Sr | Strontium |
| Th | Thorium |
| TRU | Transuranic |
| Unc. | Uncertainty |
| U | Uranium |
| WHB | Waste Handling Building |
| WIPP | Waste Isolation Pilot Plant |
| WIPP-EM | Waste Isolation Pilot Plant Environmental Monitoring |
| Y | Yttrium |
| Zn | Zinc |
| Zr | Zirconium |

## CHAPTER 1

## INTRODUCTION

The Waste Isolation Pilot Plant also known as the WIPP is a transuranic (TRU) waste repository operated by the U.S. Department of Energy (DOE). The purpose of the repository is to emplace defense-related TRU wastes in the Salado Formation, a bedded salt formation approximately 655 m (2150 ft.) below the surface of the Earth. Located near Carlsbad, New Mexico, an area with approximately 40,000 people, the WIPP facility is the world's first underground repository permitted to safely and permanently dispose of TRU waste generated through defense-related activities and programs (see Figure 1-1). TRU waste is defined in the WIPP LWA (Public Law 102-579) as radioactive waste containing more than 100 nanocuries (3,700 becquerels [Bq]) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years. Most TRU waste consists of contaminated industrial trash, such as rags and tools, sludges from solidified liquids, glass, metal, and other materials. The upper waste acceptance criteria are <0.85 TBq/liter (<23 Ci/liter) of total activity, and <10 Sv/hr dose rate on contact with unshielded waste containers. Since the start of its operation in March 1999, more than 81,000 cubic meters of Cold-War legacy TRU waste have been removed from temporary locations around the nation and shipped to WIPP for permanent disposal. The WIPP is about half full in terms of its legally defined capacity.

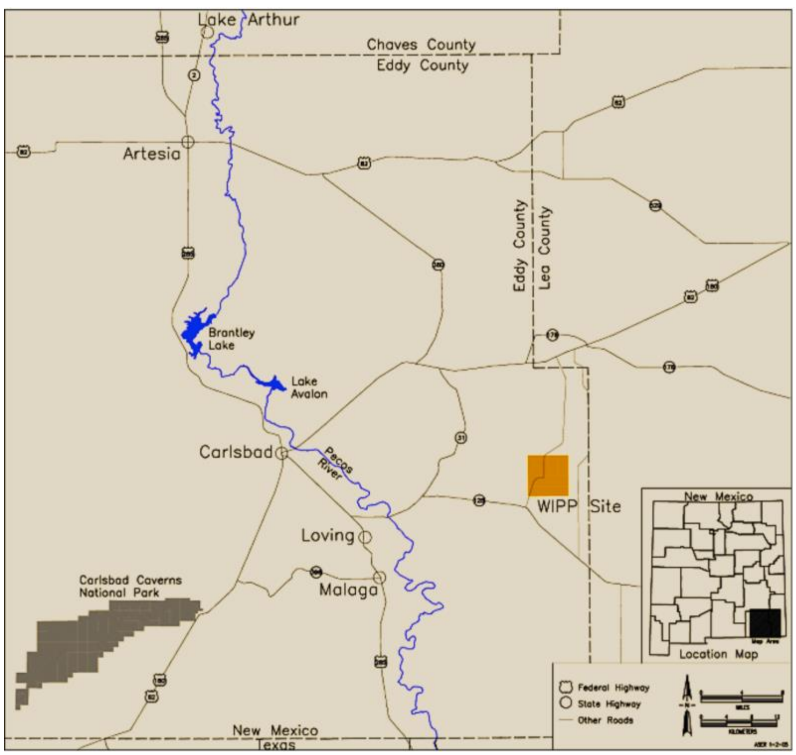



Figure 1-1: Location of the WIPP Site

Two types of TRU wastes are currently stored in the WIPP repository: (1) mixed transuranic waste (MTRU), meaning there is also hazardous waste components present and (2) non-mixed waste that contains only radioactive elements, mostly plutonium. The TRU waste is subdivided into contact-handled (CH) and remote-handled (RH) waste on the basis of the dose equivalent rate at the surface of the waste container. According to the legal definition, the term "contact-handled transuranic waste" means transuranic waste with a surface dose rate not greater than 200 millirem per hour. The term 'remote-handled transuranic waste' means transuranic waste with a surface dose rate of 200 millirem per hour or greater" (U.S. Congress, 1992). Contact-handled TRU waste typically emits relatively little gamma radiation; therefore, it can be handled directly by workers. Remote-handled TRU waste emits higher levels of gamma (penetrating) radiation; therefore, gamma rays represent the main radiological health hazard for workers handling RH-TRU waste. The WIPP became operational in March 26, 1999 for the disposal of TRU waste, and the WIPP first received mixed waste shipments on September 9, 2000. The WIPP mission is to dispose of 176,000 $m^3$ (6.2 million cubic feet) of contact-handled waste and 7,080 $m^3$ (250,000 cubic feet) of remote-handled waste which is equivalent to about 810,000 fifty-five gallon drums. Approximately 90,451 $m^3$ (319,000 cubic feet) of CH waste and 356 $m^3$ (12,572 cubic feet) of RH waste have been disposed of at the WIPP facility as of January, 2014. At least 66,200 $m^3$ of transuranic waste sit at several DOE sites, awaiting shipment to WIPP.

As shown in Figure 1-2, the WIPP repository layout currently has eight panels planned, each consisting of seven waste disposal rooms approximately 300 feet (91 meters) long and 33 feet (10 meters) wide. Seven of the panels have been excavated; and the first five have been closed and sealed from ventilation air. Panel 6 is full and is awaiting final closure. Waste disposal was in progress in the seventh panel at the time of the February 14, 2014 event. Two additional panels are being planned.

The facility also consists of common drifts for access and ventilation to the disposal panels, four shafts connecting surface operations to underground emplacement activities and above ground waste receipt and handling facilities. The repository is ventilated by drawing in a large amount of outside air, unfiltered. Since the air in the repository exits to the surface through its exhaust shaft, this shaft is the sole potential pathway for airborne radioactivity release from the WIPP during normal operations. The potential for release is mitigated by HEPA (High Efficiency Particulate Air) filters which are located at the surface. Continuous air monitors in the underground are used to control whether or not the ventilation air returning to the surface is passed through these large HEPA filter systems before being released to the atmosphere.

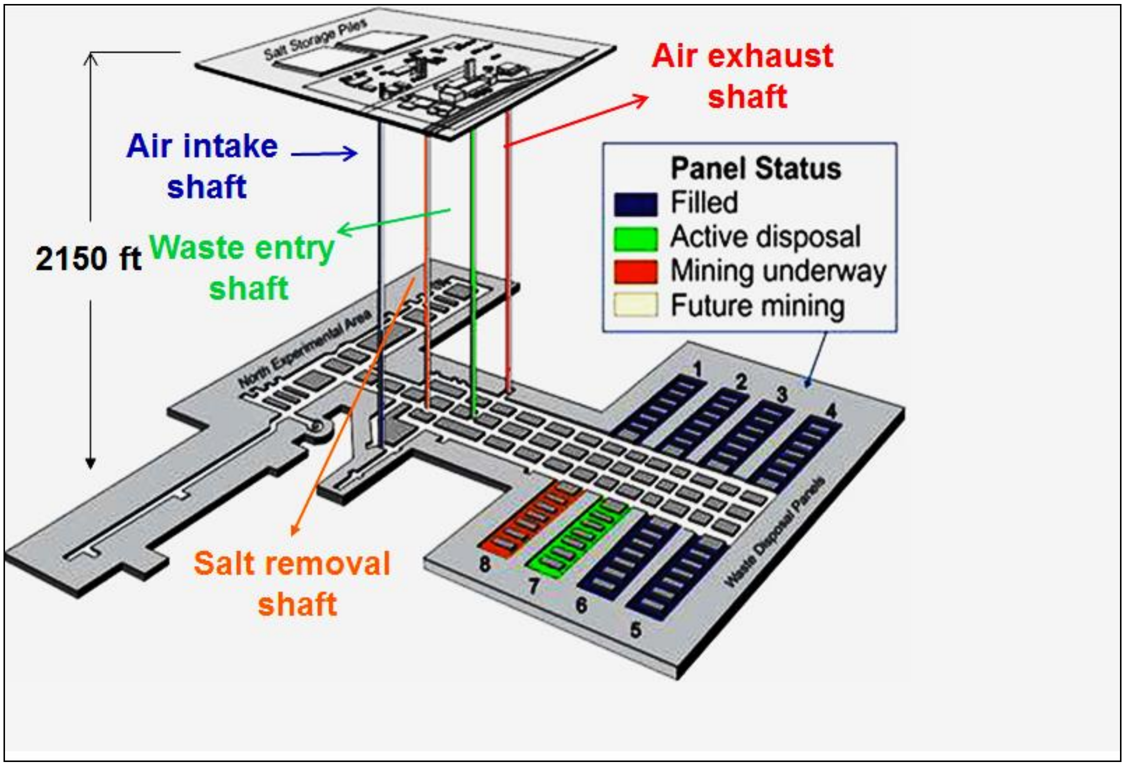



Figure 1-2: WIPP Layout

In terms of exhaust air monitoring, the WIPP facility operates three effluent air monitoring stations. These are known as Stations A, B, and C respectively. Each station is equipped with at least one fixed air sampler that collects particulates from the effluent air stream on a Versapore filter. Representative sampling is assured by system design. Under normal operating conditions (such as those encountered prior to the February 14, 2014 underground radiation event), unfiltered air is drawn through the repository and exhausted from the repository directly to the environment after passing through 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 by a continuous air monitor (such as what occurred during the radiological event on February 14, 2014), the system shifts into "filtration mode" thereby significantly lowering the quantity of air being drawn through the repository and directing this exhaust air through the bank of HEPA filters before being released into the environment.

The Station B fixed air sampler collects the air downstream of the bank of HEPA filters and is representative of the level of contamination ultimately released into the environment while operating in filtration mode. It is important to note that the WIPP exhaust air ventilation system has been operating in filtration mode since the underground event occurred on February 14, 2014. Station C is used to sample the exhaust from the Waste Handling Building (WHB) where air exhausted from the WHB passes through double HEPA filters before being vented to the environment. The waste container is the primary confinement barrier in the WHB; while negative building pressure and HEPA filtration provide secondary confinement to potential radiological contamination. CEMRC, like the New Mexico

Environment Department (NMED) and the WIPP contractor (NWP), has its own collection ports at Station A and Station B on which it collects exhaust air samples in order to perform its independent analyses. Prior to the February 14, 2014 underground radiological event, the CEMRC did not sample Stations B or C unless there was an indication of a release-detection by a CAM located in the underground or in the WHB. However, since the radiological event, CEMRC has been performing expedited sampling and analysis of Station A and B filters respectively.

## WIPP History

The WIPP site is an essential effort in support of cleaning up the nation's TRU waste which is currently stored at several federal facilities around the country. The history of the WIPP goes back to 1957, when the National Academy of Science recommended bedded salt formations as the optimal geologic formation for the underground disposal of radioactive waste. Salt deposits were selected as the host for the disposal of nuclear waste for the following reasons: 1) Most deposits of salt are found in stable geological areas with very little earthquake activity, assuring the stability of a waste repository. 2) Salt deposits also demonstrate the absence of water that could move waste to the surface. If water had been present in the past or was currently present, it would have dissolved the salt beds. 3) Salt is relatively easy to mine in comparison to many other geologic formations. 4) Finally, rock salt heals its own fractures because it behaves plastically under lithostatic pressure, constantly moving to fill voids, gaps, or cracks. The impetus to go forward with the project developed in 1969-1970 when a series of fires at the DOE Rocky Flats facility near Denver, Colorado caused an airborne release of plutonium. At that time, DOE agreed to stop storing plutonium wastes at Rocky Flats and began shipping TRU wastes to the Idaho National Engineering and Environmental Laboratory in southeastern Idaho. Idaho was promised that the wastes would only be stored for ten years in Idaho while the search began for a site where these wastes could be permanently disposed. DOE had previously evaluated a site near Lyon, Kansas, in an abandoned salt mine, but strong political opposition by state officials and a combination of numerous borehole and large volumes of water "lost" in fractures in the salt forced them to look elsewhere. They considered several New Mexico sites, eventually settling on the site near Carlsbad. The encouragement of local politicians and businesses, the depressed economic conditions in that part of the state at the time, and a ready labor force already trained in what was needed to construct the repository, were all important factors in bringing WIPP to this area. In 1979, Congress authorized the construction of the WIPP facility, and the DOE constructed the facility during the 1980s. In late 1993, the DOE created the Carlsbad Area Office (CAO), subsequently re-designated as the Carlsbad Field Office (CBFO), to lead the TRU waste disposal effort. The CBFO coordinates the TRU program throughout the DOE complex.

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

## Environmental Setting of the WIPP

The WIPP facility is located in Eddy County in Southeastern New Mexico, approximately 26 miles east of Carlsbad. 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 Levingston Ridge and Nash Draw, about 8 km (5 miles) west of the facility. Nash Draw is a shallow, dog–bone shaped drainage course between 8.5 miles and 11 miles in width, characterized by surface impoundments of brine water. 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 miles) west of the facility, and the Carlsbad Caverns National Park, located about 68 km (42 miles) west-southwest of the WIPP facility.

The nearest population centers include the village of Loving (population ~ 2000), located 29 km (18 miles) southwest of the facility, and the City of Carlsbad (Population ~ 40, 000), located 42 km (26 miles) west of the facility. Other towns with an 80 km (50 miles) radius include Artesia, Eunice, Hobbs, Jal and Lovington.

The climate in the region of the facility is semi-arid with an average annual precipitation of 280 to 300 mm ( 11 to 13 inches) with much of the precipitation falling during intense thunderstorms in the spring and summer seasons. Winds are generally from the southeast with an average speed of 14 km/hour (8.8 miles/hour).

Three ranches (Mills, Smith, and Mobley) have property in the vicinity of the WIPP facility. The Mills ranch headquarters is located 5.6 km (3.5 miles) south-southwest of the facility center, the Smith headquarters is 8.8 km (5.5 miles) west-northwest of the facility, and the Mobley ranch is 9.6 km (6 miles) southwest of the facility.

Although there are no dairies near the WIPP facility, a large amount of alfalfa is grown in the Pecos Valley between Roswell and Malaga, New Mexico. 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.

**Background Radiation**

There are several sources of naturally occurring radiation including: cosmic and cosmogenic radiation (from outer space and the earth's atmosphere), terrestrial radiation (from the earth's crust), and internal radiation (naturally occurring radioactive material in our bodies, such as potassium or $^{40}K$). The most common sources of terrestrial radiation are uranium, and thorium, and their associated decay products. Radon gas, a decay product of uranium, is a widely known naturally occurring terrestrial radionuclide. Another source of terrestrial radiation is $^{40}K$. While not a major radiation source, the presence of $^{40}K$ in the southeastern New Mexico environment may be due to the deposition of tailings from local potash mining. In addition to natural radioactivity, small amounts of radioactivity from aboveground nuclear weapons tests that occurred from 1945 through 1980, and the 1986 Chernobyl and 2011 Fukushima nuclear accidents are also present in the environment. Together, these sources of radiation are called "background" radiation (see Figure 1-3).

Naturally occurring radiation in the environment can deliver both internal and external doses to humans. An internal dose is received as a result of the intake of radionuclides through ingestion (consuming food or drink containing radionuclides) and inhalation (breathing radioactive particulates). An external dose can occur from immersion in contaminated air or deposition of contaminants on surfaces. The worldwide average natural dose to humans is about 2.4 millisievert (mSv) per year, which is four times more than the worldwide average artificial radiation exposure. Site-specific background gamma measurements on the surface, conducted by Sandia National Laboratories (SNL), showed an average dose rate of 7.65 microrem per hour (Minnema and Brewer, 1983), which would equate to the background gamma radiation dose of 0.67 millisieverts (mSv or 67.0 mrem) per year. A comprehensive radiological baseline study conducted before WIPP facility disposal operations began was also documented in *Statistical Summary of the Radiological Baseline for the Waste Isolation Pilot Plant* (DOE/WIPP-92-037), which provides the basis for environmental background comparison after WIPP facility disposal operations commenced.

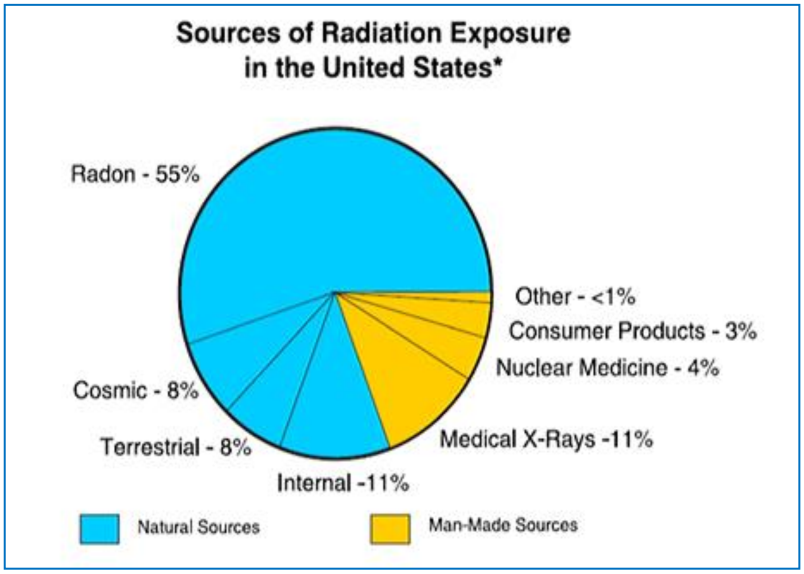



Figure 1-3: Source of Radiation Exposure
(Source: National Council on Radiation Protection (ICRP)

**Radiological Environment around WIPP**

The radiological environment near the WIPP site includes natural radioactivity, global fallout from nuclear weapons tests and, potentially, a local source of anthropogenic (man-made) radioactive contamination remaining from Project Gnome, an underground nuclear test conducted by the U.S. Atomic Energy Commission. In 1961, the surface area of the Gnome site was contaminated with fission radionuclides when an underground test of a 3.3-kiloton $^{239}$Pu device vented radioactive materials to the surface (USAEC, 1973). The Gnome project was part of the Plowshare Program intended to demonstrate the peaceful use of atomic energy. The Gnome site is located approximately 8.8 km (5.5 miles) southwest of the WIPP site.

Clean-up efforts at this site have been carried out in several campaigns since that time, and the surface contamination is now well below the risk-based action levels. However, despite these cleanup efforts, $^{137}$Cs and plutonium have been detected by the CEMRC in some samples of surface soils collected at the Gnome site. While the transport of these contaminants from the Gnome site to the WIPP remains a possibility during high wind seasons (Stout and Arimoto, 2010); a review of more than fifteen years of monitoring data and the activity levels detected, as well as their atomic ratio measurements, suggest that pre-release-event plutonium and americium in aerosol and soil samples collected near the WIPP facility mainly represent redistributed global fallout from non-Gnome related incidents.

## Independent Environmental Monitoring Program – An Overview

The success of any routinely misperceived project such as a nuclear facility is strongly tied to the degree of public participation, acceptance and understanding. The WIPP is an example where public engagement has constantly been provided at a high level. From the standpoint of addressing the operational and environmental risks, as well as allaying public concerns, the WIPP has endured extensive human health and environmental monitoring. In addition to the regulatory compliance monitoring required by the repository licensee, and also conducted by the State of New Mexico and previous entities, the local community demanded the implementation of a sophisticated environmental monitoring program carried out by an independent academic institution that would emphasize a science-based program, rather than one focused on compliance.

Many factors contributed to the success of this project during its first almost 15 years of operations. An important factor is the local acceptance engendered by an independent environmental monitoring program in the vicinity of the WIPP that began before and continues after the WIPP began receiving nuclear waste. This independent monitoring is being conducted by the Carlsbad Environmental Monitoring and Research Center (CEMRC), which is associated with the New Mexico State University system. The CEMRC is funded by the DOE through a financial assistance grant process that respects its independence in carrying out and reporting the results of environmental monitoring activities conducted at and near the WIPP site. Unlike most environmental programs which only monitor down to compliance or action levels, the mission of the CEMRC is to monitor to below background levels, as the public needs to know what is truly happening in the environment and what effect WIPP operations may have on their lives and health. As a result, some approaches the CEMRC has undertaken to accomplish this mission includes increasing counting times on alpha and gamma spectroscopy systems in order to routinely achieve the lower detection limits for alpha and gamma-emitting radionuclides or by adopting a 12-detector array for *in vivo* bioassay in order to observe the 17.1 keV spectrum thereby indicating the presence of Pu in the lung. The CEMRC has been conducting independent health and environmental monitoring in the vicinity of WIPP since 1995 and has made the results easily accessible to all interested parties. Public access to the monitoring data and their ability to directly participate in CEMRC's whole body counting program provides a key element of trust and transparency for the public.

Radionuclides present in the environment, whether naturally occurring or anthropogenic (human-made), may contribute to radiation doses to humans. Therefore, environmental monitoring around nuclear facilities is imperative to characterize radiological baseline conditions, to identify any releases, and to determine their effects, should they occur. The purpose of the radiological environmental monitoring program is to measure radionuclides in the ambient environmental media. These data allow for a comparison of sample data to results from previous years and to historical baseline data, to determine what impact, if any, the WIPP is having on the surrounding environment. Radiological monitoring at the WIPP site includes sampling and analysis of air (both WIPP underground exhaust and ambient air), drinking water, surface water, sediment and soil. Additionally, the scope of the CEMRC WIPP environmental monitoring activities is broad and includes people (whole body counting for the public and for radiological workers) as well as routine sampling of water (including both drinking water and surface waters), soil and sediment. Routine reporting is done annually and published on the CEMRC website (www.cemrc.org ). Non-routine results, if they occur, are reported as they are found after review and interpretation. One of the CEMRC's core competencies is to detect and report radioactive contaminant levels, even those below the regulatory requirements, as soon as possible and to disseminate this information to the public in a timely and understandable nature. The CEMRC program has capabilities to detect radionuclides rapidly in case of accidental releases from the repository or other portions of the facility during waste handling/waste emplacement operations.

The CEMRC's environmental monitoring activities generally fall into three categories: collecting environmental samples and analyzing them for a variety of contaminants, evaluating whether WIPP-related activities cause any environmental impacts, and taking corrective action when an adverse effect on the environment is identified. The current CEMRC operational environmental sampling and analytical plan is detailed in previous CEMRC annual reports. The four major elements of the program include WIPP exhaust air, ambient air, drinking water and human monitoring. For these four elemental areas, sample collection and analyses is more frequent whereas the sampling and analyses frequencies for other environmental media such as soil, sediment and surface water are generally acquired and analyzed once every two years on an alternating basis.

For ambient air analyses, the CEMRC operates three ambient air samplers in and around the WIPP site. The sites are located in the most prevalent wind directions from the facility. The primary purpose is to obtain baseline data and to determine whether the nuclear waste handling and storage operations at the WIPP have released radionuclides into the environment around the WIPP.

Public drinking water samples are sampled annually from six drinking water sources in the region of the WIPP.  These sampling locations are not likely to be affected by any WIPP radioactivity releases; however, because water is a primary vector in the food chain, the samples are collected and analyzed on a regular basis. As with community air sampling, the absence of WIPP radionuclides in drinking water samples provides additional public assurance associated with the WIPP and WIPP-related activities.

As mentioned previously, WIPP exhaust air is the most likely pathway for accidental radioactivity releases from the WIPP. Accident release scenarios are postulated in the WIPP Safety Analysis Report (USDOE WIPP 1997). If an underground operations accident were to occur, air samples would be collected from Stations A and B which represent the final release points of the underground repository exhaust ventilation system. Consequently, the CEMRC collects filter(s) from Station A and B each day and then performs a gross alpha/beta screening process on the individual filters for the presence of radioactive contamination.  This daily sampling process allows for a careful study of the variability of radioactivity background and trends.  Following the gross alpha/beta screening process, the CEMRC then performs the more sensitive radiochemical analyses on the composited weekly and/or monthly filters to identify specific radioactive isotopes.

From time to time, soil, sediment and surface water samples are also collected and analyzed to verify radionuclides concentrations and to establish the variability of background radioactivity. In addition, soil samples were previously collected from selected areas and control locations outside of the WIPP land withdrawal area, such as the Gnome site, and were analyzed for the presence of radionuclides thereby creating the ability to identify localized surface contamination from non-WIPP related activities. The results of the Gnome study are presented in the 2005/2006 CEMRC Annual Report.

Since the inception of the CEMRC WIPP environmental monitoring program, the CEMRC has been monitoring the concentration of plutonium (Pu) and americium (Am) in the area around the WIPP site for many years, as isotopes of these elements are the major radioactive constituents found in the TRU waste. Additionally, uranium isotopes ($^{238}U$, $^{235}U$, $^{234}U$), prominent alpha-emitting radionuclides in the natural environment, and cesium ($^{137}Cs$), a potentially important beta and gamma-emitting constituent of the TRU waste disposed at WIPP, have been the subject of background studies conducted by the CEMRC at WIPP prior to 1999 and continue to be monitored. Cobalt ($^{60}Co$) and other gamma-emitters, though not major constituents of the TRU waste, are also monitored. Lastly, potassium ($^{40}K$), a natural gamma-emitting radionuclide, which is ubiquitous in the earth's crust, is also monitored because of its possible enhancement in southeastern New Mexico due to the abundance of potash mining in the area.

In addition to the monitoring of environmental media (air, soil, drinking water, and surface water/sediment) in the vicinity of the WIPP site, the CEMRC also performs routine monitoring of adult 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. The LDBC project serves as a component of the WIPP Environmental Monitoring program that directly addresses the general concern about personal exposure to contaminants shared by residents who live near DOE sites. 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, and has continued into the disposal phase to the present. The sampling design includes the solicitation of adult volunteers from all segments of the community, with sample sizes sufficient to meet or exceed a 15% range in margin of error for comparisons between major population ethnicity and gender categories as identified in the 1990 U.S. census. Radiobioassays of the original volunteer cohort have been ongoing since July 1999. New volunteers continue to be recruited each year to establish new study cohorts and to replace volunteer attrition. While the passage of time and the overall success of the WIPP have historically made it difficult to attract new volunteers to the LDBC program, the February 14, 2014 event appears to have renewed interest on behalf of resident volunteers. Results of the LDBC, both historically and with respect to the February 14, 2014 underground radiation event are reported herein. Also, as a result of the February 14, 2014 radiation radiological event, the age for public volunteers was reduced from 18 years of age to 13 years of age in order to accommodate requests by the DOE and interested constituents.

## The Fire and Radiological Release Events at the Waste Isolation Pilot Plant

Two isolated incidents took place at WIPP in February, 2014. On February 5, a truck used to remove mined salt from the underground facility caught on fire in the northern part of the underground facility (Figure 1-4). At the time of the fire, there were 86 people in the underground and all were evacuated from the mine safely. Six personnel were evaluated for smoke inhalation and released from a local hospital the day of the underground fire; however, one employee continues to be treated for smoke inhalation as a result of the fire.

The fire burned the engine compartment of the salt haul vehicle and consumed the front tires, which contributed significantly to the amount of smoke and soot in the area of the fire. The heavy smoke from the fire damaged the immediate area of the mine and affected mechanical, electrical, ventilation, and safety systems throughout the underground. Additionally, soot was deposited on the mine's walls, shafts, and underground equipment, including the waste hoist tower, which is used to transport TRU waste containers to the underground for disposal. However, despite the damage experienced in the underground as a result of the fire, no radioactive waste was impacted by this fire as the fire occurred at a considerable distance from the waste.

On February 7, 2014, the Department of Energy appointed an Accident Investigation Board (AIB) to determine the cause of the fire incident and to develop recommendations for corrective actions to prevent recurrence (DOE 2014a). The results of the fire accident investigation were released in an extensive report issued March 13, 2014 which is available at: http://www.wipp.energy.gov/Special/AIB%20Report.pdf. This report cited numerous errors, including inadequate training and an inadequate equipment/facility maintenance program, as having contributed to the fire event and to problems associated with the overall response to the fire.


Figure 1-4: EIMCO Haul Truck 74-U-006B after Fire

As a result of this incident, the CEMRC conducted an emergency analysis of the air filters in place at the WIPP exhaust fixed air sampling station (Station A) at the time of the fire. This fixed air sampling station (Station A) collects particulates from unfiltered air used to ventilate the repository that is ultimately discharged to the environment. Analysis of the air-filter samples from the WIPP underground showed no additional radiation beyond normal background levels, indicating that the fire-incident did not result in any release of radioactive contamination; hence there were no negative health risk of radiation releases caused by the fire.

Nine days later, at approximately 11:30 PM on Friday, February 14, a second unrelated event occurred, which resulted in the release of americium and plutonium isotopes from at least one TRU waste container into the underground environment of the respository. The release was detected by an underground continuous air monitor (CAM) located near panel 7 where waste was most recently emplaced before the fire in the underground (Figure 1-5). As soon as the CAMs alarmed on the night of February 14, the WIPP ventilation system automatically switched to filtration mode, reducing the flow of air within the repository, and directing the exhaust air stream through two HEPA filter banks.

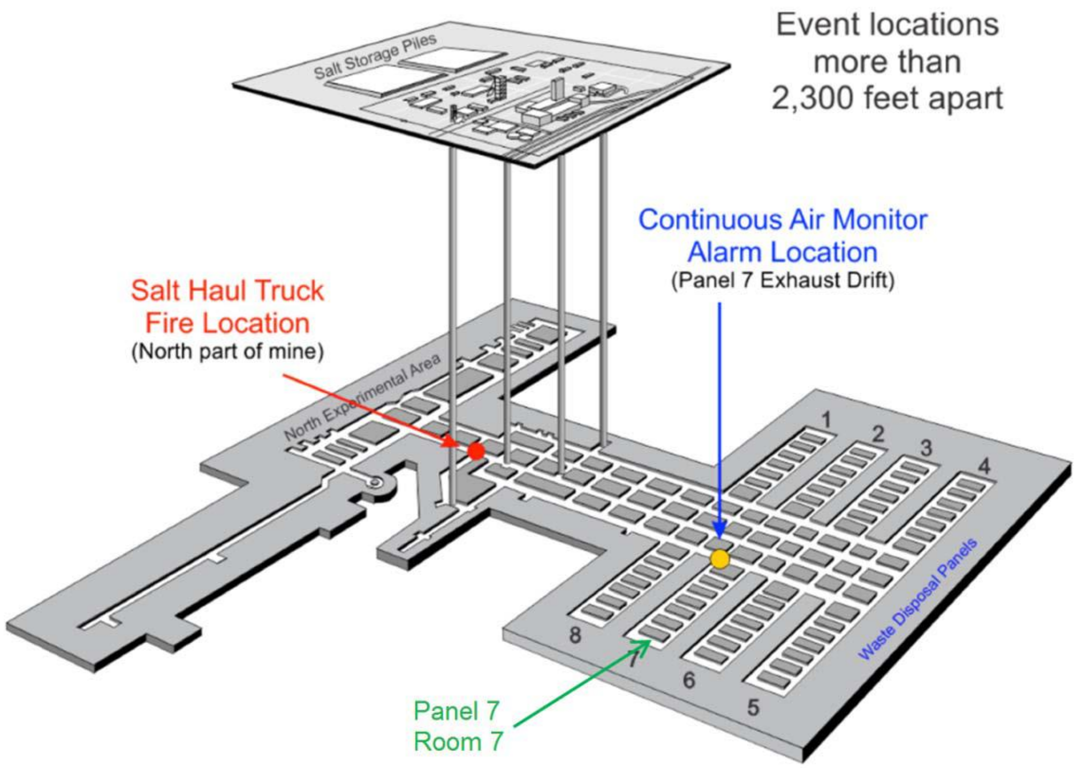



Figure 1-5: Locations of Fire and Radiological Release Event

A measurable, but small, portion of the contaminated air bypassed the HEPA filters via leakage through two imperfectly sealing ventilation system dampers and was discharged directly to the environment from an exhaust duct. Since this incident occurred during the night, only a few employees were at the WIPP site and no employees were in the underground. Personnel were frisked and none were reported to have external contamination; however, a total of 21 personnel were later found to have positive bioassay results for $^{241}$Am. Follow-up testing results were below the detectable limits of the laboratory analysis, indicating that the radioactive isotopes were ultimately excreted from the body. Additionally, on February 19, 2014, the CEMRC reported that trace amounts of americium and plutonium were detected at an off-site ambient air sampler located approximately one-half mile northwest of the WIPP site.

On February 27, 2014, the Department appointed a second AIB to determine the cause of the radiological release and to develop recommendations for corrective actions. This second AIB used a two-phased approach with the first phase focusing on the response to the radioactive material release, including related exposure to aboveground workers and the response actions, and the second phase focusing on evaluating the cause of the underground radiological release event.

The results of the Phase 1 are documented in the comprehensive report issued April 24, 2014 (DOE 2014b). According to the Phase 1 report, the cumulative effect of inadequacies in ventilation system design and operability compounded by degradation of key safety management programs and safety culture resulted in the release of a minimal amount of radioactive material from the underground to the environment. The Phase 1 report is available at:
http://www.wipp.energy.gov/Special/AIB_Final_WIPP_Rad_Release_Phase1_04_22_2014.pdf

The Phase 2 report examined the cause of the 2014 radiological release event at WIPP (DOE 2015a). Based on post-event chemical, radiological, and fire forensic investigations, the report concluded that the release was caused by a runaway chemical reaction inside a single TRU drum (drum # 68660). This drum contained nitrate salt-bearing transuranic TRU waste that originated from the Los Alamos National Laboratory. There was no indication of release from any other waste containers. The Board also concluded that the February 5, 2014, salt haul truck fire did not cause or contribute to the radiological release event.

A Technical Assessment Team (TAT) of experts from US national laboratories was established to perform a comprehensive, independent scientific review of the mechanisms and chemical reactions that may have contributed to the radioactive release (TAT Report 2015). The TAT report concluded that one drum, Drum 68660, was the source of radioactive contamination in WIPP. The TAT report further stated that the contents of Drum 68660 were chemically incompatible and that the drum breached as a result of internal chemical reactions.

Figure 1-6: Photo of Ruptured Drum # 68660 in Room 7, Panel 7
that caused Radiation Release at WIPP

After months of investigations into the cause of a truck fire and a radiological release, the U.S. Department of Energy released a recovery plan at the end of September, 2014 (WIPP-Recovery Plan, Sept, 2014) that outlines the steps necessary to clean up and to resume limited waste emplacement operations by mid 2016 (DOE 2015b). As can be imagined, decontamination of work areas is a key element of the WIPP Recovery Plan as a portion of the underground area was contaminated by the February 14, 2014, radiation release event. Other parts of the recovery plan include: (1) continue HEPA filtration of underground exhaust air through an expanded interim ventilation system, (2) expedite the closure of Panel 6, where a few hundred suspect waste drums assumed to contain nitrate salt-bearing waste are located, and (3) expedite the closure of Room 7 in Panel 7, the location of the ruptured waste drum where the February 14, 2014 radiation release event occurred. Sealing of Room 7 in Panel 7 was completed on May 29, 2015, following the initial closure of Panel 6 on May 13, 2015. Other recovery activities such as decontamination of selected underground areas, augmenting the filtration capacity to increase underground air flow, safety inspections of underground electrical equipment, cleaning and decontamination of underground vehicles, and re-establishing underground habitability to meet worker safety and health standards are presently underway.

In response to this incident, the CEMRC conducted accelerated analyses of the underground filters collected from Stations A and B as soon as site access was allowed. Rapid analyses were also performed on ambient air samples and on environmental samples collected in the vicinity of the WIPP site. This report summarizes the samples collected and analyzed during the calendar year 2014. The report also presents an evaluation of one year of environmental monitoring data that informed the public that the levels of radiation that escaped to the environment from the WIPP underground were very low and did not, and will not harm anyone or have any long-term environmental consequence. In terms of radiological risk at or in the vicinity of the WIPP site, the increased risk from the WIPP releases is exceedingly small, approaching zero.

# CHAPTER 2

# WIPP UNDERGROUND AIR MONITORING

The WIPP repository is ventilated by drawing ambient air down three widely spaced access shafts (air intake shaft, salt shaft, and waste handling shaft) to the underground and exhausting it out a single fourth shaft (exhaust shaft). Sampling the exhaust shaft air, at a point named Station A, allows an evaluation of the frequency and amount of any radioactivity released from or through the repository. The effluent studies at Station A are a major component of the WIPP Environmental Monitoring (WIPP-EM) program. Sampling operations at Station A provide a way to monitor for releases of radionuclides and other substances in the exhaust air from the WIPP. In addition, if radioactive materials were to be released from the facility, detection at Station A would precede observation in the local population or environment.

Station A is an above ground sampling platform that collects particulates from unfiltered air exhausted from the repository and directs air either to the environment or into a HEPA filter bank (Figure 2-1). Station B samples the underground exhaust air after HEPA filtration and, sometimes, non-filtered air during maintenance-related activities (Figure 2-2). While in filtration mode, Station B becomes a post-filtration sampler analyzed by the CEMRC and other entities. When not in filtration mode Station B is not sampling WIPP exhaust air, hence the CEMRC does not perform analyses on Station B filters unless the system is operating in filtration mode. The Overview of the WIPP ventilation system and normal underground air flow are depicted in Figure 2-3.

## Sample Collection

As was mentioned previously, unfiltered exhaust air from the underground repository is sampled at station A. The daily Station A air samples are collected on 47 mm diameter membrane filters (Versapor® membrane filter, PALL Corporation, pore size 3 μm) with the use of a shrouded probe, commonly referred to as a fixed air sampler or FAS. As shown in Figures 2-4 and 2-5, it has a transfer line running to each of three sampling legs; thus a total of three concurrent samples can be collected from each FAS, one each for the CEMRC, the site contractor, Nuclear Waste Partnership (NWP) and the New Mexico Environment Department (NMED). A previous test of the probes confirmed that this configuration allows for the collection of representative air samples (Gross et al., 2011). Under normal (non-filtration) operating conditions, each day approximately 81 $m^3$ (2,875 $ft^3$) of air is filtered through each of the Versapor filters at Station A. Typically, a CEMRC Field Program technician collects samples at Station A daily; however, occasionally more than one sample per day is collected if the flow rate on any of the sampler legs drops below 0.06 $m^3$. When this occurs, a low-flow alarm on the sampler is activated and the filters are changed as needed by WIPP radiological control technicians.


Figure 2-1: Location of Station A

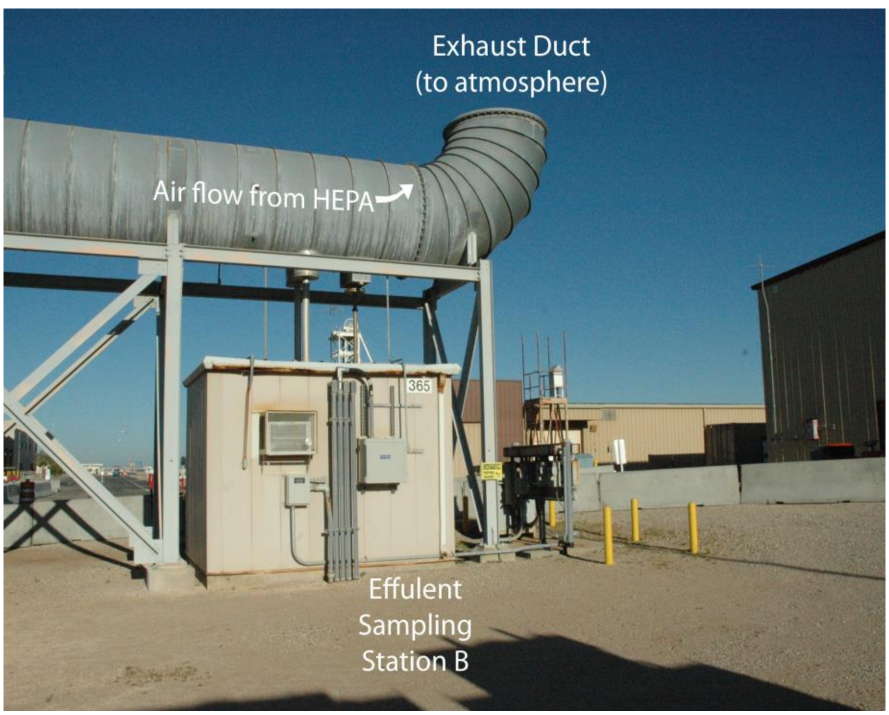



Figure 2-2: Location of Station B

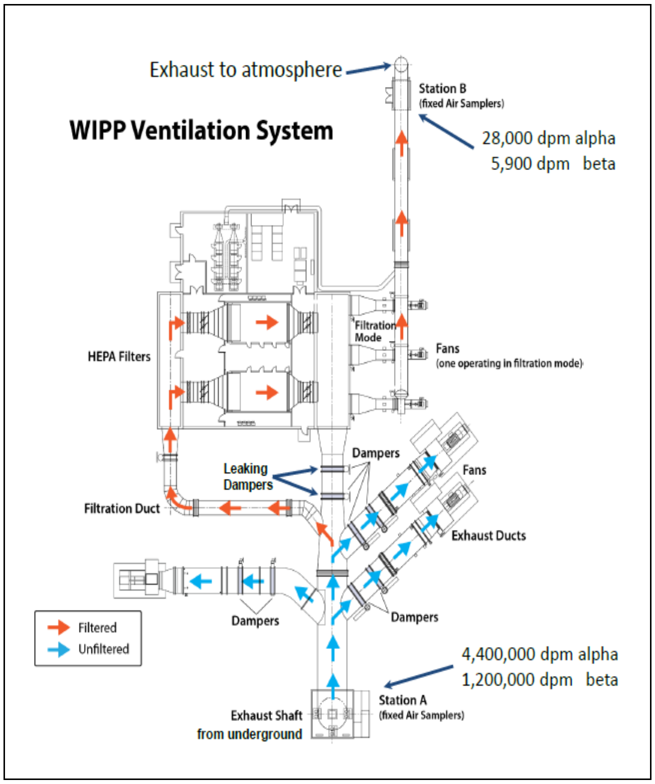



Figure 2-3: Overview of WIPP Ventilation System

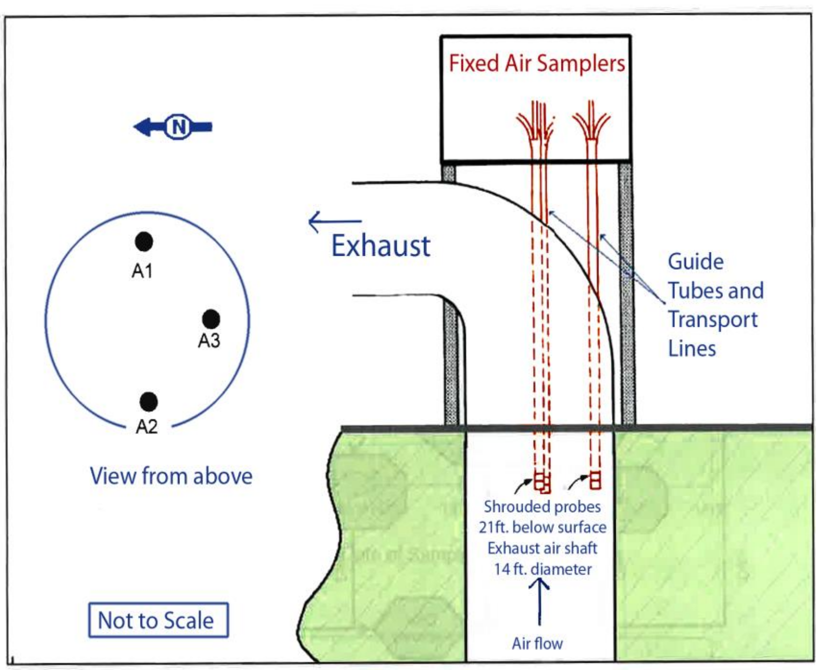



Figure 2-4: Overview of Station A

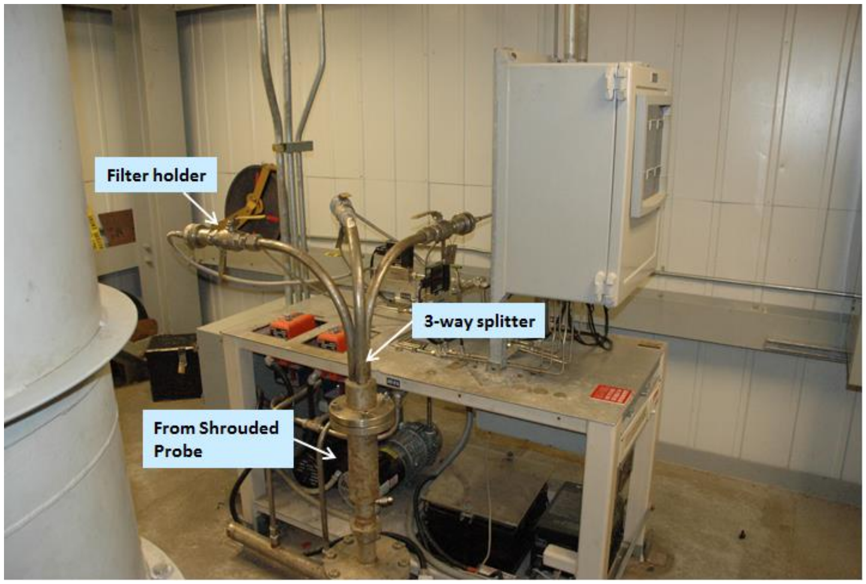



Figure 2-5: Fixed Air Samplers at Station A

Prior to the underground radiation event, weekly filter samples were typically collected at station B. Each week at Station B, approximately 583 $m^3$ (20,603 $ft^3$) of air is filtered through each of the Versapor filters. Prior to the release event, filter samples were combined monthly for Station A for analysis by CEMRC and NWP, and quarterly for Station B for analysis by NWP. For some time following the radiation release event, filters at station A and B were changed every 8 hours and measurements were performed on each individual filter initially and later on daily combined filters, by the CEMRC, depending on the levels of contamination found. As airborne concentrations receded toward pre-event ambient levels, the filter sampling and analysis program reverted back to the pre-incident schedule; however it is important to note that since the repository continues to operate in filtration mode, CEMRC technicians continue to collect Station B samples daily rather than weekly.

## Sample Preparation and Analysis

Under normal operation, once the samples are collected from the site and returned to the laboratory, individual filters are desiccated for a minimum of 48 hours to ensure that any moisture on the filters is evaporated and to ensure 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 filters are counted for gross alpha and beta activities on a Protean MPC 9604 low background gas proportional counter for 1200 minutes.

After gross alpha/beta measurements, individual filters are digested and the filter solutions are then combined into monthly composites. The monthly composite samples are used for the determination of actinide activities. Gamma analysis is performed concurrently on the same monthly composite. Only one half of the sample is used for the determination of the actinide activities. The remaining aliquot is archived. It is important to note that when not in filtration mode, Station B is not sampling WIPP exhaust air; hence CEMRC does not perform analyses on Station B filters unless the system is operating in filtration mode. Under normal operating conditions at WIPP, the exhaust is not filtered, but since the radiological incident on February 14, 2014, the WIPP ventilation system has remained in filtration mode. As a result, the CEMRC has been performing actinide analysis of Station B filters since the February 14, 2014 underground radiation release event.

Immediately following the release event, gross alpha and beta screening was not being performed routinely; instead, an emergency actinide separation was carried out on individual or daily filters collected from Station A and Station B. However as radiation levels receded, the gross alpha and beta analysis resumed beginning March, 2014 for the Station A filters and beginning July, 2014 for the Station B filters. In preparation for gross alpha/beta counting, the filter is centered on a stainless steel planchet. The standard planchets for the alpha and beta were prepared from certified solutions of $^{239}$Pu and $^{90}$Sr/$^{90}$Y obtained from Analytics, Inc. (Atlanta, GA, USA). The planchet is counted on a low-background gas proportional counter for 180-300 minutes. As airborne concentrations have continued to recede, beginning July, 2014 filters from Stations A and B have been counted for 1200 minutes. The sample detectors are gas flow window type counters with an ultra-thin window. The counting gas was P-10, which is a mixture of 90% argon and 10% methane. The operating voltage on the detector was selected as 1,450V. All samples flow at a pressure slightly exceeding atmospheric. The window consists of 80 μg/cm Mylar foil with a tint of evaporated Au. The small size of the detector and the guard ensure a very low background in this system, ~0.5 and ~0.04 counts per minute for beta and alpha respectively (see Figures 9-1 and 9-2). Daily performance checks are done using calibration sources, $^{239}$Pu for alpha and $^{90}$Sr/$^{90}$Y for beta, for efficiency control charting (2$\sigma$ warning and 3$\sigma$ limits) and ensuring that alpha/beta cross-talk are within limits ($\leq$ 0% $\alpha$ into beta and $\leq$ 0.1% beta into alpha ). Sixty-minute background counts are also recorded daily (count must be within the mean background $\pm 3\sigma$) by counting an empty planchet. The self-absorption curve was obtained individually for alpha and beta and used for all sample counts. The mean counting efficiencies for the system are found to be around 25% for alpha and 38% for beta (see Figures 9-3 and 9-4).

Filter samples for radiochemical analysis were prepared by wet digestion with $HNO_3$, HCl and perchloric acid until the filter is totally dissolved. This mixture is heated to dryness and then re-dissolved in 20 mL of 1 M HCl. Generally, half of the sample is used for the determination of the actinide activities and other half for the gamma analysis. However, for the filters collected immediately after the incident when the potential for high-levels of contaminant was significant, appropriate dilutions of filter solutions were made prior to actinide separations. The actinides are concentrated in an iron hydroxide precipitate as $Fe(OH)_3$. After decantation and centrifugation, the precipitate is dissolved in 10 ml of conc. $HNO_3$ and diluted to 20 ml to make the solution 8 M in $HNO_3$. The oxidation state of plutonium as Pu(IV) was adjusted by adding 1 ml of 1 M $NH_4I$ with a 10 min wait step, followed by 2 ml of 2 M $NaNO_2$. Plutonium is separated from americium and uranium using an anion exchange column. The fraction containing americium and uranium is separated using a TRU extraction chromatography column in 2 M $HNO_3$ as described in previous CEMRC reports (http://www.cemrc.org/report). The individual actinides are then micro-co-precipitated with a Nd-carrier and counted using alpha spectrometry. The Pre-release samples were counted for 5-days for alpha and 48 hours for gamma radionuclides as per CEMRC's standard counting protocol. The post-release samples for both alpha and gamma analysis were counted for 24 hours in order to expedite the analyses and results generation process. A simplified scheme of the radiochemical separation process is shown in Figure 2-6.

### Data Reporting

The activities of the actinides and gamma radionuclides in the WIPP underground air samples are reported in the following two ways: *activity concentration in* Bq/m$^3$ and *Activity density* (Bq/g). *Activity concentration* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by the volume of air in cubic meters (m$^3$). *Activity density* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by the aerosol mass collected on the filter in gram (g).

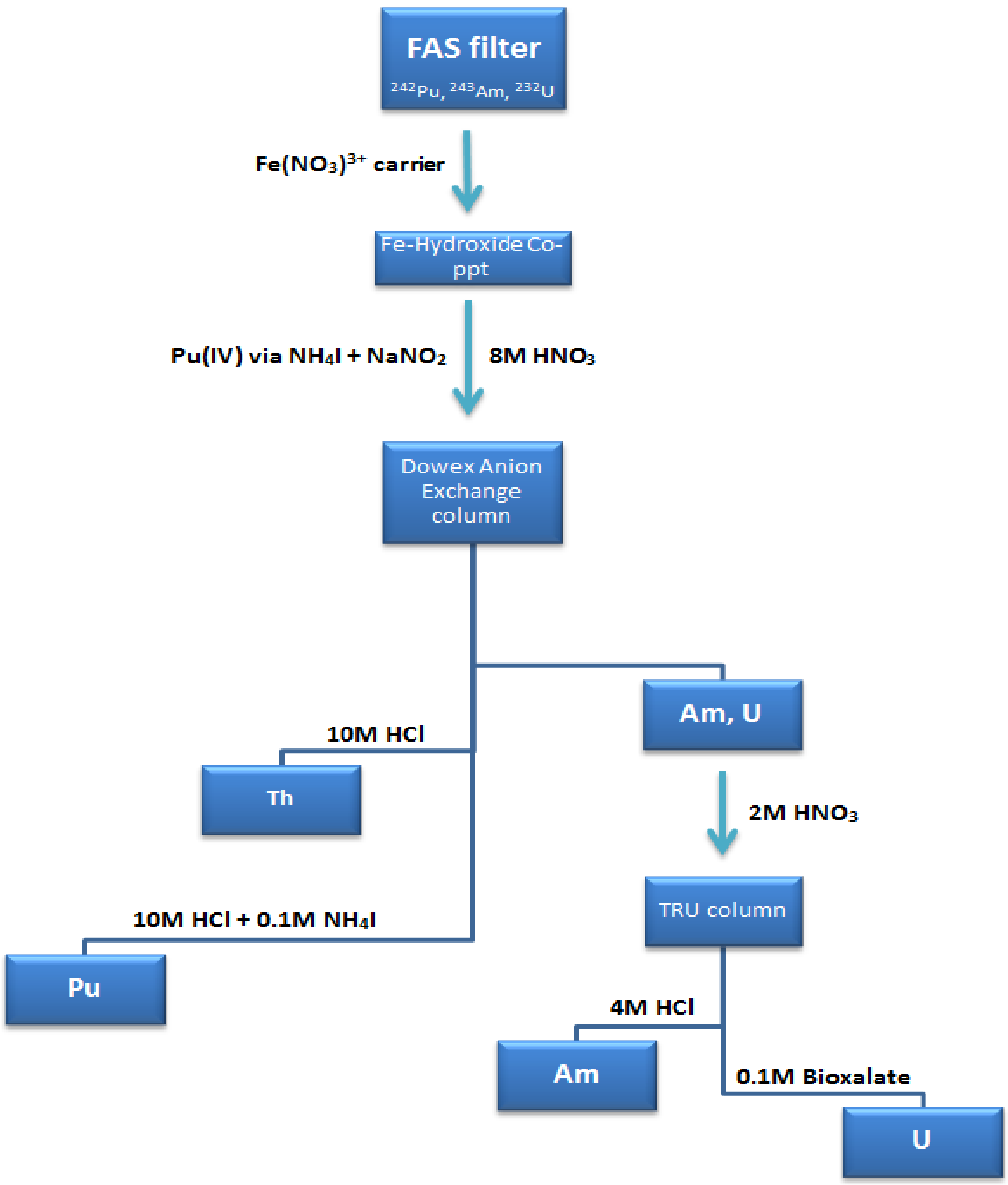



Figure 2-6: Flow Diagram Showing the Analysis of Stations A and B Filters

## Results and Discussion

Pre-Release Radionuclide concentrations in the WIPP underground Air (Station A)

Results of actinide and gamma analyses performed on Station A filters before the radiation release event are summarized in Table 2-1 (activity concentration) and Table 2-2 (Activity Density). The analyses were performed on monthly composited samples for January 2014 and on weekly composited samples collected during the first two weeks of the February 2014. No detectable concentrations of $^{238}$Pu, $^{239+240}$Pu or $^{241}$Am were detected in any of the pre-release samples. The Gamma emitters ($^{137}$Cs, $^{60}$Co and $^{40}$K) were also not measured above MDC in any of the pre-release filter samples. The filter samples collected during the February 5, fire event were analyzed separately and are discussed in the following section.

Table 2-1: Pre-release Radionuclide concentrations (Bq/m$^3$) in the unfiltered WIPP underground air filter (Station A)

| Radionuclide | Conc. Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| | Monthly composite, January 2014 | | | |
| $^{241}$Am | 1.28E-08 | 9.87E-08 | 2.56E-07 | Not detected |
| $^{239+240}$Pu | 1.29E-07 | 9.12E-08 | 1.51E-07 | Not detected |
| $^{238}$Pu | 0.00E+00 | 6.75E-08 | 1.86E-07 | Not detected |
| $^{234}$U | 4.36E-07 | 1.53E-07 | 1.73E-07 | Detection |
| $^{235}$U | 6.11E-08 | 6.03E-08 | 9.04E-08 | Not detected |
| $^{238}$U | 1.58E-07 | 1.29E-07 | 2.60E-07 | Not detected |
| $^{137}$Cs | 1.38E-05 | 1.19E-05 | 3.92E-05 | Not detected |
| $^{60}$Co | 7.50E-06 | 1.14E-05 | 3.79E-05 | Not detected |
| $^{40}$K | 1.49E-04 | 1.39E-04 | 4.58E-04 | Not detected |
| | Weekly composite, 1$^{st}$ week of February 2014 | | | |
| $^{241}$Am | 4.90E-07 | 4.93E-07 | 9.76E-07 | Not detected |
| $^{239+240}$Pu | 4.35E-08 | 2.31E-07 | 6.15E-07 | Not detected |
| $^{238}$Pu | -4.35E-08 | 1.95E-07 | 6.15E-07 | Not detected |
| $^{234}$U | 5.74E-07 | 4.64E-07 | 8.06E-07 | Not detected |
| $^{235}$U | 1.41E-07 | 3.47E-07 | 8.51E-07 | Not detected |
| $^{238}$U | 3.98E-07 | 5.49E-07 | 1.22E-06 | Not detected |
| $^{137}$Cs | -2.25E-05 | 1.09E-04 | 3.65E-04 | Not detected |
| $^{60}$Co | -1.55E-05 | 9.88E-05 | 3.32E-04 | Not detected |
| $^{40}$K | 1.13E-03 | 1.09E-03 | 3.61E-03 | Not detected |
| | Weekly composite, 2$^{nd}$ week of February 2014 | | | |
| $^{241}$Am | 7.24E-07 | 5.17E-07 | 7.93E-07 | Not detected |
| $^{239+240}$Pu | 2.30E-07 | 3.64E-07 | 8.10E-07 | Not detected |
| $^{238}$Pu | 4.02E-07 | 3.47E-07 | 5.33E-07 | Not detected |
| $^{234}$U | 3.80E-07 | 9.35E-07 | 2.24E-06 | Not detected |
| $^{235}$U | 4.69E-07 | 5.76E-07 | 1.09E-06 | Not detected |

Table 2-1: Pre-release Radionuclide concentrations (Bq/m$^3$) in the unfiltered WIPP underground air filter (Station A) (continued)

| Radionuclide | Conc. Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| | **Weekly composite, 2$^{nd}$ week of February 2014 (continued)** | | | |
| $^{238}$U | -1.33E-06 | 1.01E-06 | 3.11E-06 | Not detected |
| $^{137}$Cs | 2.05E-05 | 1.34E-04 | 4.48E-04 | Not detected |
| $^{60}$Co | -1.79E-04 | 1.52E-04 | 5.18E-04 | Not detected |
| $^{40}$K | -1.39E-03 | 1.60E-03 | 5.43E-03 | Not detected |

Table 2-2: Pre-release Radionuclide activity density (Bq/g) in the unfiltered WIPP underground air filter (Station A)

| Radionuclide | Conc. Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| | **Monthly composite, January 2014** | | | |
| $^{241}$Am | 5.27E-05 | 4.07E-04 | 1.06E-03 | Not detected |
| $^{239+240}$Pu | 5.31E-04 | 3.77E-04 | 6.23E-04 | Not detected |
| $^{238}$Pu | 0.00E+00 | 2.79E-04 | 7.67E-04 | Not detected |
| $^{234}$U | 1.80E-03 | 6.30E-04 | 7.12E-04 | Detection |
| $^{235}$U | 2.52E-04 | 2.49E-04 | 3.73E-04 | Not detected |
| $^{238}$U | 6.50E-04 | 5.34E-04 | 1.07E-03 | Not detected |
| $^{137}$Cs | 5.69E-02 | 4.91E-02 | 1.62E-01 | Not detected |
| $^{60}$Co | 3.09E-02 | 4.73E-02 | 1.57E-01 | Not detected |
| $^{40}$K | 6.13E-01 | 5.72E-01 | 1.89E+00 | Not detected |
| | **Weekly composite, 1$^{st}$ week of February 2014** | | | |
| $^{241}$Am | 1.24E-03 | 1.25E-03 | 2.47E-03 | Not detected |
| $^{239+240}$Pu | 1.10E-04 | 5.83E-04 | 1.56E-03 | Not detected |
| $^{238}$Pu | -1.10E-04 | 4.93E-04 | 1.56E-03 | Not detected |
| $^{234}$U | 1.45E-03 | 1.17E-03 | 2.04E-03 | Not detected |
| $^{235}$U | 3.58E-04 | 8.77E-04 | 2.15E-03 | Not detected |
| $^{238}$U | 1.01E-03 | 1.39E-03 | 3.07E-03 | Not detected |
| $^{137}$Cs | -5.70E-02 | 2.77E-01 | 9.24E-01 | Not detected |
| $^{60}$Co | -3.93E-02 | 2.50E-01 | 8.41E-01 | Not detected |
| $^{40}$K | 2.87E+00 | 2.76E+00 | 9.12E+00 | Not detected |
| | **Weekly composite, 2$^{nd}$ week of February 2014** | | | |
| $^{241}$Am | 3.35E-02 | 2.39E-02 | 3.67E-02 | Not detected |
| $^{239+240}$Pu | 1.06E-02 | 1.68E-02 | 3.75E-02 | Not detected |
| $^{238}$Pu | 1.86E-02 | 1.61E-02 | 2.47E-02 | Not detected |
| $^{234}$U | 1.76E-02 | 4.33E-02 | 1.03E-01 | Not detected |
| $^{235}$U | 2.17E-02 | 2.66E-02 | 5.04E-02 | Not detected |
| $^{238}$U | -6.15E-02 | 4.70E-02 | 1.44E-01 | Not detected |
| $^{137}$Cs | 9.47E-01 | 6.22E+00 | 2.07E+01 | Not detected |
| $^{60}$Co | -8.29E+00 | 7.04E+00 | 2.40E+01 | Not detected |
| $^{40}$K | -6.42E+01 | 7.42E+01 | 2.51E+02 | Not detected |

**Radionuclide concentrations in the WIPP underground air filter following the February 5, 2014 Fire Event**

The analysis results of the filter collected from Station A following the fire accident are listed in Tables 2-3 (24 hour counting results) and 2-4 (5-days counting results). The $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu were all below the detection limits. The absence of a detection of these radionuclides indicates that no nuclear waste was compromised as a result of the underground fire event.

Table 2-3: Activity Concentrations of $^{241}$Am, $^{239+240}$Pu, $^{238}$Pu, and uranium isotopes (Bq/m$^3$), in Station A filter collected soon after the fire incident at WIPP (24 hours counting)

| Radionuclide | Conc. Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| $^{241}$Am | 2.53E-06 | 7.04E-06 | 1.21E-05 | Not detected |
| $^{239+240}$Pu | 1.05E-06 | 5.88E-06 | 1.29E-05 | Not detected |
| $^{238}$Pu | -2.92E-07 | 6.85E-06 | 1.56E-05 | Not detected |
| $^{234}$U | 1.05E-04 | 3.23E-05 | 1.58E-05 | Detection |
| $^{235}$U | 1.63E-05 | 1.35E-05 | 1.58E-05 | Not detected |
| $^{238}$U | 6.22E-05 | 2.50E-05 | 2.40E-05 | Detection |

Table 2-4: Activity concentrations of actinides and gamma radionuclides (Bq/m$^3$), in Station A filter collected soon after the fire incident at WIPP (5 days counting)

| Radionuclide | Conc. Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| $^{241}$Am | -2.18E-06 | 1.79E-06 | 4.39E-06 | Not detected |
| $^{239+240}$Pu | 3.37E-06 | 3.31E-06 | 5.06E-06 | Not detected |
| $^{238}$Pu | -4.21E-07 | 2.48E-06 | 5.53E-06 | Not detected |
| $^{234}$U | 1.13E-04 | 1.92E-05 | 7.71E-06 | Detection |
| $^{235}$U | 1.08E-05 | 5.74E-06 | 7.19E-06 | Not detected |
| $^{238}$U | 7.58E-05 | 1.54E-05 | 1.28E-05 | Detection |
| $^{137}$Cs* | 9.58E-04 | 1.46E-02 | 2.48E-02 | Not detected |
| $^{60}$Co* | -6.54E-04 | 1.25E-03 | 2.14E-03 | Not detected |
| $^{40}$K* | 8.22E-04 | 1.19E-03 | 2.01E-03 | Not detected |

*counted for 48 hours for gamma emitters.

**Post-release Actinide concentrations in the WIPP underground Air (Station A, Pre-HEPA Filter)**

**Gross Alpha and Beta Activities**

The daily gross alpha and gross beta concentrations in the unfiltered underground air (air exhaust before the HEPA filtration or Station A) are shown in Figures 2-7 and 2-8. Significantly higher gross alpha and beta values were detected in filter samples collected after February 14, 2014, and through Oct, 2014. The activities appear to have gone back to the pre-release levels after Oct, 2014. A small sporadic increase in gross alpha concentrations, shown on Figure 2-7, was attributable to the disturbance of entrained materials allowing them to be transported in the WIPP underground air due to ongoing investigative and clean-up efforts by underground personnel.

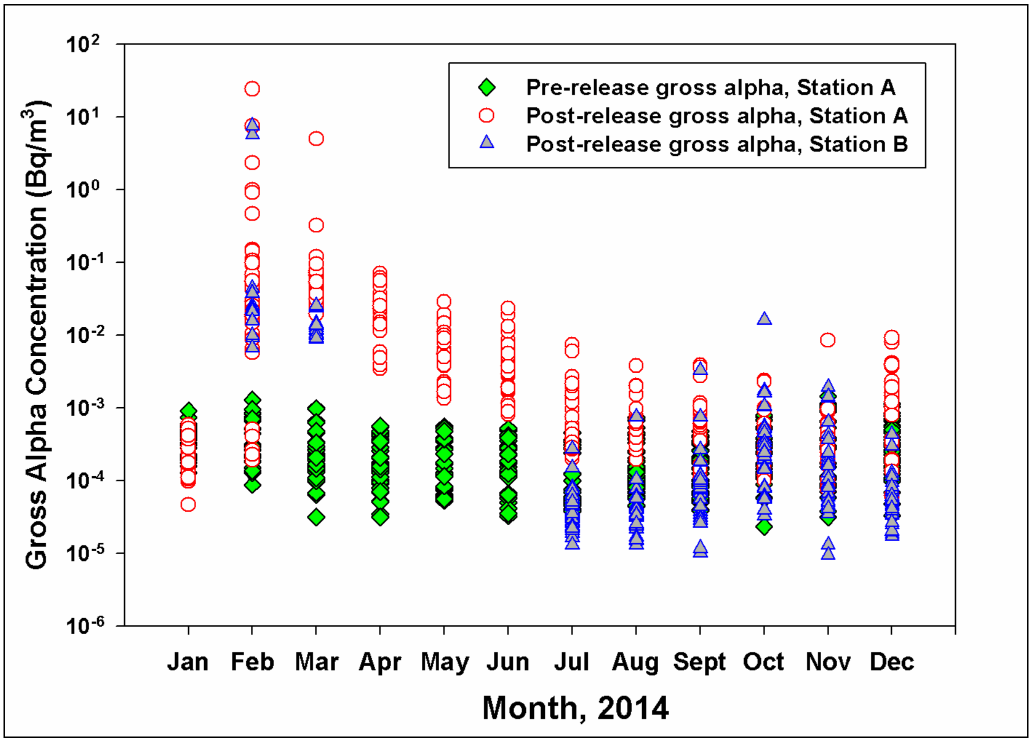



Figure 2-7: The Gross Alpha concentrations in the WIPP exhaust air before (Station A) and after HEPA filtration (Station B) in 2014

The February data for Gross Alpha taken from http://www.wipp.energy.gov

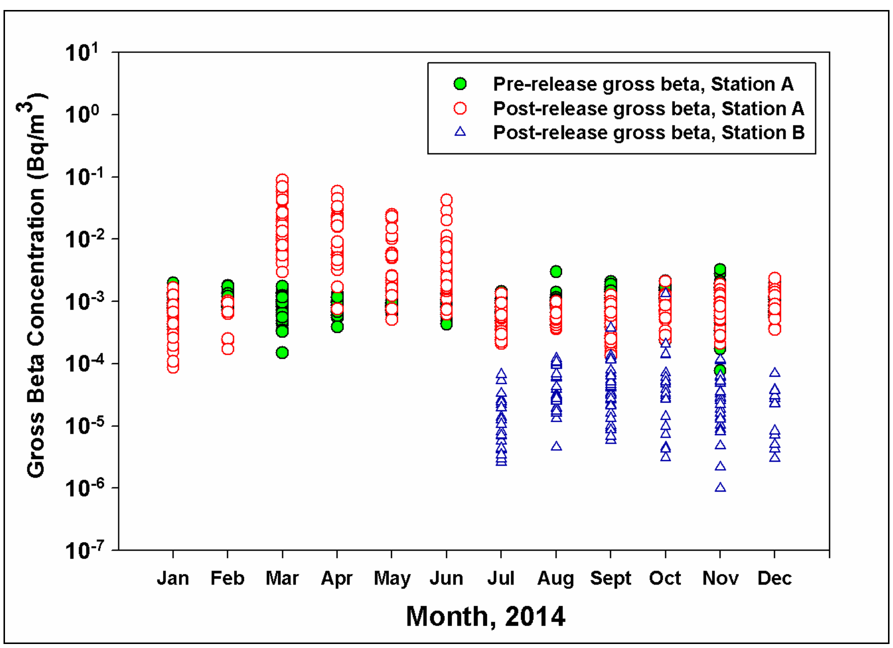



Figure 2-8: The Gross Beta Concentrations in the WIPP exhaust air before (Station A) and after HEPA filtration (Station B) in 2014

The pre- and post-release gross alpha and gross beta concentrations in the Station A filters are shown in Figures 2-9 and 2-10 for trend analysis. The gross alpha and beta concentrations exhibit clear seasonal variability with peaks occurring in the winter. Prior to the February 14 radiological event, the pre-operational baseline data is compared with the operational data to assess the integrity of the WIPP project. The gross alpha and beta activity in air filters prior to arrival of waste at WIPP were used as a baseline concentration. The bulk of the activity in those samples results from naturally occurring radioactive materials, specifically radon daughters. The baseline concentrations of gross alpha and gross beta activities were 1.49 mBq/m$^3$ and 4.90 m Bq/m$^3$, respectively. These data are then compared against disposal phase data to assess the radiological and ecological effects of radiation on workers and the general public that live and work around the WIPP. The minimum detectable activity concentrations and densities for the gross alpha emitters are $\approx 1 \times 10^{-7}$ Bq/m$^3$ and $\approx$ 0.7 Bq/g, respectively, while for gross beta emitters the corresponding values were $\approx 2 \times 10^{-7}$ Bq/m$^3$ and $\approx$ 1.7 Bq/g. The reported gross alpha and beta activities are normalized by dividing the measured activities by the mass loadings on the sample filters or by the volume of air sampled. Therefore trends in the activity densities could either be due to changes in the amount of radioactivity in the sample or the aerosol mass in the samples as the volumes of air sampled, which are not shown, have changed little during the course of the program and therefore, should have little or no effect on the activity concentrations.

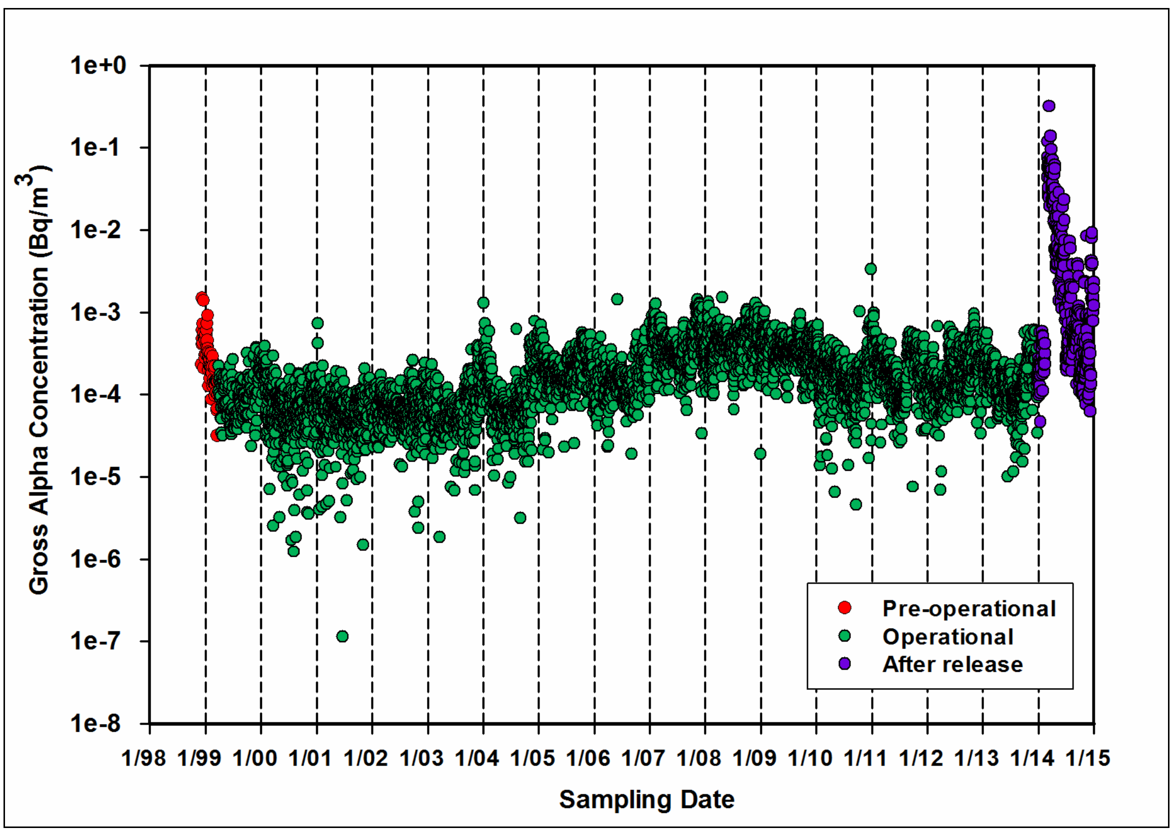



Figure 2-9: Pre- and Post-release Gross Alpha concentration in Station A (Pre-HEPA) filter

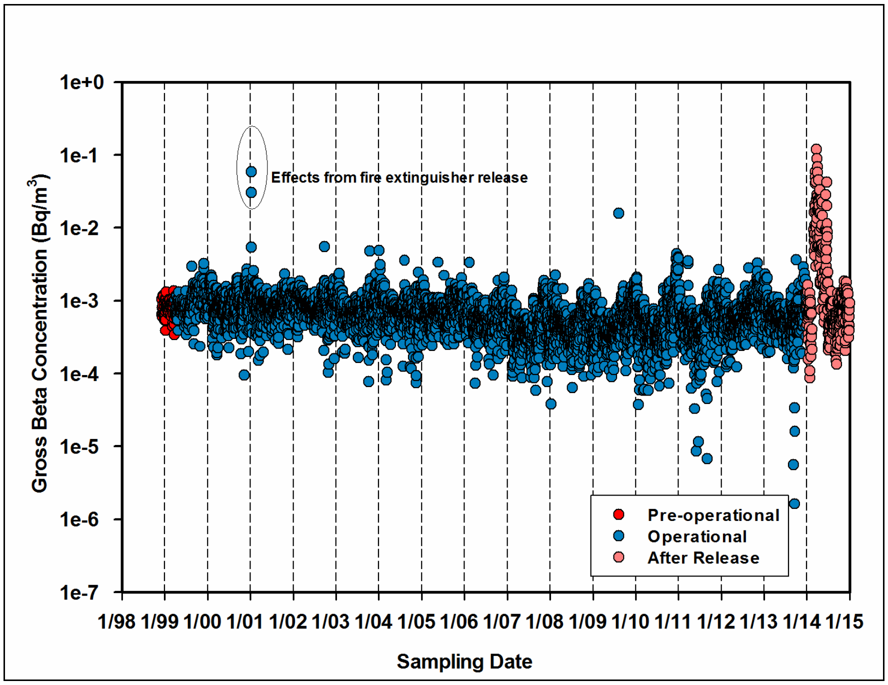



Figure 2-10: Pre- and Post-release Gross Beta concentration in Station A (Pre-HEPA) filter

Similar seasonal trends in gross beta data can also be seen (Figure 2-10). The two samples with elevated gross beta activity concentrations ca. 0.058 Bq/m$^3$ observed in early 2001 (Figure 2-10) are because of contamination released from an underground fire extinguisher. Follow-up measurements verified that the fire retardant containing $^{40}$K was the cause of the elevated results and that WIPP waste had not been released. The daily gross alpha and beta concentrations measured in unfiltered WIPP underground air following the release event, are listed in Appendix A (Table A-1).

No gravimetric data was collected from the Station A filters following the radiation release event, instead filters collected were digested and accelerated actinide analysis were performed as soon as they were received. CEMRC resumed collecting gravimetric data beginning August, 2014. A time series plot of the gross alpha and gross beta densities (Bq/g) are shown in Figures 2-11 and 2-12. The current levels are within the range of our normal background for this particular station.

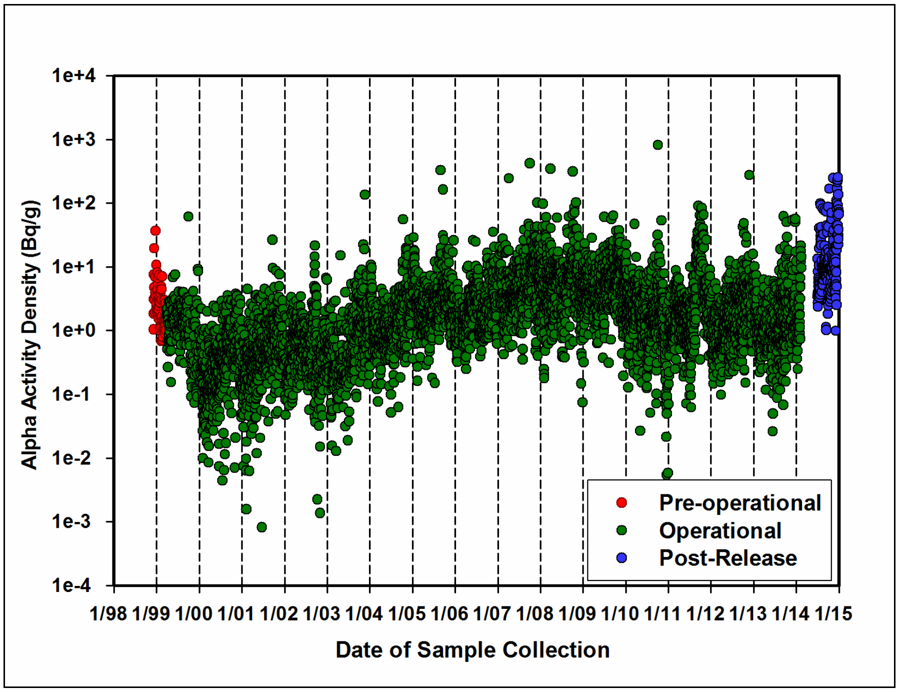



Figure 2-11: Gross Alpha Activity Densities measured in Station A filters (Post-release data from August - December 2014)

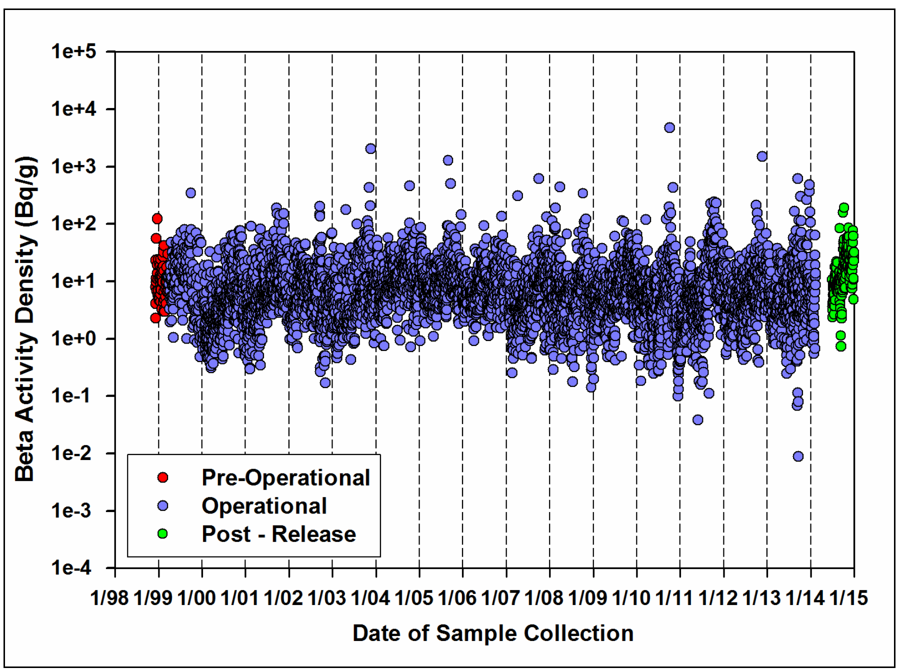



Figure 2-12: Gross Beta Activity Densities measured in Station A filters (Post-release Data from August - December 2014)

## Daily Actinide Concentrations in the WIPP's Unfiltered Underground Air (Pre-HEPA, Station A)

The time series of the activity concentrations of transuranic radionuclides $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am measured at Station A (Pre- HEPA filtration) after the release-event are shown in Figures 2-13 (daily concentration). The values detected at Station A were considerably higher than those historically measured for this Station. The daily concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu measured at Station A filter are presented in Tables 2-5 through 2-7. The maximum air concentrations of plutonium and americium detected at Station A were 4337 Bq/m$^3$ for $^{241}$Am, 672 Bq/m$^3$ for $^{239+240}$Pu and 30.3 Bq/m$^3$ for $^{238}$Pu. These results were measured on February 15, 2014. The filter that had highest activity was installed in the morning of February, 14, the day of the underground radiation release event, and was removed on February 15, 2014. The filter collected the very next day showed about 342 Bq/m$^3$ of air for $^{241}$Am and 38.8 Bq/m$^3$ of air for $^{239+240}$Pu. By the morning of February 21, these levels had dropped to about 0.65 Bq/m$^3$ for $^{241}$Am and 0.06 Bq/m$^3$ for $^{239+240}$Pu. It is important to note that these high activity values are reflective of what was detected in the unfiltered underground air prior to going through HEPA filtration systems and do not represent the activity levels that ultimately escaped to the environment.

## Weekly Actinide Concentrations in the WIPP's Unfiltered Underground Air (Pre-HEPA, Station A)

As the levels of $^{241}$Am and $^{239+240}$Pu in the WIPP exhaust air before the HEPA filtration continued to remain low after April 22, 2014, a weekly composite filter sample has been used for the determination of actinides since that date. The weekly composite filter samples results from Station A are summarized in Tables 2-8 through 2-10. Trace amounts of $^{241}$Am and $^{239+240}$Pu are still measurable above MDC (minimum detectable concentration) in these filters. Again, these levels are very low and are not expected to cause any adverse health or environmental consequences. The weekly activity concentrations of $^{241}$Am and $^{239+240}$Pu measured at filter samples collected from Station A is shown in Figure 2-14. Although the values 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. There is no risk to anyone from contamination levels this low. It is important to realize that they were only detectable because of the ultra- sensitivity of modern radiation monitoring equipment and radiochemical analyses methods performed.

The activity density data immediately following the radiation release event were not available, because filters collected during that period were not weighed. However, the aerosol mass data collected since July, 2014 showed that the activity density remained fairly consistent through December, 2014. The $^{239+240}$Pu activity density (activity per unit mass aerosol collected) at Station A was in the range of 0.26-6.6 Bq/g, while that of $^{241}$Am was in the range of 2.1-49.9 Bq/g. The weekly activity density of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu at Station A are shown in Figure 2-15 and the individual values are listed in Tables 2-11 through 2-13.

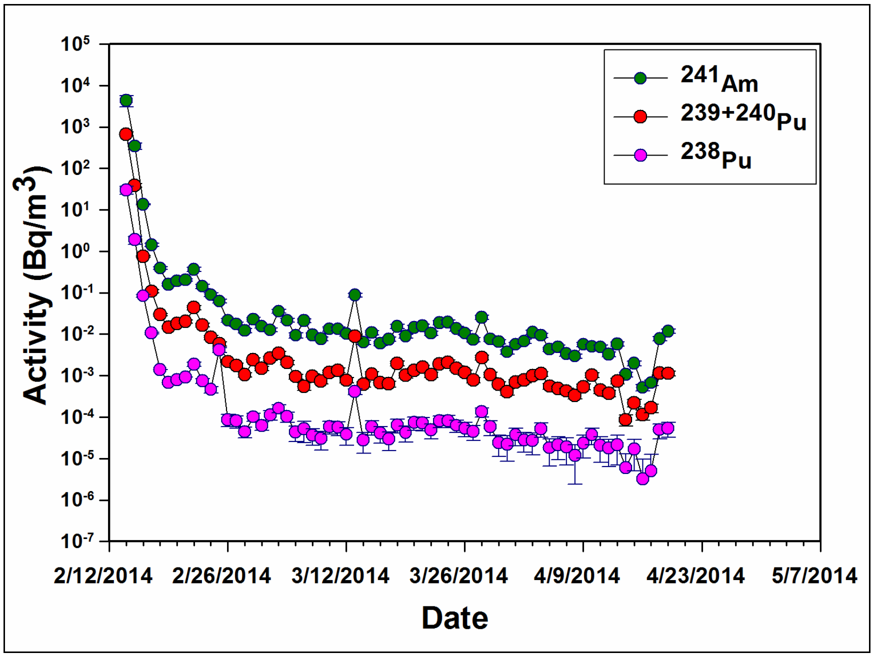



Figure 2-13: The Daily $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu concentrations in Station A (Pre-HEPA) filters following the February 14 Radiological event at WIPP

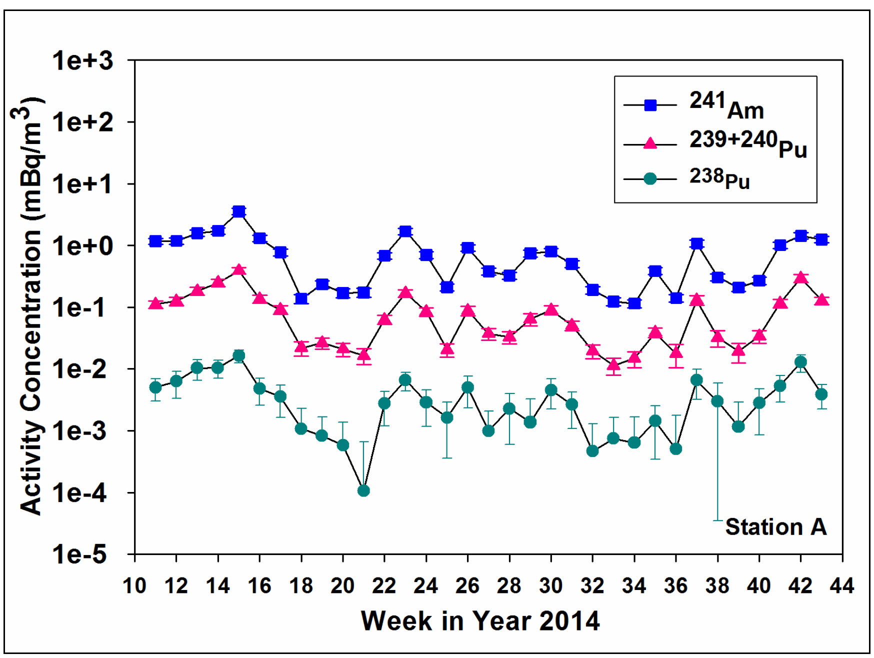



Figure 2-14: The Weekly $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu concentrations in Station A (Pre-HEPA) filters following the February 14 Radiological event at WIPP

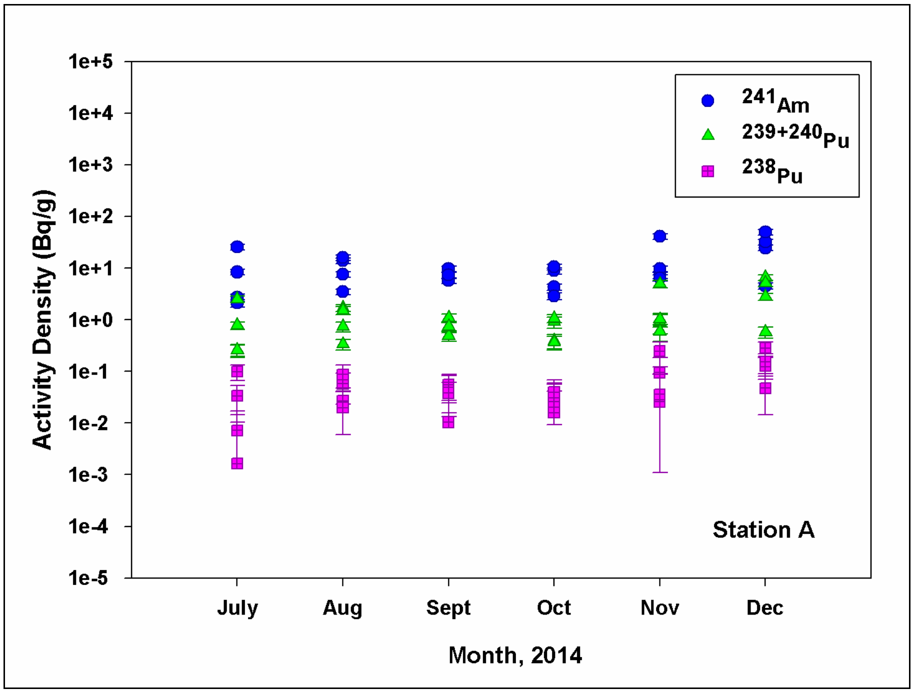



Figure 2-15: The Weekly $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu activity density in Station A (Pre-HEPA) filters following the February 14 Radiological event at WIPP

## Post-release Actinide concentrations in the WIPP underground Air (Station B, Post-HEPA filter)

In order to determine the amount and type of radionuclides that were ultimately released into the environment, the accelerated analyses of Station B filters were carried out as these filters sampled the underground exhaust air after HEPA filtration. The daily gross alpha and gross beta concentrations in the WIPP underground air after the HEPA filtration (Station B) are shown in Figure 2-16. It is important to note that the 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 and instead, an emergency actinide separation campaign was carried out on individual or daily filters collected from Station B in order 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 as the CEMRC had not routinely conducted gross alpha/beta analyses on Station B filters prior to the February 14, 2014 event. As would be expected, the Station B analyses showed much lower levels of activity as compared to those of Station A. The daily gross alpha and beta concentrations measured in filtered WIPP underground air July, 2014 are listed in Appendix B (Table B1).

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 was started on February 14, 2014, when continuous air monitors (CAM) in the WIPP underground facility detected elevated levels of radioactive contamination and shifted the underground ventilation system into filtration mode, forcing all air exiting the facility through the HEPA filters. Naturally, due to remaining contamination in the exhaust drift of the repository, the WIPP underground facility has remained in filtration mode since the event occurred. The 860A fan ran for approximately two months following the radiological incident before being taken off-line for maintenance-related activities. Since that time, the 860B or the 860C fans have been operating to continue the air filtration process. Because the 860A fan was operational immediately following the radiological release, a small amount of residual contamination could be present in the adjacent ductwork and the interior workings of the fan which could result in a low level of contamination being released during the restart. As can be seen in Figure 2.16, the current gross alpha and beta activities at Station B have returned to normal background levels.

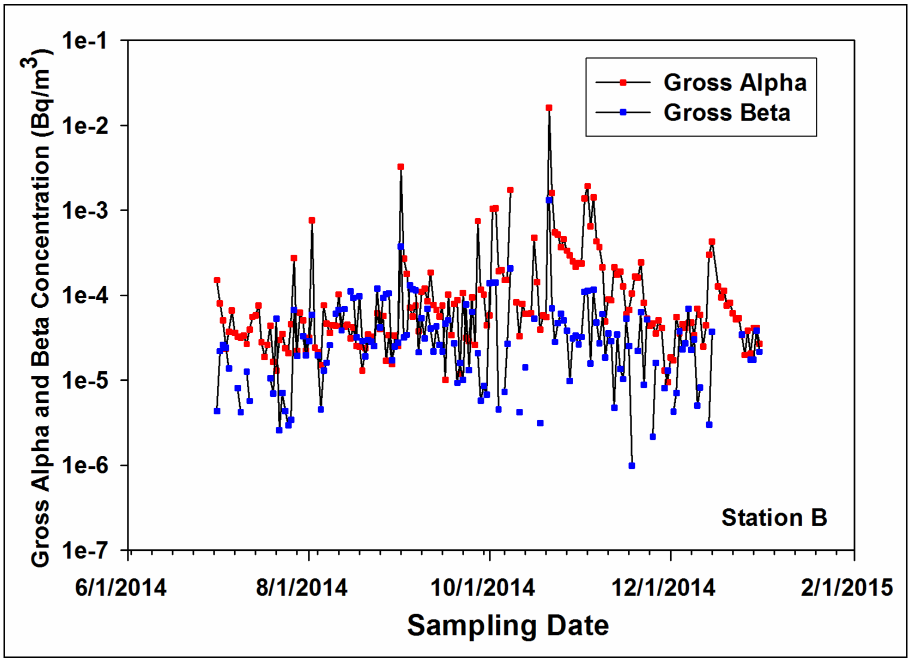



Figure 2-16: Daily Gross Alpha and Gross Beta Activity concentration measured in the filtered underground air (Station B) since July 2014

The Station B (WIPP exhaust air released to the environment after filtration) showed much lower levels, about 2.3 Bq/m$^3$ of air for $^{241}$Am and 0.22 Bq/m$^3$ of air for $^{239+240}$Pu when it was collected on February 18 at the first collection opportunity, four days after the release. Given that this particular filter remained in the sampler from the time of the underground radiation detection event until four days after the event, this filter was representative of the total amount of $^{241}$Am and $^{239+240}$Pu, and $^{238}$Pu that may have been released into the environment. By February 21, a Station B sample had only about 0.43 Bq/m$^3$ of combined Pu and Am. By the middle of April, 2014, the concentrations of $^{241}$Am and $^{239+240}$Pu measured were in the range 0.11 to 0.53 Bq/m$^3$ and 0.01 to 0.06 Bq/m$^3$ respectively, at Station B. The $^{238}$Pu level has been below the detection limit in samples from February 19 to the present. The time series of the activity concentrations of transuranic radionuclides $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am measured at Station B (Post-HEPA filtration) after the release-event are shown in Figure 2-17. As the concentration levels of these radionuclides receded, beginning April 22, 2014, actinide analyses are performed on weekly composite samples. The activity concentrations of $^{241}$Am and $^{239+240}$Pu, in the weekly filters collected from Station B is shown in Figure 2-18. The daily as well as weekly concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu measured at Station B filter are summarized in Tables 2-14 through 2-16 (Daily concentrations) and Tables 2-17 through 2-19 (Weekly concentrations).

CEMRC began collecting aerosol mass data of Station B filters beginning August of 2014. The $^{239+240}$Pu activity density (activity per unit mass aerosol collected) at Station B was in the range of 0.15-20.8 Bq/g, while that of $^{241}$Am was in the range of 2.1-222 Bq/g. The weekly activity density of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu at Station B are shown in Figure 2-19 and the individual values are summarized in Tables 2-20 through 2-22.

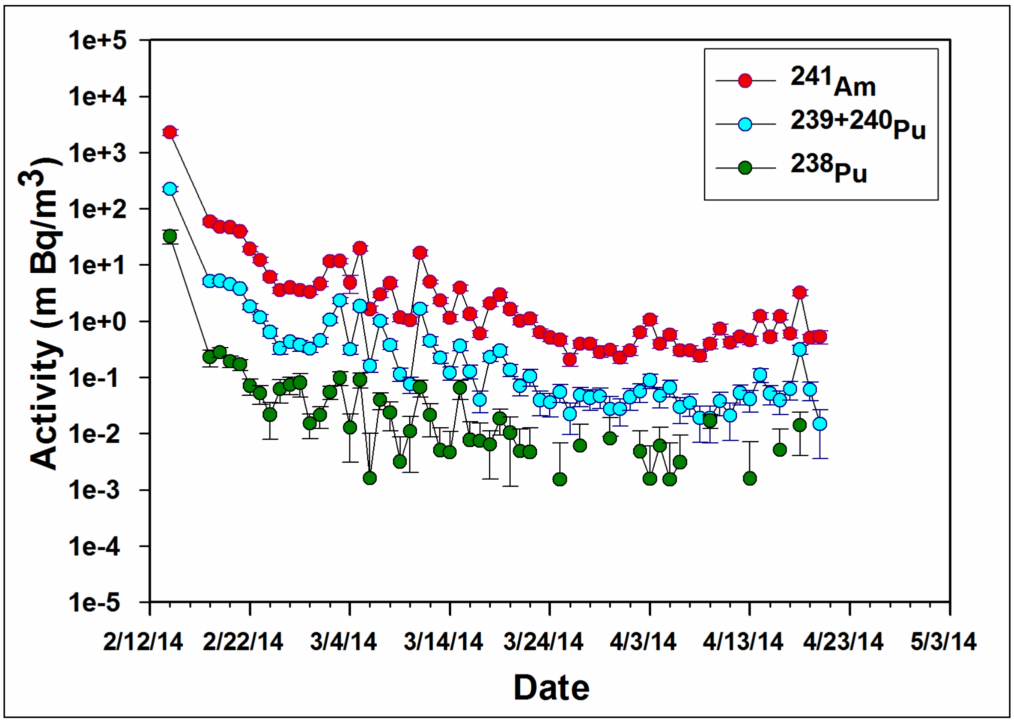



Figure 2-17: The Daily $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu concentrations in Station B (Post-HEPA) filters following the February 14 Radiological event at WIPP

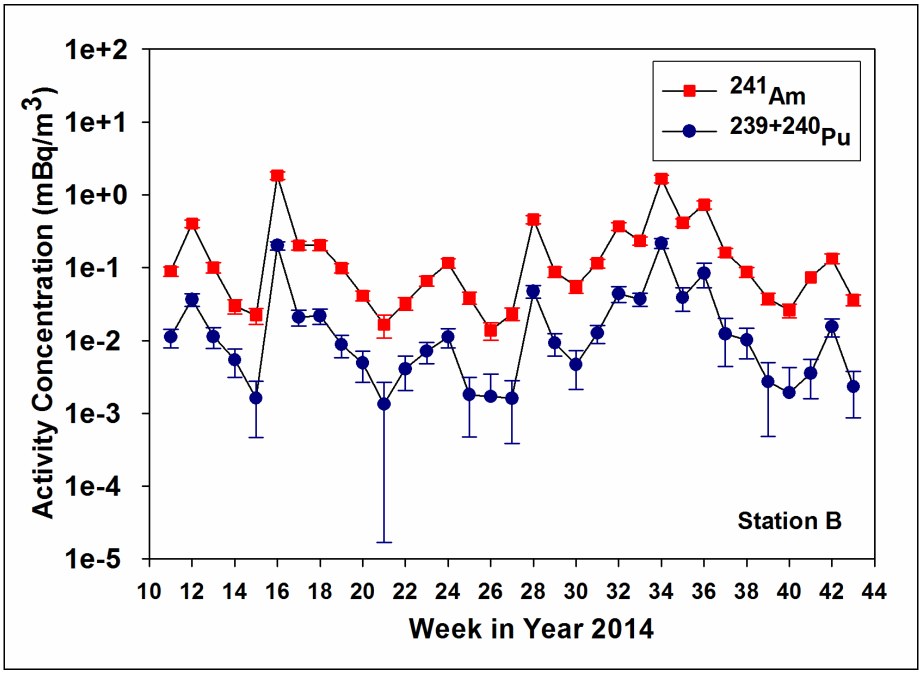



Figure 2-18: The weekly $^{241}$Am and $^{239+240}$Pu concentrations in Station B (Post-HEPA) filters following the February 14 Radiological event at WIPP

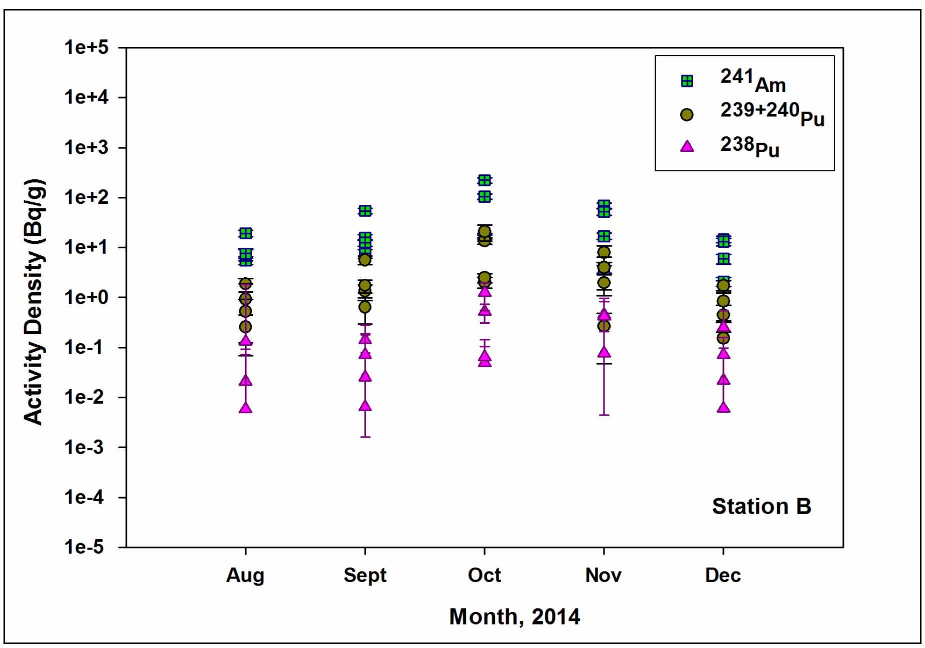



Figure 2-19: The weekly $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu activity density in Station B (Post-HEPA) filters following the February 14 Radiological event at WIPP

The flow rate through the HEPA filters is approximately 1699 $m^3$ (60,000 $ft^3$) per minute and the station B air sampler draws 0.06 $m^3$ (2 $ft^3$) per minute. Thus, the total estimated release based on CEMRC analyses of the station B sample is $2.53\times10^7$ Bq of $^{241}$Am and 2.48 $\times10^6$ Bq of $^{239+240}$Pu. Summing all isotopes (Pu and Am) measured over the first week after the event, and accounting for the total air flow, the source term was calculated as 2.8E+07 Bq (~0.8 mCi). This source term is dominated by $^{241}$Am (>90%).

An analysis of historical operational data 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 2-20). From 2000 through 2013, only nine Station A measurements can 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 and 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 compatible with a global fallout origin as reported in different studies (Kelly et al., 1999, Hardy et al., 1973). This compatibility is not proof that there was not a trace of $^{238}$Pu released from within the repository; it is only suggestive of a global fallout origin. It is important to note that activities detected in those four composites were extremely low and did not even trigger the underground Continuous Air Monitors (CAM) that are used to detect any release of radioactivity. There was no unambiguous evidence of releases from WIPP operations until the February 14, 2014 event.

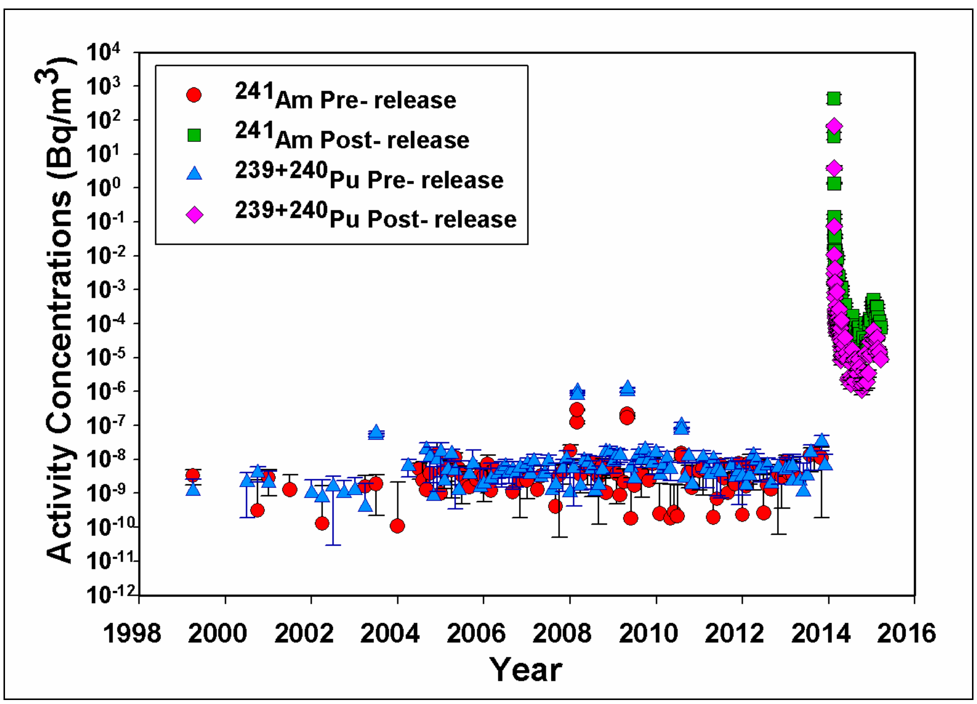



Figure 2-20: Pre- and Post-radiological event of $^{239+240}$Pu and $^{241}$Am concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

**Post-release gamma radionuclide concentrations in the WIPP underground Air (Station A and Station B)**

With the exception of one detection of $^{137}Cs$ (which was detected in Station A filter collected on February 14, 2014), no detectable gamma-emitting radionuclides were observed in any of the filter samples collected from Station A or Station B following the radiological event at WIPP. The concentrations of gamma-emitters $^{137}Cs$, $^{60}Co$ and $^{40}K$ measured in Station A and Station B filter samples are shown in Figures 2-21 through 2-26. The individual values measured are summarized in Appendix C (Station A, Tables C-1 to C-9) and Appendix D Station B; Tables D-1 to D-9).

An analysis of historical operational data indicates with the exception of occasional detections from $^{40}K$, no detectable gamma-emitting radionuclides were observed during the last fifteen years of monitoring. Since these isotopes were not detected, no comparisons between years or among locations were performed.

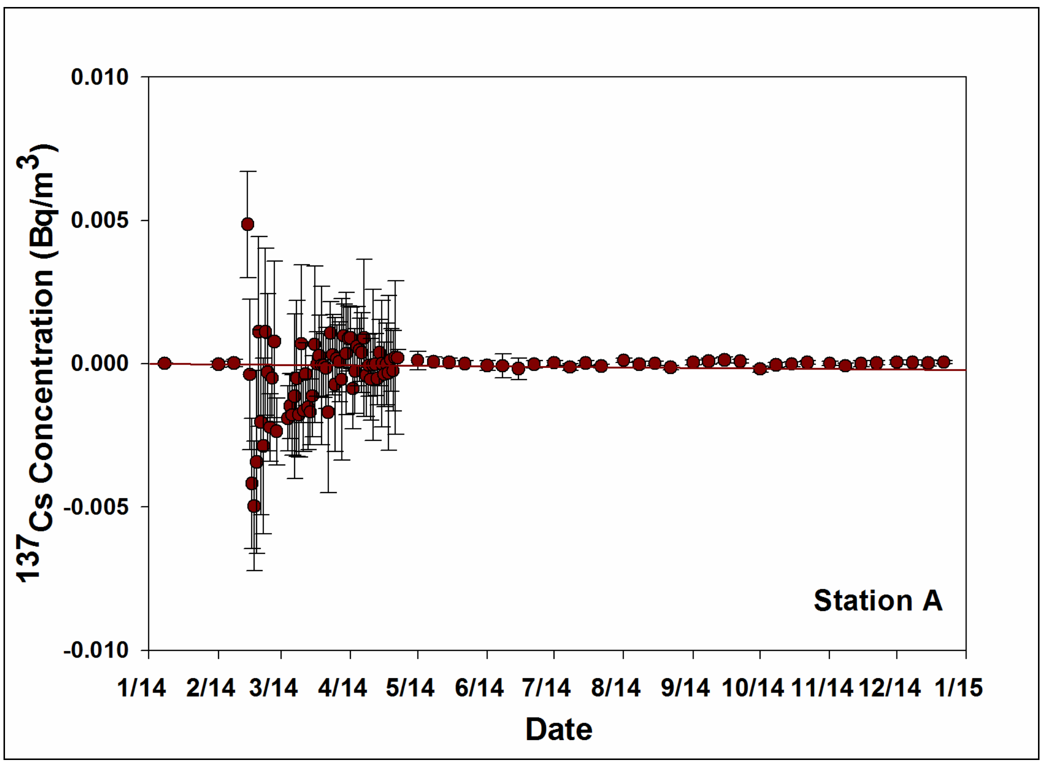



Figure 2-21: The $^{137}Cs$ concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

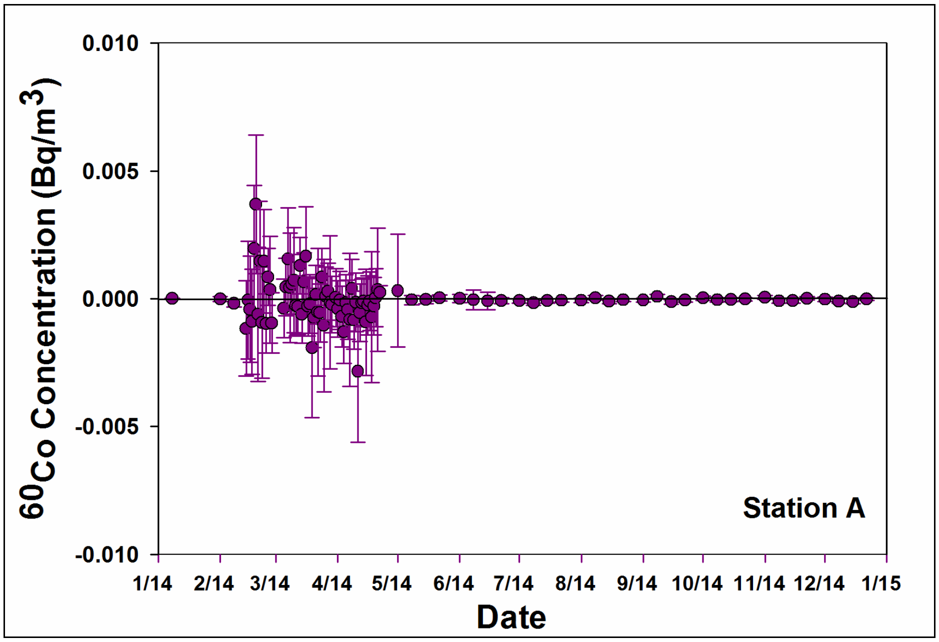



Figure 2-22: The $^{60}Co$ concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

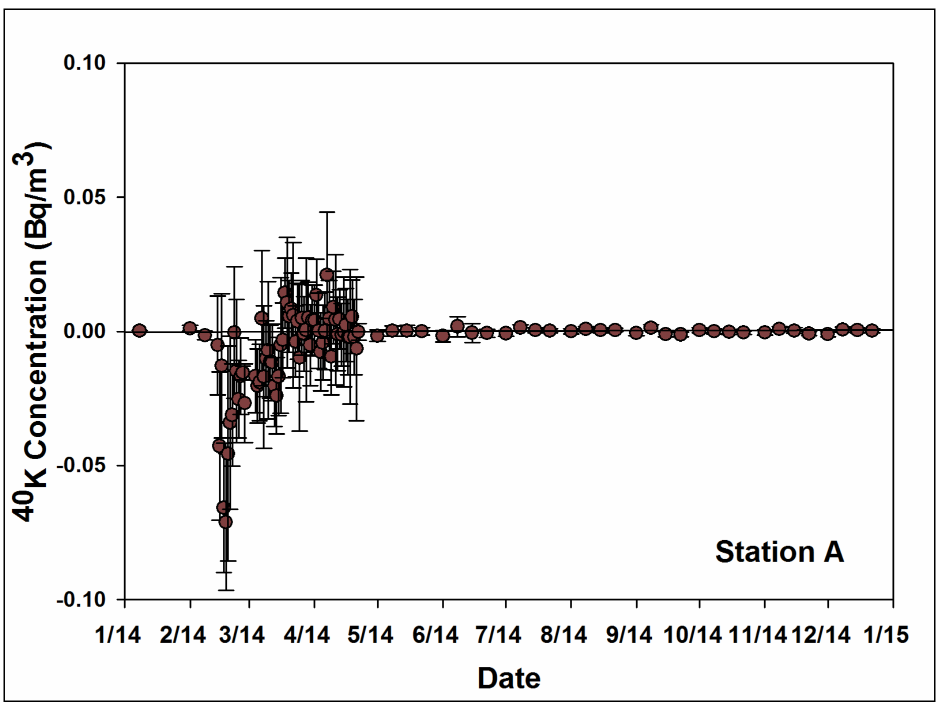



Figure 2-23: The $^{40}K$ concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

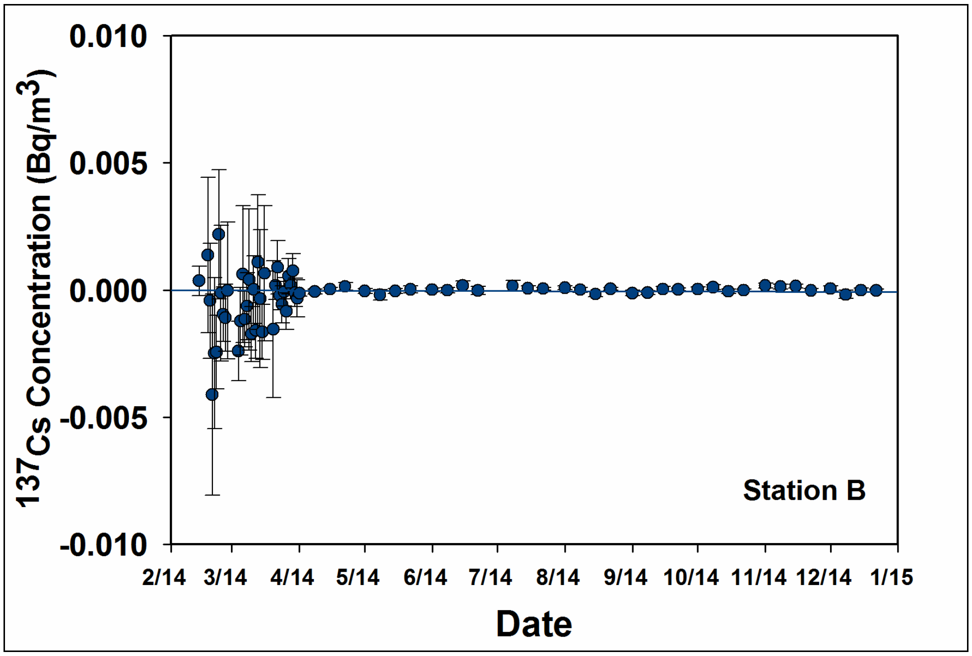



Figure 2-24: The $^{137}$Cs concentrations in the WIPP exhaust air at Station B (Post-HEPA)

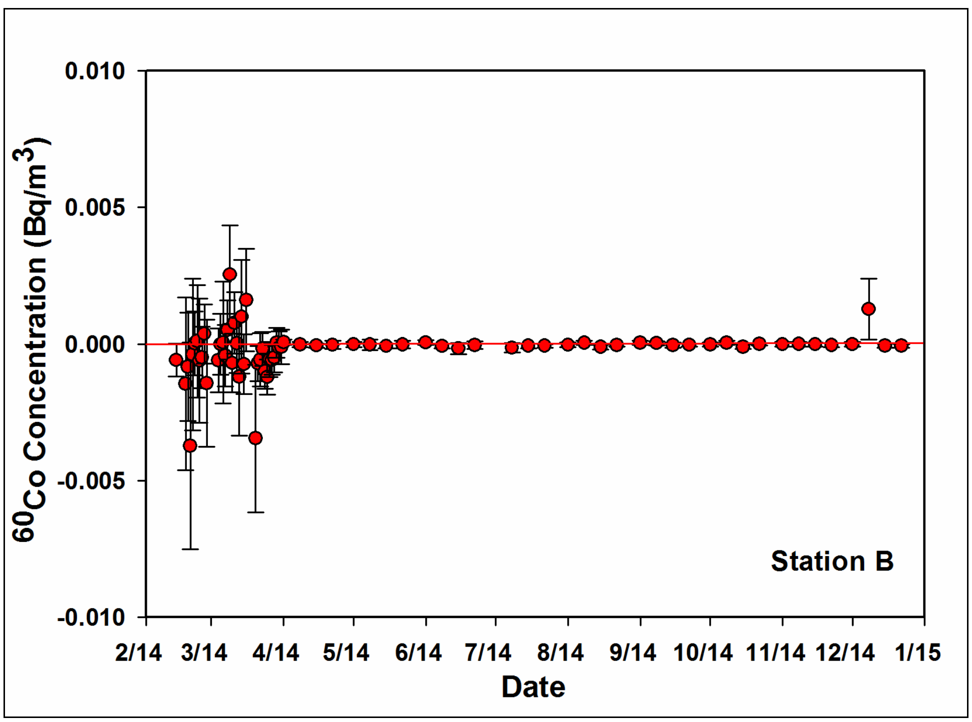



Figure 2-25: The $^{60}$Co concentrations in the WIPP exhaust air at Station B (Post-HEPA)

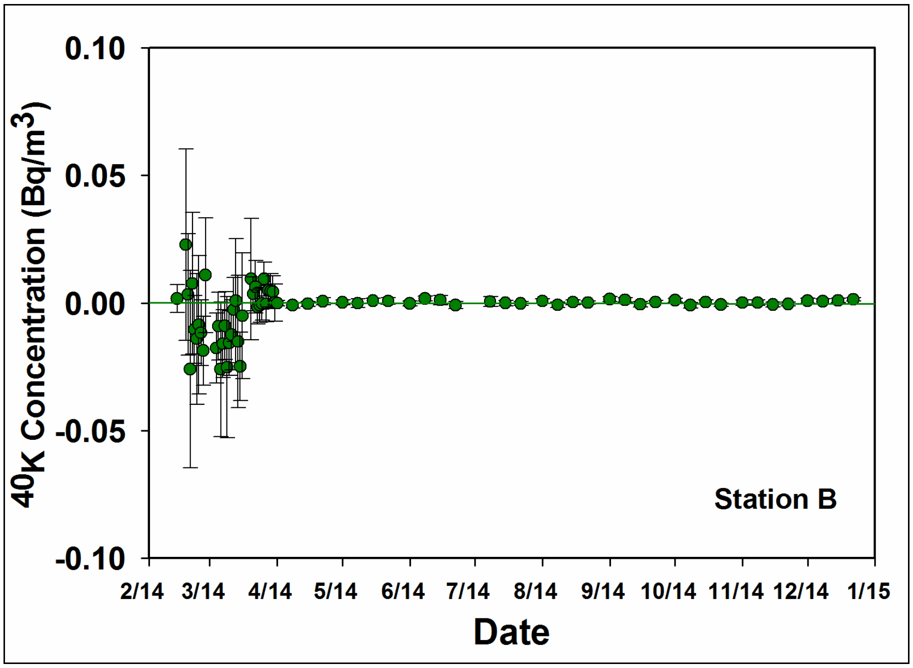



Figure 2-26: The $^{40}K$ concentrations in the WIPP exhaust air at Station B (Post-HEPA)

Table 2-5: Daily Activity concentrations of $^{241}Am$ (Bq/m$^3$) in Station A (Pre-HEPA) filters in 2014

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 4.34E+03 | 1.26E+03 | 2.77E+01 | Detected |
| 2/15/2014 | 3.43E+02 | 6.07E+01 | 3.18E+00 | Detected |
| 2/16/2014 | 1.35E+01 | 3.83E-01 | 3.01E-02 | Detected |
| 2/17/2014 | 1.43E+00 | 1.38E-01 | 2.62E-03 | Detected |
| 2/18/2014 | 3.94E-01 | 2.47E-02 | 3.48E-05 | Detected |
| 2/19/2014 | 1.60E-01 | 1.00E-02 | 2.75E-05 | Detected |
| 2/20/2014 | 1.93E-01 | 1.32E-02 | 2.79E-05 | Detected |
| 2/21/2014 | 2.05E-01 | 1.22E-02 | 2.68E-05 | Detected |
| 2/22/2014 | 3.67E-01 | 3.90E-02 | 2.04E-05 | Detected |
| 2/23/2014 | 1.43E-01 | 1.54E-02 | 2.06E-05 | Detected |
| 2/24/2014 | 9.00E-02 | 9.60E-03 | 1.34E-05 | Detected |
| 2/25/2014 | 6.29E-02 | 6.77E-03 | 1.18E-05 | Detected |
| 2/26/2014 | 2.15E-02 | 2.33E-03 | 1.33E-05 | Detected |
| 2/27/2014 | 1.73E-02 | 1.90E-03 | 1.46E-05 | Detected |
| 2/28/2014 | 1.22E-02 | 1.33E-03 | 6.60E-06 | Detected |
| 3/1/2014 | 2.29E-02 | 2.50E-03 | 5.46E-06 | Detected |
| 3/2/2014 | 1.55E-02 | 1.72E-03 | 8.15E-06 | Detected |

Table 2-5: Daily Activity concentrations of $^{241}$Am (Bq/m$^3$) in Station A (Pre-HEPA) Filters in 2014 (continued)

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 3/3/2014 | 1.27E-02 | 1.40E-03 | 7.41E-06 | Detected |
| 3/4/2014 | 3.56E-02 | 3.86E-03 | 1.45E-05 | Detected |
| 3/5/2014 | 2.17E-02 | 2.41E-03 | 1.31E-05 | Detected |
| 3/6/2014 | 9.30E-03 | 1.33E-03 | 6.35E-05 | Detected |
| 3/7/2014 | 2.12E-02 | 2.33E-03 | 1.60E-05 | Detected |
| 3/8/2014 | 9.52E-03 | 1.11E-03 | 1.23E-05 | Detected |
| 3/9/2014 | 7.70E-03 | 8.83E-04 | 1.32E-05 | Detected |
| 3/10/2014 | 1.33E-02 | 1.51E-03 | 1.08E-05 | Detected |
| 3/11/2014 | 1.34E-02 | 1.52E-03 | 1.29E-05 | Detected |
| 3/12/2014 | 1.03E-02 | 1.22E-03 | 4.24E-05 | Detected |
| 3/13/2014 | 8.77E-02 | 9.70E-03 | 1.19E-05 | Detected |
| 3/14/2014 | 6.41E-03 | 7.42E-04 | 1.41E-05 | Detected |
| 3/15/2014 | 1.09E-02 | 1.27E-03 | 1.55E-05 | Detected |
| 3/16/2014 | 5.98E-03 | 6.86E-04 | 1.02E-05 | Detected |
| 3/17/2014 | 7.53E-03 | 8.64E-04 | 1.35E-05 | Detected |
| 3/18/2014 | 1.53E-02 | 1.71E-03 | 1.02E-05 | Detected |
| 3/19/2014 | 8.94E-03 | 1.03E-03 | 1.49E-05 | Detected |
| 3/20/2014 | 1.45E-02 | 1.64E-03 | 1.11E-05 | Detected |
| 3/21/2014 | 1.56E-02 | 1.80E-03 | 1.39E-05 | Detected |
| 3/22/2014 | 1.06E-02 | 1.23E-03 | 1.17E-05 | Detected |
| 3/23/2014 | 1.89E-02 | 2.16E-03 | 1.43E-05 | Detected |
| 3/24/2014 | 1.94E-02 | 2.32E-03 | 1.56E-05 | Detected |
| 3/25/2014 | 1.36E-02 | 1.74E-03 | 2.83E-05 | Detected |
| 3/26/2014 | 1.06E-02 | 1.43E-03 | 2.86E-05 | Detected |
| 3/27/2014 | 7.35E-03 | 8.88E-04 | 1.78E-05 | Detected |
| 3/28/2014 | 2.53E-02 | 3.05E-03 | 1.67E-05 | Detected |
| 3/29/2014 | 7.63E-03 | 8.88E-04 | 1.25E-05 | Detected |
| 3/30/2014 | 6.61E-03 | 7.77E-04 | 1.13E-05 | Detected |
| 3/31/2014 | 3.74E-03 | 4.55E-04 | 1.53E-05 | Detected |
| 4/1/2014 | 5.68E-03 | 6.60E-04 | 1.26E-05 | Detected |
| 4/2/2014 | 6.79E-03 | 7.84E-04 | 1.32E-05 | Detected |
| 4/3/2014 | 1.10E-02 | 1.27E-03 | 1.76E-05 | Detected |
| 4/4/2014 | 9.41E-03 | 1.09E-03 | 1.09E-05 | Detected |
| 4/5/2014 | 4.32E-03 | 5.25E-04 | 1.43E-05 | Detected |
| 4/6/2014 | 4.87E-03 | 5.80E-04 | 9.98E-06 | Detected |
| 4/7/2014 | 3.37E-03 | 4.20E-04 | 1.21E-05 | Detected |

Table 2-5: Daily Activity concentrations of $^{241}Am$ ($Bq/m^3$) in Station A (Pre-HEPA) filters in 2014 (continued)

| Sample Date | $^{241}Am$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 4/8/2014 | 2.95E-03 | 3.75E-04 | 3.50E-05 | Detected |
| 4/9/2014 | 5.69E-03 | 6.79E-04 | 1.18E-05 | Detected |
| 4/10/2014 | 4.99E-03 | 6.00E-04 | 1.47E-05 | Detected |
| 4/11/2014 | 4.86E-03 | 5.81E-04 | 1.80E-05 | Detected |
| 4/12/2014 | 3.30E-03 | 4.35E-04 | 2.83E-05 | Detected |
| 4/13/2014 | 5.79E-03 | 7.00E-04 | 1.30E-05 | Detected |
| 4/14/2014 | 1.07E-03 | 1.53E-04 | 1.70E-05 | Detected |
| 4/15/2014 | 2.00E-03 | 2.59E-04 | 1.24E-05 | Detected |
| 4/16/2014 | 5.18E-04 | 9.10E-05 | 2.55E-05 | Detected |
| 4/17/2014 | 6.78E-04 | 1.02E-04 | 1.91E-05 | Detected |
| 4/18/2014 | 7.75E-03 | 9.17E-04 | 1.19E-05 | Detected |
| 4/19/2014 | 1.17E-02 | 1.38E-03 | 1.49E-05 | Detected |
| 4/20/2014 | 1.13E-02 | 1.32E-03 | 1.41E-05 | Detected |
| 4/21/2014 | 2.65E-03 | 3.31E-04 | 1.89E-05 | Detected |

Table 2-6: Daily Activity concentrations of $^{239+240}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{239+240}Pu$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 6.72E+02 | 7.77E+01 | 1.34E+00 | Detected |
| 2/15/2014 | 3.88E+01 | 3.50E+00 | 1.88E-01 | Detected |
| 2/16/2014 | 7.54E-01 | 4.07E-02 | 8.85E-04 | Detected |
| 2/17/2014 | 1.08E-01 | 9.60E-03 | 6.59E-04 | Detected |
| 2/18/2014 | 2.97E-02 | 1.94E-03 | 2.85E-05 | Detected |
| 2/19/2014 | 1.47E-02 | 1.01E-03 | 2.99E-05 | Detected |
| 2/20/2014 | 1.78E-02 | 1.23E-03 | 1.88E-05 | Detected |
| 2/21/2014 | 2.01E-02 | 1.57E-03 | 2.28E-05 | Detected |
| 2/22/2014 | 4.36E-02 | 4.71E-03 | 1.11E-05 | Detected |
| 2/23/2014 | 1.66E-02 | 1.81E-03 | 1.04E-05 | Detected |
| 2/24/2014 | 8.23E-03 | 9.42E-04 | 2.44E-05 | Detected |
| 2/25/2014 | 5.80E-03 | 7.30E-04 | 2.39E-05 | Detected |
| 2/26/2014 | 2.17E-03 | 2.69E-04 | 1.36E-05 | Detected |
| 2/27/2014 | 1.75E-03 | 2.23E-04 | 1.74E-05 | Detected |
| 2/28/2014 | 1.04E-03 | 1.27E-04 | 5.34E-06 | Detected |
| 3/1/2014 | 2.40E-03 | 2.86E-04 | 6.88E-06 | Detected |
| 3/2/2014 | 1.48E-03 | 1.76E-04 | 1.04E-05 | Detected |

Table 2-6: Daily Activity concentrations of $^{239+240}Pu$ (Bq/m$^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{239+240}Pu$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 3/3/2014 | 2.63E-03 | 3.21E-04 | 1.39E-05 | Detected |
| 3/4/2014 | 3.44E-03 | 4.01E-04 | 1.12E-05 | Detected |
| 3/5/2014 | 2.08E-03 | 2.54E-04 | 1.11E-05 | Detected |
| 3/6/2014 | 9.47E-04 | 1.28E-04 | 2.18E-05 | Detected |
| 3/7/2014 | 5.51E-04 | 1.08E-04 | 3.92E-05 | Detected |
| 3/8/2014 | 9.65E-04 | 1.32E-04 | 1.84E-05 | Detected |
| 3/9/2014 | 7.38E-04 | 1.06E-04 | 1.11E-05 | Detected |
| 3/10/2014 | 1.19E-03 | 1.58E-04 | 1.14E-05 | Detected |
| 3/11/2014 | 1.33E-03 | 1.78E-04 | 1.59E-05 | Detected |
| 3/12/2014 | 7.70E-04 | 1.14E-04 | 1.98E-05 | Detected |
| 3/13/2014 | 8.84E-03 | 1.03E-03 | 1.14E-05 | Detected |
| 3/14/2014 | 6.14E-04 | 9.48E-05 | 1.52E-05 | Detected |
| 3/15/2014 | 1.08E-03 | 1.54E-04 | 1.35E-05 | Detected |
| 3/16/2014 | 6.74E-04 | 9.99E-05 | 1.89E-05 | Detected |
| 3/17/2014 | 6.25E-04 | 9.38E-05 | 1.15E-05 | Detected |
| 3/18/2014 | 1.95E-03 | 2.50E-04 | 1.32E-05 | Detected |
| 3/19/2014 | 1.01E-03 | 1.40E-04 | 1.52E-05 | Detected |
| 3/20/2014 | 1.32E-03 | 1.84E-04 | 2.26E-05 | Detected |
| 3/21/2014 | 1.58E-03 | 2.13E-04 | 1.39E-05 | Detected |
| 3/22/2014 | 1.04E-03 | 1.45E-04 | 1.21E-05 | Detected |
| 3/23/2014 | 1.88E-03 | 2.44E-04 | 1.58E-05 | Detected |
| 3/24/2014 | 2.10E-03 | 2.72E-04 | 2.05E-05 | Detected |
| 3/25/2014 | 1.51E-03 | 1.96E-04 | 1.03E-05 | Detected |
| 3/26/2014 | 1.18E-03 | 1.62E-04 | 1.16E-05 | Detected |
| 3/27/2014 | 7.81E-04 | 1.14E-04 | 1.13E-05 | Detected |
| 3/28/2014 | 2.73E-03 | 3.45E-04 | 1.54E-05 | Detected |
| 3/29/2014 | 1.05E-03 | 1.52E-04 | 1.40E-05 | Detected |
| 3/30/2014 | 6.16E-04 | 9.35E-05 | 1.38E-05 | Detected |
| 3/31/2014 | 4.10E-04 | 7.31E-05 | 1.36E-05 | Detected |
| 4/1/2014 | 6.89E-04 | 1.06E-04 | 2.39E-05 | Detected |
| 4/2/2014 | 7.79E-04 | 1.13E-04 | 1.38E-05 | Detected |
| 4/3/2014 | 9.88E-04 | 1.39E-04 | 1.47E-05 | Detected |
| 4/4/2014 | 1.10E-03 | 1.54E-04 | 1.21E-05 | Detected |
| 4/5/2014 | 5.55E-04 | 8.85E-05 | 1.21E-05 | Detected |
| 4/6/2014 | 4.87E-04 | 7.71E-05 | 1.06E-05 | Detected |
| 4/7/2014 | 4.25E-04 | 7.18E-05 | 1.18E-05 | Detected |
| 4/8/2014 | 3.34E-04 | 5.91E-05 | 1.39E-05 | Detected |

Table 2-6: Daily Activity concentrations of $^{239+240}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{239+240}Pu$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 4/9/2014 | 5.35E-04 | 8.48E-05 | 1.43E-05 | Detected |
| 4/10/2014 | 1.03E-03 | 1.42E-04 | 1.11E-05 | Detected |
| 4/11/2014 | 4.43E-04 | 7.26E-05 | 1.38E-05 | Detected |
| 4/12/2014 | 3.71E-04 | 6.56E-05 | 1.50E-05 | Detected |
| 4/13/2014 | 7.42E-04 | 1.14E-04 | 1.32E-05 | Detected |
| 4/14/2014 | 8.62E-05 | 2.50E-05 | 1.12E-05 | Detected |
| 4/15/2014 | 2.20E-04 | 4.66E-05 | 1.56E-05 | Detected |
| 4/16/2014 | 1.14E-04 | 3.04E-05 | 1.19E-05 | Detected |
| 4/17/2014 | 1.67E-04 | 3.93E-05 | 2.01E-05 | Detected |
| 4/18/2014 | 1.14E-03 | 1.60E-04 | 1.58E-05 | Detected |
| 4/19/2014 | 1.13E-03 | 1.61E-04 | 1.32E-05 | Detected |
| 4/20/2014 | 1.27E-03 | 1.90E-04 | 1.70E-05 | Detected |
| 4/21/2014 | 3.04E-04 | 5.84E-05 | 1.28E-05 | Detected |

Table 2-7: Daily Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 3.03E+01 | 6.26E+00 | 2.47E+00 | Detected |
| 2/15/2014 | 1.90E+00 | 4.10E-01 | 1.58E-01 | Detected |
| 2/16/2014 | 8.41E-02 | 6.26E-03 | 2.21E-04 | Detected |
| 2/17/2014 | 1.06E-02 | 4.03E-04 | 7.60E-05 | Detected |
| 2/18/2014 | 1.38E-03 | 1.65E-06 | 8.50E-08 | Detected |
| 2/19/2014 | 6.78E-04 | 6.45E-07 | 6.29E-08 | Detected |
| 2/20/2014 | 7.98E-04 | 6.45E-07 | 1.78E-08 | Detected |
| 2/21/2014 | 9.13E-04 | 8.83E-07 | 3.56E-08 | Detected |
| 2/22/2014 | 1.89E-03 | 2.29E-04 | 1.11E-05 | Detected |
| 2/23/2014 | 7.43E-04 | 1.03E-04 | 1.32E-05 | Detected |
| 2/24/2014 | 4.60E-04 | 7.96E-05 | 1.88E-05 | Detected |
| 2/25/2014 | 4.16E-03 | 5.37E-04 | 2.39E-05 | Detected |
| 2/26/2014 | 8.69E-05 | 2.77E-05 | 1.72E-05 | Detected |
| 2/27/2014 | 8.06E-05 | 2.67E-05 | 1.74E-05 | Detected |
| 2/28/2014 | 4.43E-05 | 1.25E-05 | 6.73E-06 | Detected |
| 3/1/2014 | 1.01E-04 | 2.26E-05 | 6.88E-06 | Detected |
| 3/2/2014 | 6.25E-05 | 1.53E-05 | 6.83E-06 | Detected |
| 3/3/2014 | 1.13E-04 | 2.91E-05 | 1.11E-05 | Detected |

Table 2-7: Daily Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 3/4/2014 | 1.63E-04 | 3.64E-05 | 1.41E-05 | Detected |
| 3/5/2014 | 1.03E-04 | 2.74E-05 | 1.11E-05 | Detected |
| 3/6/2014 | 4.34E-05 | 1.76E-05 | 1.44E-05 | Detected |
| 3/7/2014 | 5.21E-05 | 2.77E-05 | 3.92E-05 | Detected |
| 3/8/2014 | 3.68E-05 | 1.62E-05 | 1.42E-05 | Detected |
| 3/9/2014 | 3.01E-05 | 1.42E-05 | 1.11E-05 | Detected |
| 3/10/2014 | 5.90E-05 | 2.08E-05 | 1.44E-05 | Detected |
| 3/11/2014 | 5.64E-05 | 2.11E-05 | 1.59E-05 | Detected |
| 3/12/2014 | 3.80E-05 | 1.70E-05 | 1.53E-05 | Detected |
| 3/13/2014 | 4.13E-04 | 6.92E-05 | 1.44E-05 | Detected |
| 3/14/2014 | 2.80E-05 | 1.46E-05 | 1.52E-05 | Detected |
| 3/15/2014 | 5.85E-05 | 2.21E-05 | 1.35E-05 | Detected |
| 3/16/2014 | 4.10E-05 | 1.73E-05 | 1.47E-05 | Detected |
| 3/17/2014 | 2.98E-05 | 1.44E-05 | 1.15E-05 | Detected |
| 3/18/2014 | 6.46E-05 | 2.33E-05 | 1.66E-05 | Detected |
| 3/19/2014 | 4.25E-05 | 1.79E-05 | 1.52E-05 | Detected |
| 3/20/2014 | 7.33E-05 | 2.55E-05 | 1.74E-05 | Detected |
| 3/21/2014 | 7.16E-05 | 2.49E-05 | 1.39E-05 | Detected |
| 3/22/2014 | 4.91E-05 | 1.94E-05 | 1.53E-05 | Detected |
| 3/23/2014 | 8.17E-05 | 2.57E-05 | 1.58E-05 | Detected |
| 3/24/2014 | 8.19E-05 | 2.60E-05 | 1.58E-05 | Detected |
| 3/25/2014 | 6.30E-05 | 2.02E-05 | 1.03E-05 | Detected |
| 3/26/2014 | 5.37E-05 | 1.99E-05 | 1.47E-05 | Detected |
| 3/27/2014 | 4.47E-05 | 1.76E-05 | 1.13E-05 | Detected |
| 3/28/2014 | 1.34E-04 | 3.37E-05 | 1.22E-05 | Detected |
| 3/29/2014 | 5.87E-05 | 2.28E-05 | 1.76E-05 | Detected |
| 3/30/2014 | 2.39E-05 | 1.26E-05 | 1.10E-05 | Detected |
| 3/31/2014 | 2.21E-05 | 1.35E-05 | 1.36E-05 | Detected |
| 4/1/2014 | 3.72E-05 | 1.68E-05 | 1.25E-05 | Detected |
| 4/2/2014 | 2.82E-05 | 1.40E-05 | 1.38E-05 | Detected |
| 4/3/2014 | 2.69E-05 | 1.48E-05 | 1.90E-05 | Detected |
| 4/4/2014 | 5.26E-05 | 2.01E-05 | 1.53E-05 | Detected |
| 4/5/2014 | 1.81E-05 | 1.16E-05 | 1.21E-05 | Detected |
| 4/6/2014 | 2.17E-05 | 1.22E-05 | 1.34E-05 | Detected |
| 4/7/2014 | 1.92E-05 | 1.22E-05 | 1.49E-05 | Detected |
| 4/8/2014 | 1.20E-05 | 9.57E-06 | 1.39E-05 | Not detected |

Table 2-7: Daily Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 4/9/2014 | 2.35E-05 | 1.31E-05 | 1.43E-05 | Detected |
| 4/10/2014 | 3.76E-05 | 1.62E-05 | 1.40E-05 | Detected |
| 4/11/2014 | 2.09E-05 | 1.29E-05 | 1.79E-05 | Detected |
| 4/12/2014 | 1.78E-05 | 1.14E-05 | 1.19E-05 | Detected |
| 4/13/2014 | 2.16E-05 | 1.46E-05 | 2.16E-05 | Not detected |
| 4/14/2014 | 6.05E-06 | 6.81E-06 | 1.12E-05 | Not detected |
| 4/15/2014 | 1.68E-05 | 1.18E-05 | 1.56E-05 | Detected |
| 4/16/2014 | 3.21E-06 | 6.45E-06 | 1.50E-05 | Not detected |
| 4/17/2014 | 5.02E-06 | 7.49E-06 | 1.55E-05 | Not detected |
| 4/18/2014 | 4.96E-05 | 1.96E-05 | 1.26E-05 | Detected |
| 4/19/2014 | 5.40E-05 | 2.10E-05 | 1.32E-05 | Detected |
| 4/20/2014 | 7.61E-05 | 2.84E-05 | 1.70E-05 | Detected |
| 4/21/2014 | 6.94E-06 | 9.84E-06 | 2.08E-05 | Not detected |

Table 2-8: Weekly Activity concentrations of $^{241}Am$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{241}Am$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 1.18E-03 | 1.34E-04 | 1.98E-06 | Detected |
| Week 1 May | 1.19E-03 | 1.35E-04 | 1.72E-06 | Detected |
| Week 2 May | 1.58E-03 | 1.86E-04 | 1.31E-06 | Detected |
| Week 3 May | 1.73E-03 | 2.15E-04 | 2.75E-06 | Detected |
| Week 4 May | 3.58E-03 | 4.19E-04 | 1.07E-06 | Detected |
| Week 1 Jun. | 1.31E-03 | 1.58E-04 | 2.55E-06 | Detected |
| Week 2 Jun. | 7.81E-04 | 1.02E-04 | 3.29E-06 | Detected |
| Week 3 Jun. | 1.38E-04 | 2.31E-05 | 2.76E-06 | Detected |
| Week 4 Jun. | 2.36E-04 | 3.10E-05 | 1.60E-06 | Detected |
| Week 1 Jul. | 1.70E-04 | 2.78E-05 | 3.98E-06 | Detected |
| Week 2 Jul. | 1.74E-04 | 2.80E-05 | 3.56E-06 | Detected |
| Week 3 Jul. | 6.84E-04 | 8.35E-05 | 1.72E-06 | Detected |
| Week 4 Jul. | 1.70E-03 | 2.04E-04 | 9.54E-07 | Detected |
| Week 1 Aug. | 7.05E-04 | 8.56E-05 | 1.88E-06 | Detected |
| Week 2 Aug. | 2.11E-04 | 2.80E-05 | 1.64E-06 | Detected |
| Week 3 Aug. | 9.19E-04 | 1.13E-04 | 1.76E-06 | Detected |
| Week 4 Aug. | 3.83E-04 | 4.81E-05 | 9.70E-07 | Detected |
| Week 1 Sep. | 3.26E-04 | 4.13E-05 | 1.93E-06 | Detected |

Table 2-8: Weekly Activity concentrations of $^{241}$Am (Bq/m$^3$), in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 2 Sep. | 7.49E-04 | 9.39E-05 | 1.56E-06 | Detected |
| Week 3 Sep. | 8.00E-04 | 1.01E-04 | 1.18E-06 | Detected |
| Week 4 Sep. | 5.05E-04 | 6.30E-05 | 9.22E-07 | Detected |
| Week 1 Oct. | 1.92E-04 | 2.63E-05 | 1.49E-06 | Detected |
| Week 2 Oct. | 1.25E-04 | 1.82E-05 | 1.73E-06 | Detected |
| Week 3 Oct. | 1.16E-04 | 1.71E-05 | 1.58E-06 | Detected |
| Week 4 Oct. | 3.88E-04 | 4.94E-05 | 1.69E-06 | Detected |
| Week 1 Nov. | 1.41E-04 | 1.99E-05 | 1.18E-06 | Detected |
| Week 2 Nov. | 1.08E-03 | 1.33E-04 | 1.68E-06 | Detected |
| Week 3 Nov. | 3.06E-04 | 3.96E-05 | 1.31E-06 | Detected |
| Week 4 Nov. | 2.10E-04 | 2.87E-05 | 1.41E-06 | Detected |
| Week 1 Dec. | 2.70E-04 | 3.61E-05 | 1.63E-06 | Detected |
| Week 2 Dec. | 1.02E-03 | 1.25E-04 | 1.71E-06 | Detected |
| Week 3 Dec. | 1.45E-03 | 1.74E-04 | 1.38E-06 | Detected |
| Week 4 Dec. | 1.25E-03 | 1.52E-04 | 7.01E-07 | Detected |

Table 2-9: Weekly Activity concentrations of $^{239+240}$Pu (Bq/m$^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{239+240}$Pu Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 1.12E-04 | 1.55E-05 | 1.55E-06 | Detected |
| Week 1 May | 1.26E-04 | 1.96E-05 | 1.79E-06 | Detected |
| Week 2 May | 1.83E-04 | 2.68E-05 | 1.82E-06 | Detected |
| Week 3 May | 2.49E-04 | 3.31E-05 | 1.42E-06 | Detected |
| Week 4 May | 3.92E-04 | 4.73E-05 | 1.56E-06 | Detected |
| Week 1 Jun. | 1.37E-04 | 1.96E-05 | 1.76E-06 | Detected |
| Week 2 Jun. | 9.10E-05 | 1.42E-05 | 1.62E-06 | Detected |
| Week 3 Jun. | 2.20E-05 | 5.81E-06 | 1.99E-06 | Detected |
| Week 4 Jun. | 2.63E-05 | 5.23E-06 | 1.50E-06 | Detected |
| Week 1 Jul. | 2.10E-05 | 5.05E-06 | 1.33E-06 | Detected |
| Week 2 Jul. | 1.65E-05 | 4.65E-06 | 1.31E-06 | Detected |
| Week 3 Jul. | 6.35E-05 | 1.05E-05 | 1.20E-06 | Detected |
| Week 4 Jul. | 1.69E-04 | 2.29E-05 | 1.11E-06 | Detected |
| Week 1 Aug. | 8.52E-05 | 1.35E-05 | 1.61E-06 | Detected |
| Week 2 Aug. | 2.04E-05 | 4.92E-06 | 1.30E-06 | Detected |
| Week 3 Aug. | 8.84E-05 | 1.57E-05 | 1.62E-06 | Detected |

Table 2-9: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/m$^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{239+240}Pu$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 4 Aug. | 3.73E-05 | 8.03E-06 | 1.93E-06 | Detected |
| Week 1 Sep. | 3.29E-05 | 7.53E-06 | 2.11E-06 | Detected |
| Week 2 Sep. | 6.43E-05 | 1.40E-05 | 3.13E-06 | Detected |
| Week 3 Sep. | 9.05E-05 | 1.52E-05 | 1.31E-06 | Detected |
| Week 4 Sep. | 5.10E-05 | 8.95E-06 | 1.25E-06 | Detected |
| Week 1 Oct. | 1.96E-05 | 4.90E-06 | 1.38E-06 | Detected |
| Week 2 Oct. | 1.14E-05 | 3.46E-06 | 1.09E-06 | Detected |
| Week 3 Oct. | 1.48E-05 | 4.31E-06 | 1.82E-06 | Detected |
| Week 4 Oct. | 3.91E-05 | 6.95E-06 | 1.06E-06 | Detected |
| Week 1 Nov. | 1.77E-05 | 7.20E-06 | 4.56E-06 | Detected |
| Week 2 Nov. | 1.31E-04 | 2.30E-05 | 2.87E-06 | Detected |
| Week 3 Nov. | 3.23E-05 | 9.82E-06 | 3.96E-06 | Detected |
| Week 4 Nov. | 1.93E-05 | 6.86E-06 | 2.42E-06 | Detected |
| Week 1 Dec. | 3.42E-05 | 8.09E-06 | 2.35E-06 | Detected |
| Week 2 Dec. | 1.17E-04 | 1.80E-05 | 1.61E-06 | Detected |
| Week 3 Dec. | 2.96E-04 | 4.07E-05 | 1.65E-06 | Detected |
| Week 4 Dec. | 1.28E-04 | 1.81E-05 | 1.04E-06 | Detected |

Table 2-10: Weekly Activity concentrations of $^{238}Pu$ (Bq/m$^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{238}Pu$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 5.01E-06 | 1.98E-06 | 1.55E-06 | Detected |
| Week 1 May | 6.28E-06 | 2.95E-06 | 2.51E-06 | Detected |
| Week 2 May | 1.03E-05 | 3.78E-06 | 1.82E-06 | Not detected |
| Week 3 May | 1.04E-05 | 3.41E-06 | 1.42E-06 | Detected |
| Week 4 May | 1.64E-05 | 3.80E-06 | 1.50E-06 | Detected |
| Week 1 Jun. | 4.83E-06 | 2.28E-06 | 1.74E-06 | Detected |
| Week 2 Jun. | 3.56E-06 | 1.93E-06 | 1.45E-06 | Detected |
| Week 3 Jun. | 1.08E-06 | 1.22E-06 | 1.77E-06 | Not detected |
| Week 4 Jun. | 8.20E-07 | 8.60E-07 | 1.42E-06 | Not detected |
| Week 1 Jul. | 5.82E-07 | 7.89E-07 | 1.33E-06 | Not detected |
| Week 2 Jul. | 1.05E-07 | 5.56E-07 | 1.75E-06 | Not detected |
| Week 3 Jul. | 2.75E-06 | 1.56E-06 | 1.20E-06 | Detected |
| Week 4 Jul. | 6.60E-06 | 2.18E-06 | 1.01E-06 | Detected |
| Week 1 Aug. | 2.89E-06 | 1.71E-06 | 1.73E-06 | Detected |

Table 2-10: Weekly Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{238}$Pu Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 2 Aug. | 1.63E-06 | 1.27E-06 | 1.47E-06 | Detected |
| Week 3 Aug. | 5.02E-06 | 2.69E-06 | 2.16E-06 | Detected |
| Week 4 Aug. | 9.97E-07 | 1.06E-06 | 1.31E-06 | Not detected |
| Week 1 Sep. | 2.27E-06 | 1.68E-06 | 1.45E-06 | Detected |
| Week 2 Sep. | 1.37E-06 | 1.86E-06 | 3.14E-06 | Not detected |
| Week 3 Sep. | 4.56E-06 | 2.32E-06 | 1.75E-06 | Detected |
| Week 4 Sep. | 2.64E-06 | 1.56E-06 | 1.87E-06 | Detected |
| Week 1 Oct. | 4.66E-07 | 8.32E-07 | 1.81E-06 | Not detected |
| Week 2 Oct. | 7.47E-07 | 8.96E-07 | 1.46E-06 | Not detected |
| Week 3 Oct. | 6.41E-07 | 1.03E-06 | 2.16E-06 | Not detected |
| Week 4 Oct. | 1.43E-06 | 1.09E-06 | 1.58E-06 | Not detected |
| Week 1 Nov. | 5.02E-07 | 1.28E-06 | 3.13E-06 | Not detected |
| Week 2 Nov. | 6.54E-06 | 3.34E-06 | 1.95E-06 | Detected |
| Week 3 Nov. | 2.97E-06 | 2.94E-06 | 4.38E-06 | Not detected |
| Week 4 Nov. | 1.16E-06 | 1.73E-06 | 3.23E-06 | Not detected |
| Week 1 Dec. | 2.81E-06 | 1.96E-06 | 1.59E-06 | Detected |
| Week 2 Dec. | 5.34E-06 | 2.43E-06 | 1.89E-06 | Detected |
| Week 3 Dec. | 1.28E-05 | 3.93E-06 | 1.65E-06 | Detected |
| Week 4 Dec. | 3.88E-06 | 1.64E-06 | 7.81E-07 | Detected |

Table 2-11: Weekly Activity density of $^{241}Am$ (Bq/g) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{241}$Am Activity Bq/g | Unc. ($2\sigma$) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | 2.10E+00 | 3.43E-01 | 4.91E-02 | Detected |
| Week 2 Jul. | 2.70E+00 | 4.34E-01 | 5.53E-02 | Detected |
| Week 3 Jul. | 8.37E+00 | 1.02E+00 | 2.11E-02 | Detected |
| Week 4 Jul. | 2.55E+01 | 3.06E+00 | 1.43E-02 | Detected |
| Week 1 Aug. | 1.40E+01 | 1.70E+00 | 3.74E-02 | Detected |
| Week 2 Aug. | 3.47E+00 | 4.62E-01 | 2.71E-02 | Detected |
| Week 3 Aug. | 1.58E+01 | 1.94E+00 | 3.03E-02 | Detected |
| Week 4 Aug. | 7.62E+00 | 9.57E-01 | 1.93E-02 | Detected |
| Week 1 Sep. | 7.23E+00 | 9.18E-01 | 4.28E-02 | Detected |
| Week 2 Sep. | 5.67E+00 | 7.10E-01 | 1.18E-02 | Detected |
| Week 3 Sep. | 9.72E+00 | 1.23E+00 | 1.43E-02 | Detected |
| Week 4 Sep. | 7.34E+00 | 9.16E-01 | 1.34E-02 | Detected |

Table 2-11: Weekly Activity density of $^{241}$Am (Bq/g) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{241}$Am Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Oct. | 8.84E+00 | 1.21E+00 | 6.89E-02 | Detected |
| Week 2 Oct. | 4.29E+00 | 6.28E-01 | 5.98E-02 | Detected |
| Week 3 Oct. | 2.86E+00 | 4.23E-01 | 3.91E-02 | Detected |
| Week 4 Oct. | 1.06E+01 | 1.35E+00 | 4.61E-02 | Detected |
| Week 1 Nov. | 7.18E+00 | 1.01E+00 | 6.04E-02 | Detected |
| Week 2 Nov. | 4.10E+01 | 5.02E+00 | 6.38E-02 | Detected |
| Week 3 Nov. | 9.65E+00 | 1.25E+00 | 4.14E-02 | Detected |
| Week 4 Nov. | 6.44E+00 | 8.81E-01 | 4.34E-02 | Detected |
| Week 1 Dec. | 4.54E+00 | 6.06E-01 | 2.74E-02 | Detected |
| Week 2 Dec. | 2.46E+01 | 3.03E+00 | 4.14E-02 | Detected |
| Week 3 Dec. | 3.21E+01 | 3.88E+00 | 3.06E-02 | Detected |
| Week 4 Dec. | 4.99E+01 | 6.06E+00 | 2.79E-02 | Detected |

Table 2-12: Weekly Activity density of $^{239+240}$Pu (Bq/g) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{239+240}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | 2.59E-01 | 6.23E-02 | 1.64E-02 | Detected |
| Week 2 Jul. | 2.56E-01 | 7.22E-02 | 2.04E-02 | Detected |
| Week 3 Jul. | 7.77E-01 | 1.28E-01 | 1.47E-02 | Detected |
| Week 4 Jul. | 2.53E+00 | 3.43E-01 | 1.66E-02 | Detected |
| Week 1 Aug. | 1.70E+00 | 2.69E-01 | 3.21E-02 | Detected |
| Week 2 Aug. | 3.36E-01 | 8.10E-02 | 2.15E-02 | Detected |
| Week 3 Aug. | 1.52E+00 | 2.71E-01 | 2.79E-02 | Detected |
| Week 4 Aug. | 7.42E-01 | 1.60E-01 | 3.84E-02 | Detected |
| Week 1 Sep. | 7.32E-01 | 1.67E-01 | 4.70E-02 | Detected |
| Week 2 Sep. | 4.86E-01 | 1.06E-01 | 2.37E-02 | Detected |
| Week 3 Sep. | 1.10E+00 | 1.85E-01 | 1.59E-02 | Detected |
| Week 4 Sep. | 7.42E-01 | 1.30E-01 | 1.83E-02 | Detected |
| Week 1 Oct. | 9.07E-01 | 2.26E-01 | 6.35E-02 | Detected |
| Week 2 Oct. | 3.91E-01 | 1.19E-01 | 3.77E-02 | Detected |
| Week 3 Oct. | 3.66E-01 | 1.06E-01 | 4.49E-02 | Detected |
| Week 4 Oct. | 1.07E+00 | 1.90E-01 | 2.90E-02 | Detected |
| Week 1 Nov. | 9.02E-01 | 3.67E-01 | 2.32E-01 | Detected |
| Week 2 Nov. | 4.94E+00 | 8.72E-01 | 1.09E-01 | Detected |
| Week 3 Nov. | 1.02E+00 | 3.10E-01 | 1.25E-01 | Detected |
| Week 4 Nov. | 5.93E-01 | 2.11E-01 | 7.43E-02 | Detected |

Table 2-12: Weekly Activity density of $^{239+240}Pu$ (Bq/g) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{239+240}Pu$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Dec. | 5.75E-01 | 1.36E-01 | 3.95E-02 | Detected |
| Week 2 Dec. | 2.81E+00 | 4.34E-01 | 3.89E-02 | Detected |
| Week 3 Dec. | 6.57E+00 | 9.04E-01 | 3.67E-02 | Detected |
| Week 4 Dec. | 5.11E+00 | 7.21E-01 | 4.15E-02 | Detected |

Table 2-13: Weekly Activity density of $^{238}Pu$ (Bq/g) in Station A (Pre-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{238}Pu$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | 7.18E-03 | 9.73E-03 | 1.64E-02 | Detected |
| Week 2 Jul. | 1.63E-03 | 8.63E-03 | 2.71E-02 | Detected |
| Week 3 Jul. | 3.37E-02 | 1.91E-02 | 1.47E-02 | Detected |
| Week 4 Jul. | 9.88E-02 | 3.26E-02 | 1.52E-02 | Detected |
| Week 1 Aug. | 5.75E-02 | 3.41E-02 | 3.45E-02 | Detected |
| Week 2 Aug. | 2.68E-02 | 2.09E-02 | 2.41E-02 | Detected |
| Week 3 Aug. | 8.65E-02 | 4.63E-02 | 3.72E-02 | Detected |
| Week 4 Aug. | 1.98E-02 | 2.11E-02 | 2.60E-02 | Detected |
| Week 1 Sep. | 5.05E-02 | 3.72E-02 | 3.23E-02 | Detected |
| Week 2 Sep. | 1.04E-02 | 1.41E-02 | 2.37E-02 | Detected |
| Week 3 Sep. | 5.54E-02 | 2.81E-02 | 2.13E-02 | Detected |
| Week 4 Sep. | 3.84E-02 | 2.27E-02 | 2.72E-02 | Detected |
| Week 1 Oct. | 2.15E-02 | 3.84E-02 | 8.37E-02 | Detected |
| Week 2 Oct. | 2.57E-02 | 3.09E-02 | 5.02E-02 | Detected |
| Week 3 Oct. | 1.58E-02 | 2.54E-02 | 5.33E-02 | Detected |
| Week 4 Oct. | 3.92E-02 | 2.98E-02 | 4.32E-02 | Detected |
| Week 1 Nov. | 2.56E-02 | 6.52E-02 | 1.60E-01 | Detected |
| Week 2 Nov. | 2.48E-01 | 1.27E-01 | 7.37E-02 | Detected |
| Week 3 Nov. | 9.38E-02 | 9.27E-02 | 1.38E-01 | Detected |
| Week 4 Nov. | 3.58E-02 | 5.30E-02 | 9.90E-02 | Detected |
| Week 1 Dec. | 4.72E-02 | 3.29E-02 | 2.68E-02 | Detected |
| Week 2 Dec. | 1.29E-01 | 5.86E-02 | 4.56E-02 | Detected |
| Week 3 Dec. | 2.84E-01 | 8.73E-02 | 3.67E-02 | Detected |
| Week 4 Dec. | 1.54E-01 | 6.51E-02 | 3.11E-02 | Detected |

Table 2-14: Daily Activity concentrations of $^{241}$Am (Bq/m$^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 2.28E+00 | 2.76E-01 | 1.26E-02 | Detected |
| 2/18/2014 | 5.88E-02 | 6.79E-03 | 4.34E-05 | Detected |
| 2/19/2014 | 4.74E-02 | 3.24E-03 | 1.81E-05 | Detected |
| 2/20/2014 | 4.68E-02 | 3.26E-03 | 1.68E-05 | Detected |
| 2/21/2014 | 3.92E-02 | 1.04E-03 | 1.42E-05 | Detected |
| 2/22/2014 | 1.91E-02 | 2.05E-03 | 1.02E-05 | Detected |
| 2/23/2014 | 1.22E-02 | 1.33E-03 | 1.06E-05 | Detected |
| 2/24/2014 | 6.09E-03 | 7.74E-04 | 2.68E-05 | Detected |
| 2/25/2014 | 3.53E-03 | 4.08E-04 | 1.11E-05 | Detected |
| 2/26/2014 | 3.96E-03 | 4.49E-04 | 2.25E-05 | Detected |
| 2/27/2014 | 3.56E-03 | 4.06E-04 | 1.75E-05 | Detected |
| 2/28/2014 | 3.29E-03 | 3.73E-04 | 5.05E-06 | Detected |
| 3/1/2014 | 4.56E-03 | 5.18E-04 | 5.93E-06 | Detected |
| 3/2/2014 | 1.16E-02 | 1.28E-03 | 1.12E-05 | Detected |
| 3/3/2014 | 1.17E-02 | 1.28E-03 | 7.86E-06 | Detected |
| 3/4/2014 | 4.81E-03 | 1.68E-03 | 3.11E-04 | Detected |
| 3/5/2014 | 1.96E-02 | 2.24E-03 | 1.09E-05 | Detected |
| 3/6/2014 | 1.63E-03 | 2.34E-04 | 3.91E-05 | Detected |
| 3/7/2014 | 2.97E-03 | 3.70E-04 | 1.98E-05 | Detected |
| 3/8/2014 | 4.72E-03 | 6.16E-04 | 1.75E-05 | Detected |
| 3/9/2014 | 1.16E-03 | 1.79E-04 | 2.04E-05 | Detected |
| 3/10/2014 | 1.02E-03 | 1.48E-04 | 1.17E-05 | Detected |
| 3/11/2014 | 1.64E-02 | 1.93E-03 | 1.21E-05 | Detected |
| 3/12/2014 | 4.99E-03 | 3.54E-04 | 4.22E-06 | Detected |
| 3/13/2014 | 2.31E-03 | 2.87E-04 | 9.96E-06 | Detected |
| 3/14/2014 | 1.14E-03 | 1.55E-04 | 1.09E-05 | Detected |
| 3/15/2014 | 3.88E-03 | 4.76E-04 | 1.83E-05 | Detected |
| 3/16/2014 | 1.33E-03 | 1.85E-04 | 1.74E-05 | Detected |
| 3/17/2014 | 5.97E-04 | 7.99E-05 | 7.01E-06 | Detected |
| 3/18/2014 | 2.04E-03 | 2.42E-04 | 4.84E-06 | Detected |
| 3/19/2014 | 2.94E-03 | 3.47E-04 | 6.84E-06 | Detected |
| 3/20/2014 | 1.63E-03 | 2.11E-04 | 1.45E-05 | Detected |
| 3/21/2014 | 9.99E-04 | 1.36E-04 | 1.35E-05 | Detected |
| 3/22/2014 | 1.11E-03 | 1.60E-04 | 1.66E-05 | Detected |
| 3/23/2014 | 6.30E-04 | 9.81E-05 | 1.60E-05 | Detected |
| 3/24/2014 | 5.08E-04 | 7.83E-05 | 1.30E-05 | Detected |

Table 2-14: Daily Activity concentrations of $^{241}Am$ (Bq/m$^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{241}$Am Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 3/25/2014 | 4.62E-04 | 7.55E-05 | 1.46E-05 | Detected |
| 3/26/2014 | 2.08E-04 | 5.31E-05 | 1.91E-05 | Detected |
| 3/27/2014 | 3.91E-04 | 6.59E-05 | 1.39E-05 | Detected |
| 3/28/2014 | 3.91E-04 | 6.82E-05 | 1.55E-05 | Detected |
| 3/29/2014 | 2.79E-04 | 5.18E-05 | 1.38E-05 | Detected |
| 3/30/2014 | 3.05E-04 | 5.53E-05 | 1.12E-05 | Detected |
| 3/31/2014 | 2.22E-04 | 4.47E-05 | 1.41E-05 | Detected |
| 4/1/2014 | 2.98E-04 | 5.28E-05 | 1.03E-05 | Detected |
| 4/2/2014 | 6.25E-04 | 9.29E-05 | 1.35E-05 | Detected |
| 4/3/2014 | 1.05E-03 | 1.43E-04 | 1.07E-05 | Detected |
| 4/4/2014 | 3.93E-04 | 6.62E-05 | 2.10E-05 | Detected |
| 4/5/2014 | 5.71E-04 | 9.32E-05 | 1.33E-05 | Detected |
| 4/6/2014 | 2.97E-04 | 5.54E-05 | 1.15E-05 | Detected |
| 4/7/2014 | 2.99E-04 | 5.89E-05 | 1.68E-05 | Detected |
| 4/8/2014 | 2.39E-04 | 4.95E-05 | 1.26E-05 | Detected |
| 4/9/2014 | 3.93E-04 | 7.79E-05 | 1.75E-05 | Detected |
| 4/10/2014 | 7.32E-04 | 1.52E-04 | 4.16E-05 | Detected |
| 4/11/2014 | 4.11E-04 | 6.83E-05 | 1.10E-05 | Detected |
| 4/12/2014 | 5.27E-04 | 8.19E-05 | 1.08E-05 | Detected |
| 4/13/2014 | 4.56E-04 | 7.63E-05 | 1.53E-05 | Detected |
| 4/14/2014 | 1.23E-03 | 1.64E-04 | 1.76E-05 | Detected |
| 4/15/2014 | 5.21E-04 | 8.04E-05 | 1.04E-05 | Detected |
| 4/16/2014 | 1.21E-03 | 1.69E-04 | 1.61E-05 | Detected |
| 4/17/2014 | 5.94E-04 | 8.97E-05 | 1.34E-05 | Detected |
| 4/18/2014 | 3.22E-03 | 3.96E-04 | 1.89E-05 | Detected |
| 4/19/2014 | 5.03E-04 | 8.04E-05 | 1.14E-05 | Detected |
| 4/20/2014 | 5.31E-04 | 1.39E-04 | 6.57E-05 | Detected |
| 4/21/2014 | 1.11E-04 | 2.90E-05 | 1.10E-05 | Detected |

Table 2-15: Daily Activity concentrations of $^{239+240}Pu$ ($Bq/m^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{239+240}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 2.24E-01 | 2.26E-02 | 5.82E-03 | Detected |
| 2/18/2014 | 5.11E-03 | 6.89E-04 | 4.39E-05 | Detected |
| 2/19/2014 | 5.18E-03 | 4.47E-04 | 2.74E-05 | Detected |
| 2/20/2014 | 4.53E-03 | 3.95E-04 | 2.10E-05 | Detected |
| 2/21/2014 | 3.75E-03 | 1.18E-04 | 1.34E-05 | Detected |
| 2/22/2014 | 1.81E-03 | 2.22E-04 | 1.15E-05 | Detected |
| 2/23/2014 | 1.15E-03 | 1.50E-04 | 1.13E-05 | Detected |
| 2/24/2014 | 6.35E-04 | 9.94E-05 | 1.44E-05 | Detected |
| 2/25/2014 | 3.25E-04 | 7.14E-05 | 2.07E-05 | Detected |
| 2/26/2014 | 4.28E-04 | 7.33E-05 | 1.71E-05 | Detected |
| 2/27/2014 | 3.73E-04 | 8.44E-05 | 4.69E-05 | Detected |
| 2/28/2014 | 3.20E-04 | 4.65E-05 | 5.27E-06 | Detected |
| 3/1/2014 | 4.51E-04 | 6.35E-05 | 5.98E-06 | Detected |
| 3/2/2014 | 1.05E-03 | 1.29E-04 | 9.34E-06 | Detected |
| 3/3/2014 | 2.33E-03 | 2.83E-04 | 1.35E-05 | Detected |
| 3/4/2014 | 3.11E-04 | 5.73E-05 | 1.17E-05 | Detected |
| 3/5/2014 | 1.84E-03 | 2.41E-04 | 1.17E-05 | Detected |
| 3/6/2014 | 1.60E-04 | 3.70E-05 | 1.91E-05 | Detected |
| 3/7/2014 | 1.01E-03 | 1.26E-04 | 6.78E-06 | Detected |
| 3/8/2014 | 3.76E-04 | 6.39E-05 | 1.08E-05 | Detected |
| 3/9/2014 | 1.13E-04 | 2.97E-05 | 1.15E-05 | Detected |
| 3/10/2014 | 7.54E-05 | 2.41E-05 | 1.46E-05 | Detected |
| 3/11/2014 | 1.65E-03 | 2.19E-04 | 2.21E-05 | Detected |
| 3/12/2014 | 4.45E-04 | 7.42E-05 | 1.20E-05 | Detected |
| 3/13/2014 | 2.22E-04 | 4.65E-05 | 1.24E-05 | Detected |
| 3/14/2014 | 1.20E-04 | 3.11E-05 | 1.84E-05 | Detected |
| 3/15/2014 | 3.60E-04 | 6.60E-05 | 2.77E-05 | Detected |
| 3/16/2014 | 1.27E-04 | 3.44E-05 | 1.40E-05 | Detected |
| 3/17/2014 | 3.97E-05 | 1.64E-05 | 1.09E-05 | Detected |
| 3/18/2014 | 2.28E-04 | 3.73E-05 | 9.51E-06 | Detected |
| 3/19/2014 | 2.94E-04 | 4.57E-05 | 1.32E-05 | Detected |
| 3/20/2014 | 1.36E-04 | 3.44E-05 | 1.26E-05 | Detected |
| 3/21/2014 | 6.96E-05 | 2.29E-05 | 1.19E-05 | Detected |
| 3/22/2014 | 1.04E-04 | 3.46E-05 | 2.78E-05 | Detected |
| 3/23/2014 | 3.87E-05 | 1.83E-05 | 2.45E-05 | Detected |
| 3/24/2014 | 3.56E-05 | 1.61E-05 | 1.44E-05 | Detected |

Table 2-15: Daily Activity concentrations of $^{239+240}Pu$ ($Bq/m^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{239+240}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 3/25/2014 | 5.45E-05 | 1.95E-05 | 1.11E-05 | Detected |
| 3/26/2014 | 2.21E-05 | 1.25E-05 | 1.16E-05 | Detected |
| 3/27/2014 | 4.80E-05 | 1.84E-05 | 1.40E-05 | Detected |
| 3/28/2014 | 4.29E-05 | 1.70E-05 | 1.09E-05 | Detected |
| 3/29/2014 | 4.59E-05 | 1.82E-05 | 1.17E-05 | Detected |
| 3/30/2014 | 2.73E-05 | 1.84E-05 | 2.00E-05 | Detected |
| 3/31/2014 | 2.71E-05 | 1.35E-05 | 1.11E-05 | Detected |
| 4/1/2014 | 4.39E-05 | 1.82E-05 | 1.51E-05 | Detected |
| 4/2/2014 | 5.56E-05 | 2.02E-05 | 1.17E-05 | Detected |
| 4/3/2014 | 8.75E-05 | 2.58E-05 | 1.15E-05 | Detected |
| 4/4/2014 | 4.70E-05 | 1.87E-05 | 1.82E-05 | Detected |
| 4/5/2014 | 6.54E-05 | 2.17E-05 | 1.41E-05 | Detected |
| 4/6/2014 | 2.92E-05 | 1.42E-05 | 1.13E-05 | Detected |
| 4/7/2014 | 3.49E-05 | 1.51E-05 | 1.07E-05 | Detected |
| 4/8/2014 | 1.89E-05 | 1.20E-05 | 1.46E-05 | Detected |
| 4/9/2014 | 1.86E-05 | 1.19E-05 | 1.25E-05 | Detected |
| 4/10/2014 | 3.76E-05 | 1.69E-05 | 1.51E-05 | Detected |
| 4/11/2014 | 2.08E-05 | 1.34E-05 | 1.93E-05 | Detected |
| 4/12/2014 | 5.25E-05 | 2.03E-05 | 2.31E-05 | Detected |
| 4/13/2014 | 4.11E-05 | 1.74E-05 | 1.46E-05 | Detected |
| 4/14/2014 | 1.10E-04 | 3.03E-05 | 1.23E-05 | Detected |
| 4/15/2014 | 5.09E-05 | 1.92E-05 | 1.43E-05 | Detected |
| 4/16/2014 | 3.90E-05 | 1.72E-05 | 1.25E-05 | Detected |
| 4/17/2014 | 6.15E-05 | 2.20E-05 | 1.26E-05 | Detected |
| 4/18/2014 | 3.10E-04 | 5.69E-05 | 1.15E-05 | Detected |
| 4/19/2014 | 5.97E-05 | 2.13E-05 | 1.22E-05 | Detected |
| 4/20/2014 | 1.48E-05 | 1.12E-05 | 1.36E-05 | Detected |
| 4/21/2014 | 1.31E-05 | 9.98E-06 | 1.21E-05 | Detected |

Table 2-16: Daily Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station B (Post-HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 3.23E-02 | 8.65E-03 | 5.82E-03 | Detected |
| 2/18/2014 | 2.29E-04 | 7.66E-05 | 5.06E-05 | Detected |
| 2/19/2014 | 2.79E-04 | 5.63E-05 | 2.99E-05 | Detected |
| 2/20/2014 | 1.91E-04 | 4.25E-05 | 2.15E-05 | Detected |
| 2/21/2014 | 1.68E-04 | 3.70E-05 | 2.13E-05 | Detected |
| 2/22/2014 | 7.01E-05 | 2.25E-05 | 1.15E-05 | Detected |
| 2/23/2014 | 5.21E-05 | 1.90E-05 | 1.13E-05 | Detected |
| 2/24/2014 | 2.15E-05 | 1.38E-05 | 1.44E-05 | Detected |
| 2/25/2014 | 6.19E-05 | 2.78E-05 | 2.07E-05 | Detected |
| 2/26/2014 | 7.36E-05 | 2.49E-05 | 1.35E-05 | Detected |
| 2/27/2014 | 7.98E-05 | 3.51E-05 | 3.10E-05 | Detected |
| 2/28/2014 | 1.50E-05 | 6.91E-06 | 5.27E-06 | Detected |
| 3/1/2014 | 2.11E-05 | 8.75E-06 | 5.98E-06 | Detected |
| 3/2/2014 | 5.45E-05 | 1.48E-05 | 1.10E-05 | Detected |
| 3/3/2014 | 9.76E-05 | 2.64E-05 | 1.35E-05 | Detected |
| 3/4/2014 | 1.27E-05 | 9.66E-06 | 1.17E-05 | Detected |
| 3/5/2014 | 9.05E-05 | 2.65E-05 | 1.17E-05 | Detected |
| 3/6/2014 | 1.60E-06 | 8.45E-06 | 2.25E-05 | Not detected |
| 3/7/2014 | 3.96E-05 | 1.34E-05 | 1.11E-05 | Detected |
| 3/8/2014 | 2.35E-05 | 1.24E-05 | 1.08E-05 | Detected |
| 3/9/2014 | 3.14E-06 | 5.43E-06 | 1.15E-05 | Not detected |
| 3/10/2014 | 1.10E-05 | 9.00E-06 | 1.16E-05 | Not detected |
| 3/11/2014 | 6.58E-05 | 2.22E-05 | 1.46E-05 | Detected |
| 3/12/2014 | 2.11E-05 | 1.24E-05 | 1.20E-05 | Detected |
| 3/13/2014 | 5.03E-06 | 7.54E-06 | 1.56E-05 | Detected |
| 3/14/2014 | 4.61E-06 | 6.16E-06 | 1.13E-05 | Not detected |
| 3/15/2014 | 6.44E-05 | 2.41E-05 | 2.46E-05 | Detected |
| 3/16/2014 | 7.60E-06 | 8.52E-06 | 1.40E-05 | Not detected |
| 3/17/2014 | 7.37E-06 | 7.85E-06 | 1.37E-05 | Not detected |
| 3/18/2014 | 6.34E-06 | 4.82E-06 | 5.83E-06 | Detected |
| 3/19/2014 | 1.83E-05 | 9.02E-06 | 1.17E-05 | Detected |
| 3/20/2014 | 1.03E-05 | 9.15E-06 | 1.26E-05 | Not detected |
| 3/21/2014 | 4.84E-06 | 7.25E-06 | 1.50E-05 | Not detected |
| 3/22/2014 | 4.64E-06 | 8.06E-06 | 1.70E-05 | Not detected |
| 3/23/2014 | -1.55E-06 | 6.91E-06 | 2.18E-05 | Not detected |
| 3/24/2014 | 0.00E+00 | 4.39E-06 | 1.14E-05 | Not detected |

Table 2-16: Daily Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station B (Post-HEPA) filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 3/25/2014 | 1.51E-06 | 5.24E-06 | 1.41E-05 | Not detected |
| 3/26/2014 | 0.00E+00 | 4.48E-06 | 1.47E-05 | Not detected |
| 3/27/2014 | 6.01E-06 | 8.54E-06 | 1.81E-05 | Not detected |
| 3/28/2014 | -1.48E-06 | 4.19E-06 | 1.38E-05 | Not detected |
| 3/29/2014 | 0.00E+00 | 4.47E-06 | 1.47E-05 | Not detected |
| 3/30/2014 | 8.17E-06 | 1.09E-05 | 2.00E-05 | Not detected |
| 3/31/2014 | 0.00E+00 | 4.27E-06 | 1.40E-05 | Not detected |
| 4/1/2014 | 0.00E+00 | 4.61E-06 | 1.20E-05 | Not detected |
| 4/2/2014 | 4.78E-06 | 6.39E-06 | 1.17E-05 | Not detected |
| 4/3/2014 | 1.56E-06 | 4.41E-06 | 1.15E-05 | Not detected |
| 4/4/2014 | 6.06E-06 | 6.80E-06 | 1.11E-05 | Not detected |
| 4/5/2014 | 1.52E-06 | 5.25E-06 | 1.41E-05 | Not detected |
| 4/6/2014 | 3.06E-06 | 6.15E-06 | 1.43E-05 | Not detected |
| 4/7/2014 | -1.45E-06 | 5.04E-06 | 1.75E-05 | Not detected |
| 4/8/2014 | 0.00E+00 | 4.45E-06 | 1.46E-05 | Not detected |
| 4/9/2014 | 1.69E-05 | 4.78E-06 | 1.25E-05 | Detected |
| 4/10/2014 | 0.00E+00 | 4.61E-06 | 1.51E-05 | Not detected |
| 4/11/2014 | 0.00E+00 | 4.54E-06 | 1.18E-05 | Not detected |
| 4/12/2014 | 0.00E+00 | 7.16E-06 | 2.06E-05 | Not detected |
| 4/13/2014 | 1.58E-06 | 5.46E-06 | 1.46E-05 | Not detected |
| 4/14/2014 | -1.67E-06 | 5.77E-06 | 2.00E-05 | Not detected |
| 4/15/2014 | 0.00E+00 | 4.38E-06 | 1.14E-05 | Not detected |
| 4/16/2014 | 5.08E-06 | 6.80E-06 | 1.25E-05 | Not detected |
| 4/17/2014 | 0.00E+00 | 6.85E-06 | 2.05E-05 | Not detected |
| 4/18/2014 | 1.40E-05 | 9.99E-06 | 1.15E-05 | Detected |
| 4/19/2014 | 0.00E+00 | 4.69E-06 | 1.22E-05 | Not detected |
| 4/20/2014 | -1.85E-06 | 6.41E-06 | 2.22E-05 | Not detected |
| 4/21/2014 | 0.00E+00 | 4.65E-06 | 1.21E-05 | Not detected |

Table 2-17: Weekly Activity concentrations of $^{241}Am$ ($Bq/m^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{241}Am$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 8.98E-05 | 1.30E-05 | 1.27E-06 | Detected |
| Week 1 May | 4.04E-04 | 4.81E-05 | 1.89E-06 | Detected |
| Week 2 May | 1.01E-04 | 1.59E-05 | 2.08E-06 | Detected |
| Week 3 May | 2.98E-05 | 6.75E-06 | 2.05E-06 | Detected |
| Week 4 May | 2.21E-05 | 5.54E-06 | 1.92E-06 | Detected |
| Week 1 Jun. | 1.84E-03 | 2.26E-04 | 3.32E-06 | Detected |
| Week 2 Jun. | 2.02E-04 | 2.81E-05 | 2.16E-06 | Detected |
| Week 3 Jun. | 2.05E-04 | 3.13E-05 | 3.14E-06 | Detected |
| Week 4 Jun. | 9.90E-05 | 1.48E-05 | 1.92E-06 | Detected |
| Week 1 Jul. | 4.14E-05 | 6.38E-06 | 9.51E-07 | Detected |
| Week 2 Jul. | 1.66E-05 | 5.79E-06 | 3.75E-06 | Detected |
| Week 3 Jul. | 3.25E-05 | 6.45E-06 | 1.68E-06 | Detected |
| Week 4 Jul. | 6.61E-05 | 9.94E-06 | 1.56E-06 | Detected |
| Week 1 Aug. | 1.16E-04 | 1.69E-05 | 1.82E-06 | Detected |
| Week 2 Aug. | 3.91E-05 | 7.44E-06 | 1.92E-06 | Detected |
| Week 3 Aug. | 1.38E-05 | 3.74E-06 | 1.66E-06 | Detected |
| Week 4 Aug. | 2.33E-05 | 4.57E-06 | 1.16E-06 | Detected |
| Week 1 Sep. | 4.59E-04 | 5.72E-05 | 2.15E-06 | Detected |
| Week 2 Sep. | 8.79E-05 | 1.38E-05 | 1.63E-06 | Detected |
| Week 3 Sep. | 5.56E-05 | 1.12E-05 | 2.25E-06 | Detected |
| Week 4 Sep. | 1.15E-04 | 1.57E-05 | 8.17E-07 | Detected |
| Week 1 Oct. | 3.70E-04 | 4.72E-05 | 1.38E-06 | Detected |
| Week 2 Oct. | 2.35E-04 | 3.14E-05 | 1.44E-06 | Detected |
| Week 3 Oct. | 1.66E-03 | 1.97E-04 | 2.38E-06 | Detected |
| Week 4 Oct. | 4.16E-04 | 5.13E-05 | 1.26E-06 | Detected |
| Week 1 Nov. | 7.34E-04 | 9.07E-05 | 1.62E-06 | Detected |
| Week 2 Nov. | 1.62E-04 | 2.29E-05 | 1.44E-06 | Detected |
| Week 3 Nov. | 8.72E-05 | 1.30E-05 | 1.48E-06 | Detected |
| Week 4 Nov. | 3.79E-05 | 6.72E-06 | 1.15E-06 | Detected |
| Week 1 Dec. | 2.60E-05 | 5.50E-06 | 1.30E-06 | Detected |
| Week 2 Dec. | 4.71E-05 | 1.07E-05 | 3.87E-06 | Detected |
| Week 3 Dec. | 1.33E-04 | 2.00E-05 | 1.62E-06 | Detected |
| Week 4 Dec. | 3.65E-05 | 6.24E-06 | 6.78E-07 | Detected |

Table 2-18: Weekly Activity concentrations of $^{239+240}Pu$ ($Bq/m^3$) in Station B (Post HEPA) filters following the February 14 radiological event at WIPP

| Sample Date | $^{239+240}Pu$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 1.12E-05 | 3.21E-06 | 1.39E-06 | Not detected |
| Week 1 May | 3.66E-05 | 7.29E-06 | 1.72E-06 | Detected |
| Week 2 May | 1.13E-05 | 3.62E-06 | 1.78E-06 | Detected |
| Week 3 May | 5.39E-06 | 2.28E-06 | 1.55E-06 | Detected |
| Week 4 May | 1.61E-06 | 1.14E-06 | 1.47E-06 | Detected |
| Week 1 Jun. | 2.01E-04 | 2.70E-05 | 1.49E-06 | Detected |
| Week 2 Jun. | 2.08E-05 | 5.07E-06 | 1.72E-06 | Detected |
| Week 3 Jun. | 2.18E-05 | 5.12E-06 | 1.48E-06 | Detected |
| Week 4 Jun. | 8.74E-06 | 2.95E-06 | 1.28E-06 | Detected |
| Week 1 Jul. | 4.91E-06 | 2.24E-06 | 1.75E-06 | Detected |
| Week 2 Jul. | 1.33E-06 | 1.32E-06 | 1.72E-06 | Not detected |
| Week 3 Jul. | 4.08E-06 | 2.01E-06 | 1.14E-06 | Detected |
| Week 4 Jul. | 7.11E-06 | 2.35E-06 | 1.19E-06 | Detected |
| Week 1 Aug. | 1.12E-05 | 3.38E-06 | 1.73E-06 | Detected |
| Week 2 Aug. | 1.80E-06 | 1.33E-06 | 1.70E-06 | Detected |
| Week 3 Aug. | 1.70E-06 | 1.77E-06 | 2.57E-06 | Not detected |
| Week 4 Aug. | 1.60E-06 | 1.22E-06 | 1.47E-06 | Detected |
| Week 1 Sep. | 4.73E-05 | 9.19E-06 | 1.74E-06 | Detected |
| Week 2 Sep. | 9.26E-06 | 3.13E-06 | 1.49E-06 | Detected |
| Week 3 Sep. | 4.66E-06 | 2.53E-06 | 2.22E-06 | Detected |
| Week 4 Sep. | 1.26E-05 | 3.57E-06 | 9.99E-07 | Detected |
| Week 1 Oct. | 4.39E-05 | 1.07E-05 | 3.47E-06 | Detected |
| Week 2 Oct. | 3.71E-05 | 7.75E-06 | 1.70E-06 | Detected |
| Week 3 Oct. | 2.17E-04 | 3.28E-05 | 1.45E-06 | Detected |
| Week 4 Oct. | 3.90E-05 | 1.37E-05 | 2.21E-06 | Detected |
| Week 1 Nov. | 8.39E-05 | 3.11E-05 | 4.55E-06 | Detected |
| Week 2 Nov. | 1.23E-05 | 7.90E-06 | 3.87E-06 | Detected |
| Week 3 Nov. | 1.01E-05 | 4.60E-06 | 3.01E-06 | Detected |
| Week 4 Nov. | 2.71E-06 | 2.23E-06 | 2.84E-06 | Not detected |
| Week 1 Dec. | 1.92E-06 | 2.31E-06 | 4.34E-06 | Not detected |
| Week 2 Dec. | 3.53E-06 | 1.94E-06 | 1.74E-06 | Detected |
| Week 3 Dec. | 1.55E-05 | 4.23E-06 | 1.36E-06 | Detected |
| Week 4 Dec. | 2.32E-06 | 1.45E-06 | 1.35E-06 | Detected |

Table 2-19: Weekly Activity concentrations of $^{238}Pu$ ($Bq/m^3$) in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{238}Pu$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 1.89E-07 | 6.56E-07 | 1.76E-06 | Not detected |
| Week 1 May | 1.61E-06 | 1.27E-06 | 1.18E-06 | Detected |
| Week 2 May | -1.96E-07 | 5.27E-07 | 1.78E-06 | Not detected |
| Week 3 May | 4.28E-08 | 4.61E-07 | 1.55E-06 | Not detected |
| Week 4 May | 3.35E-08 | 3.62E-07 | 1.22E-06 | Not detected |
| Week 1 Jun. | 7.98E-06 | 2.85E-06 | 1.33E-06 | Detected |
| Week 2 Jun. | 1.08E-06 | 1.18E-06 | 2.05E-06 | Not detected |
| Week 3 Jun. | 1.16E-06 | 1.11E-06 | 1.62E-06 | Not detected |
| Week 4 Jun. | 6.45E-07 | 8.85E-07 | 1.68E-06 | Not detected |
| Week 1 Jul. | 5.81E-07 | 7.86E-07 | 1.32E-06 | Not detected |
| Week 2 Jul. | 1.16E-07 | 8.83E-07 | 2.65E-06 | Not detected |
| Week 3 Jul. | -9.17E-08 | 4.75E-07 | 1.36E-06 | Not detected |
| Week 4 Jul. | 1.32E-07 | 3.35E-07 | 8.20E-07 | Not detected |
| Week 1 Aug. | 1.25E-07 | 4.32E-07 | 1.24E-06 | Not detected |
| Week 2 Aug. | -4.08E-08 | 4.55E-07 | 1.70E-06 | Not detected |
| Week 3 Aug. | 0.00E+00 | 1.09E-06 | 2.85E-06 | Not detected |
| Week 4 Aug. | 4.02E-07 | 5.23E-06 | 1.47E-06 | Not detected |
| Week 1 Sep. | 1.20E-06 | 1.19E-06 | 1.55E-06 | Not detected |
| Week 2 Sep. | -4.48E-08 | 4.99E-07 | 1.85E-06 | Not detected |
| Week 3 Sep. | 1.83E-07 | 1.14E-06 | 3.24E-06 | Not detected |
| Week 4 Sep. | 5.21E-07 | 8.30E-07 | 1.75E-06 | Not detected |
| Week 1 Oct. | 1.08E-06 | 1.19E-06 | 2.06E-06 | Not detected |
| Week 2 Oct. | 9.73E-07 | 1.18E-06 | 2.13E-06 | Not detected |
| Week 3 Oct. | 8.24E-06 | 3.37E-06 | 2.65E-06 | Detected |
| Week 4 Oct. | 2.37E-06 | 1.34E-06 | 1.61E-06 | Detected |
| Week 1 Nov. | 4.79E-06 | 5.46E-06 | 5.04E-06 | Not detected |
| Week 2 Nov. | 1.31E-06 | 1.30E-06 | 1.93E-06 | Not detected |
| Week 3 Nov. | -1.81E-07 | 9.40E-07 | 2.68E-06 | Not detected |
| Week 4 Nov. | 7.77E-07 | 1.35E-06 | 2.84E-06 | Not detected |
| Week 1 Dec. | 2.73E-07 | 9.44E-07 | 2.70E-06 | Not detected |
| Week 2 Dec. | 4.72E-08 | 5.09E-07 | 1.72E-06 | Not detected |
| Week 3 Dec. | 6.40E-07 | 8.03E-07 | 1.14E-06 | Not detected |
| Week 4 Dec. | 6.92E-07 | 8.31E-07 | 1.35E-06 | Not detected |

Table 2-20: Weekly Activity concentrations of $^{241}$Am (Bq/g) in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{241}$Am Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.93E+01 | 2.81E+00 | 3.02E-01 | Detected |
| Week 2 Aug. | 5.60E+00 | 1.07E+00 | 2.75E-01 | Detected |
| Week 3 Aug. | 7.45E+00 | 2.02E+00 | 8.97E-01 | Detected |
| Week 4 Aug. | 7.59E+00 | 1.49E+00 | 3.77E-01 | Detected |
| Week 1 Sep. | 5.43E+01 | 6.76E+00 | 2.54E-01 | Detected |
| Week 2 Sep. | 1.26E+01 | 1.99E+00 | 2.34E-01 | Detected |
| Week 3 Sep. | 7.61E+00 | 1.53E+00 | 3.08E-01 | Detected |
| Week 4 Sep. | 1.59E+01 | 2.17E+00 | 1.13E-01 | Detected |
| Week 1 Oct. | 1.69E+01 | 2.16E+00 | 6.32E-02 | Detected |
| Week 2 Oct. | 1.56E+01 | 2.09E+00 | 9.55E-02 | Detected |
| Week 3 Oct. | 1.05E+02 | 1.24E+01 | 1.51E-01 | Detected |
| Week 4 Oct. | 2.22E+02 | 2.73E+01 | 6.70E-01 | Detected |
| Week 1 Nov. | 6.95E+01 | 8.59E+00 | 1.53E-01 | Detected |
| Week 2 Nov. | 5.19E+01 | 7.33E+00 | 4.59E-01 | Detected |
| Week 3 Nov. | 1.69E+01 | 2.52E+00 | 2.88E-01 | Detected |
| Week 4 Nov. | 3.72E+00 | 6.58E-01 | 1.12E-01 | Detected |
| Week 1 Dec. | 2.08E+00 | 4.39E-01 | 1.04E-01 | Detected |
| Week 2 Dec. | 5.97E+00 | 1.35E+00 | 4.90E-01 | Detected |
| Week 3 Dec. | 1.48E+01 | 2.22E+00 | 1.80E-01 | Detected |
| Week 4 Dec. | 1.31E+01 | 2.25E+00 | 2.44E-01 | Detected |

Table 2-21: Weekly Activity concentrations of $^{29+240}$Pu (Bq/g) in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{239+240}$Pu Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.86E+00 | 5.62E-01 | 2.87E-01 | Detected |
| Week 2 Aug. | 2.58E-01 | 1.90E-01 | 2.43E-01 | Detected |
| Week 3 Aug. | 9.19E-01 | 9.54E-01 | 1.39E+00 | Not detected |
| Week 4 Aug. | 5.22E-01 | 3.98E-01 | 4.80E-01 | Detected |
| Week 1 Sep. | 5.59E+00 | 1.09E+00 | 2.06E-01 | Detected |
| Week 2 Sep. | 1.33E+00 | 4.50E-01 | 2.14E-01 | Detected |
| Week 3 Sep. | 6.37E-01 | 3.47E-01 | 3.04E-01 | Detected |
| Week 4 Sep. | 1.74E+00 | 4.93E-01 | 1.38E-01 | Detected |
| Week 1 Oct. | 2.01E+00 | 4.88E-01 | 1.59E-01 | Detected |
| Week 2 Oct. | 2.47E+00 | 5.16E-01 | 1.13E-01 | Detected |
| Week 3 Oct. | 1.37E+01 | 2.07E+00 | 9.15E-02 | Detected |
| Week 4 Oct. | 2.08E+01 | 7.32E+00 | 1.18E+00 | Detected |

Table 2-21: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/g) in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{239+240}Pu$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Nov. | 7.94E+00 | 2.94E+00 | 4.31E-01 | Detected |
| Week 2 Nov. | 3.95E+00 | 2.53E+00 | 1.24E+00 | Detected |
| Week 3 Nov. | 1.97E+00 | 8.91E-01 | 5.83E-01 | Detected |
| Week 4 Nov. | 2.66E-01 | 2.19E-01 | 2.79E-01 | Not detected |
| Week 1 Dec. | 1.53E-01 | 1.84E-01 | 3.47E-01 | Not detected |
| Week 2 Dec. | 4.47E-01 | 2.46E-01 | 2.21E-01 | Detected |
| Week 3 Dec. | 1.71E+00 | 4.69E-01 | 1.50E-01 | Detected |
| Week 4 Dec. | 8.34E-01 | 5.21E-01 | 4.87E-01 | Detected |

Table 2-22: Weekly Activity concentrations of $^{238}Pu$ (Bq/g) in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{238}Pu$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 2.08E-02 | 7.18E-02 | 2.06E-01 | Not detected |
| Week 2 Aug. | -5.84E-03 | 6.52E-02 | 2.43E-01 | Detected |
| Week 3 Aug. | 0.00E+00 | 5.91E-01 | 1.54E+00 | Not detected |
| Week 4 Aug. | 1.31E-01 | 1.70E+00 | 4.80E-01 | Not detected |
| Week 1 Sep. | 1.42E-01 | 1.40E-01 | 1.84E-01 | Not detected |
| Week 2 Sep. | -6.44E-03 | 7.17E-02 | 2.66E-01 | Detected |
| Week 3 Sep. | 2.51E-02 | 1.56E-01 | 4.43E-01 | Not detected |
| Week 4 Sep. | 7.19E-02 | 1.15E-01 | 2.42E-01 | Not detected |
| Week 1 Oct. | 4.95E-02 | 5.43E-02 | 9.43E-02 | Not detected |
| Week 2 Oct. | 6.47E-02 | 7.85E-02 | 1.41E-01 | Not detected |
| Week 3 Oct. | 5.21E-01 | 2.13E-01 | 1.68E-01 | Not detected |
| Week 4 Oct. | 1.26E+00 | 7.13E-01 | 8.58E-01 | Not detected |
| Week 1 Nov. | 4.53E-01 | 5.16E-01 | 4.77E-01 | Not detected |
| Week 2 Nov. | 4.20E-01 | 4.15E-01 | 6.19E-01 | Not detected |
| Week 3 Nov. | -3.50E-02 | 1.82E-01 | 5.20E-01 | Not detected |
| Week 4 Nov. | 7.61E-02 | 1.32E-01 | 2.79E-01 | Not detected |
| Week 1 Dec. | 2.18E-02 | 7.54E-02 | 2.15E-01 | Not detected |
| Week 2 Dec. | 5.98E-03 | 6.45E-02 | 2.18E-01 | Not detected |
| Week 3 Dec. | 7.09E-02 | 8.89E-02 | 1.26E-01 | Not detected |
| Week 4 Dec. | 2.49E-01 | 2.99E-01 | 4.87E-01 | Not detected |

## Non-Radiological Monitoring

Some of WIPP wastes, known as "mixed" transuranic waste, contain hazardous materials regulated under the Resource Conservation and Recovery Act (RCRA). Several potentially toxic elements, i.e., Pb, Cd, U, Th that are components of the WIPP mixed waste, are routinely monitor by CEMRC. The WIPP first received mixed waste on September 9, 2000, and therefore data for samples collected prior to that date compose a pre-mixed waste baseline for the elemental data, while those collected afterwards are considered operational. In the Non-Radiological results, data points are distinguished by color for the pre-operational and operational monitoring phases. Since all metals analysis on FAS filters was suspended from February 14, 2014 through December 31, 2014, only the first 6 weeks of 2014 (i.e. January 1, 2014 – February 14, 2014) metals analysis is reported in this section. Metals analysis was performed on the backup FAS filters between February 5, 2014 and February 14, 2014 once it was determined that no radioactivity was detected as a result of the WIPP fire event. However, all metals analysis ceased on February 14, 2014 as the CEMRC went into an expedited analyses mode with all filters being transferred directly to the Radiochemical (RC) Group for immediate processing. Since elevated levels of radioactive materials were detected on all Station A FAS filters and many Station B FAS filters following the February 14, 2014 event, metals analysis was suspended for the remainder of the 2014 calendar year. Metals analysis on the Station A and B FAS filters will resume again effective January 2015. Most important, there is no evidence for a long-term increase in the concentrations of any of these elements that can be linked to the WIPP operations in any way.

## Sample Preparation and Analysis

All analyses of the FAS filters are performed according to the methods detailed in the CEMRC document-controlled, standard operating procedures. A simplified scheme of the pre-radiological release event sample preparation process is shown in Figure 3-1.

Once the collected samples return to the laboratory, the individual FAS filters are desiccated for a minimum of 48 hours to ensure that any moisture on the filters is evaporated and to ensure complete decay of radon daughters. The filters are then weighed to determine mass loadings.

## Results and Discussion

Samples for metals analyses are prepared by acid digestion in a CEM MARS™ Xpress™ microwave unit according to CEMRC procedures. Individual FAS filters are placed in separate Teflon vessels and digested at 195˚C using an acid matrix consisting of nitric acid, hydrochloric acid, and hydrofluoric acids. A blank filter and Certified Reference Material (CRM) filter are also digested in the same manner for QC-purposes. All acids used in the digestions are either purchased as “trace metal” grade or purified in-house with a Milestone Inc. sub-boiling quartz distillation apparatus. After digestion, the FAS filter solutions are then combined into weekly composites and a small aliquot of each weekly composite is removed for inorganic analysis by Inductively-Coupled Plasma Mass Spectrometry (ICP-MS).

Elemental analysis by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) is conducted on weekly composites of the FAS filters using a low-resolution Perkin Elmer Elan 6100 ICP-MS, which has a peak resolution of <0.71amu for the mass range reported. The mass calibration value is within 0.1amu of the published true values. The system is configured with a cyclonic spray chamber. Triplicate readings were performed on each digestate, with the average result reported. The ICP-MS analyses used at CEMRC can provide data for up to 35 elements in the FAS filters, but in practice the concentrations of some elements, including, but not limited to, arsenic (As), beryllium (Be), cadmium (Cd), erbium (Er), europium (Eu), scandium (Sc), selenium (Se), samarium (Sm), thallium (Tl) and vanadium (V) are often below detectable or quantifiable levels. A second set of elements, notably silver (Ag), lithium (Li), and tin (Sn), often have variable concentrations in the blank filters which makes their quantification difficult.

Only the following metals are reported herein: aluminum (Al), cadmium (Cd), magnesium (Mg), lead (Pb), thorium (Th), and uranium (U). Table 2-23 shows the concentrations of the metals measured for the first six weeks of 2014. Time-series plots from 1998 through 2014 of the trace elemental data for these metals are exhibited in Figures 2-28 through 2-33. Data shown in red represents concentrations measured prior to September 2000 when the WIPP received its first shipment of mixed waste (depicted as the pre-operational phase with respect to CEMRC metals analyses). Different colors are used to represent "post operational" data. Some data is missing from the elemental data plots because of a sample holding time issue in the fourth quarter of 2004. As mentioned previously, only data between January 1, 2014 through February 13, 2014 is reported for metal analyses for the 2014 calendar year due to the February 14, 2014 underground radiological event. Furthermore, the data presented in these plots only reflect concentrations above MDC. The MDCs are re-calculated annually, and vary slightly from year to year. The concentrations of Cd, Th, and U regularly hover right around the MDC and in 2009, concentrations for these elements never exceeded the MDC.

Among the many inorganic pollutants originating from anthropogenic (human-caused) activities, heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), and lead (Pb) are of a major concern due to their toxic and potentially carcinogenic characteristics (Melaku, 2008). Cadmium (Cd) and lead (Pb) are doubly of concern as they are also components of the WIPP mixed waste, in addition to Th and U. It should be noted that these four elements (Cd, Pb, Th, and U) shown in Figures 2-30 through 2-33, respectively, were already present in measurable amounts in the WIPP aerosol effluent prior to the receipt of mixed waste. An increase in Cd and Pb were observed as a result of the February 5, 2014 underground fire event and is to be expected as the fire destroyed an underground mining vehicle. Al, Mg, Th and U concentrations observed during the week of the fire event were unchanged.

Information about the limits and potential health effects for the metals presented in this chapter are listed in Table 2-24. The US Environmental Protection Agency (EPA) only has National Ambient Air Quality Standards (NAAQS) for six principal pollutants, of which Pb is the only metal listed (U.S. EPA, 2012). Only the EPA limit for Pb is enforceable. The other limits listed in Table 2-24 from the Occupational Safety & Health Administration (O.S.H.A.) are just Recommended Exposure Limits (RELs).

Lead (Pb) is found naturally in the environment as well as in manufactured products. The major sources of Pb emissions have historically been from fuels in on-road motor vehicles (such as cars and trucks) and industrial sources (U.S. EPA, 2012). The EPA primary standard (established limit to protect the public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly) for Pb in ambient air is 150 ng/m$^3$ (0.15 µg/m$^3$) averaged over a rolling 3-month period. The highest recorded Pb concentration in the WIPP effluent air during 2014, totaling 541 ng/m$^3$, was measured in the FAS weekly composite during the first week of February and is attributed to the burning of the salt haul truck associated with the February 5, 2014 WIPP underground fire event. Lead concentrations returned to normal levels (1.30 ng/m$^3$) the following week. Figure 2-31 shows the measured concentrations of Pb from the WIPP exhaust air from 1998 through February 13, 2014. Prior to the February 5, 2014 fire event, the maximum Pb concentration measured by CEMRC (since 1998) was recorded in August of 2001 at 79.3 ng/m$^3$ although typically concentrations do not exceed 18.9 ng/m$^3$.

Cadmium (Cd) is often measured in the air as a result of burning fossil fuels and/or municipal waste materials. Figure 2-30 shows the measured concentrations from the WIPP exhaust air from 1998 through February 13, 2014. An increase in the Cd concentration was also observed in the weekly FAS composite as a result of the WIPP fire with a concentration of 367 ng/m$^3$ (0.000367mg/m$^3$). Despite the noticeable increase, this value never exceeded the EPA recommended guideline (0.002mg/m$^3$) for cadmium (see Table 2-24). Furthermore, the observed concentration dropped to 0.393 ng/m$^3$ (0.000000393mg/m$^3$) the following week.

Aluminum is of particular interest because of the correlation between the Al concentrations in ambient aerosols and the activities of $^{239+240}$Pu and $^{241}$Am (Arimoto, et. al. 2002, 2005, 2006). Windblown dust is the main source of Al and many other elements (such as Iron (Fe), Magnesium (Mg), Manganese (Mn), Scandium (Sc), and the rare earth elements). Dust is also the main source of naturally occurring radionuclides, including U, and fallout radionuclides such as plutonium (Pu) and Americium (Am). Kirchner, et al. (2002) has also discussed the relationships between Al and various radionuclides, both artificial and naturally occurring, in soils.  No changes in the average Al concentration was observed as a result of the WIPP fire event.

Historical studies at Station A have shown that concentrations of hazardous metals and various trace elements can be highly variable over time. This was true even in the samples collected prior to WIPP receiving the mixed waste in September 2000. The concentrations measured in the FAS samples collected for 2013 and the first six weeks of 2014 were no exception. Monthly averages for 2013 and the first six weeks of 2014 are shown for Al, Mg, Cd, Pb, Th, and U in Figures 2-8 through Figure 2-13, respectively. A fairly large variation is typically observed in the Cd levels (shown in Figure 2-10) ranging from values less than the MDC to the highest concentration of 1.21 ng/m$^3$ measured in December of 2013. This is approximately half of the highest concentration measured in 2012 (2.45 ng/m$^3$). The largest concentration of cadmium measured in the FAS filters since 1998 was in March 2000 of 14.7 ng/m$^3$ which was prior to receiving mixed waste at the WIPP (Figure 2-4). All of these values are well below the Recommended Exposure Limit (REL) of 2000 ng/m$^3$ (0.002mg/m$^3$) listed for Cd in Table 2-23. During the fourth quarter of 2010 with carry-over into the first quarter of 2011 there was an increase in the mining activity at the WIPP due to additional panel mining as well as mining in the experimental operations (XO) area. The increase in metal concentrations as a result of the increased mining activity for January 2011 could also be augmented by the fact that the winter weather has been noticeably dryer and windier than in recent history. The mining activity is particularly noticeable in the concentrations of Al and Mg (components of dust) concentrations shown in Figures 2-28 and 2-29, respectively.

Table 2-23: Summarizing 2014 FAS Inorganic Results (ng/m$^3$)

| Batch Start Date | Aluminum (Al) | Cadmium (Cd) | Magnesium (Mg) | Lead (Pd) | Thorium (Th) | Uranium (U) |
|---|---|---|---|---|---|---|
| 1/2/2014 | 158.3 | 0.285 | 1545.5 | 2.03 | 0.0337 | 0.0266 |
| 1/8/2014 | 240.2 | 0.325 | 2086.1 | 1.94 | 0.0472 | 0.0408 |
| 1/15/2014 | 221.2 | 0.289 | 1190.9 | 3.24 | 0.0403 | 0.0198 |
| 1/22/2014 | 278.7 | 0.363 | 1632.9 | 3.01 | 0.0538 | 0.0260 |
| 2/1/2014 | *168.4** | 366.9 | 611.7 | 541.6 | 0.0371 | 0.0361 |
| 2/8/2014 | 95.2 | 0.393 | 104.9 | 1.30 | 0.0161 | 0.0064 |

*There was a small problem with the analysis of the corresponding blank for the sample filters collected during the week of February 1, 2014, possibly the result of a possible contamination issue due to the vast quantity of loose material associated with this batch of filters. It should be noted that there was a large increase in the amount of particulates observed on the FAS filters a result of the fire on February 5, 2014. Multiple low-flow alarms occurred within a 24 hour time frame during and immediately following the fire event which necessitated 3 filter changes (compared to the typical single filter change per day). The amount of aluminum observed on the blank filter was abnormally high during this week and therefore the value reported for aluminum during the week of February 1, 2014 is an estimation only and is not included in the figures. A slight increase in the amount of other metals was also observed on the blank filter, however, the amounts for Cd, Mg, Pb, Th, and U were still within the typical background range observed in blank filters. As with all routine FAS filter analyses, blank subtraction is performed when the measured blank concentration is greater than the MDL value.

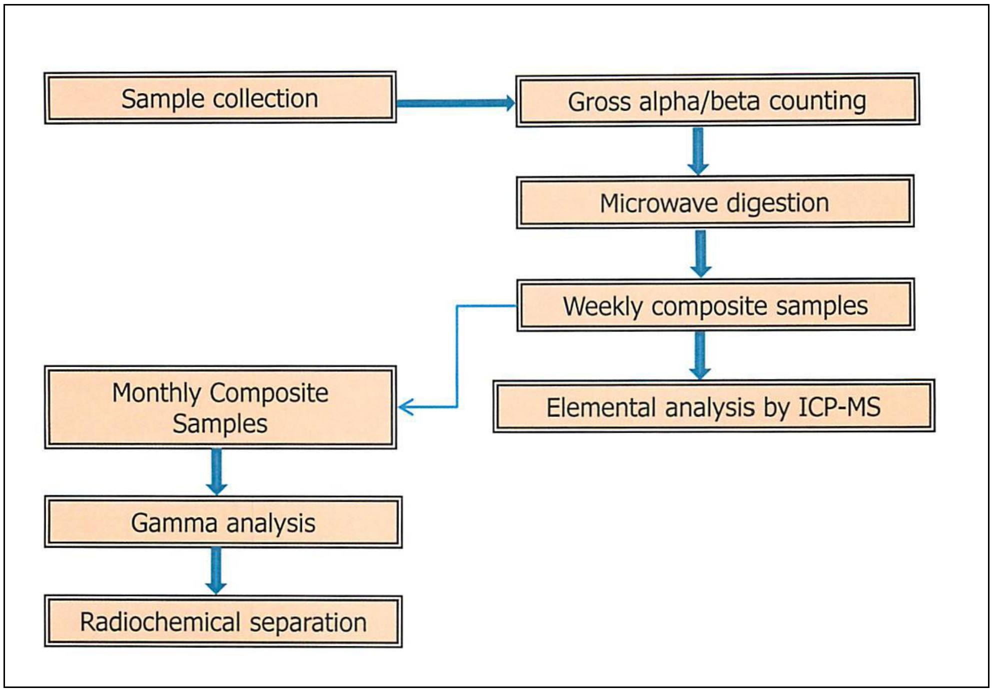



Figure 2-27: Flow Diagram Showing the Handling and Analysis of FAS Filters at the CEMRC prior to February 14, 2014

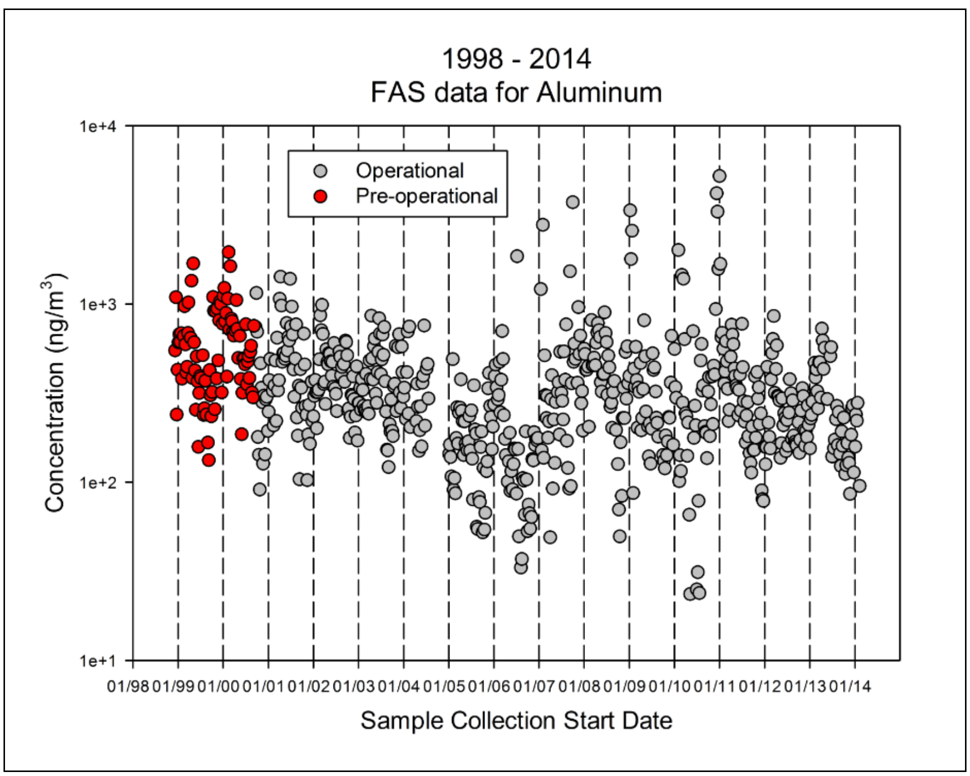



Figure 2-28: Concentrations of Al in WIPP Exhaust Air from 1998 through February 13, 2014

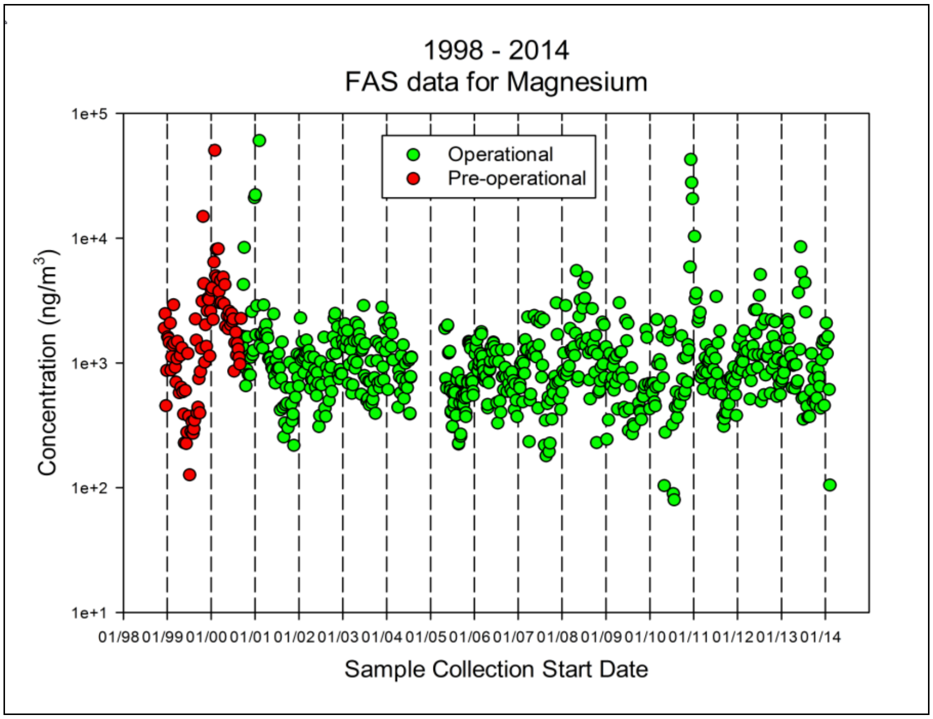



Figure 2-29: Concentrations of Mg in WIPP Exhaust Air from 1998 through February 13, 2014

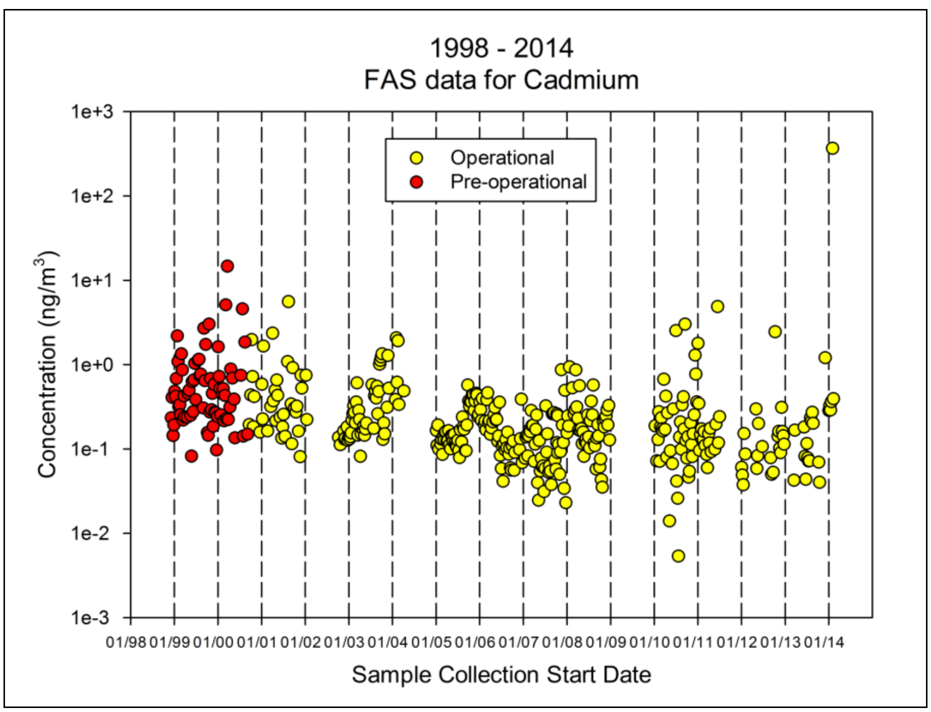



Figure 2-30: Concentrations of Cd in WIPP Exhaust Air from 1998 through February 13, 2014

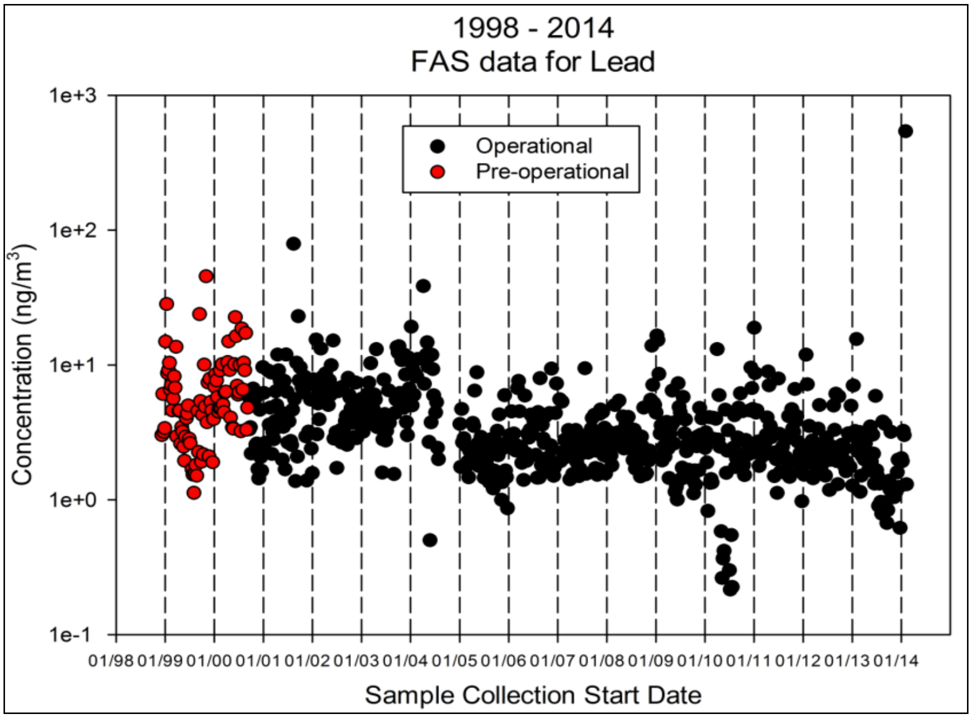



Figure 2-31: Concentrations of Pb in WIPP Exhaust Air from 1998 through February 13, 2014

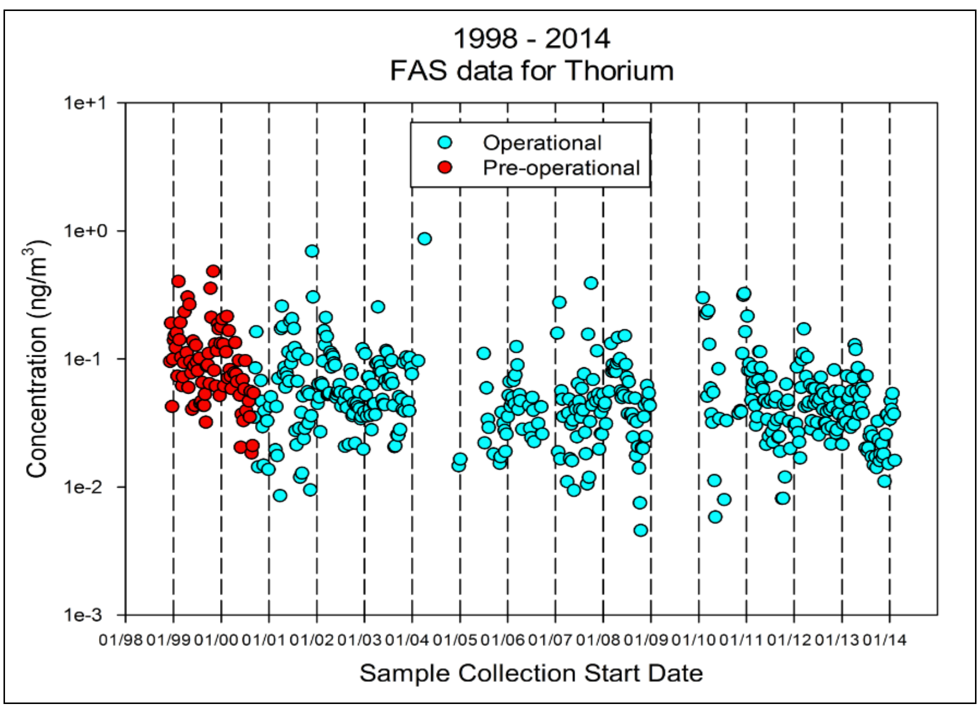



Figure 2-32: Concentrations of Th in WIPP Exhaust Air from 1998 through February 13, 2014

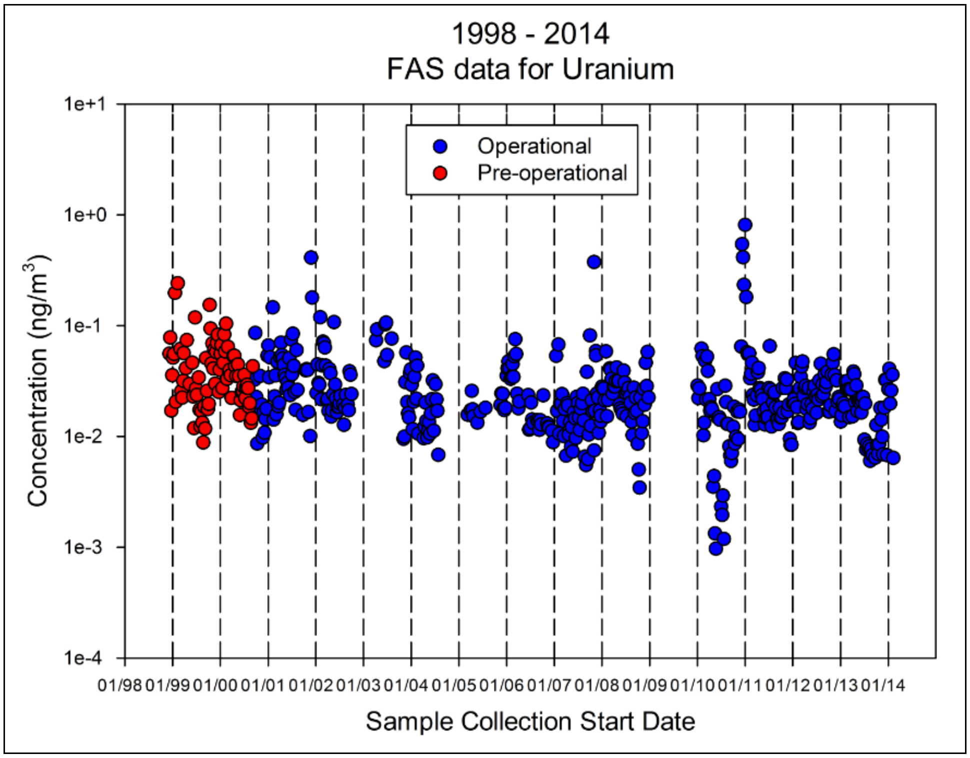



Figure 2-33: Concentrations of U in WIPP Exhaust Air from 1998 through February 13, 2014

Table 2-24: General Information about Inorganic Contaminants in Air

| Contaminant | Limit | Sources of contaminants | Potential Health Effects from Long Term Exposure | Source |
|---|---|---|---|---|
| Aluminum (respirable fraction) | 5mg/m$^3$ (8-hour time weighted average) | Dust, solder fumes | Pulmonary fibrosis | NIOSH Recommended Exposure Limit (REL)[(2)] |
| Cadmium (respirable dusts) | 0.002mg/m$^3$ | Burning fossil fuels, smoking, and incineration of municipal waste materials | Irritation/damage to lungs, kidney damage | EPA[(3)] |
| Magnesium | None | N/A | N/A | N/A |
| Lead (Pb)[(1)] | 0.15µg/m$^3$ | Dust, mining, smelting, refining activities | Neurological effects in children and cardiovascular effects in adults | EPA[(4)] |
| Thorium | None | Dust | N/A | EPA[(5)] |
| Uranium (insoluble and soluble compounds) | 0.2mg/m$^3$ | Dust, uranium mining | Chronic lung disease, cancer | NIOSH Recommended Exposure Limit (REL)[(6)] |

(1) EPA limit is enforceable

(2) http://www.cdc.gov/niosh/npg/npgd0022.html *and* http://www.cdc.gov/niosh/npg/nengapdxg.html

(3) American Conference of Governmental Industrial Hygienists (ACGIH). *1999 TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents. Biological Exposure Indices.* Cincinnati, OH. 1999. *and* http://www.epa.gov/ttn/atw/hlthef/cadmium.html

(4) http://www.epa.gov/superfund/lead/health.html

(5) http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/thorium.pdf

(6) National Institute for Occupational Safety and Health (NIOSH). *Pocket Guide to Chemical Hazards*. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention. Cincinnati, OH. 1997 *and* http://www.epa.gov/ttnatw01/hlthef/radionuc.html

(7) http://www.cescenter.com/documents/Regulatory%20Limits%20for%20Contaminants%20of%20Concern.pdf

(8) https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9992

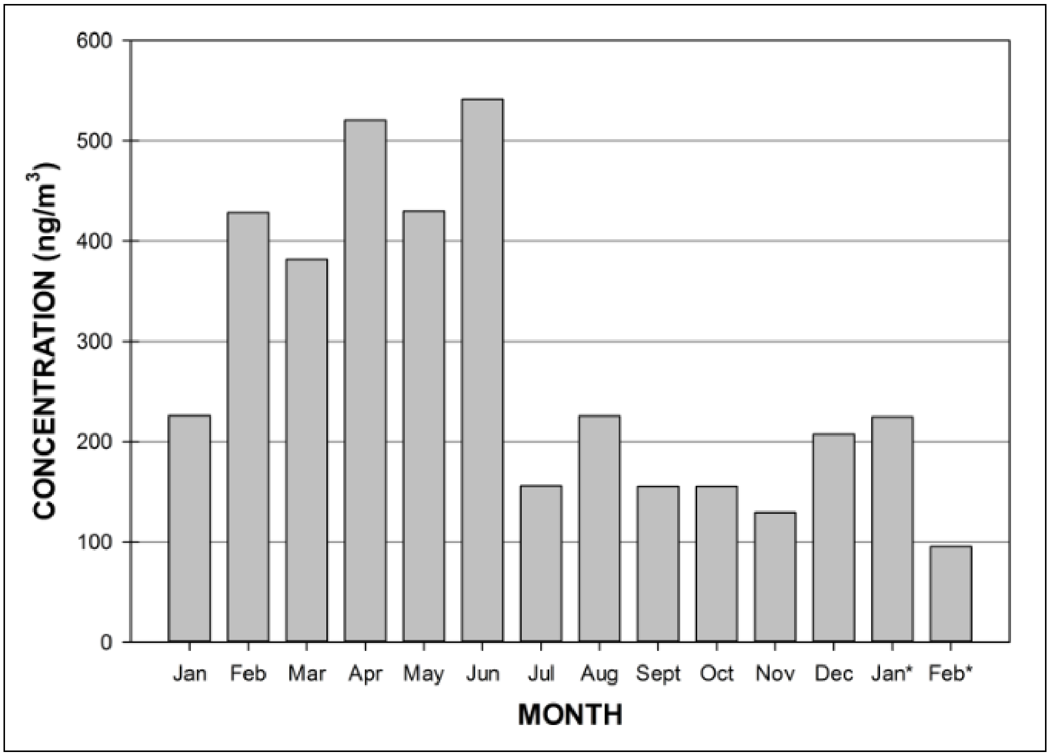



Figure 2-34: Monthly Average Concentrations of Al for 2013 and 2014

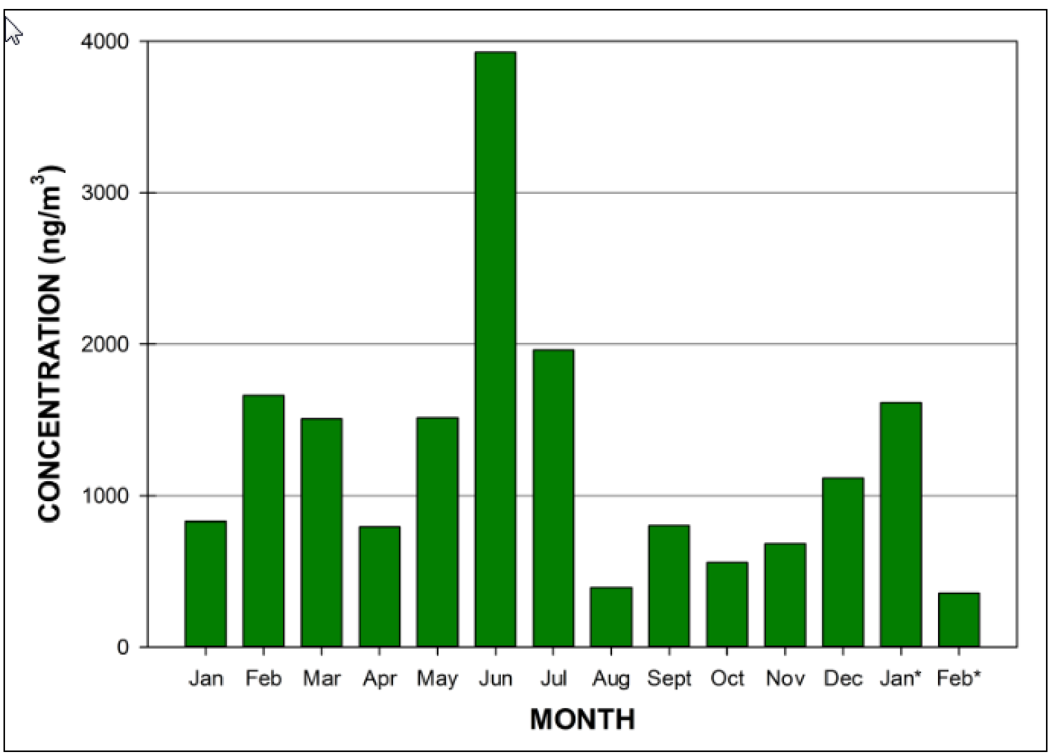



Figure 2-35: Monthly Average Concentrations of Mg for 2013 and 2014

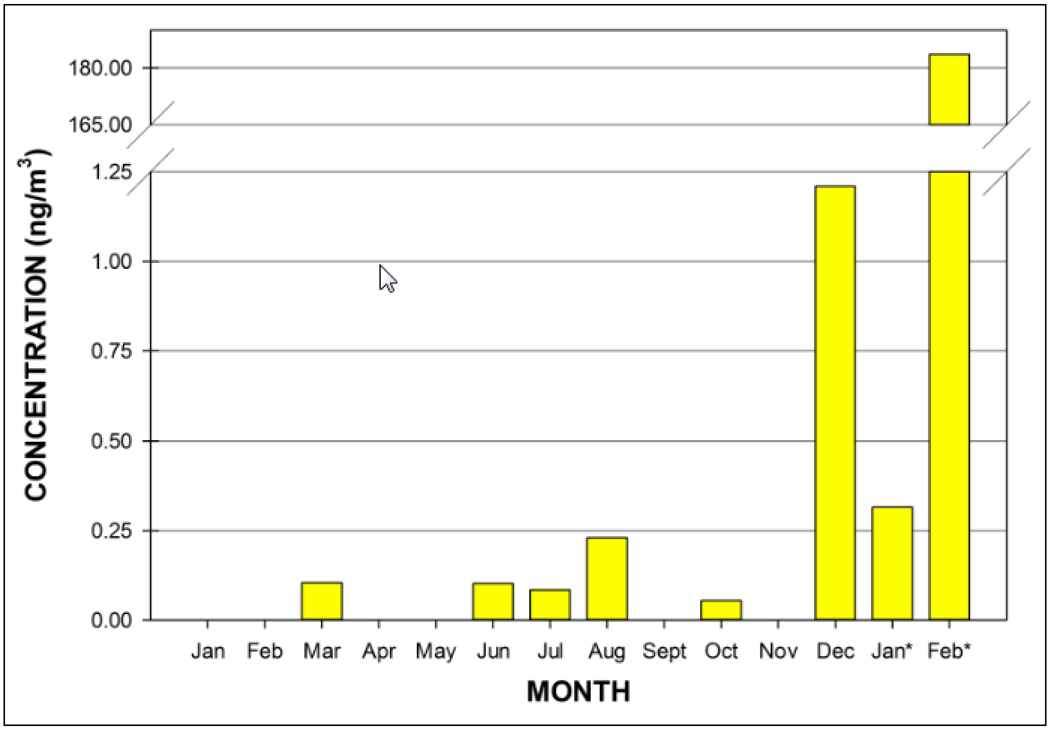



Figure 2-36: Monthly Average Concentrations of Cd for 2013 and 2014

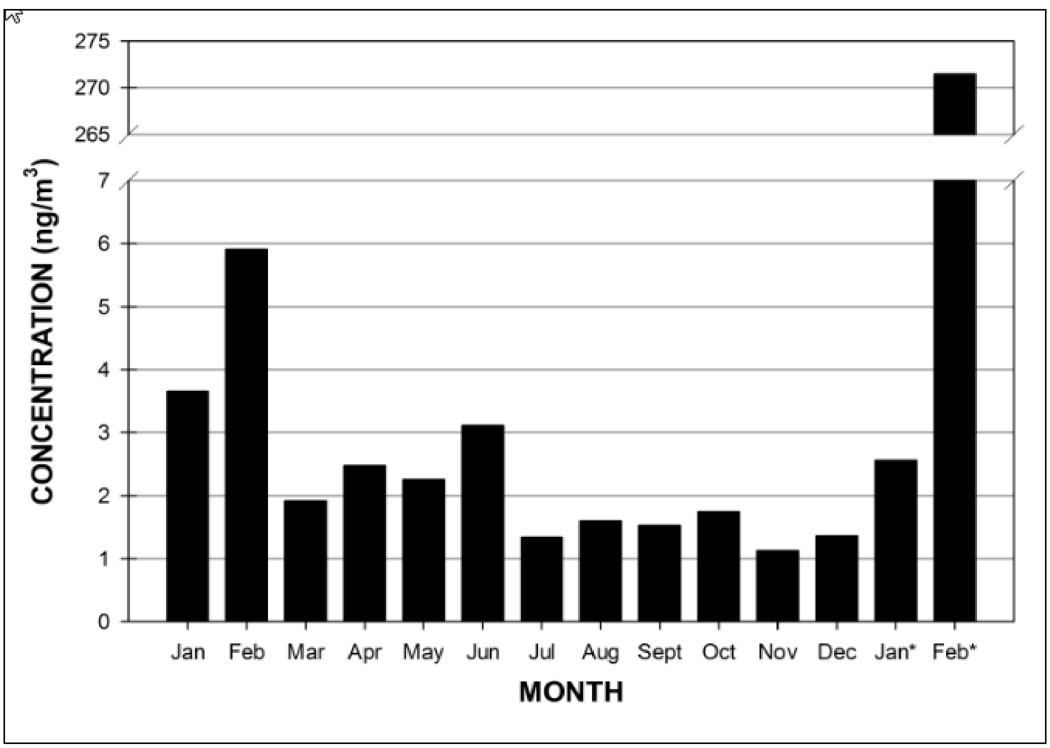



Figure 2-37: Monthly Average Concentrations of Pb for 2013 and 2014

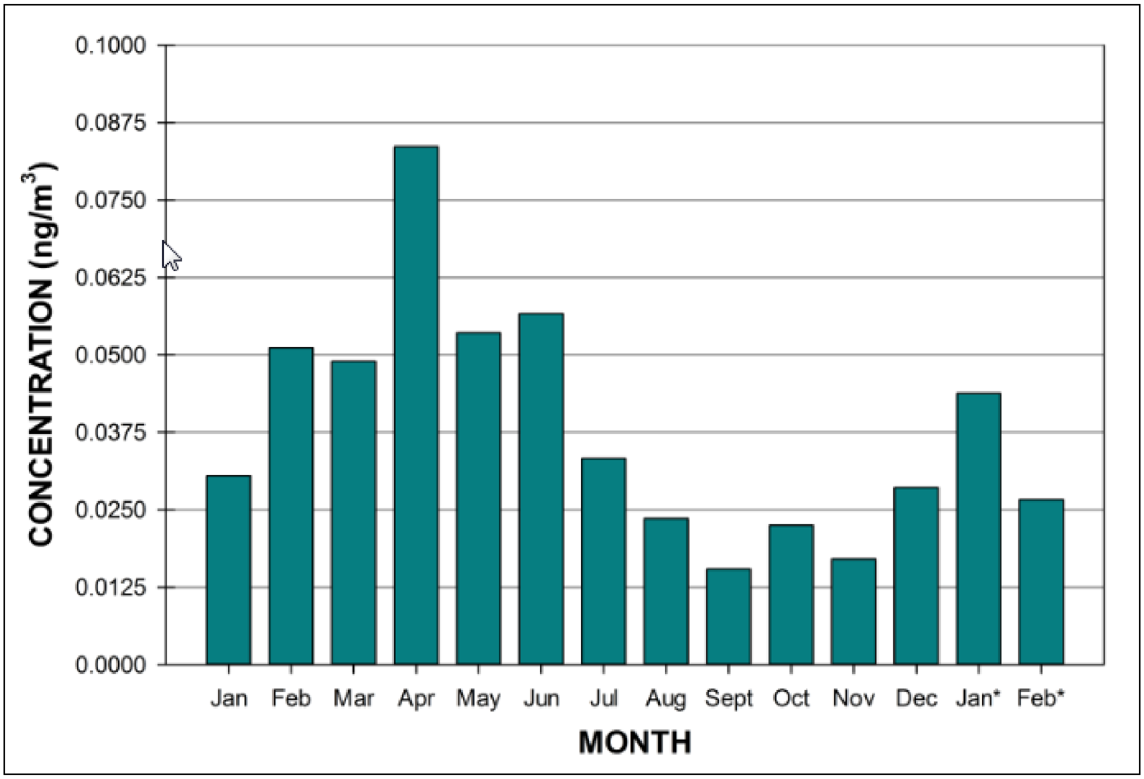



Figure 2-38: Monthly Average Concentrations of Th for 2013 and 2014

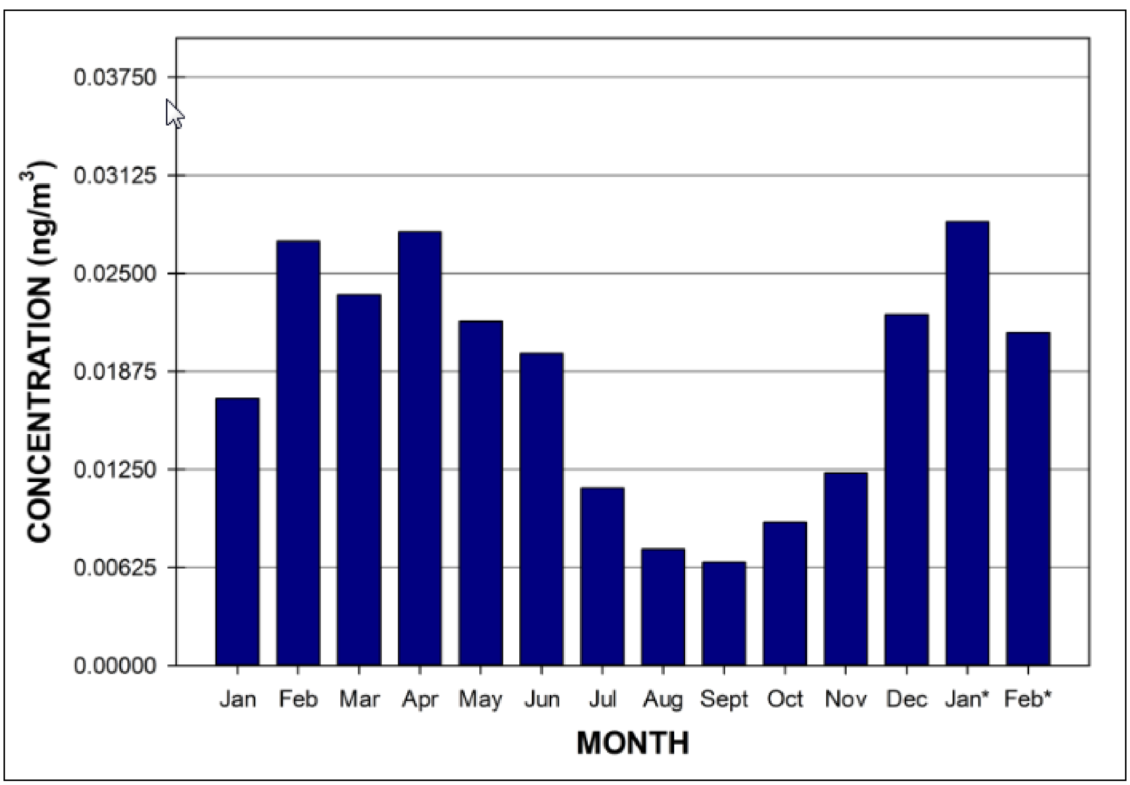



Figure 2-39: Monthly Average Concentrations of U for 2013 and 2014

# Chapter 3

## Ambient Air Monitoring

Ambient air monitoring essentially means the monitoring of "the air around us". Ambient air monitoring can provide a precautionary measure in the event of accidental releases of radioactivity. The CEMRC operates a network of continuously operating samplers at three locations in the vicinity of the WIPP site to monitor radioactive constituents in the ambient air. The program is design to detect radioactive materials in the air in case of an emergency response situation. The ambient air monitoring is an important aspect of the CEMRC environmental monitoring program that seeks to monitor the source of radionuclides in the WIPP environment, to detect any release of radioactive materials into the environment from the WIPP-related activities, and to ensure the protection of human and environmental health.

Currently, $^{238}$Pu, $^{239}$Pu and $^{240}$Pu isotopes can be measured as traces in environmental samples, with a $^{238}$Pu/$^{239+240}$Pu activity ratio of 0.03 at mean latitudes of 40$^{o}$-50$^{o}$ N tracing their global origin (UNSCEAR, 2000). At present, almost all plutonium being introduced into the atmosphere can be found in the surface soil. Depending on meteorological conditions, physiochemical properties of soil, and human activity, plutonium can migrate vertically with various rates, can be transported into plants or re-suspended into the air with eroded soil particles. These aerosol particles can be trapped on a filter in an air monitoring station or subjected to wash-down from the atmosphere with precipitation (i.e. rainfall or snowfall). Air samples can thus give information about activity levels both in the air and soil of a particular area, and allow evaluation of seasonal variations of plutonium in the air.

At the CEMRC, ambient aerosols are collected using high volume samplers ("hivols," flow rate ~1.13 $m^3$ $min^{-1}$) from three monitoring stations: (1) Onsite, which is about 0.1 km northwest of the WIPP exhaust shaft, (2) Near Field, about 1 km northwest of the facility; and (3) Cactus Flats, about 19 km southeast of the WIPP site. The locations of the three ambient air sampling stations are depicted in Figure 3-1. The 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 the WIPP. The aerosol samples were collected on 20×25 cm A/E$^{TM}$ glass fiber filters (Pall German Laboratory, Ann Arbor, MI). As shown in Figure 3-2, the sampling height of each aerosol station is ~5 m from the ground.

Under normal operating conditions, these filters are collected over a period of 3 to 6 weeks depending on the levels of particulate matter that accumulate on the filters. Following the radiation release event, filters were changed and analyzed weekly in order to provide isotopic results as quickly as possible.

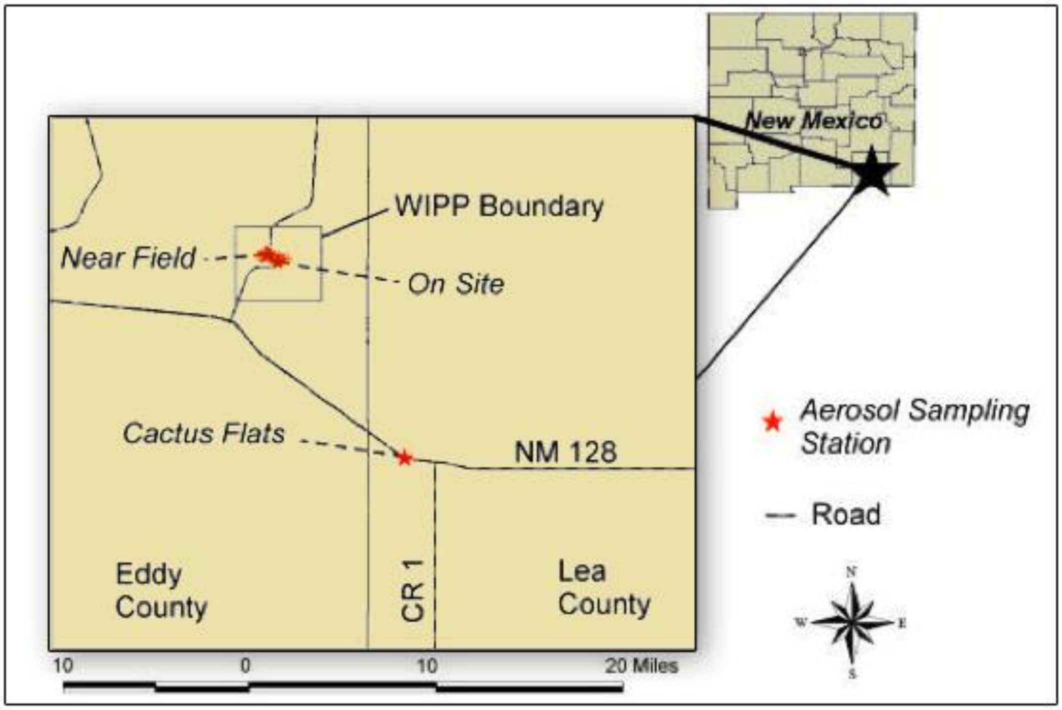



Figure 3-1: Ambient Aerosol Sampling Locations

Figure 3-2: Typical WIPP Site High Volume Air Sampling Station

## Sample Preparation

For radiochemical analyses, each filter was treated with strong acid mixtures, $HCl+HF+HClO_4$ up to the complete decomposition of silica. Then it was treated with conc. $HClO_4$ and $HNO_3$ for the removal of fluoride ions. The inside walls of the beaker were rinsed carefully with $HNO_3$ to gather residual HF, evaporation was repeated to ensure that all residual HF is removed from the matrix. The residues were dissolved in 1.0 M HCl for subsequent radionuclide separation and analysis. The acid digestates of the filter composite samples were split into two fractions. One fraction was analyzed by gamma spectroscopy for $^{40}K$, $^{60}Co$, and $^{137}Cs$. The other fraction was analyzed for the actinides. The actinides are separated as a group by co-precipitation on $Fe(OH)_3$. Pu isotopes are separated and purified using a two-column anion exchange resin (Dowex1-× 8, Eichrome, 100-200 mesh), while TRU chromatography columns are for the separation of Am. The samples are then micro-co-precipitated using an Nd-carrier, deposited onto filters, mounted on planchettes, and counted by Alpha spectroscopy for 24 hours. Gamma-emitting nuclides in the air filters are measured using a high purity germanium detector, HpGe (Canberra).

## Data Reporting

The activities of the actinides and gamma radionuclides in the air samples are reported as *activity concentration* ($Bq/m^3$) and *activity density* (Bq/g). *Activity concentration* is calculated as the activity of radionuclides detected in bequerels (Bq) divided by the volume of air in cubic meters, while *activity density* is calculated as the nuclides activity divided by the aerosol mass in grams collected on the filter.

## Results and Discussion

Intensified ambient air sampling and accelerated radiochemical analyses were performed in and around the WIPP site to ascertain whether or not there were releases to the ground surface following the radiation release event from the WIPP underground. Trace amounts of $^{241}Am$ and $^{239+240}Pu$ were briefly detected at two sampling locations (Onsite and Near Field). The filters that were analyzed had been installed at these stations prior to the event, on February 11, 2014 and the Near Field filter was removed on February 16, 2014. The Onsite filter was installed on February 11, 2014 and was removed on February 18, 2014 because the site was not accessible until then. A third ambient air filter station (Cactus Flats), located approximately 19 km (12 miles) southeast of the WIPP site, had a filter installed on February 11, 2014 and removed on February 16, 2014, but showed no detectable concentrations of americium or plutonium. The highest concentrations detected were 10.2 $\mu Bq/m^3$ for $^{239+240}Pu$ and 115.2 $\mu Bq/m^3$ for $^{241}Am$ at the Onsite sampling Station, and 81.4 $\mu Bq/m^3$ for $^{241}Am$ and 5.78 $\mu Bq/m^3$ for $^{239+240}Pu$ at the Near Field Station (Figures 3-3 and 3-4). The $^{241}Am$ to $^{239+240}Pu$ ratios of the elevated airborne radioactive concentrations are generally consistent with the waste stream suspected to have been released at WIPP.

The concentrations of $^{239+240}Pu$, $^{241}Am$ and $^{238}Pu$ measured in the ambient air filters following the WIPP underground radiation detection event are listed in Tables 3-1 through 3-4 (Onsite Station), Tables 3-5 through 3-8 (Near Field Station) and Tables 3-9 through 3-12 (Cactus Flats Station). Although these values are above the 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 levels of activity in all ambient air filters have decreased significantly since February 25, 2014. The mid-April analyses indicate that both the $^{241}$Am and $^{239+240}$Pu concentrations have returned to previous background levels. These analyses continue to reflect that the air around the WIPP site is safe and poses no health risk to the public.

A low level of contamination was again detected at our onsite and Near Field monitoring locations during Oct-Nov-2014. This increase in activity is attributed to the restart of the 860A fan on October 21, 2014. The 860A fan, which is part of the underground ventilation and filtration system, ran for approximately two months following the radiological incident before being taken off-line for maintenance. Since that time, the 860B or the 860C fans have been operating to continue the air filtration process. A small level of contamination that was detected in the ambient air was expected because the restart of fan 860A could have dislodged some residual contaminated particles. The current levels were all below the minimum detectable limit of the laboratory.

The highest levels of activity attributable to the February 14, 2014 radiological event, both in terms of activity concentrations and activity densities, occurred at the Onsite station, which is where one would expect any emission from the WIPP to be most evident. Naturally, the lowest levels of activity attributable to this event occurred at the Cactus Flats location, the reference station farthest from WIPP. The Am and Pu activity concentration follows the order: Onsite> Near Field >Cactus Flats, which is consistent with the aerosol mass loadings, which also follow the same trend: On Site (0.33-1.59 g)> Near Field (0.37-1.37 g) > Cactus Flats (0.31-0.99 g).

The WIPP's historical ambient air monitoring data also indicate frequent detection of $^{239+240}$Pu and $^{241}$Am in ambient air samples collected around WIPP (Figures 3-3 and 3-4). The detection of $^{238}$Pu is relatively infrequent because this radionuclide is not primarily from weapons fallout, but was released by the burn-up of nuclear powered satellites such as SNAP-9A (Hardy et al., 1973, Harley 1980). Peaks in $^{239+240}$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 plutonium and americium activity concentrations in the WIPP environment is therefore attributable to the re-suspension of contaminated soil dust. In cases where $^{238}$Pu was detected, its activity tended to increase with $^{239+240}$Pu, suggesting that the detected plutonium and americium isotopes are likely being re-suspended by wind and have an atomic-testing and satellite burn-up fallout origin.

Additionally, in the vicinity of WIPP there is a potential local source of anthropogenic (human-caused) radioactivity from an underground nuclear test that was part of the Plowshare project, the Gnome test (USAEC. 1973). The Gnome site is located about 8.8 km southwest of the WIPP site. In 1961 an underground test of a 3.3-kiloton $^{239}$Pu device vented radioactive materials to the surface (USAEC. 1973, Faller, 1994). Clean-up efforts at this site have been carried out in several campaigns since that time, and the surface contamination is now well below any level of public health and environmental concern. However, low levels of $^{137}$Cs and plutonium are still detectable in some surface soil samples collected from the Gnome site (CEMRC Annual Report, 2005/2006). The transport of these contaminants from the Gnome site to the WIPP remains a possibility during high wind seasons (Stout and

Arimoto, 2010); however, more than fifteen years of monitoring data and the activity levels detected, as well as their atomic ratio measurements, suggest that pre-release-event plutonium and americium in aerosol and soil samples collected near the WIPP facility primarily represent redistributed global fallout.

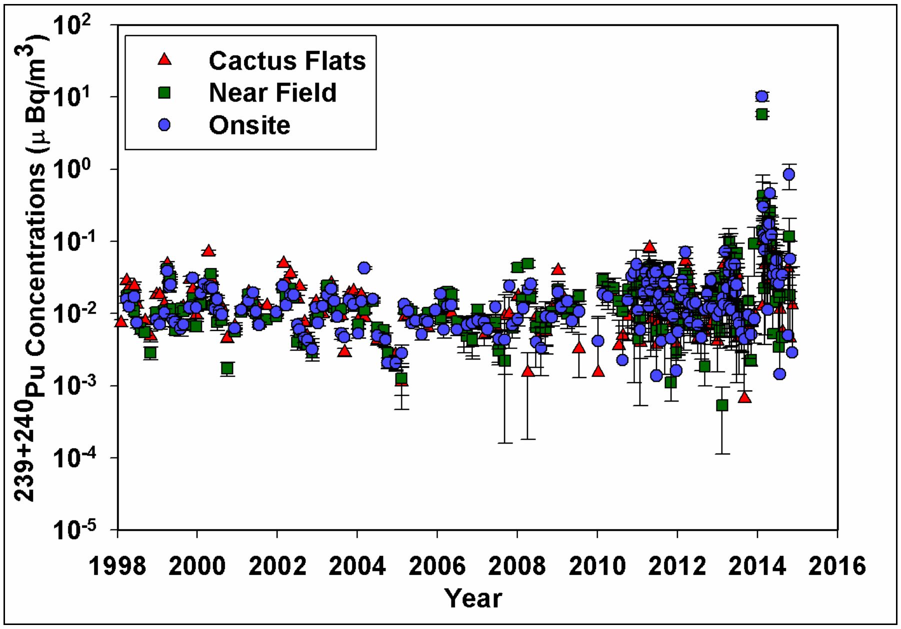



Figure 3-3: The Pre- and Post-radiological event $^{239+240}Pu$ concentrations in ambient air at three stations in the vicinity of the WIPP site

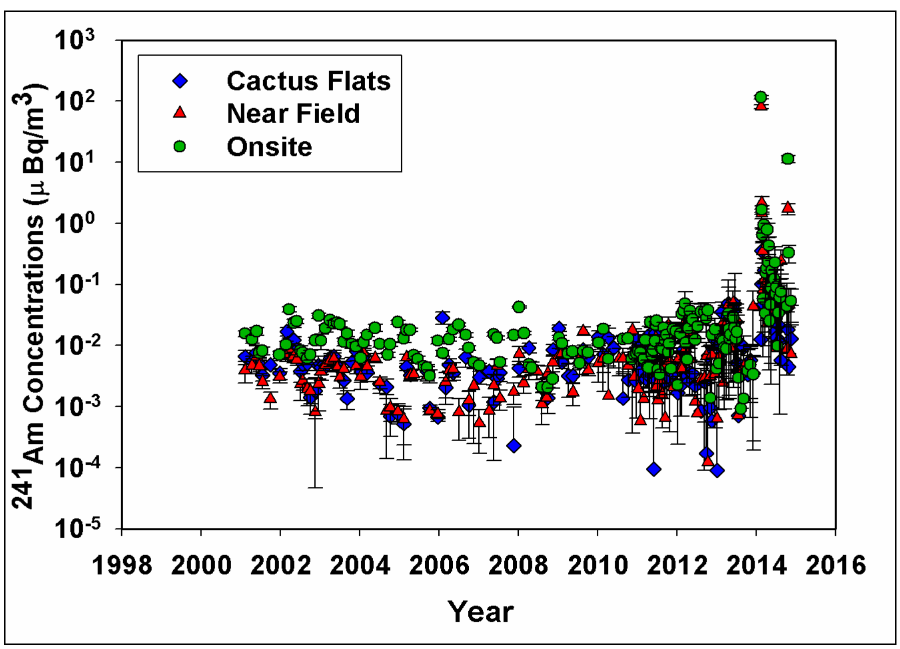



Figure 3-4: The Pre- and Post-radiological event $^{241}Am$ concentrations in ambient air at three stations in the vicinity of the WIPP site

Under normal operations (i.e. prior to the February 14, 2014 radiological event), the plutonium activity concentration and activity density are usually higher in Cactus flats samples with the activity following the order: Cactus Flats >Near Field> Onsite. The activity density data immediately following the radiation release event were not available, because filters collected during that period were not weighed. However, the aerosol mass data collected since July, 2014 showed that the activity density at all three stations were fairly consistent. The $^{239+240}$Pu activity densities (activity per unit mass aerosol collected) were in the range of 0.00-0.67 Bq/g at the Onsite station, 0.00-0.44 Bq/g at the Near Field station and 0.052-0.45 Bq/g at the Cactus Flats station, while that of $^{241}$Am were in the range of 0.085-0.96 Bq/g at the Onsite station, 0.18-0.79 Bq/g at the Near Field station and 0.14-0.83 Bq/g at the Cactus Flats station. Furthermore, the mass loadings at all stations tend to track one another remarkably well as shown in Figures 3-5 and 3-6.

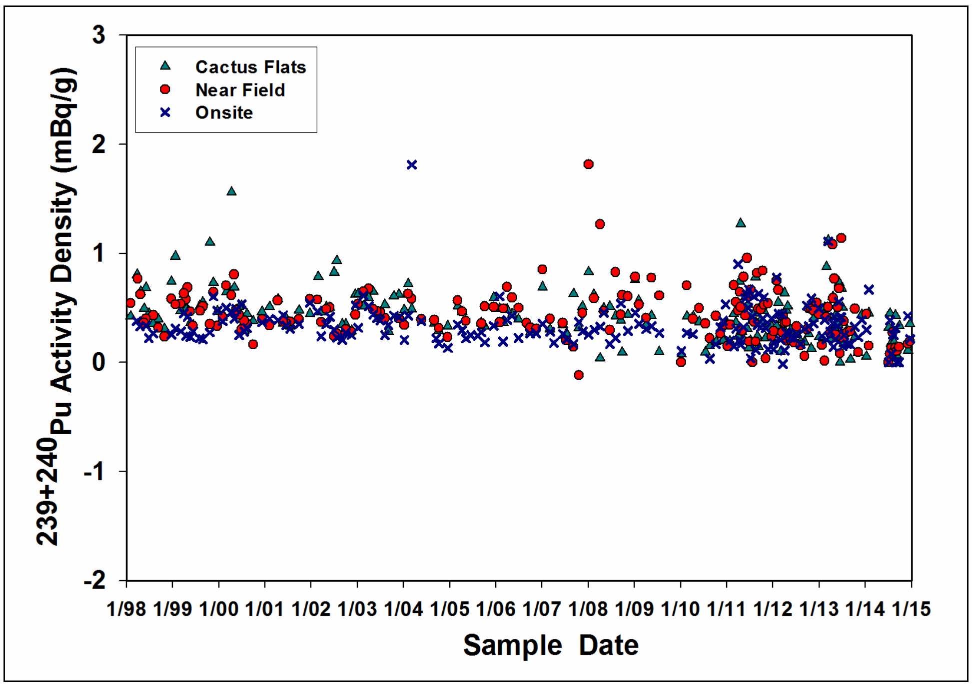



Figure 3-5: The Pre- and Post-radiological event $^{239+240}$Pu densities in ambient air at three stations in the vicinity of the WIPP site (Post-release dates are from July–December 2014)

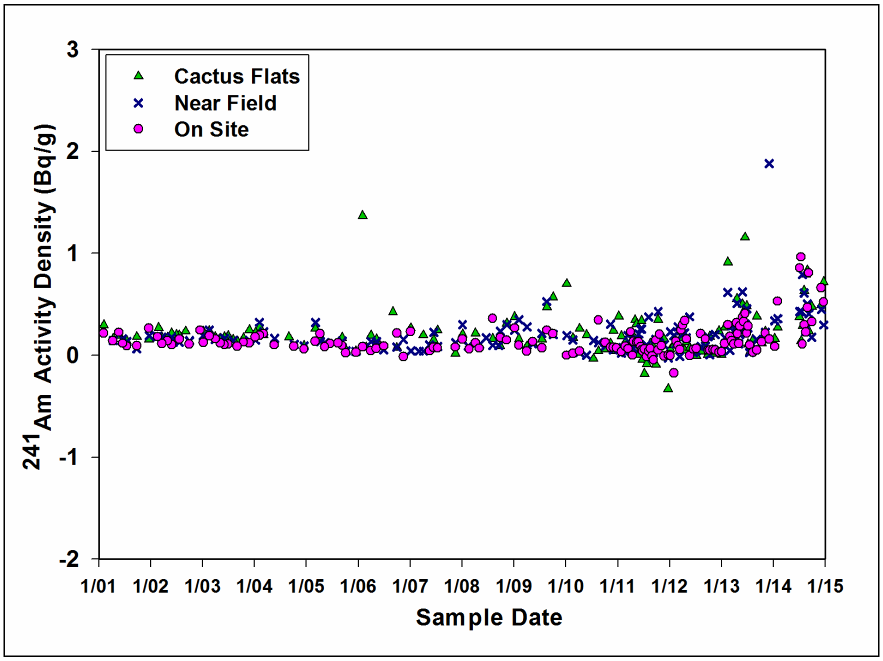



Figure 3-6: The Pre- and Post-radiological event $^{241}$Am densities in ambient air at three stations in the vicinity of the WIPP site (Post-release dates are from July-December 2014)

## Ambient Air Uranium Concentrations

Uranium is naturally occurring radionuclides found in the environment. 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 uranium in the ambient air is normal. Natural sources of uranium in ambient air include resuspension of soil and volcanic eruptions (ATSDR 1999; Kuroda et al. 1984); as well as anthropogenic sources of airborne uranium from coal and fuel combustion. The concentrations of uranium isotopes measured in the ambient air in the WIPP vicinity are listed in Table 4-4 (Onsite station), Table 4-8 (Near Field Station) and Table 4-12 (Cactus Flats Station). The isotopes of uranium were detected at all sample locations. The highest concentrations detected were 2.36E-6 Bq/m$^3$ for $^{234}$U and 2.10E-6 Bq/m$^3$ for $^{238}$U measured at Onsite sampling station. The concentrations detected between Onsite location and distant locations were not statistically different.

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 of 1.10±0.10 at Onsite Station, 1.15±0.48 at Near Field station, and 1.16±0.39 at Cactus Flats station are consistent with naturally occurring uranium. The uranium concentrations in the ambient air samples collected around WIPP site since 2011 are shown in Figures 3-7 and 3-8.

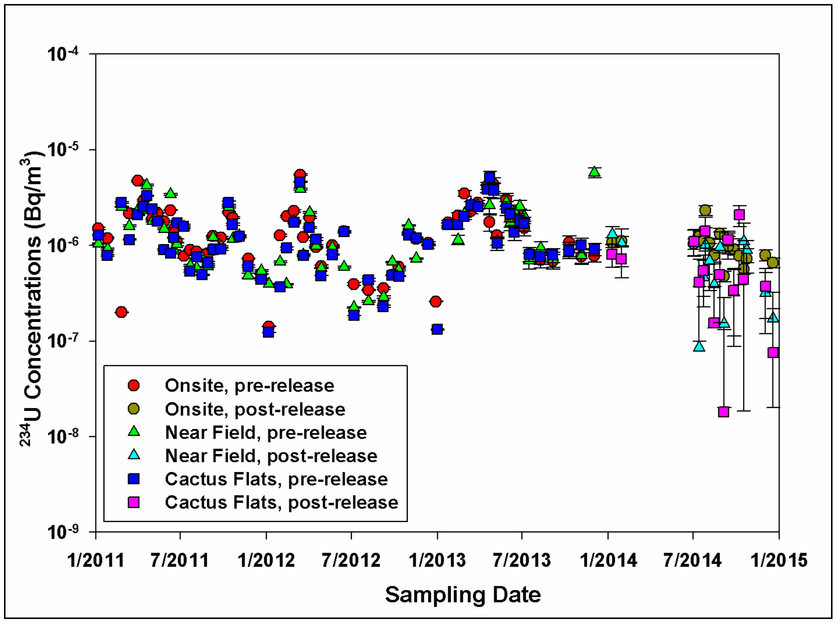



Figure 3-7: The Pre- and Post-radiological event $^{234}U$ concentrations in ambient air at three stations in the vicinity of the WIPP site (Post-release data are from July-December 2014)

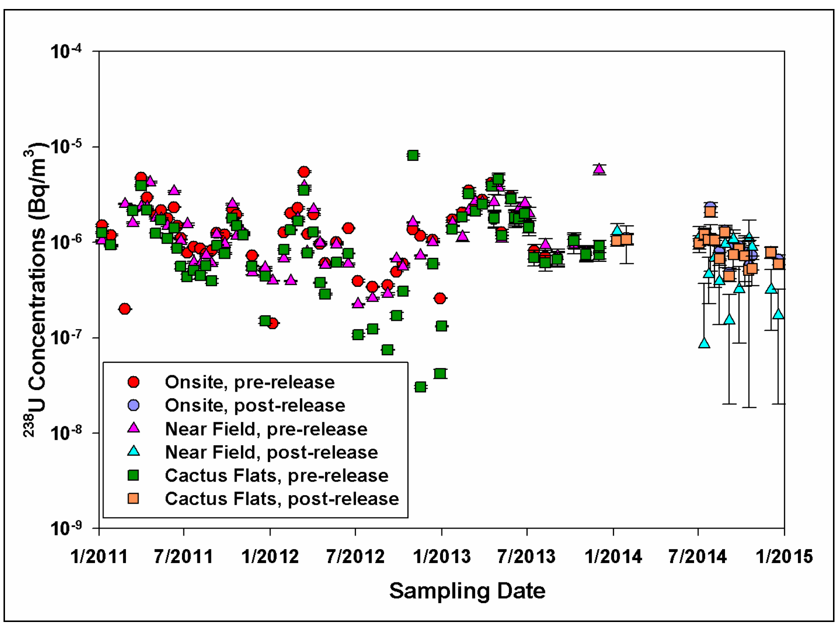



Figure 3-8: The Pre- and Post-radiological event $^{238}U$ concentrations in ambient air at three stations in the vicinity of the WIPP site (Post-release data are from July-December 2014)

## Ambient Air gamma radionuclide Concentrations

There were no measurable concentrations of $^{137}Cs$ or $^{60}Co$ in any of the ambient air filter samples collected following the radiation release event. However, $^{40}K$ was detected in a few ambient air filter samples. The $^{40}K$ is ubiquitous in the earth's crust and thus would be expected to show up in environmental air samples. There was no significant difference in the concentrations of $^{40}K$ among locations. The concentrations of $^{137}Cs$ and $^{40}K$ measured in ambient aerosol samples before and after the radiological event at WIPP are shown in Figures 3-9 through 3-14.

Additionally, there was no increase in gamma radionuclide concentrations that can be attributed to the February 14, radiation recent release event. The individual concentrations of these radionuclides measured in three aerosol stations are listed in Appendix E (Tables E1-E3). The individual activity densities of these radionuclides in these three monitoring stations are summarized Appendix E (Tables E4-E6).

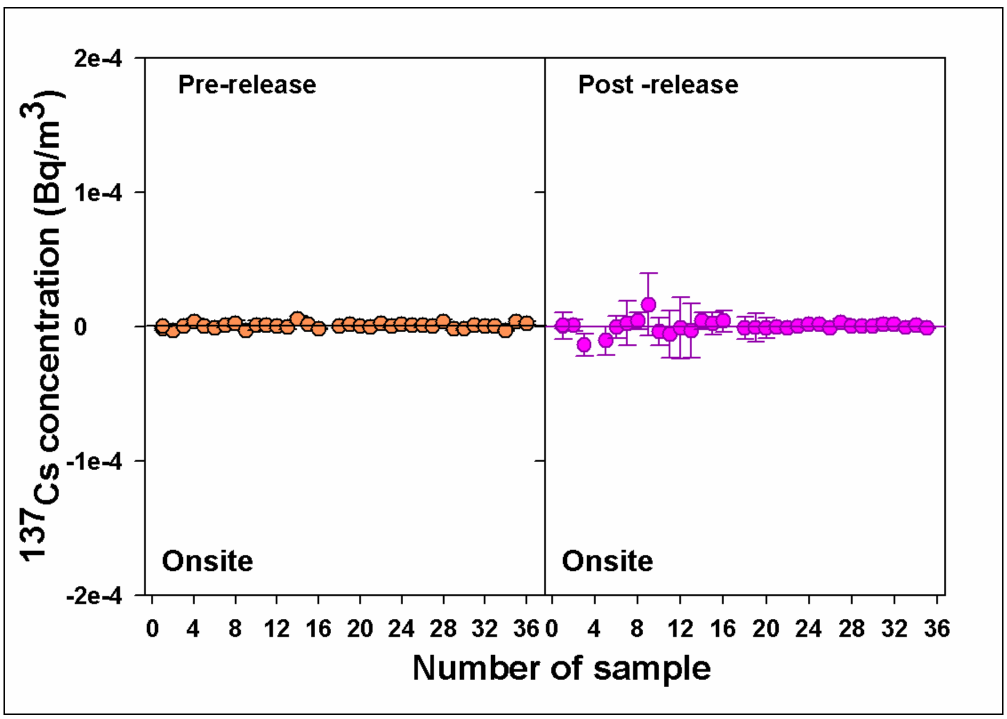



Figure 3-9: The Pre- and Post-release event $^{137}Cs$ concentrations in ambient air at Onsite station

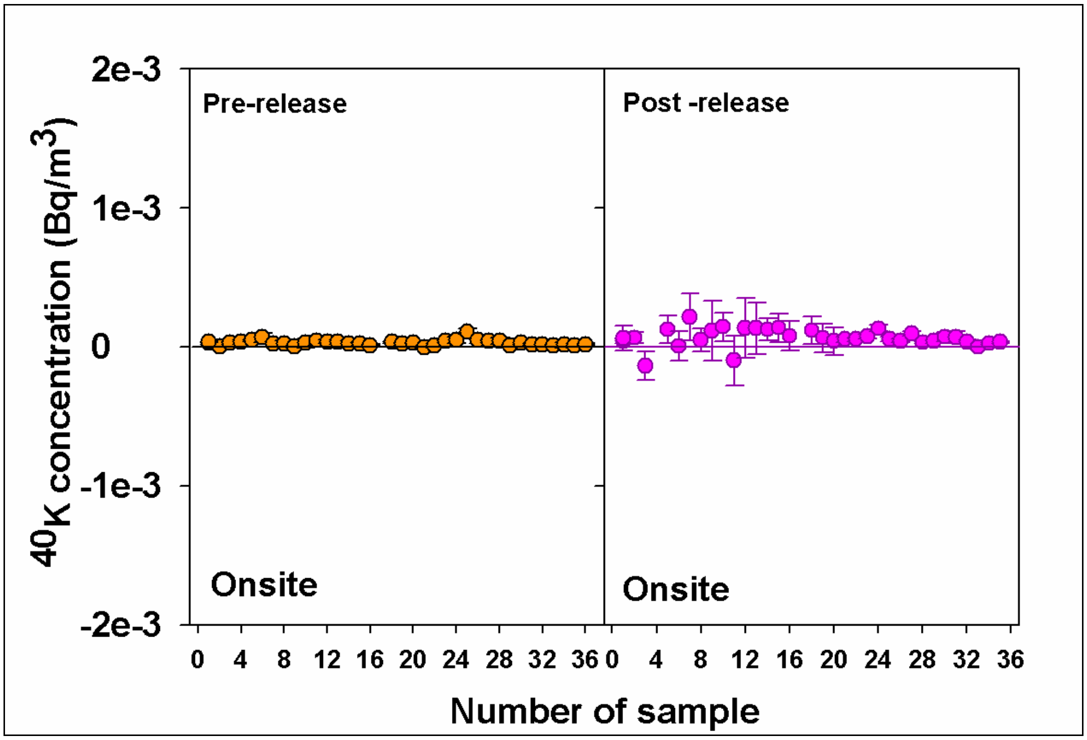



Figure 3-10: The Pre- and Post-radiological event $^{40}$K concentrations in ambient air at Onsite station

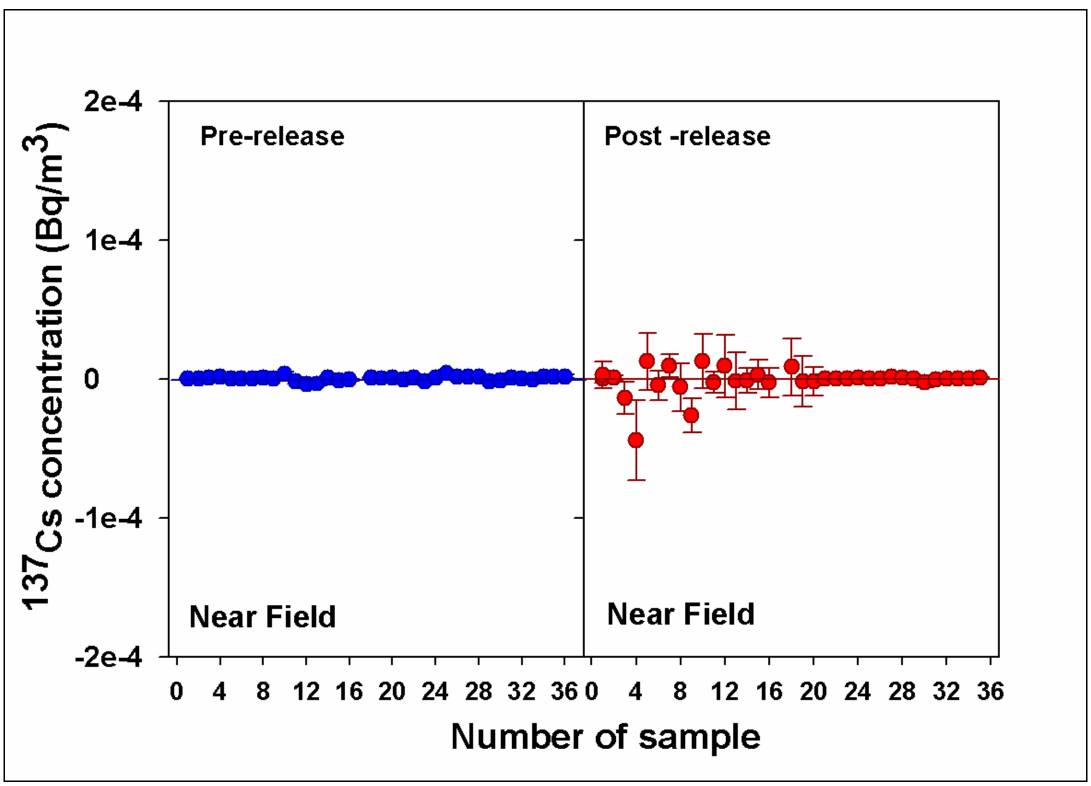



Figure 3-11: The Pre- and Post-radiological event $^{137}$Cs concentrations in ambient air at Near Field station

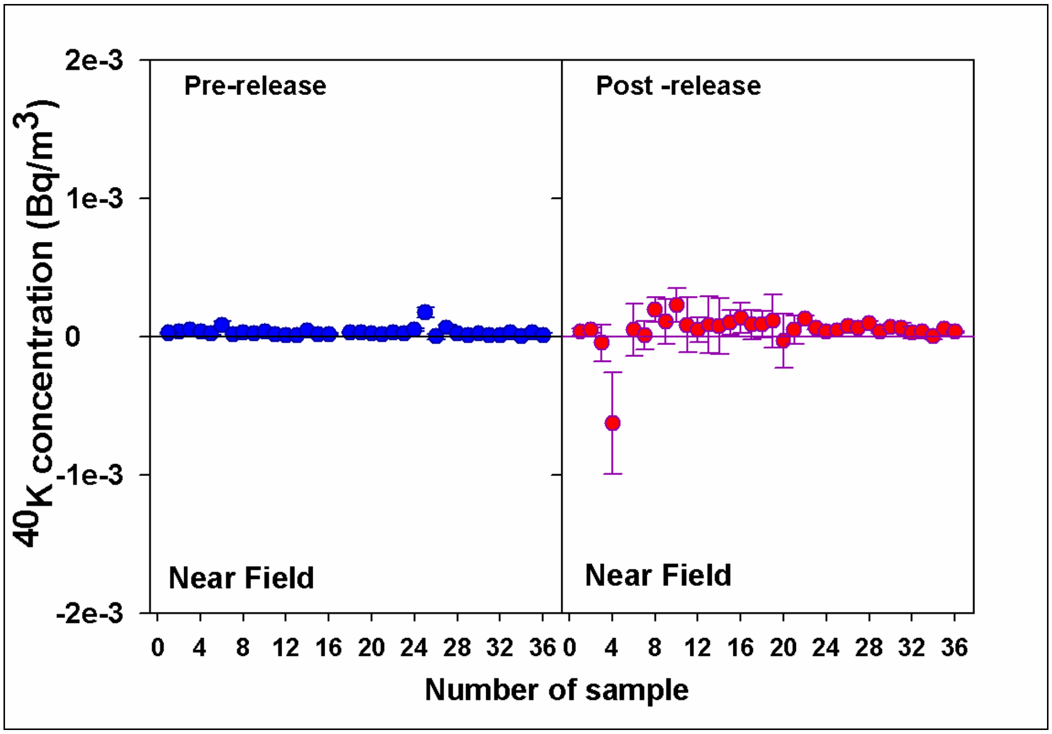



Figure 3-12: The Pre- and Post-radiological event $^{40}$K concentrations in ambient air at Near Field station

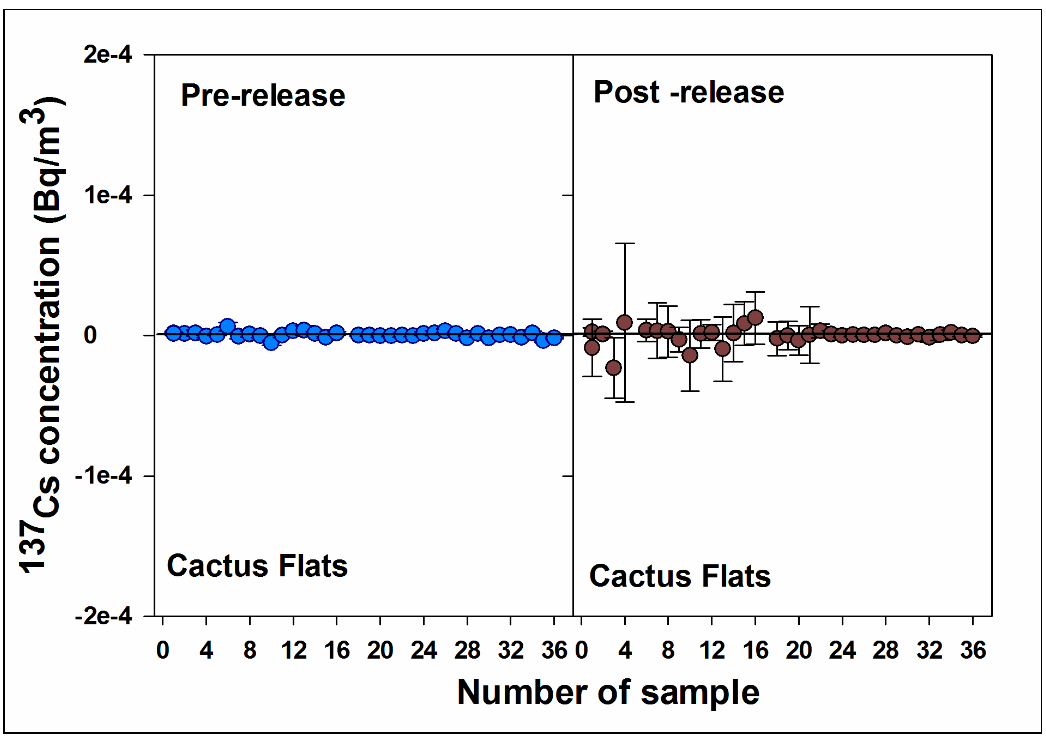



Figure 3-13: The Pre- and Post-radiological event $^{137}$Cs concentrations in ambient air at Cactus Flats station

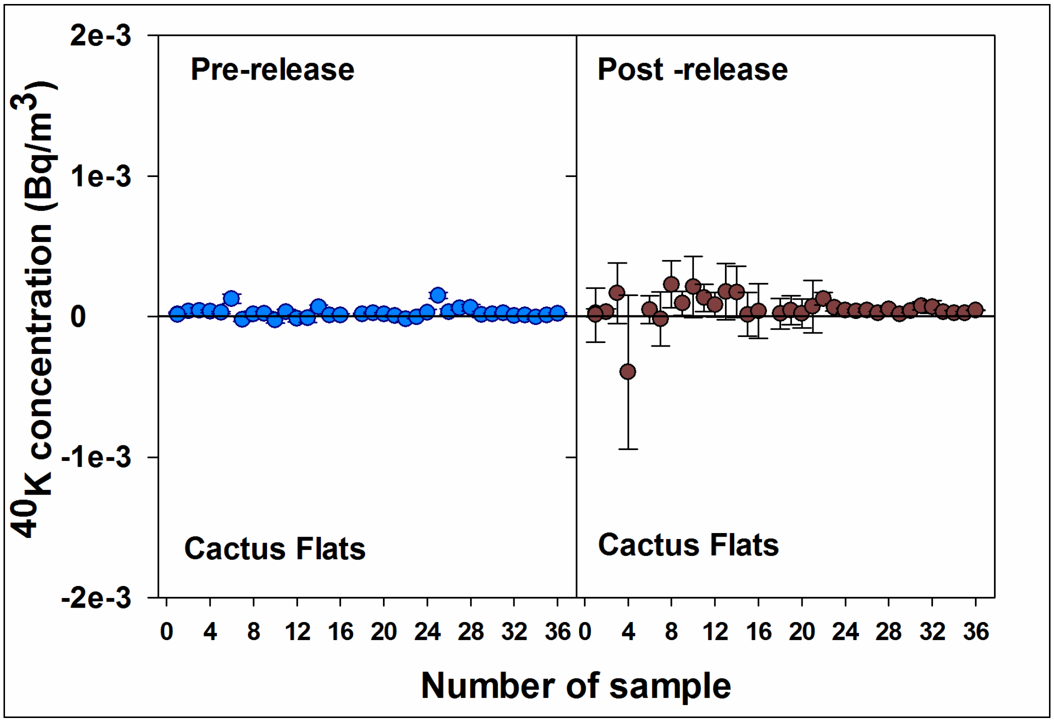



Figure 3-14: The Pre- and Post-radiological event $^{40}$K concentrations in ambient air at Cactus Flats station

Table 3-1A: Activity concentrations of $^{241}$Am in the filter samples collected from Onsite station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Feb. 11 - Feb 18 | 1.15E-04 | 6.94E-06 | 3.37E-08 | Detected |
| | Feb. 18 - Feb. 25 | 1.66E-06 | 2.53E-07 | 4.40E-08 | Detected |
| | Feb. 25 - Mar. 4 | 6.51E-07 | 1.54E-07 | 6.35E-08 | Detected |
| | Mar. 4 - Mar. 11 | 5.84E-08 | 5.20E-08 | 7.17E-08 | Not detected |
| | Mar. 11 - Mar. 21 | 9.34E-07 | 2.45E-07 | 9.42E-08 | Detected |
| | Mar. 21 - Mar. 29 | 3.35E-08 | 2.37E-08 | 1.39E-08 | Detected |
| | Mar. 29 - Apr. 4 | 1.54E-07 | 1.02E-07 | 1.30E-07 | Detected |
| | Apr. 4 - Apr. 11 | 1.82E-07 | 9.26E-08 | 7.83E-08 | Detected |
| | Apr. 11 - Apr. 19 | 7.86E-07 | 2.07E-07 | 9.99E-08 | Detected |
| | Apr. 19 - Apr. 25 | 2.33E-07 | 1.73E-07 | 2.40E-07 | Not detected |
| | Apr. 25 - May 2 | 4.32E-07 | 1.68E-07 | 1.06E-07 | Detected |
| | May 2 - May 9 | 2.52E-08 | 9.47E-08 | 2.63E-07 | Not detected |
| | May 9 - May 16 | 4.65E-08 | 5.34E-08 | 9.07E-08 | Not detected |
| | May 16 - May 23 | 8.77E-08 | 8.26E-08 | 9.10E-08 | Not detected |
| | May 23 – Jun. 6 | 1.69E-07 | 7.70E-08 | 5.27E-08 | Detected |

Table 3-1A: Activity concentrations of $^{241}Am$ in the filter samples collected from Onsite station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Jun. 6 - Jun. 13 | 7.10E-08 | 1.05E-07 | 1.97E-07 | Not detected |
| | Jun. 13 – Jun. 20 | 1.22E-07 | 1.26E-07 | 1.85E-07 | Not detected |
| | Jun. 20 - Jun. 27 | 2.26E-07 | 1.87E-07 | 2.52E-07 | Not detected |
| | Jun. 27 – Jul. 3 | 3.49E-08 | 5.08E-08 | 1.04E-07 | Not detected |
| | Jul. 3 – Jul. 14 | 4.53E-08 | 3.96E-08 | 5.31E-08 | Not detected |
| | Jul. 14 - Jul. 23 | 4.93E-09 | 2.48E-08 | 7.18E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 3.43E-08 | 6.87E-08 | 1.58E-07 | Not detected |
| | Aug. 5 - Aug. 15 | 6.10E-08 | 6.03E-08 | 7.86E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 7.57E-08 | 7.10E-08 | 1.08E-07 | Not detected |
| | Aug. 27 – Sep. 5 | 3.55E-08 | 3.68E-08 | 5.36E-08 | Not detected |
| | Sep. 5 - Sep. 26 | 1.33E-08 | 1.63E-08 | 2.95E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 3.15E-08 | 2.92E-08 | 3.93E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 4.42E-08 | 4.09E-08 | 5.44E-08 | Not detected |
| | Oct. 17 - Oct. 24 | 1.14E-05 | 1.55E-06 | 9.13E-08 | Detected |
| | Oct. 24 – Nov. 14 | 3.27E-07 | 1.06E-07 | 5.36E-08 | Detected |
| | Nov. 14 – Dec. 3 | 5.36E-08 | 2.98E-08 | 1.94E-08 | Detected |
| | Dec. 3 – Dec. 19 | 7.46E-09 | 1.35E-08 | 2.76E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 4.04E-09 | 1.15E-08 | 2.98E-08 | Not detected |

Table 3-1B: Activity concentrations of $^{241}Am$ in the filter samples collected from Onsite station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Jan. 9 – Jan. 29 | 4.18E-09 | 6.22E-09 | 1.40E-08 | Not Detected |
| | Jan. 29 - Feb. 11 | 1.39E-08 | 1.07E-08 | 2.00E-08 | Not Detected |
| | | | | | |
| | Jun. 27 – Jul. 3 | 9.29E-09 | 2.18E-08 | 5.22E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 3.44E-08 | 8.43E-08 | 2.06E-07 | Not detected |
| | Jul. 14 - Jul. 23 | 3.99E-08 | 3.55E-08 | 7.08E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 4.28E-09 | 1.21E-08 | 3.02E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 9.69E-09 | 1.71E-08 | 3.88E-08 | Not detected |
| | Aug. 15 – Aug. 27 | 7.56E-09 | 1.67E-08 | 3.99E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 1.88E-08 | 2.99E-08 | 6.83E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 1.16E-08 | 7.45E-09 | 1.29E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 1.11E-08 | 8.30E-09 | 1.15E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.62E-08 | 1.29E-08 | 2.34E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 7.75E-09 | 8.71E-09 | 1.82E-08 | Not detected |

*Feb.11-June 27: Emergency phase, samples collected were counted for 24 hours only

Table 3-2A: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Onsite station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Feb. 11 - Feb 18 | 1.02E-05 | 1.49E-06 | 1.03E-07 | Detected |
| | Feb. 18 - Feb. 25 | 3.01E-07 | 9.50E-08 | 3.21E-08 | Detected |
| | Feb. 25 - Mar. 4 | 1.24E-07 | 1.01E-07 | 1.30E-07 | Not detected |
| | Mar. 4 - Mar. 11 | 7.54E-08 | 7.17E-08 | 1.17E-07 | Not detected |
| | Mar. 11 - Mar. 21 | 1.12E-07 | 1.07E-07 | 1.91E-07 | Not detected |
| | Mar. 21 - Mar. 29 | 0.00E+00 | 5.42E-08 | 1.78E-07 | Not detected |
| | Mar. 29 - Apr. 4 | 1.09E-07 | 9.72E-08 | 1.34E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 1.12E-08 | 3.88E-08 | 1.04E-07 | Not detected |
| | Apr. 11 - Apr. 19 | 1.60E-07 | 8.87E-08 | 1.14E-07 | Detected |
| | Apr. 19 - Apr. 25 | 1.74E-07 | 2.14E-07 | 4.03E-07 | Not detected |
| | Apr. 25 - May 2 | 4.64E-07 | 1.70E-07 | 1.00E-07 | Detected |
| | May 2 - May 9 | -1.36E-08 | 7.05E-08 | 2.01E-07 | Not detected |
| | May 9 - May 16 | 1.22E-07 | 9.61E-08 | 8.93E-08 | Detected |
| | May 16 - May 23 | 3.39E-08 | 4.60E-08 | 7.74E-08 | Not detected |
| | May 23 – Jun. 6 | 3.45E-08 | 3.87E-08 | 6.34E-08 | Not detected |
| | Jun. 6 - Jun. 13 | 2.71E-08 | 4.00E-08 | 7.51E-08 | Not detected |
| | Jun. 13 – Jun. 20 | 4.30E-08 | 6.34E-08 | 1.19E-07 | Not detected |
| | Jun. 20 - Jun. 27 | 5.45E-08 | 6.97E-08 | 1.24E-07 | Not detected |
| | Jun. 27 – Jul. 3 | 3.51E-08 | 5.20E-08 | 9.76E-08 | Not detected |
| | Jul. 3 – Jul. 14 | -1.96E-09 | 2.19E-08 | 8.14E-08 | Not detected |
| | Jul. 14 - Jul. 23 | 2.59E-08 | 4.20E-08 | 8.55E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.44E-09 | 1.54E-08 | 5.21E-08 | Not detected |
| | Aug. 5 - Aug. 15 | -1.75E-09 | 1.79E-08 | 4.37E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 3.41E-08 | 3.86E-08 | 5.63E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 2.51E-08 | 3.14E-08 | 4.47E-08 | Not detected |
| | Sep. 5 - Sep. 26 | -5.56E-15 | 1.13E-08 | 4.04E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 3.34E-09 | 1.77E-08 | 5.56E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 5.00E-09 | 2.65E-08 | 8.32E-08 | Not detected |
| | Oct. 17 - Oct. 24 | 8.42E-07 | 3.20E-07 | 1.28E-07 | Detected |
| | Oct. 24 – Nov. 14 | 5.68E-08 | 4.33E-08 | 4.44E-08 | Detected |
| | Nov. 14 – Dec. 3 | 2.89E-09 | 3.13E-08 | 1.05E-07 | Not detected |
| | Dec. 3 – Dec. 19 | 1.21E-08 | 1.64E-08 | 2.76E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 4.04E-09 | 1.15E-08 | 2.98E-08 | Not detected |

Table 3-2B: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Onsite station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m³ | Unc. (2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Jan. 9 – Jan. 29 | 1.47E-08 | 9.98E-09 | 1.66E-08 | Detected |
| | Jan. 29 - Feb. 11 | 1.75E-08 | 1.19E-08 | 1.76E-08 | Detected |
| | Jun. 27 – Jul. 3 | 1.78E-08 | 2.08E-08 | 4.19E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 1.04E-15 | 1.51E-08 | 4.11E-08 | Not detected |
| | Jul. 14 - Jul. 23 | 1.60E-08 | 1.86E-08 | 3.77E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 3.10E-09 | 9.80E-09 | 2.46E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 8.27E-09 | 8.80E-09 | 1.54E-08 | Not detected |
| | Aug. 15 – Aug. 27 | 8.26E-09 | 1.04E-08 | 2.18E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 1.26E-08 | 1.09E-08 | 1.67E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 0.00E+00 | 5.48E-09 | 1.54E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 0.00E+00 | 9.16E-09 | 2.57E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.04E-08 | 7.45E-09 | 1.14E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 3.21E-09 | 3.61E-09 | 5.90E-09 | Not detected |

*Feb.11-June 27: Emergency phase, samples collected were counted for 24 hours only

Table 3-3A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Onsite station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m³ | Unc. (2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Feb. 11 - Feb 18 | 3.73E-07 | 1.83E-07 | 1.03E-07 | Detected |
| | Feb. 18 - Feb. 25 | 3.01E-07 | 9.50E-08 | 3.21E-08 | Detected |
| | Feb. 25 - Mar. 4 | 1.24E-07 | 1.01E-07 | 1.30E-07 | Not detected |
| | Mar. 4 - Mar. 11 | 1.26E-08 | 4.35E-08 | 1.17E-07 | Not detected |
| | Mar. 11 - Mar. 21 | 1.60E-08 | 4.52E-08 | 1.18E-07 | Not detected |
| | Mar. 21 - Mar. 29 | 3.85E-08 | 6.67E-08 | 1.41E-07 | Not detected |
| | Mar. 29 - Apr. 4 | 0.00E+00 | 7.29E-08 | 2.19E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 1.12E-08 | 3.17E-08 | 8.25E-08 | Not detected |
| | Apr. 11 - Apr. 19 | 1.90E-08 | 3.28E-08 | 6.97E-08 | Not detected |
| | Apr. 19 - Apr. 25 | 1.74E-07 | 1.96E-07 | 3.20E-07 | Not detected |
| | Apr. 25 - May 2 | 9.53E-08 | 9.10E-08 | 1.64E-07 | Not detected |
| | May 2 - May 9 | 1.22E-07 | 1.38E-07 | 2.01E-07 | Not detected |
| | May 9 - May 16 | 0.00E+00 | 3.92E-08 | 1.40E-07 | Not detected |
| | May 16 - May 23 | -1.31E-08 | 2.86E-08 | 1.02E-07 | Not detected |
| | May 23 – Jun. 6 | -6.89E-09 | 1.86E-08 | 6.26E-08 | Not detected |

Table 3-3A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Onsite station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Jun. 6 - Jun. 13 | -4.51E-09 | 2.34E-08 | 6.70E-08 | Not detected |
| | Jun. 13 – Jun. 20 | 1.07E-08 | 3.72E-08 | 1.06E-07 | Not detected |
| | Jun. 20 - Jun. 27 | 1.70E-08 | 5.05E-08 | 1.33E-07 | Not detected |
| | Jun. 27 – Jul. 3 | -5.88E-09 | 3.04E-08 | 8.69E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 9.82E-09 | 2.78E-08 | 7.23E-08 | Not detected |
| | Jul. 14 - Jul. 23 | -1.18E-08 | 2.59E-08 | 9.19E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 0.00E+00 | 1.57E-08 | 5.60E-08 | Not detected |
| | Aug. 5 - Aug. 15 | 1.75E-09 | 1.88E-09 | 6.35E-08 | Not detected |
| | Aug. 15 - Aug. 27 | -5.69E-09 | 2.01E-08 | 6.31E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -5.38E-09 | 1.89E-08 | 5.97E-08 | Not detected |
| | Sep. 5 - Sep. 26 | -1.04E-09 | 1.16E-08 | 4.30E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 5.02E-09 | 1.74E-08 | 4.96E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 2.00E-08 | 3.62E-08 | 7.42E-08 | Not detected |
| | Oct. 17 - Oct. 24 | 6.68E-08 | 9.06E-08 | 1.52E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 1.20E-08 | 2.16E-08 | 4.44E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 4.93E-08 | 5.91E-08 | 9.63E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 7.46E-09 | 1.35E-08 | 2.76E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -4.04E-09 | 8.85E-09 | 3.15E-08 | Not detected |

Table 3-3B: Activity concentrations of $^{238}Pu$ in the filter samples collected from Onsite station (5 days of counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Jan. 9 – Jan. 29 | 3.15E-09 | 5.56E-09 | 1.26E-08 | Not Detected |
| | Jan. 29 - Feb. 11 | -2.92E-09 | 1.01E-08 | 2.94E-08 | Not Detected |
| | Jun. 27 – Jul. 3 | 3.56E-16 | 1.19E-08 | 3.58E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 6.56E-09 | 8.77E-09 | 1.61E-08 | Not detected |
| | Jul. 14 - Jul. 23 | 1.60E-08 | 1.70E-08 | 3.22E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.40E-08 | 1.13E-08 | 1.87E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 1.65E-09 | 8.76E-09 | 2.33E-08 | Not detected |
| | Aug. 15 – Aug. 27 | -4.12E-09 | 7.29E-09 | 2.40E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -1.80E-09 | 8.05E-09 | 2.54E-08 | Not detected |
| | Sep. 5 – Sep. 26 | -9.68E-10 | 5.81E-09 | 1.68E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 1.63E-09 | 1.08E-08 | 2.82E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.90E-09 | 4.66E-09 | 1.14E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -8.02E-10 | 4.81E-09 | 1.40E-08 | Not detected |

*Feb.11-June 27: Emergency phase, samples collected were counted for 24 hours only

Table 3-4: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Onsite station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}U$ | Jan. 9 – Jan. 29 | 1.08E-06 | 1.26E-07 | 8.60E-09 | Detected |
| | Jan. 29 – Feb. 11 | 1.10E-06 | 1.39E-07 | 1.62E-08 | Detected |
| | Jun. 27 - Jul. 3 | 2.32E-06 | 2.85E-07 | 2.45E-08 | Detected |
| | Jul. 3 – Jul. 14 | 1.04E-06 | 1.31E-07 | 2.09E-08 | Detected |
| | Jul. 14 - Jul. 23 | 1.24E-06 | 1.60E-07 | 3.23E-08 | Detected |
| | Jul. 23 – Aug. 5 | 1.10E-06 | 1.37E-07 | 1.53E-08 | Detected |
| | Aug. 5 – Aug. 15 | 1.05E-06 | 1.35E-07 | 1.79E-08 | Detected |
| | Aug. 15 – Aug. 27 | 7.87E-07 | 1.17E-07 | 2.54E-08 | Detected |
| | Aug. 27 – Sep. 5 | 1.33E-06 | 1.76E-07 | 3.48E-08 | Detected |
| | Sep. 5 – Sep. 26 | 4.75E-07 | 5.84E-08 | 6.46E-09 | Detected |
| | Sep. 26 – Oct. 8 | 9.05E-07 | 1.11E-07 | 1.54E-08 | Detected |
| | Oct. 8 – Oct. 17 | 7.82E-07 | 3.95E-07 | 5.72E-08 | Detected |
| | Oct. 17 - Oct. 24 | 5.66E-07 | 5.48E-07 | 1.87E-07 | Detected |
| | Oct. 24 – Nov. 14 | 7.21E-07 | 2.08E-07 | 3.25E-08 | Detected |
| | Nov. 14 - Dec. 3 | 9.79E-07 | 2.59E-07 | 2.73E-08 | Detected |
| | Dec. 3 - Dec. 19 | 7.93E-07 | 1.06E-07 | 2.04E-08 | Detected |
| | Dec. 19 - Jan. 6 | 6.58E-07 | 8.13E-08 | 1.31E-08 | Detected |
| | | | | | |
| $^{235}U$ | Jan. 9 – Jan. 29 | 8.53E-08 | 1.73E-08 | 7.33E-09 | Detected |
| | Jan. 29 – Feb. 11 | 9.07E-08 | 2.33E-08 | 1.38E-08 | Detected |
| | Jun. 27 - Jul. 3 | 1.13E-07 | 3.45E-08 | 2.57E-08 | Detected |
| | Jul. 3 – Jul. 14 | 4.22E-08 | 1.58E-08 | 1.45E-08 | Detected |
| | Jul. 14 - Jul. 23 | 6.03E-08 | 2.23E-08 | 1.64E-08 | Detected |
| | Jul. 23 – Aug. 5 | 4.40E-08 | 1.59E-08 | 1.43E-08 | Detected |
| | Aug. 5 – Aug. 15 | 5.56E-08 | 1.95E-08 | 1.67E-08 | Detected |
| | Aug. 15 – Aug. 27 | 1.09E-07 | 3.30E-08 | 2.38E-08 | Detected |
| | Aug. 27 – Sep. 5 | 1.05E-07 | 3.22E-08 | 2.70E-08 | Detected |
| | Sep. 5 – Sep. 26 | 2.51E-08 | 7.72E-09 | 4.67E-09 | Detected |
| | Sep. 26 – Oct. 8 | 5.66E-08 | 1.68E-08 | 1.50E-08 | Detected |
| | Oct. 8 – Oct. 17 | -3.96E-08 | 4.69E-08 | 6.01E-08 | Not detected |
| | Oct. 17 - Oct. 24 | -1.09E-08 | 1.07E-07 | 1.82E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 3.17E-08 | 2.81E-08 | 2.26E-08 | Detected |
| | Nov. 14 - Dec. 3 | 5.33E-08 | 3.59E-08 | 2.22E-08 | Detected |
| | Dec. 3 - Dec. 19 | 2.48E-08 | 1.30E-08 | 1.87E-08 | Detected |
| | Dec. 19 - Jan. 6 | 3.29E-08 | 1.11E-08 | 1.33E-08 | Detected |

Table 3-4: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Onsite station (5 days counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m³ | Unc. (2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Jan. 9 – Jan. 29 | 1.04E-06 | 1.21E-07 | 6.93E-09 | Detected |
| | Jan. 29 – Feb. 11 | 1.07E-06 | 1.35E-07 | 1.31E-08 | Detected |
| | Jun. 27 - Jul. 3 | 2.10E-06 | 2.59E-07 | 2.44E-08 | Detected |
| | Jul. 3 – Jul. 14 | 9.75E-07 | 1.24E-07 | 1.83E-08 | Detected |
| | Jul. 14 - Jul. 23 | 1.21E-06 | 1.57E-07 | 3.78E-08 | Detected |
| | Jul. 23 – Aug. 5 | 1.07E-06 | 1.33E-07 | 1.67E-08 | Detected |
| | Aug. 5 – Aug. 15 | 1.05E-06 | 1.35E-07 | 1.35E-08 | Detected |
| | Aug. 15 – Aug. 27 | 6.74E-07 | 1.03E-07 | 3.00E-08 | Detected |
| | Aug. 27 – Sep. 5 | 1.28E-06 | 1.70E-07 | 2.69E-08 | Detected |
| | Sep. 5 – Sep. 26 | 4.40E-07 | 5.46E-08 | 7.63E-09 | Detected |
| | Sep. 26 – Oct. 8 | 8.59E-07 | 1.06E-07 | 2.51E-08 | Detected |
| | Oct. 8 – Oct. 17 | 7.26E-07 | 3.80E-07 | 7.60E-08 | Detected |
| | Oct. 17 - Oct. 24 | 5.11E-07 | 5.28E-07 | 2.37E-07 | Detected |
| | Oct. 24 – Nov. 14 | 5.33E-07 | 1.82E-07 | 2.86E-08 | Detected |
| | Nov. 14 - Dec. 3 | 7.45E-07 | 2.27E-07 | 3.06E-08 | Detected |
| | Dec. 3 - Dec. 19 | 7.85E-07 | 1.05E-07 | 1.79E-08 | Detected |
| | Dec. 19 - Jan. 6 | 5.93E-07 | 7.47E-08 | 2.00E-08 | Detected |

Table 3-5A: Activity concentrations of $^{241}Am$ in the filter samples collected from Near Field station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m³ | Unc. (2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Feb. 11 - Feb. 16 | 8.14E-05 | 6.61E-06 | 1.64E-07 | Detected |
| | Feb. 16 - Feb. 18 | 2.14E-06 | 6.13E-07 | 2.52E-07 | Detected |
| | Feb. 18 - Feb. 25 | 1.45E-06 | 2.60E-07 | 5.14E-08 | Detected |
| | Feb. 25 – Mar. 4 | 3.48E-07 | 1.27E-07 | 7.52E-08 | Detected |
| | Mar. 4 - Mar. 11 | 8.28E-08 | 6.62E-08 | 9.62E-08 | Not detected |
| | Mar. 11 – Mar. 21 | 1.2E-07 | 6.96E-08 | 7.93E-08 | Detected |
| | Mar. 21 - Mar. 29 | 3.68E-08 | 6.40E-08 | 1.36E-07 | Not detected |
| | Mar. 29 - Apr.4 | 1.06E-07 | 8.05E-08 | 9.76E-08 | Detected |
| | Apr. 4 - Apr. 11 | 1.76E-07 | 9.55E-08 | 1.02E-07 | Detected |
| | Apr. 11 – Apr. 19 | 2.26E-08 | 4.52E-08 | 1.05E-07 | Not detected |
| | Apr. 19 – Apr. 25 | 1.49E-07 | 1.58E-07 | 2.77E-07 | Not detected |
| | Apr. 25 - May 2 | 8.79E-08 | 8.39E-08 | 1.51E-07 | Not detected |
| | May 2 - May 9 | 1.04E-07 | 7.39E-08 | 7.17E-08 | Detected |
| | May 9 - May 16 | 8.75E-08 | 9.83E-08 | 1.61E-07 | Not detected |

Table 3-5A: Activity concentrations of $^{241}Am$ in the filter samples collected from Near Field station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | May 16 - May 23 | 5.69E-08 | 5.46E-08 | 7.95E-08 | Not detected |
| | May 23 - Jun. 6 | 3.82E-08 | 7.26E-08 | 1.65E-07 | Not detected |
| | Jun. 6 – Jun. 13 | 1.00E-07 | 1.49E-07 | 2.99E-07 | Not detected |
| | Jun. 13 - Jun. 20 | -2.04E-08 | 7.19E-08 | 2.26E-07 | Not detected |
| | Jun. 20 – Jun.27 | 0.00E+00 | 7.17E-08 | 2.56E-07 | Not detected |
| | Jun. 27 - Jul. 3 | 8.82E-08 | 1.13E-07 | 2.00E-07 | Not detected |
| | Jul. 3 - Jul. 14 | 9.00E-09 | 4.54E-08 | 1.31E-07 | Not detected |
| | Jul. 14 – Jul. 23 | 3.86E-08 | 6.25E-08 | 1.27E-07 | Not detected |
| | Jul. 23 – Aug. 5 | 4.48E-08 | 5.06E-08 | 7.39E-08 | Not detected |
| | Aug .5 - Aug. 15 | 5.50E-08 | 6.67E-08 | 1.20E-07 | Not detected |
| | Aug .15 - Aug. 27 | 2.43E-07 | 1.19E-07 | 8.76E-08 | Detected |
| | Aug. 27 – Sep. 5 | 3.77E-08 | 4.11E-08 | 6.52E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 4.39E-09 | 1.09E-08 | 2.73E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 4.83E-09 | 1.70E-08 | 4.88E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 8.88E-09 | 2.64E-08 | 6.93E-08 | Not detected |
| | Oct. 17 – Oct. 24 | 1.74E-06 | 3.59E-07 | 1.20E-07 | Detected |
| | Oct. 24 – Nov. 14 | 4.62E-08 | 3.90E-08 | 4.82E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 7.16E-09 | 1.44E-08 | 3.31E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 2.84E-09 | 9.86E-09 | 2.81E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 3.11E-09 | 1.08E-08 | 3.07E-08 | Not detected |

Table 3-5B: Activity concentrations of $^{241}Am$ in the filter samples collected from Near Field station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Jan. 9 - Jan 29 | 1.49E-08 | 1.06E-08 | 1.82E-08 | Not detected |
| | Jan. 29 - Feb. 11 | 1.08E-08 | 8.03E-09 | 1.11E-08 | Not detected |
| | Jun. 27 – Jul. 3 | 3.48E-08 | 2.49E-08 | 4.26E-08 | Not detected |
| | Jul. 3 - Jul. 14 | 2.01E-08 | 1.54E-08 | 2.88E-08 | Not detected |
| | Jul. 14 - Jul. 23 | 1.84E-08 | 3.25E-08 | 7.50E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 3.42E-08 | 2.55E-08 | 4.59E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 2.28E-08 | 1.54E-08 | 2.65E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 8.22E-09 | 9.72E-09 | 2.05E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 2.07E-08 | 1.56E-08 | 2.74E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 6.95E-09 | 5.64E-09 | 9.31E-09 | Not detected |
| | Sep. 26 – Oct. 8 | 7.03E-09 | 9.99E-09 | 2.11E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.24E-08 | 1.24E-08 | 2.45E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 5.14E-09 | 6.19E-09 | 1.24E-08 | Not detected |

Table 3-6A: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Near Field station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Feb. 11 - Feb. 16 | 5.78E-06 | 4.67E-07 | 1.77E-07 | Detected |
| | Feb. 16 - Feb. 18 | 1.41E-07 | 2.42E-07 | 5.14E-07 | Not detected |
| | Feb. 18 - Feb. 25 | 4.24E-07 | 2.30E-07 | 1.84E-07 | Detected |
| | Feb. 25 – Mar. 4 | 1.17E-07 | 7.45E-08 | 7.79E-08 | Detected |
| | Mar. 4 - Mar. 11 | 2.23E-08 | 3.88E-08 | 8.21E-08 | Not detected |
| | Mar. 11 – Mar. 21 | 1.35E-07 | 8.77E-08 | 1.43E-07 | Not detected |
| | Mar. 21 - Mar. 29 | 8.46E-08 | 9.50E-08 | 1.56E-07 | Not detected |
| | Mar. 29 - Apr.4 | 1.14E-07 | 1.40E-07 | 2.65E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 1.15E-07 | 8.08E-08 | 1.07E-07 | Detected |
| | Apr. 11 – Apr. 19 | 1.24E-07 | 7.93E-08 | 8.27E-08 | Detected |
| | Apr. 19 – Apr. 25 | 6.29E-08 | 7.75E-08 | 1.46E-07 | Not detected |
| | Apr. 25 - May 2 | 2.64E-07 | 1.49E-07 | 1.38E-07 | Detected |
| | May 2 - May 9 | 1.02E-07 | 1.15E-07 | 1.88E-07 | Not detected |
| | May 9 - May 16 | 5.7E-08 | 9.14E-08 | 2.01E-07 | Not detected |
| | May 16 - May 23 | 3.55E-08 | 5.17E-08 | 1.06E-07 | Not detected |
| | May 23 - Jun. 6 | 5.24E-09 | 2.78E-08 | 8.71E-08 | Not detected |
| | Jun. 6 – Jun. 13 | 2.54E-08 | 4.41E-08 | 9.36E-08 | Not detected |
| | Jun. 13 - Jun. 20 | 1.46E-08 | 4.14E-08 | 1.08E-07 | Not detected |
| | Jun. 20 – Jun.27 | 5.25E-08 | 7.21E-08 | 1.37E-07 | Not detected |
| | Jun. 27 - Jul. 3 | 5.51E-08 | 8.77E-08 | 1.52E-07 | Not detected |
| | Jul. 3 - Jul. 14 | -9.07E-09 | 2.44E-08 | 8.23E-08 | Not detected |
| | Jul. 14 – Jul. 23 | 3.49E-09 | 1.84E-08 | 5.80E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.70E-08 | 2.75E-08 | 5.60E-08 | Not detected |
| | Aug .5 - Aug. 15 | -3.99E-09 | 2.08E-08 | 5.92E-08 | Not detected |
| | Aug .15 - Aug. 27 | 6.82E-08 | 1.19E-07 | 1.60E-07 | Not detected |
| | Aug. 27 – Sep. 5 | -4.90E-15 | 2.25E-08 | 8.03E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 2.82E-09 | 9.79E-09 | 2.79E-08 | Not detected |
| | Sep. 26 – Oct. 8 | -1.91E-09 | 1.94E-08 | 4.74E-08 | Not detected |
| | Oct. 8 - Oct. 17 | -2.40E-08 | 8.50E-08 | 2.67E-07 | Not detected |
| | Oct. 17 – Oct. 24 | 1.16E-07 | 9.17E-08 | 1.23E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 1.80E-08 | 2.44E-08 | 4.11E-08 | Not detected |
| | Nov. 14 – Dec. 3 | -7.93E-09 | 2.80E-08 | 8.78E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.90E-09 | 1.00E-08 | 3.15E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -8.51E-10 | 8.72E-09 | 2.13E-08 | Not detected |

Table 3-6B: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Near Field station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Jan. 9 - Jan 29 | 1.95E-08 | 1.16E-08 | 1.71E-08 | Detected |
| | Jan. 29 - Feb. 11 | 4.65E-09 | 1.74E-08 | 4.37E-08 | Detected |
| | Jun. 27 – Jul. 3 | 3.29E-08 | 3.12E-08 | 5.10E-08 | Not detected |
| | Jul. 3 - Jul. 14 | 5.33E-16 | 1.26E-08 | 3.54E-08 | Not detected |
| | Jul. 14 – Jul. 23 | 3.41E-09 | 1.36E-08 | 3.42E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 5.66E-09 | 8.98E-09 | 2.00E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 1.03E-08 | 1.02E-08 | 1.52E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 3.31E-09 | 1.15E-08 | 2.89E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 5.55E-09 | 1.34E-08 | 3.22E-09 | Not detected |
| | Sep. 5 – Sep. 26 | 1.77E-09 | 5.02E-09 | 1.25E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 5.64E-09 | 1.25E-08 | 2.99E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 4.60E-09 | 6.12E-09 | 1.30E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 3.36E-09 | 4.13E-09 | 7.82E-09 | Not detected |

Table 3-7A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Near Field station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Feb. 11 - Feb. 16 | 1.97E-07 | 1.80E-07 | 2.08E-07 | Not detected |
| | Feb. 16 - Feb. 18 | 3.01E-08 | 1.42E-07 | 4.39E-07 | Not detected |
| | Feb. 18 - Feb. 25 | 4.24E-07 | 2.30E-07 | 1.84E-07 | Detected |
| | Feb. 25 – Mar. 4 | 2.12E-08 | 4.24E-08 | 9.84E-08 | Not detected |
| | Mar. 4 - Mar. 11 | 2.23E-08 | 3.88E-08 | 8.21E-08 | Not detected |
| | Mar. 11 – Mar. 21 | 2.71E-08 | 5.41E-08 | 1.27E-07 | Not detected |
| | Mar. 21 - Mar. 29 | 0.00E+00 | 8.46E-08 | 2.54E-07 | Not detected |
| | Mar. 29 - Apr.4 | 1.01E-07 | 8.26E-08 | 1.06E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 0.00E+00 | 3.26E-08 | 8.47E-08 | Not detected |
| | Apr. 11 – Apr. 19 | 2.25E-08 | 3.91E-08 | 8.27E-08 | Not detected |
| | Apr. 19 – Apr. 25 | 4.71E-08 | 6.31E-08 | 1.16E-07 | Not detected |
| | Apr. 25 - May 2 | 1.13E-07 | 1.00E-07 | 1.38E-07 | Not detected |
| | May 2 - May 9 | 5.09E-09 | 5.49E-08 | 1.84E-07 | Not detected |
| | May 9 - May 16 | 0.00E+00 | 6.76E-08 | 2.04E-07 | Not detected |
| | May 16 - May 23 | -6.68E-09 | 2.55E-08 | 1.02E-07 | Not detected |
| | May 23 - Jun. 6 | 2.10E-08 | 3.79E-08 | 7.77E-08 | Not detected |
| | Jun. 6 – Jun. 13 | -5.10E-09 | 2.87E-08 | 1.11E-07 | Not detected |
| | Jun. 13 - Jun. 20 | 8.77E-09 | 4.41E-08 | 1.28E-07 | Not detected |

Table 3-7A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Near Field station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Jun. 20 – Jun.27 | 6.99E-09 | 5.33E-08 | 1.6E-07 | Not detected |
| | Jun. 27 - Jul. 3 | -1.83E-08 | 6.47E-08 | 2.03E-07 | Not detected |
| | Jul. 3 - Jul. 14 | -4.54E-09 | 2.36E-08 | 6.72E-08 | Not detected |
| | Jul. 14 – Jul. 23 | -1.05E-08 | 1.94E-08 | 7.22E-08 | Not detected |
| | Jul. 23 – Aug. 5 | -1.08E-08 | 1.76E-08 | 6.74E-08 | Not detected |
| | Aug .5 - Aug. 15 | 0.00E+00 | 2.18E-08 | 7.79E-08 | Not detected |
| | Aug .15 - Aug. 27 | -7.85E-09 | 1.72E-08 | 6.12E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -1.23E-08 | 2.30E-08 | 8.53E-08 | Not detected |
| | Sep. 5 – Sep. 26 | -1.88E-09 | 9.79E-09 | 2.79E-08 | Not detected |
| | Sep. 26 – Oct. 8 | -3.80E-09 | 1.98E-08 | 5.64E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 2.40E-08 | 8.33E-08 | 2.38E-07 | Not detected |
| | Oct. 17 – Oct. 24 | 5.06E-08 | 6.08E-08 | 9.90E-08 | Not detected |
| | Oct. 24 – Nov. 14 | 1.80E-08 | 2.44E-08 | 4.11E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 1.32E-08 | 3.74E-08 | 9.72E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 2.84E-09 | 9.86E-09 | 2.81E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -1.02E-09 | 1.04E-08 | 4.52E-08 | Not detected |

Table 3-7B: Activity concentrations of $^{238}Pu$ in the filter samples collected from Near Field station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Jan. 9 - Jan 29 | 0.00E+00 | 4.87E-09 | 1.46E-08 | Detected |
| | Jan. 29 - Feb. 11 | 4.65E-09 | 1.14E-08 | 2.79E-08 | Detected |
| | Jun. 27 – Jul. 3 | -1.10E-08 | 2.19E-08 | 7.74E-08 | Not detected |
| | Jul. 3 - Jul. 14 | -2.23E-09 | 7.74E-09 | 2.68E-08 | Not detected |
| | Jul. 14 – Jul. 23 | -3.41E-09 | 8.35E-09 | 2.70E-08 | Not detected |
| | Jul. 23 – Aug. 5 | -4.25E-09 | 9.41E-09 | 2.85E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 4.13E-09 | 8.28E-09 | 1.92E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 1.66E-09 | 8.78E-09 | 2.34E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -1.11E-08 | 9.86E-09 | 3.49E-08 | Not detected |
| | Sep. 5 – Sep. 26 | -8.88E-10 | 5.87E-09 | 1.67E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 0.00E+00 | 1.40E-08 | 3.78E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.84E-09 | 4.51E-09 | 1.10E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -6.73E-09 | 6.77E-09 | 2.14E-08 | Not detected |

Table 3-8: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Near Field station (5 days of counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m³ | Unc. (2σ) Bq/m³ | MDC Bq/m³ | Status |
|---|---|---|---|---|---|
| $^{234}U$ | Jan. 9 – Jan. 29 | 1.30E-06 | 2.69E-07 | 1.82E-08 | Detected |
| | Jan. 29 – Feb. 11 | 1.05E-06 | 4.47E-07 | 1.18E-07 | Detected |
| | Jun. 27 - Jul. 3 | 1.01E-06 | 5.16E-07 | 5.78E-08 | Detected |
| | Jul. 3 – Jul. 14 | 1.12E-06 | 3.48E-07 | 2.76E-08 | Detected |
| | Jul. 14 - Jul. 23 | 8.51E-08 | 2.87E-07 | 5.67E-08 | Detected |
| | Jul. 23 – Aug. 5 | 4.62E-07 | 2.35E-07 | 2.17E-08 | Detected |
| | Aug. 5 – Aug. 15 | 6.89E-07 | 3.51E-07 | 4.82E-08 | Detected |
| | Aug. 15 – Aug. 27 | 3.91E-07 | 2.53E-07 | 4.84E-08 | Detected |
| | Aug. 27 – Sep. 5 | 9.57E-07 | 4.16E-07 | 4.64E-08 | Detected |
| | Sep. 5 – Sep. 26 | 1.51E-07 | 1.31E-07 | 2.01E-08 | Detected |
| | Sep. 26 – Oct. 8 | 3.22E-07 | 2.33E-07 | 2.92E-08 | Detected |
| | Oct. 8 – Oct. 17 | -5.44E-07 | 2.05E-07 | 3.83E-08 | Not detected |
| | Oct. 17 - Oct. 24 | 1.10E-06 | 6.06E-07 | 1.76E-07 | Detected |
| | Oct. 24 – Nov. 14 | 8.90E-07 | 2.28E-07 | 2.37E-08 | Detected |
| | Nov. 14 - Dec. 3 | 1.08E-06 | 2.60E-07 | 2.09E-08 | Detected |
| | Dec. 3 - Dec. 19 | 3.19E-07 | 2.00E-07 | 3.82E-08 | Detected |
| | Dec. 19 - Jan. 6 | 1.72E-07 | 1.52E-07 | 2.31E-08 | Detected |
| | | | | | |
| $^{235}U$ | Jan. 9 – Jan. 29 | 2.00E-07 | 4.80E-08 | 1.99E-08 | Detected |
| | Jan. 29 – Feb. 11 | 1.16E-07 | 1.01E-07 | 1.29E-07 | Not detected |
| | Jun. 27 - Jul. 3 | 5.24E-09 | 6.11E-08 | 4.54E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 1.32E-08 | 3.53E-08 | 2.00E-08 | Not detected |
| | Jul. 14 - Jul. 23 | -1.30E-08 | 4.49E-08 | 5.21E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.72E-08 | 2.97E-08 | 1.57E-08 | Detected |
| | Aug. 5 – Aug. 15 | 5.47E-08 | 5.49E-08 | 2.75E-08 | Detected |
| | Aug. 15 – Aug. 27 | 3.94E-09 | 3.38E-08 | 2.26E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 2.52E-08 | 5.62E-08 | 4.87E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 1.82E-08 | 2.03E-08 | 1.56E-08 | Detected |
| | Sep. 26 – Oct. 8 | -2.42E-09 | 2.85E-08 | 2.39E-08 | Not detected |
| | Oct. 8 – Oct. 17 | -4.43E-08 | 3.17E-08 | 3.01E-08 | Not detected |
| | Oct. 17 - Oct. 24 | -2.11E-08 | 1.01E-07 | 1.71E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 5.53E-09 | 2.28E-08 | 1.71E-08 | Not detected |
| | Nov. 14 - Dec. 3 | 1.21E-08 | 2.51E-08 | 1.70E-08 | Not detected |
| | Dec. 3 - Dec. 19 | -2.86E-08 | 2.17E-08 | 2.66E-08 | Not detected |
| | Dec. 19 - Jan. 6 | -7.52E-09 | 1.93E-08 | 1.89E-08 | Not detected |

Table 3-8: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Near Field station (5 days of counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Jan. 9 – Jan. 29 | 1.39E-06 | 2.75E-07 | 1.80E-08 | Detected |
| | Jan. 29 – Feb. 11 | 9.41E-07 | 4.24E-07 | 1.17E-07 | Detected |
| | Jun. 27 - Jul. 3 | 1.07E-06 | 5.10E-07 | 5.33E-08 | Detected |
| | Jul. 3 – Jul. 14 | 1.14E-06 | 3.41E-07 | 3.27E-08 | Detected |
| | Jul. 14 - Jul. 23 | 4.21E-07 | 3.17E-07 | 7.23E-08 | Detected |
| | Jul. 23 – Aug. 5 | 2.70E-07 | 2.09E-07 | 2.90E-08 | Detected |
| | Aug. 5 – Aug. 15 | 6.61E-07 | 3.38E-07 | 4.79E-08 | Detected |
| | Aug. 15 – Aug. 27 | 4.21E-07 | 2.51E-07 | 5.01E-08 | Detected |
| | Aug. 27 – Sep. 5 | 7.20E-07 | 3.78E-07 | 6.59E-08 | Detected |
| | Sep. 5 – Sep. 26 | 3.58E-08 | 1.15E-07 | 1.41E-08 | Detected |
| | Sep. 26 – Oct. 8 | 2.99E-07 | 2.24E-07 | 2.38E-08 | Detected |
| | Oct. 8 – Oct. 17 | -6.16E-07 | 1.89E-07 | 3.80E-08 | Detected |
| | Oct. 17 - Oct. 24 | 7.98E-07 | 5.51E-07 | 1.52E-07 | Detected |
| | Oct. 24 – Nov. 14 | 7.80E-07 | 2.12E-07 | 2.80E-08 | Detected |
| | Nov. 14 - Dec. 3 | 7.16E-07 | 2.14E-07 | 2.08E-08 | Detected |
| | Dec. 3 – Dec. 19 | 1.31E-07 | 1.72E-07 | 3.36E-08 | Detected |
| | Dec. 19 – Jan. 6 | 2.12E-07 | 1.52E-07 | 3.04E-08 | Detected |

Table 3-9A: Activity concentrations of $^{241}Am$ in the filter samples collected from Cactus Flats station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Feb. 11 - Feb. 16 | 4.90E-08 | 6.91E-08 | 4.76E-08 | Detected |
| | Feb. 16 - Feb. 18 | 1.41E-06 | 2.54E-07 | 1.16E-07 | Detected |
| | Feb. 18 - Feb. 25 | 5.87E-07 | 1.38E-07 | 5.73E-08 | Detected |
| | Feb. 25 – Mar. 4 | 1.95E-08 | 3.4E-08 | 7.18E-08 | Not detected |
| | Mar. 4 - Mar. 11 | 1.11E-07 | 7.81E-08 | 1.03E-07 | Detected |
| | Mar. 11 – Mar. 21 | 1.37E-07 | 8.71E-08 | 1.06E-07 | Detected |
| | Mar. 21 - Mar. 29 | 1.77E-08 | 4.34E-08 | 1.06E-07 | Detected |
| | Mar. 29 - Apr.4 | 6.07E-08 | 7.47E-08 | 1.41E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 9.21E-08 | 7.52E-08 | 9.69E-08 | Not detected |
| | Apr. 11 – Apr. 19 | 1.28E-07 | 8.28E-08 | 1.19E-07 | Detected |
| | Apr. 19 – Apr. 25 | 6.00E-08 | 2.09E-07 | 5.57E-07 | Not detected |
| | Apr. 25 - May 2 | 3.99E-08 | 5.34E-08 | 9.79E-08 | Not detected |
| | May 2 - May 9 | 2.19E-07 | 1.08E-07 | 6.15E-08 | Detected |
| | May 9 - May 16 | 4.28E-08 | 6.32E-08 | 1.19E-07 | Not detected |

Table 3-9A: Activity concentrations of $^{241}Am$ in the filter samples collected from Cactus Flats station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | May 16 - May 23 | 1.06E-08 | 3.66E-08 | 1.04E-07 | Not detected |
| | May 23 - Jun. 6 | 3.96E-08 | 4.46E-08 | 6.52E-08 | Not detected |
| | Jun. 6 – Jun. 13 | 6.25E-08 | 8.36E-08 | 1.53E-07 | Not detected |
| | Jun. 13 - Jun. 20 | 0.00E+00 | 5.76E-08 | 2.04E-07 | Not detected |
| | Jun. 20 – Jun.27 | 1.03E-07 | 1.23E-07 | 2.02E-07 | Not detected |
| | Jun. 27 - Jul. 3 | 0.00E+00 | 5.25E-08 | 1.86E-07 | Not detected |
| | Jul. 3 - Jul. 14 | 2.76E-09 | 2.99E-08 | 1.01E-07 | Not detected |
| | Jul. 14 – Jul. 23 | 2.04E-08 | 6.22E-08 | 1.62E-07 | Not detected |
| | Jul. 23 – Aug. 5 | 2.53E-08 | 3.73E-08 | 7.00E-08 | Not detected |
| | Aug .5 - Aug. 15 | 1.96E-08 | 4.09E-08 | 9.32E-08 | Not detected |
| | Aug .15 - Aug. 27 | 8.66E-08 | 6.76E-08 | 7.77E-08 | Detected |
| | Aug. 27 – Sep. 5 | 2.63E-08 | 3.36E-08 | 5.97E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 9.02E-09 | 1.23E-08 | 2.08E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 1.00E-08 | 2.11E-08 | 4.86E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 1.60E-08 | 3.76E-08 | 9.15E-08 | Not detected |
| | Oct. 17 – Oct. 24 | 3.65E-08 | 4.68E-08 | 8.86E-08 | Not detected |
| | Oct. 24 – Nov. 14 | -2.86E-09 | 8.33E-09 | 3.42E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 1.37E-08 | 1.65E-08 | 2.69E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 4.36E-09 | 1.30E-08 | 3.41E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 2.22E-08 | 1.98E-08 | 2.35E-08 | Not detected |

Table 3-9B: Activity concentrations of $^{241}Am$ in the filter samples collected from Cactus Flats station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{241}Am$ | Jan. 9 – Jan. 29 | 4.41E-09 | 5.89E-09 | 1.28E-08 | Not detected |
| | Jan. 29 - Feb. 11 | 7.56E-09 | 7.21E-09 | 1.30E-08 | Not detected |
| | Jun. 27 – Jul. 3 | 2.11E-08 | 2.05E-08 | 4.08E-08 | Not detected |
| | Jul. 3 - Jul. 14 | 1.56E-08 | 1.18E-08 | 2.07E-08 | Not detected |
| | Jul. 14 – Jul. 23 | 4.35E-09 | 2.89E-08 | 7.58E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.11E-08 | 8.38E-09 | 1.33E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 1.82E-08 | 1.25E-08 | 1.99E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 2.48E-08 | 4.12E-07 | 6.67E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 1.79E-08 | 1.43E-08 | 2.59E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 3.55E-09 | 4.28E-09 | 8.55E-09 | Not detected |
| | Sep. 26 – Oct. 8 | 1.89E-08 | 2.01E-08 | 4.10E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 1.10E-08 | 8.71E-09 | 1.60E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 1.26E-08 | 8.44E-09 | 1.46E-08 | Not detected |

Table 3-10A: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Cactus Flats station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Feb. 11 - Feb. 16 | 1.25E-08 | 2.47E-08 | 1.04E-07 | Not detected |
| | Feb. 16 - Feb. 18 | 3.57E-07 | 4.77E-07 | 8.82E-07 | Not detected |
| | Feb. 18 - Feb. 25 | 1.01E-07 | 5.24E-08 | 3.18E-08 | Not detected |
| | Feb. 25 – Mar. 4 | -1.05E-08 | 3.63E-08 | 1.26E-07 | Not detected |
| | Mar. 4 - Mar. 11 | 4.71E-08 | 5.31E-08 | 8.68E-08 | Not detected |
| | Mar. 11 – Mar. 21 | 1.69E-07 | 9.37E-08 | 1.32E-07 | Detected |
| | Mar. 21 - Mar. 29 | 0.00E+00 | 5.55E-08 | 1.44E-07 | Not detected |
| | Mar. 29 - Apr. 4 | 5.24E-08 | 7.01E-08 | 1.28E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 0.00E+00 | 3.35E-08 | 1.1E-07 | Not detected |
| | Apr. 11 – Apr. 19 | 5.00E-08 | 5.32E-08 | 9.28E-08 | Not detected |
| | Apr. 19 – Apr. 25 | 2.87E-08 | 1.28E-07 | 3.44E-07 | Not detected |
| | Apr. 25 - May 2 | 1.03E-07 | 8.94E-08 | 1.37E-07 | Not detected |
| | May 2 - May 9 | 1.04E-07 | 1.25E-07 | 2.03E-07 | Not detected |
| | May 9 - May 16 | 7.32E-08 | 9.82E-08 | 1.79E-07 | Not detected |
| | May 16 - May 23 | 3.69E-08 | 5.9E-08 | 1.24E-07 | Not detected |
| | May 23 - Jun. 6 | -2.85E-09 | 1.48E-08 | 4.21E-08 | Not detected |
| | Jun. 6 – Jun. 13 | 2.77E-08 | 4.08E-08 | 7.68E-08 | Not detected |
| | Jun. 13 - Jun. 20 | 3.54E-08 | 5.23E-08 | 9.82E-08 | Not detected |
| | Jun. 20 – Jun. 27 | 1.68E-08 | 4.12E-08 | 1.02E-07 | Not detected |
| | Jun. 27 - Jul. 3 | -1.13E-08 | 4.00E-08 | 1.26E-07 | Not detected |
| | Jul. 3 - Jul. 14 | 1.35E-08 | 2.16E-08 | 3.74E-08 | Not detected |
| | Jul. 14 – Jul. 23 | 2.24E-08 | 3.03E-08 | 5.10E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 1.13E-08 | 2.35E-08 | 5.37E-08 | Not detected |
| | Aug. 5 - Aug. 15 | -4.09E-09 | 2.13E-08 | 6.08E-08 | Not detected |
| | Aug. 15 - Aug. 27 | 5.71E-09 | 1.46E-08 | 3.56E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 5.42E-09 | 1.87E-08 | 5.35E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 2.90E-09 | 1.00E-08 | 2.87E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 6.70E-09 | 1.71E-08 | 4.18E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 4.23E-08 | 6.13E-08 | 1.26E-07 | Not detected |
| | Oct. 17 – Oct. 24 | 1.81E-08 | 4.61E-08 | 1.13E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 4.50E-09 | 1.56E-08 | 4.45E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 1.30E-08 | 3.18E-08 | 7.86E-08 | Not detected |
| | Dec. 3 – Dec. 19 | -1.25E-09 | 1.28E-08 | 3.11E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 8.92E-09 | 1.55E-08 | 3.28E-08 | Not detected |

Table 3-10B: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Cactus Flats station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{239+240}Pu$ | Jan. 9 - Jan 29 | 1.42E-09 | 1.23E-08 | 3.18E-08 | Detected |
| | Jan. 29 - Feb. 11 | 1.26E-08 | 1.33E-08 | 2.52E-08 | Detected |
| | Jun. 27 – Jul. 3 | 1.14E-08 | 2.27E-08 | 5.35E-08 | Not detected |
| | Jul. 3 - Jul. 14 | 1.32E-08 | 1.43E-08 | 2.98E-08 | Not detected |
| | Jul. 14 – Jul. 23 | 1.40E-08 | 1.32E-08 | 2.47E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 6.77E-09 | 8.33E-09 | 1.57E-08 | Not detected |
| | Aug. 5 – Aug. | 8.64E-09 | 1.50E-08 | 3.43E-08 | Not detected |
| | Aug. 15 - Aug. | 5.65E-09 | 8.96E-09 | 1.99E-08 | Not detected |
| | Aug. 27 – Sep. 5 | 9.26E-09 | 1.12E-08 | 2.22E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 9.74E-10 | 4.37E-09 | 1.17E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 1.33E-08 | 1.16E-08 | 2.08E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 2.45E-09 | 4.90E-09 | 1.14E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 6.16E-09 | 5.02E-09 | 6.47E-09 | Not detected |

Table 3-11A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Cactus Flats station (24 hours counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Feb. 11 - Feb. 16 | -8.34E-09 | 8.57E-08 | 1.73E-07 | Not detected |
| | Feb. 16 - Feb. 18 | 1.89E-07 | 3.35E-07 | 6.73E-07 | Not detected |
| | Feb. 18 - Feb. 25 | -3.83E-09 | 1.47E-08 | 5.85E-08 | Not detected |
| | Feb. 25 – Mar. 4 | 1.05E-08 | 3.63E-08 | 9.73E-08 | Not detected |
| | Mar. 4 - Mar. 11 | 0.00E+00 | 3.33E-08 | 1.10E-07 | Not detected |
| | Mar. 11 – Mar. 21 | 9.35E-08 | 6.30E-08 | 6.89E-08 | Detected |
| | Mar. 21 - Mar. 29 | 1.96E-08 | 5.55E-08 | 1.44E-07 | Not detected |
| | Mar. 29 - Apr.4 | 8.41E-08 | 1.08E-07 | 1.31E-07 | Not detected |
| | Apr. 4 - Apr. 11 | 3.56E-08 | 4.76E-08 | 8.74E-08 | Not detected |
| | Apr. 11 – Apr. 19 | 9.99E-09 | 3.47E-08 | 9.28E-08 | Not detected |
| | Apr. 19 – Apr. 25 | 2.87E-08 | 8.11E-08 | 2.11E-07 | Not detected |
| | Apr. 25 - May 2 | 7.38E-08 | 7.86E-08 | 1.37E-07 | Not detected |
| | May 2 - May 9 | 1.84E-08 | 6.36E-08 | 1.82E-07 | Not detected |
| | May 9 - May 16 | 7.32E-08 | 1.00E-07 | 1.90E-07 | Not detected |
| | May 16 - May 23 | 2.84E-09 | 3.06E-08 | 1.03E-07 | Not detected |
| | May 23 - Jun. 6 | 0.00E+00 | 1.55E-08 | 5.55E-08 | Not detected |
| | Jun. 6 – Jun. 13 | 2.31E-09 | 2.48E-08 | 8.39E-08 | Not detected |
| | Jun. 13 - Jun. 20 | 1.76E-08 | 4.34E-08 | 1.07E-07 | Not detected |

Table 3-11A: Activity concentrations of $^{238}Pu$ in the filter samples collected from Cactus Flats station (24 hours counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| | Jun. 20 – Jun. 27 | -1.40E-08 | 3.07E-08 | 1.09E-07 | Not detected |
| | Jun. 27 - Jul. 3 | 0.00E+00 | 5.35E-08 | 1.39E-07 | Not detected |
| | Jul. 3 - Jul. 14 | -1.50E-09 | 1.53E-08 | 3.74E-08 | Not detected |
| | Jul. 14 – Jul. 23 | -6.87E-09 | 1.86E-08 | 6.25E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 3.23E-09 | 1.70E-08 | 5.37E-08 | Not detected |
| | Aug. 5 - Aug. 15 | -4.09E-09 | 2.13E-08 | 6.08E-08 | Not detected |
| | Aug. 15 - Aug. | -5.71E-09 | 1.54E-08 | 5.18E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -3.61E-09 | 1.87E-08 | 5.35E-08 | Not detected |
| | Sep. 5 – Sep. 26 | -1.94E-09 | 1.00E-08 | 2.87E-08 | Not detected |
| | Sep. 26 – Oct. 8 | -5.02E-09 | 1.77E-08 | 5.58E-08 | Not detected |
| | Oct. 8 - Oct. 17 | 5.01E-08 | 5.35E-08 | 6.58E-08 | Not detected |
| | Oct. 17 – Oct. 24 | 1.81E-08 | 6.78E-08 | 1.87E-07 | Not detected |
| | Oct. 24 – Nov. 14 | 3.15E-08 | 3.44E-08 | 5.45E-08 | Not detected |
| | Nov. 14 – Dec. 3 | 1.95E-08 | 3.10E-08 | 5.40E-08 | Not detected |
| | Dec. 3 – Dec. 19 | -2.50E-09 | 1.30E-08 | 3.70E-08 | Not detected |
| | Dec. 19 – Jan. 6 | -3.57E-09 | 9.61E-09 | 3.24E-08 | Not detected |

Table 3-11B: Activity concentrations of $^{238}Pu$ in the filter samples collected from Cactus Flats station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{238}Pu$ | Jan. 9 - Jan 29 | 9.18E-10 | 4.85E-09 | 1.29E-08 | Not detected |
| | Jan. 29 - Feb. 11 | 2.09E-09 | 7.26E-09 | 1.94E-08 | Not detected |
| | Jun. 27 – Jul. 3 | 1.90E-08 | 1.87E-08 | 2.79E-08 | Not detected |
| | Jul. 3 - Jul. 14 | 0.00E+00 | 5.91E-09 | 1.77E-08 | Not detected |
| | Jul. 14 – Jul. 23 | -5.25E-09 | 9.29E-09 | 3.06E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 3.39E-09 | 8.30E-09 | 2.04E-08 | Not detected |
| | Aug. 5 – Aug. 15 | 2.16E-09 | 7.48E-09 | 2.01E-09 | Not detected |
| | Aug. 15 - Aug. 27 | 1.42E-09 | 6.32E-09 | 1.70E-08 | Not detected |
| | Aug. 27 – Sep. 5 | -1.85E-09 | 6.42E-09 | 2.22E-08 | Not detected |
| | Sep. 5 – Sep. 26 | 9.74E-10 | 4.37E-09 | 1.17E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 8.87E-09 | 1.03E-08 | 2.08E-08 | Not detected |
| | Dec. 3 – Dec. 19 | 4.89E-09 | 6.94E-09 | 1.47E-08 | Not detected |
| | Dec. 19 – Jan. 6 | 2.64E-09 | 5.84E-09 | 1.39E-08 | Not detected |

Table 3-12: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Cactus Flats station (5 days counting results)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{234}U$ | Jan. 9 – Jan. 29 | 8.07E-07 | 2.14E-07 | 2.13E-08 | Detected |
| | Jan. 29 – Feb. 11 | 7.24E-07 | 2.65E-07 | 3.24E-08 | Detected |
| | Jun. 27 - Jul. 3 | 1.41E-06 | 5.41E-07 | 5.51E-08 | Detected |
| | Jul. 3 – Jul. 14 | 1.10E-06 | 3.35E-07 | 3.55E-08 | Detected |
| | Jul. 14 - Jul. 23 | 4.10E-07 | 3.10E-07 | 1.79E-08 | Detected |
| | Jul. 23 – Aug. 5 | 5.43E-07 | 2.50E-07 | 3.95E-08 | Detected |
| | Aug. 5 – Aug. 15 | -3.64E-08 | 2.36E-06 | 4.32E-07 | Not detected |
| | Aug. 15 – Aug. 27 | 1.55E-07 | 2.17E-07 | 4.35E-08 | Detected |
| | Aug. 27 – Sep. 5 | 4.97E-07 | 3.40E-07 | 5.57E-08 | Detected |
| | Sep. 5 – Sep. 26 | 1.82E-08 | 1.13E-07 | 1.25E-08 | Detected |
| | Sep. 26 – Oct. 8 | 3.41E-07 | 2.28E-07 | 2.96E-08 | Detected |
| | Oct. 8 – Oct. 17 | 2.08E-06 | 5.11E-07 | 6.21E-08 | Detected |
| | Oct. 17 - Oct. 24 | 4.41E-07 | 4.83E-07 | 1.58E-07 | Detected |
| | Oct. 24 – Nov. 14 | -2.52E-07 | 8.22E-08 | 1.80E-08 | Not detected |
| | Nov. 14 - Dec. 3 | 1.14E-06 | 2.70E-07 | 3.39E-08 | Detected |
| | Dec. 3 - Dec. 19 | 3.74E-07 | 2.01E-07 | 2.54E-08 | Detected |
| | Dec. 19 - Jan. 6 | 7.58E-08 | 1.41E-07 | 1.71E-08 | Detected |
| | | | | | |
| $^{235}U$ | Jan. 9 – Jan. 29 | 5.45E-08 | 2.84E-08 | 2.08E-08 | Detected |
| | Jan. 29 – Feb. 11 | 8.02E-09 | 3.12E-08 | 3.15E-08 | Not detected |
| | Jun. 27 - Jul. 3 | -9.35E-09 | 5.59E-08 | 4.34E-08 | Not detected |
| | Jul. 3 – Jul. 14 | 6.78E-09 | 3.31E-08 | 2.47E-08 | Detected |
| | Jul. 14 - Jul. 23 | -1.05E-08 | 4.06E-08 | 3.59E-08 | Not detected |
| | Jul. 23 – Aug. 5 | 2.96E-08 | 3.71E-08 | 2.91E-08 | Detected |
| | Aug. 5 – Aug. 15 | -3.46E-08 | 3.00E-08 | 2.32E-08 | Not detected |
| | Aug. 15 – Aug. 27 | 5.05E-08 | 3.90E-08 | 2.86E-08 | Detected |
| | Aug. 27 – Sep. 5 | -1.94E-08 | 4.36E-08 | 4.38E-08 | Not detected |
| | Sep. 5 – Sep. 26 | -5.66E-09 | 1.52E-08 | 1.17E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 7.85E-08 | 3.85E-08 | 1.51E-08 | Detected |
| | Oct. 8 – Oct. 17 | -9.11E-09 | 4.73E-08 | 5.70E-08 | Not detected |
| | Oct. 17 - Oct. 24 | 4.82E-09 | 8.21E-08 | 8.05E-08 | Not detected |
| | Oct. 24 – Nov. 14 | 1.33E-07 | 3.40E-08 | 1.40E-08 | Detected |
| | Nov. 14 - Dec. 3 | 3.06E-08 | 3.08E-08 | 2.92E-08 | Detected |
| | Dec. 3 - Dec. 19 | 2.28E-09 | 2.60E-08 | 1.83E-08 | Not detected |
| | Dec. 19 - Jan. 6 | -1.99E-08 | 1.78E-08 | 2.31E-08 | Not detected |

Table 3-12: Activity concentrations of uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) in the filter samples collected from Cactus Flats station (5 days counting results) (continued)

| Radionuclides | Sample Date 2014 | Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{238}U$ | Jan. 9 – Jan. 29 | 8.91E-07 | 2.19E-07 | 1.49E-08 | Detected |
| | Jan. 29 – Feb. 11 | 8.82E-07 | 2.77E-07 | 2.26E-08 | Detected |
| | Jun. 27 - Jul. 3 | 1.13E-06 | 4.98E-07 | 5.49E-08 | Detected |
| | Jul. 3 – Jul. 14 | 7.74E-07 | 2.91E-07 | 2.34E-08 | Detected |
| | Jul. 14 - Jul. 23 | 3.40E-07 | 2.93E-07 | 3.82E-08 | Detected |
| | Jul. 23 – Aug. 5 | 5.23E-07 | 2.43E-07 | 3.10E-08 | Detected |
| | Aug. 5 – Aug. 15 | -2.56E-08 | 2.29E-07 | 6.18E-08 | Not detected |
| | Aug. 15 – Aug. 27 | 3.80E-07 | 2.33E-07 | 4.88E-08 | Detected |
| | Aug. 27 – Sep. 5 | 4.40E-07 | 3.24E-07 | 5.54E-08 | Detected |
| | Sep. 5 – Sep. 26 | -4.23E-08 | 1.03E-07 | 1.11E-08 | Not detected |
| | Sep. 26 – Oct. 8 | 4.12E-07 | 2.28E-07 | 3.08E-08 | Detected |
| | Oct. 8 – Oct. 17 | 1.08E-06 | 3.91E-07 | 5.06E-08 | Detected |
| | Oct. 17 - Oct. 24 | 2.45E-07 | 4.47E-07 | 1.72E-07 | Detected |
| | Oct. 24 – Nov. 14 | -2.84E-07 | 7.45E-08 | 1.13E-08 | Not detected |
| | Nov. 14 - Dec. 3 | 1.00E-06 | 2.50E-07 | 2.66E-08 | Detected |
| | Dec. 3 - Dec. 19 | 2.95E-07 | 1.87E-07 | 2.99E-08 | Detected |
| | Dec. 19 - Jan. 6 | 2.01E-08 | 1.30E-07 | 3.28E-08 | Detected |

# CHAPTER 4

## Soil Monitoring

Soil is weathered material, mainly composed of disintegrated rock and organic material that sustains growing plants. Soil can contain pollutants originally released directly to the ground, to the air, or through liquid effluents. The U.S. Department of Energy (DOE) guidance for environmental monitoring states that soil should be sampled to determine if there is a measurable, long-term buildup of radionuclides in the terrestrial environment and to estimate environmental radionuclide inventories (U.S. DOE 1991).

Soil monitoring is of high interest to the CEMRC environmental monitoring program because aerosol releases of contaminants would eventually be deposited in surface soils, which then can serve as a source for continuing contaminant exposure and uptake via direct contact, food chain pathways, and re-suspension. A soil monitoring program also offers the most direct means of determining the concentrations (activities), distribution, and long-term trends of radionuclides and chemicals present around nuclear facilities. From these perspectives, soil is an integrating medium of primary concern in predictive ecosystem and contaminant transport modeling that requires good information about the dispersion of analytes of concern across the landscape. The source of transuranic radionuclides in soils are mainly because of integrated global fallout from the testing of above-ground nuclear devices, such as $^{238}$Pu injected into the stratosphere by the burn-up of a failed radioactive thermal generator in 1964 (Krey, 1967), a release at the Gnome Site, and the regional fallout from the above-ground testing at the Trinity Test Site, the Nevada Test Site (NTS) or the Nevada National Security Site (NNSS) as it is known today. Each of these sources has characteristic radionuclide signatures and /or abundances that can, in principle, be used to identify their presence in the soils and to estimate their concentrations. In order to determine if such a signature exists for the WIPP, routine soil sampling occurs at locations near the WIPP site.

Since 1998, surface soil sampling near the WIPP site has been part of a continuing CEMRC monitoring program designed to measure any changes in environmental levels of radioactivity and to evaluate any increase in radioactivity that might have developed as a result of WIPP operations. These samples have been analyzed for transuranic actinides and gamma-emitting radionuclides. Following the radiological event at WIPP, several soil samples were collected from within a 10-mile radius of the WIPP to assess the regional impact of the February 14 radiation release event to the local environment.

### Sample Collection

Soil samples at the depth of (0-2 cm) were collected following the February 14, 2014 radiation release event at random short distances and orientations from the 'Near Field' ambient air sampling site, which is located about 1 km northwest of the WIPP site. 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 4L of soil were collected from within a 50×50 cm area for radionuclide analyses. As shown in Figure 4-2, soil samples were excavated using a trowel and placed in plastic bags for transport and storage. Sampling equipment was cleaned and surveyed for radiological contamination between samples. Samples were sieved through a 1 mm mesh screen to remove rocks, roots, and other large material. The soil samples were then grounded with a ball mill and homogenized by mixing.

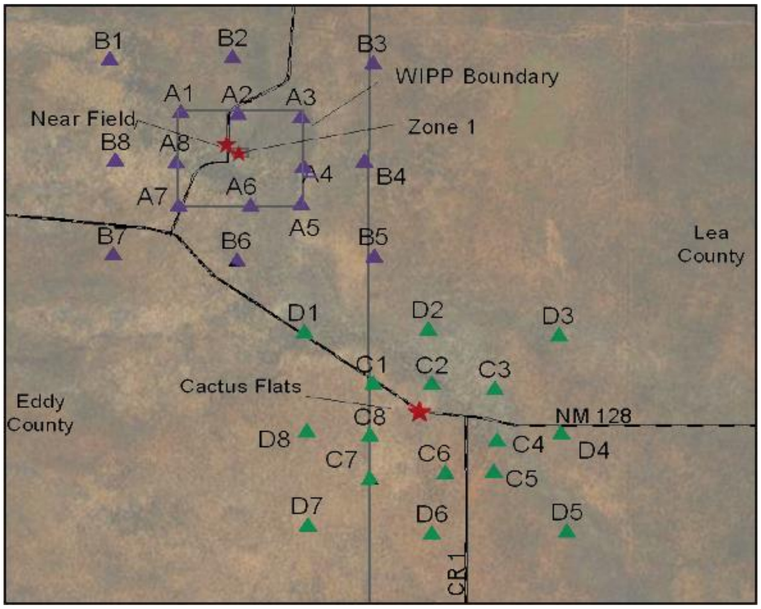



Figure 4-1: Soil Sampling locations in the vicinity of the WIPP Site

Figure 4-2: Soil Sampling in the vicinity of the WIPP site by CEMRC Personnel Sample Preparation

Soil samples were dried at 110°C and blended prior to sampling. For actinides analyses, 10g of each 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 trace and digested in a Teflon beaker with 30 ml of HCl, 10 ml of $HNO_3$ and 40 ml of HF. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. The samples were heated at 250°C for at least 2 hours; however, longer heating does no harm. After digestion was completed, the samples were evaporated to dryness and 40 ml of $HClO_4$ was added and evaporated to complete dryness. This step was repeated once more with 30 ml of $HClO_4$. Then 20 ml of HF were added and evaporated to dryness. To each beaker 80 ml of 8M $HNO_3$, 1.5 g of $H_3BO_3$ and 0.5 ml of 30% $H_2O_2$ were added, covered with a watch glass and heated to boiling for 30 minutes. After cooling, samples were transferred to a 50 ml centrifuge tube and centrifuged at 3600 rpm for 10 minutes. The leachate was filtered through a 0.45 micron filter and transferred to a 250 ml beaker.

### Determination of Individual Radionuclides

The oxidation state of Pu was adjusted by adding 1 ml of 1.0M $NH_4I$ with a 10 min wait step, followed by 2 ml of $NaNO_2$. The sample solutions were then ready for the purification procedure with anion exchange and by extraction chromatography. Next Pu was separated from Am and U using an anion exchange column. U was separated from Am on TRU and the Am subsequently purified from lanthanides with TEVA as shown in Figure 4-3. Finally, Pu, Am and U were micro co-precipitated on stainless steel discs for alpha spectrometry (Canberra). The soil samples were counted for 24 hours, so that results can be made immediately available to the public and other interested parties and also for five days as per CEMRC's standard counting protocol.

The samples for gamma analysis were sealed in a 300-mL paint-can and stored for a few days to allow radon progeny to reach equilibrium with parent radionuclides before counting. Dried and sieved soil samples were counted for 48 hours in a high purity germanium detector, HpGe (Canberra).

### Data Reporting

The activities of the actinides and gamma radionuclides in the soil samples are reported as *activity concentration* in Bq/kg. The *Activity concentration* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by the weight of the soil in kilograms (kg).

### Results and Discussion

The $^{238}$Pu, $^{239+240}$Pu, $^{241}$Am, isotopes of uranium and gamma radionuclides $^{40}$K, $^{137}$Cs and $^{60}$Co were analyzed for all the soil samples. The individual concentrations of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu in the soil samples collected from the Near Field grid are presented in Tables 4-1A (24 hour counting results) and 4-1B (5 days counting results). The $^{239+240}$Pu concentrations in the Near Field ranged from 0.032 to 0.28 Bq/kg, with a mean value of 0.012 Bq/kg, while that for $^{241}$Am ranged from 0.048 to 0.14 Bq/kg, with a mean value of 0.082 Bq/kg. All detected concentration of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am were extremely low and were relatively close to the respective MDCs. The concentrations of these nuclides are comparable to our historical data recorded for these areas prior to arrival of TRU wastes in the WIPP and are typical "background soil" Historical plots of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am concentrations in soil in the vicinity of the WIPP site are shown in Figures 4-4 and 4-6.

The range of $^{239+240}Pu$ concentrations (0.032-0.28 Bq/kg) fell within the range reported by Kenney et al., 1995 at the WIPP site (0-0.74 Bq/kg). These values are lower than those measured at Hueston Woods and Urbana, Ohio (0.7-1.0 Bq/kg) (Alberts et al., 1980) and between Ft. Collins and Colorado Springs, Colorado (0.6-1.7 Bq/kg) (Hodge et al., 1996). These results demonstrate that significant variability in background levels of soil contaminants and constituents can occur in areas having relatively low variability in soil texture. The high correlations of the radionuclides and many of the non-radioactive metals to the percentages of silt and clay in the soil explain much of the between-sample variability. The background concentrations of $^{137}Cs$, $^{239+240}Pu$ and $^{241}Am$ (Bq/kg) in surface soil around the WIPP site are summarized in Table 4-2.

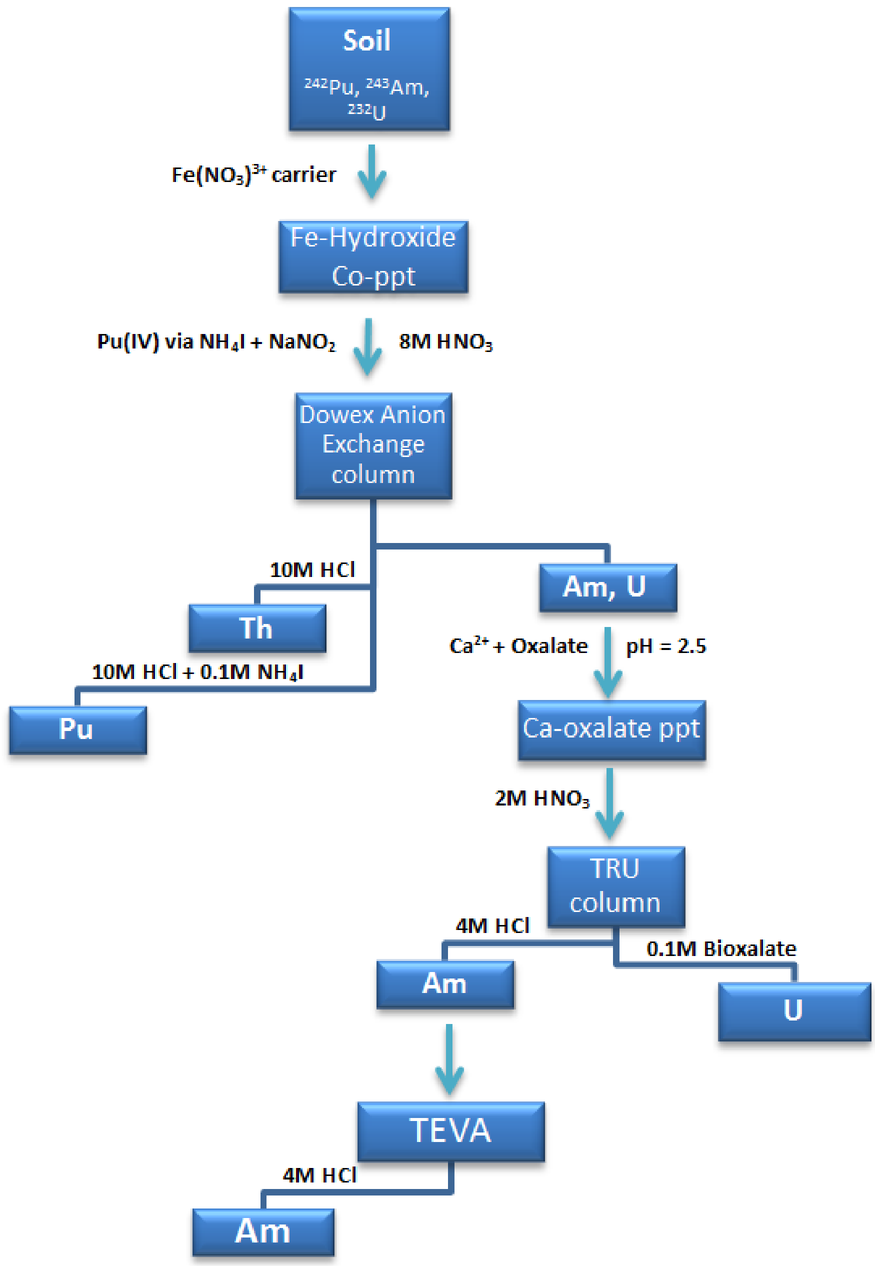



Figure 4-3: Radiochemical separation of Soil Samples

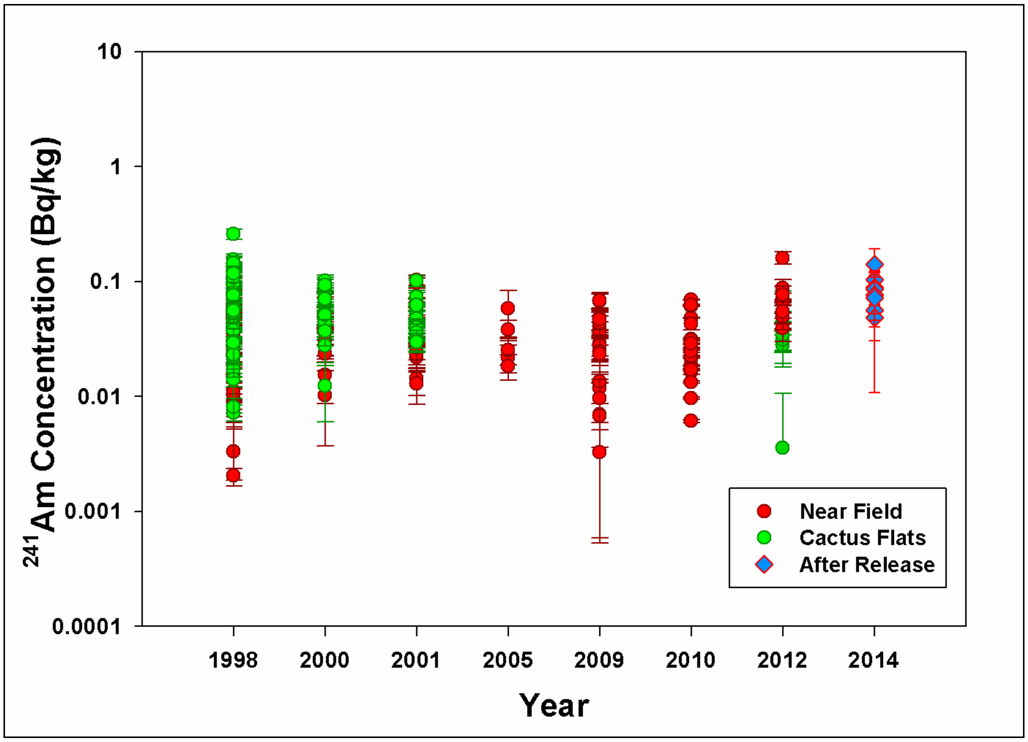



Figure 4-4: The Pre- and Post-radiological event soil concentrations of $^{241}$Am in the vicinity of the WIPP site

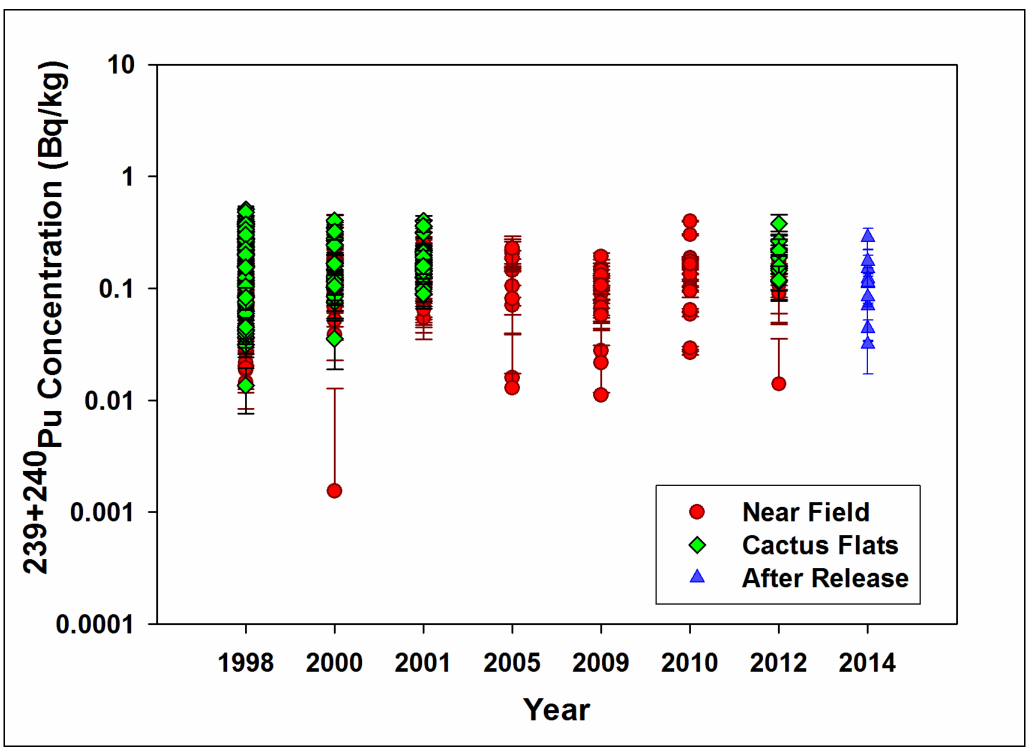



Figure 4-5: The Pre- and Post-radiological event soil concentrations of $^{239+240}$Pu in the vicinity of the WIPP site

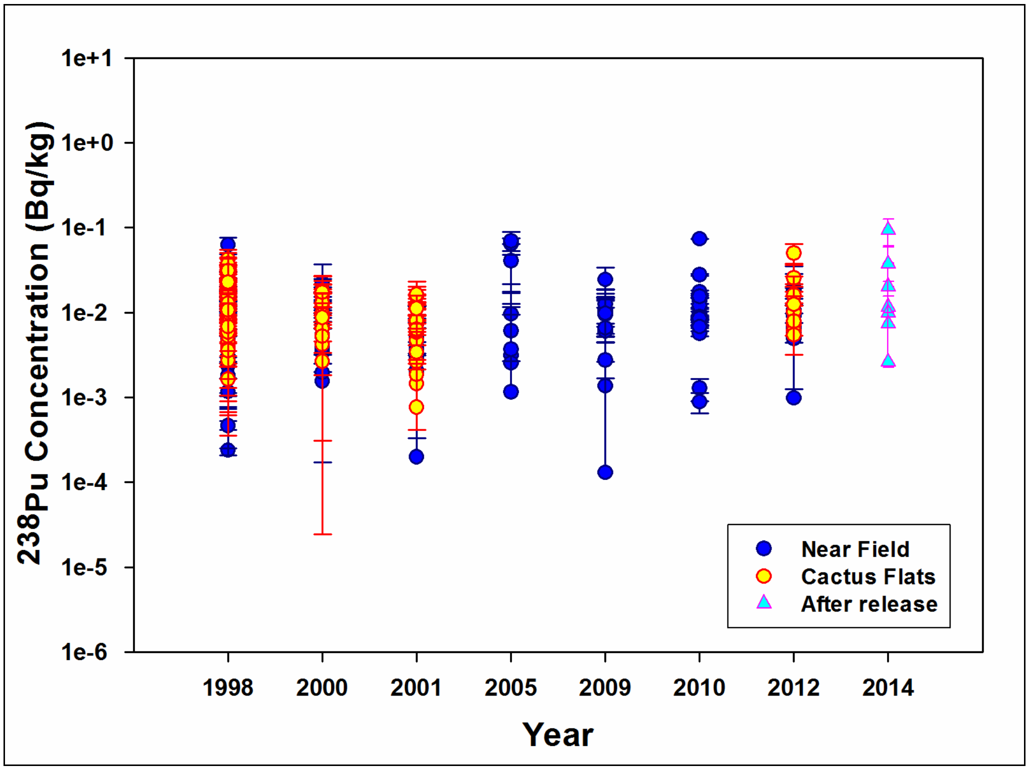



Figure 4-6: The Pre- and Post-radiological event soil concentrations of $^{238}Pu$ in the vicinity of the WIPP site

## Concentrations of uranium Isotopes in the WIPP soil

The naturally occurring isotopes of U were detected in all soil samples collected in 2014. Table 4-3 presents the uranium isotope analysis data for the soil samples collected in 2014. The highest concentrations of $^{234}U$ and $^{238}U$ detected in soil were 9.97 Bq/kg and 9.89 Bq/kg. The concentration of uranium in soil varies widely, but typically contains about 3 parts per million (ppm), or about 0.074 (Bq/g). A square mile of earth, one foot deep, will typically contain over a ton of uranium. The average background concentration of uranium in surface soil is about 2 mg/kg (NCRP 1984). Figure 4-7 illustrates the soil uranium concentration levels in the United States. The concentrations of uranium isotopes measured in soil samples following the February, 14 release were within the range of the baseline phase data for the soil samples collected in 1998 (Figures 4-8 and 4-9) and showed no detectable increases above those typical of previously measured natural variation. The calculated $^{234}U/^{238}U$ activity ratio in the vicinity of WIPP soil varied between 0.93 to 1.01 with an average value of 0.96±0.02 indicating the presence of natural uranium. The Figure 4-10 shows the variation in $^{234}U/^{238}U$ ratio in the soil samples collected in the vicinity of the WIPP site. The $^{234}U/^{238}U$ activity ratio obtained indicated that these two uranium isotopes are in the state of secular radioactive equilibrium. When soil samples are analyzed using alpha spectrometry the expected secular equilibrium between $^{238}U$ and $^{234}U$ is typically observed, but the expected ratio of $^{238}U$ and $^{235}U$ is seldom found. In practice it is more common for the $^{238}U$ to $^{235}U$ ratio to be lower than expected. This indicates that either there is more $^{235}U$ present in the sample than is true for natural uranium or there is high bias in the $^{235}U$ measurement.

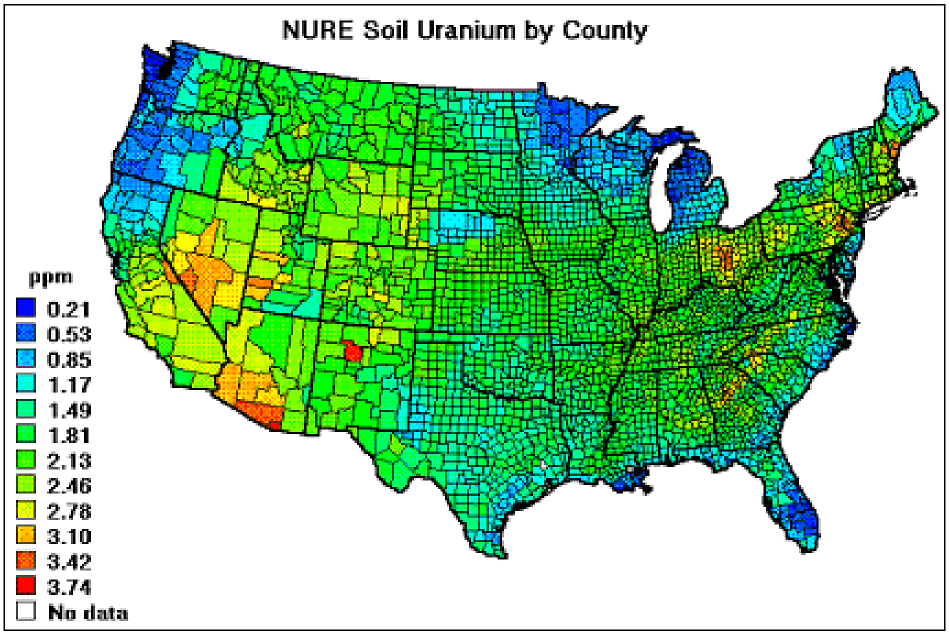



Figure 4-7: Soil uranium concentration levels in the United States
*Courtesy: USGS.gov*

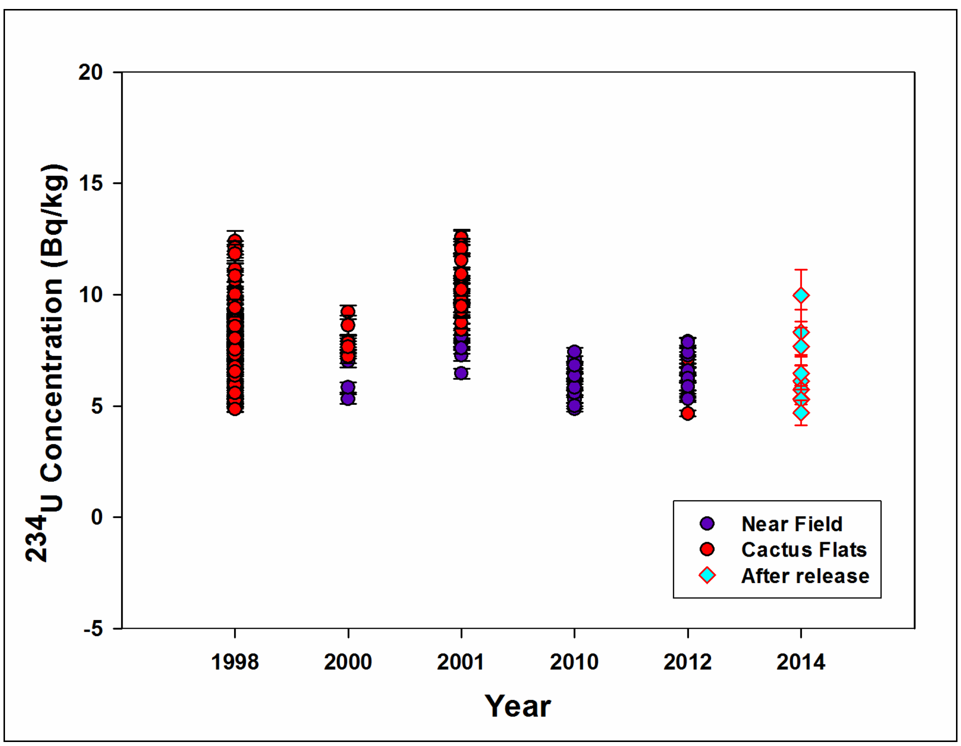



Figure 4-8: The Pre- and Post-radiological event soil concentrations of $^{234}U$ in the vicinity of the WIPP site

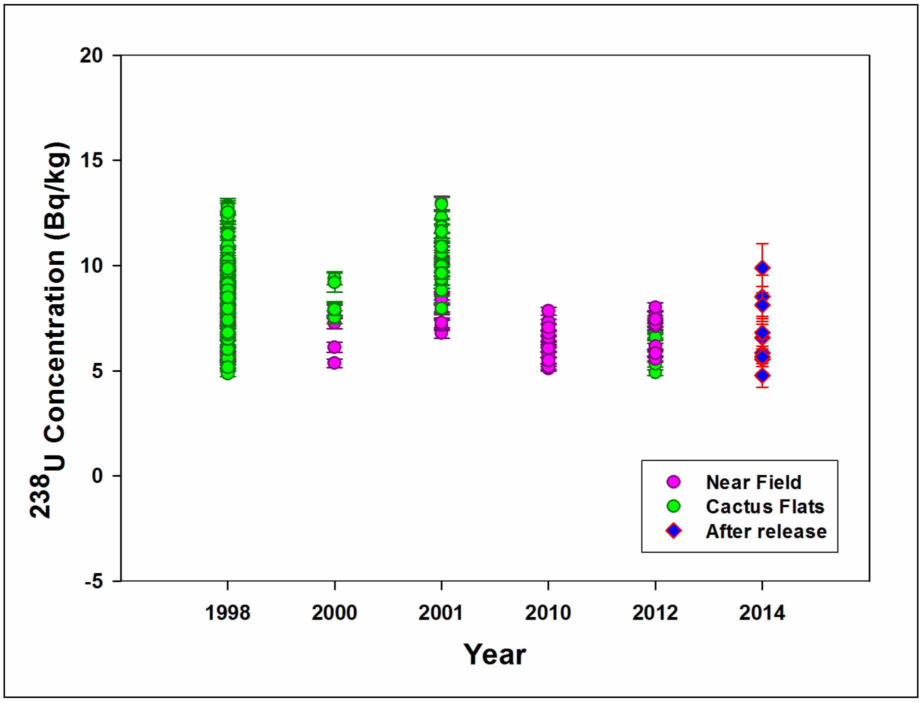



Figure 4-9: The Pre- and Post-radiological event soil concentrations of $^{238}$U in the vicinity of the WIPP site

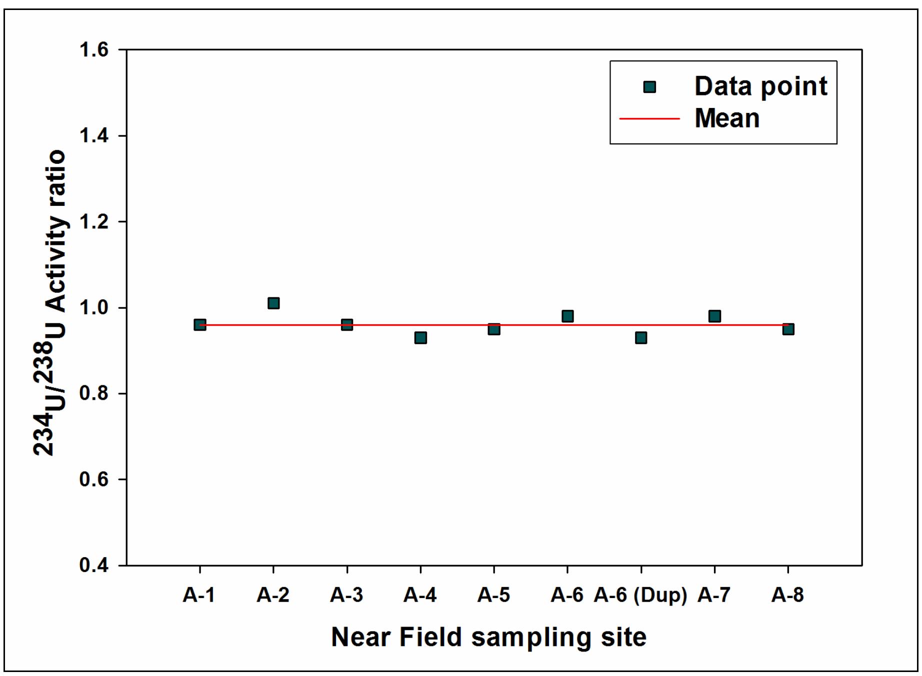



Figure 4-10: The $^{234}$U/$^{238}$U activity ratio in the soil samples collected from Near Field grid in the vicinity of the WIPP site

## Concentrations of Gamma Radionuclides in the WIPP soil

The $^{137}$Cs was detected in all soil samples (Table 4-4). The activity concentration of $^{137}$Cs in the Near Field surface soil ranged from 0.48 to 3.89 Bq/kg, with a mean value of 2.0 Bq/kg. Variability among the $^{137}$Cs concentrations was not very significant. Although $^{137}$Cs is a fission product, it is ubiquitous in soils because of global fallout from atmospheric weapons testing (Beck and Bennett, 2002 and UNSCEAR, 2000). Like, $^{137}$Cs, the $^{40}$K was detected in every sample (Table 4-4). This naturally occurring gamma-emitting radionuclide is ubiquitous in soils. The concentrations of $^{40}$K fell within the range of values previously measured for the WIPP soil samples. 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 was not detected at any sampling locations. Historical plots of $^{137}$Cs and $^{40}$K concentrations in soil in the vicinity of the WIPP site are shown in Figures 4-11 and 4-12. 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.

Surface soils were not collected from Cactus Flats following the radiation release event. However those collected in 1998 to 2005 and in 2012 show activity concentrations of $^{239+240}$Pu ranging from 0.01 to 0.51 Bq/kg, while that of $^{241}$Am varied from 0.01 to 0.26 Bq/kg. The $^{137}$Cs concentration ranged from 0.69 to 14.83 Bq/kg. The concentration of $^{137}$Cs in the surface soil at Cactus Flats is approximately 3 times higher than that of surface soil at Near Field, while concentrations of $^{239+240}$Pu and $^{241}$Am are approximately 2-3 times higher. It is important to note that there is no apparent difference between the radionuclides concentration in soil collected before and after WIPP started receiving TRU waste. Similarly, the Cactus Flats soil radionuclide concentrations continue to be higher than those measured in the soil samples collected following the radiological event at WIPP.

A finding presented in the CEMRC 2000 Report was that there were significant differences in many analyte concentrations between the Near Field and Cactus Flats grids. In a subsequent publication, differences in soil texture were identified as a likely cause for these observations (Kirchner et al., 2002).

Additionally, the Gnome Site lies approximately 9 km southwest of the WIPP Site and was contaminated with actinide and fission products in 1961 when an underground detonation of a 3-kiloton $^{239}$Pu device vented to the atmosphere. The concentrations of $^{239+240}$Pu, $^{238}$Pu, and $^{241}$Am in Gnome soil were in the range 0.073-1550 Bq/kg, 0.016-219 Bq/kg and 0.043-346 Bq/kg, respectively with an overall mean of 149.0 Bq/kg, 28.8 Bq/kg and 36.1 Bq/kg, respectively (CEMRC Annual Report, 2005/2006). In comparison, the WIPP $^{137}$Cs concentration in the surface soil was significantly lower than the Gnome soil (CEMRC Annual Report, 2005/2006). The maximum concentration of $^{137}$Cs for the Gnome samples, 2890 Bq/kg, was more than 100 times larger than the largest concentration (3.89 Bq/kg) seen in the WIPP surface soil samples following the February 14, 2014 radiological event. These monitoring results indicate that there is no evidence of increase in soil radionuclide concentrations that can be attributed to the recent radiological event at WIPP.

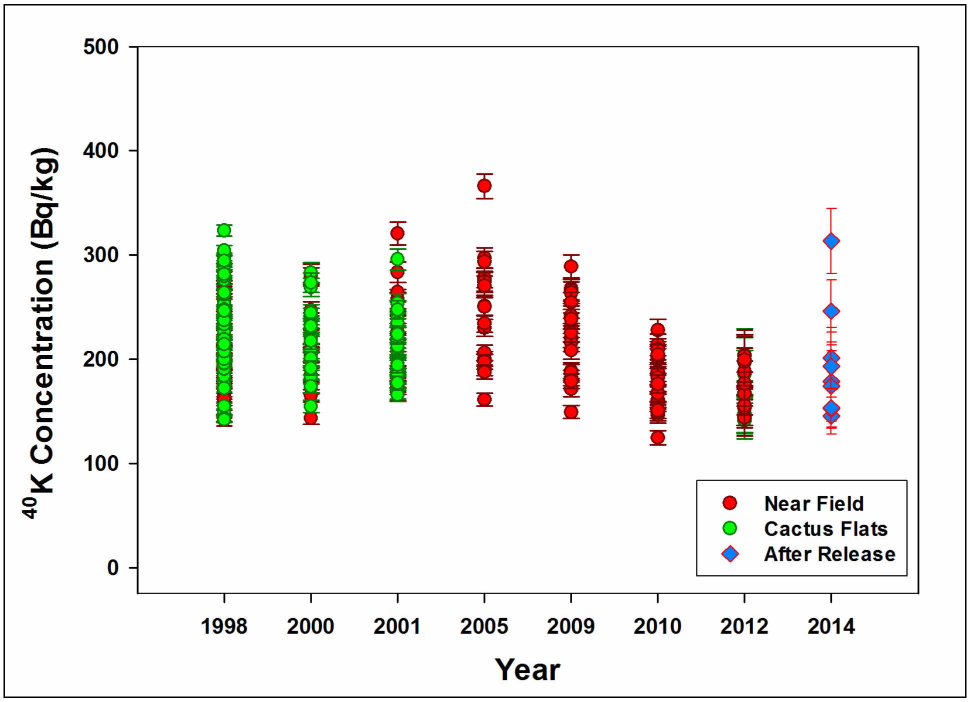



Figure 4-11: The Pre- and Post-radiological event soil concentrations of $^{40}K$ in the vicinity of the WIPP site

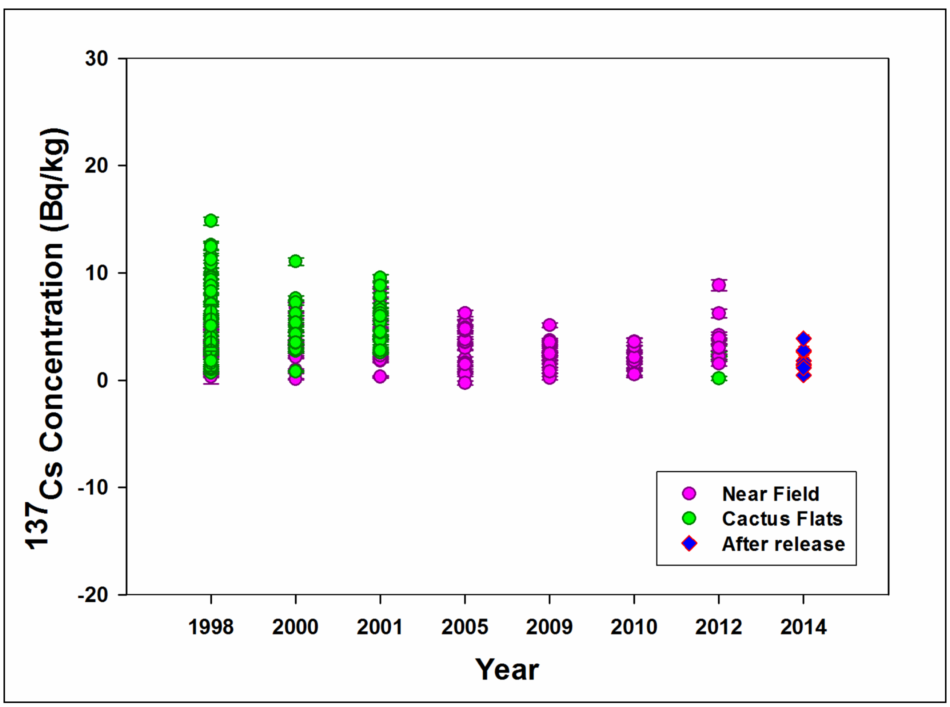



Figure 4-12: The Pre- and Post-radiological event soil concentrations of $^{137}Cs$ in the vicinity of the WIPP site

Table 4-1A: Activity concentrations of $^{241}Am$, $^{239+240}Pu$ and $^{238}Pu$ (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP (24 hours counting results)

| Radionuclides | Location | Grid Nodes | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{241}Am$ | Near field | A-2 | 3/13/2014 | 9.49E-02 | 8.44E-02 | 1.17E-01 | Not detected |
| | Near field | A-1 | 3/13/2014 | 1.20E-01 | 9.21E-02 | 1.00E-01 | Detected |
| | Near field | A-3 | 3/13/2014 | 9.96E-02 | 8.12E-02 | 1.05E-01 | Not detected |
| | Near field | A-4 | 3/13/2014 | 9.42E-02 | 1.14E-01 | 2.26E-01 | Not detected |
| | Near field | A-5 | 3/13/2014 | 1.93E-01 | 1.18E-01 | 1.19E-01 | Detected |
| | Near field | A-6 | 3/13/2014 | 1.17E-01 | 8.73E-02 | 1.21E-01 | Not detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 6.76E-02 | 7.60E-02 | 1.25E-01 | Not detected |
| | Near field | A-7 | 3/13/2014 | 3.25E-02 | 6.50E-02 | 1.51E-01 | Not detected |
| | Near field | A-8 | 3/13/2014 | 6.69E-02 | 6.06E-02 | 8.82E-02 | Not detected |
| | Blank | - | - | 8.41E-02 | 7.34E-02 | 1.26E-01 | Not detected |
| | | | | | | | |
| $^{239+240}Pu$ | Near field | A-2 | 3/13/2014 | 1.58E-01 | 1.20E-01 | 1.45E-01 | Detected |
| | Near field | A-1 | 3/13/2014 | 3.04E-01 | 1.31E-01 | 9.31E-02 | Detected |
| | Near field | A-3 | 3/13/2014 | 1.92E-01 | 1.23E-01 | 1.28E-01 | Detected |
| | Near field | A-4 | 3/13/2014 | 4.72E-02 | 6.32E-02 | 1.16E-01 | Not detected |
| | Near field | A-5 | 3/13/2014 | 1.49E-01 | 1.19E-01 | 1.73E-01 | Not detected |
| | Near field | A-6 | 3/13/2014 | 1.56E-01 | 1.05E-01 | 1.15E-01 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 7.52E-02 | 8.45E-02 | 1.38E-01 | Not detected |
| | Near field | A-7 | 3/13/2014 | 7.04E-02 | 8.66E-02 | 1.64E-01 | Not detected |
| | Near field | A-8 | 3/13/2014 | 1.98E-01 | 1.07E-01 | 9.65E-02 | Detected |
| | Blank | - | - | -1.41E-02 | 4.00E-02 | 1.31E-01 | Not detected |
| | | | | | | | |
| $^{238}Pu$ | Near field | A-2 | 3/13/2014 | 9.88E-02 | 9.74E-02 | 1.45E-01 | Not detected |
| | Near field | A-1 | 3/13/2014 | 1.26E-02 | 3.59E-02 | 9.31E-02 | Not detected |
| | Near field | A-3 | 3/13/2014 | 0.00E+00 | 4.93E-02 | 1.62E-01 | Not detected |
| | Near field | A-4 | 3/13/2014 | 9.44E-02 | 8.40E-02 | 1.16E-01 | Not detected |
| | Near field | A-5 | 3/13/2014 | 9.30E-02 | 9.19E-02 | 1.37E-01 | Not detected |
| | Near field | A-6 | 3/13/2014 | 1.09E-01 | 9.45E-02 | 1.45E-01 | Not detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 0.00E+00 | 5.31E-02 | 1.75E-01 | Not detected |
| | Near field | A-7 | 3/13/2014 | 7.04E-02 | 1.00E-01 | 2.11E-01 | Not detected |
| | Near field | A-8 | 3/13/2014 | 3.93E-02 | 5.26E-02 | 9.65E-02 | Not detected |
| | Blank | - | - | 2.82E-02 | 4.89E-02 | 1.04E-01 | Not detected |

Table 4-1B: Activity concentrations of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP (5 days counting results)

| Radionuclides | Location | Grid Nodes | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{241}$Am | Near field | A-2 | 3/13/2014 | 7.14E-02 | 3.12E-02 | 2.27E-02 | Detected |
| | Near field | A-1 | 3/13/2014 | 1.04E-01 | 4.20E-02 | 2.82E-02 | Detected |
| | Near field | A-3 | 3/13/2014 | 7.61E-02 | 1.35E-02 | 5.92E-03 | Detected |
| | Near field | A-4 | 3/13/2014 | 5.64E-02 | 6.17E-02 | 1.36E-01 | Not detected |
| | Near field | A-5 | 3/13/2014 | 1.41E-01 | 5.15E-02 | 8.44E-02 | Detected |
| | Near field | A-6 | 3/13/2014 | 4.84E-02 | 3.76E-02 | 7.59E-02 | Not detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 8.80E-02 | 3.57E-02 | 2.40E-02 | Detected |
| | Near field | A-7 | 3/13/2014 | 8.63E-02 | 3.42E-02 | 2.27E-02 | Detected |
| | Near field | A-8 | 3/13/2014 | 7.68E-02 | 3.09E-02 | 3.94E-02 | Detected |
| | Blank | - | - | 7.18E-02 | 4.16E-02 | 8.18E-02 | Not detected |
| | | | | | | | |
| $^{239+240}$Pu | Near field | A-2 | 3/13/2014 | 6.96E-02 | 3.53E-02 | 3.60E-02 | Detected |
| | Near field | A-1 | 3/13/2014 | 2.84E-01 | 6.14E-02 | 1.85E-02 | Detected |
| | Near field | A-3 | 3/13/2014 | 1.50E-01 | 4.84E-02 | 2.51E-02 | Detected |
| | Near field | A-4 | 3/13/2014 | 1.22E-01 | 4.26E-02 | 2.42E-02 | Detected |
| | Near field | A-5 | 3/13/2014 | 1.10E-01 | 5.79E-02 | 1.03E-01 | Detected |
| | Near field | A-6 | 3/13/2014 | 1.13E-01 | 3.94E-02 | 2.24E-02 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 4.39E-02 | 2.68E-02 | 2.69E-02 | Detected |
| | Near field | A-7 | 3/13/2014 | 8.39E-02 | 5.06E-02 | 9.46E-02 | Not detected |
| | Near field | A-8 | 3/13/2014 | 1.74E-01 | 4.64E-02 | 1.91E-02 | Detected |
| | Blank | - | - | 3.16E-02 | 3.70E-02 | 8.11E-02 | Not detected |
| | | | | | | | |
| $^{238}$Pu | Near field | A-2 | 3/13/2014 | 1.16E-02 | 2.57E-02 | 6.14E-02 | Not detected |
| | Near field | A-1 | 3/13/2014 | 9.31E-02 | 3.24E-02 | 1.85E-02 | Detected |
| | Near field | A-3 | 3/13/2014 | -6.83E-03 | 3.62E-02 | 9.61E-02 | Not detected |
| | Near field | A-4 | 3/13/2014 | 9.90E-03 | 1.33E-02 | 2.42E-02 | Not detected |
| | Near field | A-5 | 3/13/2014 | 7.33E-03 | 1.27E-02 | 2.69E-02 | Not detected |
| | Near field | A-6 | 3/13/2014 | -1.22E-02 | 3.10E-02 | 8.59E-02 | Not detected |
| | Near field | A-6 (Dup) | 3/13/2014 | -1.46E-02 | 3.73E-02 | 1.03E-01 | Not detected |
| | Near field | A-7 | 3/13/2014 | 2.01E-02 | 1.79E-02 | 2.47E-02 | Not detected |
| | Near field | A-8 | 3/13/2014 | 2.60E-03 | 7.34E-03 | 1.91E-02 | Not detected |
| | Blank | - | - | 1.15E-02 | 1.69E-02 | 3.64E-02 | Not detected |

Table 4-2: The background concentrations of $^{137}Cs$, $^{239+240}Pu$ and $^{241}Am$ (Bq/kg) in surface soil in the vicinity of the WIPP site

| Location | Year | $^{137}Cs$ | $^{239+240}Pu$ | $^{241}Am$ | Reference |
|---|---|---|---|---|---|
| 100 M NW of WIPP Met. Tower | 1991 | 0.00 | 0.00 | - | Kenny et al., 1995 |
| 390 M east of WIPP exhaust | 1990 | 7.4 | 0.37 | - | Kenny et al., 1995 |
| 530 M south of WIPP exhaust | 1994-1995 | 0.00 | 0.74 | - | Kenny et al., 1995 |
| 775 M west of WIPP exhaust | 1990 | 3.7 | 0.37 | - | Kenny et al., 1995 |
| 1000 M NW of WIPP exhaust | 1989 | 7.4 | 0.00 | - | Kenny et al., 1995 |
| WIPP vicinity, Near Field | 1998 | 0.31-5.96 | 0.015-0.22 | 0.002-0.13 | CEMRC Data 1998 |
| WIPP vicinity, Cactus Flats | 1998 | 0.70- 14.8 | 0.013-0.51 | 0.007-0.26 | CEMRC Data 1998 |
| WIPP vicinity | 1995 | 0-7.40 | 0.00-0.74 | - | Kenny et al., 1995 |
| Gnome site | 1995 | 2.59-3090 | 4.4-48000 | 0.40-7600 | Kenny et al., 1995 |
| Gnome site | 2002 | 45.9-2980 | 0.07-1550 | 0.04-3460 | CEMRC Data 2005/2006 |
| Distant Locations | 1982-1987 | 6.45-47.25 | 0.13-6.98 | - | Krey and Beck, 1981 |

Table 4-3: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP (5 days counting results)

| Radionuclides | Location | Grid Nodes | Samplin g Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{234}U$ | Near field | A-2 | 3/13/20 | 5.31E+00 | 6.19E-01 | 6.45E-02 | Detected |
| | Near field | A-1 | 3/13/20 | 9.97E+00 | 1.17E+00 | 8.48E-02 | Detected |
| | Near field | A-3 | 3/13/20 | 8.32E+00 | 1.01E+00 | 8.42E-02 | Detected |
| | Near field | A-4 | 3/13/20 | 6.13E+00 | 7.23E-01 | 8.48E-02 | Detected |
| | Near field | A-5 | 3/13/20 | 7.67E+00 | 8.47E-01 | 3.94E-02 | Detected |
| | Near field | A-6 | 3/13/20 | 5.73E+00 | 6.45E-01 | 5.18E-02 | Detected |
| | Near field | A-6 (Dup) | 3/13/20 14 | 5.30E+00 | 6.09E-01 | 4.85E-02 | Detected |
| | Near field | A-7 | 3/13/20 | 4.70E+00 | 5.52E-01 | 7.16E-02 | Detected |
| | Near field | A-8 | 3/13/20 | 6.47E+00 | 7.43E-01 | 5.25E-02 | Detected |
| | | | | | | | |
| $^{235}U$ | Near field | A-2 | 3/13/20 | 2.17E-01 | 6.22E-02 | 3.47E-02 | Detected |
| | Near field | A-1 | 3/13/20 | 3.69E-01 | 1.16E-01 | 1.24E-01 | Detected |
| | Near field | A-3 | 3/13/20 | 3.61E-01 | 1.16E-01 | 1.04E-01 | Detected |
| | Near field | A-4 | 3/13/20 | 2.42E-01 | 7.53E-02 | 6.55E-02 | Detected |
| | Near field | A-5 | 3/13/20 | 4.94E-01 | 9.13E-02 | 3.36E-02 | Detected |
| | Near field | A-6 | 3/13/20 | 2.40E-01 | 6.23E-02 | 5.23E-02 | Detected |

Table 4-3: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP (5 days counting results) (continued)

| Radionuclides | Location | Grid Nodes | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{235}U$ | Near field | A-6 (Dup) | 3/13/2014 | 2.55E-01 | 6.49E-02 | 4.48E-02 | Detected |
| | Near field | A-7 | 3/13/2014 | 2.72E-01 | 7.23E-02 | 3.66E-02 | Detected |
| | Near field | A-8 | 3/13/2014 | 4.83E-01 | 1.00E-01 | 4.46E-02 | Detected |
| | | | | | | | |
| $^{238}U$ | Near field | A-2 | 3/13/2014 | 5.54E+00 | 6.42E-01 | 1.01E-01 | Detected |
| | Near field | A-1 | 3/13/2014 | 9.89E+00 | 1.16E+00 | 1.07E-01 | Detected |
| | Near field | A-3 | 3/13/2014 | 8.51E+00 | 1.03E+00 | 1.33E-01 | Detected |
| | Near field | A-4 | 3/13/2014 | 6.59E+00 | 7.74E-01 | 1.02E-01 | Detected |
| | Near field | A-5 | 3/13/2014 | 8.12E+00 | 8.95E-01 | 5.06E-02 | Detected |
| | Near field | A-6 | 3/13/2014 | 5.86E+00 | 6.60E-01 | 5.93E-02 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 5.67E+00 | 6.46E-02 | 9.63E-02 | Detected |
| | Near field | A-7 | 3/13/2014 | 4.79E+00 | 5.64E-01 | 7.80E-02 | Detected |
| | Near field | A-8 | 3/13/2014 | 6.82E+00 | 7.80E-01 | 9.36E-02 | Detected |

Table 4-4: Activity concentrations of $^{137}Cs$, $^{40}K$ and $^{60}Co$ (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP

| Radionuclides | Location | Grid Nodes | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{137}Cs$ | Near field | A-2 | 3/13/2014 | 1.80E+00 | 3.20E-01 | 4.64E-01 | Detected |
| | Near field | A-1 | 3/13/2014 | 2.68E+00 | 2.52E-01 | 3.37E-01 | Detected |
| | Near field | A-3 | 3/13/2014 | 2.65E+00 | 3.46E-01 | 4.41E-01 | Detected |
| | Near field | A-4 | 3/13/2014 | 1.36E+00 | 3.09E-01 | 4.74E-01 | Detected |
| | Near field | A-5 | 3/13/2014 | 2.79E+00 | 3.61E-01 | 4.58E-01 | Detected |
| | Near field | A-6 | 3/13/2014 | 1.47E+00 | 2.05E-01 | 3.07E-01 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 4.85E-01 | 1.95E-01 | 4.47E-01 | Detected |
| | Near field | A-7 | 3/13/2014 | 1.14E+00 | 1.98E-01 | 3.08E-01 | Detected |
| | Near field | A-1 | 3/13/2014 | 2.01E+02 | 2.46E+01 | 2.55E+00 | Detected |
| | Near field | A-3 | 3/13/2014 | 3.13E+02 | 3.11E+01 | 5.06E+00 | Detected |
| | Near field | A-4 | 3/13/2014 | 1.74E+02 | 3.38E+01 | 5.30E+00 | Detected |
| | Near field | A-5 | 3/13/2014 | 1.93E+02 | 3.74E+01 | 5.23E+00 | Detected |
| | Near field | A-6 | 3/13/2014 | 1.46E+02 | 1.79E+01 | 2.41E+00 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 1.52E+02 | 1.87E+01 | 2.53E+00 | Detected |

Table 4-4: Activity concentrations of $^{137}Cs$, $^{40}K$ and $^{60}Co$ (Bq/kg) in soil samples collected in the vicinity of the WIPP site following the February 14 radiological event at WIPP (continued)

| Radionuclides | Location | Grid Nodes | Sampling Date | Activity Bq/kg | Unc. (2σ) Bq/kg | MDC Bq/kg | Status |
|---|---|---|---|---|---|---|---|
| $^{137}Cs$ | Near field | A-7 | 3/13/2014 | 1.53E+02 | 1.88E+01 | 2.46E+00 | Detected |
| | Near field | A-8 | 3/13/2014 | 2.46E+02 | 3.01E+01 | 5.41E+00 | Detected |
| | | | | | | | |
| $^{60}Co$ | Near field | A-2 | 3/13/2014 | -3.72E-01 | 3.75E-01 | 6.41E-01 | Not detected |
| | Near field | A-1 | 3/13/2014 | 4.15E-02 | 9.32E-02 | 3.09E-01 | Not detected |
| | Near field | A-3 | 3/13/2014 | -1.42E-01 | 3.65E-01 | 6.21E-01 | Not detected |
| | Near field | A-4 | 3/13/2014 | -4.99E-02 | 3.65E-01 | 6.20E-01 | Not detected |
| | Near field | A-5 | 3/13/2014 | 1.47E-01 | 3.71E-01 | 6.25E-01 | Not detected |
| | Near field | A-6 | 3/13/2014 | 7.43E-02 | 1.64E-01 | 2.76E-01 | Not detected |
| | Near field | A-6 (Dup) | 3/13/2014 | -9.91E-02 | 1.75E-01 | 2.99E-01 | Not detected |
| | Near field | A-7 | 3/13/2014 | 9.51E-03 | 1.67E-01 | 2.83E-01 | Not detected |
| | Near field | A-8 | 3/13/2014 | -1.77E-01 | 1.04E-01 | 3.47E-01 | Not detected |
| | | | | | | | |
| $^{40}K$ | Near field | A-2 | 3/13/2014 | 1.79E+02 | 3.47E+01 | 5.05E+00 | Detected |
| | Near field | A-1 | 3/13/2014 | 2.01E+02 | 2.46E+01 | 2.55E+00 | Detected |
| | Near field | A-3 | 3/13/2014 | 3.13E+02 | 3.11E+01 | 5.06E+00 | Detected |
| | Near field | A-4 | 3/13/2014 | 1.74E+02 | 3.38E+01 | 5.30E+00 | Detected |
| | Near field | A-5 | 3/13/2014 | 1.93E+02 | 3.74E+01 | 5.23E+00 | Detected |
| | Near field | A-6 | 3/13/2014 | 1.46E+02 | 1.79E+01 | 2.41E+00 | Detected |
| | Near field | A-6 (Dup) | 3/13/2014 | 1.52E+02 | 1.87E+01 | 2.53E+00 | Detected |
| | Near field | A-7 | 3/13/2014 | 1.53E+02 | 1.88E+01 | 2.46E+00 | Detected |
| | Near field | A-8 | 3/13/2014 | 2.46E+02 | 3.01E+01 | 5.41E+00 | Detected |

# CHAPTER 5

## Surface Water and Sediment Monitoring

Surface water is a term used to describe water in a watercourse, lake or wetland, and includes water flowing over or lying on land after having precipitated naturally, or after having risen to the surface naturally from underground (groundwater). Rivers, lakes, streams, ponds, wetlands and oceans are all examples of surface water. Continually replenished by precipitation or rain runoff, surface water is a body of water easily seen as it flows downhill to where it collects. Retention of radionuclide fallout by catchment soils and river and lake sediments plays an important role in determining subsequent transport in aquatic systems. In rivers and small lakes, the radioactive contamination results mainly from erosion of the surface layers of soil in the watershed, followed by runoff in the water bodies; however, deposition of radioactive materials also occurs on water surfaces. The fraction of a radionuclide that is adsorbed to suspended particles, which varies considerably in surface waters, strongly influences both its transport and its bio-accumulation.

Samples of surface water in the vicinity of the WIPP site were collected and analyzed to determine the concentrations of radiological contaminants in the aquatic environment attributed to the recent radiation event at the WIPP. The surface water samples were collected from three regional reservoirs situated along the Pecos river at a considerable distance from the WIPP site including: Brantley Lake, ~55 km (34 miles) north-northwest of the WIPP site, Red Bluff reservoir on the Pecos River, the upstream end of which is the nearest standing water body ~ 48 km (30 miles) to the southwest of the WIPP site, and Lake Carlsbad in the center of Carlsbad about 40 km (25 miles) northwest from the WIPP site. The Pecos River is the dominant surface-water body in the vicinity of the WIPP Site and is used for a variety of recreational activities including fishing, boating, water skiing, and swimming. Accelerated radiochemical analyses were performed to assess the regional impact of the February 14, 2014 radiological event to the surface waters in the local environment.

### Sample Collection

The surface water samples were collected in the same general area as the sediment samples (see 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. Approximately 8 L of surface water was collected from each location (See Figure 5-2).


Figure 5-1: Surface Water and Sediment Sampling locations in the vicinity of the WIPP Site

Figure 5-2: Surface water samples collection from the Brantley Lake
by the CEMRC Personnel

## Sample Preparation

In the laboratory, surface water samples collected for radiological analyses were acidified with $HNO_3$ 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. 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 and Ziegler, Analytics (GA) in the energy range between 60 to 2000 keV for a 2L Marinelli geometry. The counting time for each sample was 48 hours.

The second, 1 L aliquot, was used for actinides 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 hydrofluoric acid. The samples were heated to dryness and wet-ashed using concentrated nitric acid and hydrogen peroxide. Finally, the samples were heated to dryness again, and the isotopic separation steps were initiated.

## Actinides Separation

The actinides are separated as a group by co-precipitation on $Fe(OH)_3$. The oxidation state of Pu is adjusted by adding 1 ml of 1.0M $NH_4I$ with a 10 min wait step, followed by 2 ml of 2M $NaNO_2$. Pu isotopes are then separated and purified using a two-column anion exchange resin (Dowex1-× 8, 100-200 mesh), while TRU chromatography columns are for the separation of Am and U. The samples are then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for 24 hours, so that results can be made immediately available to the public and other interested parties. The samples are also counted for five days as per CEMRC's standard counting protocol.

## Data Reporting

The activities of the actinides and gamma radionuclides are reported as *activity concentration* in Bq/L. *Activity concentration* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by weight of the surface water in *liters* (L).

## Results and Discussion

The activity concentrations measured for $^{241}Am$, $^{238}Pu$, and $^{239+240}Pu$ were below the respective MDCs for each analyte in all surface water samples collected following the radiological event at WIPP (Figures 5-3 through 5-5). The individual values of $^{241}Am$, $^{238}Pu$, and $^{239+240}Pu$ measured in the three reservoirs are listed in Table 5-1 (A and B). Since 1998, neither $^{239+240}Pu$, $^{238}Pu$ or $^{241}Am$ have been measured above the MDC in any surface water samples. Figures 5-6 through 5-8 show the historic values for $^{239+240}Pu$, $^{238}Pu$ and $^{241}Am$ at all sites as a function of their range (vertical lines), medians (stars), and boxes indicating with horizontal lines the means plus or minus two standard deviations. The interpretation of

Figures 5-6 through 5-8 is that activities of these radionuclides measured were close to zero (all are below the MDC). The absence of a detection of WIPP radionuclides in surface water samples collected indicates that the recent radiological event at WIPP has not impacted the regional reservoirs.

Uranium isotopes ($^{234}U$, $^{235}U$ and $^{238}U$) were detected in all the surface water samples collected in 2014 as shown Table 5-2. The concentrations range of $^{234}U$, $^{235}U$, and $^{238}U$ measured in three reservoirs in 2014 are shown in Figure 5-9. The concentration ranges for these isotopes, showed no significant difference between baseline and monitoring phases (CEMRC Report, 1998). The $^{234}U/^{238}U$ isotopic ratios were very similar among these three reservoirs. The reservoirs appeared to be slightly enriched in $^{234}U$ compared to $^{238}U$, with the activity ratios ranging from 1.96 to 2.18 (Figure 5-10). Maximum activity concentrations for $^{234}U$, $^{235}U$ and $^{238}U$ (Table 5-2) increased slightly in the monitoring phase relative to the baseline phase for samples collected from all three reservoirs. No significant difference between the baseline and monitoring phase concentrations was observed. The baseline concentration of uranium in surface water samples collected in 1998 is listed in Table 5-3.

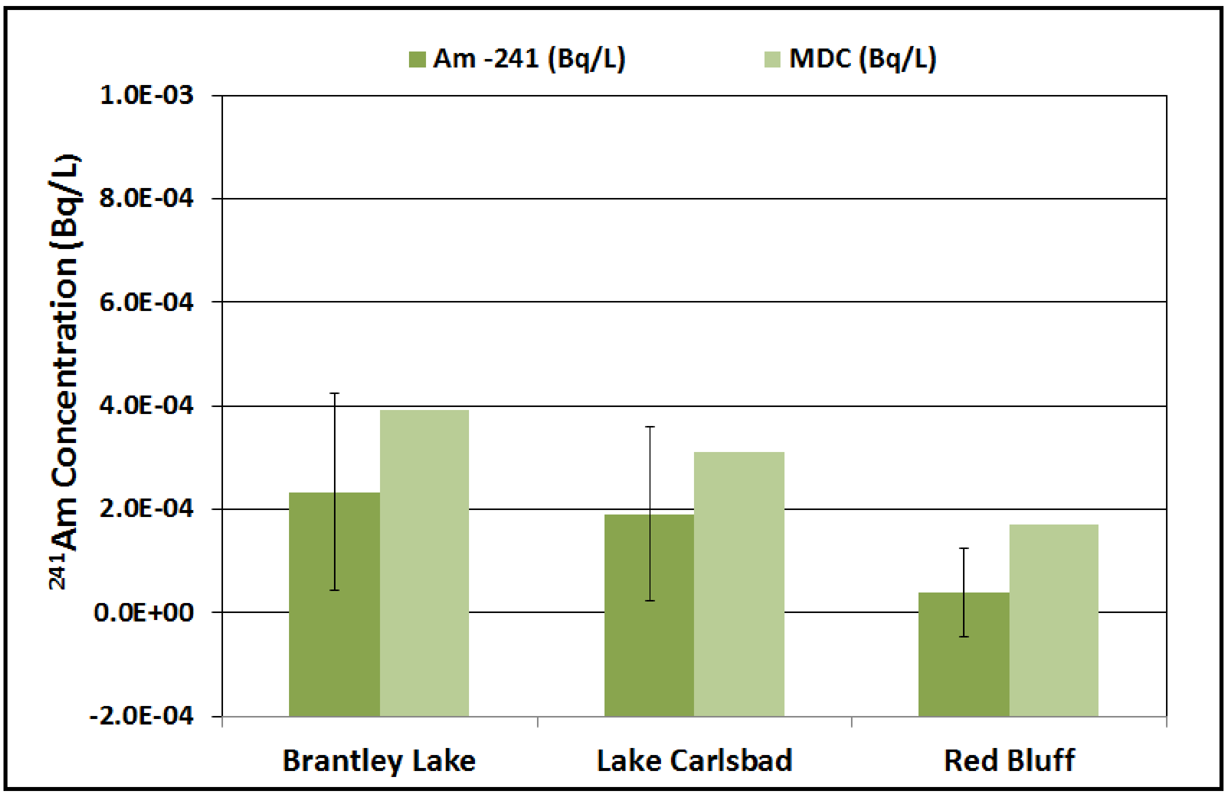



Figure 5-3: $^{241}Am$ concentration in surface water samples in three regional reservoirs following the February 14 radiological event at the WIPP

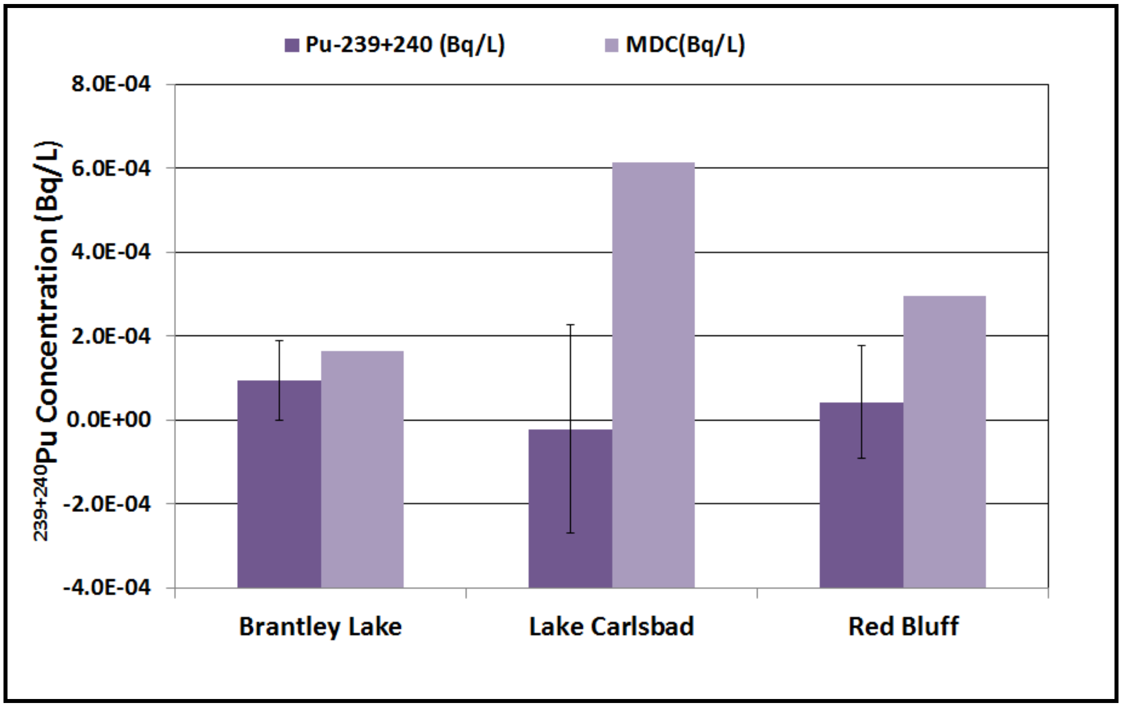



Figure 5-4: $^{239+240}$Pu concentration in surface water samples in three regional reservoirs following the February 14 release event at the WIPP

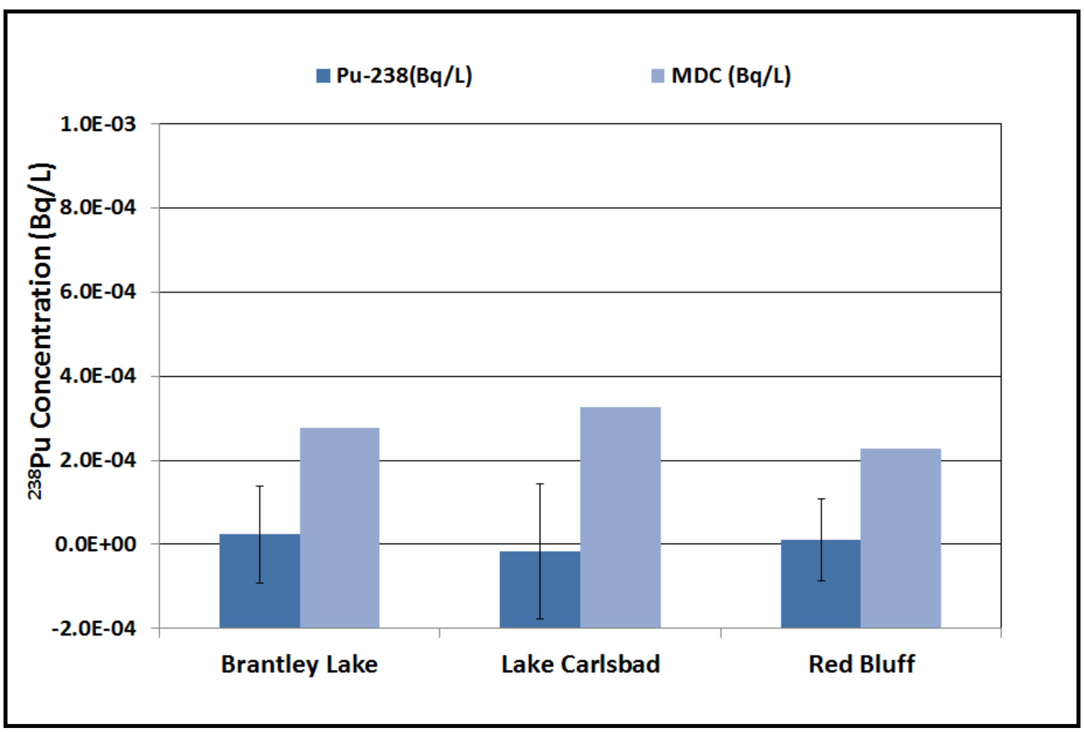



Figure 5-5: $^{238}$Pu concentration in surface water samples in three regional reservoirs following the February 14 radiological event at the WIPP

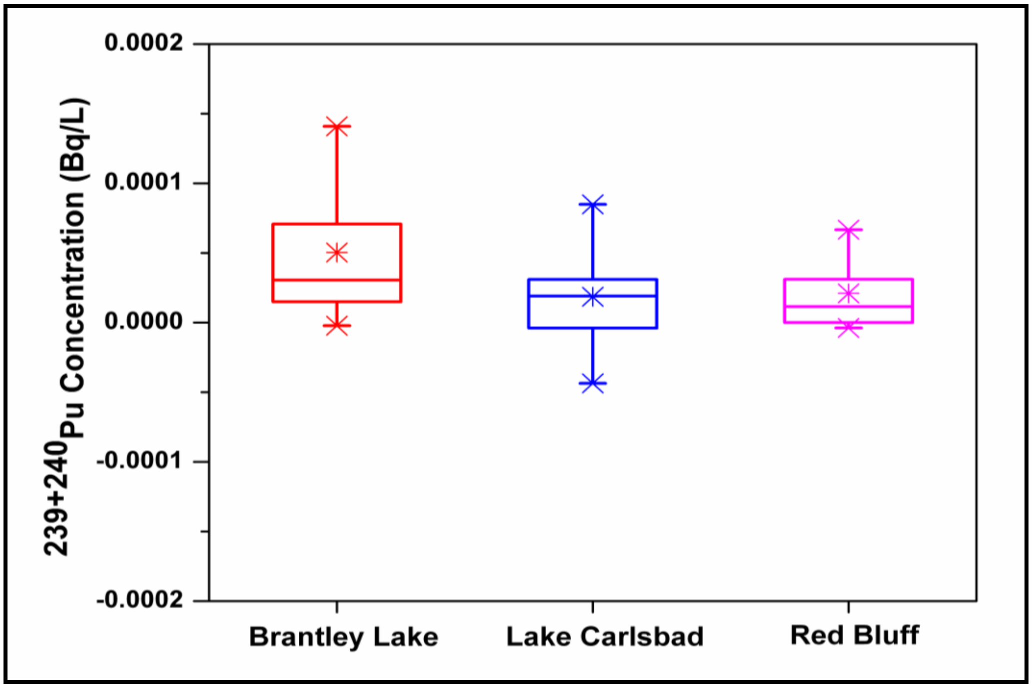



Figure 5-6: $^{239+240}$Pu activity in regional surface water in three regional reservoirs from 1998 to 2014 (All samples are below MDC)

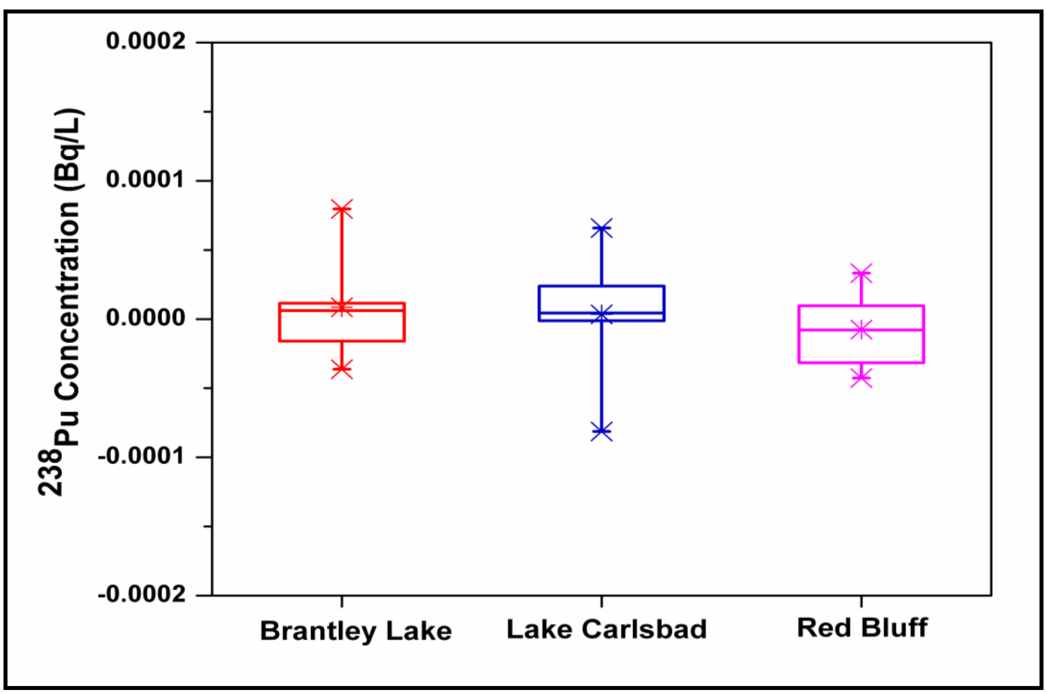



Figure 5-7: $^{238}$Pu activity in regional surface water in three regional reservoirs from 1998 to 2014 (All samples are below MDC)

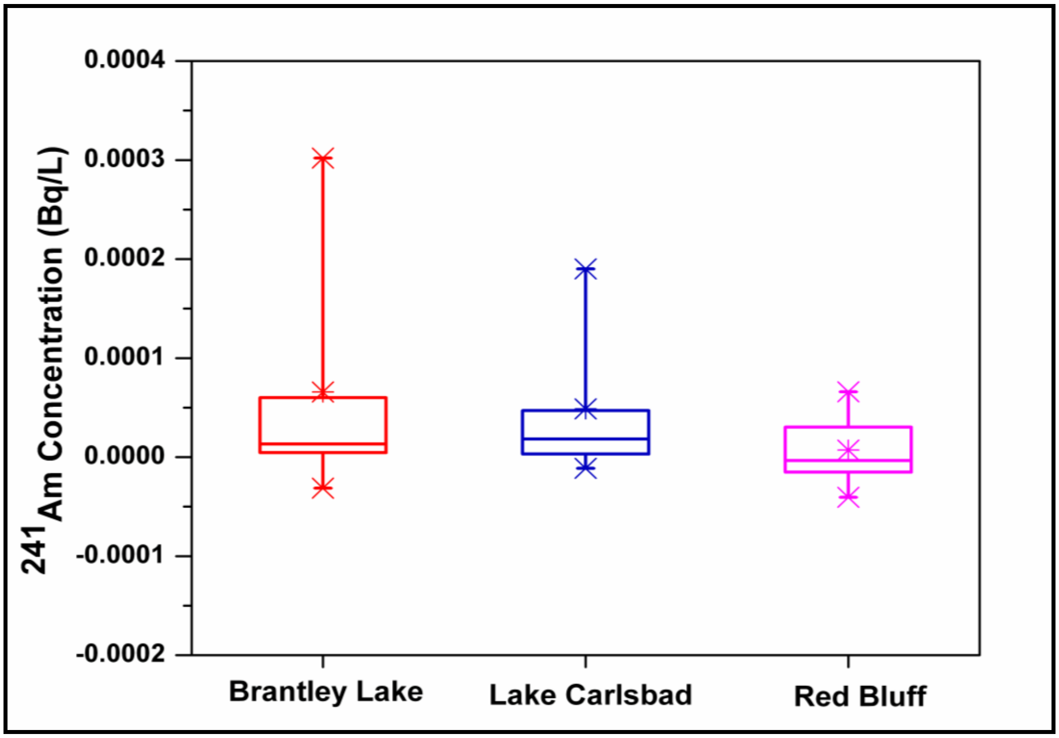



Figure 5-8: $^{241}$Am activity in regional surface water in three regional reservoirs from 1998 to 2014 (All samples are below MDC)

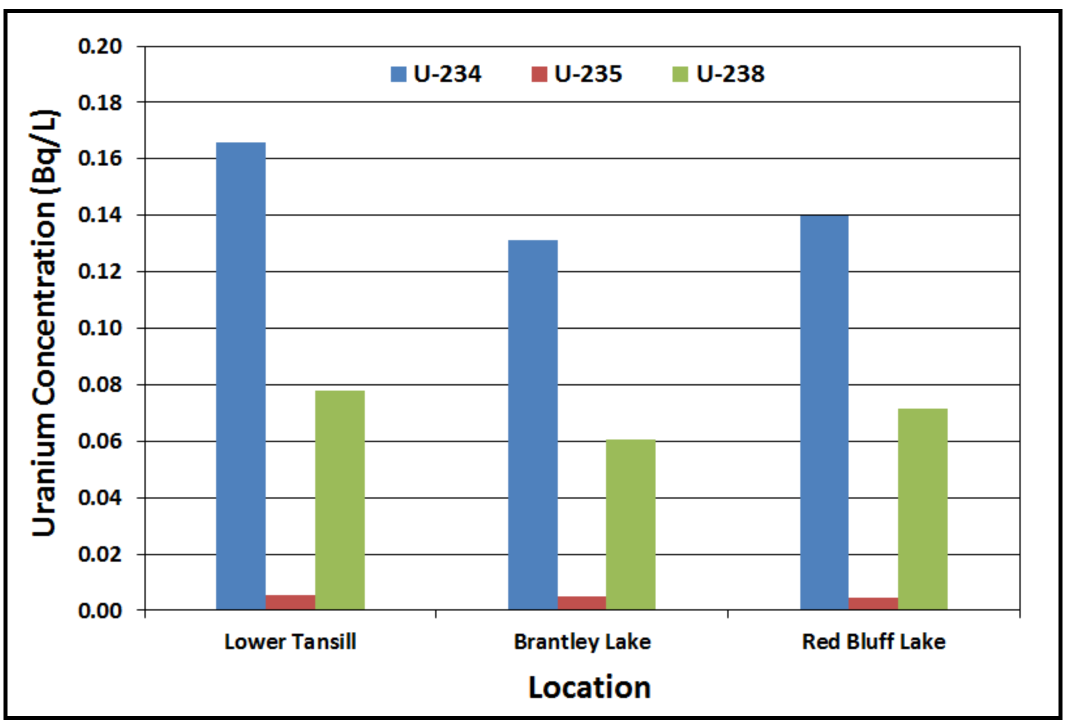



Figure 5-9: Uranium concentrations in surface water samples in three regional reservoirs following the February 14 radiological event at the WIPP

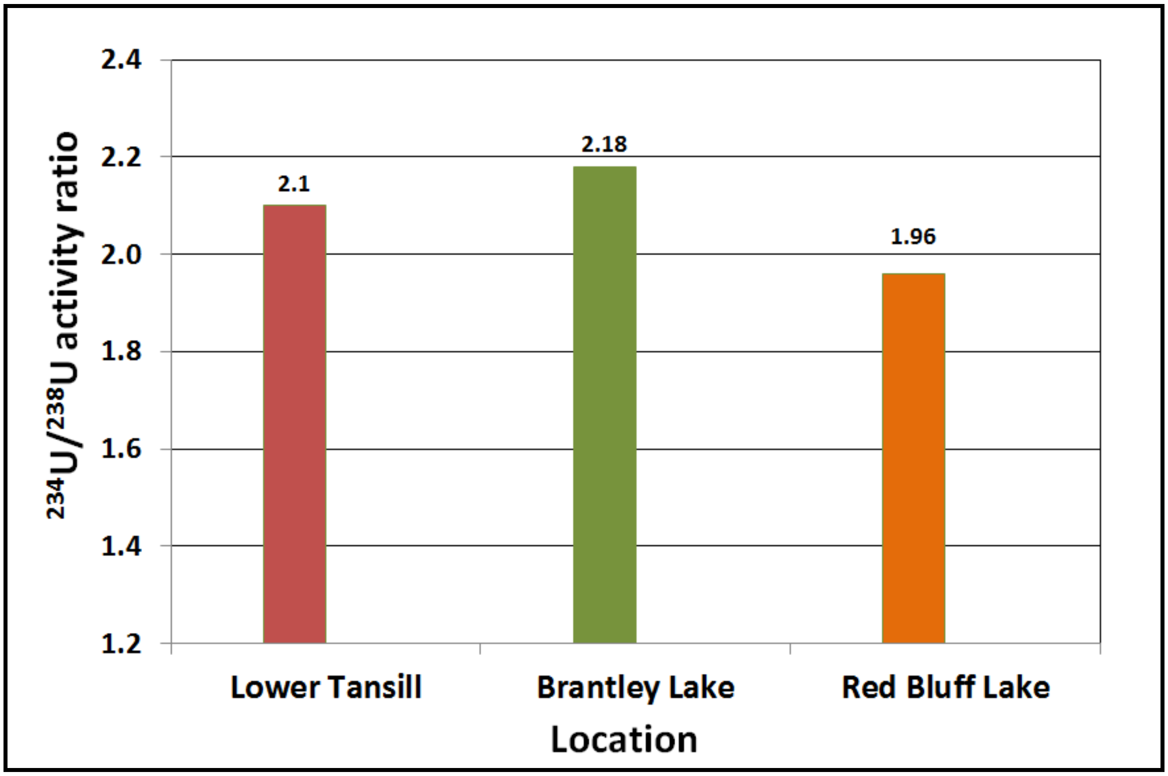



Figure 5-10: The $^{234}U/^{238}U$ Activity Ratio in surface water samples of three reservoirs in the vicinity of the WIPP site

**Concentration of Gamma radionuclides in the Surface water in the WIPP vicinity**

The analysis data for the gamma isotopes are presented in Table 5-4. As shown in the table, $^{40}K$ was detected in two of the surface water samples collected from Red Bluff reservoir (1.57-1.94 Bq/L). The Red Bluff was the only location where $^{40}K$ was detected in 1998, 2000, and 2012 (CEMRC Annual Report, 1998, 2000, 2012). The concentrations detected were in the range: 0.81-1.25 Bq/L in 1998; 1.22-1.25 Bq/L in 2000; and 2.47-2.72 Bq/L in 2012. The other two gamma radionuclides ($^{137}Cs$ and $^{60}Co$) were not detected in any of the surface water samples (Table 5-4). Since these isotopes were not detected, no comparisons between years or among locations were performed.

Table 5-1A: Activity concentrations of $^{241}Am$, $^{239+240}Pu$ and $^{238}Pu$ (Bq/L) in surface water samples collected from the three reservoirs in the vicinity of the WIPP site following the February 14 radiological event at WIPP (24 hours counting results)

| Radionuclides | Location | Sample Date | Activity Bq/L | Unc. (2σ) Bq/L | MDC Bq/L | Status |
|---|---|---|---|---|---|---|
| $^{241}Am$ | Red Bluff (shallow) | 3/20/2014 | 2.47E-04 | 2.77E-04 | 4.54E-04 | Not detected |
| | Red bluff (deep) | 3/20/2014 | -1.37E-05 | 1.39E-04 | 3.40E-04 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 0.00E+00 | 1.62E-04 | 5.32E-04 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 1.79E-04 | 2.68E-04 | 5.56E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | 3.49E-04 | 3.72E-04 | 6.49E-04 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | 2.86E-04 | 4.29E-04 | 8.89E-04 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | 7.42E-05 | 2.58E-04 | 6.92E-04 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 3.59E-04 | 3.19E-04 | 4.40E-04 | Not detected |
| | Blank | 3/28/2014 | 0.00E+00 | 2.05E-04 | 5.34E-04 | Not detected |
| | | | | | | |
| $^{239+240}Pu$ | Red Bluff (shallow) | 3/20/2014 | -1.28E-04 | 2.19E-04 | 7.53E-04 | Not detected |
| | Red Bluff (deep) | 3/20/2014 | 5.95E-05 | 1.69E-04 | 4.38E-04 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 1.11E-04 | 1.92E-04 | 4.08E-04 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 0.00E+00 | 1.64E-04 | 4.26E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | 2.33E-04 | 2.92E-04 | 5.59E-04 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | 1.65E-04 | 2.21E-04 | 4.06E-04 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | -2.02E-04 | 2.96E-04 | 1.04E-03 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 5.63E-05 | 2.81E-04 | 7.59E-04 | Not detected |
| | Blank | 3/28/2014 | 1.88E-04 | 2.52E-04 | 4.62E-04 | Not detected |
| | | | | | | |
| $^{238}Pu$ | Red Bluff (shallow) | 3/20/2014 | 5.85E-05 | 2.15E-04 | 5.81E-04 | Not detected |
| | Red bluff (deep) | 3/20/2014 | 1.19E-04 | 2.07E-04 | 4.38E-04 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 5.30E-05 | 1.95E-04 | 5.26E-04 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 1.16E-04 | 2.01E-04 | 4.26E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | 5.63E-05 | 2.07E-04 | 5.59E-04 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | -2.40E-06 | 1.59E-04 | 5.24E-04 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | -7.21E-05 | 2.93E-04 | 9.22E-04 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 0.00E+00 | 1.74E-04 | 4.54E-04 | Not detected |
| | Blank | 3/28/2014 | -1.34E-04 | 2.60E-04 | 9.08E-04 | Not detected |

Table 5-1B: Activity concentrations of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu (Bq/L) in surface water samples collected from the three reservoirs in the vicinity of the WIPP site following the February 14 radiological event at WIPP (5 days counting results)

| Radionuclides | Location | Sample Date | Activity Bq/L | Unc. (2σ) Bq/L | MDC Bq/L | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | Red Bluff (shallow) | 3/20/2014 | 9.07E-05 | 1.30E-04 | 2.11E-04 | Not detected |
| | Red bluff (deep) | 3/20/2014 | -1.39E-05 | 3.92E-05 | 1.29E-04 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 2.23E-05 | 3.87E-05 | 8.21E-05 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 3.24E-04 | 1.84E-04 | 3.38E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | 2.99E-04 | 2.06E-04 | 4.02E-04 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | 2.89E-04 | 3.35E-04 | 7.45E-04 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | 2.11E-04 | 2.02E-04 | 4.26E-04 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 1.72E-04 | 1.36E-04 | 1.93E-04 | Not detected |
| | | | | | | |
| $^{239+240}$Pu | Red Bluff (shallow) | 3/20/2014 | 0.00E+00 | 1.99E-04 | 4.99E-04 | Not detected |
| | Red bluff (deep) | 3/20/2014 | 8.65E-05 | 7.04E-05 | 9.09E-05 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 7.08E-05 | 6.29E-05 | 8.69E-05 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 9.98E-05 | 9.21E-05 | 1.34E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | 1.25E-04 | 1.59E-04 | 3.52E-04 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | 8.16E-05 | 6.65E-05 | 8.58E-05 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | -6.89E-05 | 2.96E-04 | 7.40E-04 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 2.54E-05 | 2.00E-04 | 4.91E-04 | Not detected |
| | | | | | | |
| $^{238}$Pu | Red Bluff (shallow) | 3/20/2014 | -3.86E-05 | 1.34E-04 | 3.63E-04 | Not detected |
| | Red bluff (deep) | 3/20/2014 | 6.18E-05 | 6.08E-05 | 9.09E-05 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 2.36E-05 | 1.34E-04 | 3.33E-04 | Not detected |
| | Brantley (deep) | 3/20/2014 | -1.25E-05 | 1.35E-04 | 3.52E-04 | Not detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 7.23E-05 | 6.42E-05 | 8.86E-05 | Not detected |
| | Brantley (deep) duplicate | 3/20/2014 | 1.17E-05 | 1.30E-04 | 3.29E-04 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | -1.24E-04 | 2.48E-04 | 6.45E-04 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 8.88E-05 | 7.24E-05 | 9.34E-05 | Not detected |

Table 5-2: Activity concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) in surface water samples collected from the three reservoirs in the vicinity of the WIPP site following the February 14 radiological event at WIPP (5 days counting results)

| Radionuclides | Location | Sample Date | Activity Bq/L | Unc. (2σ) Bq/L | MDC Bq/L | Status |
|---|---|---|---|---|---|---|
| $^{234}U$ | Red bluff (deep) | 3/20/2014 | 1.40E-01 | 1.52E-02 | 1.95E-04 | Detected |
| | Brantley (shallow) | 3/20/2014 | 1.25E-01 | 1.39E-02 | 3.54E-04 | Detected |
| | Brantley(shallow) duplicate | 3/20/2014 | 1.17E-01 | 1.27E-02 | 2.16E-04 | Detected |
| | Brantley (deep) | 3/20/2014 | 1.31E-01 | 1.41E-02 | 2.44E-04 | Detected |
| | Brantley (deep) duplicate | 3/20/2014 | 1.34E-01 | 1.44E-02 | 1.41E-04 | Detected |
| | Lower Tansill (shallow) | 3/28/2014 | 1.66E-01 | 1.78E-02 | 1.44E-04 | Detected |
| | Lower Tansill (deep) | 3/28/2014 | 1.59E-01 | 1.70E-02 | 1.45E-04 | Detected |
| | | | | | | |
| $^{235}U$ | Red bluff (deep) | 3/20/2014 | 4.37E-03 | 6.97E-04 | 1.82E-04 | Detected |
| | Brantley(shallow) | 3/20/2014 | 4.87E-03 | 8.13E-04 | 1.81E-04 | Detected |
| | Brantley(shallow) duplicate | 3/20/2014 | 7.62E-03 | 1.06E-03 | 2.16E-04 | Detected |
| | Brantley (deep) | 3/20/2014 | 3.78E-03 | 6.07E-04 | 2.13E-04 | Detected |
| | Brantley (deep) duplicate | 3/20/2014 | 4.05E-03 | 6.50E-04 | 1.74E-04 | Detected |
| | Lower Tansill (shallow) | 3/28/2014 | 5.21E-03 | 7.86E-04 | 1.77E-04 | Detected |
| | Lower Tansill (deep) | 3/28/2014 | 5.29E-03 | 7.63E-04 | 1.52E-04 | Detected |
| | Blank | 3/28/2014 | 2.99E-05 | 6.00E-05 | 1.39E-04 | Detected |
| | | | | | | |
| $^{238}U$ | Red bluff (deep) | 3/20/2014 | 7.14E-02 | 7.83E-03 | 3.12E-04 | Detected |
| | Brantley (shallow) | 3/20/2014 | 5.98E-02 | 6.77E-03 | 3.85E-04 | Detected |
| | Brantley (shallow) duplicate | 3/20/2014 | 5.92E-02 | 6.55E-03 | 2.33E-04 | Detected |
| | Brantley (deep) | 3/20/2014 | 6.02E-02 | 6.58E-03 | 3.06E-04 | Detected |
| | Brantley (deep) duplicate | 3/20/2014 | 6.37E-02 | 6.99E-03 | 2.49E-04 | Detected |
| | Lower Tansill (shallow) | 3/28/2014 | 7.81E-02 | 8.54E-03 | 2.07E-04 | Detected |
| | Lower Tansill (deep) | 3/28/2014 | 7.57E-02 | 8.19E-03 | 2.30E-04 | Detected |
| | Blank | 3/28/2014 | 8.46E-05 | 1.06E-04 | 2.27E-04 | Detected |

Table 5-3: Range of Activity Concentrations for Uranium Isotopes in surface water samples collected from three regional lakes during 1998

| Radionuclides | Baseline N | Baseline Minimum (Bq/L) | Baseline Maximum (Bq/L) |
|---|---|---|---|
| **Brantley Lake** | | | |
| $^{234}U$ | 2 | 6.99E-02 | 7.54E-02 |
| $^{235}U$ | 4 | <MDC | 8.43E-02 |
| $^{238}U$ | 2 | 3.80E-02 | 3.89E-02 |
| **Lake Carlsbad** | | | |
| $^{234}U$ | 2 | 1.13E-01 | 1.16E-01 |
| $^{235}U$ | 4 | <MDC | 2.74E-03 |
| $^{238}U$ | 2 | 5.66E-02 | 5.71E-02 |
| **Red Bluff reservoir** | | | |
| $^{234}U$ | 2 | 2.13E-01 | 2.14E-01 |
| $^{235}U$ | 4 | <MDC | 5.78E-03 |
| $^{238}U$ | 2 | 1.06E-01 | 1.06E-01 |

N = number of samples

Table 5-4: Activity concentrations of $^{137}Cs$, $^{40}K$ and $^{60}Co$ (Bq/L) in surface water samples collected from the three reservoirs in the vicinity of the WIPP site following the February 14 radiological event at WIPP

| Radionuclides | Location | Sample Date | Activity Bq/L | Unc. (2σ) Bq/L | MDC Bq/L | Status |
|---|---|---|---|---|---|---|
| $^{137}Cs$ | Red Bluff (shallow) | 3/20/2014 | -8.16E-03 | 5.71E-02 | 9.68E-02 | Not detected |
| | Red bluff (deep) | 3/20/2014 | 1.12E-02 | 5.67E-02 | 9.57E-02 | Not detected |
| | Brantley(shallow) | 3/20/2014 | 1.83E-02 | 5.61E-02 | 9.46E-02 | Not detected |
| | Brantley(shallow) duplicate | 3/20/2014 | 5.67E-04 | 5.58E-02 | 9.44E-02 | Not detected |
| | Brantley (deep) | 3/20/2014 | 3.44E-02 | 5.65E-02 | 9.49E-02 | Not detected |
| | Brantley(deep) duplicate | 3/20/2014 | -2.84E-02 | 5.65E-02 | 9.61E-02 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | 1.45E-02 | 5.56E-02 | 9.38E-02 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 3.20E-02 | 5.64E-02 | 9.49E-02 | Not detected |
| $^{40}K$ | Red Bluff (shallow) | 3/20/2014 | 1.57E+00 | 6.81E-01 | 1.11E+00 | Detected |
| | Red bluff (deep) | 3/20/2014 | 1.94E+00 | 6.74E-01 | 1.08E+00 | Detected |
| | Brantley(shallow) | 3/20/2014 | 5.26E-01 | 6.77E-01 | 1.14E+00 | Not detected |
| | Brantley(deep) | 3/20/2014 | 3.46E-01 | 6.57E-01 | 1.11E+00 | Not detected |

Table 5-4: Activity concentrations of $^{137}Cs$, $^{40}K$ and $^{60}Co$ (Bq/L) in surface water samples collected from the three reservoirs in the vicinity of the WIPP site following the February 14 radiological event at WIPP (continued)

| Radionuclides | Location | Sample Date | Activity Bq/L | Unc. (2σ) Bq/L | MDC Bq/L | Status |
|---|---|---|---|---|---|---|
| | Brantley(shallow) duplicate | 3/20/2014 | 2.50E-01 | 6.61E-01 | 1.12E+00 | Not detected |
| | Brantley(deep) duplicate | 3/20/2014 | 7.42E-01 | 6.61E-01 | 1.10E+00 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | 4.23E-01 | 6.60E-01 | 1.11E+00 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 1.11E-01 | 6.76E-01 | 1.14E+00 | Not detected |
| $^{60}Co$ | Red Bluff(shallow) | 3/20/2014 | 5.87E-03 | 5.17E-02 | 8.76E-02 | Not detected |
| | Red bluff (deep) | 3/20/2014 | 2.22E-02 | 5.25E-02 | 8.86E-02 | Not detected |
| | Brantley (shallow) | 3/20/2014 | 2.34E-02 | 5.11E-02 | 8.62E-02 | Not detected |
| | Brantley(shallow) duplicate | 3/20/2014 | 2.76E-03 | 5.17E-02 | 8.78E-02 | Not detected |
| | Brantley (deep) | 3/20/2014 | 1.72E-02 | 5.23E-02 | 8.83E-02 | Not detected |
| | Brantley(deep) duplicate | 3/20/2014 | 3.20E-02 | 5.11E-02 | 8.61E-02 | Not detected |
| | Lower Tansill (shallow) | 3/28/2014 | 4.59E-02 | 5.06E-02 | 8.49E-02 | Not detected |
| | Lower Tansill (deep) | 3/28/2014 | 3.86E-02 | 5.24E-01 | 8.81E-02 | Not detected |
| | Blank | 3/28/2014 | -1.34E-04 | 2.60E-04 | 9.08E-04 | Not detected |

## SEDIMENT MONITORING

Sediments are defined as finely divided solid materials that have settled out of a liquid stream or from standing water. The sediments accumulate soluble radionuclides by sorption on suspended sediment and insoluble radionuclides by settling. The CEMRC has been monitoring sediment samples from the 3 public reservoirs in the vicinity of WIPP (Brantley Lake, Lake Carlsbad, and Red Bluff Lake) since 1998. Many of the sediment samples were found to contain 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 $^{241}Am$. The presence of these radionuclides in sediments is attributed mostly to discharges at the monitored facilities. Some $^{137}Cs$, $^{90}Sr$, and $^{239}Pu$ are fallout from atmospheric nuclear tests, which peaked in 1962-1963 and to a minor extent from the 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. The accumulation of radioactive materials in sediment could lead to exposure of humans through ingestion of aquatic species, through sediment re-suspension into drinking water supplies, or as an external radiation source (U.S. Department of Energy 1991).

To evaluate current conditions, the CEMRC sampled sediment in the vicinity of the WIPP site shortly after the February 14, 2014 underground radiation event occurred. The sediment samples were collected from three regional reservoirs situated along the Pecos river at a considerable distance from the WIPP site including Brantley Lake, ~55 km (34 miles) north-northwest of the WIPP site, Red Bluff reservoir on the Pecos River, the upstream end of which is the nearest standing water body ~ 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. The Pecos River is the dominant surface-water body in the vicinity of the WIPP Site and is used for a variety of recreational activities including fishing, boating, water-skiing, and swimming. Accelerated radiochemical analyses were performed to evaluate the current trend of the radionuclides, especially Pu and Am, in the vicinity of the WIPP site. The results presented here indicate that there is no evidence of increased radiological contamination in sediment samples collected in the region that could be attributed to recent radiation release from the WIPP.

## Sample collection

Sediment samples were collected from three locations around the WIPP site as shown in Figure 5-1, with one duplicate sample collected from one site chosen at random. Routinely in early spring, water levels are lowered in the Pecos River so that the city of Carlsbad and riverfront residents can do maintenance and repair work on docks or other features.

Figure 5-11: Sediment Samples collection by the CEMRC Personnel

Due to the low water levels, the post-event sediment samples for the Lake Carlsbad reservoir were collected from near Lower Tansill Dam, which is just downstream from the City of Carlsbad and represents a deep basin area for the 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 in 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. Sediment samples were collected using an Eckman dredge and excess water was decanted from the sediment upon collection (Figure 5-11). Approximately 5 L of sediment was sealed in a pre-cleaned plastic bucket in the field and transported to CEMRC laboratory for preparation prior to analyses.

### Sample Preparation

In the laboratory, the sediment samples were air-dried, pulverized to pass a 2-mm sieve, and homogenized for radiochemical analyses. Samples for radiochemical analyses were dried at 105° for at least 12 hours and pulverized in a jar mill prior to analysis. Approximately 300-mL (500g) aliquots were used for gamma spectroscopy analysis. The samples for gamma analysis were sealed in a ~ 300-mL can and counted for 48 hours using a high purity HPGe detector. A set of soil matrix standards procured from Eckert and Ziegler Analytics (GA) was used to establish matrix-specific calibration and counting efficiencies. Reported concentrations are blank-corrected.

For actinides analyses, 5-10g of sample was heated in a muffle furnace at 500$^{o}$C for at least 6 hours or more to combust organic material. Each sample was then spiked with a radioactive trace and digested in a Teflon beaker with 30 ml of HCl, 10 ml of $HNO_3$ and 40 ml of HF. Sea sand was used as a matrix for Laboratory Control Standard (LCS) and reagent blank. The samples were heated at 250$^{o}$C for at least 2 hours; however, longer heating does no harm. After digestion was complete, the samples were evaporated to dryness and 40 ml of $HClO_4$ was added and evaporated to complete dryness. This step was repeated once more with 30 ml of $HClO_4$. Then 20 ml of HF were added and evaporated to dryness. To each beaker 80 ml of 8M $HNO_3$, 1.5 g of $H_3BO_3$ and 0.5 ml of 30% $H_2O_2$ were added, covered with a watch glass and heated to boiling for 30 minutes. After cooling, samples were transferred to a 50 ml centrifuge tube and centrifuged at 3600 rpm for 10 minutes. The leachate was filtered through a 0.45 micron filter and transferred to a 250 ml beaker.

### Actinides Separation

The actinides are separated as a group by co-precipitation on $Fe(OH)_3$. The oxidation state of Pu was adjusted by adding 1 ml of 1.0M $NH_4I$ with a 10 min wait step, followed by 2 ml of 2M $NaNO_2$. Pu isotopes are then separated and purified using a two-column anion exchange resin (Dowex1-× 8, 100-200 mesh), while TRU chromatography columns are used for the separation of Am and U. The Am fraction is subsequently purified from lanthanides using a TEVA column. The samples are then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for 24 hours, so that results can be made immediately available to the public and other interested parties. The samples are also counted for five days as per CEMRC's standard counting protocol.

## Data Reporting

The activities of the actinides and gamma radionuclides are reported as *activity concentration* in Bq/g. *Activity concentration* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by the weight of the sediment in *grams* (g).

## Results and Discussion

The concentrations of $^{241}$Am, $^{239+240}$Pu and $^{238}$Pu in the sediment samples collected from three regional reservoirs are listed in Tables 5-5A and 5-5B. The $^{241}$Am and $^{239+240}$Pu concentrations slightly greater than MDC were detected in all sediment samples, whereas $^{238}$Pu was not detected in any sediment samples. The activity concentrations of $^{241}$Am in the sediment samples ranged from 0.095-0.18 mBq/g, while that of $^{239+240}$Pu varied from 0.14-0.27 mBq/g. The baseline concentrations of $^{239+240}$Pu ranged from 0.07 to 0.41 mBq/g with the mean values of 0.13±0.03 mBq/g for the Lake Carlsbad, 0.26±0.02 mBq/g for the Brantley lake and 0.36±0.07 mBq/g for the Red Bluff reservoir (CEMRC Annual Report, 1998). The concentrations of $^{239+240}$Pu and $^{241}$Am measured in sediments samples following the February, 14 release were within the range of the baseline phase data for the sediment samples collected in 1998. As in the case of soil, levels of radionuclides in sediment samples from the aforementioned three reservoirs in the region following the February 14 radiation release event showed no detectable increases above those typical of previously measured natural variation.

The $^{241}$Am activities in sediment samples from the three reservoirs are lower than $^{239+240}$Pu activities. The $^{239+240}$Pu activities are highest in the sediment collected from Red Bluff Reservoir (0.26 mBq/g). Maxima range from 0.43 mBq/g observed in the baseline phase compared to 0.45 mBq/g in the monitoring phase. Maxima $^{239+240}$Pu activities from Lake Carlsbad are lower ranging from 0.163 mBq/g in the baseline phase compared to 0.28 mBq/g in the monitoring phase. The $^{239+240}$Pu activities in samples from Brantley Lake are intermediate between Red Bluff Reservoir and Lake Carlsbad. Comparison of activity concentrations of $^{241}$Am, $^{239+240}$Pu, and $^{238}$Pu determined following the February 14, radiological event at WIPP to that of the baseline and monitoring phase activities reflects no increase in radionuclide concentrations (Figures 5-12 through 5-14).

## Concentrations of uranium Isotopes in the sediment

Uranium isotopes ($^{234}$U, $^{235}$U and $^{238}$U) were detected in all the sediment samples collected in 2014. The concentrations of uranium isotopes measured in the sediment samples are summarized in Table 5-5B. The concentrations range of uranium isotopes measured in the sediment samples collected from all three reservoirs for 2014 are shown in Figure 5-15 and historically in Figures 5-16 and 5-18. Maximum activity concentrations for $^{234}$U, $^{235}$U and $^{238}$U increased slightly in the monitoring phase relative to the baseline phase for samples collected from all three reservoirs. The concentrations of $^{238}$U and $^{234}$U were lowest in Lake Carlsbad, and highest in Red bluff reservoir. 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. Although the sediment concentrations of uranium isotopes were variable between reservoirs, the isotopic ratios were very similar across all three reservoirs. The reservoirs appeared to be slightly enriched in $^{234}$U compared to $^{238}U$, with the activity ratios ranging from 1.2 to 1.8 (Figure 5-16) Concentrations of uranium-238 in soil samples collected around the perimeter of the WIPP facility have generally remained close to the baseline levels.

### Concentrations of gamma radionuclides in the sediment

The gamma radionuclides $^{40}K$, $^{137}Cs$, and $^{60}Co$ were analyzed for all the sediment samples. The individual concentrations of these radionuclides collected are listed in Table 5-6. The $^{137}Cs$ was detected in all sediment samples collected (Table 5-6). Variability among the $^{137}Cs$ concentrations was not very significant. Maximum activity concentrations for $^{137}Cs$ (6.1 m Bq/g) decreased slightly in the monitoring phase relative to the baseline phase for samples collected from all three reservoirs. The $^{137}Cs$ is a fission product and is consistently found in sediment and soil because of global fallout from atmospheric nuclear weapons testing (Beck and Bennett, 2002; UNSCEAR, 2000). The $^{40}K$ was also detected in every sediment sample (Table 5-6). This naturally occurring gamma-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 WIPP sediments. As shown in Table 5-6, the $^{60}Co$ were not detected at any sampling location. Comparison of activity concentrations of $^{137}Cs$ and $^{40}K$ determined following the February 14, 2014 radiological event at WIPP to that of the baseline and monitoring phase activities reflects no increase in radionuclide concentrations (Figures 5-19 and 5-20).

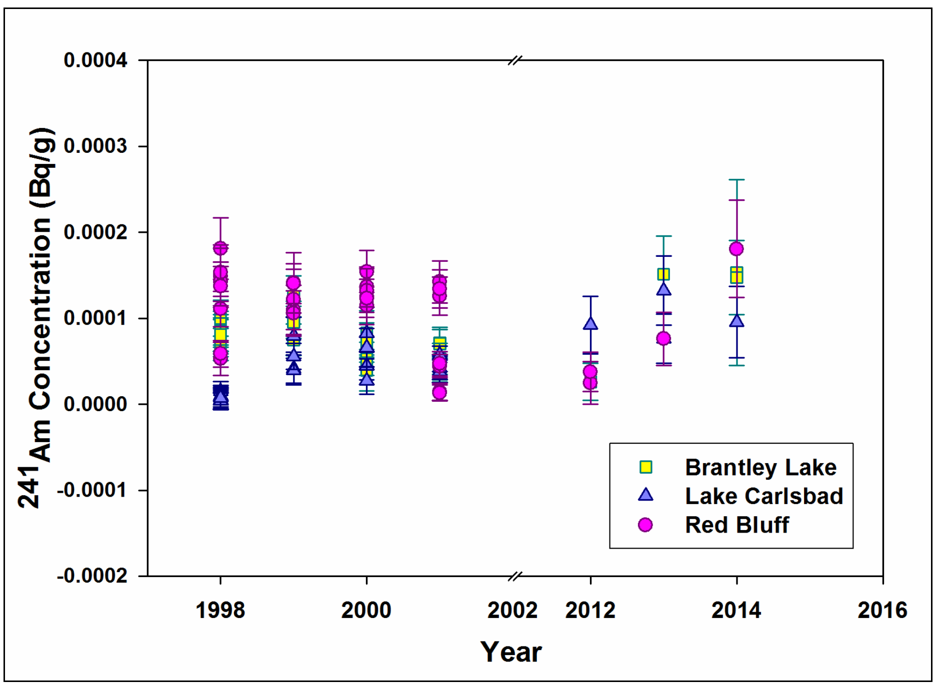



Figure 5-12: The Pre- and Post-radiological event sediment concentrations of $^{241}Am$ from the three reservoirs in the vicinity of the WIPP site

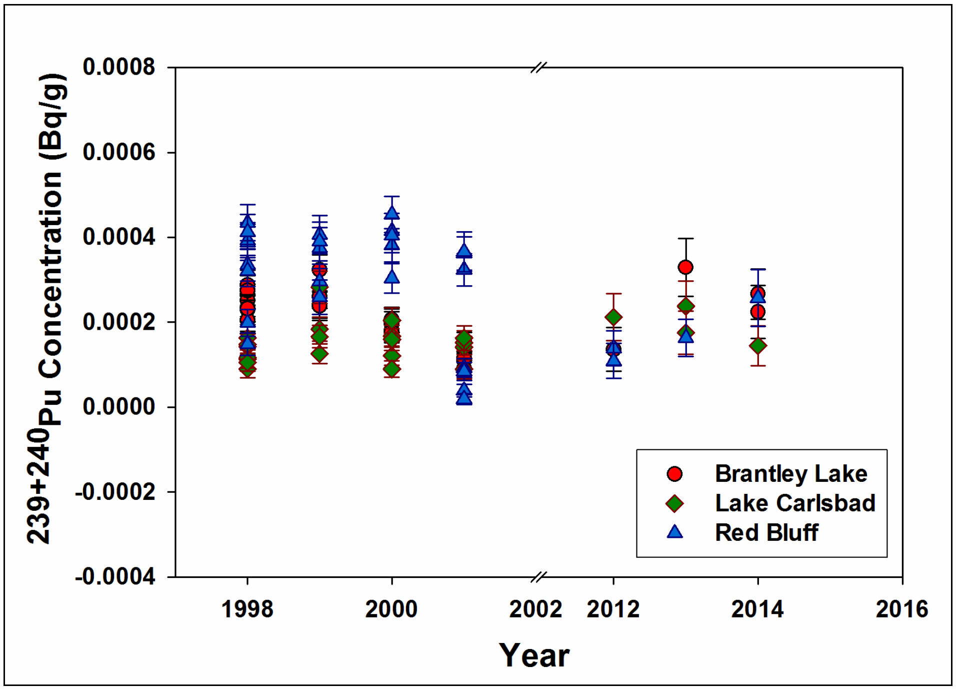



Figure 5-13: The Pre- and Post-radiological event sediment concentrations of $^{239+240}Pu$ from the three reservoirs in the vicinity of the WIPP site

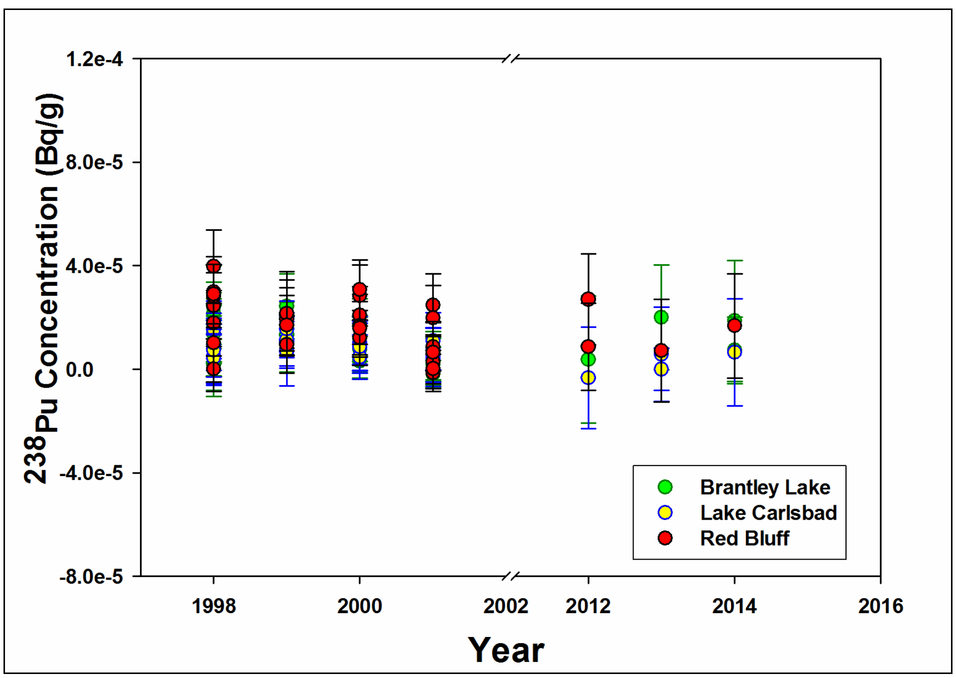



Figure 5-14: The Pre- and Post-radiological event sediment concentrations of $^{238}Pu$ from the three reservoirs in the vicinity of the WIPP site

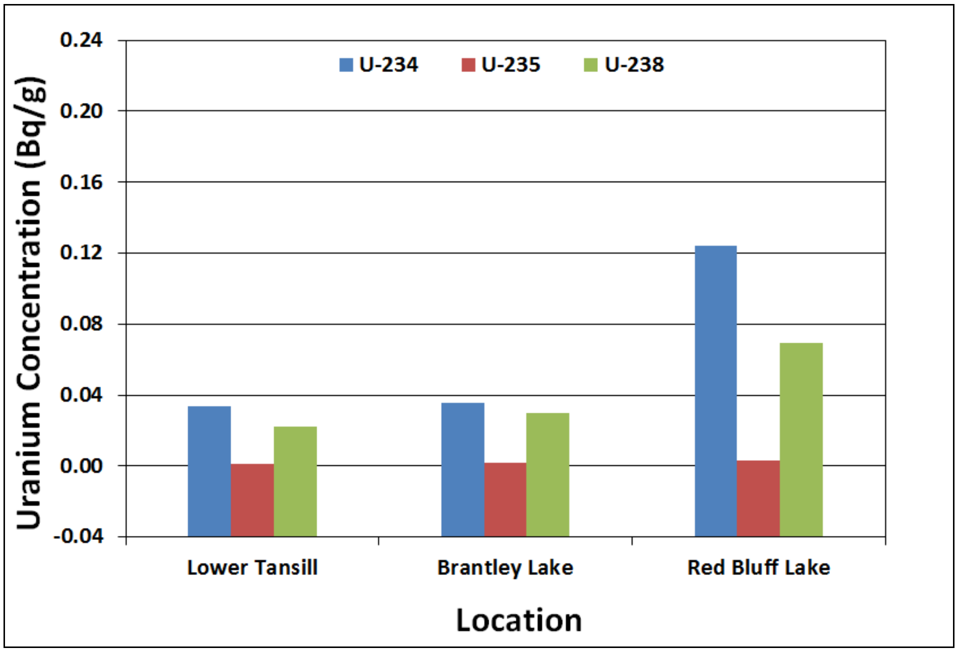



Figure 5-15: Uranium concentrations in sediment samples in three regional reservoirs following the February 14 radiological event at the WIPP

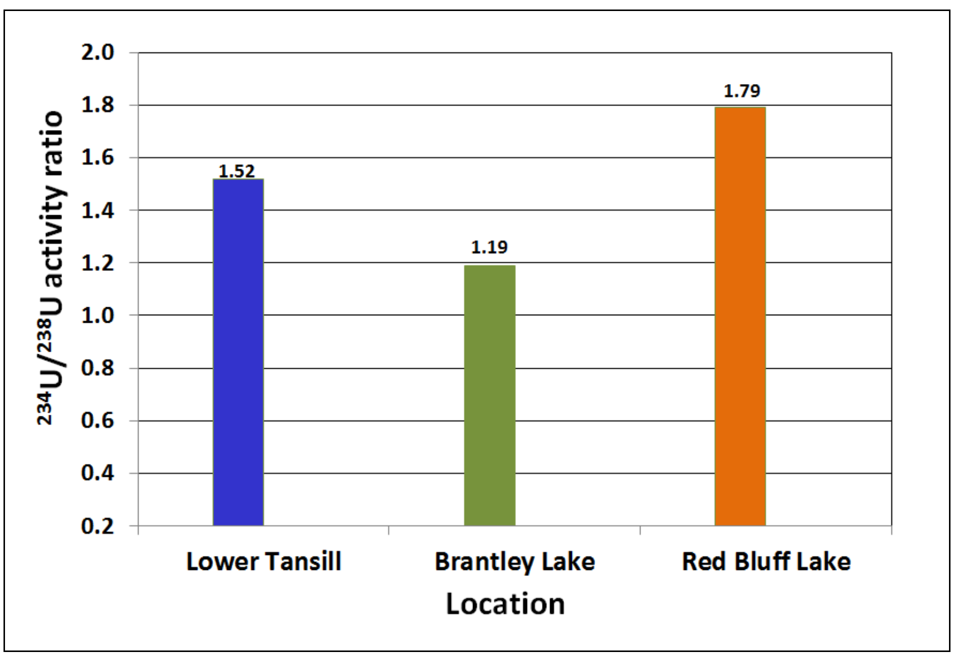



Figure 5-16: The $^{234}U/^{238}U$ Activity Ratio in sediment samples of three reservoirs in the vicinity of the WIPP site

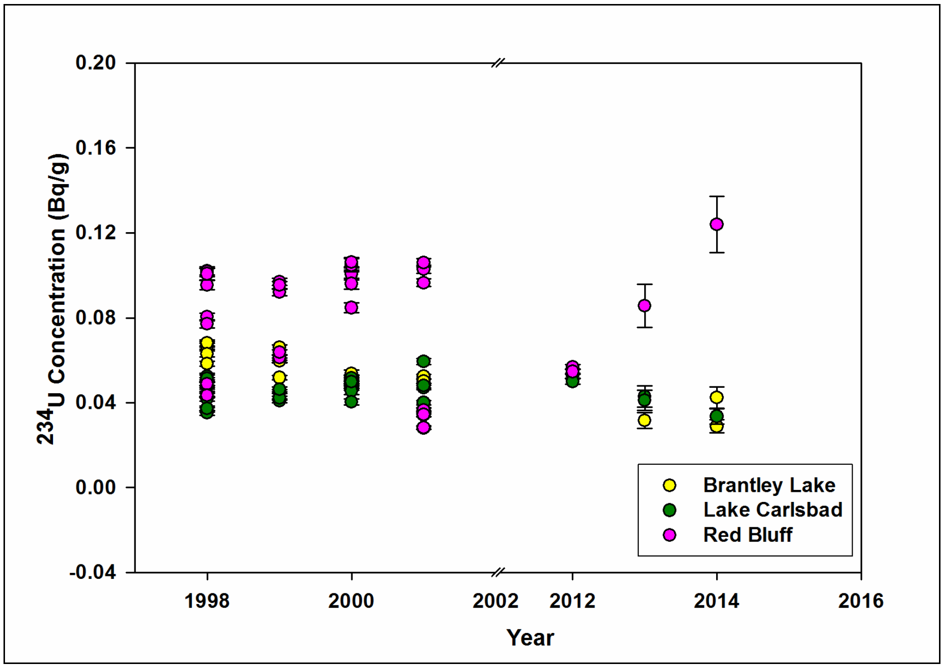



Figure 5-17: The Pre- and Post-radiological event sediment concentrations of $^{234}U$ from the three reservoirs in the vicinity of the WIPP site

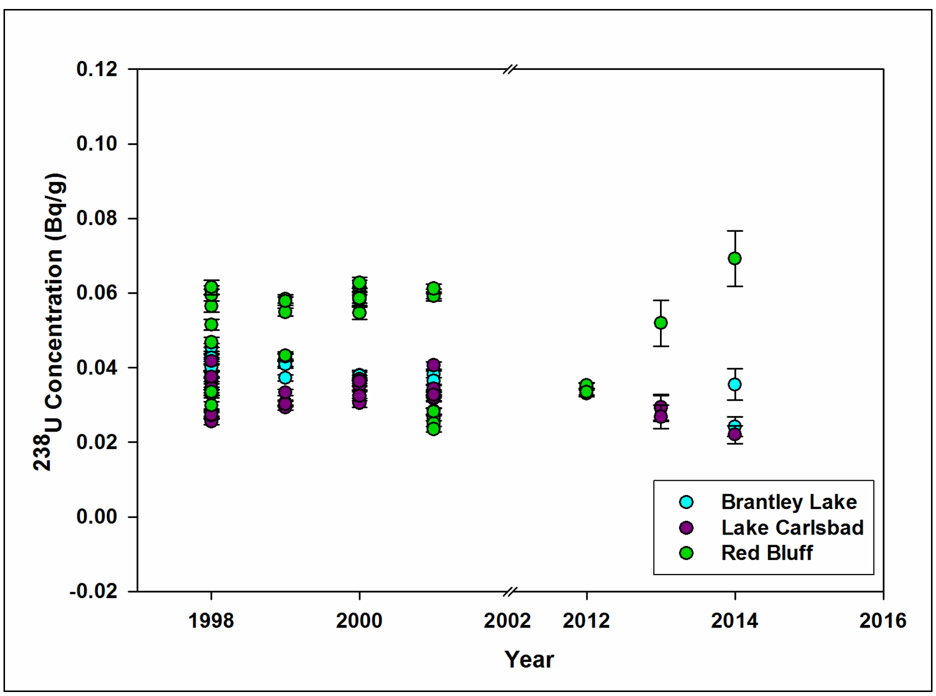



Figure 5-18: The Pre- and Post-radiological event sediment concentrations of $^{238}U$ from the three reservoirs in the vicinity of the WIPP site

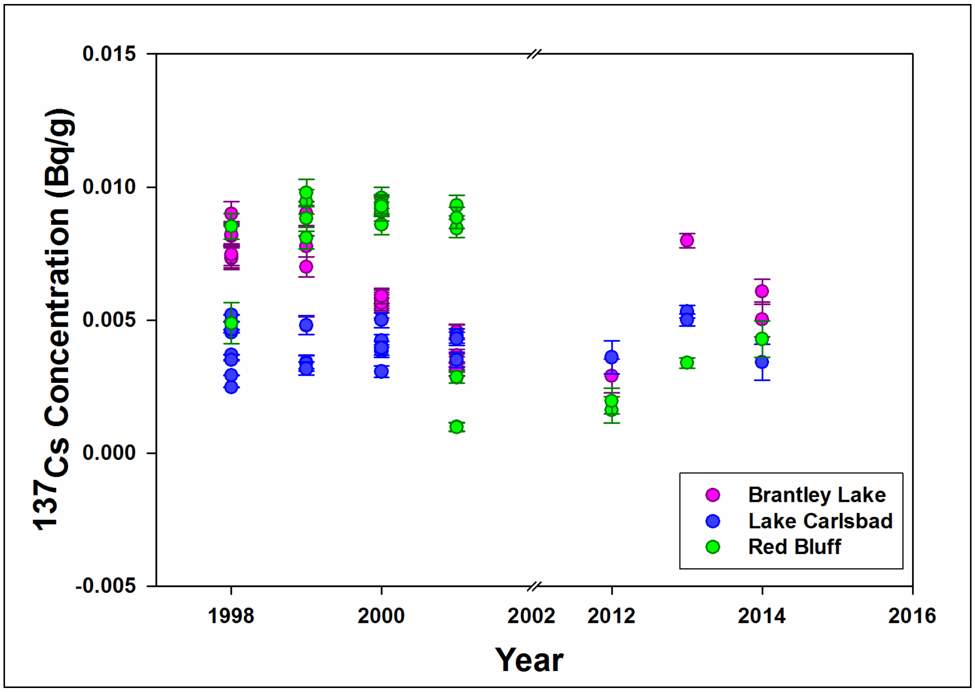



Figure 5-19: The Pre- and Post-radiological event sediment concentrations of $^{137}Cs$ from the three reservoirs in the vicinity of the WIPP site

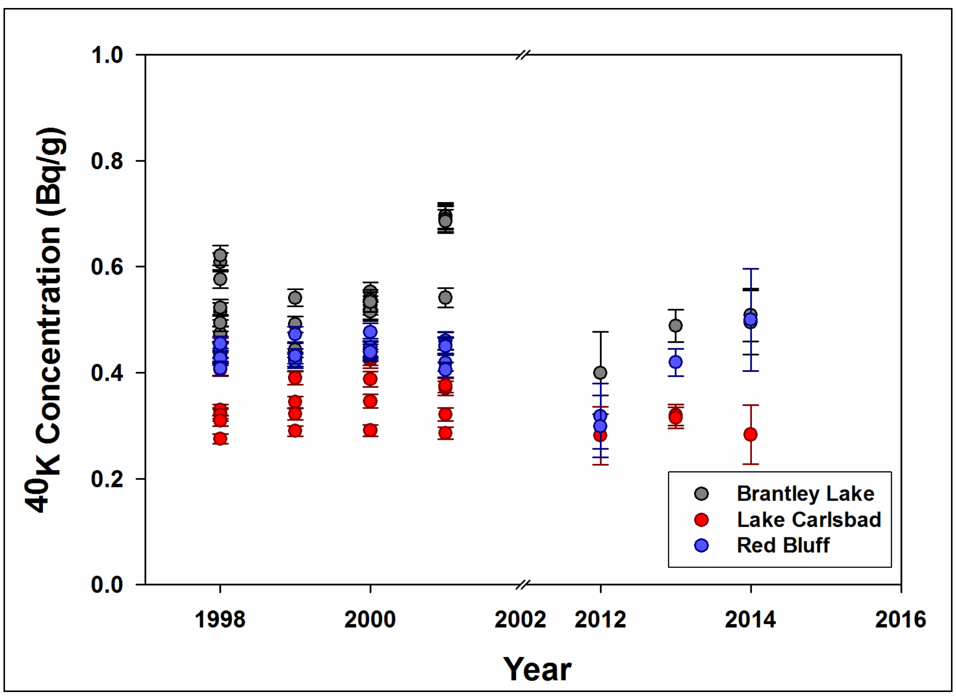



Figure 5-20: The Pre- and Post-radiological event sediment concentrations of $^{40}K$ from the three reservoirs in the vicinity of the WIPP site

Table 5-5A: 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 following the February 14 radiological event at WIPP (24 hours counting results)

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | Red Bluff | 3/20/2014 | 2.02E-04 | 1.20E-04 | 1.23E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 1.53E-04 | 1.08E-04 | 1.15E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 1.45E-04 | 8.64E-05 | 7.84E-05 | Detected |
| | Lower Tansill | 3/28/2014 | 9.74E-05 | 8.68E-05 | 1.04E-04 | Not detected |
| | Blank | - | 1.25E-05 | 7.41E-05 | 2.04E-04 | Not detected |
| | | | | | | |
| $^{239+240}$Pu | Red Bluff | 3/20/2014 | 2.28E-04 | 1.26E-04 | 1.06E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 2.75E-04 | 1.50E-04 | 1.53E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 3.44E-04 | 1.39E-04 | 8.39E-05 | Detected |
| | Lower Tansill | 3/28/2014 | 1.79E-04 | 1.14E-04 | 1.20E-04 | Detected |
| | Blank | - | 1.36E-05 | 4.76E-05 | 1.37E-04 | Not detected |
| | | | | | | |
| $^{238}$Pu | Red Bluff | 3/20/2014 | -6.44E-06 | 3.29E-05 | 9.46E-05 | Not detected |
| | Brantley Lake | 3/20/2014 | 3.87E-05 | 6.25E-05 | 1.27E-04 | Not detected |
| | Brantley Lake | 3/20/2014 | 7.43E-06 | 2.62E-05 | 7.48E-05 | Not detected |
| | Lower Tansill | 3/28/2014 | 3.03E-06 | 3.50E-05 | 1.19E-04 | Not detected |
| | Blank | - | 4.55E-05 | 8.20E-05 | 1.80E-04 | Not detected |

Table 5-5B: 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 following the February 14 radiological event at WIPP (5 days counting results)

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{241}$Am | Red Bluff | 3/20/2014 | 1.81E-04 | 5.68E-05 | 5.84E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 1.53E-04 | 1.08E-04 | 1.24E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 1.47E-04 | 4.28E-05 | 3.46E-05 | Detected |
| | Lower Tansill | 3/28/2014 | 9.55E-05 | 4.13E-05 | 4.40E-05 | Detected |
| | Blank | - | 1.46E-05 | 4.37E-05 | 1.06E-04 | Not detected |
| | | | | | | |
| $^{239+240}$Pu | Red Bluff | 3/20/2014 | 2.57E-04 | 6.67E-05 | 4.72E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 2.25E-04 | 6.25E-05 | 6.28E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 2.67E-04 | 5.92E-05 | 3.42E-05 | Detected |
| | Lower Tansill | 3/28/2014 | 1.45E-04 | 4.66E-05 | 2.42E-05 | Detected |
| | Blank | - | 1.39E-05 | 2.45E-05 | 5.56E-05 | Not detected |

Table 5-5B: 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 following the February 14 radiological event at WIPP (5 days counting results) (continued)

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{238}$Pu | Red Bluff | 3/20/2014 | 1.68E-05 | 2.02E-05 | 4.03E-05 | Not detected |
| | Brantley Lake | 3/20/2014 | 1.87E-05 | 2.34E-05 | 4.94E-05 | Not detected |
| | Brantley Lake | 3/20/2014 | 7.28E-06 | 1.29E-05 | 2.92E-05 | Not detected |
| | Lower Tansill | 3/28/2014 | 6.58E-06 | 2.08E-05 | 5.21E-05 | Not detected |
| | Blank | - | 4.63E-05 | 4.15E-05 | 8.04E-05 | Not detected |
| | | | | | | |
| $^{234}$U | Red Bluff | 3/20/2014 | 1.24E-01 | 1.32E-02 | 6.09E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 2.88E-02 | 3.09E-03 | 6.21E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 4.23E-02 | 4.98E-03 | 1.73E-04 | Detected |
| | Lower Tansill | 3/28/2014 | 0.0335 | 3.5904e-3 | 0.0335 | Detected |
| | | | | | | |
| $^{235}$U | Red Bluff | 3/20/2014 | 3.16E-03 | 3.93E-04 | 3.11E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 1.29E-03 | 1.88E-04 | 3.04E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 2.14E-03 | 3.83E-04 | 1.20E-04 | Detected |
| | Lower Tansill | 3/28/2014 | 1.21E-03 | 1.76E-04 | 4.19E-05 | Detected |
| | | | | | | |
| $^{238}$U | Red Bluff | 3/20/2014 | 6.92E-02 | 7.41E-03 | 6.64E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 2.42E-02 | 2.61E-03 | 7.63E-05 | Detected |
| | Brantley Lake | 3/20/2014 | 3.55E-02 | 4.21E-03 | 1.72E-04 | Detected |
| | Lower Tansill | 3/28/2014 | 2.20E-02 | 2.38E-03 | 9.01E-05 | Detected |

Table 5-6: 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 following the February 14 radiological event at WIPP

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{137}$Cs | Red Bluff | 3/20/2014 | 4.29E-03 | 6.88E-04 | 9.79E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 5.03E-03 | 6.51E-04 | 8.51E-04 | Detected |
| | Brantley Lake | 3/20/2014 | 6.07E-03 | 4.72E-04 | 5.74E-04 | Detected |
| | Lower Tansill | 3/28/2014 | 3.42E-03 | 6.74E-04 | 9.99E-04 | Detected |
| | | | | | | |
| $^{40}$K | Red Bluff | 3/20/2014 | 5.00E-01 | 9.67E-02 | 9.21E-03 | Detected |
| | Brantley Lake | 3/20/2014 | 5.09E-01 | 5.01E-02 | 7.91E-03 | Detected |
| | Brantley Lake | 3/20/2014 | 4.95E-01 | 6.04E-02 | 4.14E-03 | Detected |
| | Lower Tansill | 3/28/2014 | 2.83E-01 | 5.55E-02 | 1.21E-02 | Detected |

Table 5-6: 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 following the February 14 radiological event at WIPP (continued)

| Radionuclides | Location | Sample Date | Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|---|
| $^{60}Co$ | Red Bluff | 3/20/2014 | 7.08E-05 | 7.11E-04 | 1.20E-03 | Not detected |
| | Brantley Lake | 3/20/2014 | 6.23E-05 | 6.02E-04 | 1.02E-03 | Not detected |
| | Brantley Lake | 3/20/2014 | 2.09E-04 | 3.09E-04 | 5.18E-04 | Not detected |
| | Lower Tansill | 3/28/2014 | 3.89E-04 | 7.98E-04 | 1.34E-03 | Not detected |

# CHAPTER 6

## Drinking Water Monitoring

### Introduction

Drinking water is typically defined as water that is safe enough to be consumed by humans or to be used with low risk of immediate or long term impact to human health. The quality of drinking water available in the area surrounding of the WIPP site is routinely checked to assure the public that health and environmental standards are met and to seek to identify any changes in water quality which might have a negative impact on public health and/or the environment. Aquifers in the region surrounding the WIPP include the Dewey Lake, the Culebra-Magenta, the Ogallala, the Dockum, the Pecos River alluvium, and the Capitan Reef. The main Carlsbad water supply is the Sheep Draw well field whose primary source is the Capitan Reef aquifer. The Hobbs and WIPP (Double Eagle) public water supply systems are drawn from the Ogallala aquifer, while the Loving, Malaga, and Otis public water supply wells are drawn from deposits that are hydraulically linked to the flow of the Pecos River. An additional CEMRC sampling site, situated at a private well located seven miles southwest of the WIPP, which obtains its water from the Culebra aquifer has been historically sampled and analyzed; however, this sampling site has been dry since approximately 2001.

In 1974, the United States Congress passed the Safe Drinking Water Act. This law requires the U.S. Environmental Protection Agency (EPA) to determine the safe levels of contaminants in U.S. drinking water. The EPA conducts research of drinking water to determine the level of a contaminant that is safe for a person to consume over a lifetime and that a water system can reasonably be required to remove from it, given present technology and resources. This safe level is called the maximum contaminant level (MCL). Maximum contaminant levels in drinking water have been established for a variety of radionuclides. For radium, the MCL has been set at 5 pCi/L (picocuries per liter, a unit of measure for levels of radiation). The MCL for gross alpha radiation is 15 pCi/L, and the maximum limit for gross beta radiation is 50 pCi/L. In addition to causing cancer, exposure to uranium in drinking water may cause toxic effects to the kidney. Based on human kidney toxicity data, the MCL for uranium is 4 millirems per year. The EPA says that a treatment system would be considered vulnerable if it contained 50 pCi/L of uranium. Although the MCL applies only to public drinking water sources, it can give those who use private wells an idea of what an appropriate level of a contaminant should be for private wells also.

During 2014, the drinking water samples were collected from the major drinking water supplies used by communities in the WIPP region. The sources included the community water supplies of Carlsbad (Sheep Draw), Double Eagle, Loving, Otis, Hobbs, and Malaga. The drinking water wells in the vicinity of the WIPP provide water primarily for livestock, industrial usage by oil and gas production operations, and are subject to monitoring studies conducted by various groups. These sampling locations are not likely to be affected by any WIPP radioactivity releases, but because water is a primary vector in the food chain, the samples are collected and analyzed by the CEMRC annually. As with community air sampling, the verification of the absence of WIPP-related radionuclides from drinking water samples collected provides further public assurance of the safety of the WIPP and its negligible impact on the local populace or the environment.

## History of CEMRC's Drinking Water Monitoring

CEMRC began collecting drinking water samples for radiochemical analyses in 1997 and inorganic analyses on drinking water samples commenced in 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. Drinking water samples were not collected during 2004 and 2006. Present results as well as the results of previous analyses of drinking water were consistent for each source across sampling periods, and were found to be below levels specified under the Safe Drinking Water Act.

It is important to note that after more than ten years of monitoring, isotopes of $^{238}$Pu, $^{239+240}$Pu, and $^{241}$Am have never been detected above MDC in any of the samples collected from well sites around the WIPP site. Although uranium has been found, the levels of uranium detected in regional drinking water are very low and the activity ratio indicates its presence in drinking water is most likely from natural sources. For most people in the world, the intake of uranium through food is around 1µg/day. The worldwide average of dietary uranium is estimated at 1.3µg/day from which the portion from drinking water is 0.2µg/day or 15.4% (UNSCEAR, 2001). Thus drinking water is not usually the main source of ingested uranium. The CEMRC Monitoring results for drinking water analyses conducted to date ***show no increase in the levels of radionuclides or inorganics that could be attributed to the WIPP related activities.***

Analyses reported herein for are for 2014 drinking water samples only. These samples were analyzed for radionuclides including alpha and gamma emitting radionuclides of interest to the WIPP. In addition, inorganic studies were performed separately and include elemental analysis as well as an analysis for mercury. ***The 2014 monitoring results for drinking water analyses continue to show no increase in the levels of radionuclides or inorganics that could be attributed to recent radiological event at WIPP***.

## Sampling, Sample Preparation, and Measurements

All drinking water samples were processed according to CEMRC protocols for the collection, handling, and preservation of drinking water. This year, the drinking water samples were collected in September of 2014. The following samples were taken from each sampling location: (1) 8L for gamma and alpha analyses, (2) 1L for elemental analyses, (3) 1L for anion tests, and (4) 500mL for mercury analysis. None of the samples were filtered before analysis. Current methods used for the various analyses are summarized in Table 6-1. Basic information about contaminants in drinking water is listed in Table 6-2.

For radioactive analyses, two aliquots were taken from each 8L sample: (a) Approximately 2L for gamma analyses and (b) 1L for alpha analyses. Both aliquots were acidified to approximately pH = 2 with nitric acid upon collection to avoid losses through microbial activity and adsorption onto the vessel walls. The first aliquot was transferred to 2L 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 and Ziegler, Analytics (GA) in the energy range between 60 to 2000keV. The counting time for each sample was 48 hours.

The second, 1L aliquot, was used for alpha analysis of uranium (U) and transuranic radionuclides. Tracers consisting of uranium, americium, and plutonium ($^{232}U$, $^{243}Am$, and $^{242}Pu$) were added and the samples were digested using concentrated nitric and hydrochloric acid. The samples were then heated to dryness and wet-ashed using concentrated nitric and hydrogen peroxide. The separation process began by co-precipitation on $Fe(OH)_3$. Plutonium isotopes are separated and purified using a two-column anion exchange resin (Dowex1-× 8, Bio-Rad, 100-200 mesh), while TRU chromatography columns are used for the separation of Am and U. The samples are then micro-co-precipitated using neodymium fluoride ($NaF_3$) and deposited onto planchets for counting uranium/transuranics by alpha spectroscopy for five days.

The 1L samples collected for elemental analysis were preserved with distilled nitric acid during sample collection. Samples from Otis, Malaga, and Hobbs were diluted using a similar nitric acid matrix prior to analysis by ICP-MS due to the elevated calcium (Ca) and sodium (Na) levels in these samples. All other 1L samples were analyzed directly. For Mercury analysis, the 500mL samples were preserved with a bromomonochloride solution and analyzed directly by ICP-MS. For each type of inorganic analysis, aliquots were blank-corrected after the application of dilution factors. As per the CEMRC procedure, only concentrations above laboratory MDC values are reported.

Each 1L sample used for anion analysis was refrigerated immediately upon arrival and analyzed within 48 hours of collection. No preservatives were added to the samples used for anion analysis. However, due to the high chloride and sulfate content, all of the samples were diluted with ultrapure water prior to analysis. Sample results were blank-corrected if applicable. As with the inorganic analyses, only concentrations above laboratory MDC values are reported.

Table 6-1: Drinking Water Parameters, Methods, and Detection Levels used to Analyze Samples from all Locations

| Method/Parameters | Analytes of Interest | Typical Detection Limits |
|---|---|---|
| Gross alpha/beta<br>EPA 900.0 | (Under Development) | 0.037-0.11 Bq/L* |
| Gamma emitters | $^{60}Co$, $^{137}Cs$ and $^{40}K$ | 0.03-1.0 Bq/L* |
| Alpha emitters | $^{239+240}Pu$, $^{238}Pu$, $^{241}Am$, $^{234}U$, $^{238}U$, $^{235}U$ | 0.001-0.002 Bq/L* |
| Elemental analysis<br>EPA 200.8 | Over 30 different metals | Varies by element** |
| Anions (EPA 300.0) | $F^-$, $Cl^-$, $Br^-$, $NO_2^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$ | 1.2 – 23.9 µg/L ** |
| Mercury (EPA 200.8) | Hg | 0.015 µg/L** |

* Detection limits may vary depending on sample volume, solid concentrations, counting system and time
** Detection limits are determined annually

Table 6-2: General Information about Inorganic Contaminants in Drinking Water from the EPA

| Contaminant | Minimum Contaminants Level | Potential Health Effects from Long-term Exposure | Sources of Drinking Water Contaminants |
|---|---|---|---|
| Antimony, Sb | 0.006mg/L | Increase in blood cholesterol; decrease in blood sugar | Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder |
| Arsenic, As | 0.010mg/L | Skin damage or problems with circulatory systems, and may have increased risk of cancer | Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes |
| Barium, Ba | 2mg/L | Increase in blood pressure | Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits |
| Beryllium, Be | 0.004mg/L | Intestinal lesions | Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries |
| Cadmium, Cd | 0.005mg/L | Kidney damage | Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints |
| Chloride, $Cl^-$ | 250mg/L* | N/A | N/A |
| Chromium, Cr (total) | 0.1mg/L | Allergic dermatitis | Discharge from steel and pulp mills; erosion of natural deposits |

Table 6-2: General Information about Inorganic Contaminants in Drinking Water from the EPA (continued)

| Contaminant | Minimum Contaminants Level | Potential Health Effects from Long-term Exposure | Sources of Drinking Water Contaminants |
|---|---|---|---|
| Copper, Cu | 1.3mg/L | **Short term exposure**: gastrointestinal distress. **Long term exposure**: liver or kidney damage | Corrosion of household plumbing systems; erosion of natural deposits |
| Fluoride, $F^-$ | 4.0 | Bone disease; children may get mottled teeth | Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories |
| Lead, Pb | 0.015mg/L | **Infants and children**: delays in physical or mental development; **Adults**: kidney problems; high blood pressure | Corrosion of household plumbing systems; erosion of natural deposits |
| Mercury, Hg (Inorganic) | 0.002mg/L | Kidney damage | Erosion of natural deposits; discharge from refineries; runoff from landfills and croplands |
| Nitrate (measured as N) | 10mg/L | Shortness of breath and blue-baby syndrome | Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits |
| Nitrite (measured as N) | 1mg/L | | |
| Selenium, Se | 0.05mg/L | Hair or fingernail loss; numbness in fingers or toes; circulatory problems | Discharge from petroleum and metal refineries; erosion of natural deposits; discharge from mines |
| Sulfate, $SO_4^{2-}$ | 250mg/L* | N/A | N/A |
| Thallium, Tl | 0.002mg/L | Hair loss; changes in blood; kidney, intestine, or liver problems | Leaching from ore-processing sites; discharge from electronics, glass, and drug factories |
| Uranium, U | 30µg/L | Increased risk of cancer; kidney toxicity | Erosion of natural deposits |

* Secondary regulations are not enforceable.
N/A = Not available

## Data Reporting

The activities of the actinides and gamma radionuclides are reported as *activity concentration* in Bq/L. *Activity concentration* is calculated as the activity of radionuclides detected in Becquerel (Bq) divided by weight of the surface water in *liters* (L).

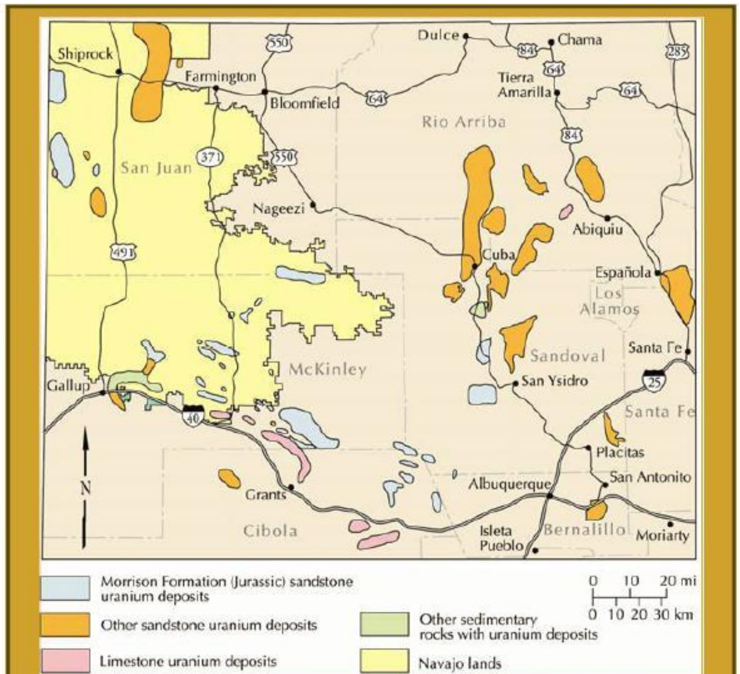
## Radiological Monitoring Results

The activity concentrations of $^{238}$Pu, $^{239+240}$Pu, $^{241}$Am, $^{234}$U, $^{235}$U, and $^{238}$U in regional drinking water samples collected in 2014 are listed in Table 6-3. The alpha radionuclides, $^{238}$Pu, $^{239+240}$Pu, and $^{241}$Am have not been detected in any of the drinking water samples above the MDC since monitoring commenced in 1997. The federal and state action level for gross alpha emitters, which includes isotopes of Pu and U, is 15pCi/L (0.56Bq/L). This level measured is over 10,000 times the MDCs used at CEMRC. The historical concentrations of $^{239+240}$Pu, $^{238}$Pu and $^{241}$Am measured in the drinking water in the vicinity of the WIPP site are shown in Figures 6-1 through 6-8.

Isotopes of naturally occurring uranium were detected in all the drinking water samples in 2014 as shown in Table 6-3. Natural uranium is a mixture of three alpha-emitting isotopes ($^{234}$U, $^{235}$U, and $^{238}$U). They have long half-lives ($t_{1/2}$) that allow them to be transported to water supplies. Natural uranium contains 99.27% $^{238}$U, 0.0055% $^{234}$U and 0.72% $^{235}$U .The mass ratio of natural uranium $^{235}$U to $^{238}$U is about 0.0073 and the activity ratio is 0.046. Many studies on $^{238}$U and $^{234}$U in natural waters indicate that these isotopes occur in a disequilibrium state and that, with a few exceptions, waters contain more $^{234}$U than $^{238}$ U. (Cothern et al, 1983; Skwarzec et al, 2002).

The isotopes of uranium are also found in the earth's crust with a natural abundance of about $4 \times 10^{-4}$ % (Hursh et al, 1973) in rocks and minerals such as granite, metamorphic rocks lignite, monazite sand; phosphate deposits; as well as in uranium minerals such as uraninite, carnotite and pitchblende. It is also present as a trace element in coal, peat, asphalt and in some phosphate fertilizers at a level of about 100 µg/g or 2.5 Bq/g (Hess et al, 1985). All of these sources can come in contact with water which can influence the amount of natural uranium present in our drinking water. The natural level of uranium in water can also be enhanced due to human activity. For example, the increased concentration of natural radionuclides in water can be caused by the intensive use of phosphate fertilizers in agriculture. Phosphate fertilizers contain uranium which can leach from the soil to nearby rivers and lakes (Fleischer, 1980; UNSCEAR, 1982).

Uranium contaminated drinking water is a common problem, particularly in the Western United States. The map shown on the right highlights the major uranium deposits in New Mexico. Natural uranium mineral deposits are concentrated in northern Santa Fe County, the Grants-Gallup area, and in other areas within the State. These mineral deposits can leach uranium into ground water. From the early 1950s until the early 1980s, New Mexico had the second largest uranium ore reserves of any state in the United States (after Wyoming). Although, no uranium ore has been mined in New Mexico since 1998, there are many areas within New Mexico with elevated levels of uranium in their groundwater. The Maximum Contaminant Level (MCL) for uranium in drinking Water is 30 ug/L (ppb). Despite this limit, water wells in several New Mexico communities show uranium levels three to six times higher than federal recommended levels for drinking water. Ingesting uranium in drinking water may have both toxicological and radiological health impacts. The primary target organ from chronic (long term) ingestion of uranium is the kidney, but liver and thyroid damage can also result. Radiological impacts from ingestion of uranium are not clear; however, it is still the subject of some research and debate. Bathing in water with elevated levels of Uranium is not considered to be a health risk.




**This image demonstrates distribution of uranium deposits in Northwest New Mexico. *Source:* *New Mexico Bureau of Geology and Mineral Resources***

Map 1: Major uranium deposits in New Mexico

Measured values for the drinking water samples collected around the WIPP site following the radiation release event ranged between 10.6-72.4 mBq/L for $^{238}$U, 0.58-3.46 mBq/L for $^{235}$U, and 28-171 mBq/L for $^{234}$U. The average activity concentrations of $^{234}$U, $^{235}$U, and $^{238}$U in drinking water from the six sources are presented in Figure 6-1. These uranium concentrations are well below the reference concentration level for radiological protection, i.e. 3.0 Bq/L. They are also below the EPA Action level of 0.56 Bq/L and within the range expected in waters from this region. The greatest variations appear in the amounts of $^{235}$U. The low concentration of $^{235}$U in the water samples is consistent with the lower concentration of $^{235}$U in the natural environment as compared to the concentrations of $^{234}$U and $^{238}$U. The highest activity concentrations were found in Malaga and Otis waters. Figure 6-2 shows the total uranium concentration at each location.

It has been reported that the activity of natural water from $^{234}$U is higher than that of $^{238}$U. The $^{234}$U/$^{238}$U activity ratio usually ranges between 1.0 and 3.0 (Cherdynstev et al, 1971; Gilkeson et al, 1982). According to the most recent reports, the fixed mass ratio and fixed activity ratios are still used for reporting the activity of natural uranium. The isotopic composition of natural uranium activities are 48.9, 2.2, and 48.9 %, respectively (IAEA, 1989). In radiochemical equilibrium, natural activity ratios are typically unity 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 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.

The average activity ratio of $^{235}U$ and $^{238}U$ in the water samples collected around the WIPP site ranged from 0.044-0.078. The natural ratio is reported to be 0.045 in nature. The $^{235}U/^{238}U$ ratio in environmental samples differing from the natural ratio results from anthropogenic nuclear activities. Figure 6-9 shows the average $^{234}U/^{238}U$ ratios in the drinking water samples in the vicinity of the WIPP site. The results of the activity ratios in this study compared very well with data observed in other countries as shown in Table 6-4. The calculated $^{234}U/^{238}U$ activity ratio varies between 2.38 to 3.21 which means that two isotopes are not in radioactive equilibrium. The historical activity concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ measured at well sites in the region of the WIPP site are summarized in Tables 6-5 through 6-10.

## Gamma Radionuclides in the Drinking Water

The analysis data for the gamma isotopes are presented in Table 6-11. As shown in the table, $^{40}K$ was detected in one of the surface water samples collected from Hobbs (1.35E+00 Bq/L). This naturally occurring gamma-emitting radionuclide is ubiquitous in nature. The $^{40}K$ was also detected in drinking water samples collected from Carlsbad, Malaga and Otis in 2013. 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 these drinking water locations. The other two gamma radionuclides ($^{137}Cs$ and $^{60}Co$) were not detected in any of the surface water samples (Table 6-11). Since these isotopes were not detected, no comparisons between years or among locations were performed.

Table 6-3: Actinide Concentrations Measured in Drinking Water in 2014

| Radionuclide | Location | Activity Bq/L | Unc (2-sig) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{241}$Am | Hobbs | 5.34E-05 | 1.18E-04 | 2.82E-04 | Not detected |
| | Malaga | -8.05E-12 | 9.55E-05 | 2.68E-04 | Not detected |
| | Otis | 4.24E-05 | 5.68E-05 | 1.04E-04 | Not detected |
| | Loving | 4.27E-05 | 5.71E-05 | 1.05E-04 | Not detected |
| | Carlsbad | 9.69E-05 | 9.23E-05 | 1.67E-04 | Not detected |
| | Carlsbad -dup | 2.55E-05 | 9.52E-05 | 2.40E-04 | Not detected |
| | Double Eagle | 1.60E-04 | 1.22E-04 | 1.92E-04 | Not detected |
| | Blank | 9.31E-05 | 9.96E-05 | 2.03E-04 | Not detected |
| | | | | | |
| $^{239+240}$Pu | Hobbs | 9.09E-05 | 8.66E-05 | 1.56E-04 | Not detected |
| | Malaga | 0.00E+00 | 6.24E-05 | 1.80E-04 | Not detected |
| | Otis | -1.27E-05 | 8.44E-05 | 2.40E-04 | Not detected |
| | Loving | 4.86E-05 | 7.70E-05 | 1.71E-04 | Not detected |
| | Carlsbad | 1.42E-05 | 6.35E-05 | 1.70E-04 | Not detected |
| | Carlsbad -dup | 7.94E-05 | 8.22E-05 | 1.60E-04 | Not detected |
| | Double Eagle | 1.01E-04 | 8.74E-05 | 1.34E-04 | Not detected |
| | Blank | 0.00E+00 | 6.82E-05 | 1.96E-04 | Not detected |
| | | | | | |
| $^{238}$Pu | Hobbs | -2.59E-05 | 5.20E-05 | 1.83E-04 | Not detected |
| | Malaga | -1.28E-05 | 5.70E-05 | 1.80E-04 | Not detected |
| | Otis | 0.00E+00 | 5.09E-05 | 1.53E-04 | Not detected |
| | Loving | 6.07E-05 | 5.99E-05 | 8.94E-05 | Not detected |
| | Carlsbad | 1.42E-05 | 9.41E-05 | 2.48E-04 | Not detected |
| | Carlsbad -dup | -3.40E-05 | 9.36E-05 | 2.67E-04 | Not detected |
| | Double Eagle | 4.34E-05 | 8.69E-05 | 2.04E-04 | Not detected |
| | Blank | -4.18E-05 | 8.37E-05 | 2.62E-04 | Not detected |
| | | | | | |
| $^{234}$U | Hobbs | 9.82E-02 | 1.13E-02 | 4.83E-04 | Detected |
| | Malaga | 1.67E-01 | 1.93E-02 | 3.02E-04 | Detected |
| | Otis | 1.71E-01 | 1.97E-02 | 4.92E-04 | Detected |
| | Loving | 7.57E-02 | 8.22E-03 | 2.14E-04 | Detected |
| | Carlsbad | 2.85E-02 | 3.30E-03 | 2.14E-04 | Detected |
| | Carlsbad -dup | 2.80E-02 | 3.50E-03 | 4.84E-04 | Detected |
| | Double Eagle | 4.94E-02 | 5.69E-03 | 3.10E-04 | Detected |
| | Blank | 2.51E-05 | 1.03E-04 | 2.56E-04 | Not detected |
| | | | | | |
| $^{235}$U | Hobbs | 1.89E-03 | 5.11E-04 | 3.74E-04 | Detected |
| | Malaga | 4.59E-03 | 9.25E-04 | 3.73E-04 | Detected |
| | Otis | 3.46E-03 | 7.75E-04 | 4.79E-04 | Detected |
| | Loving | 1.63E-03 | 3.52E-04 | 1.68E-04 | Detected |
| | Carlsbad | 5.83E-04 | 2.17E-04 | 2.00E-04 | Detected |
| | Carlsbad -dup | 6.12E-04 | 3.13E-04 | 4.63E-04 | Detected |

Table 6-3: Actinide Concentrations Measured in Drinking Water in 2014 (continued)

| Radionuclide | Location | Activity Bq/L | Unc (2-sig) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| | Double Eagle | 1.00E-03 | 3.10E-04 | 1.89E-04 | Detected |
| | Blank | 7.28E-05 | 1.04E-04 | 2.18E-04 | Not detected |
| | | | | | |
| $^{238}U$ | Hobbs | 4.01E-02 | 4.83E-03 | 5.85E-04 | Detected |
| | Malaga | 6.19E-02 | 7.45E-03 | 6.14E-04 | Detected |
| | Otis | 7.24E-02 | 8.59E-03 | 4.58E-04 | Detected |
| | Loving | 2.24E-02 | 2.58E-03 | 2.13E-04 | Detected |
| | Carlsbad | 1.06E-02 | 1.37E-03 | 2.13E-04 | Detected |
| | Carlsbad -dup | 1.07E-02 | 1.54E-03 | 3.40E-04 | Detected |
| | Double Eagle | 1.85E-02 | 2.31E-03 | 4.34E-04 | Detected |
| | Blank | -2.94E-05 | 1.24E-04 | 3.45E-04 | Not detected |

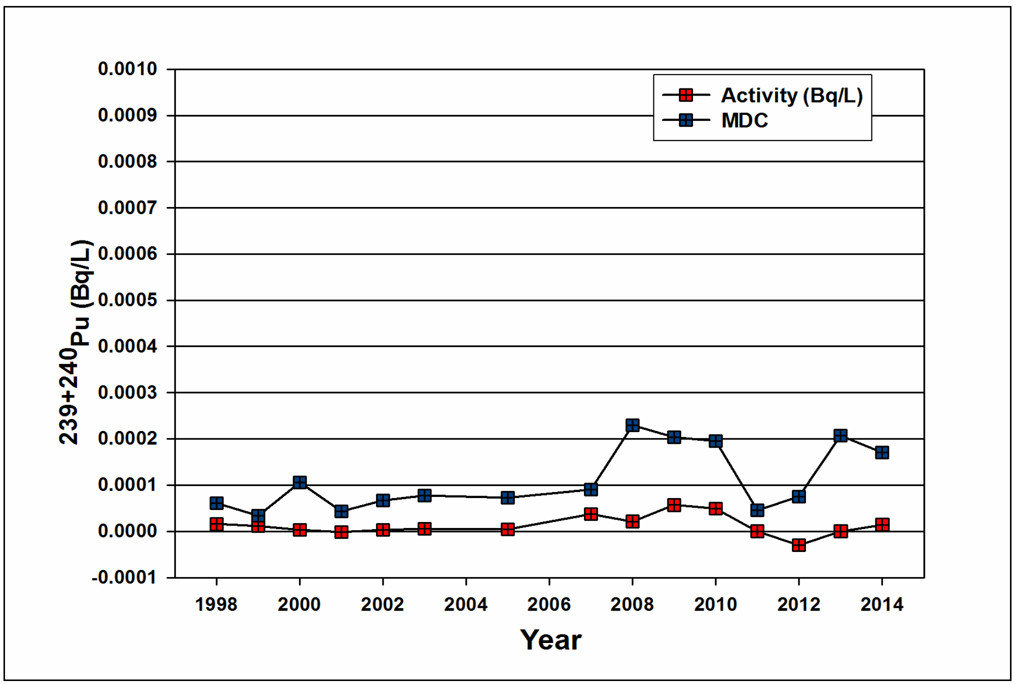



Figure 6-1: $^{239+240}Pu$ in Carlsbad Drinking Water from 1998 – 2014

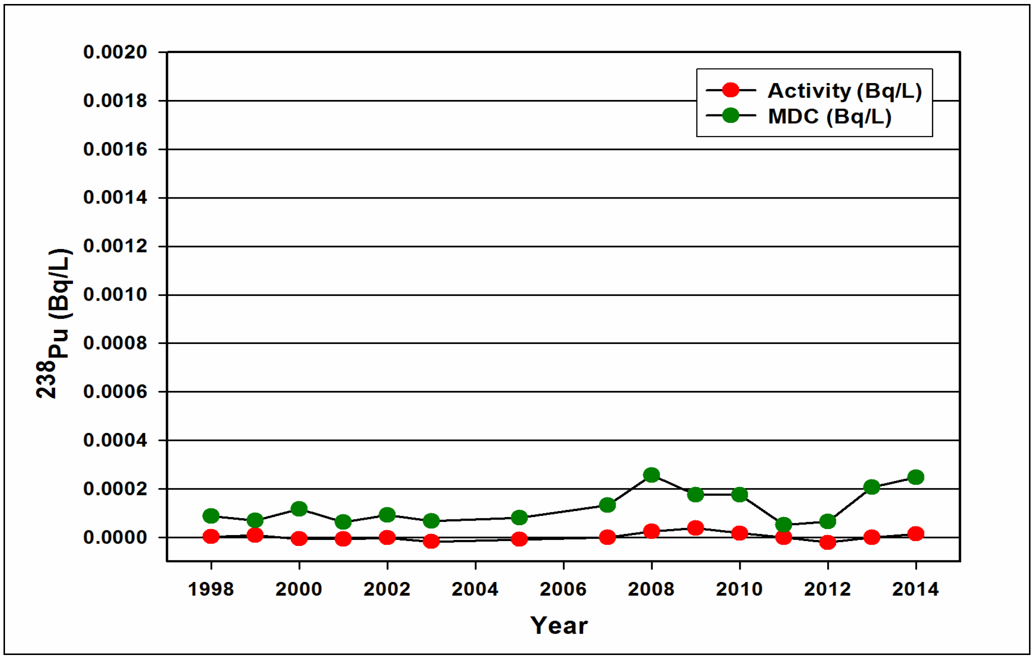



Figure 6-2: $^{238}$Pu in Carlsbad Drinking Water from 1998 – 2014

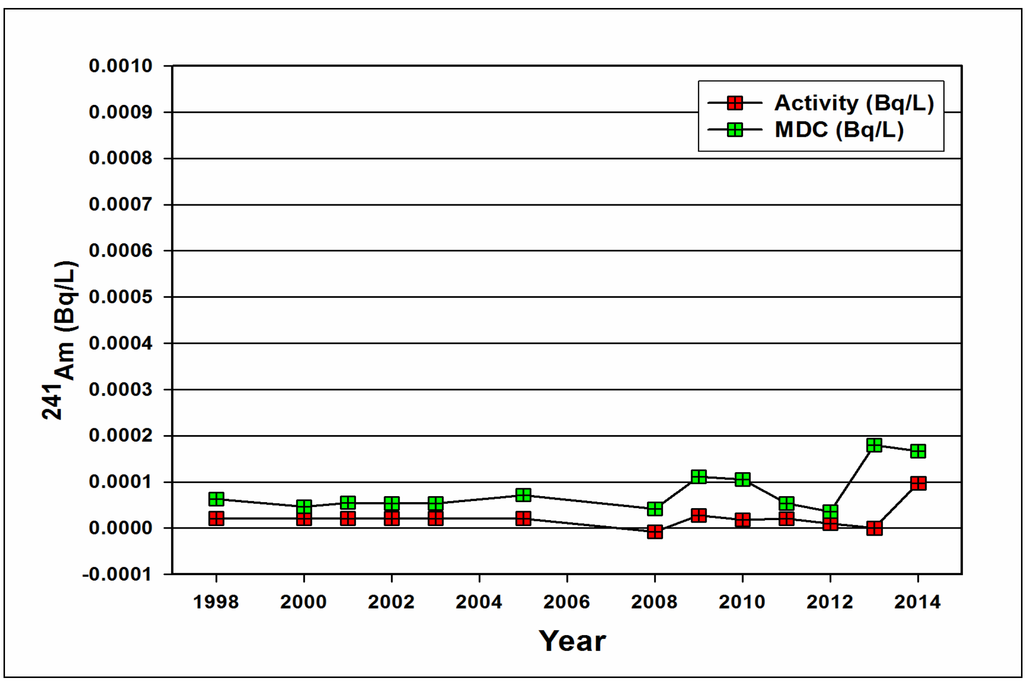



Figure 6-3: $^{241}$Am in Carlsbad Drinking Water from 1998 – 2014

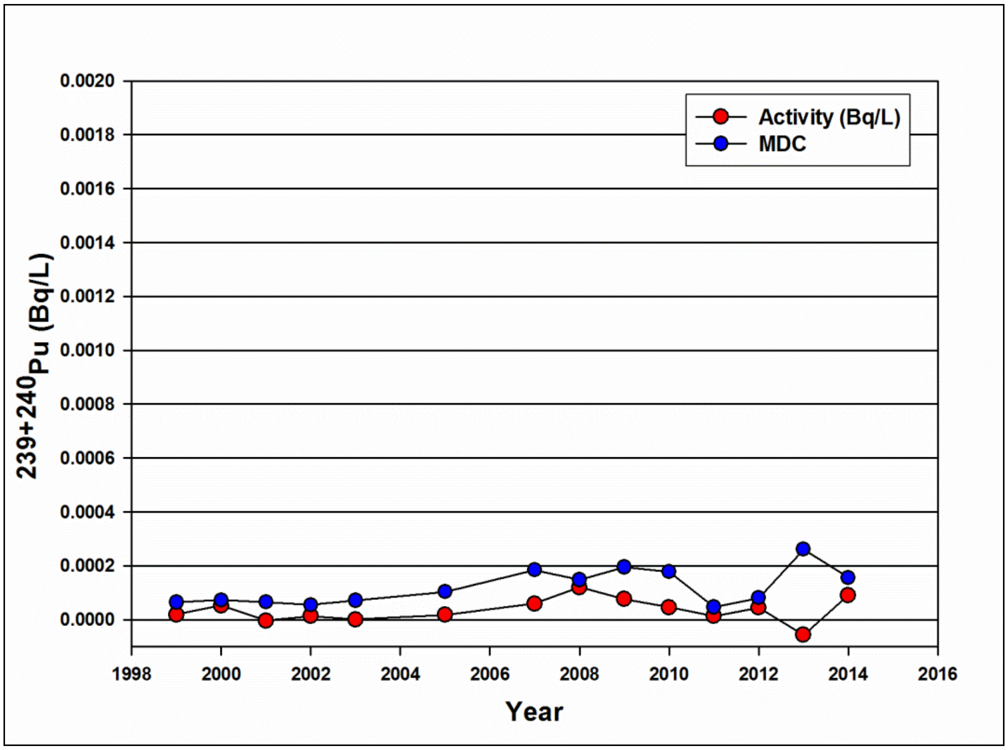



Figure 6-4: $^{239+240}$Pu in Hobbs Drinking Water from 1999 – 2014

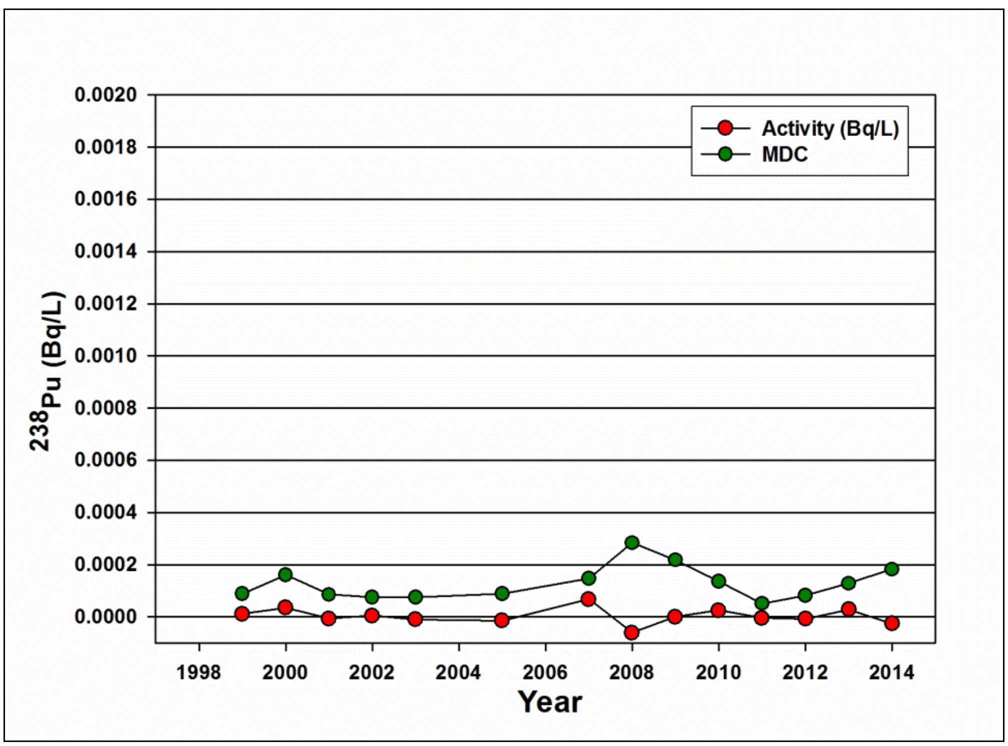



Figure 6-5: $^{238}$Pu in Hobbs Drinking Water from 1999 – 2014

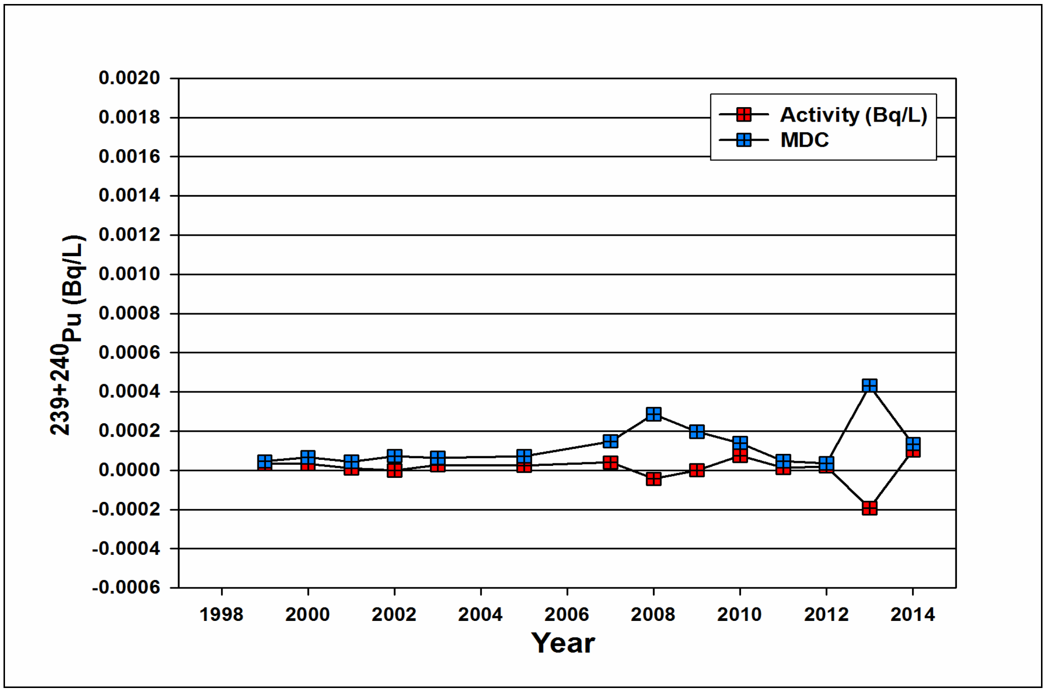



Figure 6-6: $^{239+240}$Pu in Double Eagle Drinking Water from 1999 -2014

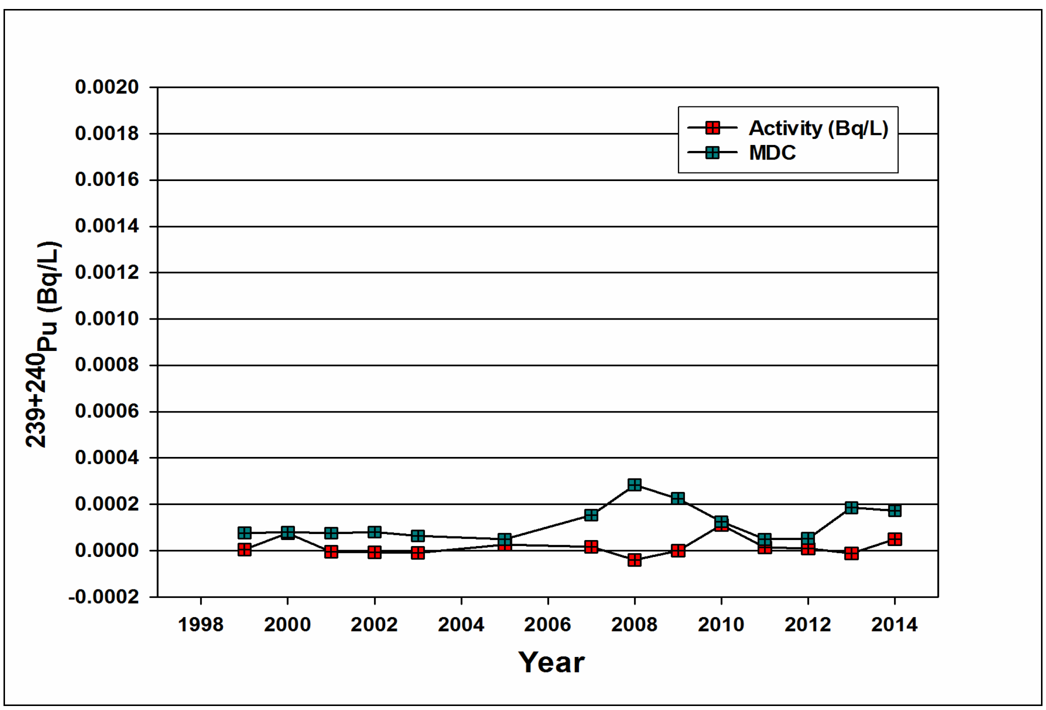



Figure 6-7: $^{239+240}$Pu in Loving Drinking Water from 1999 – 2014

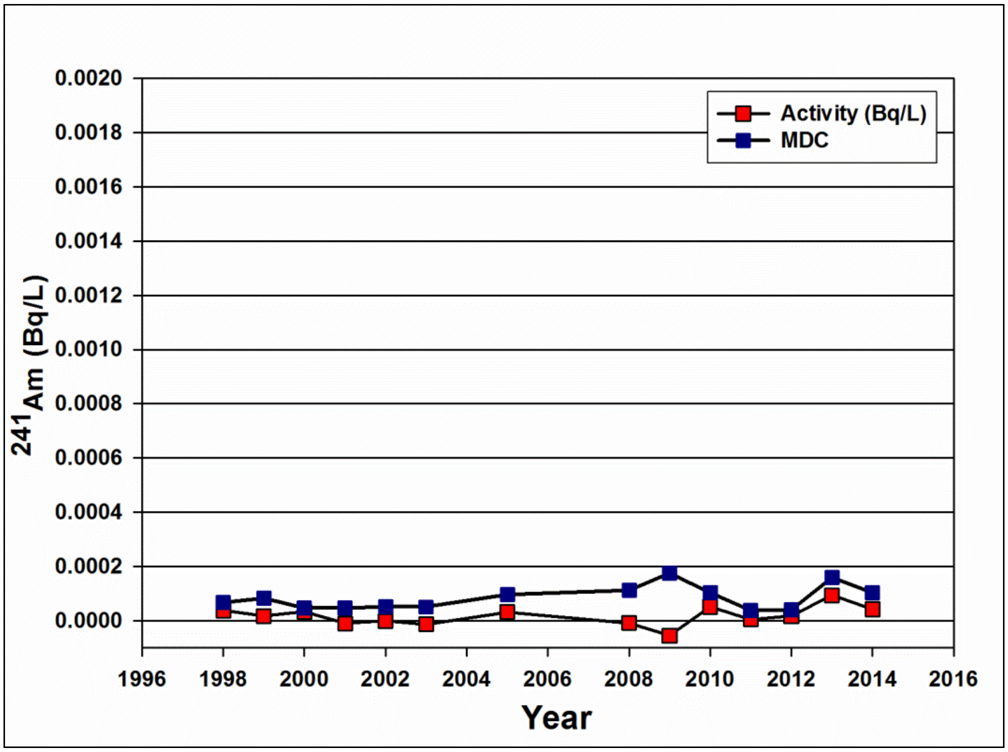



Figure 6-8: $^{241}$Am in Otis Drinking Water from 1998 - 2014

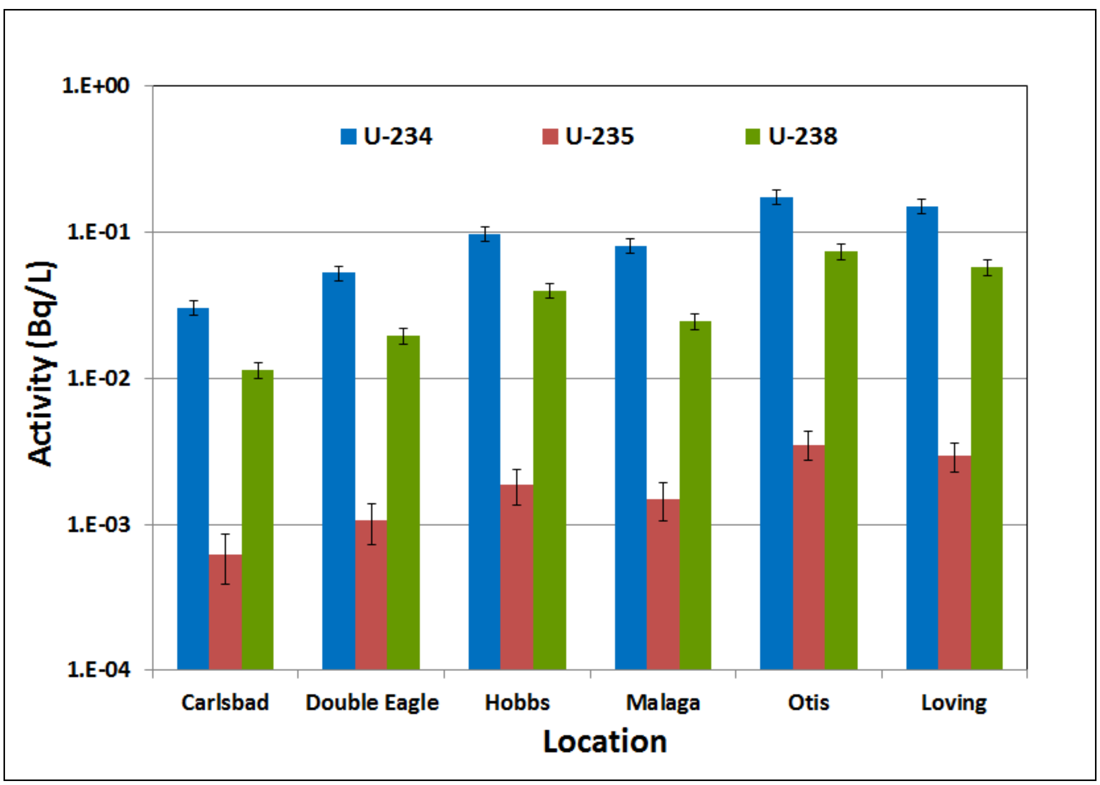



Figure 6-9: The $^{234}$U, $^{235}$U, and $^{238}$U concentrations (Bq/L) in Regional Drinking Water in 2014

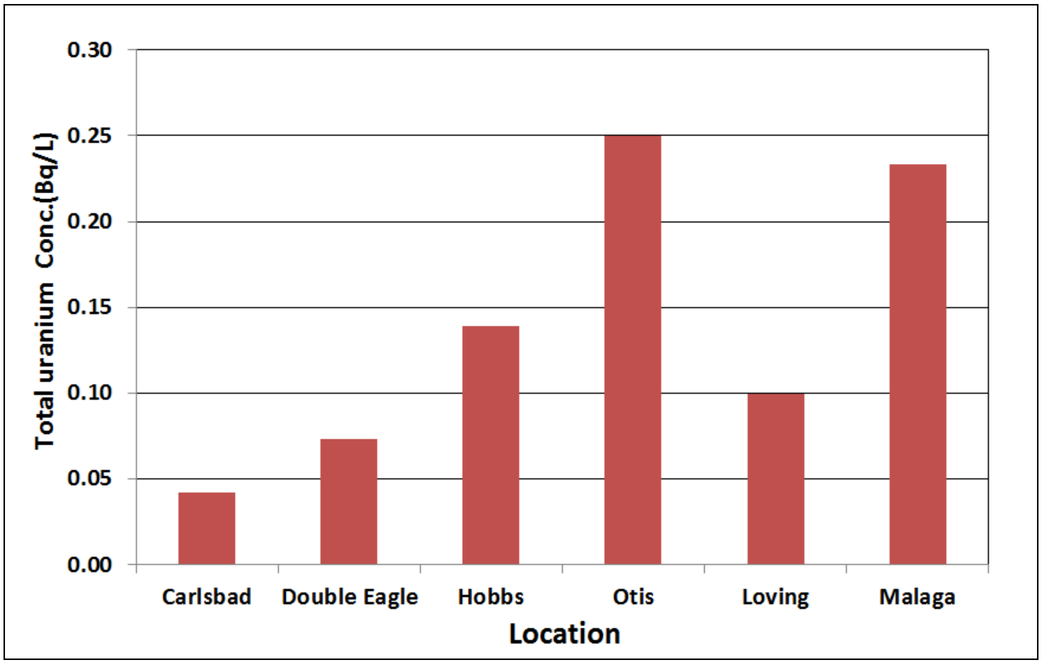



Figure 6-10: Total Uranium Concentrations in Bq/L in Regional Drinking Water collected in 2014

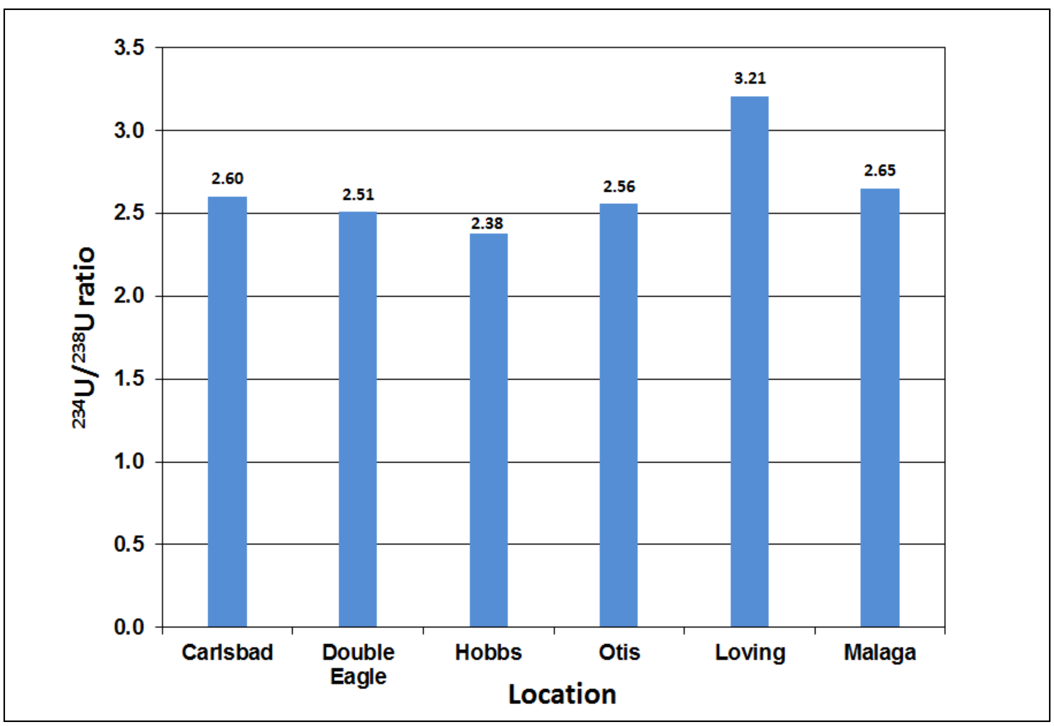



Figure 6-11: Average $^{234}U/^{238}U$ Activity Ratio in Regional Drinking Water from 1998 - 2014

Table 6-4: Comparison of Activity Concentration Ratios of $^{234}U/^{238}U$ and $^{235}U/^{238}U$ in Water Samples collected near the WIPP Site with other countries

| Source of water sample | Type of water | $^{234}U/^{238}U$ | $^{235}U/^{238}U$ | Reference |
|---|---|---|---|---|
| Carlsbad | Drinking water | 2.59 | 0.072 | Present work |
| Double Eagle | Drinking water | 2.48 | 0.078 | Present work |
| Hobbs | Drinking water | 2.37 | 0.063 | Present work |
| Otis | Drinking water | 2.57 | 0.059 | Present work |
| Loving | Drinking water | 3.2 | 0.058 | Present work |
| Malaga | Drinking water | 2.66 | 0.044 | Present work |
| UK | Water | 1.0-3.0 | - | Gilkeson et al. |
| Poland | Mineral water | 0.82-1.12 | - | Nguyen et al. |
| India | Sea water | 1.11-1.14 | 0.045-0.047 | Joshi et al. |
| Ghana, Obuasi | Ground water | 1.07-1.44 | 0.042-0.045 | Awudu et al. |
| Ghana, Obuasi | Surface water | 1.06-1.76 | 0.044-0.045 | Awudu et al. |
| Ghana, Obuasi | Tap water | 1.06-1.73 | 0.044-0.045 | Awudu et al. |
| INL, Idaho | Ground water | 1.5-3.1 | - | Roback et al. |
| Tunisia | Mineral water | 1.16-2.46 | - | Gharbi et al. |

Table 6-5: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Carlsbad Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

NR = not reported

Table 6-6: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Double Eagle Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

NR = not reported

Table 6-7: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Hobbs Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

NR = not reported

Table 6-8: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Otis Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

NR = not reported

Table 6-9: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Loving Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

NR = not reported

Table 6-10: Historical Activity Concentrations of $^{234}U$, $^{235}U$ and $^{238}U$ (Bq/L) measured in Malaga Drinking Water

| Year | $^{234}U$ | $^{235}U$ | $^{238}U$ |
|---|---|---|---|
| 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 |

*Collection started in 2011, NR = not reported

Table 6-11: Gamma Emitting Radionuclides measured in Drinking Water in 2014

| Radionuclide | Location | Activity Bq/L | Unc(2-sig) (Bq/L) | MDC (Bq/L) | Status |
|---|---|---|---|---|---|
| $^{137}Cs$ | Hobbs | -5.04E-02 | 4.45E-02 | 1.48E-01 | Not detected |
| | Malaga | 1.57E-02 | 2.85E-02 | 9.41E-02 | Not detected |
| | Otis | -4.35E-02 | 2.90E-02 | 9.69E-02 | Not detected |
| | Loving | 1.67E-02 | 2.82E-02 | 9.32E-02 | Not detected |
| | Carlsbad | -1.54E-02 | 4.34E-02 | 1.44E-01 | Not detected |
| | Carlsbad -dup | 4.68E-02 | 4.22E-02 | 1.39E-01 | Not detected |
| | Double Eagle | 3.10E-02 | 2.89E-02 | 9.53E-02 | Not detected |
| | Blank | -2.27E-02 | 4.28E-02 | 1.42E-01 | Not detected |
| | | | | | |
| $^{60}Co$ | Hobbs | -1.22E-01 | 3.75E-02 | 1.27E-01 | Not detected |
| | Malaga | 1.98E-02 | 2.66E-02 | 8.80E-02 | Not detected |
| | Otis | 1.31E-02 | 2.73E-02 | 9.04E-02 | Not detected |
| | Loving | 2.07E-02 | 2.64E-02 | 8.74E-02 | Not detected |
| | Carlsbad | -4.85E-02 | 3.62E-02 | 1.22E-01 | Not detected |
| | Carlsbad -dup | -4.53E-02 | 3.58E-02 | 1.20E-01 | Not detected |
| | Double Eagle | 2.05E-02 | 2.68E-02 | 8.89E-02 | Not detected |
| | Blank | -5.42E-02 | 3.68E-02 | 1.24E-01 | Not detected |
| | | | | | |
| $^{40}K$ | Hobbs | 1.35E+00 | 3.02E-01 | 9.64E-01 | Detected |
| | Malaga | 1.36E-01 | 3.33E-01 | 1.10E+00 | Not detected |
| | Otis | 1.78E-01 | 3.38E-01 | 1.12E+00 | Not detected |
| | Loving | 4.15E-01 | 3.32E-01 | 1.09E+00 | Not detected |
| | Carlsbad | 4.73E-01 | 3.14E-01 | 1.03E+00 | Not detected |
| | Carlsbad -dup | 2.98E-01 | 3.18E-01 | 1.05E+00 | Not detected |
| | Double Eagle | -8.74E-02 | 3.44E-01 | 1.14E+00 | Not detected |
| | Blank | 4.58E-01 | 3.12E-01 | 1.03E+00 | Not detected |

## Non-Radiological Monitoring Results

The CEMRC has the ability to analyze drinking water samples for seven different inorganic anions and over 30 different inorganic elements. The 2014 inorganic results and how they compare to past results are summarized in Tables 6-12 through 6-17 for the six regional drinking water sources. While the results exhibited in these Tables are not used in assessing regulatory compliance, it is important to note that the CEMRC results for drinking water from the Carlsbad (Sheep Draw) and WIPP (Double Eagle) locations generally agree with the measurements for the same elements published by the City of Carlsbad every year (**http://www.carlsbadca.gov/civicax/filebank/blobdload.aspx?BlobID=25132**).

Figures 6-12 through 6-17 compare the history of the following selected elements measured in drinking water collected from the surrounding areas of WIPP: Arsenic (As), Barium (Ba), Chromium (Cr), Copper (Cu), Lead (Pb), Antimony (Sb), and Uranium (U). As mentioned earlier, drinking water sampling did not take place during the 2004 and 2006 years due to a change in sampling frequency. Since the CEMRC began monitoring inorganic analytes in regional drinking water, the results have exhibited a high level of consistency with past results. Historical data shows that differences of a factor of two or three between one set of successive years is common, as it is for all natural water systems. Additionally, there has been no noticeable increase in the inorganic levels found in the regional drinking water after the WIPP site started accepting mixed waste in August of 2000.

Minerals are a natural part of all water sources. The amount of inorganic materials in drinking 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/or farming, etc. The elemental constituents, As, Ba, Cr, Cu, Pb, Sb, and U are commonly found in the drinking water of the southwest. For example, the city of Midland, TX, has naturally occurring levels of Arsenic, Fluoride, and Selenium in their drinking water (http://www.midlandtexas.gov/ArchiveCenter/ViewFile/Item/152). Comparisons to this area are used as drinking water from this part of Texas is supplied from the Ogallala and Dockum formations which are also accessed by the WIPP (Double Eagle) and Hobbs communities. While the concentrations of Arsenic measured at the Double Eagle and Hobbs sites are higher than the drinking water for other sampling locations around the WIPP site, most of which have concentrations below the MDC, as shown in Figure 6-19. The levels determined for Double Eagle and Hobbs are still below the EPA limit of 10µg/L (0.01mg/L) for Arsenic as listed in Table 6-2.

The WIPP site is located in the Delaware Basin of New Mexico, the second largest region of the greater Permian Basin. This 600-meter deep salt basin was formed during the Permian Era approximately 250 million years ago when an ancient Sea, once covering the area, evaporated and left behind a nearly impermeable layer of salt. Over time this salt layer was covered by 300 meters of soil and rock (The Permian Basin is now a major source of potassium salts (potash), which are mined from bedded deposits of sylvite and langbeinite.

Sylvite is potassium chloride (KCl) in its natural mineral form while langbeinite is a potassium magnesium sulfate mineral ($K_2Mg_2(SO_4)_3$). Langbeinite ore occurs in evaporated marine deposits in association with carnallite, halite, and sylvite. Therefore, it is to be expected that through leaching and other natural processes, the water in this region would contain significant quantities of potassium (K), magnesium (Mg) and, of course, sodium (Na). Figure 6-19 summarizes the concentrations of common salts measured in the areas surrounding the WIPP site. Currently there are no EPA regulations for salts like K, Mg, and Na in drinking water.

By far, the highest concentration of the measured elements found in the drinking water of this area is Calcium (Ca) for each of the sites sampled around the WIPP (Figure 6-19). This is likely due to the natural limestone deposits found along the edge of the Delaware Basin which once existed as the Capitan Reef during the Permian Era. Limestone is a sedimentary rock composed largely of the minerals calcite and aragonite, which are different crystal forms of calcium carbonate ($CaCO_3$). Limestone leaching creates the stalactites and stalagmites found in the world-famous Carlsbad Caverns, located approximately 18 miles southwest of Carlsbad, NM and is a likely source of Calcium (Ca) in the drinking water of the area.

Anion analysis results are shown separately in Tables 6-18 through 6-23 for the following anions: bromide, chloride, fluoride, nitrate, nitrite, phosphate and sulfate. Drinking water samples have been analyzed for chloride, fluoride, nitrate, phosphate, and sulfate since the CEMRC commenced drinking water analyses in 1998. Only once (at Loving in 2009) has phosphate ever been detected in the drinking water above the MDC while chloride, fluoride, nitrate, and sulfate are routinely detected.

Figures 6-20 through 6-23 are shown for chloride, fluoride, nitrate and sulfate. Just like with inorganic elements, annual measurements for these anions in drinking water show some variation within several orders of magnitude. Chloride has never been detected above the EPA secondary limit of 250mg/L for Carlsbad, Double Eagle, Hobbs, and Loving since 1998. However, this anion has frequently been detected above the EPA limit for the Otis drinking water site (See Figure 6-20). All measurements made from the Malaga site thus far have been detected above the EPA secondary limit; however no baseline is available for the Malaga site for comparison. It should be noted that secondary EPA regulations are not enforceable.

All reported fluoride concentrations are below the EPA limit of 4mg/L. Due to the high chloride and sulfate concentrations, all drinking water samples must be diluted prior to analysis for anions by IC. This sometimes makes it difficult to detect fluoride anions (which frequently hover just above the MDC). Gaps (such as between 2004 and 2008 for Carlsbad drinking water and after 2008 for Otis drinking water), are often observed when fluoride concentrations are below the MDC.

Nitrate is regularly measured in the drinking water at all of the locations around the WIPP site. Loving, Otis, Malaga, and Hobbs water typically have higher nitrate concentrations than Double Eagle and Carlsbad. See Figure 6-22 for nitrate concentrations at all of the sites. All reported nitrate concentrations are below the EPA limit for nitrate (measured as nitrogen = 10mg/L nitrate ion). According to the EPA, common sources of nitrogen (i.e. in the form of nitrites and nitrates) are fertilizer runoff, leaching from septic tanks and sewage, and from erosion of natural deposits.

Like nitrate and chloride, sulfate is another common constituent of drinking water sampled around the WIPP site. Sulfate (see Figure 6-23) has never been detected above the EPA secondary limit for the Carlsbad, Double Eagle, Hobbs, and Loving locations. On the other hand, sulfate in Malaga and Otis water are routinely above the EPA secondary limit of 250mg/L. There are no baseline measurements available for the Malaga site. High sulfate concentrations in Otis water have been observed since CEMRC commenced sulfate analyses in 1998 (before the WIPP began accepting mixed waste). Therefore, sulfate concentrations in Otis water cannot be a result of the WIPP activities. It should be noted that secondary EPA regulations are not enforceable. Furthermore, the EPA does not list any potential health effects from long-term exposure to sulfate.

In 2007, bromide and nitrite were added to the list of anions analyzed in drinking water. Therefore a baseline is not available for these two anions. Nitrite has never been detected at any of the sites above the MDC. Bromide has occasionally been detected above the MDC in drinking water collected at Double Eagle, Hobbs, Loving, and Otis, although the observations are few. The EPA (see Table 6-2) does not list regulatory information about bromide.

### Sampling, Sample Preparation, and Measurements

All drinking water samples were processed according to the CEMRC protocols for the collection, handling, and preservation of drinking water. This year, the drinking water samples were collected in September from Loving, Otis, Malaga, Sheep Draw, Hobbs, Double Eagle and included a Trip Blank. The following samples were taken from each sampling location: (1) 8L for gamma and alpha analyses, (2) 1L for elemental analyses, (3) 1L for anion analyses, and (4) 500mL for mercury analysis. None of the samples were filtered before analysis. Current methods used for the various analyses performed on each sample are summarized in Table 6-2.

Table 6-12: Measured Concentration of Selected Inorganic Elements in Carlsbad Drinking Water from 1998 – 2014

| Carlsbad | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 11 | 1 | 1.75E-02 | 1.75E-02 | 6.70E-03 | 1.88E-04 | <MDC |
| Al | 12 | 5 | 1.83E+00 | 4.11E+01 | 1.10E-01 | 2.20E-01 | 7.25E+00 |
| As | 14 | 10 | 2.97E-01 | 1.42E+00 | 6.00E-01 | -2.35E-02 | 7.91E-01 |
| B | 3 | 3 | 2.89E+01 | 4.44E+01 | N/A | N/A | N/A |
| Ba | 10 | 10 | 6.64E+01 | 8.19E+01 | 2.50E-02 | 6.87E-03 | 7.14E+01 |
| Be | 11 | 0 | N/A | N/A | 1.20E-02 | -2.69E-03 | <MDC |
| Ca | 7 | 7 | 5.90E+04 | 7.30E+04 | 6.80E+01 | 2.96E+00 | 6.95E+04 |
| Cd | 10 | 0 | N/A | N/A | 1.00E-01 | -1.85E-01 | <MDC |
| Ce | 11 | 4 | 5.81E-03 | 3.42E-02 | 8.10E-04 | -4.15E-04 | 8.50E-03 |
| Co | 12 | 10 | 8.80E-02 | 3.41E-01 | 7.00E-03 | 7.70E-04 | 1.01E-01 |
| Cr | 13 | 11 | 1.24E+00 | 1.02E+01 | 1.00E-01 | -1.39E-01 | 5.14E-01 |
| Cu | 12 | 11 | 1.30E+00 | 1.67E+01 | 5.30E-02 | 6.43E-03 | 7.65E+00 |
| Dy | 12 | 1 | 3.56E-03 | 3.56E-03 | 2.40E-03 | -1.27E-04 | <MDC |
| Er | 12 | 2 | 3.32E-03 | 3.38E-03 | 4.70E-03 | 8.80E-05 | <MDC |
| Eu | 11 | 8 | 1.35E-02 | 2.42E-02 | 2.70E-03 | 3.44E-04 | 1.69E-02 |
| Fe | 9 | 6 | 7.10E-01 | 2.24E+02 | 2.30E+00 | -6.94E+00 | 6.52E+02 |
| Ga | 1 | 1 | 3.25E+00 | 3.25E+00 | N/A | N/A | N/A |
| Gd | 10 | 2 | 3.80E-03 | 3.91E-03 | 1.30E-03 | 2.31E-04 | 1.96E-03 |
| Hg | 6 | 2 | 2.26E-02 | 3.14E-02 | 5.80E-02 | -8.07E-03 | <MDC |
| K | 11 | 11 | 1.02E+03 | 3.56E+03 | 9.10E+00 | -2.45E+01 | 1.04E+03 |
| La | 11 | 5 | 5.81E-03 | 4.42E-02 | 3.50E-03 | 1.74E-04 | 9.13E-03 |
| Li | 10 | 10 | 5.14E+00 | 8.86E+00 | 2.00E-02 | 3.46E-03 | 5.45E+00 |
| Mg | 10 | 10 | 2.73E+04 | 3.47E+04 | 2.50E+00 | 1.99E-01 | 3.19E+04 |
| Mn | 13 | 8 | 5.50E-02 | 2.04E+00 | 1.70E-02 | -3.18E-02 | 8.71E+00 |
| Mo | 9 | 8 | 8.93E-01 | 1.37E+00 | 2.50E-02 | -6.85E-03 | 1.15E+00 |
| Na | 12 | 12 | 8.16E+03 | 4.55E+04 | 1.00E+00 | 6.91E-01 | 1.38E+04 |
| Nd | 12 | 1 | 9.35E-03 | 9.35E-03 | 2.70E-03 | -1.14E-04 | 8.50E-03 |
| Ni | 12 | 11 | 1.46E+00 | 3.14E+00 | 4.10E-02 | 1.47E-03 | 2.15E+00 |
| P | 6 | 5 | 1.61E+01 | 4.09E+01 | 3.50E+00 | -8.26E+00 | 2.30E+01 |
| Pb | 11 | 9 | 1.01E-01 | 1.44E+00 | 2.10E-03 | 9.23E-04 | 2.07E+00 |
| Pr | 12 | 1 | 3.72E-03 | 3.72E-03 | 9.20E-04 | 2.50E-05 | 1.93E-03 |

Table 6-12: Measured Concentration of Selected Inorganic Elements in Carlsbad Drinking Water from 1998 – 2014 (continued)

| Carlsbad | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Sb | 11 | 6 | 3.14E-02 | 1.99E-01 | 5.80E-03 | 1.27E-03 | 3.64E-02 |
| Sc | 10 | 9 | 1.20E+00 | 3.03E+00 | 5.20E-02 | -1.45E-02 | 1.18E+00 |
| Se | 11 | 7 | -8.83E-02 | 1.93E+00 | 1.10E+00 | -2.05E-02 | <MDC |
| Si | 8 | 8 | 5.39E+03 | 6.87E+03 | 3.10E+00 | -4.31E+00 | 5.82E+03 |
| Sr | 11 | 11 | 2.61E+02 | 3.62E+02 | 6.30E-02 | 5.70E-03 | 3.45E+02 |
| Th | 9 | 3 | 6.32E-03 | 1.76E-02 | 6.30E-03 | -1.19E-03 | <MDC |
| Tl | 11 | 11 | 8.97E-02 | 1.62E-01 | 3.30E-03 | -6.40E-05 | 3.47E-01 |
| U | 12 | 12 | 8.21E-01 | 1.05E+00 | 3.30E-03 | 3.30E-05 | 8.80E-01 |
| V | 13 | 13 | 3.54E+00 | 6.57E+00 | 5.00E-02 | -3.71E-02 | 4.92E+00 |
| Zn | 12 | 11 | 2.13E+00 | 1.52E+01 | 1.00E-01 | 1.02E-01 | 1.08E+01 |

[1]El = Element analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-13: Measured Concentration of Selected Inorganic Elements in Double Eagle Drinking Water from 1998 - 2014

| Double Eagle | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 13 | 2 | 3.62E-03 | 1.78E-01 | 6.70E-03 | 1.88E-04 | <MDC |
| Al | 14 | 8 | 1.93E+00 | 7.22E+01 | 1.10E-01 | 2.20E-01 | 2.63E+00 |
| As | 13 | 12 | 4.48E+00 | 9.11E+00 | 6.00E-01 | -2.35E-02 | 7.58E+00 |
| B | 3 | 3 | 2.98E+01 | 8.55E+01 | N/A | N/A | N/A |
| Ba | 11 | 11 | 3.82E+01 | 1.25E+02 | 2.50E-02 | 6.87E-03 | 8.93E+01 |
| Be | 12 | 2 | 3.63E-02 | 6.76E-02 | 1.20E-02 | -2.69E-03 | <MDC |
| Ca | 7 | 7 | 4.15E+04 | 5.94E+04 | 6.80E+01 | 2.96E+00 | 5.43E+04 |
| Cd | 11 | 1 | 1.87E-02 | 1.87E-02 | 1.00E-01 | -1.85E-01 | <MDC |
| Ce | 12 | 3 | 3.63E-03 | 3.22E-02 | 8.10E-04 | -4.15E-04 | <MDC |
| Co | 13 | 10 | 6.48E-02 | 1.12E+00 | 7.00E-03 | 7.70E-04 | 9.13E-02 |
| Cr | 14 | 13 | 1.29E+00 | 3.25E+01 | 1.00E-01 | -1.39E-01 | 9.11E-01 |
| Cu | 13 | 12 | 8.09E-01 | 5.69E+00 | 5.30E-02 | 6.43E-03 | 1.18E+00 |
| Dy | 13 | 0 | N/A | N/A | 2.40E-03 | -1.27E-04 | <MDC |
| Er | 13 | 0 | N/A | N/A | 4.70E-03 | 8.80E-05 | <MDC |
| Eu | 12 | 9 | 1.68E-02 | 2.86E-02 | 2.70E-03 | 3.44E-04 | 2.14E-02 |
| Fe | 10 | 8 | 3.01E-02 | 9.32E+02 | 2.30E+00 | -6.94E+00 | 1.26E+02 |
| Ga | 1 | 1 | 4.46E+00 | 4.46E+00 | N/A | N/A | N/A |
| Gd | 12 | 0 | N/A | N/A | 1.30E-03 | 2.31E-04 | <MDC |
| Hg | 5 | 0 | N/A | N/A | 5.80E-02 | -8.07E-03 | <MDC |
| K | 12 | 12 | 2.22E+03 | 2.94E+04 | 9.10E+00 | -2.45E+01 | 2.86E+03 |
| La | 12 | 5 | 1.19E-02 | 6.26E-02 | 3.50E-03 | 1.74E-04 | <MDC |
| Li | 11 | 11 | 9.97E+00 | 1.95E+01 | 2.00E-02 | 3.46E-03 | 1.52E+01 |
| Mg | 10 | 10 | 8.51E+03 | 1.25E+04 | 2.50E+00 | 1.99E-01 | 1.06E+04 |
| Mn | 14 | 11 | 2.22E-01 | 6.04E+00 | 1.70E-02 | -3.18E-02 | 2.15E+00 |
| Mo | 10 | 10 | 1.42E+00 | 6.70E+00 | 2.50E-02 | -6.85E-03 | 1.80E+00 |
| Na | 13 | 13 | 3.84E+03 | 4.04E+04 | 1.00E+00 | 6.91E-01 | 3.56E+04 |
| Nd | 13 | 0 | N/A | N/A | 2.70E-03 | -1.14E-04 | <MDC |
| Ni | 13 | 12 | 1.16E+00 | 4.03E+00 | 4.10E-02 | 1.47E-03 | 1.52E+00 |
| P | 6 | 3 | 1.04E+01 | 1.95E+01 | 3.50E+00 | -8.26E+00 | 6.38E+00 |
| Pb | 12 | 11 | 2.56E-01 | 1.56E+00 | 2.10E-03 | 9.23E-04 | 5.32E+00 |
| Pr | 13 | 1 | 9.05E-04 | 9.05E-04 | 9.20E-04 | 2.50E-05 | <MDC |

Table 6-13: Measured Concentration of Selected Inorganic Elements in Double Eagle Drinking Water from 1998 – 2014 (continued)

| Double Eagle | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Sb | 12 | 8 | 2.41E-02 | 1.39E-01 | 5.80E-03 | 1.27E-03 | 3.65E-02 |
| Sc | 10 | 9 | 1.40E+00 | 6.59E+00 | 5.20E-02 | -1.45E-02 | 3.00E+00 |
| Se | 11 | 9 | -4.16E-02 | 5.30E+00 | 1.10E+00 | -2.05E-02 | 2.69E+00 |
| Si | 8 | 8 | 7.37E+03 | 1.81E+04 | 3.10E+00 | -4.31E+00 | 1.52E+04 |
| Sr | 12 | 12 | 5.06E+01 | 5.68E+02 | 6.30E-02 | 5.70E-03 | 5.82E+02 |
| Th | 11 | 4 | 2.07E-03 | 8.38E-02 | 6.30E-03 | -1.19E-03 | <MDC |
| Tl | 12 | 1 | -1.23E-02 | -1.23E-02 | 3.30E-03 | -6.40E-05 | <MDC |
| U | 13 | 13 | 1.17E+00 | 2.38E+00 | 3.30E-03 | 3.30E-05 | 1.45E+00 |
| V | 14 | 14 | 7.71E+00 | 3.26E+01 | 5.00E-02 | -3.71E-02 | 2.72E+01 |
| Zn | 13 | 12 | 1.46E+00 | 1.25E+01 | 1.00E-01 | 1.02E-01 | 2.68E+00 |

[1]El = Element analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-14: Measured Concentration of Selected Inorganic Elements in Hobbs Drinking Water from 1998 - 2014

| Hobbs | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 13 | 2 | 3.86E-03 | 1.04E-01 | 1.34E-02 | 1.88E-04 | <MDC |
| Al | 14 | 11 | 3.03E+00 | 1.14E+02 | 2.20E-01 | 2.20E-01 | 6.60E+00 |
| As | 13 | 12 | 4.55E+00 | 8.56E+00 | 1.20E+00 | -2.35E-02 | 6.45E+00 |
| B | 3 | 3 | 1.41E+02 | 1.97E+02 | N/A | N/A | N/A |
| Ba | 11 | 11 | 5.63E+01 | 6.79E+01 | 5.00E-02 | 6.87E-03 | 5.65E+01 |
| Be | 12 | 1 | 5.39E-02 | 5.39E-02 | 2.40E-02 | -2.69E-03 | <MDC |
| Ca | 7 | 7 | 7.63E+04 | 1.10E+05 | 1.36E+02 | 2.96E+00 | 1.04E+05 |
| Cd | 11 | 0 | N/A | N/A | 2.00E-01 | -1.85E-01 | <MDC |
| Ce | 12 | 9 | 5.10E-03 | 3.56E-02 | 1.62E-03 | -4.15E-04 | 1.39E-02 |
| Co | 13 | 11 | 9.78E-02 | 3.61E-01 | 1.40E-02 | 7.70E-04 | 1.49E-01 |

Table 6-14: Measured Concentration of Selected Inorganic Elements in Hobbs Drinking Water from 1998 – 2014 (continued)

| Hobbs | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Cr | 14 | 13 | 6.44E-01 | 1.13E+01 | 2.00E-01 | -1.39E-01 | 8.02E-01 |
| Cu | 13 | 12 | 1.06E+00 | 6.93E+00 | 1.06E-01 | 6.43E-03 | 1.60E+00 |
| Dy | 13 | 1 | 4.18E-03 | 4.18E-03 | 4.80E-03 | -1.27E-04 | <MDC |
| Er | 13 | 0 | N/A | N/A | 9.40E-03 | 8.80E-05 | <MDC |
| Eu | 12 | 9 | 1.12E-02 | 1.97E-02 | 5.40E-03 | 3.44E-04 | 1.17E-02 |
| Fe | 10 | 8 | 3.64E+01 | 4.44E+02 | 4.60E+00 | -6.94E+00 | 1.73E+02 |
| Ga | 1 | 1 | 2.56E+00 | 2.56E+00 | N/A | N/A | N/A |
| Gd | 12 | 0 | N/A | N/A | 2.60E-03 | 2.31E-04 | <MDC |
| Hg | 5 | 0 | N/A | N/A | 5.80E-02 | -8.07E-03 | <MDC |
| K | 12 | 12 | 2.11E+03 | 2.52E+04 | 1.82E+01 | -2.45E+01 | 2.53E+03 |
| La | 12 | 5 | 1.25E-02 | 5.01E-02 | 7.00E-03 | 1.74E-04 | <MDC |
| Li | 11 | 11 | 2.65E+01 | 3.89E+01 | 4.00E-02 | 3.46E-03 | 2.69E+01 |
| Mg | 10 | 10 | 1.90E+04 | 2.67E+04 | 5.00E+00 | 1.99E-01 | 2.48E+04 |
| Mn | 14 | 13 | 3.79E-01 | 3.62E+00 | 3.40E-02 | -3.18E-02 | 1.48E+00 |
| Mo | 10 | 10 | 2.46E+00 | 3.31E+00 | 5.00E-02 | -6.85E-03 | 2.46E+00 |
| Na | 13 | 13 | 4.97E+03 | 5.80E+04 | 2.00E+00 | 6.91E-01 | 5.08E+04 |
| Nd | 13 | 4 | 3.01E-03 | 1.44E-02 | 5.40E-03 | -1.14E-04 | 6.38E-03 |
| Ni | 13 | 13 | 1.67E+00 | 4.78E+00 | 8.20E-02 | 1.47E-03 | 2.98E+00 |
| P | 6 | 5 | 1.76E+01 | 5.65E+01 | 7.00E+00 | -8.26E+00 | 1.74E+01 |
| Pb | 12 | 10 | 9.44E-02 | 1.19E+00 | 4.20E-03 | 9.23E-04 | 1.54E-01 |
| Pr | 13 | 1 | 1.57E-03 | 1.57E-03 | 1.84E-03 | 2.50E-05 | 1.88E-03 |
| Sb | 12 | 8 | 3.88E-02 | 8.53E-02 | 1.16E-02 | 1.27E-03 | 6.78E-02 |
| Sc | 10 | 10 | 3.06E+00 | 1.05E+01 | 1.04E-01 | -1.45E-02 | 3.80E+00 |
| Se | 11 | 9 | -1.70E-01 | 1.23E+01 | 2.20E+00 | -2.05E-02 | 7.23E+00 |
| Si | 8 | 8 | 2.41E+04 | 2.86E+04 | 6.20E+00 | -4.31E+00 | 2.48E+04 |
| Sr | 12 | 12 | 7.89E+01 | 1.12E+03 | 1.26E-01 | 5.70E-03 | 1.14E+03 |
| Th | 11 | 3 | 2.29E-03 | 1.36E-01 | 1.26E-02 | -1.19E-03 | <MDC |
| Tl | 11 | 2 | 9.45E-03 | 2.24E-02 | 6.60E-03 | -6.40E-05 | <MDC |
| U | 13 | 13 | 2.90E+00 | 4.30E+00 | 6.60E-03 | 3.30E-05 | 3.21E+00 |
| V | 14 | 14 | 3.11E+01 | 3.79E+01 | 1.00E-01 | -3.71E-02 | 3.24E+01 |
| Zn | 13 | 10 | 8.44E-01 | 4.37E+00 | 2.00E-01 | 1.02E-01 | 1.04E+00 |

[1]El = Element analyzed

[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values

[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-15: Measured Concentration of Selected Inorganic Elements in Loving Drinking Water from 1998 - 2014

| Loving | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 14 | 4 | 2.55E-03 | 2.17E-01 | 6.70E-03 | 1.88E-04 | <MDC |
| Al | 14 | 9 | 1.43E+00 | 3.76E+02 | 1.10E-01 | 2.20E-01 | 4.07E+00 |
| As | 13 | 10 | 7.89E-01 | 2.22E+00 | 6.00E-01 | -2.35E-02 | 1.72E+00 |
| B | 3 | 3 | 7.55E+01 | 1.12E+02 | N/A | N/A | N/A |
| Ba | 11 | 11 | 2.96E+01 | 3.47E+01 | 2.50E-02 | 6.87E-03 | 3.25E+01 |
| Be | 12 | 1 | 9.35E-02 | 9.35E-02 | 1.20E-02 | -2.69E-03 | <MDC |
| Ca | 7 | 7 | 6.71E+04 | 1.00E+05 | 6.80E+01 | 2.96E+00 | 8.40E+04 |
| Cd | 12 | 0 | N/A | N/A | 1.00E-01 | -1.85E-01 | <MDC |
| Ce | 13 | 5 | 9.74E-04 | 2.53E-01 | 8.10E-04 | -4.15E-04 | 2.89E-03 |
| Co | 13 | 11 | 1.02E-01 | 4.04E-01 | 7.00E-03 | 7.70E-04 | 1.05E-01 |
| Cr | 14 | 12 | 1.12E+00 | 1.12E+01 | 1.00E-01 | -1.39E-01 | 1.65E+00 |
| Cu | 13 | 11 | 9.60E-01 | 5.59E+00 | 5.30E-02 | 6.43E-03 | 8.06E-01 |
| Dy | 13 | 0 | N/A | N/A | 2.40E-03 | -1.27E-04 | <MDC |
| Er | 14 | 0 | N/A | N/A | 4.70E-03 | 8.80E-05 | <MDC |
| Eu | 13 | 9 | 7.00E-03 | 1.04E-02 | 2.70E-03 | 3.44E-04 | 9.60E-03 |
| Fe | 10 | 7 | 3.60E+00 | 2.57E+02 | 2.30E+00 | -6.94E+00 | 1.67E+02 |
| Ga | 1 | 1 | 1.26E+00 | 1.26E+00 | N/A | N/A | N/A |
| Gd | 13 | 2 | 2.15E-03 | 1.04E-02 | 1.30E-03 | 2.31E-04 | <MDC |
| Hg | 5 | 0 | N/A | N/A | 5.80E-02 | -8.07E-03 | <MDC |
| K | 12 | 12 | 1.69E+03 | 1.98E+04 | 9.10E+00 | -2.45E+01 | 1.82E+03 |
| La | 13 | 4 | 6.66E-03 | 2.22E-02 | 3.50E-03 | 1.74E-04 | <MDC |
| Li | 11 | 11 | 1.66E+01 | 2.24E+01 | 2.00E-02 | 3.46E-03 | 1.50E+01 |
| Mg | 10 | 10 | 3.02E+04 | 4.21E+04 | 2.50E+00 | 1.99E-01 | 3.66E+04 |
| Mn | 14 | 8 | 1.43E-02 | 1.77E+00 | 1.70E-02 | -3.18E-02 | 5.87E-02 |
| Mo | 10 | 9 | 1.28E+00 | 1.72E+00 | 2.50E-02 | -6.85E-03 | 1.54E+00 |
| Na | 13 | 13 | 2.33E+03 | 2.82E+04 | 1.00E+00 | 6.91E-01 | 2.11E+04 |
| Nd | 14 | 2 | 3.37E-03 | 7.68E-03 | 2.70E-03 | -1.14E-04 | <MDC |
| Ni | 13 | 12 | 1.91E+00 | 3.38E+00 | 4.10E-02 | 1.47E-03 | 2.41E+00 |

Table 6-15: Measured Concentration of Selected Inorganic Elements in Loving Drinking Water from 1998 – 2014 (continued)

| Loving | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| P | 6 | 5 | 2.46E+01 | 4.73E+01 | 3.50E+00 | -8.26E+00 | 2.58E+01 |
| Pb | 12 | 8 | 8.03E-02 | 1.67E+00 | 2.10E-03 | 9.23E-04 | 9.28E-02 |
| Pr | 14 | 0 | N/A | N/A | 9.20E-04 | 2.50E-05 | <MDC |
| Sb | 12 | 7 | 3.51E-02 | 1.84E-01 | 5.80E-03 | 1.27E-03 | 3.46E-02 |
| Sc | 10 | 9 | 1.50E+00 | 4.72E+00 | 5.20E-02 | -1.45E-02 | 1.91E+00 |
| Se | 11 | 6 | -2.89E+00 | 1.53E+00 | 1.10E+00 | -2.05E-02 | <MDC |
| Si | 8 | 8 | 9.23E+03 | 1.09E+04 | 3.10E+00 | -4.31E+00 | 9.10E+03 |
| Sr | 12 | 12 | 7.60E+01 | 9.37E+02 | 6.30E-02 | 5.70E-03 | 7.76E+02 |
| Th | 12 | 2 | 5.69E-03 | 7.38E-03 | 6.30E-03 | -1.19E-03 | <MDC |
| Tl | 13 | 2 | 2.24E-03 | 4.32E-02 | 3.30E-03 | -6.40E-05 | <MDC |
| U | 13 | 13 | 1.98E+00 | 2.30E+00 | 3.30E-03 | 3.30E-05 | 1.90E+00 |
| V | 14 | 14 | 1.11E+01 | 1.61E+01 | 5.00E-02 | -3.71E-02 | 1.20E+01 |
| Zn | 13 | 12 | 4.79E+00 | 2.01E+01 | 1.00E-01 | 1.02E-01 | 5.49E+00 |

[1]El = Element analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MD
N/A = Not Available

Table 6-16: Measured Concentration of Selected Inorganic Elements in Otis Drinking Water from 1998 - 2014

| Otis | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 11 | 1 | 2.63E-02 | 2.63E-02 | 3.35E-02 | 1.88E-04 | <MDC |
| Al | 12 | 3 | 5.74E+00 | 1.06E+03 | 5.50E-01 | 2.20E-01 | 2.69E+00 |
| As | 13 | 7 | 6.53E-01 | 2.34E+00 | 3.00E+00 | -2.35E-02 | <MDC |
| B | 3 | 3 | 1.46E+02 | 2.39E+02 | N/A | N/A | N/A |
| Ba | 10 | 9 | 1.39E+01 | 1.75E+01 | 1.25E-01 | 6.87E-03 | 1.40E+01 |
| Be | 11 | 0 | N/A | N/A | 6.00E-02 | -2.69E-03 | <MDC |
| Ca | 7 | 7 | 1.89E+05 | 3.31E+05 | 6.80E+02 | 2.96E+00 | 3.57E+05 |

Table 6-16: Measured Concentration of Selected Inorganic Elements in Otis Drinking Water from 1998 – 2014 (continued)

| Otis | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Cd | 10 | 0 | N/A | N/A | 5.00E-01 | -1.85E-01 | <MDC |
| Ce | 11 | 1 | 2.75E-02 | 2.75E-02 | 4.05E-03 | -4.15E-04 | <MDC |
| Co | 12 | 10 | 2.44E-01 | 9.51E-01 | 3.50E-02 | 7.70E-04 | 4.22E-01 |
| Cr | 13 | 11 | 8.76E-01 | 8.72E+00 | 5.00E-01 | -1.39E-01 | 8.12E-01 |
| Cu | 12 | 11 | 2.43E+00 | 6.02E+00 | 2.65E-01 | 6.43E-03 | 2.86E+00 |
| Dy | 12 | 1 | 3.39E-03 | 3.39E-03 | 1.20E-02 | -1.27E-04 | <MDC |
| Er | 12 | 0 | N/A | N/A | 2.35E-02 | 8.80E-05 | <MDC |
| Eu | 11 | 3 | 3.42E-03 | 9.48E-03 | 1.35E-02 | 3.44E-04 | <MDC |
| Fe | 10 | 9 | 2.87E+00 | 1.02E+03 | 1.15E+01 | -6.94E+00 | 8.43E+02 |
| Ga | 1 | 1 | 6.54E-01 | 6.54E-01 | N/A | N/A | N/A |
| Gd | 11 | 0 | N/A | N/A | 6.50E-03 | 2.31E-04 | <MDC |
| Hg | 5 | 1 | 3.23E-02 | 3.23E-02 | 5.80E-02 | -8.07E-03 | <MDC |
| K | 11 | 11 | 2.41E+03 | 4.01E+03 | 4.55E+01 | -2.45E+01 | 3.08E+03 |
| La | 11 | 2 | 3.36E-03 | 6.30E-03 | 1.75E-02 | 1.74E-04 | <MDC |
| Li | 10 | 10 | 3.37E+01 | 6.79E+01 | 1.00E-01 | 3.46E-03 | 4.49E+01 |
| Mg | 10 | 10 | 5.16E+04 | 1.08E+05 | 2.50E+01 | 1.99E-01 | 8.58E+04 |
| Mn | 12 | 4 | 2.00E-01 | 2.32E+00 | 8.50E-02 | -3.18E-02 | 1.98E-01 |
| Mo | 9 | 9 | 2.25E+00 | 4.42E+00 | 1.25E-01 | -6.85E-03 | 4.68E+00 |
| Na | 11 | 11 | 5.35E+04 | 1.97E+05 | 1.00E+01 | 6.91E-01 | 1.06E+05 |
| Nd | 12 | 3 | 4.80E-03 | 3.97E-02 | 1.35E-02 | -1.14E-04 | <MDC |
| Ni | 12 | 11 | 2.62E+00 | 1.11E+01 | 2.05E-01 | 1.47E-03 | 1.05E+01 |
| P | 6 | 6 | 4.54E+01 | 2.59E+02 | 1.75E+01 | -8.26E+00 | 1.40E+02 |
| Pb | 11 | 6 | 1.08E-01 | 5.98E-01 | 1.05E-02 | 9.23E-04 | 2.48E-01 |
| Pr | 12 | 0 | N/A | N/A | 4.60E-03 | 2.50E-05 | <MDC |
| Sb | 11 | 7 | 3.66E-02 | 4.10E-01 | 2.90E-02 | 1.27E-03 | 4.53E-02 |
| Sc | 10 | 8 | 6.55E-01 | 5.35E+00 | 2.60E-01 | -1.45E-02 | 2.30E+00 |
| Se | 11 | 6 | -2.43E-02 | 1.19E+00 | 5.50E+00 | -2.05E-02 | <MDC |
| Si | 8 | 8 | 9.30E+03 | 1.39E+04 | 1.55E+01 | -4.31E+00 | 1.06E+04 |
| Sr | 10 | 10 | 2.20E+03 | 4.62E+03 | 6.30E-01 | 5.70E-03 | 4.53E+03 |
| Th | 9 | 3 | 1.19E-03 | 5.11E-02 | 3.15E-02 | -1.19E-03 | <MDC |
| Tl | 11 | 1 | -6.30E-03 | -6.30E-03 | 1.65E-02 | -6.40E-05 | <MDC |

Table 6-16: Measured Concentration of Selected Inorganic Elements in Otis Drinking Water from 1998 – 2014 (continued)

| Otis | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| U | 12 | 12 | 3.73E+00 | 5.88E+00 | 1.65E-02 | 3.30E-05 | 5.62E+00 |
| V | 13 | 12 | 1.05E+01 | 1.29E+01 | 2.50E-01 | -3.71E-02 | 7.87E+00 |
| Zn | 11 | 8 | 1.54E+00 | 1.16E+01 | 5.00E-01 | 1.02E-01 | 6.85E+00 |

[1]El = Element analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-17: Measured Concentration of Selected Inorganic Elements in Malaga Drinking Water from 2011 - 2014

| Malaga | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2011-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ag | 3 | 0 | N/A | N/A | 3.35E-02 | 1.88E-04 | <MDC |
| Al | 3 | 0 | N/A | N/A | 5.50E-01 | 2.20E-01 | 2.39E+00 |
| As | 3 | 1 | 5.44E+00 | 5.44E+00 | 3.00E+00 | -2.35E-02 | <MDC |
| B | 0 | 0 | N/A | N/A | N/A | N/A | N/A |
| Ba | 3 | 3 | 1.53E+01 | 1.66E+01 | 1.25E-01 | 6.87E-03 | 1.44E+01 |
| Be | 3 | 1 | 3.04E-01 | 3.04E-01 | 6.00E-02 | -2.69E-03 | <MDC |
| Ca | 3 | 3 | 2.41E+05 | 3.51E+05 | 6.80E+02 | 2.96E+00 | 3.23E+05 |
| Cd | 3 | 0 | N/A | N/A | 5.00E-01 | -1.85E-01 | <MDC |
| Ce | 3 | 0 | N/A | N/A | 4.05E-03 | -4.15E-04 | <MDC |
| Co | 3 | 3 | 3.54E-01 | 8.57E-01 | 3.50E-02 | 7.70E-04 | 3.80E-01 |
| Cr | 3 | 3 | 1.95E+00 | 1.00E+01 | 5.00E-01 | -1.39E-01 | 5.80E-01 |
| Cu | 3 | 2 | 2.79E+00 | 3.66E+00 | 2.65E-01 | 6.43E-03 | 2.62E+00 |
| Dy | 3 | 0 | N/A | N/A | 1.20E-02 | -1.27E-04 | <MDC |
| Er | 3 | 0 | N/A | N/A | 2.35E-02 | 8.80E-05 | <MDC |
| Eu | 3 | 0 | N/A | N/A | 1.35E-02 | 3.44E-04 | <MDC |
| Fe | 3 | 3 | 5.90E+02 | 1.02E+03 | 1.15E+01 | -6.94E+00 | 9.65E+02 |

Table 6-17: Measured Concentration of Selected Inorganic Elements in Malaga Drinking Water from 2011 – 2014 (continued)

| Malaga | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2011-2013 | | | | | 2014 | | |
| EL[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Ga | 0 | 0 | N/A | N/A | N/A | N/A | N/A |
| Gd | 3 | 0 | N/A | N/A | 6.50E-03 | 2.31E-04 | <MDC |
| Hg | 3 | 0 | N/A | N/A | 5.80E-02 | -8.07E-03 | <MDC |
| K | 3 | 3 | 2.57E+03 | 3.38E+03 | 4.55E+01 | -2.45E+01 | 3.06E+03 |
| La | 3 | 0 | N/A | N/A | 1.75E-02 | 1.74E-04 | <MDC |
| Li | 3 | 3 | 4.39E+01 | 5.40E+01 | 1.00E-01 | 3.46E-03 | 3.72E+01 |
| Mg | 3 | 3 | 6.98E+04 | 9.14E+04 | 2.50E+01 | 1.99E-01 | 9.90E+04 |
| Mn | 3 | 0 | N/A | N/A | 8.50E-02 | -3.18E-02 | 8.34E-01 |
| Mo | 2 | 2 | 3.98E+00 | 3.99E+00 | 1.25E-01 | -6.85E-03 | 3.54E+00 |
| Na | 3 | 3 | 7.53E+04 | 1.02E+05 | 1.00E+01 | 6.91E-01 | 1.11E+05 |
| Nd | 3 | 0 | N/A | N/A | 1.35E-02 | -1.14E-04 | <MDC |
| Ni | 3 | 3 | 6.84E+00 | 1.06E+01 | 2.05E-01 | 1.47E-03 | 9.65E+00 |
| P | 3 | 3 | 5.64E+01 | 2.25E+02 | 1.75E+01 | -8.26E+00 | 1.69E+02 |
| Pb | 3 | 2 | 3.68E-01 | 4.81E-01 | 1.05E-02 | 9.23E-04 | 1.75E+00 |
| Pr | 3 | 0 | N/A | N/A | 4.60E-03 | 2.50E-05 | <MDC |
| Sb | 3 | 1 | 6.38E-02 | 6.38E-02 | 2.90E-02 | 1.27E-03 | 3.95E-02 |
| Sc | 2 | 2 | 1.54E+00 | 2.41E+00 | 2.60E-01 | -1.45E-02 | 2.06E+00 |
| Se | 3 | 1 | 1.65E+01 | 1.65E+01 | 5.50E+00 | -2.05E-02 | <MDC |
| Si | 3 | 3 | 9.12E+03 | 1.04E+04 | 1.55E+01 | -4.31E+00 | 9.45E+03 |
| Sr | 3 | 3 | 3.71E+03 | 3.80E+03 | 6.30E-01 | 5.70E-03 | 3.87E+03 |
| Th | 2 | 0 | N/A | N/A | 3.15E-02 | -1.19E-03 | <MDC |
| Tl | 3 | 0 | N/A | N/A | 1.65E-02 | -6.40E-05 | <MDC |
| U | 3 | 3 | 4.96E+00 | 5.38E+00 | 1.65E-02 | 3.30E-05 | 4.38E+00 |
| V | 3 | 3 | 8.70E+00 | 1.20E+01 | 2.50E-01 | -3.71E-02 | 8.30E+00 |
| Zn | 3 | 3 | 1.52E+01 | 4.64E+01 | 5.00E-01 | 1.02E-01 | 3.85E+01 |

[1]El = Element analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-18: Measured Concentration of Select Anions in Carlsbad Drinking Water from 1998 – 2014

| Carlsbad | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 7 | 0 | N/A | N/A | 1.09E+02 | 0.00E+00 | <MDC |
| Chloride | 13 | 12 | 7.83E+03 | 7.88E+04 | 9.13E+01 | 0.00E+00 | 1.72E+04 |
| Fluoride | 10 | 9 | 1.23E+02 | 8.62E+02 | 1.14E+02 | 0.00E+00 | 5.64E+02 |
| Nitrate | 14 | 14 | 3.52E+03 | 5.91E+03 | 2.43E+02 | 0.00E+00 | 4.28E+03 |
| Nitrite | 6 | 0 | N/A | N/A | 1.69E+02 | 0.00E+00 | <MDC |
| Phosphate | 14 | 0 | N/A | N/A | 2.34E+02 | 0.00E+00 | <MDC |
| Sulfate | 13 | 13 | 7.61E+04 | 1.17E+05 | 7.46E+02 | 0.00E+00 | 8.07E+04 |

[1]Anion = Anion analyzed
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values
[3]Min = the lowest value measured above MDC; Max = the highest value measured
[4]MDC = Minimum detectable concentration
[5]Concentrations below the MDC are reported as <MDC
N/A = Not Available

Table 6-19: Measured Concentration of Select Anions in Double Eagle Drinking Water from 1998 - 2014

| Double Eagle | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 7 | 3 | 9.49E+01 | 2.39E+02 | 8.70E+02 | 0.00E+00 | <MDC |
| Chloride | 14 | 14 | 2.23E+04 | 4.59E+04 | 1.83E+02 | 0.00E+00 | 4.07E+04 |
| Fluoride | 11 | 11 | 4.40E+02 | 1.36+03 | 9.08E+02 | 0.00E+00 | <MDC |
| Nitrate | 13 | 13 | 6.98E+03 | 1.46E+04 | 1.95E+02 | 0.00E+00 | 1.12E+04 |
| Nitrite | 7 | 0 | N/A | N/A | 1.35E+03 | 0.00E+00 | <MDC |
| Phosphate | 14 | 0 | N/A | N/A | 1.87E+03 | 0.00E+00 | <MDC |
| Sulfate | 14 | 14 | 3.81E+04 | 5.69E+04 | 3.73E+02 | 0.00E+00 | 4.25E+04 |

[1]Anion = Anion analyzed;
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values;
[3]Min = the lowest value measured above MDC; Max = the highest value measured;
[4]MDC = Minimum detectable concentration;
[5]Concentrations below the MDC are reported as <MDC;
N/A = Not Available

Table 6-20: Measured Concentration of Select Anions in
Hobbs Drinking Water from 1998 - 2014

| Hobbs | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 7 | 2 | 8.27E+01 | 1.84E+02 | 1.74E+02 | 0.00E+00 | <MDC |
| Chloride | 14 | 14 | 6.32E+04 | 1.07E+05 | 3.65E+02 | 0.00E+00 | 1.05E+05 |
| Fluoride | 11 | 11 | 4.91E+02 | 2.88E+03 | 1.82E+02 | 0.00E+00 | 1.22E+03 |
| Nitrate | 14 | 14 | 1.56E+04 | 2.21E+04 | 3.89E+02 | 0.00E+00 | 1.92E+04 |
| Nitrite | 7 | 0 | N/A | N/A | 2.70E+02 | 0.00E+00 | <MDC |
| Phosphate | 13 | 0 | N/A | N/A | 3.74E+02 | 0.00E+00 | <MDC |
| Sulfate | 14 | 14 | 9.60E+04 | 1.51E+05 | 7.46E+02 | 0.00E+00 | 1.41E+05 |

[1]Anion = Anion analyzed;
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values;
[3]Min = the lowest value measured above MDC; Max = the highest value measured;
[4]MDC = Minimum detectable concentration;
[5]Concentrations below the MDC are reported as <MDC;
N/A = Not Available

Table 6-21: Measured Concentration of Select Anions in
Loving Drinking Water from 1998 - 2014

| Loving | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 6 | 1 | 3.58E+01 | 3.58E+01 | 2.18E+02 | 0.00E+00 | <MDC |
| Chloride | 13 | 13 | 1.59E+04 | 3.62E+04 | 1.83E+02 | 0.00E+00 | 2.61E+04 |
| Fluoride | 10 | 8 | 1.31E+02 | 2.34E+03 | 2.27E+02 | 0.00E+00 | <MDC |
| Nitrate | 13 | 13 | 1.59E+04 | 2.91E+04 | 4.86E+02 | 0.00E+00 | 1.93E+04 |
| Nitrite | 5 | 0 | N/A | N/A | 3.38E+02 | 0.00E+00 | <MDC |
| Phosphate | 13 | 1 | 5.28E+01 | 5.28E+01 | 4.68E+02 | 0.00E+00 | <MDC |
| Sulfate | 12 | 12 | 1.28E+05 | 2.05E+05 | 7.46E+02 | 0.00E+00 | 1.27E+05 |

[1]Anion = Anion analyzed;
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values;
[3]Min = the lowest value measured above MDC; Max = the highest value measured;
[4]MDC = Minimum detectable concentration;
[5]Concentrations below the MDC are reported as <MDC;
N/A = Not Available

Table 6-22: Measured Concentration of Select Anions in Malaga Drinking Water from 1998 - 2014

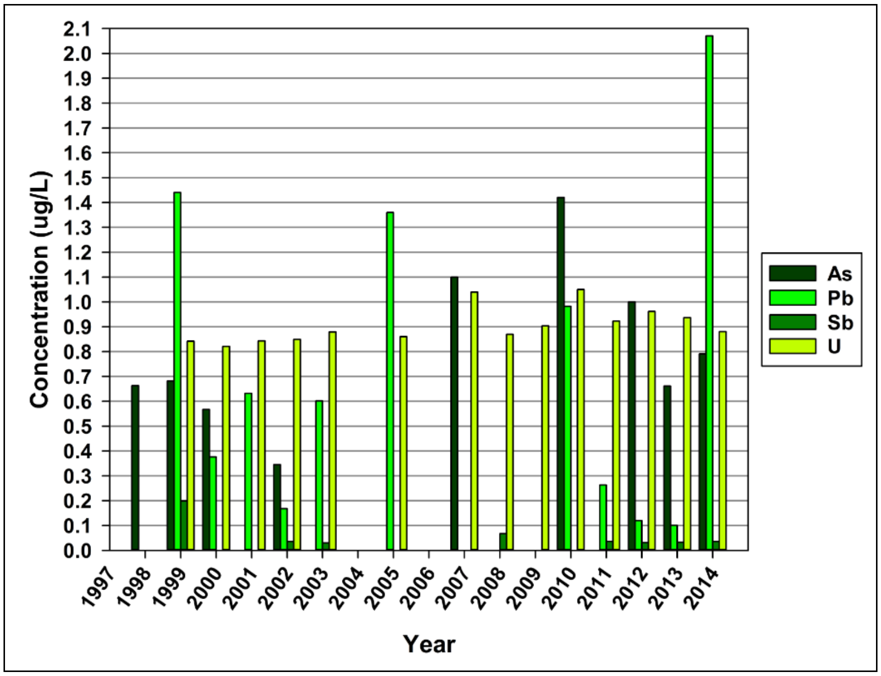
| Malaga | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 3 | 0 | N/A | N/A | 8.70E+02 | 0.00E+00 | <MDC |
| Chloride | 3 | 3 | 3.63E+05 | 4.23E+05 | 1.83E+03 | 0.00E+00 | 4.30E+05 |
| Fluoride | 3 | 0 | N/A | N/A | 9.08E+02 | 0.00E+00 | <MDC |
| Nitrate | 3 | 3 | 1.07E+04 | 2.41E+04 | 1.95E+03 | 0.00E+00 | 1.84E+04 |
| Nitrite | 3 | 0 | N/A | N/A | 1.35E+03 | 0.00E+00 | <MDC |
| Phosphate | 3 | 0 | N/A | N/A | 1.87E+03 | 0.00E+00 | <MDC |
| Sulfate | 3 | 3 | 6.73E+05 | 7.28E+05 | 3.73E+03 | 0.00E+00 | 7.98E+05 |

[1]Anion = Anion analyzed;
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values;
[3]Min = the lowest value measured above MDC; Max = the highest value measured;
[4]MDC = Minimum detectable concentration;
[5]Concentrations below the MDC are reported as <MDC;
N/A = Not Available

Table 6-23: Measured Concentration of Select Anions in Otis Drinking Water from 1998 - 2014

| Otis | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1998-2013 | | | | | 2014 | | |
| Anion[1] | N[2] | $N_{DET}$[2] | Min[3] | Max[3] | MDC[4] (µg/L) | Blank Conc. (µg/L) | Sample Conc. (µg/L)[5] |
| Bromide | 7 | 1 | 5.67E+01 | 5.67E+01 | N/A | N/A | N/A |
| Chloride | 13 | 13 | 1.26E+05 | 4.21E+05 | 9.13E+02 | 0.00E+00 | 3.73E+05 |
| Fluoride | 11 | 7 | 4.70E+02 | 1.53E+03 | 1.14E+03 | 0.00E+00 | <MDC |
| Nitrate | 14 | 14 | 9.59E+03 | 2.53E+04 | 2.43E+03 | 0.00E+00 | 2.23E+04 |
| Nitrite | 6 | 0 | N/A | N/A | 1.69E+03 | 0.00E+00 | <MDC |
| Phosphate | 14 | 0 | N/A | N/A | 2.34E+03 | 0.00E+00 | <MDC |
| Sulfate | 12 | 12 | 3.27E+05 | 8.30E+05 | 4.66E+03 | 0.00E+00 | 8.94E+05 |

[1]Anion = Anion analyzed;
[2]N = Total number of samples analyzed; $N_{det}$ = number of samples with detectable (above MDC) values;
[3]Min = the lowest value measured above MDC; Max = the highest value measured;
[4]MDC = Minimum detectable concentration;
[5]Concentrations below the MDC are reported as <MDC;
N/A = Not Available



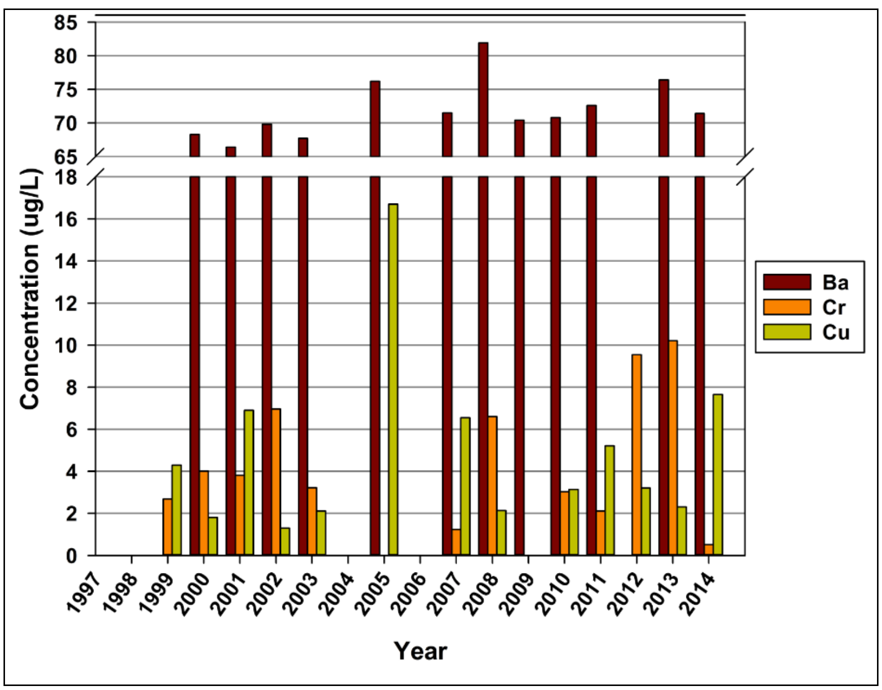
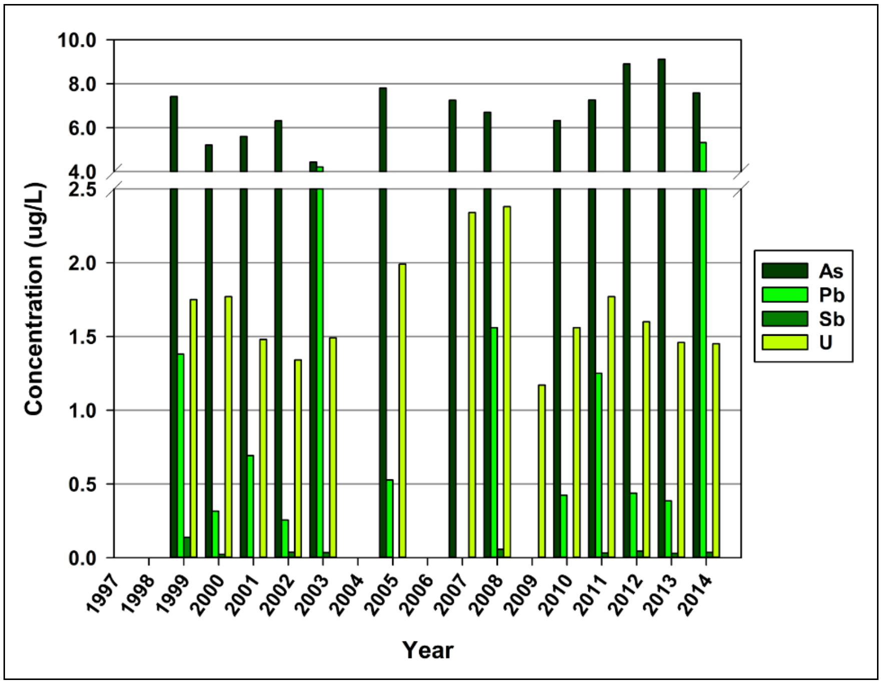




Figure 6-12: Concentrations (µg/L) of Select Inorganic Analytes Measured in Carlsbad Drinking Water from 1998 - 2014



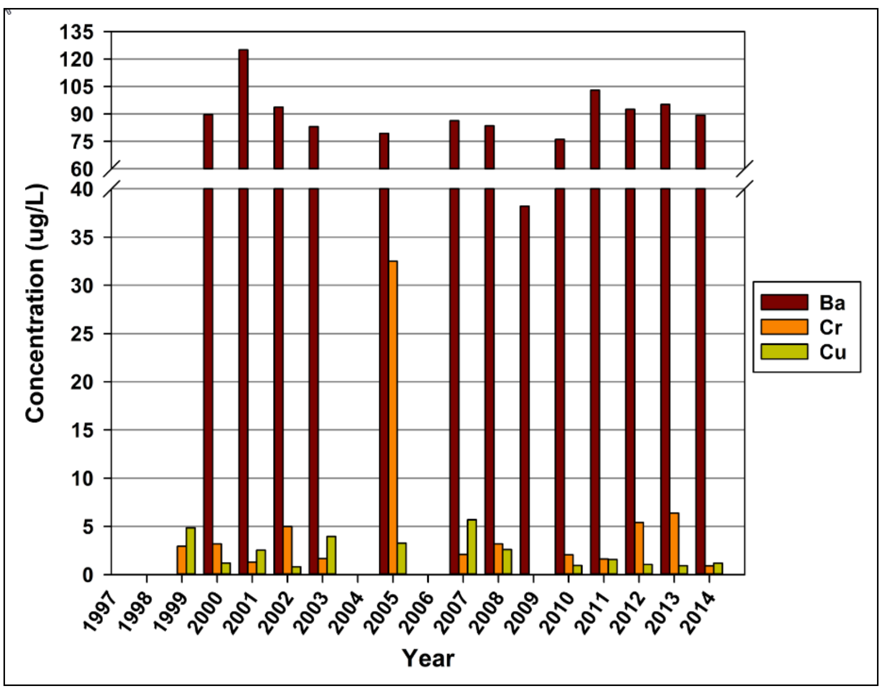
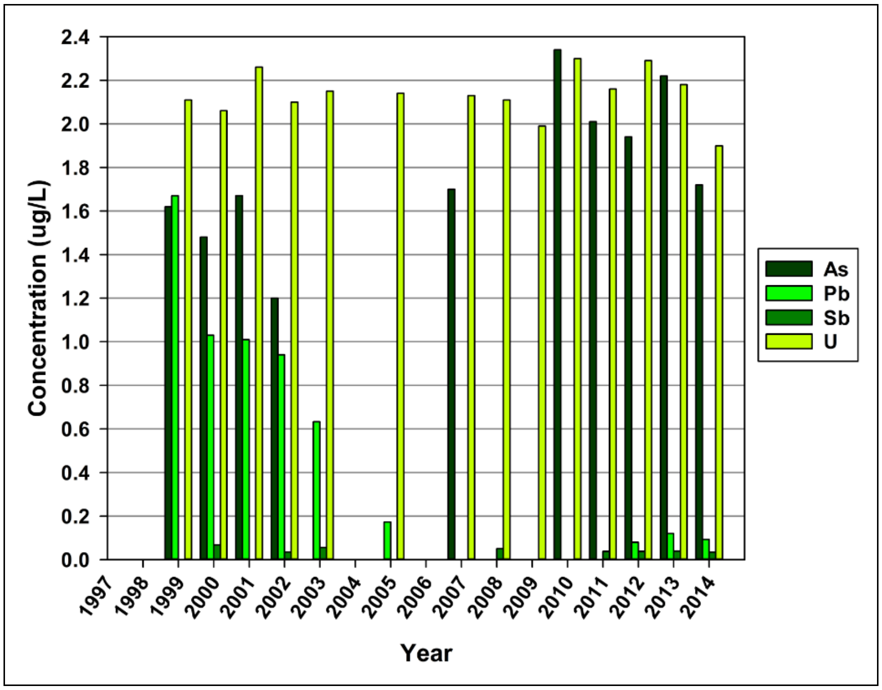




Figure 6-13: Concentrations (µg/L) of Select Inorganic Analytes Measured Near the WIPP site (Double Eagle) from 1998 - 2014



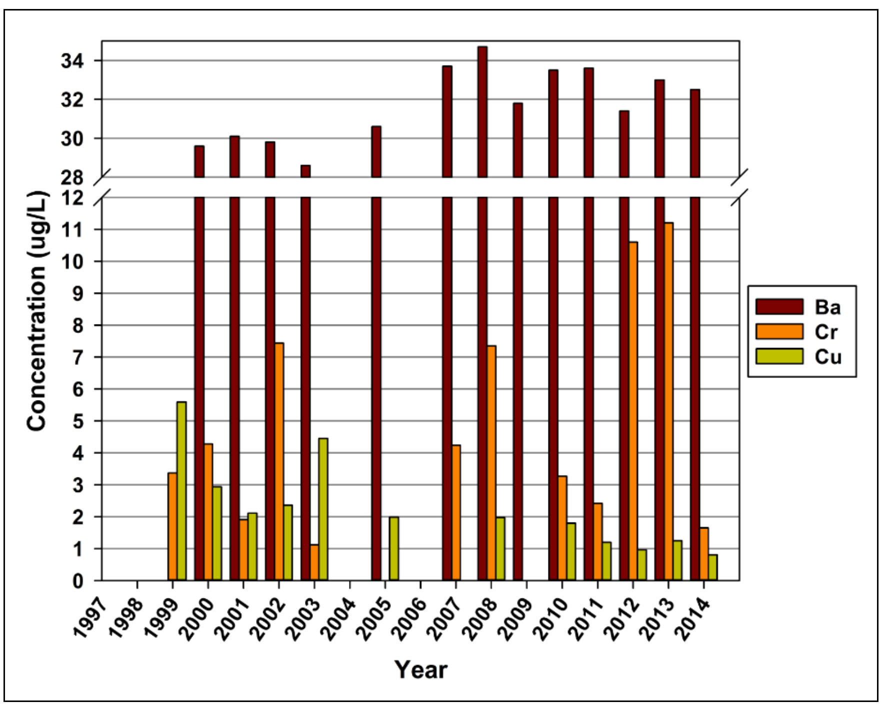
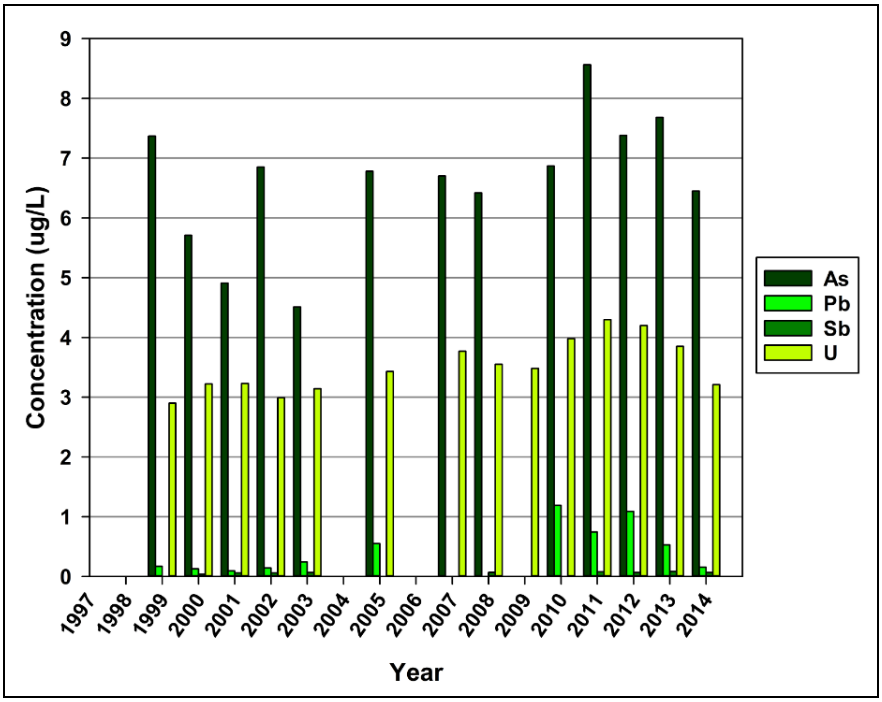




Figure 6-14: Concentrations (µg/L) of Select Inorganic Analytes Measured in Loving Drinking Water from 1998 - 2014



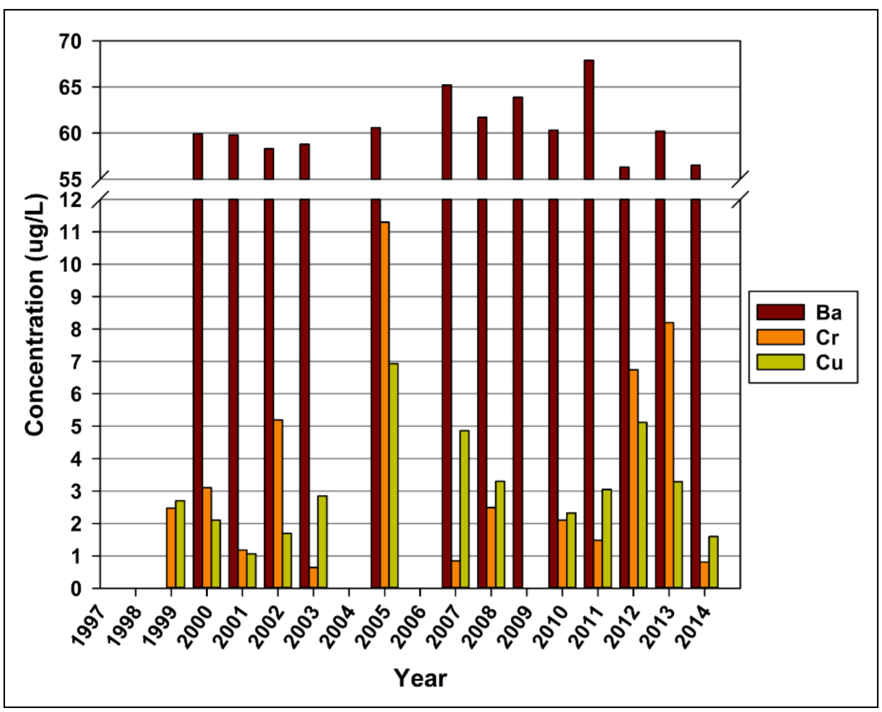
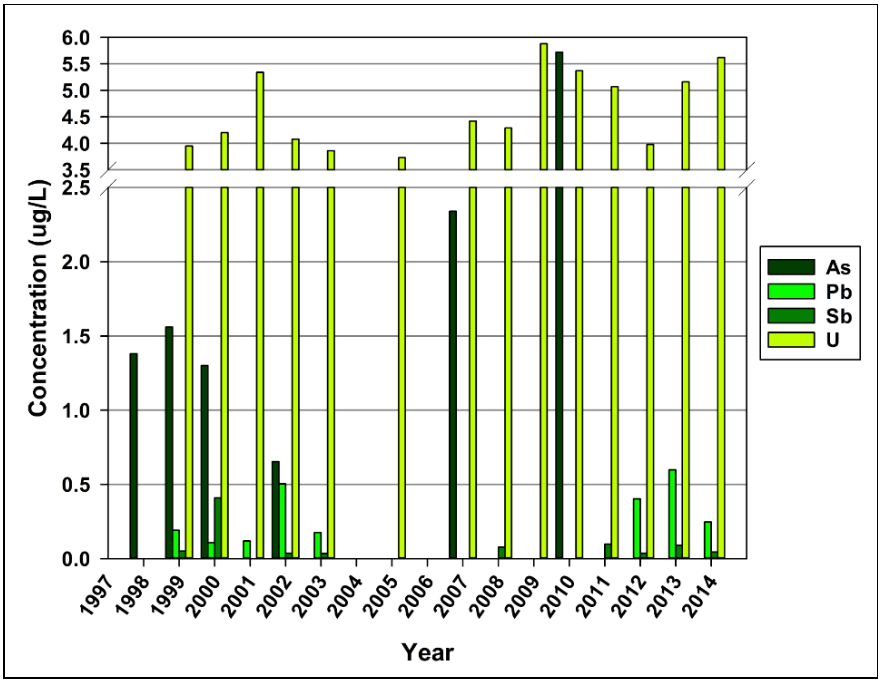




Figure 6-15: Concentrations (µg/L) of Select Inorganic Analytes Measured in Hobbs Drinking Water from 1998 - 2014



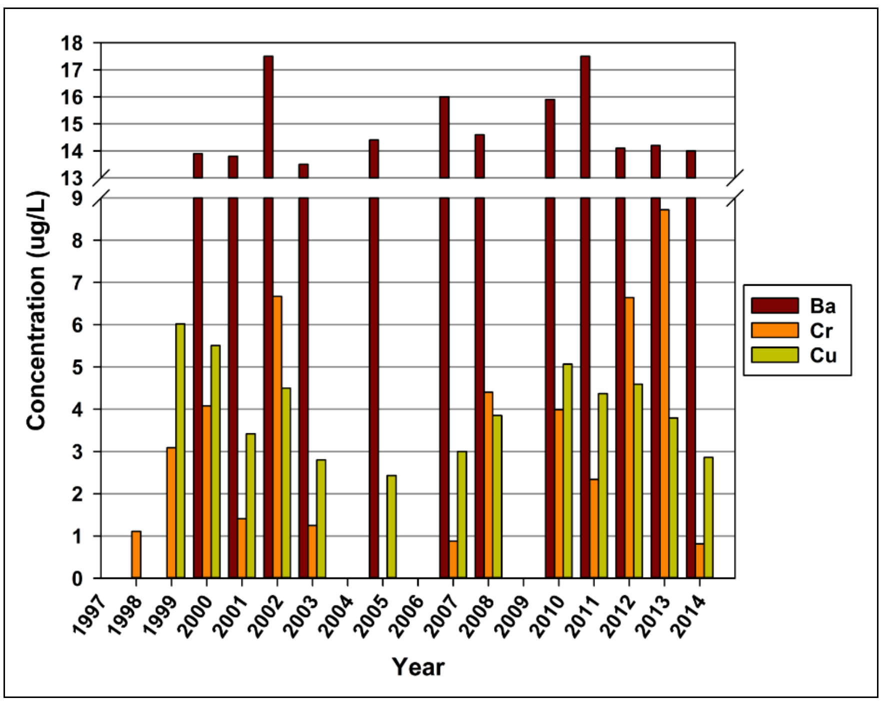
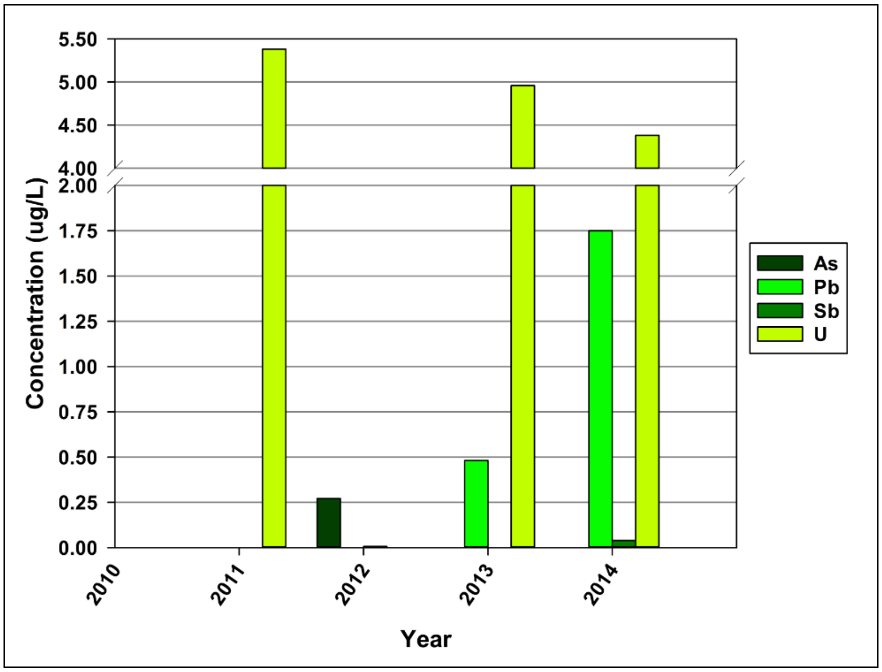




Figure 6-16: Concentrations (µg/L) of Select Inorganic Analytes Measured in Otis Drinking Water from 1998 - 2014



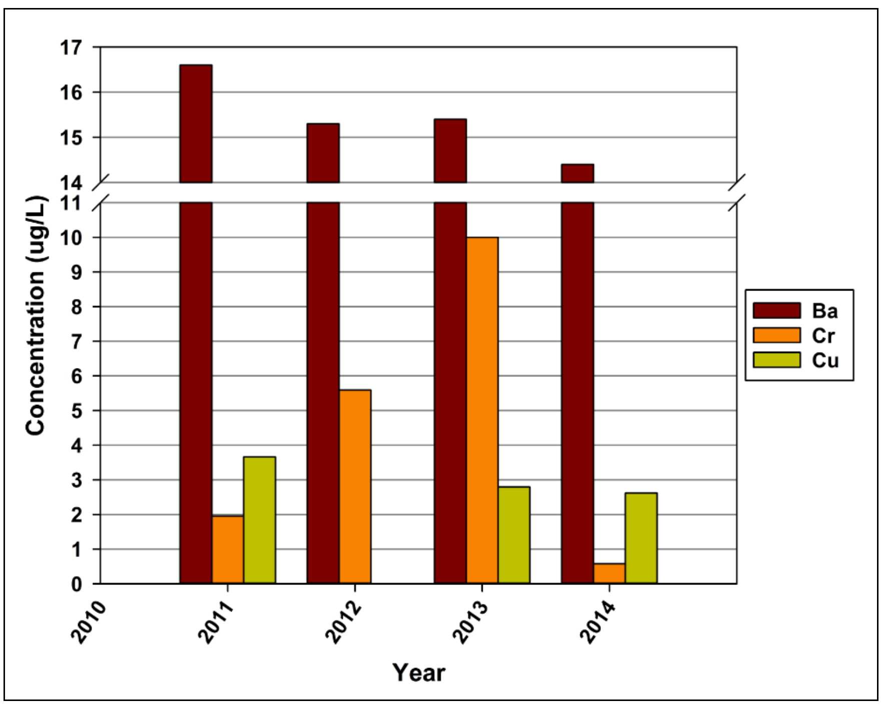




Figure 6-17: Concentrations (µg/L) of Select Inorganic Analytes Measured in Malaga Drinking Water from 2011 – 2014

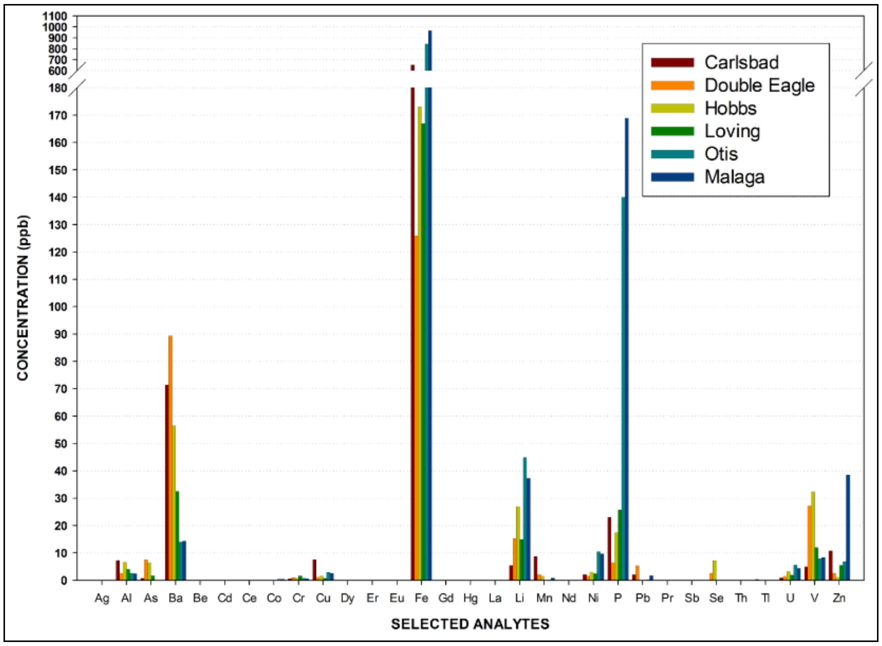



Figure 6-18: Select Metals in 2014 Drinking Water

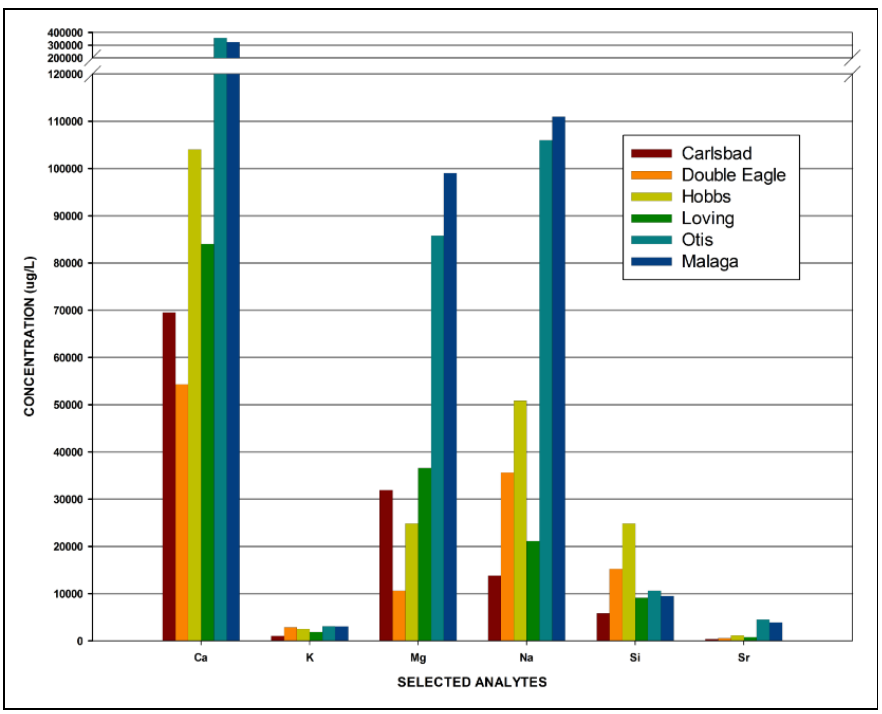



Figure 6-19: Concentrations of Common Salts in 2014 Drinking Water

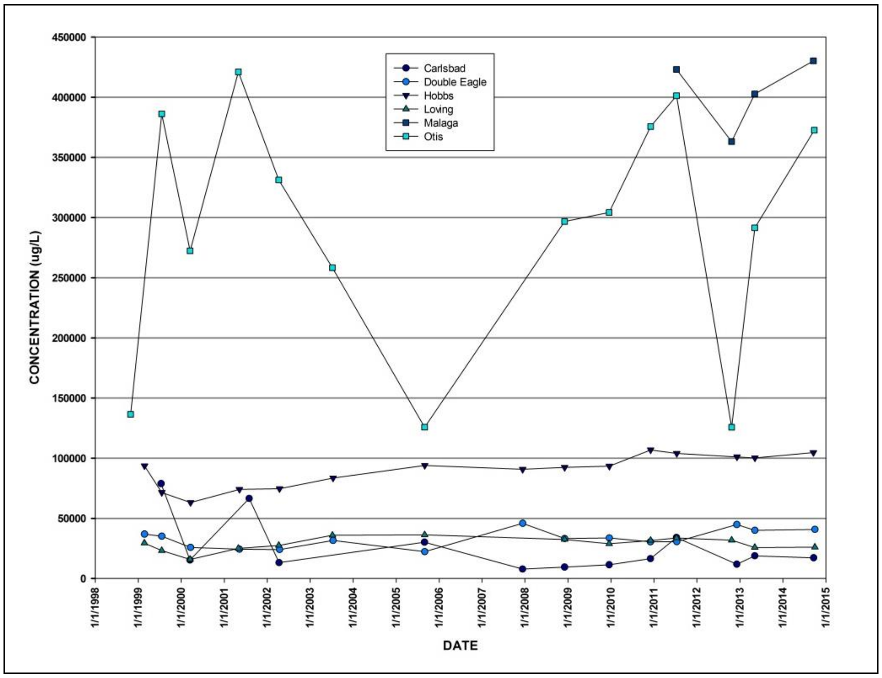



Figure 6-20: Measured Concentrations of Chloride in Drinking Water from 1998 - 2014

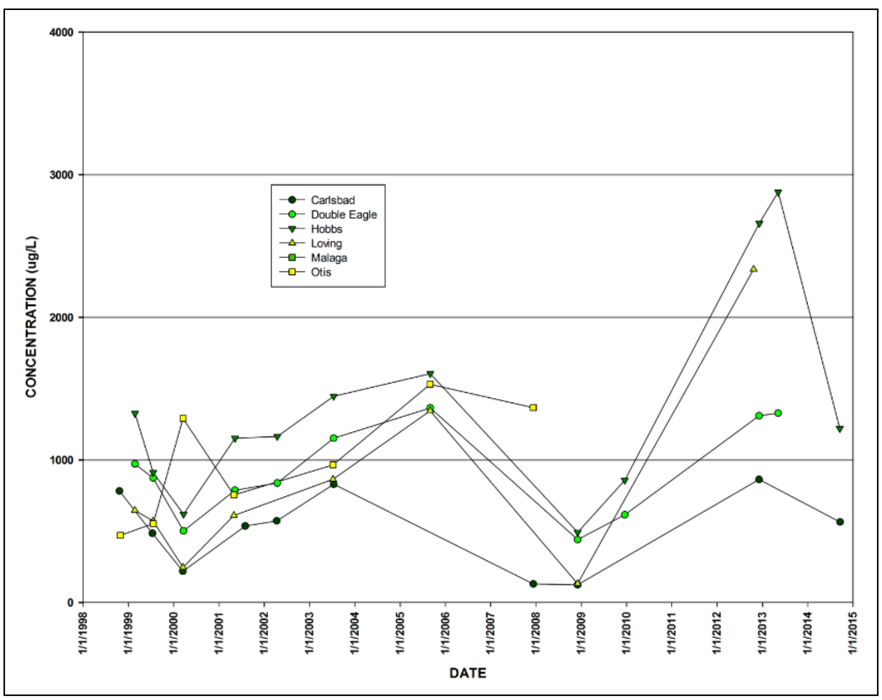



Figure 6-21: Measured Concentrations of Fluoride in Drinking Water from 1998 - 2014

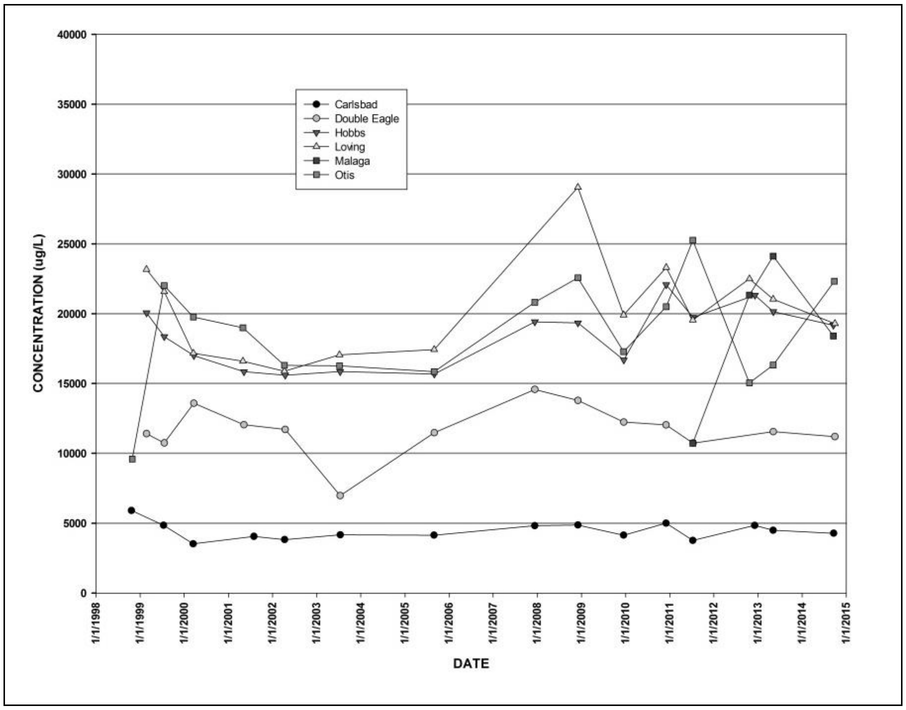



Figure 6-22: Measured Concentrations of Nitrate in Drinking Water from 1998 - 2014

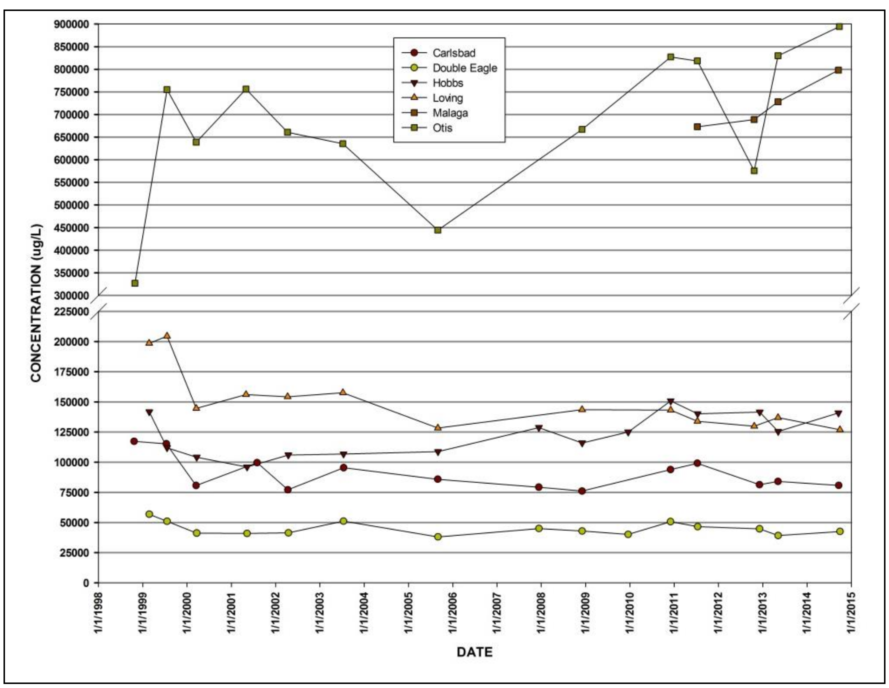



Figure 6-23: Measured Concentrations of Sulfate in Drinking Water from 1998 - 2014

# CHAPTER 7

## Whole Body Counting (Human Monitoring)

### Introduction

The "Lie Down and Be Counted" (LDBC) project monitors internally deposited radionuclides by a non-invasive in-vivo radiobioassay of the lungs and of the whole body. The LDBC project provides a scientific understanding of how low-level nuclear waste disposed may impact the residents living near the Waste Isolation Pilot Plant (WIPP) repository. This project is provided free of charge to residents living within a 100-mile radius of the WIPP site as an outreach service to the public and to support educational initiatives regarding naturally occurring and man-made radioactivity present in people, especially those living in the vicinity of the WIPP. The data collected prior to the opening of the WIPP facility (March 26, 1999) serves as a baseline for comparisons with periodic follow-up measurements that are slated to continue throughout the approximate 35-year operational phase of the WIPP project. It is important to note that the data presented in this report represent an interim summary (through December 31, 2014) of an ongoing study.

Participating in the LDBC consists of having a lung and whole body count, also referred to as an internal dosimetry (ID) measurement. The internal dosimetry activity is an *In Vivo* concept, a Latin term that means “within the living” and refers to an experimental concept that uses live organisms as opposed to dead or partial organisms. To solicit volunteers for the LDBC activity, CEMRC staff members conduct presentations to local community groups and businesses and solicit volunteers via community events. The entire measurement process takes approximately one hour and culminates with the volunteer receiving a detailed report showing the results obtained from the whole body count process. A technical staff member provides an overview of the contents of the report. A detailed description of the measurement protocol, analysis and instrument detection limits is provided in the CEMRC 1998 Report. In addition, the status of the project and results along with more detailed information are available on the CEMRC website (http://www.cemrc.org).

The Department of Energy Laboratory Accreditation Program (DOELAP) maintains the competency for dosimetry measurement laboratories by conducting performance evaluation test measurements, calibration inter-comparisons programs, and site assessments to ensure that the performance of dosimetry and radiobioassay measurements are adequate and meet the standards of Title 10, Code of Federal Regulations, Part 835, “Occupational Radiation Protection,” and related requirements and guidance. In conjunction with the WIPP site and its management and operations contractor, the CEMRC Internal Dosimetry lung and whole body counting laboratory has been DOELAP accredited since 1999. Additional information pertaining to the CEMRC ID in-vivo lung and whole body counting system information is available at http://www.cemrc.org/departments/internal-dosimetry web site.

## In-Vivo Bioassay Results

As of December 31, 2014, 1111 individuals had participated in the LDBC project. At the time the Waste Isolation Pilot Plant (WIPP) opened, 366[1] individuals had been measured using the *in vivo* protocol. This group of 366 measurements constituted the pre-operational baseline to which subsequent results are compared. Counts performed after the opening of the WIPP are considered to be a part of the operational monitoring phase of the WIPP environmental monitoring program. Figure 7-1 shows the yearly number of male, female and total number of voluntary participants counted thus far in the program period (7/21/1997 to 12/31/2014).

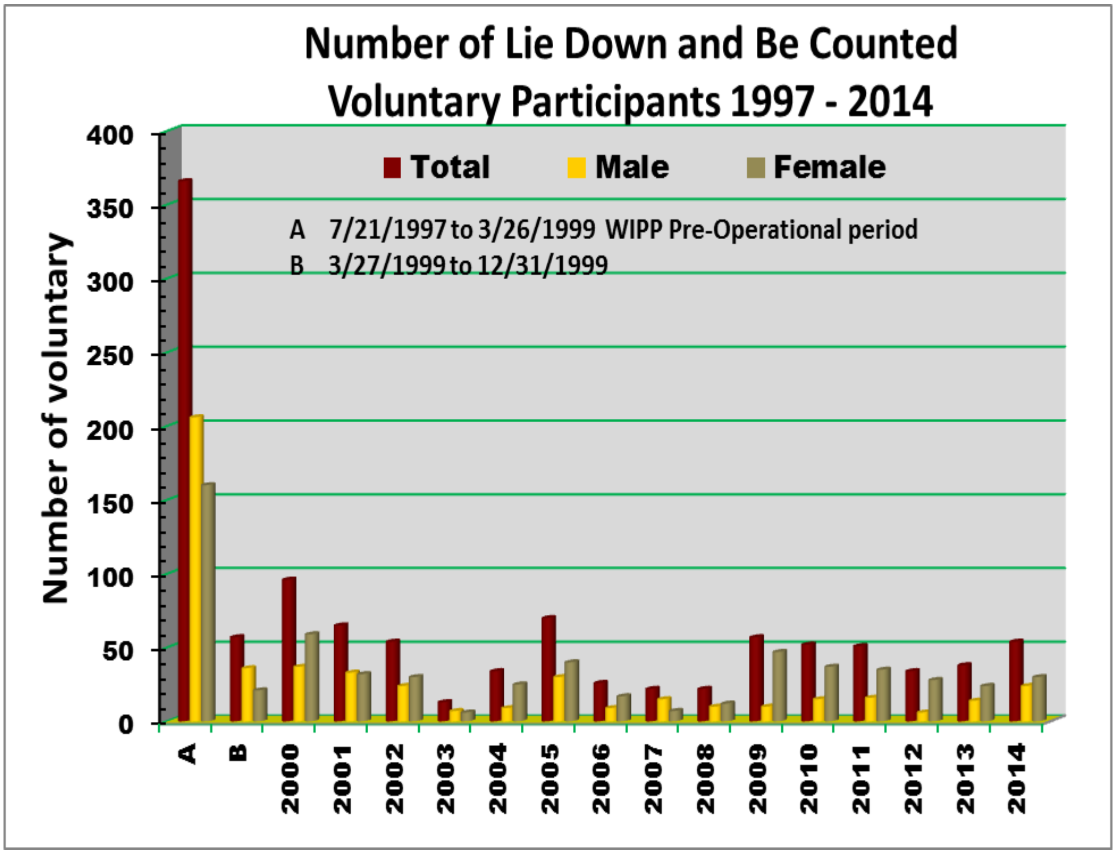



Figure 7-1: Number of LDBC voluntary participants (total and by gender) counted during the period 1997 – 2014

On February 14, 2014 an underground radiation incidence at the WIPP site resulted in a small release of radioactive contamination into the environment. In this context, the LDBC program's 17 years of valuable information can be divided into four categories, shown pictorially in Figure 7-1, and described as:

[1] This number was previously reported at 367 but that number included one test that was not part of the subject population.

1) Baseline *in vivo* analyses on public volunteers, from 1997 to 1999, prior to the opening of the Waste Isolation Pilot Plant (WIPP).
2) *In vivo* analyses performed on public and contract personnel from 1999 up to the WIPP radiation incidence on February 14, 2014
3) *In vivo* analyses performed on public and contract personnel during WIPP radiation incidence from February 14, to June 30, 2014
4) *In vivo* analyses performed on public and contract personnel after WIPP radiation incidence from July 1, 2014 to December 31, 2014.

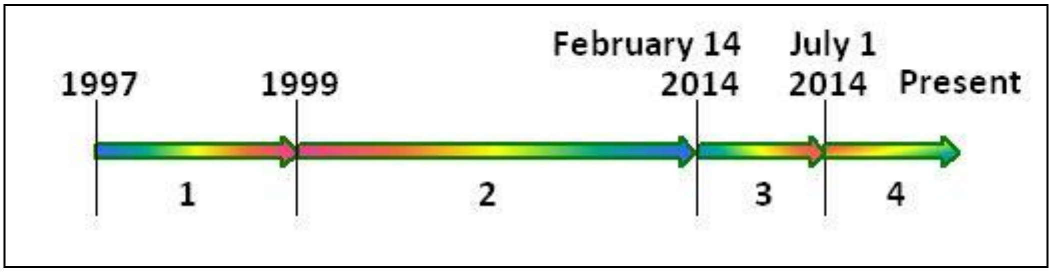



Figure 7-2: Time periods (not drawn to scale) of the LDBC *in vivo* radio-bioassay measurements of the public volunteers

An interim release event report providing the evaluation of the LDBC results is available on the CEMRC website:

*2014 Release Event Section 7: Wholebody Counting pp 109-118.*
http://www.cemrc.org/annual-reports/

In addition to the LDBC program, the CEMRC conducts *In* Vivo internal dosimetry counting services for radiation control workers in the area and has performed about 4485 counts which include baseline (in this context baseline means the first time counted at CEMRC), routine, recounts, exit, potential intake, and any other special counts on radiation trained workers in the region. Current contracts for internal dosimetry services include WIPP (Nuclear Waste Partnerships, LLC); Waste Control Specialists (WCS) of Andrews, TX; and Los Alamos National Laboratory (LANL), Carlsbad, NM; as well as CEMRC radiation workers.

Demographic characteristics (Table 7-1) of the current LDBC cohort are statistically[2] unchanged from those reported in previous CEMRC reports and are generally consistent with those reported in the 2014 census estimated for citizens living in Carlsbad. The largest deviation between the LDBC cohort and population estimated by the 2014 census is under-sampling of Latinos. 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.

[2] The statistics reported for the bioassay program assume that the individuals participating are a random sample of the population. Given that the bioassay program relies on voluntary participation, randomness of the sample cannot be assured and, as is discussed later, sampling appears to be biased by ethnicity.

For the purposes of the LDBC program, baseline monitoring is held constant and includes only the initial count of individuals made prior to March 26, 1999. Seven people were recounted during the baseline interval but these data are not reported in order to remain consistent with previous reports. Likewise, operational monitoring includes the counting of new volunteers and the recounting of previously measured participants that have occurred since the repository began accepting waste on March 27, 1999. Based on the data reported herein, there is no evidence of any increase in the frequency of detection of internally-deposited radionuclides for citizens living within the vicinity of the WIPP since the WIPP began receiving radioactive waste.

As discussed in detail in the CEMRC 1998 Report and elsewhere (Webb and Kirchner, 2000), the criterion, $L_C$, was used to evaluate whether a result exceeded background as the use of this criterion will result in a statistically inherent 5% false-positive error rate per pair-wise comparison (i.e. 5% of all measurements will be determined to be positive when there is no activity present in the person). The radionuclides being investigated by the CEMRC Internal Dosimetry group and their minimum detectable activities are listed in Tables 7-2A through 7-2F for the 2012-2015 timeframe which coincides with the current DOELAP accreditation period.

For the baseline measurements (see Table 7-3, 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 $^{228}Ac$ (see Tables 7-2A through 7-2F). As discussed in detail 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. $^{40}K$ is a naturally occurring isotope of an essential biological element, so detection in all individuals is expected. $^{137}Cs$ and $^{235}U$ / $^{226}Ra$ 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 monitoring counts (see Table 7-3, N = 1049), the percentage of results greater than $L_C$ were consistent with 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 $^{60}Co$, since the radionuclide has a relatively short half-life (5.2 years) and the content of $^{60}Co$ within the shield has decreased via decay by approximately 80% since the baseline phase of monitoring. Additionally, 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 (tends to contain Th and U) in some of the detector cryostat components with those manufactured from low radiation background steel.

$^{40}K$ results, from July 22, 1997 to December 31, 2014, were positive for all participants, and ranged from 868 to 5559 Bq per person with an overall average (± Std. Err.) of 2443 (± 22) Bq per person. Such results are expected since K is an essential biological element contained primarily in muscle. Therefore, $^{40}K$, the radioactive isotope, is the theoretical constant fraction of all naturally occurring K. $^{40}K$ average value (± Std. Err.), was 3039 (± 26) Bq per person for males, which was significantly greater ($p < 0.0001$) than that of females, which was 1883 (± 17) Bq per person. This result was expected since; in general, males tend to have larger body sizes and greater muscle content than females.

For citizens living around Carlsbad area, 95% confidence level detectable $^{137}Cs$ is present in 18.1% (with margin of error 16.9% to 19.3%) for operational monitoring counts for the period March 27, 1999 through December 31, 2014; and in 28.4% (with margin of error 26.1% to 30.8%) for the baseline period prior to March 27, 1999. These results are in the same range with findings previously reported in CEMRC reports and elsewhere (Webb and Kirchner, 2000). From July 22, 1997 to December 31, 2014, detectable $^{137}Cs$ body burdens ranged from 5 to 128 Bq per person with an overall average (± Std. Err.) of 10.8 (± 0.6) Bq per person. The average $^{137}Cs$ body burden (± Std. Err.), was 10.9 (± 0.6) Bq for males per person. The average body burden for female was also 10.5 (± 1.3) Bq per person. Reports such as previous CEMRC Reports and Webb & Kirchner(2000, provide initial correlation studies of detectable $^{137}Cs$ with parameters like age, ethnicity, European travel, gender, consumption of wild game, nuclear medical treatments, radiation work history, and smoking. A follow-up analysis of over 15 years of accumulated data is currently under progress and will be reported in a future CEMRC annual report.

$^{40}K$ and $^{137}Cs$ results, from July 22, 1997 to December 31, 2014, of LDBC voluntary participants through December 2014 are shown in Figures 7-3 through 7-6.

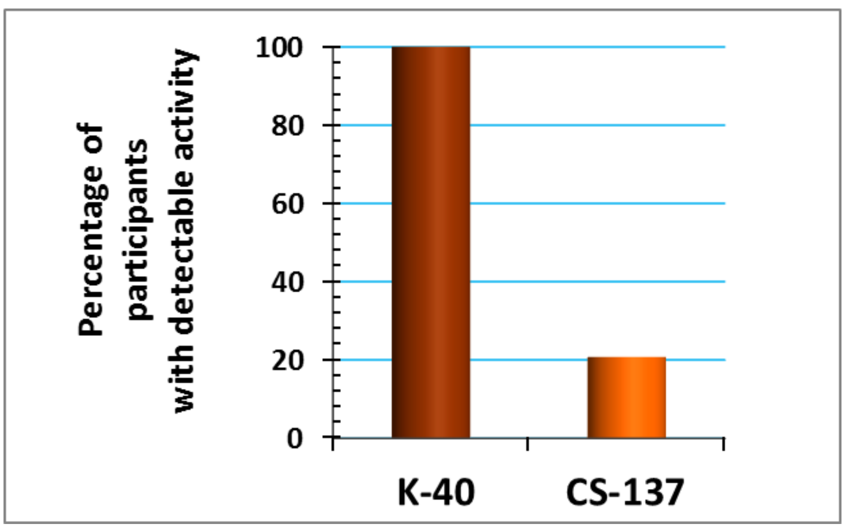



Figure 7-3: Percentage of voluntary participants with detectable $^{40}K$ and $^{137}Cs$ activities from July 22, 1997 to December 31, 2014

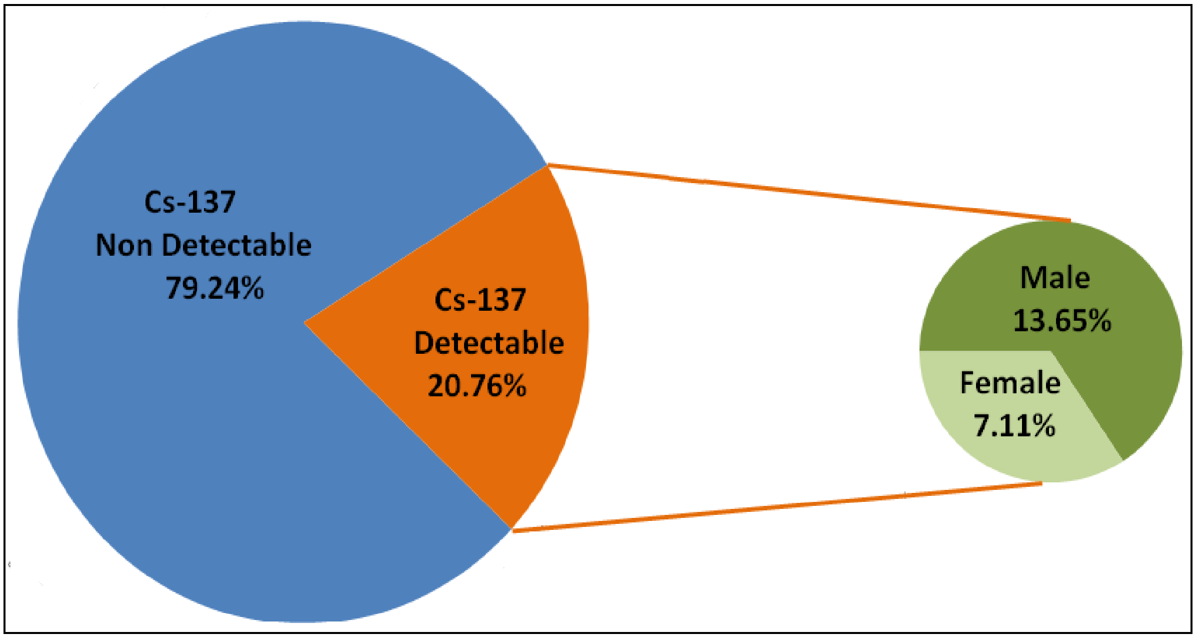



Figure 7-4: Percentage of voluntary participants with detectable $^{137}$Cs activity from July 22, 1997 to December 31, 2014. (This figure displays the total percentage of participants with detectable $^{137}$Cs activity and the percentage of participants with detectable $^{137}$Cs activity by gender)

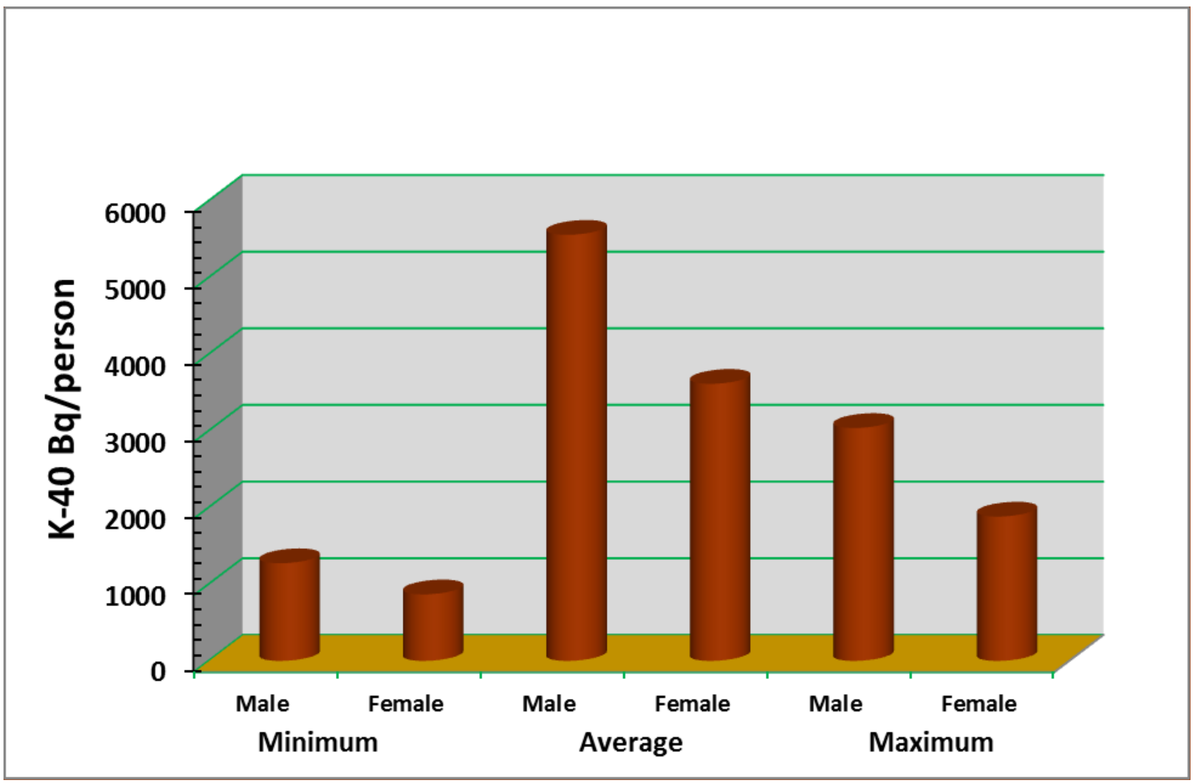



Figure 7-5: Minimum, average, and maximum $^{40}$K activity for participants, separated by gender, from July 22, 1997 to December 31, 2014

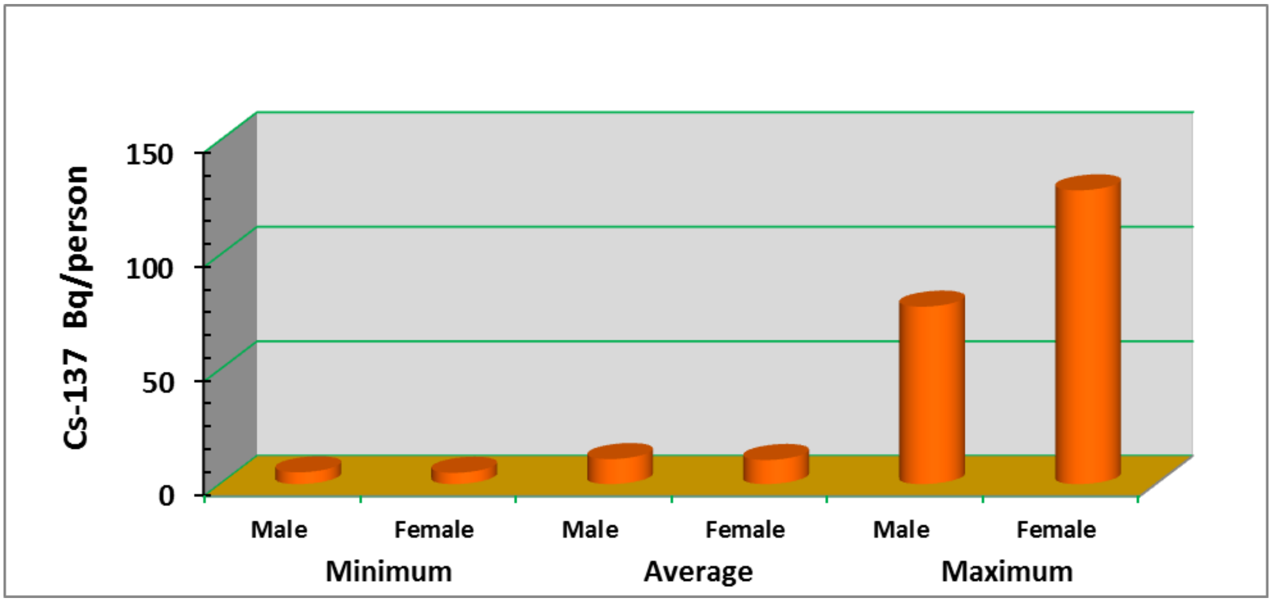



Figure 7-6: Minimum, average, and maximum $^{137}$Cs activity for participants, separated by gender, through December 2014

As reported in previous CEMRC reports, the percentage of results greater than $L_C$ for $^{235}$U/$^{226}$Ra (11 %) are 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. Although $^{235}$U and $^{226}$Ra cannot be differentiated via gamma spectroscopy, it is likely that the signal observed is the result of $^{226}$Ra because the natural abundance of $^{226}$Ra is much greater than that of $^{235}$U. This finding shows the necessity of further research and procedural development needed to further enhance the detection capability of the CEMRC Internal Dosimetry group.

Lastly, these results, particularly with no significant variation in the percentage of public participants with detectable levels of plutonium, suggest that there have been no observable health-related effects from WIPP on the citizens living within a 100-mile radius of the WIPP repository.

Table 7-1: Demographic Characteristics of the
"Lie Down and Be Counted"
Population Sample through December 31, 2014

| Characteristic | | 2014 Sample Group[a] (margin of error) | Census 2010[b,c] | | Census 2014[d] Estimates | |
|---|---|---|---|---|---|---|
| | | | NM | US | NM | US |
| Gender | Male | 45.1% (43.6 to 46.6%) | 49.4% | 49.1% | 49.5% | 49.2% |
| | Female | 54.9% (53.4 to 56.4%) | 50.6% | 50.9% | 50.5% | 50.8% |
| Ethnicity | Latino | 22.8% (21.5 to 24.0%) | 46.3% | 16.3% | 47.7% | 17.4% |
| | Non-Latino | 77.2% (76.0 to 78.5%) | 53.7% | 83.7% | 52.3% | 82.6% |
| Age 65 years or over | | 28.8% (27.5 to 30.1%) | 13.2% | 13.0% | 15.3% | 14.5% |
| Currently or previously classified as a radiation worker | | 8.1% (7.3 to 8.9%) | NA | NA | NA | NA |
| Consumption of wild game within 3 months prior to count | | 20.6% (19.4 to 21.8%) | NA | NA | NA | NA |
| Medical treatment other than X-rays using radionuclides | | 6.6% (5.8 to 7.3%) | NA | NA | NA | NA |
| European travel within 2 years prior to the count | | 3.7% (3.1 to 4.2%) | NA | NA | NA | NA |
| Current smoker | | 15.5% (14.4 to 16.5%) | N/A | NA | 16%-18.9%[e] | 12.5%[e] |

[a] The margin of error represents the 95% confidence interval of the observed proportion; under complete replication of this experiment, one would expect the confidence interval to include the true population proportion 95% of the time if the sample was representative of the true population.
[b] Chapter 3: Table 3.1 in Carlsbad Environmental Monitoring and Research Center 2012 Annual Report, http://www.cemrc.org/annual-reports
[c] http://www.census.gov/prod/cen2010/briefs/c2010br-03.pdf US Census 2010, US.
[d] 2014 Population Estimates, http://quickfacts.census.gov/qfd/states/35000.html
[e] http://www.cdc.gov/vitalsigns/Adultsmoking/index.html#StateInfo US Center for Disease Control, 2011, US (Web site accessed October 9, 2015).

Table 7-2A: Minimum Detectable Activities
2012-2013 Calibration (4 Lung detectors)

| **Radionuclides Deposited in the Lungs** | | **Chest Wall Thickness** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **1.6 cm** | **2.22 cm** | **3.01 cm** | **3.33 cm** | **4.18 cm** | **5.1 cm** | **6.0 cm** |
| **Radionuclide** | **Energy (keV)** | **MDA (nCi)** | | | | | | |
| Am-241 | 59.5 | 0.16 | 0.20 | 0.26 | 0.29 | 0.40 | 0.57 | 0.79 |
| Ce-144 | 133.5 | 0.39 | 0.48 | 0.60 | 0.66 | 0.86 | 1.13 | 1.48 |
| Cf-252 | 19.2 | 14.65 | 29.52 | 71.94 | 103 | 268 | 755 | 2082 |
| Cm-244 | 18.1 | 12.32 | 26.56 | 71.03 | 105 | 303 | 947 | 2902 |
| Eu-155 | 105.3 | 0.22 | 0.27 | 0.35 | 0.39 | 0.51 | 0.69 | 0.93 |
| Np-237 | 86.5 | 0.37 | 0.46 | 0.61 | 0.68 | 0.91 | 1.25 | 1.71 |
| Pu-238 | 17.1 | 15.48 | 36.16 | 107 | 166 | 531 | 1877 | 6441 |
| Pu-239 | 17.1 | 38.52 | 89.97 | 266 | 413 | 1321 | 4669 | 16025 |
| Pu-240 | 17.1 | 15.13 | 35.35 | 104 | 162 | 519 | 1834 | 6295 |
| Pu-242 | 17.1 | 18.26 | 42.64 | 126 | 196 | 626 | 2213 | 7594 |
| Ra-226 | 186.1 | 1.30 | 1.53 | 1.89 | 2.06 | 2.58 | 3.29 | 4.18 |
| Th-232 via Pb-212 | 238.6 | 0.11 | 0.13 | 0.16 | 0.17 | 0.22 | 0.28 | 0.36 |
| Th-232 | 59 | 24.03 | 30.13 | 40.40 | 45.50 | 62.31 | 87.74 | 123 |
| Th-232 via Th-228 | 84.3 | 3.54 | 4.40 | 5.79 | 6.47 | 8.69 | 11.98 | 16.38 |
| U-233 | 440.3 | 0.54 | 0.63 | 0.77 | 0.83 | 1.03 | 1.29 | 1.62 |
| U-235 | 185.7 | 0.08 | 0.09 | 0.12 | 0.13 | 0.16 | 0.20 | 0.26 |
| Nat U via Th-234 | 63.3 | 1.24 | 1.56 | 2.08 | 2.34 | 3.19 | 4.47 | 6.22 |

Table 7-2B: Minimum Detectable Activities
Whole Body data (3 detectors) during 12/1/2011 to 11/22/2012

| **Radionuclides Deposited in the Whole Body** | | |
|---|---|---|
| Nuclide | Energy (keV) | MDA (nCi) |
| Ba-133 | 356 | 0.74 |
| Ba-140 | 537 | 1.56 |
| Ce-141 | 145 | 1.23 |
| Co-58 | 811 | 0.39 |
| Co-60 | 1333 | 0.39 |
| Cr-51 | 320 | 3.74 |
| Cs-134 | 604 | 0.33 |
| Cs-137 | 662 | 0.49 |
| Eu-152 | 344 | 1.42 |
| Eu-154 | 1275 | 1.05 |
| Eu-155 | 105 | 2.63 |
| Fe-59 | 1099 | 0.68 |
| I-131 | 365 | 0.43 |
| I-133 | 530 | 0.46 |
| Ir-192 | 317 | 0.42 |
| Mn-54 | 835 | 0.50 |
| Ru-103 | 497 | 0.40 |
| Ru-106 | 622 | 3.36 |
| Sb-125 | 428 | 1.26 |
| Th-232 via Ac-228 | 911 | 1.37 |
| Y-88 | 898 | 0.39 |
| Zn-65 | 1116 | 1.31 |
| Zr-95 | 757 | 0.61 |

Table 7-2C: Minimum Detectable Activities
2013-2014 Calibration (4 Lung detectors)

| Radionuclides Deposited in the Lungs | | Chest Wall Thickness | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1.6 cm | 2.22 cm | 3.01 cm | 3.33 cm | 4.18 cm | 5.1 cm | 6.0 cm |
| **Radionuclide** | **Energy (keV)** | **MDA (nCi)** | | | | | | |
| Am-241 | 59.5 | 0.18 | 0.23 | 0.30 | 0.34 | 0.46 | 0.64 | 0.88 |
| Ce-144 | 133.5 | 0.47 | 0.56 | 0.71 | 0.78 | 1.00 | 1.31 | 1.71 |
| Cf-252 | 19.2 | 16.84 | 34.18 | 84.20 | 121 | 320 | 912 | 2541 |
| Cm-244 | 18.1 | 15.94 | 34.70 | 93.62 | 140 | 407 | 1288 | 3986 |
| Eu-155 | 105.3 | 0.27 | 0.33 | 0.43 | 0.48 | 0.62 | 0.84 | 1.12 |
| Np-237 | 86.5 | 0.49 | 0.60 | 0.78 | 0.87 | 1.15 | 1.57 | 2.13 |
| Pu-238 | 17.1 | 17.27 | 40.68 | 121 | 189 | 612 | 2191 | 7615 |
| Pu-239 | 17.1 | 42.98 | 101 | 302 | 471 | 1523 | 5451 | 18947 |
| Pu-240 | 17.1 | 16.88 | 39.76 | 119 | 185 | 598 | 2142 | 7443 |
| Pu-242 | 17.1 | 20.37 | 47.97 | 143 | 223 | 722 | 2584 | 8979 |
| Ra-226 | 186.1 | 1.63 | 1.92 | 2.36 | 2.57 | 3.22 | 4.10 | 5.20 |
| Th-232 via Pb-212 | 238.6 | 0.15 | 0.17 | 0.22 | 0.23 | 0.29 | 0.38 | 0.48 |
| Th-232 | 59 | 33.62 | 42.03 | 55.97 | 62.80 | 85.48 | 119 | 165 |
| Th-232 via Th-228 | 84.3 | 4.81 | 5.90 | 7.71 | 8.61 | 11.47 | 15.67 | 21.22 |
| U-233 | 440.3 | 0.66 | 0.76 | 0.93 | 1.00 | 1.22 | 1.53 | 1.91 |
| U-235 | 185.7 | 0.10 | 0.12 | 0.15 | 0.16 | 0.20 | 0.25 | 0.32 |
| Nat U via Th-234 | 63.3 | 1.61 | 2.00 | 2.66 | 2.98 | 4.03 | 5.59 | 7.72 |

Table 7-2D: Minimum Detectable Activities
2013-2014 Calibration (4 Whole Body detectors)

| Radionuclides Deposited in the Whole Body | | |
|---|---|---|
| **Nuclide** | **Energy (keV)** | **MDA (nCi)** |
| Ba-133 | 356 | 0.81 |
| Ba-140 | 537 | 1.59 |
| Ce-141 | 145 | 1.69 |
| Co-58 | 811 | 0.38 |
| Co-60 | 1333 | 0.37 |
| Cr-51 | 320 | 4.65 |
| Cs-134 | 604 | 0.37 |
| Cs-137 | 662 | 0.43 |
| Eu-152 | 344 | 1.67 |
| Eu-154 | 1275 | 0.99 |
| Eu-155 | 105 | 4.00 |
| Fe-59 | 1099 | 0.69 |
| I-131 | 365 | 0.50 |
| I-133 | 530 | 0.44 |
| Ir-192 | 317 | 0.57 |
| Mn-54 | 835 | 0.46 |
| Ru-103 | 497 | 0.42 |
| Ru-106 | 622 | 3.44 |
| Sb-125 | 428 | 1.40 |
| Th-232 via Ac-228 | 911 | 1.30 |
| Y-88 | 898 | 0.39 |
| Zn-65 | 1116 | 1.15 |
| Zr-95 | 757 | 0.62 |

Table 7-2E: Minimum Detectable Activities
2014-2015 Calibration (4 Lung detectors)

| Radionuclides Deposited in the Lungs | | Chest Wall Thickness | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1.6 cm | 2.22 cm | 3.01 cm | 3.33 cm | 4.18 cm | 5.1 cm | 6.0 cm |
| Radionuclide | Energy (keV) | MDA (nCi) | | | | | | |
| Am-241 | 59.5 | 0.18 | 0.23 | 0.30 | 0.33 | 0.45 | 0.61 | 0.84 |
| Ce-144 | 133.5 | 0.49 | 0.56 | 0.70 | 0.77 | 0.98 | 1.26 | 1.63 |
| Cf-252 | 19.2 | 19.32 | 34.76 | 84.13 | 120 | 311 | 870 | 2382 |
| Cm-244 | 18.1 | 17.33 | 35.17 | 93.85 | 139 | 399 | 1249 | 3813 |
| Eu-155 | 105.3 | 0.27 | 0.33 | 0.43 | 0.47 | 0.61 | 0.82 | 1.08 |
| Np-237 | 86.5 | 0.46 | 0.60 | 0.78 | 0.86 | 1.14 | 1.53 | 2.06 |
| Pu-238 | 17.1 | 17.66 | 41.54 | 123 | 191 | 616 | 2183 | 7503 |
| Pu-239 | 17.1 | 43.94 | 103 | 305 | 475 | 1532 | 5432 | 18667 |
| Pu-240 | 17.1 | 17.26 | 40.61 | 120 | 187 | 602 | 2134 | 7334 |
| Pu-242 | 17.1 | 20.82 | 48.98 | 145 | 225 | 726 | 2574 | 8847 |
| Ra-226 | 186.1 | 1.83 | 1.93 | 2.34 | 2.53 | 3.12 | 3.92 | 4.90 |
| Th-232 via Pb-212 | 238.6 | 0.15 | 0.18 | 0.22 | 0.23 | 0.29 | 0.37 | 0.46 |
| Th-232 | 59 | 32.49 | 42.13 | 55.43 | 61.84 | 83.00 | 114 | 155 |
| Th-232 via Th-228 | 84.3 | 4.54 | 5.95 | 7.68 | 8.53 | 11.25 | 15.23 | 20.41 |
| U-233 | 440.3 | 0.67 | 0.77 | 0.92 | 0.99 | 1.21 | 1.50 | 1.85 |
| U-235 | 185.7 | 0.11 | 0.12 | 0.14 | 0.16 | 0.19 | 0.24 | 0.30 |
| Nat U via Th-234 | 63.3 | 1.52 | 2.01 | 2.62 | 2.92 | 3.90 | 5.33 | 7.24 |

Table 7-2F: Minimum Detectable Activities
2014-2015 (4 Whole Body detectors)

| Radionuclides Deposited in the Whole Body | | |
|---|---|---|
| **Nuclide** | **Energy (keV)** | **MDA (nCi)** |
| Ba-133 | 356 | 0.82 |
| Ba-140 | 537 | 1.59 |
| Ce-141 | 145 | 1.67 |
| Co-58 | 811 | 0.38 |
| Co-60 | 1333 | 0.37 |
| Cr-51 | 320 | 4.74 |
| Cs-134 | 604 | 0.37 |
| Cs-137 | 662 | 0.44 |
| Eu-152 | 344 | 1.69 |
| Eu-154 | 1275 | 0.99 |
| Eu-155 | 105 | 3.89 |
| Fe-59 | 1099 | 0.70 |
| I-131 | 365 | 0.50 |
| I-133 | 530 | 0.44 |
| Ir-192 | 317 | 0.57 |
| Mn-54 | 835 | 0.46 |
| Ru-103 | 497 | 0.42 |
| Ru-106 | 622 | 3.47 |
| Sb-125 | 428 | 1.41 |
| Th-232 via Ac-228 | 911 | 1.30 |
| Y-88 | 898 | 0.39 |
| Zn-65 | 1116 | 1.15 |
| Zr-95 | 757 | 0.62 |

Table 7-3: "Lie Down and Be Counted"
Results through December 31, 2014

| Radionuclide | *In Vivo* Count Type | Baseline Counts[c] (margin of error) (data prior to 27 March 1999) [a]N = 366 | Operational Monitoring Counts[e] (margin of error) (27 March 1999 – 31 December 2014) N = 1049 |
|---|---|---|---|
| | | % of Results ≥ $^{b}L_C$ | % of Results ≥ $^{b}L_C$ |
| $^{241}Am$ | Lung | 5.2 (4.0 to 6.4) | 4.2 (3.6 to 4.8) |
| $^{144}Ce$ | Lung | 4.6 (3.5 to 5.7) | 4.4 (3.8 to 5.0) |
| $^{252}Cf$ | Lung | 4.1 (3.1 to 5.1) | 5.8 (5.1 to 6.5) |
| $^{244}Cm$ | Lung | 5.7 (4.5 to 7.0) | 4.8 (4.1 to 5.4) |
| $^{155}Eu$ | Lung | 7.1 (5.8 to 8.4) | 8.8 (7.9 to 9.6) |
| $^{237}Np$ | Lung | 3.6 (2.6 to 4.5) | 3.0 (3.1 to 4.2) |
| $^{210}Pb$ | Lung | 4.4 (3.3 to 5.4) | 6.4 (5.6 to 7.1) |
| Plutonium Isotope | Lung | 5.7 (4.5 to 7.0) | 5.2 (4.6 to 5.9) |
| [d] $^{232}Th$ via $^{212}Pb$ | Lung | 34.2 (31.7 to 36.6) | 31.4 (30 to 32.8) |
| $^{232}Th$ | Lung | 4.9 (3.8 to 6.0) | 5.3 (4.7 to 6.0) |
| $^{232}Th$ via $^{228}Th$ | Lung | 4.1 (3.1 to 5.1) | 4.6 (3.9 to 5.2) |
| $^{233}U$ | Lung | 5.7 (4.5 to 7.0) | 9.2 (8.4 to 10.1) |
| $^{235}U/^{226}Ra$ | Lung | 10.7 (9.0 to 12.3) | 11.0 (10.0 to 11.9) |
| Natural Uranium via $^{234}Th$ | Lung | 5.2 (4.0 to 6.4) | 5.7 (5.0 to 6.4) |
| $^{133}Ba$ | Whole Body | 3.6 (2.6 to 4.5) | 3.1 (2.6 to 3.7) |
| $^{140}Ba$ | Whole Body | 5.2 (4.0 to 6.4) | 3.9 (3.3 to 4.5) |
| $^{141}Ce$ | Whole Body | 3.6 (2.6 to 4.5) | 4.8 (4.1 to 5.4) |
| $^{58}Co$ | Whole Body | 4.4 (3.3 to 5.4) | 3.4 (2.9 to 4.0) |
| [d] $^{60}Co$ | Whole Body | 54.6 (52.0 to 57.2) | 23.6 (22.4 to 24.9) |
| $^{51}Cr$ | Whole Body | 5.7 (4.5 to 7.0) | 4.1 (3.5 to 4.7) |
| $^{134}Cs$ | Whole Body | 1.6 (1.0 to 2.3) | 2.5 (2.0 to 2.9) |
| $^{137}Cs$ | Whole Body | 28.4 (26.1 to 30.8) | 18.1 (16.9 to 19.3) |
| $^{152}Eu$ | Whole Body | 7.4 (6.0 to 8.7) | 5.8 (5.1 to 6.5) |
| $^{154}Eu$ | Whole Body | 3.8 (2.8 to 4.8) | 3.3 (2.8 to 3.9) |
| $^{155}Eu$ | Whole Body | 3.8 (2.8 to 4.8) | 3.5 (3.0 to 4.1) |
| $^{59}Fe$ | Whole Body | 3.8 (2.8 to 4.8) | 5.9 (5.2 to 6.6) |
| $^{131}I$ | Whole Body | 5.2 (4.0 to 6.4) | 4.1 (3.5 to 4.7) |
| $^{133}I$ | Whole Body | 3.3 (2.3 to 4.2) | 4.2 (3.6 to 4.8) |
| $^{192}Ir$ | Whole Body | 4.1 (3.1 to 5.1) | 4.3 (3.7 to 4.9) |
| $^{40}K$ | Whole Body | 100.0 (100.0 to 100.0) | 100 (100 to 100) |
| [d] $^{54}Mn$ | Whole Body | 12.3 (10.6 to 14.0) | 11.8 (10.8 to 12.8) |
| $^{103}Ru$ | Whole Body | 2.2 (1.4 to 3.0) | 1.8 (1.4 to 2.2) |
| $^{106}Ru$ | Whole Body | 4.4 (3.3 to 5.4) | 4.5 (3.9 to 5.1) |
| $^{125}Sb$ | Whole Body | 5.2 (4.0 to 6.4) | 4.4 (3.8 to 5.0) |

Table 7-3: "Lie Down and Be Counted"
Results through December 31, 2014 (continued)

| Radionuclide | *In Vivo* Count Type | Baseline Counts[c] (margin of error) (data prior to 27 March 1999) [a]N = 366 | Operational Monitoring Counts[e] (margin of error) (27 March 1999 – 31 December 2014) N = 1049 |
|---|---|---|---|
| | | % of Results ≥ [b]$L_C$ | % of Results ≥ [b]$L_C$ |
| $^{232}$Th via $^{228}$Ac | Whole Body | 34.7 (32.2 to 37.2) | 25.3 (23.9 to 26.6) |
| $^{88}$Y | Whole Body | 7.7 (6.3 to 9.0) | 6.2 (5.5 to 6.9) |
| $^{95}$Zr | Whole Body | 6.6 (5.3 to 7.9) | 3.9 (3.3 to 4.5) |

[a] N = number of individuals. Baseline counts include only the initial counts during this baseline period.
[b] To determine whether or not activity has been detected in a particular person, the parameter $L_C$ is used; the $L_C$ represents the 95th percentile of a null distribution that results 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 $L_C$.
[c] The margin of error represents the 95% confidence interval of the observed percentage; under replication of this experiment, one would expect 95 % of the confidence intervals to include the true population if the sample was representative of the true population.
[d] These radionuclides are present in the shield background, so they are expected to be detected periodically. [e] Operational monitoring counts include the counting of new individuals and the recounting of previously measured participants.

## Considerations for the in-vivo measurement of pCi level radioactivity using a Ge detector in a deep underground science laboratory

Because of its capabilities to detect minute levels of radiation, *In Vivo* internal dosimetry counting is very sensitive to background radiation. Thus, the detection sensitivity of a surface located *In Vivo* counting facility, built with existing low background counting concepts and techniques, can be further improved by developing an *In Vivo* low background facility in an underground environment whereby the earth acts as an added shield in terms of reducing the amount of background radiation.

Reliable detection of the radioactivity of trans-uranium (TRU) radioisotopes, especially Plutonium isotopes ($^{238-240,242}$Pu) and Americium ($^{241}$Am) is an ongoing requirement for Internal Dosimetry (ID) considerations for radiological workers handling TRU waste generated at the Department of Energy (DOE) facilities. These radioisotopes emit high linear energy transfer (LET) alpha radiations which become hazardous when present internally in the body. Urine samples collected from the radiation workers can be analyzed with high sensitivity for $^{241}$Am and the Pu isotopes by radiochemical techniques using alpha spectroscopy. The current in-vivo gamma analyses are not as robust as the radiochemical process because of the low intensities and low energies of the gamma rays emitted from the TRU isotopes.

Also, one of the most contemplated subjects in life sciences research involves low dose radiation effects on the living, especially doses delivered at low rates characteristic of most human exposures to environmental levels of radioactivity.  Naturally occurring radioactive sources internal to the human body provide the closest exposure to high LET radiation from alpha-radionuclides. The most important short-lived radioactive sources of interest appear to be those derived from radon and its immediate decay products such as $^{210}$Pb (lead) which is a part of the chain of radon decay products. One of the latest research interests in cranium internal dosimetry involves the study of $^{210}Pb$ activity by *In Vivo* gamma-ray spectrometry, especially considering its relation to Alzheimer's disease (AD), Parkinson's disease (PD) and multiple sclerosis (MS).

The CEMRC ID facility is in a unique position to enhance its WBC capability by developing a high sensitivity whole body counter taking advantage of the under-ground infrastructure facility at an underground repository such as the WIPP. The advantage is that the background can be reduced by a factor of three and thus sensitivity can be enhanced within an underground science laboratory. Research is on-going, with minimum available resources, for the development of a reliable non-invasive non-destructive in-vivo method for the detection of the activities of the TRU isotopes at sub-nano curie level, or for the determination of $^{210}Pb$ at pico-curie level in a cranium. The first step was initial measurement[1] of the minimum detection activity using minimum available resources such as HPGe detector, a volunteer and an existing shielded chamber at 2150' below ground at the experimental area at the WIPP. The second step was to identify[2] the transmitted component arising from the $^{40}K$ 1461 keV incident photon flux on site at the WIPP underground location. The third step was[3] to estimate the interfering background recorded in the energy regions of interest (ROI), that represent the detection of trans-uranium (TRU) isotopes deposited in the lungs, in the presence of $^{40}K$ internal to the human body. GEANT simulations[3] were carried out for a point source without and with the shielding, and for a BOMAB phantom in the shielded whole body counting chamber underground at the Waste Isolation Pilot Plant (WIPP).

# CHAPTER 8

## Analysis of Volatile Organic Compounds, Hydrogen and Methane

### Introduction

The WIPP Hazardous Waste Treatment Facility (HWTF) permit, Attachment N, issued by the New Mexico Environment Department under the Resource Conservation and Recovery Act (RCRA), mandates the monitoring of volatile organic compound (VOC) emissions from mixed waste that may be entrained in the ambient air from the WIPP underground hazardous waste disposal units (HWDUs) to assure that VOC concentrations do not exceed regulatory limits, during or after disposal. Ten target VOCs are actively monitored as they represent 99% risk to safety due to air emissions, and any other compounds consistently detected in air samples may be added to the list of compounds of interest. HWTF permit, Attachment N1 describes the monitoring plan for hydrogen and methane generated from underground panels.

VOC monitoring is conducted in accordance with the *"Volatile Organic Compound Monitoring Plan (WP 12-VC.01)",* prepared by the Nuclear Waste Partnership LLC (NWP), formerly Washington TRU Solutions (WTS). Hydrogen and Methane monitoring is performed in accordance with the *"Hydrogen and Methane Monitoring Plan (WP 12-VC.03)".* NWP personnel collect ambient air samples in six liter passivated canisters which are delivered for analysis to CEMRC in weekly batches.

CEMRC first began analysis of samples for the Confirmatory VOCs Monitoring Plan in April 2004. The program was established and successfully audited by the WTS QA group prior to acceptance of actual samples and has since been audited at yearly intervals. Initially, CEMRC had one 6890/5973 Hewlett Packard (now Agilent) gas chromatograph/mass spectrometer (GC/MS) which had previously been used by Los Alamos National Laboratory (LANL). CEMRC purchased an Entech 7100 Preconcentrator for use as the sample concentration and introduction system, and an Entech 3100 Canister Cleaning System for cleaning and evacuation of canisters after analysis.

In 2014, there were two incidents at the underground WIPP site, which affected the sampling of VOCs. The first incident was an underground fire on February 5$^{th}$, 2014, and the second was an underground radiological release on February 14$^{th}$, 2014. The last regular VOC, H, and M samples were taken on February 3$^{rd}$, 2014. As a result of the underground radiation event, the WIPP started collecting surface samples on February 26$^{th}$, 2014 to ensure that VOCs on the surface were well within regulatory limits and that there was no seepage of VOCs from the underground.

### VOC Project Expansion

The original VOC laboratory was set up in room 149 in the science laboratory wing at CEMRC and only included the equipment necessary for Confirmatory VOCs analysis. In late 2003, the Department of Energy (DOE) requested that CEMRC expand its capabilities to prepare for the analysis of headspace gas (HSG) samples collected from waste drums required under the WIPP Permit, Attachment B. In preparation for this expansion of scope, CEMRC purchased an HSG analysis system consisting of a 6890/5973N Agilent GC/MS with a loop injection system and three Entech 7032 auto-samplers installed in series. Also included in this purchase was an Entech 3100A oven-based canister cleaning system, an Entech 4600 Dynamic Diluter for automatic preparation of VOCs calibration standards, and fifty 400 mL Silonite-coated mini-canisters with Nupro valves and attached pressure gauges.

After a few months of VOCs Confirmatory Analyses, it became critical to expand the laboratory to accommodate the addition of a backup analysis system. This shortcoming was noted by auditors for the next two years. CEMRC did purchase a backup Preconcentrator to minimize system downtime. However, there was no available space in which to set up the backup GC/MS instrument.

With the addition of headspace gas analysis, it was decided in July 2005 to move the VOCs Confirmatory Analysis and Headspace Gas Analysis programs from the EC group into the newly created Organic Chemistry (OC) Group. The primary management focus for the EC group was research oriented, whereas the functions of the OC group were regulatory in nature and required different QA/QC measures and documentation.

Analyses were originally conducted by manually changing the sample attached to the preconcentrator for each sample. Due to the need to maximize efficiency, an Entech 7016 canister autosampler was obtained in June 2005. This autosampler allows for up to sixteen samples to be run in sequence with minimal operator supervision.

Funding was obtained in mid-2005 through a DOE baseline change request to remodel the old CEMRC garage into a functional GC/MS Laboratory. The design for the remodel was completed in late 2005, and construction began in January 2006. Construction was completed in April 2006 and the OC Group moved into the new laboratory.

Around this time, a backup Agilent 6890/5973 GC/MS system was transferred to CEMRC by the Central Characterization Project (CCP) for use in headspace gas analysis. A backup autosampler for HSG analysis was also purchased by CEMRC. Shortly thereafter a new Agilent 6890/5975 GC/MS was obtained with a portion of the lab setup funding to be used as a backup analysis system for the Confirmatory VOCs Monitoring.

The VOC Monitoring expanded from 353 samples in 2005 to 430 samples in 2006. Analysis of closed room samples for VOCs, hydrogen, and methane began in 2007 as well and continues to the present. In 2007, 2008, 2009, 2010, 2011, 2012, and 2013 CEMRC analyzed a total of 749, 608, 571, 711, 615, 559, and 709 samples for VOCs and 182, 254, 339, 441, 398, 376, and 360 samples, respectively, for hydrogen and methane. In 2014, CEMRC analyzed a total of 342 samples for VOCs and 46 samples for hydrogen and methane.

Although CEMRC performed well on the DOE audit for the headspace gas analysis project, a decision was made not to submit these samples for analysis at CEMRC. However, some equipment obtained for this project is currently being used for analysis of closed room samples for VOCs and percent levels of hydrogen and methane.

## Methods for Volatile Organic Compound Monitoring

Confirmatory VOCs Monitoring requires method detection limits at low parts per billion volume (ppbv) range. This type of analysis requires pre-concentration of a given volume of ambient air into a much smaller volume prior to introduction into the GC column. In order to maintain performance of the mass analyzer, most of the water vapor and carbon dioxide present in the air sample must be removed prior to analysis. The Entech 7100 Pre-concentrator performs these tasks automatically by transferring the sample through three consecutive cryogenic traps at different controlled temperatures. This results in very low detection limits unattainable without cryogenic pre-concentration.

Stock cylinders of Calibration Standard and Laboratory Control Sample gases are purchased certified from a reputable supplier, and then diluted to working concentrations with Ultra-High Purity (UHP) Nitrogen using the Entech 4600 Dynamic Diluter. Canisters are cleaned after sample analysis using the Entech 3100 Canister Cleaning system, which consists of a computerized control module with vacuum pumps and an oven containing a passivated manifold with fittings for connection of canisters. The control software initiates the cleaning of canisters by heating coupled with multiple pressurization/evacuation cycles. A blank sample is analyzed from each cleaning batch as a control to assure proper cleaning has been achieved.

Analyses for Volatile Organic Compound Monitoring were conducted under procedures using concepts of EPA 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).

Quality assurance requirements for these activities were detailed in the *"Quality Assurance Project Plan for Volatile Organic Compound Monitoring (WP 12-VC.02)"* prepared by NWP. CEMRC personnel wrote procedures for this project under the CEMRC Quality Assurance Plan, which were verified, validated, and placed in the CEMRC Document Control Program. Procedures were composed to include QA requirements from EPA Method TO-15 and all WIPP documents relevant to the Confirmatory Monitoring Program. See Table 8-1 for a list of CEMRC Procedures for Confirmatory Monitoring.

In November 2006, a WIPP permit modification incorporated an expansion of sampling in the Volatile Organic Compounds Monitoring Program. Originally, the samples were collected from only two stations in the WIPP underground (VOC-A and VOC-B). The permit change requires sampling from closed rooms within the current panel until the entire panel is full. Therefore, Attachment N now refers to both Repository VOCs Monitoring and Disposal Room Monitoring.

Table 8-2 summarizes the ten permit specified target compounds and their required reporting limits for different types of samples. Trichloroethylene was an additionally requested compound at the start of 2014, but was made a target analyte based on an order from NMED in May 2014.

Method Modification for Analysis of Low-Levels of VOCs

The February 2014 incidents essentially made it impossible to collect samples in the WIPP underground due to radioactivity. It was decided to continue collection of surface samples to determine if there was any VOC seepage from the underground and to ensure worker safety.

CEMRC modified the regular VOC analysis method so as to analyze low-levels of VOCs. The regular method was based on a calibration range of 1 to 100 ppbv, the calibration range of the modified method is 0.2 to 10 ppbv. This ensured that sub-ppbv level VOCs can be accurately reported as the method reporting limit for undiluted samples was changed to 0.2 ppbv. The regular and modified methods are based on the GC/MS full scan mode, wherein, the system will monitor a range of masses to detect compound fragments within that range. This full scan mode is quite useful to monitor unknown compounds in a sample, but the major drawback, is that it prevents the GC/MS system from being calibrated to a much lower range.

The CEMRC was tasked with developing a methodology for analysis of target analytes in the pptv range using the Selected Ion Monitoring (SIM) GC/MS mode. SIM is a GC/MS scanning mode in which only a limited mass-to-charge ratio range is transmitted/detected by the instrument, as opposed to the full spectrum range. The SIM mode increases sensitivity for target analytes through the selective detection of ions most indicative of the compounds of interest. As a result, the CEMRC has developed a low-level VOC analysis method using the SIM mode where the low calibration level is 100 pptv (0.1 ppbv) with MDLs less than 10 pptv. The SIM mode is 10 to 100 times more sensitive than the full scan mode. The CEMRC has been analyzing surface samples using both SIM and full scan mode synchronously from December 2014.

**Methods for Hydrogen And Methane Analysis**

The analysis of hydrogen and methane in closed room samples began in August 2007. Under the analysis scheme used at CEMRC, sample canisters would be pressurized to twice the canister pressure (if not already received at above atmospheric pressure) by the addition of ultra-high purity nitrogen, and then simultaneously analyzed for hydrogen and methane by a GC/Thermal Conductivity Detector (TCD) and screened for VOCs by GCMS. The sampling system incorporates three auto-samplers in series to allow for the analysis of two complete batches of six 6L samples per run. Samples from the auto-samplers pass through heated transfer lines into two injection loops attached to an automated valve for simultaneous injection into the GC. The VOC screening results are used to determine pre-analysis dilutions required for analysis by Method TO-15. The hydrogen and methane analysis results are reported in separate data packages from the VOCs results. Quality assurance requirements for these activities were detailed in the *"Quality Assurance Project Plan for Hydrogen and Methane Monitoring (WP 12-VC.04)"* prepared by NWP.

## Laboratory Precision

Laboratory Control Sample (LCS) and LCS-duplicate are analyzed at a rate of once per batch, or once each ten samples, whichever is applicable, to verify instrument calibration and quantitative analytical accuracy. LCS is a standard that contains compounds of interest which has been prepared from a different source than that used to prepare the calibration standard. An LCS is the same as a spiked blank or blank spike. The LCS % recovery must be within ± 40% for all target and additional requested compounds. The relative percentage deviation (RPD) must be 25% or less for all target and additional requested compounds. The laboratory achieved the precision limit for all the target compounds. Figures 8-4 show an example of laboratory precision through LCS % recovery and RPD for the target analytes Carbon tetrachloride, Trichloroethylene. Figures 8-1and 8-2 is the combined data for the regular analysis method from 2004 to 2014, whereas Figures 8-3 and 8-4 shows the data for the modified low level full scan method for 2014 surface samples.

## Results and Discussion

The OC lab analyzed a total of 388 samples in 2014. All of the samples were analyzed and reported in a timely manner under an extensive quality assurance (QA) / quality control (QC) program. The 388 samples consisted of 342 samples for VOCs measurement (48 routine air samples, 56 blank and recovery gas samples, 238 low-level surface samples) and 46 samples for hydrogen and methane analysis. All of these samples achieved 100% completeness. Blank and recovery gas samples were collected by Shaw Environmental and were part of the sampler cleaning and certification program; they were analyzed in expedited turnaround batches (7 calendar days) at various times throughout the year.

The OC lab also received a number of canisters for cleaning and certification at various times throughout the year. All of the canisters were cleaned and certified with appropriate QA/QC in place. The lab cleaned and certified 463 canisters from batches which had been analyzed and reported. In addition, the lab also cleaned and certified 45 additional canisters in 2014.

Batch reports for VOCs results are submitted in hardcopy in the EPA Contract Laboratory Program format. An electronic report in the client's specified format is also provided for each batch. Hardcopy and electronic reports for hydrogen and methane analyses are submitted in the formats specified by the client. Copies of batch reports and all QA records associated with these analyses are maintained according to the CEMRC records management policies, detailed in the QAP.

## Summary Statements

Due to the proprietary nature of the VOC data, none are reported herein. The success of the VOCs Monitoring Program and the successful HSG Program audit demonstrate CEMRC's ability to initiate new programs to successfully perform regulatory monitoring tasks in accordance with specific QA/QC requirements.

CEMRC presently has the capability to analyze over 2,000 VOC and hydrogen/methane samples per year. CEMRC has the instrumentation and facilities to analyze air samples for VOCs from and around Carlsbad which might be affected due to the ever increasing mining, oil and gas industries.

Table 8-1: CEMRC Procedures for Volatile Organic Compounds and Hydrogen/Methane Monitoring Program

| Procedure Number | Procedure Title |
|---|---|
| OC-PLAN-001 | Quality Assurance Project Plan for Analysis of Volatile Organic Compounds and/or Hydrogen and Methane in Canister Samples |
| OC-PROC-002 | Preparation of Canisters and Sample Trains for Ambient Air Sampling |
| OC-PROC-003 | Gas Chromatography-Mass Spectrometry Analysis of Volatile Organic Compounds (VOCs) in Ambient Air from Canisters at |
| OC-PROC-004 | Preparation of Calibration Standards in Specially Prepared Canisters for Analysis by Gas Chromatography/Mass Spectrometry |
| OC-PROC-005 | Data Validation and Reporting of Volatile Organic Compounds from Gas Chromatography/Mass Spectrometry Analysis of Ambient Air in Canisters for the WIPP Volatile Organic Compound Monitoring Plan |
| OC-PROC-006 | Receipt, Control, and Storage of Gas Samples in Passivated Canisters |
| OC-PROC-009 | Analysis of Hydrogen and Methane in Passivated Canisters Using Gas Chromatography with Thermal Conductivity Detection |

Table 8-2: Compounds of Interest for WIPP Confirmatory Volatile Organic Compounds Monitoring Program

| Compound | Repository Sample Reporting Limit (ppbv) | Closed Room Sample Reporting Limit (ppbv) | SIM VOC Analysis (ppbv) | Low-Level VOC Analysis (ppbv) |
|---|---|---|---|---|
| 1,1-Dichloroethylene | 5 | 500 | 0.1 | 0.2 |
| Carbon tetrachloride | 2 | 500 | 0.1 | 0.2 |
| Methylene chloride | 5 | 500 | 0.1 | 0.2 |
| Chloroform | 2 | 500 | 0.1 | 0.2 |
| 1,1,2,2-Tetrachloroethane | 2 | 500 | 0.1 | 0.2 |
| 1,1,1-Trichloroethane | 5 | 500 | 0.1 | 0.2 |
| Chlorobenzene | 2 | 500 | 0.1 | 0.2 |
| 1,2-Dichloroethane | 2 | 500 | 0.1 | 0.2 |
| Toluene | 5 | 500 | 0.1 | 0.2 |
| Trichloroethylene | 2 | 500 | 0.1 | 0.2 |

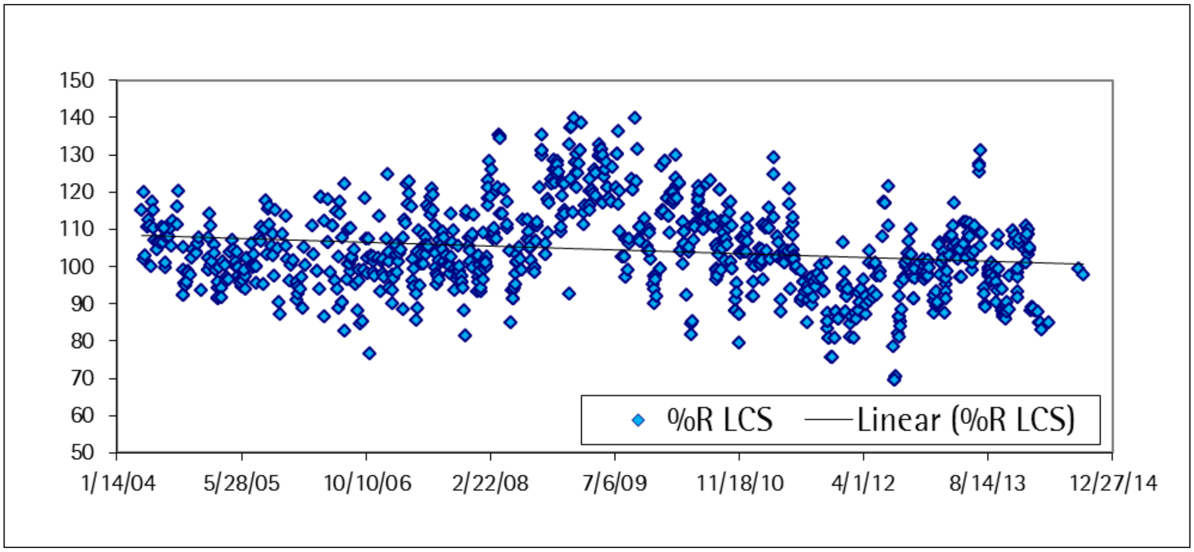



Figure 8-1: Percent Recovery of Carbon Tetrachloride in LCS (Recovery range: 60-140%)

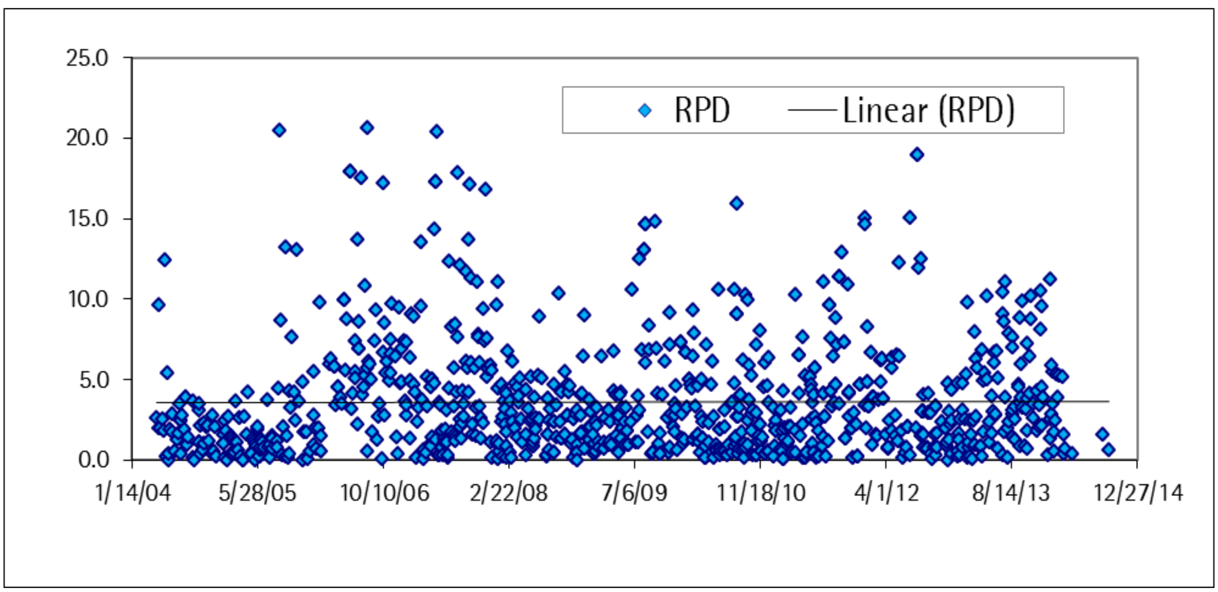



Figure 8-2: Relative Percent Deviation (RPD) between LCS and LCS-Duplicate for Carbon Tetrachloride (RPD range: 25%)

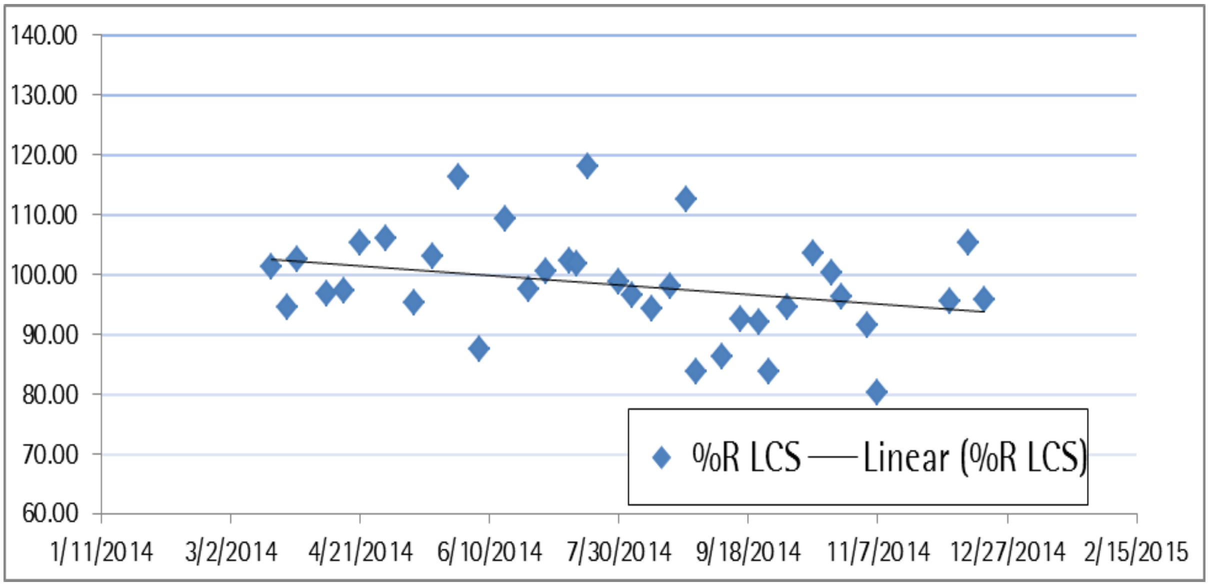



Figure 8-3: Percent Recovery of Trichloroethylene in LCS (Recovery range: 60-140%)

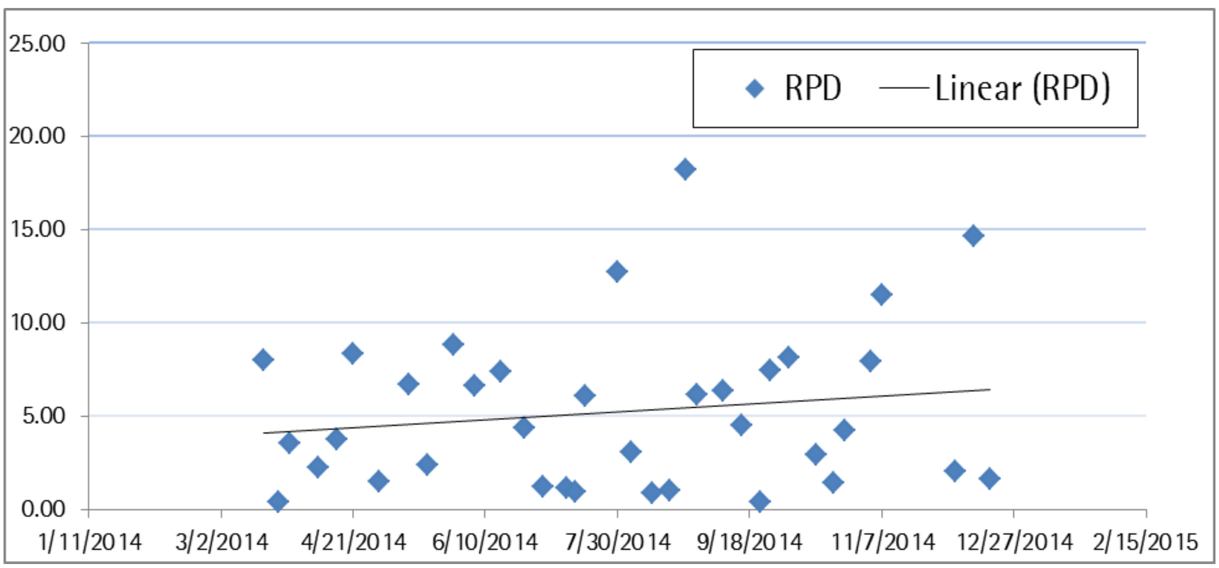



Figure 8-4: Relative Percent Deviation (RPD) between LCS and LCS-Duplicate for Trichloroethylene (RPD range: 25%)

# CHAPTER 9

# QUALITY ASSURANCE

## 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.

The 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. Since its inception, CEMRC's WIPP-EM program has been conducted as a scientific investigation, that is, without any compliance, regulatory, or oversight responsibilities. As such, there are no specific requirements for reporting data other than good scientific practices.

Samples for the CEMRC's WIPP-EM Programs were collected by personnel trained in accordance with approved procedures. Established sampling locations were accurately identified and documented to ensure continuity of data. Field duplicate samples were used to assess sampling and measurement precision. Quality control in the analytical laboratories is maintained through tracking and verification of analytical instrument performance, use of American Chemical Society certified reagents, use of National Institute of Standards and Technology (NIST) traceable radionuclide solutions and verification testing of radionuclide concentrations for tracers not purchased directly from NIST or Eckert and Ziegler Analytics. 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 were 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 $\alpha/\beta$ proportional counter used for the FAS program, efficiency control charting was performed using $^{239}Pu$ and $^{90}Sr$ check sources along with ensuring that $\alpha/\beta$ cross-talk was within limits. Sixty-minute background counts were recorded daily. Two blanks per week for the FAS program were counted for 20 hours and were used as a background history for calculating results.

Routine background determinations were made on the HPGe detector systems by counting blank samples, and the data was used to blank correct the sample concentrations.

For the alpha spectrometer, efficiency, resolution and centroid control charting was performed using Eckert and Ziegler Analytics check sources on a regular basis. Before each sample count, pulser checks were performed to ensure acceptable detector resolution and centroid. Blanks counted for 5 days were used as a background history for calculating results. Analytical data were verified and validated as required by project-specific quality objectives before being used to support decision making.

CEMRC also participates in the two national performance evaluation programs, NIST Radiochemistry Intercomparison Program (NIST-RIP) (Figure 9-5) and the DOE-Mixed-Analyte Performance Evaluation Program (MAPEP) (Figure 9-6) for soil, air filter and water analysis. The proficiency tests help to ensure the accuracy of analytical results reported to DOE and other stakeholders, while also providing an efficient means for laboratories to demonstrate analytical proficiency. Under these programs, CEMRC analyzed blind check samples, and the analysis results were compared with the official results measured by the MAPEP, and NRIP laboratories. During 2014, CEMRC radio-analytical program analyzed MAPEP- air filter, water, soil, gross alpha/beta on air filters and NIST-NRIP - glass fiber filters, soil and acidified water samples. Isotopes of interest in these performance evolution programs were $^{233/234}$U, $^{238}$U, $^{238}$Pu, $^{239+240}$Pu, and $^{241}$Am and gamma emitters. The analyses were carried out using CEMRC's actinide separation procedures, and were treated as a regular sample set to test regular performance. CEMRC's results were consistently close to the known value. MAPEP and NIST-NRIP results are presented in this annual report. Only one analysis result for MAPEP, (gross alpha) was deemed not acceptable. 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 the WIPP environmental samples. In addition, for each set of samples, reagent blank and tracer spikes are also carried through the entire separation and counting process for recovery determination and quality control.

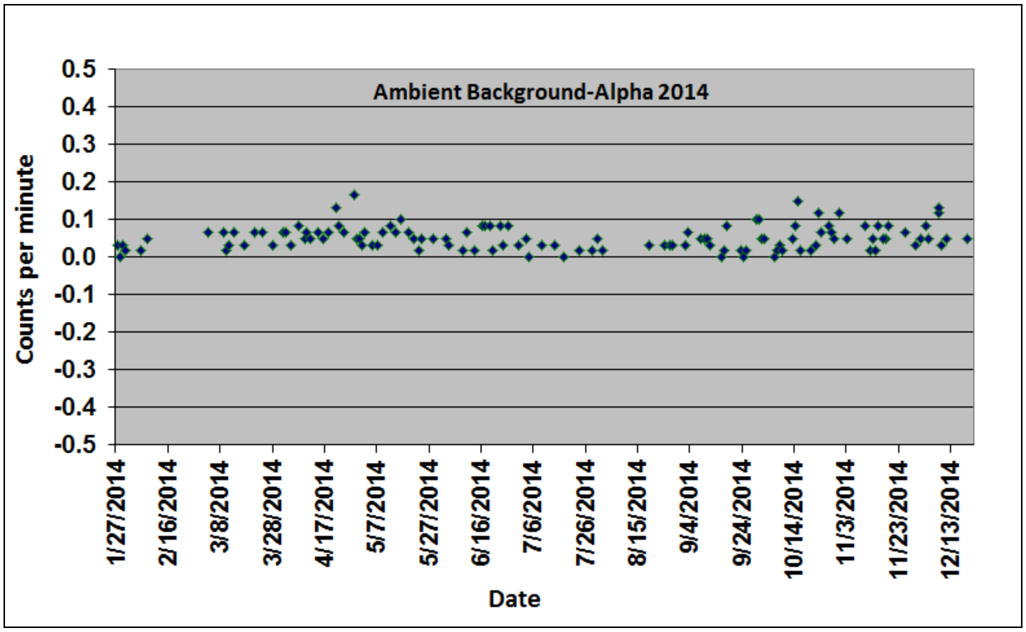



Figure 9-1: Sixty Minutes Alpha Ambient Background Count for the PIC-MPC 9604 Gross Alpha and Beta

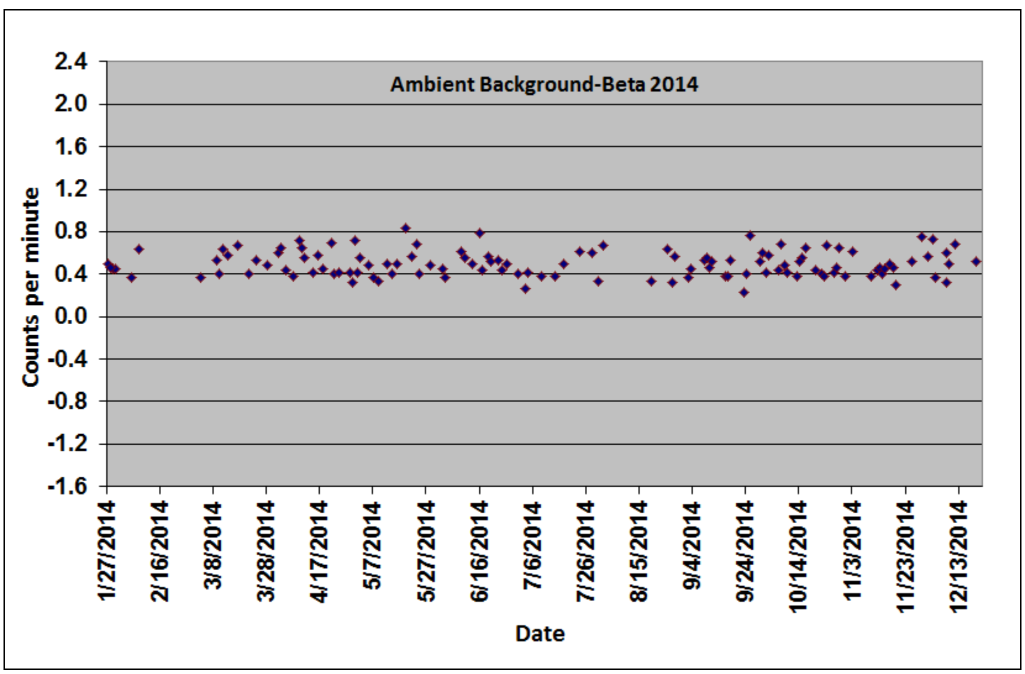



Figure 9-2: Sixty Minutes Beta Ambient Background Count for PICMPC 9604 Gross Alpha and Beta Counter

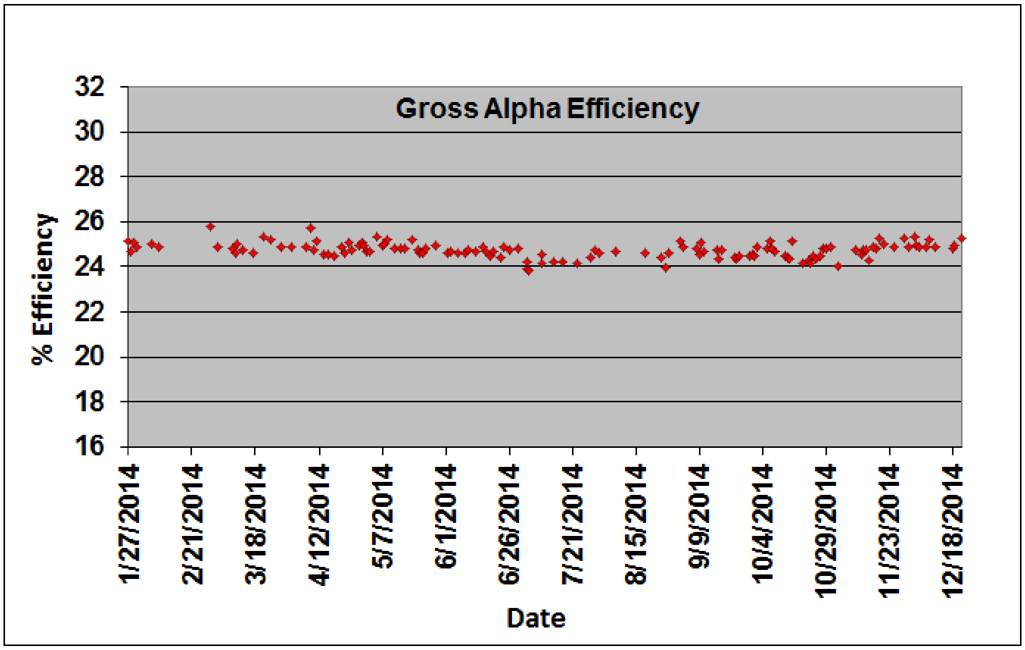



Figure 9-3: Control Chart of Daily Alpha Efficiency of the PICMPC 9604 Gross Alpha and Beta Counter

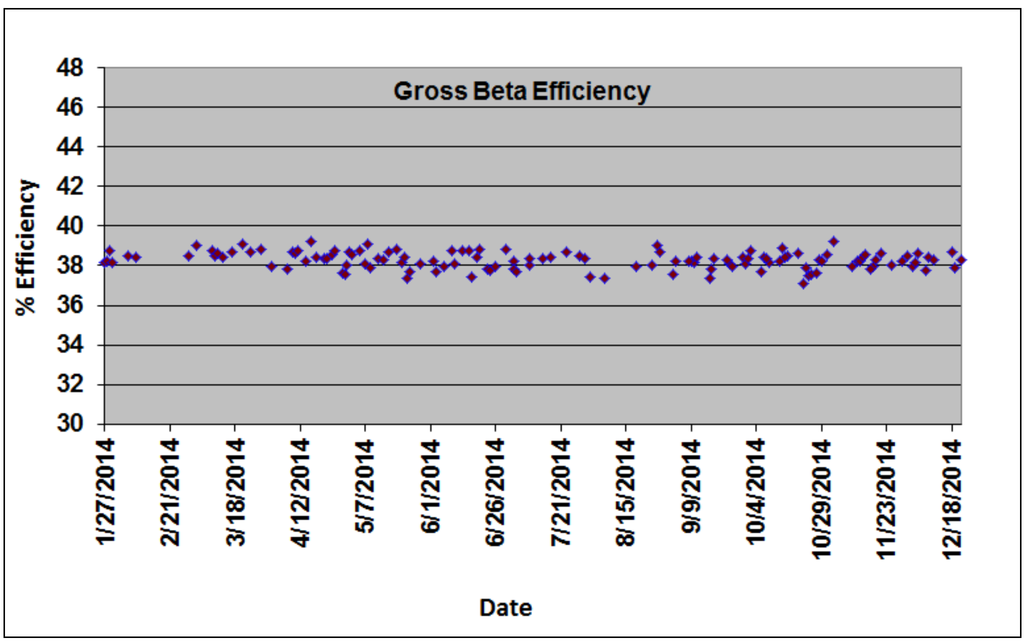



Figure 9-4: Control Chart of Daily Beta Efficiency of the PIC-MPC 9604 Gross Alpha and Beta Counter

**U.S. DEPARTMENT OF COMMERCE**
National Institute of Standards and Technology
Gaithersburg, MD

**REPORT OF TRACEABILITY**

**Carlsbad Environmental Monitoring and Research Center, Carlsbad, NM**

| | |
|---|---|
| Test Identification | NRIP'14-SS |
| Test Radionuclides | $^{57}$Co, $^{60}$Co, $^{90}$Sr, $^{137}$Cs, $^{210}$Pb, $^{210}$Po, $^{226}$Ra, $^{230}$Th, $^{234}$U, $^{235}$U, $^{238}$U, $^{238}$Pu, $^{240}$Pu, $^{241}$Am, $^{243}$Cm in soil[1] |
| Test Activity Range | 0.01 Bq•sample$^{-1}$ to 250 Bq•sample$^{-1}$ |
| Reference Time | 12:00 EST, April 1, 2014 |

**Measurement Results**

| Nuclide | NIST Value[2,3] | | Reported Value[4] | | Difference[5] |
|---|---|---|---|---|---|
| | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | (%) |
| $^{57}$Co | 1.82 | 2.41 | 2.26 | 85 | 24 |
| $^{60}$Co | 399.4 | 0.59 | 390.9 | 3.5 | -2.1 |
| $^{137}$Cs | 671.6 | 0.76 | 656.9 | 4.0 | -2.2 |
| $^{234}$U | 4.36 | 1.00 | 4.97 | 12.9 | 14.2 |
| $^{235}$U | 0.208 | 0.65 | 0.243 | 19.9 | 16.8 |
| $^{238}$U | 4.52 | 0.63 | 5.02 | 12.9 | 10.9 |
| $^{238}$Pu | 1.305 | 0.71 | 1.293 | 14.8 | -0.9 |
| $^{240}$Pu | 1.701 | 0.79 | 1.670 | 14.4 | -1.8 |
| $^{241}$Am | 3.97 | 0.82 | 4.08 | 12.3 | 2.8 |

**Methods**

| | NIST[6] | Reporting Laboratory[7] |
|---|---|---|
| Activity Measurements | Alpha-, Beta-, Gamma-Spectrometry, Mass Spectrometry | Alpha- and Beta-Spectrometry |

**Evaluation (per ANSI N42.22)**

| Nuclide | ANSI N42.22 Traceable[8] | Traceability Limit (%) |
|---|---|---|
| $^{57}$Co | Yes | 158 |
| $^{60}$Co | Yes | 5.1 |
| $^{137}$Cs | Yes | 6.0 |
| $^{234}$U | Yes | 22 |
| $^{235}$U | Yes | 35 |

| Nuclide | ANSI N42.22 Traceable[8] | Traceability Limit (%) |
|---|---|---|
| $^{238}$U | Yes | 22 |
| $^{238}$Pu | Yes | 22 |
| $^{240}$Pu | Yes | 21 |
| $^{241}$Am | Yes | 19 |

Samples Distributed September 29, 2014
Reporting Data Received December 22, 2014

For the Director

Michael P. Unterweger, Group Leader
Radioactivity Group
**Physical Measurement Laboratory**
(continued)

Figure 9-5: Participation in NIST Radiochemistry Intercomparison Program

# U.S. DEPARTMENT OF COMMERCE

National Institute of Standards and Technology
Gaithersburg, MD

## REPORT OF TRACEABILITY
## (Revised[1])

**Carlsbad Environmental Monitoring and Research Center**
**Carlsbad, NM**

| | |
|---|---|
| Test Identification | NRIP'14-AF |
| Matrix Description | $^{54}$Mn, $^{60}$Co, $^{90}$Sr, $^{134}$Cs, $^{230}$Th, $^{234}$U, $^{235}$U, $^{238}$U, $^{237}$Np, $^{238}$Pu, $^{240}$Pu, and $^{241}$Am on Paper Filters[2] |
| Test Activity Range | 0.02 Bq•sample$^{-1}$ to 250 Bq•sample$^{-1}$ |
| Reference Time | 12:00 EST, April 1, 2014 |

**Measurement Results**

| Nuclide | NIST Value[3,4] | | Reported Value[5] | | Difference[6] |
|---|---|---|---|---|---|
| | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | (±% Bias) |
| $^{54}$Mn | 3.82 | 1.6 | 4.08 | 37.7 | 6.6 |
| $^{60}$Co | 143.7 | 0.8 | 147.9 | 3.6 | 2.9 |
| $^{134}$Cs | 52.0 | 1.8 | 51.5 | 3.9 | -1.0 |
| $^{234}$U | 3.07 | 2.8 | 3.33 | 16.1 | 8.3 |
| $^{235}$U | 0.145 | 8.5 | 0.141 | 27.1 | -3.0 |
| $^{238}$U | 3.20 | 2.1 | 3.11 | 16.2 | -2.7 |
| $^{238}$Pu | 1.75 | 4.3 | 1.63 | 12.6 | -7.1 |
| $^{240}$Pu | 1.91 | 3.0 | 1.79 | 12.5 | -6.5 |
| $^{241}$Am | 2.74 | 4.0 | 2.80 | 12.3 | 2.2 |

**Methods**

| | NIST[7] | Reporting Laboratory[8] |
|---|---|---|
| Activity Measurements | Alpha- and Gamma-Spectrometry | Alpha, Beta, and Gamma Spectrometry |

**Evaluation (per ANSI N42.22)**

| Nuclide | ANSI N42.22 Traceable[9] | Traceability Limit (%) |
|---|---|---|
| $^{54}$Mn | Yes | 60 |
| $^{60}$Co | Yes | 5.6 |
| $^{134}$Cs | Yes | 6.4 |
| $^{234}$U | Yes | 26 |
| $^{235}$U | Yes | 41 |

| Nuclide | ANSI N42.22 Traceable[9] | Traceability Limit (%) |
|---|---|---|
| $^{238}$U | Yes | 24 |
| $^{238}$Pu | Yes | 18.7 |
| $^{240}$Pu | Yes | 18.1 |
| $^{241}$Am | Yes | 19.8 |

| | |
|---|---|
| Samples Distributed | 29 September 2014 |
| Reporting Data Received | 22 December 2014 |
| **Revised Report Issued** | 5 November 2015 |

For the Director

Michael P. Unterweger, Group Leader
Radioactivity Group
**Physical Measurement Laboratory**
(continued)

Figure 9-5: Participation in NIST Radiochemistry Intercomparison Program (continued)

## U.S. DEPARTMENT OF COMMERCE

National Institute of Standards and Technology
Gaithersburg, MD

## REPORT OF TRACEABILITY

**Carlsbad Environmental Monitoring and Research Center, Carlsbad, NM**

| | |
|---|---|
| Test Identification | NRIP'14-AW |
| Matrix Description | $^{57}$Co, $^{60}$Co, $^{90}$Sr, $^{137}$Cs, $^{210}$Pb, $^{210}$Po, $^{226}$Ra, $^{230}$Th, $^{234}$U, $^{235}$U, $^{238}$U, $^{238}$Pu, $^{240}$Pu, $^{241}$Am, $^{243}$Cm in acidified water[1] |
| Test Activity Range | 0.01 Bq•sample$^{-1}$ to 50 Bq•sample$^{-1}$ |
| Reference Time | 12:00 EST, April 1, 2014 |

**Measurement Results**

| Nuclide | NIST Value[2,3] | | Reported Value[4] | | Difference[5] |
|---|---|---|---|---|---|
| | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | Massic Activity Bq•g$^{-1}$ | Relative Expanded Uncertainty (%, k=2) | (%) |
| $^{60}$Co | 327.2 | 0.59 | 325.8 | 6.0 | -0.4 |
| $^{137}$Cs | 550.3 | 0.76 | 557.0 | 5.4 | 1.2 |
| $^{234}$U | 3.57 | 1.00 | 3.46 | 19.7 | -2.9 |
| $^{235}$U | 0.171 | 0.65 | 0.245 | 70 | 44 |
| $^{238}$U | 3.71 | 0.63 | 3.61 | 19.6 | -2.7 |
| $^{238}$Pu | 1.069 | 0.71 | 1.089 | 25 | 1.9 |
| $^{240}$Pu | 1.394 | 0.79 | 1.319 | 24 | -5.4 |
| $^{241}$Am | 3.25 | 0.82 | 3.09 | 17.7 | -5.0 |

**Methods**

| | NIST[6] | Reporting Laboratory[7] |
|---|---|---|
| Activity Measurements | Alpha-, Beta-, Gamma-Spectrometry Mass Spectrometry | Alpha-, Gamma-Spectrometry |

**Evaluation (per ANSI N42.22)**

| Nuclide | ANSI N42.22 Traceable[8] | Traceability Limit (%) |
|---|---|---|
| $^{60}$Co | Yes | 9.0 |
| $^{137}$Cs | Yes | 8.3 |
| $^{234}$U | Yes | 29 |
| $^{235}$U | Yes | 152 |

| Nuclide | ANSI N42.22 Traceable[8] | Traceability Limit (%) |
|---|---|---|
| $^{238}$U | Yes | 29 |
| $^{238}$Pu | Yes | 39 |
| $^{240}$Pu | Yes | 34 |
| $^{241}$Am | Yes | 25 |

Samples Distributed September 29, 2014
Reporting Data Received December 22, 2014

For the Director

Michael P. Unterweger, Group Leader
Radioactivity Group
**Physical Measurement Laboratory**
(continued)

Figure 9-5: Participation in NIST Radiochemistry Intercomparison Program (continued)

**MAPEP** Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP-14-GrF31*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

| Radiological | | | | | | | Units: (Bq/sample) | |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Gross alpha | 0.106 | 0.53 | N | | -80.0 | 0.16 - 0.90 | 0.003 | A |
| Gross beta | 1.094 | 1.06 | A | | 3.2 | 0.53 - 1.59 | 0.016 | N |

*Radiological Reference Date: August 1, 2014*

**Gross Alpha Flags:**

A = Result acceptable, Bias <= +/- 70% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 70% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

**Gross Beta Flags:**

A = Result acceptable, Bias <= +/- 50% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 50% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

**Uncertainty Flags:**

1) NOT ACCEPTABLE...........................RP<2%

2) ACCEPTABLE.................................2%<=RP<=15%

3) ACCEPTABLE WITH WARNING...........15%<RP<=30%

4) NOT ACCEPTABLE............................RP>30%

RP = Relative Precision

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP-14-GrW31*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

| Radiological | | | | | | | | Units: (Bq/L) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Gross alpha | 0.4909 | 1.40 | A | | -64.9 | 0.42 - 2.38 | 0.0174 | A |
| Gross beta | 6.409 | 6.50 | A | | -1.4 | 3.25 - 9.75 | 0.084 | N |

*Radiological Reference Date: August 1, 2014*

**Gross Alpha Flags:**

A = Result acceptable, Bias <= +/- 70% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 70% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

**Gross Beta Flags:**

A = Result acceptable, Bias <= +/- 50% with a statistically positive result at two standard deviations (Result/Uncertainty > 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, does not include zero).

N = Result not acceptable, Bias > +/- 50% or the reported result is not statistically positive at two standard deviations (Result/Uncertainty <= 2, i.e., the range encompassing the result, plus or minus the total uncertainty at two standard deviations, includes zero).

**Uncertainty Flags:**

1) NOT ACCEPTABLE...........................RP<2%

2) ACCEPTABLE.................................2%<=RP<=15%

3) ACCEPTABLE WITH WARNING...........15%<RP<=30%

4) NOT ACCEPTABLE............................RP>30%

RP = Relative Precision

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP-14-MaS31*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

| Inorganic | | | | | | | | Units: (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Antimony | NR | 82 | | | | 57 - 107 | | |
| Arsenic | NR | 67.9 | | | | 47.5 - 88.3 | | |
| Barium | NR | 802 | | | | 561 - 1043 | | |
| Beryllium | NR | 53.5 | | | | 37.5 - 69.6 | | |
| Cadmium | NR | 7.75 | | | | 5.43 - 10.08 | | |
| Chromium | NR | 112 | | | | 78 - 146 | | |
| Cobalt | NR | 291 | | | | 204 - 378 | | |
| Copper | NR | 177 | | | | 124 - 230 | | |
| Lead | NR | 51.7 | | | | 36.2 - 67.2 | | |
| Mercury | NR | 0.155 | | | | 0.109 - 0.202 | | |
| Nickel | NR | 212 | | | | 148 - 276 | | |
| Selenium | NR | 19.9 | | | | 13.9 - 25.9 | | |
| Silver | NR | 69.6 | | | | 48.7 - 90.5 | | |
| Technetium-99 | NR | 9.4E-4 | | | | 0.000658 - 0.001222 | | |
| Thallium | NR | 157 | | | | 110 - 204 | | |
| Uranium-235 | NR | 0.0670 | | | | 0.0469 - 0.0871 | | |
| Uranium-238 | NR | 20.8 | | | | 14.6 - 27.0 | | |
| Uranium-Total | NR | 20.9 | | | | 14.6 - 27.2 | | |
| Vanadium | NR | 154 | | | | 108 - 200 | | |
| Zinc | NR | 606 | | | | 424 - 788 | | |

| Radiological | | | | | | | | Units: (Bq/kg) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Americium-241 | 8.33E+01 | 85.5 | A | | -2.6 | 59.9 - 111.2 | 5.30 | A |
| Cesium-134 | 6.77E+02 | 622 | A | | 8.8 | 435 - 809 | 1.45 | A |
| Cesium-137 | 1.09E-01 | | A | | | False Positive Test | 7.24E-01 | |
| Cobalt-57 | 1.19E+03 | 1116 | A | | 6.6 | 781 - 1451 | 3.33 | A |
| Cobalt-60 | 9.03E+02 | 779 | A | | 15.9 | 545 - 1013 | 2.01 | A |
| Iron-55 | NR | 680 | | | | 476 - 884 | | |
| Manganese-54 | 1.09E+03 | 1009 | A | | 8.0 | 706 - 1312 | 2.79 | A |
| Nickel-63 | NR | 980 | | | | 686 - 1274 | | |
| Plutonium-238 | 3.94E-01 | 0.48 | A | | | Sensitivity Evaluation | 1.23E-01 | |
| Plutonium-239/240 | 6.16E+01 | 58.6 | A | | 5.1 | 41.0 - 76.2 | 4.91 | A |
| Potassium-40 | 9.29E+02 | 824 | A | | 12.7 | 577 - 1071 | 7.68 | A |
| Strontium-90 | NR | 858 | | | | 601 - 1115 | | |
| Technetium-99 | NR | 589 | | | | 412 - 766 | | |

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

| Radiological | | | | | | | Units: (Bq/kg) | |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Uranium-234/233 | 9.47E+01 | 89 | A | | 6.4 | 62 - 116 | 1.01 | A |
| Uranium-238 | 2.64E+02 | 259 | A | | 1.9 | 181 - 337 | 1.95 | A |
| Zinc-65 | 6.27E+02 | 541 | A | | 15.9 | 379 - 703 | 1.78 | A |

*Radiological Reference Date: August 1, 2014*

**Results Flags:**

A = Result acceptable Bias <=20%

W = Result acceptable with warning 20% < Bias < 30%

N = Result not acceptable Bias > 30%

RW = Report Warning

NR = Not Reported

**Uncertainty Flags:**

1) NOT ACCEPTABLE............................RP<2%

2) ACCEPTABLE..................................2%<=RP<=15%

3) ACCEPTABLE WITH WARNING...........15%<RP<=30%

4) NOT ACCEPTABLE............................RP>30%

RP = Relative Precision

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP-14-MaW31*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

| Inorganic | | | | | | | | Units: (mg/L) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Antimony | NR | | | | | False Positive Test | | |
| Arsenic | NR | 3.90 | | | | 2.73 - 5.07 | | |
| Barium | NR | 14.8 | | | | 10.4 - 19.2 | | |
| Beryllium | NR | 2.16 | | | | 1.51 - 2.81 | | |
| Cadmium | NR | 0.629 | | | | 0.440 - 0.818 | | |
| Chromium | NR | 0.0169 | | | | Sensitivity Evaluation | | |
| Cobalt | NR | 6.74 | | | | 4.72 - 8.76 | | |
| Copper | NR | 4.33 | | | | 3.03 - 5.63 | | |
| Lead | NR | | | | | False Positive Test | | |
| Mercury | NR | 0.00956 | | | | 0.00669 - 0.01243 | | |
| Nickel | NR | 6.09 | | | | 4.26 - 7.92 | | |
| Selenium | NR | 0.499 | | | | 0.349 - 0.649 | | |
| Technetium-99 | NR | 1.11E-5 | | | | 0.0000078 - 0.0000144 | | |
| Thallium | NR | 2.18 | | | | 1.53 - 2.83 | | |
| Uranium-235 | NR | 2.19E-4 | | | | 0.000153 - 0.000285 | | |
| Uranium-238 | NR | 0.114 | | | | 0.080 - 0.148 | | |
| Uranium-Total | NR | 0.114 | | | | 0.080 - 0.148 | | |
| Vanadium | NR | 7.20 | | | | 5.04 - 9.36 | | |
| Zinc | NR | 8.36 | | | | 5.85 - 10.87 | | |

| Radiological | | | | | | | | Units: (Bq/L) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Americium-241 | 7.46E-01 | 0.88 | A | | -15.2 | 0.62 - 1.14 | 4.89E-02 | A |
| Cesium-134 | 2.70E-01 | | A | | | False Positive Test | 5.25E-01 | |
| Cesium-137 | 1.74E+01 | 18.4 | A | | -5.4 | 12.9 - 23.9 | 6.72E-01 | A |
| Cobalt-57 | 2.34E+01 | 24.7 | A | | -5.3 | 17.3 - 32.1 | 7.34E-01 | A |
| Cobalt-60 | 1.30E+01 | 12.4 | A | | 4.8 | 8.7 - 16.1 | 5.53E-01 | A |
| Hydrogen-3 | NR | 208 | | | | 146 - 270 | | |
| Iron-55 | NR | 31.5 | | | | 22.1 - 41.0 | | |
| Manganese-54 | 1.28E+01 | 14.0 | A | | -8.6 | 9.8 - 18.2 | 6.44E-01 | A |
| Nickel-63 | NR | 24.6 | | | | 17.2 - 32.0 | | |
| Plutonium-238 | 5.77E-01 | 0.618 | A | | -6.6 | 0.433 - 0.803 | 6.77E-02 | A |
| Plutonium-239/240 | 4.97E-03 | 0.0048 | A | | | Sensitivity Evaluation | 1.57E-03 | |
| Potassium-40 | 1.66E+02 | 161 | A | | 3.1 | 113 - 209 | 7.63 | A |
| Strontium-90 | NR | | | | | False Positive Test | | |
| Technetium-99 | NR | 6.99 | | | | 4.89 - 9.09 | | |

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

| Radiological | | | | | | | Units: (Bq/L) | |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Uranium-234/233 | 2.01E-01 | 0.205 | A | | -2.0 | 0.144 - 0.267 | 1.53E-02 | A |
| Uranium-238 | 1.36E+00 | 1.42 | A | | -4.2 | 0.99 - 1.85 | 9.81E-02 | A |
| Zinc-65 | 1.06E+01 | 10.9 | A | | -2.8 | 7.6 - 14.2 | 1.19 | A |

*Radiological Reference Date: August 1, 2014*

**Result Flags:**

A = Result acceptable Bias <=20%

W = Result accepatble with warning 20% < Bias < 30%

N = Result not acceptable Bias > 30%

RW = Report Warning

NR = Not Reported

**Uncertainty Flags:**

1) NOT ACCEPTABLE............................RP<2%

2) ACCEPTABLE..................................2%<=RP<=15%

3) ACCEPTABLE WITH WARNING...........15%<RP<=30%

4) NOT ACCEPTABLE............................RP>30%

RP = Relative Precision

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

**MAPEP** Mixed Analyte Performance Evaluation Program

Department of Energy RESL - 1955 Fremont Ave, MS4149 - Idaho Falls, ID 83415

*Laboratory Results For MAPEP-14-RdF31*
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

| Inorganic | | | | | | | | Units: (ug/sample) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Uranium-235 | NR | 0.0397 | | | | 0.0278 - 0.0516 | | |
| Uranium-238 | NR | 20.3 | | | | 14.2 - 26.4 | | |
| Uranium-Total | NR | 20.4 | | | | 14.3 - 26.5 | | |

| Radiological | | | | | | | | Units: (Bq/sample) |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |
| Americium-241 | 6.43E-02 | 0.0674 | A | | -4.6 | 0.0472 - 0.0876 | 4.42E-03 | A |
| Cesium-134 | 9.53E-01 | 0.96 | A | | -0.7 | 0.67 - 1.25 | 3.72E-02 | A |
| Cesium-137 | 1.26E+00 | 1.20 | A | | 5.0 | 0.84 - 1.56 | 4.84E-02 | A |
| Cobalt-57 | 1.49E+00 | 1.43 | A | | 4.2 | 1.00 - 1.86 | 4.79E-02 | A |
| Cobalt-60 | 1.25E+00 | 1.10 | A | | 13.6 | 0.77 - 1.43 | 4.54E-02 | A |
| Manganese-54 | 7.89E-01 | 0.75 | A | | 5.2 | 0.53 - 0.98 | 4.42E-02 | A |
| Plutonium-238 | 1.14E-01 | 0.107 | A | | 6.5 | 0.075 - 0.139 | 8.18E-03 | A |
| Plutonium-239/240 | 4.80E-02 | 0.0468 | A | | 2.6 | 0.0328 - 0.0608 | 3.99E-03 | A |
| Strontium-90 | NR | 0.703 | | | | 0.492 - 0.914 | | |
| Uranium-234/233 | 3.38E-02 | 0.0358 | A | | -5.6 | 0.0251 - 0.0465 | 3.36E-03 | A |
| Uranium-238 | 2.36E-01 | 0.253 | A | | -6.7 | 0.177 - 0.329 | 1.94E-02 | A |
| Zinc-65 | 8.24E-01 | 0.76 | A | | 8.4 | 0.53 - 0.99 | 8.57E-02 | A |

*Radiological Reference Date: August 1, 2014*

**Result Flags:**

A = Result acceptable Bias <=20%

W = Result accepatble with warning 20% < Bias < 30%

N = Result not acceptable Bias > 30%

RW = Report Warning

NR = Not Reported

**Uncertainty Flags:**

1) NOT ACCEPTABLE............................RP<2%

2) ACCEPTABLE..................................2%<=RP<=15%

3) ACCEPTABLE WITH WARNING...........15%<RP<=30%

Issued 11/20/2014 Printed 2/25/2015

Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

| Radiological | | | | | | | Units: (Bq/sample) | |
|---|---|---|---|---|---|---|---|---|
| Analyte | Result | Ref Value | Flag | Notes | Bias (%) | Acceptance Range | Unc Value | Unc Flag |

4) NOT ACCEPTABLE............................RP>30%

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Figure 9-6: Radiochemistry MAPEP 2014 Intercomparison Results (continued)

# APPENDICES

## Helpful Information

The following information is provided to assist the reader in understanding this report. Included here is information on scientific notation, radioactivity units, understanding data tables and data uncertainty, understanding graphs, and selected mathematical symbols.

### Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion could be written as 1,000,000,000 or, by using scientific or E notation, written as $1 \times 10^9$ or 1.0E+09. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from its current location. If the value given is $2.0 \times 10^3$ (or 2.0E+03), the decimal point should be moved three places to the **right** so that the number would then read 2,000. If the value given is $2.0 \times 10^{-5}$ (or 2.0E-05), the decimal point should be moved five places to the **left** so that the result would be 0.00002.

### Radioactivity Units

Much of this report provides data on levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of **curies (Ci)**, with conversions to **becquerels (Bq)**, the International System of Units measure (Table 1). The curie is the basic unit used to describe the amount of activity present, and activities are generally expressed in terms of curies per mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. One becquerel is equivalent to one disintegration per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or various combinations of these.

### Understanding the Data Tables

Some degree of variability, or uncertainty, is associated with all analytical measurements. This uncertainty is the consequence of random or systematic inaccuracies related to collecting, preparing, and analyzing the samples. These inaccuracies could include errors associated with reading or recording the result, handling or processing the sample, calibrating the counting instrument, and numerical rounding. With radionuclides, inaccuracies can also result from the randomness of radioactive decay. In this report, the uncertainties used include standard deviation, total propagated analytical uncertainty, and standard error of the mean.

| Table 1: Names and symbols for Units of Radioactivity | | | |
|---|---|---|---|
| Symbol | Name | Symbol | Name |
| Ci | curie | Bq | becquerel (2.7 × $10^{-11}$ Ci) |
| mCi | millicurie (1 x $10^{-3}$ Ci) | kBq | kilobecquerel (1 × $10^{3}$ Bq) |
| µCi | microcurie (1 x $10^{-6}$ Ci) | MBq | megabecquerel (1 × $10^{6}$ Bq) |
| nCi | nanocurie (1 x $10^{-9}$ Ci) | mBq | millibecquerel (1 × $10^{-3}$ Bq) |
| pCi | picocurie (1 x $10^{-12}$ Ci) | GBq | gigabecquerel (1 × $10^{9}$ Bq) |
| fCi | femtocurie (1 x $10^{-15}$ Ci) | TBq | terabecquerel (1 × $10^{12}$ Bq) |

## Standard Deviation

The standard deviation (SD) of sample data relates to the variation around the mean of a set of individual sample results. If differences in analytical results occur among samples, then two times the standard deviation (or ±2 SD) implies that 95% of the time, a re-count or re-analysis of the same sample would give a value somewhere between the mean result minus two times the standard deviation and the mean result plus two times the standard deviation.

## Total Propagated Analytical Uncertainty

For samples that are prepared or manipulated in the laboratory prior to counting (counting the rate of radioactive emissions from a sample), the total propagated analytical uncertainty includes both the counting uncertainty and the uncertainty associated with sample preparation and chemical separations. For samples that are not manipulated (e.g., ashed, dried, or chemically treated) in the laboratory before counting, the total propagated analytical uncertainty only accounts for the uncertainty associated with counting the sample. The uncertainty associated with samples that are analyzed but not counted (e.g., chemical or water quality measurements) includes only the analytical process uncertainty. In this situation, the total propagated analytical uncertainty is assumed to be the nominal detection limit.

## Standard Error of the Mean

Just as individual values are accompanied by counting uncertainties, the mean of mean values (averages) is accompanied by ±2 times the standard error of the calculated mean. Two times the standard error of the mean implies that approximately 95% of the time the next calculated mean will fall somewhere between the reported value minus two times the standard error and the reported value plus two times the standard error.

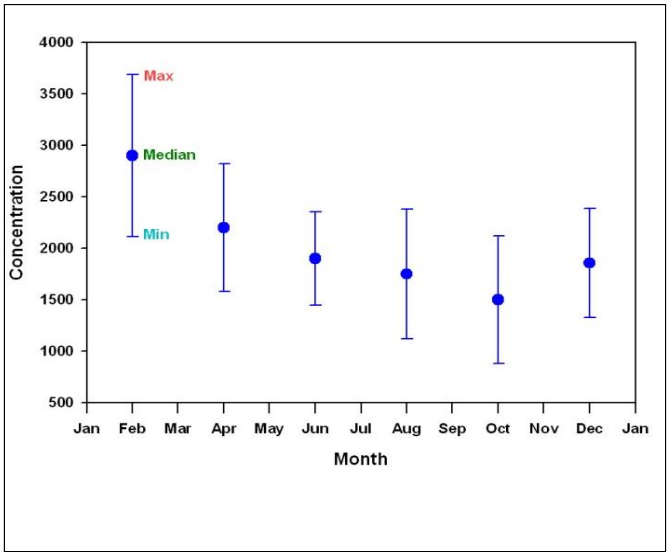


Figure A-1: Graphical representation of maximum, median and minimum values

## Median, Maximum, and Minimum Values

Median, maximum, and minimum values are reported in some sections of this report. A median value is the middle value of an odd numbered set and the average of the two central values in an even numbered set. For example, the median value in the odd numbered series of numbers - 1, 2, 3, 3, 4, 5, 5, 5, 6 is 4. The maximum value would be 6 and the minimum value would be 1. Median, maximum, and minimum values are reported when there are too few analytical results to accurately determine the average with a ± statistical uncertainty or when the data do not follow a bellshape (i.e., normal) distribution. Figure A-1 provides a graphical representation of median, maximum, and minimum values. The upper line is the maximum value, the center dot is the median value, and the lower line is the minimum value.

## Negative Concentrations

Instruments used in the laboratory to measure radioactivity in WIPP Site environmental samples are sensitive enough to measure natural, or background, radiation along with any contaminant radiation in a sample. To obtain a true measure of the contaminant level in a sample, the background radiation level must be subtracted from the total amount of radioactivity measured by an instrument. Because of the randomness of radio-active emissions, the very low activities of some contaminants, or the presence of undesirable materials, it is possible to obtain a background measurement that is larger than the actual contaminant measurement. When the larger background measurement is subtracted from the smaller contaminant measurement, a negative result is generated. The negative results are reported because they are essential when conducting statistical evaluations of the data.

## Understanding Graphs

Graphs are useful when comparing numbers collected at several locations or at one location over time. Graphs often make it easy to visualize differences in data where they exist. However, careful consideration should be given to the scale (linear or logarithmic) and units. Some of the data graphed in this report may be plotted using logarithmic, or compressed, scales.

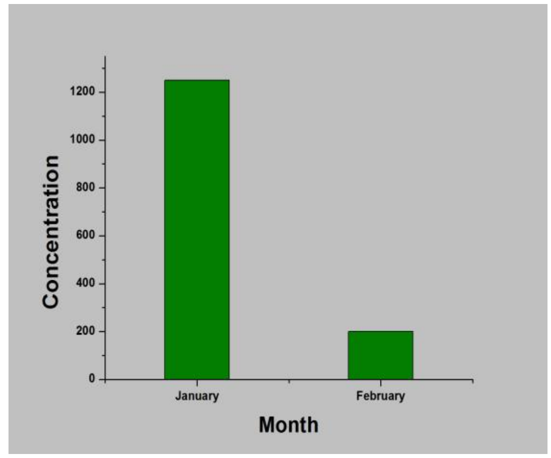


Figure A-2: Data plotted using a linear scale

Logarithmic scales are useful when plotting two or more numbers that differ greatly in size or are very close together. For example, a sample with a concentration of 5 grams per liter would get lost at the bottom of the graph if plotted on a linear scale with a sample having a concentration of 1,000 grams per liter (Figure A-2). A logarithmic plot of these same two numbers allows the reader to see both data points clearly (Figure A-3).

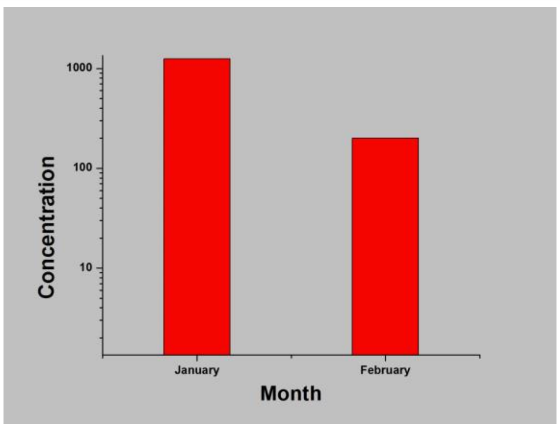


Figure A-3: Data plotted using a logarithmic scale

The mean (average) and median (defined earlier) values seen in graphics in this report have vertical lines extending above and below the data point. When used with a value, these lines (called error bars) indicate the amount of uncertainty (standard deviation, total propagated analytical uncertainty, or two standard error of the mean) in the reported value.

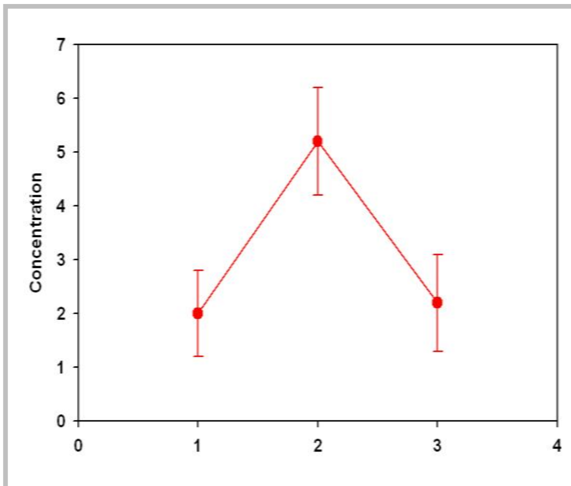


Figure A-4: Data with error bars plotted using a linear scale

The error bars in this report represent a 95% chance that the value is between the upper and lower ends of the error bar and a 5% chance that the true value is either lower or higher than the error bar. For example, in Figure A-4, the first plotted value is $2.0 \pm 1.1$, so there is a 95% chance that the true value is between 0.9 and 3.1, a 2.5% chance that it is less than 0.9, and a 2.5% chance that it is greater than 3.1. Error bars are computed statistically, employing all of the information used to generate the value. These bars provide a quick, visual indication that one value may be statistically similar to or different from another value. If the error bars of two or more values overlap, as is the case with values 1 and 3 and values 2 and 3, the values may be statistically similar. If the error bars do not overlap (values 1 and 2), the values may be statistically different. Values that appear to be very different visually (values 2 and 3) may actually be quite similar when compared statistically. Lastly, when vertical lines are used with median values, the lower end of each bar represents the minimum concentration measured while the upper end of each bar represents the maximum concentration measured (see Figure A-1).

## Appendix A: WIPP Underground Air Station A

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 3/1/2014 | 7.66E-02 | 1.21E-03 | 9.45E-03 | 3.12E-04 |
| 3/2/2014 | 5.75E-02 | 9.46E-04 | 8.13E-03 | 2.70E-04 |
| 3/3/2014 | 4.43E-02 | 8.03E-04 | 6.51E-03 | 2.52E-04 |
| 3/4/2014 | 1.19E-01 | 1.98E-03 | 1.63E-02 | 4.95E-04 |
| 3/5/2014 | 5.64E-02 | 1.18E-03 | 8.10E-03 | 3.55E-04 |
| 3/6/2014 | 3.04E-02 | 7.56E-04 | 4.77E-03 | 2.79E-04 |
| 3/7/2014 | 6.83E-02 | 1.33E-03 | 1.08E-02 | 4.14E-04 |
| 3/8/2014 | 2.56E-02 | 6.81E-04 | 4.14E-03 | 2.27E-04 |
| 3/9/2014 | 3.26E-02 | 7.79E-04 | 7.09E-03 | 3.17E-04 |
| 3/10/2014 | 5.53E-02 | 1.14E-03 | 8.34E-03 | 3.58E-04 |
| 3/11/2014 | 5.89E-02 | 1.14E-03 | 2.07E-02 | 5.05E-04 |
| 3/12/2014 | 6.18E-02 | 5.71E-02 | 5.85E-02 | 8.79E-04 |
| 3/13/2014 | 3.20E-01 | 6.18E-03 | 4.08E-02 | 8.91E-04 |
| 3/14/2014 | 2.49E-02 | 6.73E-04 | 5.52E-03 | 2.89E-04 |
| 3/15/2014 | 5.18E-02 | 1.09E-03 | 1.94E-02 | 4.83E-04 |
| 3/16/2014 | 5.02E-02 | 1.01E-03 | 4.96E-02 | 7.81E-04 |
| 3/17/2014 | 1.97E-02 | 5.82E-04 | 2.95E-03 | 2.41E-04 |
| 3/18/2014 | 6.52E-02 | 1.28E-03 | 1.05E-02 | 3.81E-04 |
| 3/19/2014 | 4.24E-02 | 9.26E-04 | 1.66E-02 | 4.50E-04 |
| 3/20/2014 | 7.13E-02 | 1.31E-03 | 4.30E-02 | 7.45E-04 |
| 3/21/2014 | 5.46E-02 | 1.09E-03 | 1.03E-02 | 3.78E-04 |
| 3/22/2014 | 4.94E-02 | 1.01E-03 | 2.44E-02 | 5.41E-04 |
| 3/23/2014 | 5.00E+00 | 2.10E-03 | 1.19E-01 | 1.41E-03 |
| 3/24/2014 | 7.32E-02 | 1.33E-03 | 9.93E-03 | 3.87E-04 |
| 3/25/2014 | 5.64E-02 | 1.10E-03 | 1.18E-02 | 3.95E-04 |
| 3/26/2014 | 5.15E-02 | 1.05E-03 | 2.83E-02 | 5.86E-04 |
| 3/27/2014 | 7.54E-02 | 1.33E-03 | 8.92E-02 | 1.12E-03 |
| 3/28/2014 | 9.61E-02 | 1.82E-03 | 1.35E-02 | 4.53E-04 |
| 3/29/2014 | 3.13E-02 | 7.64E-04 | 8.01E-03 | 3.30E-04 |
| 3/30/2014 | 3.71E-02 | 8.38E-04 | 2.66E-02 | 5.49E-04 |
| 3/31/2014 | 5.41E-02 | 1.09E-03 | 6.86E-02 | 9.83E-04 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 4/1/2014 | 2.33E-02 | 6.57E-04 | 5.53E-03 | 2.83E-04 |
| 4/2/2014 | 3.25E-02 | 7.93E-04 | 1.71E-02 | 4.45E-04 |
| 4/3/2014 | 7.03E-02 | 1.29E-03 | 5.78E-02 | 8.65E-04 |
| 4/4/2014 | 3.71E-02 | 8.77E-04 | 7.11E-03 | 3.28E-04 |
| 4/5/2014 | 2.88E-02 | 7.23E-04 | 2.39E-02 | 5.27E-04 |
| 4/6/2014 | 2.09E-02 | 6.12E-04 | 7.10E-03 | 3.07E-04 |
| 4/7/2014 | 2.48E-02 | 6.60E-04 | 1.76E-02 | 4.45E-04 |
| 4/8/2014 | 2.57E-02 | 6.81E-04 | 2.27E-02 | 5.09E-04 |
| 4/9/2014 | 2.92E-02 | 7.38E-04 | 1.82E-02 | 4.61E-04 |
| 4/10/2014 | 3.09E-02 | 7.65E-04 | 2.18E-02 | 5.30E-04 |
| 4/11/2014 | 2.08E-02 | 1.98E-02 | 5.57E-03 | 2.82E-04 |
| 4/12/2014 | 2.31E-02 | 6.52E-04 | 1.72E-02 | 4.33E-04 |
| 4/13/2014 | 4.74E-02 | 1.07E-03 | 4.50E-02 | 7.82E-04 |
| 4/14/2014 | 1.33E-02 | 4.72E-04 | 1.75E-02 | 4.44E-04 |
| 4/15/2014 | 1.26E-02 | 4.57E-04 | 5.65E-03 | 2.79E-04 |
| 4/16/2014 | 1.70E-02 | 5.38E-04 | 2.02E-02 | 4.78E-04 |
| 4/17/2014 | 5.85E-03 | 3.10E-04 | 3.20E-03 | 2.30E-04 |
| 4/18/2014 | 3.21E-02 | 8.05E-04 | 7.23E-03 | 3.19E-04 |
| 4/19/2014 | 6.12E-02 | 1.23E-03 | 1.57E-02 | 4.48E-04 |
| 4/20/2014 | 5.61E-02 | 1.12E-03 | 3.15E-02 | 6.10E-04 |
| 4/21/2014 | 1.53E-02 | 5.08E-04 | 9.08E-03 | 3.34E-04 |
| 4/22/2014 | 2.53E-02 | 6.75E-04 | 3.35E-02 | 6.40E-04 |
| 4/23/2014 | 1.15E-02 | 4.36E-04 | 2.85E-03 | 2.37E-04 |
| 4/24/2014 | 5.62E-03 | 3.03E-04 | 1.90E-03 | 1.89E-04 |
| 4/25/2014 | 5.75E-03 | 3.06E-04 | 5.02E-03 | 2.64E-04 |
| 4/26/2014 | 3.47E-03 | 2.42E-04 | 1.69E-03 | 2.00E-04 |
| 4/27/2014 | 3.90E-03 | 2.49E-04 | 7.60E-04 | 1.60E-04 |
| 4/28/2014 | 5.84E-03 | 3.13E-04 | 3.88E-03 | 2.40E-04 |
| 4/29/2014 | 4.87E-03 | 2.83E-04 | 4.59E-03 | 2.61E-04 |
| 4/30/2014 | 1.42E-02 | 4.82E-04 | 1.61E-02 | 4.20E-04 |
| 5/1/2014 | 3.83E-03 | 2.52E-04 | 1.75E-03 | 1.99E-04 |
| 5/2/2014 | 1.11E-02 | 4.25E-04 | 5.11E-03 | 2.59E-04 |
| 5/3/2014 | 7.96E-03 | 3.71E-04 | 1.01E-02 | 3.48E-04 |
| 5/4/2014 | 5.43E-03 | 2.95E-04 | 4.94E-03 | 2.54E-04 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 5/5/2014 | 1.75E-02 | 5.43E-04 | 2.45E-02 | 5.22E-04 |
| 5/6/2014 | 5.56E-03 | 3.02E-04 | 5.93E-03 | 2.81E-04 |
| 5/7/2014 | 1.02E-02 | 4.22E-04 | 1.11E-02 | 3.62E-04 |
| 5/8/2014 | 3.97E-03 | 2.53E-04 | 2.18E-03 | 2.12E-04 |
| 5/9/2014 | 6.46E-03 | 3.25E-04 | 4.92E-03 | 2.53E-04 |
| 5/10/2014 | 1.93E-02 | 5.80E-04 | 2.13E-02 | 4.80E-04 |
| 5/11/2014 | 1.05E-02 | 4.27E-04 | 5.82E-03 | 2.88E-04 |
| 5/12/2014 | 1.46E-02 | 4.99E-04 | 1.49E-02 | 4.10E-04 |
| 5/13/2014 | 5.44E-03 | 2.94E-04 | 5.22E-03 | 2.71E-04 |
| 5/14/2014 | 2.86E-02 | 7.17E-04 | 2.28E-02 | 5.05E-04 |
| 5/15/2014 | 1.10E-02 | 4.29E-04 | 2.40E-03 | 2.07E-04 |
| 5/16/2014 | 1.00E-02 | 4.08E-04 | 5.06E-03 | 2.70E-04 |
| 5/17/2014 | 1.39E-03 | 1.32E-04 | 1.02E-03 | 1.26E-04 |
| 5/18/2014 | 2.30E-03 | 1.17E-04 | 1.85E-03 | 8.60E-05 |
| 5/19/2014 | 4.39E-03 | 1.70E-04 | 2.01E-03 | 9.08E-05 |
| 5/20/2014 | 6.07E-03 | 2.07E-04 | 5.16E-03 | 1.45E-04 |
| 5/21/2014 | 5.82E-03 | 2.03E-04 | 5.43E-03 | 1.50E-04 |
| 5/22/2014 | 9.59E-03 | 2.85E-04 | 1.58E-03 | 8.64E-05 |
| 5/23/2014 | 1.01E-02 | 2.94E-04 | 1.65E-03 | 8.85E-05 |
| 5/24/2014 | 7.93E-03 | 2.48E-04 | 1.63E-03 | 8.55E-05 |
| 5/25/2014 | 3.91E-03 | 1.60E-04 | 7.29E-04 | 6.22E-05 |
| 5/26/2014 | 1.90E-03 | 1.03E-04 | 7.53E-04 | 5.95E-05 |
| 5/27/2014 | 2.14E-03 | 1.09E-04 | 5.07E-04 | 4.82E-05 |
| 5/28/2014 | 5.05E-03 | 1.85E-04 | 7.59E-04 | 6.17E-05 |
| 5/29/2014 | 1.36E-03 | 8.80E-05 | 1.22E-03 | 6.96E-05 |
| 5/30/2014 | 9.19E-03 | 2.73E-04 | 2.60E-03 | 1.05E-04 |
| 5/31/2014 | 1.68E-03 | 4.29E-05 | 2.54E-03 | 5.31E-05 |
| 6/1/2014 | 2.73E-03 | 1.26E-04 | 1.13E-03 | 6.82E-05 |
| 6/2/2014 | 4.86E-03 | 2.37E-04 | 1.48E-03 | 1.40E-04 |
| 6/3/2014 | 1.12E-03 | 7.72E-05 | 6.17E-04 | 5.28E-05 |
| 6/4/2014 | 2.92E-03 | 1.80E-04 | 1.10E-03 | 1.22E-04 |
| 6/5/2014 | 1.97E-03 | 1.85E-04 | 1.46E-03 | 1.70E-04 |
| 6/6/2014 | 8.43E-03 | 3.74E-04 | 2.53E-03 | 2.20E-04 |
| 6/7/2014 | 1.12E-02 | 4.19E-04 | 9.26E-03 | 3.25E-04 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 6/8/2014 | 4.44E-03 | 2.74E-04 | 1.89E-03 | 2.07E-04 |
| 6/9/2014 | 3.08E-03 | 1.98E-04 | 1.58E-03 | 1.77E-04 |
| 6/10/2014 | 5.10E-03 | 2.35E-04 | 5.43E-03 | 2.22E-04 |
| 6/11/2014 | 1.90E-02 | 5.88E-04 | 2.85E-02 | 5.89E-04 |
| 6/12/2014 | 4.90E-03 | 2.80E-04 | 4.27E-03 | 2.47E-04 |
| 6/13/2014 | 3.76E-03 | 2.44E-04 | 2.97E-03 | 2.26E-04 |
| 6/14/2014 | 5.52E-03 | 3.03E-04 | 6.51E-03 | 2.87E-04 |
| 6/15/2014 | 1.65E-03 | 1.70E-04 | 3.73E-03 | 2.34E-04 |
| 6/16/2014 | 6.47E-03 | 3.28E-04 | 9.93E-03 | 3.41E-04 |
| 6/17/2014 | 5.10E-03 | 2.87E-04 | 8.90E-03 | 3.26E-04 |
| 6/18/2014 | 2.35E-02 | 6.45E-04 | 4.23E-02 | 7.09E-04 |
| 6/19/2014 | 1.79E-03 | 1.78E-04 | 2.29E-03 | 2.03E-04 |
| 6/20/2014 | 3.70E-03 | 2.51E-04 | 4.98E-03 | 2.60E-04 |
| 6/21/2014 | 1.32E-02 | 4.69E-04 | 2.00E-02 | 4.68E-04 |
| 6/22/2014 | 7.27E-03 | 3.48E-04 | 1.14E-02 | 3.73E-04 |
| 6/23/2014 | 7.43E-03 | 3.47E-04 | 8.79E-03 | 3.21E-04 |
| 6/24/2014 | 5.63E-03 | 3.17E-04 | 7.53E-03 | 3.15E-04 |
| 6/25/2014 | 1.17E-03 | 1.56E-04 | 7.51E-04 | 1.67E-04 |
| 6/26/2014 | 1.89E-03 | 1.88E-04 | 1.76E-03 | 2.01E-04 |
| 6/27/2014 | 1.16E-03 | 1.33E-04 | 2.47E-03 | 1.65E-04 |
| 6/28/2014 | 1.08E-03 | 7.77E-05 | 7.38E-04 | 5.72E-05 |
| 6/29/2014 | 8.08E-04 | 6.72E-05 | 1.63E-03 | 7.74E-05 |
| 6/30/2014 | 8.93E-04 | 6.81E-05 | 1.77E-03 | 8.05E-05 |
| 7/1/2014 | 9.49E-04 | 3.47E-05 | 7.46E-04 | 2.57E-05 |
| 7/2/2014 | 2.93E-04 | 1.81E-05 | 3.51E-04 | 2.00E-05 |
| 7/3/2014 | 2.65E-04 | 1.86E-05 | 3.52E-04 | 1.98E-05 |
| 7/4/2014 | 2.12E-04 | 1.66E-05 | 2.11E-04 | 1.53E-05 |
| 7/5/2014 | 2.95E-04 | 1.86E-05 | 2.43E-04 | 1.59E-05 |
| 7/6/2014 | 3.04E-04 | 1.87E-05 | 4.42E-04 | 2.11E-05 |
| 7/7/2014 | 5.91E-04 | 2.58E-05 | 5.31E-04 | 2.19E-05 |
| 7/8/2014 | 1.99E-04 | 1.63E-05 | 4.59E-04 | 2.08E-05 |
| 7/9/2014 | 2.23E-04 | 1.64E-05 | 2.61E-04 | 1.62E-05 |
| 7/10/2014 | 3.75E-04 | 2.05E-05 | 2.37E-04 | 1.53E-05 |
| 7/11/2014 | 3.09E-04 | 1.86E-05 | 3.71E-04 | 2.00E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 7/12/2014 | 4.18E-04 | 2.17E-05 | 2.92E-04 | 1.65E-05 |
| 7/13/2014 | 2.72E-04 | 1.81E-05 | 4.60E-04 | 2.14E-05 |
| 7/14/2014 | 7.48E-04 | 2.94E-06 | 4.55E-04 | 2.11E-05 |
| 7/15/2014 | 2.71E-03 | 7.03E-05 | 5.71E-04 | 2.37E-05 |
| 7/16/2014 | 1.46E-03 | 4.51E-05 | 5.25E-04 | 2.24E-05 |
| 7/17/2014 | 4.86E-04 | 2.30E-05 | 4.65E-04 | 2.28E-05 |
| 7/18/2014 | 2.78E-04 | 1.75E-05 | 2.24E-04 | 1.53E-05 |
| 7/19/2014 | 5.26E-04 | 2.49E-05 | 3.30E-04 | 1.72E-05 |
| 7/20/2014 | 3.42E-04 | 1.98E-05 | 8.00E-04 | 2.56E-05 |
| 7/21/2014 | 3.85E-04 | 2.09E-05 | 8.63E-04 | 2.69E-05 |
| 7/22/2014 | 4.40E-04 | 2.18E-05 | 2.96E-04 | 1.67E-05 |
| 7/23/2014 | 3.37E-04 | 2.01E-05 | 8.26E-04 | 2.66E-05 |
| 7/24/2014 | 2.84E-04 | 1.81E-05 | 9.60E-04 | 2.73E-05 |
| 7/25/2014 | 7.35E-03 | 1.62E-04 | 1.33E-03 | 3.52E-05 |
| 7/26/2014 | 1.20E-03 | 6.01E-05 | 5.36E-04 | 2.28E-05 |
| 7/27/2014 | 1.61E-03 | 3.91E-05 | 8.03E-04 | 2.67E-05 |
| 7/28/2014 | 1.59E-03 | 4.68E-05 | 7.92E-04 | 2.63E-05 |
| 7/29/2014 | 1.99E-03 | 5.53E-05 | 9.46E-04 | 2.95E-05 |
| 7/30/2014 | 5.97E-03 | 1.35E-04 | 5.61E-04 | 2.34E-05 |
| 7/31/2014 | 2.17E-03 | 5.97E-05 | 6.07E-04 | 2.43E-05 |
| 8/1/2014 | 1.54E-03 | 4.64E-05 | 8.68E-04 | 2.70E-05 |
| 8/2/2014 | 1.52E-03 | 4.61E-05 | 7.83E-04 | 2.57E-05 |
| 8/3/2014 | 2.02E-03 | 5.65E-05 | 3.81E-04 | 1.87E-05 |
| 8/4/2014 | 9.52E-04 | 3.34E-05 | 3.56E-04 | 1.79E-05 |
| 8/5/2014 | 5.31E-04 | 2.37E-05 | 9.66E-04 | 2.84E-05 |
| 8/6/2014 | 5.84E-04 | 2.56E-05 | 4.71E-04 | 1.94E-05 |
| 8/7/2014 | 6.22E-04 | 2.66E-05 | 8.44E-04 | 2.62E-05 |
| 8/8/2014 | 2.64E-04 | 1.68E-05 | 5.84E-04 | 2.22E-05 |
| 8/9/2014 | 1.95E-04 | 1.51E-05 | 4.70E-04 | 2.21E-05 |
| 8/10/2014 | 2.66E-04 | 1.73E-05 | 4.30E-04 | 2.01E-05 |
| 8/11/2014 | 3.20E-04 | 2.00E-05 | 3.79E-04 | 2.00E-05 |
| 8/12/2014 | 3.74E-04 | 2.04E-05 | 4.98E-04 | 2.25E-05 |
| 8/13/2014 | 7.01E-04 | 2.90E-05 | 5.10E-04 | 2.16E-05 |
| 8/14/2014 | 7.66E-04 | 3.06E-05 | 6.57E-04 | 2.40E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 8/15/2014 | 3.83E-03 | 9.22E-05 | 9.87E-04 | 2.99E-05 |
| 8/16/2014 | 4.49E-04 | 2.26E-05 | 4.13E-04 | 2.02E-05 |
| 8/17/2014 | 5.48E-04 | 2.56E-05 | 5.61E-04 | 2.31E-05 |
| 8/18/2014 | 3.12E-04 | 1.94E-05 | 5.23E-04 | 2.17E-05 |
| 8/19/2014 | 4.78E-04 | 2.28E-05 | 5.72E-04 | 2.08E-05 |
| 8/20/2014 | 1.99E-03 | 5.60E-05 | 4.71E-04 | 2.00E-05 |
| 8/21/2014 | 4.14E-04 | 2.14E-05 | 5.67E-04 | 2.32E-05 |
| 8/22/2014 | 3.99E-04 | 2.19E-05 | 4.50E-04 | 2.06E-05 |
| 8/23/2014 | 4.60E-04 | 2.25E-05 | 4.02E-04 | 2.01E-05 |
| 8/24/2014 | 4.58E-04 | 2.28E-05 | 4.98E-04 | 2.14E-05 |
| 8/25/2014 | 4.41E-04 | 2.19E-05 | 5.14E-04 | 2.27E-05 |
| 8/26/2014 | 3.89E-04 | 2.06E-05 | 4.55E-04 | 2.12E-05 |
| 8/27/2014 | 4.99E-04 | 2.42E-05 | 5.06E-04 | 2.19E-05 |
| 8/28/2014 | 6.92E-04 | 2.77E-05 | 5.21E-04 | 2.22E-05 |
| 8/29/2014 | 6.09E-04 | 2.57E-05 | 6.72E-04 | 2.39E-05 |
| 8/30/2014 | 6.44E-04 | 2.66E-05 | 5.36E-04 | 2.23E-05 |
| 8/31/2014 | 9.69E-04 | 3.44E-05 | 6.50E-04 | 2.45E-05 |
| 9/1/2014 | 5.77E-04 | 2.43E-05 | 6.35E-04 | 2.33E-05 |
| 9/2/2014 | 5.56E-04 | 2.56E-05 | 5.37E-04 | 2.17E-05 |
| 9/3/2014 | 4.27E-04 | 2.12E-05 | 2.75E-04 | 1.93E-05 |
| 9/4/2014 | 3.85E-04 | 2.02E-05 | 1.88E-04 | 1.76E-05 |
| 9/5/2014 | 3.60E-04 | 2.02E-05 | 1.91E-04 | 1.73E-05 |
| 9/6/2014 | 4.77E-04 | 2.27E-05 | 1.51E-04 | 1.64E-05 |
| 9/7/2014 | 5.50E-04 | 2.55E-05 | 2.22E-04 | 1.76E-05 |
| 9/8/2014 | 4.56E-04 | 2.33E-05 | 5.77E-04 | 2.23E-05 |
| 9/9/2014 | 6.08E-04 | 2.62E-05 | 4.40E-04 | 2.04E-05 |
| 9/10/2014 | 8.46E-04 | 3.19E-05 | 5.81E-04 | 2.34E-05 |
| 9/11/2014 | 6.31E-04 | 2.65E-05 | 6.80E-04 | 2.42E-05 |
| 9/12/2014 | 1.35E-04 | 1.36E-05 | 1.34E-04 | 1.71E-05 |
| 9/13/2014 | 5.25E-04 | 3.54E-05 | 3.78E-04 | 2.00E-05 |
| 9/14/2014 | 3.91E-03 | 9.42E-05 | 7.03E-04 | 2.62E-05 |
| 9/15/2014 | 1.05E-03 | 3.67E-05 | 5.00E-04 | 2.17E-05 |
| 9/16/2014 | 6.95E-04 | 2.82E-05 | 6.58E-04 | 2.47E-05 |
| 9/17/2014 | 5.74E-04 | 2.55E-05 | 4.59E-04 | 2.10E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 9/18/2014 | 3.60E-03 | 8.84E-05 | 4.48E-04 | 2.27E-05 |
| 9/19/2014 | 9.38E-04 | 3.42E-05 | 2.22E-04 | 1.92E-05 |
| 9/20/2014 | 6.30E-04 | 2.74E-05 | 2.83E-04 | 1.87E-05 |
| 9/21/2014 | 9.30E-04 | 3.43E-05 | 2.52E-04 | 1.86E-05 |
| 9/22/2014 | 2.75E-03 | 7.20E-05 | 9.56E-04 | 2.88E-05 |
| 9/23/2014 | 1.18E-03 | 3.98E-05 | 1.26E-03 | 3.27E-05 |
| 9/24/2014 | 6.49E-04 | 2.77E-05 | 9.78E-04 | 2.83E-05 |
| 9/25/2014 | 6.71E-04 | 2.84E-05 | 9.13E-04 | 2.72E-05 |
| 9/26/2014 | 1.06E-03 | 3.60E-05 | 8.96E-04 | 2.75E-05 |
| 9/27/2014 | 3.57E-04 | 1.95E-05 | 3.80E-04 | 2.00E-05 |
| 9/28/2014 | 1.67E-04 | 1.44E-05 | 4.36E-04 | 2.06E-05 |
| 9/29/2014 | 1.11E-04 | 1.26E-05 | 5.91E-04 | 2.26E-05 |
| 9/30/2014 | 1.45E-04 | 1.33E-05 | 6.63E-04 | 2.44E-05 |
| 10/1/15 | 4.64E-04 | 6.80E-05 | 1.15E-03 | 1.09E-04 |
| 10/2/2014 | 9.94E-04 | 3.41E-05 | 8.45E-04 | 2.71E-05 |
| 10/3/2014 | 1.95E-04 | 1.54E-05 | 7.10E-04 | 2.43E-05 |
| 10/4/2014 | 2.63E-04 | 1.74E-05 | 9.08E-04 | 2.73E-05 |
| 10/5/2014 | 1.59E-04 | 1.33E-05 | 8.78E-04 | 2.76E-05 |
| 10/6/2014 | 1.89E-04 | 1.51E-05 | 5.65E-04 | 2.94E-05 |
| 10/7/2014 | 1.78E-04 | 1.38E-05 | 8.81E-04 | 2.67E-05 |
| 10/8/2014 | 6.06E-04 | 8.70E-05 | 2.09E-03 | 1.09E-04 |
| 10/9/2014 | 2.07E-04 | 1.50E-05 | 4.18E-04 | 2.18E-05 |
| 10/10/2014 | 9.41E-04 | 6.75E-05 | 1.31E-03 | 1.03E-04 |
| 10/11/2014 | 3.17E-04 | 1.83E-05 | 2.42E-04 | 1.85E-05 |
| 10/12/2014 | 1.59E-04 | 1.39E-05 | 7.37E-04 | 2.45E-05 |
| 10/13/2014 | 2.98E-04 | 1.80E-05 | 2.42E-04 | 1.88E-05 |
| 10/14/2014 | 1.09E-04 | 1.26E-05 | 3.36E-04 | 1.98E-05 |
| 10/15/2014 | 1.00E-04 | 1.23E-05 | 5.97E-04 | 2.35E-05 |
| 10/16/2014 | 1.16E-04 | 1.31E-05 | 8.37E-04 | 2.60E-05 |
| 10/17/2014 | 1.87E-04 | 1.57E-05 | 1.29E-03 | 3.34E-05 |
| 10/18/2014 | 1.24E-04 | 1.34E-05 | 8.34E-04 | 2.61E-05 |
| 10/19/2014 | 1.28E-04 | 1.33E-05 | 2.86E-04 | 2.67E-05 |
| 10/20/2014 | 2.27E-04 | 1.59E-05 | 5.08E-04 | 2.21E-05 |
| 10/21/2014 | 4.41E-04 | 2.27E-05 | 6.87E-04 | 2.44E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 10/22/2014 | 2.11E-04 | 1.55E-05 | 6.98E-04 | 2.49E-05 |
| 10/23/2014 | 1.24E-04 | 1.21E-05 | 6.21E-04 | 2.35E-05 |
| 10/24/2014 | 9.91E-05 | 1.34E-05 | 8.68E-04 | 2.64E-05 |
| 10/25/2014 | 1.56E-04 | 1.42E-05 | 1.13E-03 | 3.07E-05 |
| 10/26/2014 | 2.47E-04 | 1.69E-05 | 1.06E-03 | 2.96E-05 |
| 10/27/2014 | 1.59E-04 | 1.38E-05 | 6.46E-04 | 2.35E-05 |
| 10/28/2014 | 1.70E-04 | 1.41E-05 | 5.39E-04 | 2.27E-05 |
| 10/29/2014 | 2.39E-03 | 6.40E-05 | 1.28E-03 | 3.33E-05 |
| 10/30/2014 | 4.97E-04 | 2.33E-05 | 1.24E-03 | 3.19E-05 |
| 10/31/2014 | 2.29E-03 | 6.11E-05 | 8.62E-04 | 2.80E-05 |
| 11/1/2014 | 1.68E-04 | 1.40E-05 | 1.07E-03 | 2.91E-05 |
| 11/2/2014 | 3.10E-04 | 1.83E-05 | 1.09E-03 | 2.99E-05 |
| 11/3/2014 | 1.61E-04 | 1.31E-05 | 7.19E-04 | 2.47E-05 |
| 11/4/2014 | 1.80E-04 | 1.58E-05 | 3.68E-04 | 1.95E-05 |
| 11/5/2014 | 2.43E-04 | 1.63E-05 | 6.29E-04 | 2.38E-05 |
| 11/6/2014 | 4.24E-04 | 2.20E-05 | 7.43E-04 | 2.44E-05 |
| 11/7/2014 | 8.84E-05 | 1.18E-05 | 6.96E-04 | 2.47E-05 |
| 11/8/2014 | 7.65E-05 | 1.31E-05 | 3.65E-04 | 1.99E-05 |
| 11/9/2014 | 2.82E-04 | 1.76E-05 | 8.48E-04 | 2.68E-05 |
| 11/10/2014 | 1.94E-04 | 1.60E-05 | 9.04E-04 | 2.81E-05 |
| 11/11/2014 | 8.98E-04 | 3.23E-05 | 4.99E-04 | 2.25E-05 |
| 11/12/2014 | 2.43E-04 | 1.76E-05 | 5.75E-04 | 2.35E-05 |
| 11/13/2014 | 6.30E-04 | 2.66E-05 | 9.25E-04 | 2.76E-05 |
| 11/14/2014 | 8.47E-03 | 1.83E-04 | 1.85E-03 | 4.23E-05 |
| 11/15/2014 | 6.04E-04 | 2.61E-05 | 9.37E-04 | 2.90E-05 |
| 11/16/2014 | 9.41E-04 | 3.31E-05 | 1.54E-03 | 3.55E-05 |
| 11/17/2014 | 2.77E-04 | 1.77E-05 | 1.34E-03 | 3.38E-05 |
| 11/18/2014 | 2.54E-04 | 1.80E-05 | 1.22E-03 | 3.11E-05 |
| 11/19/2014 | 3.20E-04 | 1.88E-05 | 9.66E-04 | 2.80E-05 |
| 11/20/2014 | 4.76E-04 | 2.32E-05 | 1.24E-03 | 3.17E-05 |
| 11/21/2014 | 3.05E-04 | 1.95E-05 | 9.55E-04 | 2.83E-05 |
| 11/22/2014 | 2.17E-04 | 1.73E-05 | 9.43E-04 | 2.79E-05 |
| 11/23/2014 | 3.17E-04 | 1.87E-05 | 5.04E-04 | 2.29E-05 |
| 11/24/2014 | 9.83E-05 | 1.24E-05 | 2.07E-04 | 1.85E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 11/25/2014 | 3.09E-04 | 1.85E-05 | 2.66E-04 | 1.89E-05 |
| 11/26/2014 | 8.93E-05 | 1.25E-05 | 2.84E-04 | 1.82E-05 |
| 11/27/2014 | 1.02E-04 | 1.33E-05 | 5.16E-04 | 2.31E-05 |
| 11/28/2014 | 2.64E-04 | 1.74E-05 | 6.39E-04 | 2.43E-05 |
| 11/29/2014 | 3.98E-04 | 2.13E-05 | 8.32E-04 | 2.62E-05 |
| 11/30/2014 | 9.66E-04 | 3.48E-05 | 8.36E-04 | 2.72E-05 |
| 12/1/2014 | 1.94E-04 | 1.56E-05 | 1.21E-03 | 3.19E-05 |
| 12/2/2014 | 3.73E-04 | 2.08E-05 | 1.57E-03 | 3.65E-05 |
| 12/3/2014 | 8.51E-04 | 3.25E-05 | 1.80E-03 | 3.97E-05 |
| 12/4/2014 | 3.73E-04 | 3.91E-05 | 2.10E-03 | 7.32E-05 |
| 12/5/2014 | 6.24E-05 | 3.29E-06 | 3.71E-04 | 8.03E-06 |
| 12/6/2014 | 3.17E-04 | 1.94E-05 | 7.80E-04 | 2.65E-05 |
| 12/7/2014 | 8.58E-04 | 3.23E-05 | 1.21E-03 | 3.14E-05 |
| 12/8/2014 | 1.26E-04 | 1.36E-05 | 9.30E-04 | 2.86E-05 |
| 12/9/2014 | 4.11E-03 | 6.98E-05 | 2.31E-03 | 5.19E-05 |
| 12/10/2014 | 1.35E-04 | 1.34E-05 | 7.59E-04 | 2.47E-05 |
| 12/11/2014 | 3.45E-04 | 2.92E-05 | 1.54E-03 | 5.96E-05 |
| 12/12/2014 | 4.19E-03 | 9.84E-05 | 1.38E-03 | 3.52E-05 |
| 12/13/2014 | 8.74E-04 | 3.23E-05 | 9.06E-04 | 2.83E-05 |
| 12/14/2014 | 4.01E-03 | 9.64E-05 | 6.17E-04 | 2.56E-05 |
| 12/15/2014 | 4.19E-03 | 1.00E-04 | 8.02E-04 | 2.78E-05 |
| 12/16/2014 | 1.46E-03 | 4.52E-05 | 3.52E-04 | 2.19E-05 |
| 12/17/2014 | 8.02E-03 | 1.74E-04 | 1.22E-03 | 3.44E-05 |
| 12/18/2014 | 3.77E-03 | 9.13E-05 | 5.20E-04 | 2.45E-05 |
| 12/19/2014 | 9.22E-03 | 1.98E-04 | 1.24E-03 | 3.49E-05 |
| 12/20/2014 | 8.04E-04 | 3.01E-05 | 8.92E-04 | 2.74E-05 |
| 12/21/2014 | 1.35E-03 | 4.19E-05 | 7.53E-04 | 2.62E-05 |
| 12/22/2014 | 3.92E-03 | 9.37E-05 | 7.93E-04 | 2.78E-05 |
| 12/23/2014 | 1.48E-03 | 4.43E-05 | 3.11E-04 | 1.95E-05 |
| 12/24/2014 | 1.60E-03 | 4.63E-05 | 4.85E-04 | 2.26E-05 |
| 12/25/2014 | 1.01E-03 | 3.50E-05 | 4.62E-04 | 2.24E-05 |
| 12/26/2014 | 1.32E-03 | 4.13E-05 | 4.56E-04 | 2.15E-05 |
| 12/27/2014 | 7.87E-04 | 3.05E-05 | 3.94E-04 | 2.19E-05 |
| 12/28/2014 | 3.72E-03 | 9.76E-05 | 9.97E-04 | 6.45E-05 |

Table A-1: Daily Gross Alpha and Gross Beta concentration ($Bq/m^3$) measured in Station A (Pre-HEPA) filter (continued)

| Sample Date | Gross alpha activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | Gross beta activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ |
|---|---|---|---|---|
| 12/29/2014 | 1.21E-03 | 3.93E-05 | 8.42E-04 | 2.73E-05 |
| 12/30/2014 | 2.31E-03 | 6.13E-05 | 7.44E-04 | 2.63E-05 |
| 12/31/2014 | 1.93E-03 | 5.38E-05 | 9.27E-04 | 2.79E-05 |

## Appendix B: WIPP Underground Air Station B

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 7/1/2014 | 1.51E-04 | 1.25E-05 | 4.37E-06 | 1.41E-05 |
| 7/2/2014 | 8.07E-05 | 1.08E-05 | 2.19E-05 | 1.43E-05 |
| 7/3/2014 | 5.09E-05 | 9.59E-06 | 2.60E-05 | 1.08E-05 |
| 7/4/2014 | 2.35E-05 | 7.83E-06 | 2.41E-05 | 1.12E-05 |
| 7/5/2014 | 3.74E-05 | 9.24E-06 | 1.38E-05 | 1.12E-05 |
| 7/6/2014 | 6.60E-05 | 1.04E-05 | -1.14E-05 | 1.44E-05 |
| 7/7/2014 | 3.63E-05 | 8.72E-06 | -4.16E-05 | 1.63E-05 |
| 7/8/2014 | 3.25E-05 | 8.91E-06 | 8.11E-06 | 1.05E-05 |
| 7/9/2014 | 3.17E-05 | 8.18E-06 | 4.19E-06 | 1.08E-05 |
| 7/10/2014 | 3.35E-05 | 8.14E-06 | -2.78E-06 | 1.39E-05 |
| 7/11/2014 | 2.67E-05 | 8.83E-06 | 1.26E-05 | 1.41E-05 |
| 7/12/2014 | 3.97E-05 | 8.46E-06 | 5.70E-06 | 1.34E-05 |
| 7/13/2014 | 5.60E-05 | 9.67E-06 | -1.25E-05 | 1.61E-05 |
| 7/14/2014 | 5.78E-05 | 1.00E-05 | -1.34E-05 | 1.43E-05 |
| 7/15/2014 | 7.60E-05 | 9.93E-06 | -1.95E-05 | 1.11E-05 |
| 7/16/2014 | 2.80E-05 | 8.87E-06 | -1.87E-05 | 1.44E-05 |
| 7/17/2014 | 1.89E-05 | 9.03E-06 | -3.81E-06 | 1.08E-05 |
| 7/18/2014 | 2.59E-05 | 7.91E-06 | -6.33E-06 | 1.34E-05 |
| 7/19/2014 | 4.40E-05 | 9.31E-06 | 1.05E-05 | 1.07E-05 |
| 7/20/2014 | 1.65E-05 | 7.35E-06 | 6.95E-06 | 1.39E-05 |
| 7/21/2014 | 1.29E-05 | 8.24E-06 | 5.33E-05 | 1.47E-05 |
| 7/22/2014 | 2.98E-05 | 7.54E-06 | 2.58E-06 | 1.43E-05 |
| 7/23/2014 | 3.53E-05 | 8.03E-06 | 7.05E-06 | 1.37E-05 |
| 7/24/2014 | 2.38E-05 | 7.13E-06 | 4.36E-06 | 1.39E-05 |
| 7/25/2014 | 2.10E-05 | 8.62E-06 | 2.94E-06 | 1.12E-05 |
| 7/26/2014 | 4.60E-05 | 1.00E-05 | 3.40E-06 | 1.36E-05 |
| 7/27/2014 | 2.75E-04 | 1.68E-05 | 6.71E-05 | 1.52E-05 |
| 7/28/2014 | 2.20E-05 | 7.53E-06 | 1.94E-05 | 1.41E-05 |
| 7/29/2014 | 6.25E-05 | 9.36E-06 | -2.79E-05 | 1.12E-05 |
| 7/30/2014 | 5.07E-05 | 8.46E-06 | 3.30E-05 | 1.46E-05 |
| 7/31/2014 | 2.21E-05 | 7.58E-06 | 1.95E-05 | 1.42E-05 |

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014) (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 8/1/2014 | 3.19E-05 | 8.32E-06 | 2.89E-05 | 1.49E-05 |
| 8/2/2014 | 7.60E-04 | 2.81E-05 | 5.87E-05 | 1.59E-05 |
| 8/3/2014 | 2.41E-05 | 1.08E-05 | -8.23E-06 | 1.41E-05 |
| 8/4/2014 | 2.16E-05 | 8.61E-06 | 1.96E-05 | 1.36E-05 |
| 8/5/2014 | 1.50E-05 | 9.67E-06 | 4.54E-06 | 1.32E-05 |
| 8/6/2014 | 7.65E-05 | 1.08E-05 | 1.30E-05 | 1.04E-05 |
| 8/7/2014 | 4.65E-05 | 1.07E-05 | 1.61E-05 | 1.37E-05 |
| 8/8/2014 | 3.63E-05 | 1.03E-05 | 2.58E-05 | 1.38E-05 |
| 8/9/2014 | 4.44E-05 | 1.10E-05 | -2.15E-05 | 1.40E-05 |
| 8/10/2014 | 4.37E-05 | 8.59E-06 | 6.09E-05 | 1.19E-05 |
| 8/11/2014 | 1.03E-04 | 1.14E-05 | 6.79E-05 | 1.12E-05 |
| 8/12/2014 | 4.31E-05 | 8.77E-06 | 3.87E-05 | 1.40E-05 |
| 8/13/2014 | 4.26E-05 | 1.05E-05 | 6.88E-05 | 1.21E-05 |
| 8/14/2014 | 4.50E-05 | 8.93E-06 | -9.13E-06 | 1.35E-05 |
| 8/15/2014 | 3.12E-05 | 8.90E-06 | 1.11E-04 | 1.21E-05 |
| 8/16/2014 | 4.19E-05 | 8.43E-06 | 9.37E-05 | 1.21E-05 |
| 8/17/2014 | 2.52E-05 | 8.80E-06 | 3.20E-05 | 1.38E-05 |
| 8/18/2014 | 2.49E-05 | 7.98E-06 | 9.77E-05 | 1.28E-05 |
| 8/19/2014 | 1.29E-05 | 7.45E-06 | 2.88E-05 | 1.45E-05 |
| 8/20/2014 | 2.38E-05 | 8.15E-06 | 1.91E-05 | 1.37E-05 |
| 8/21/2014 | 3.47E-05 | 8.34E-06 | 3.00E-05 | 1.39E-05 |
| 8/22/2014 | 3.28E-05 | 8.56E-06 | 2.85E-05 | 1.49E-05 |
| 8/23/2014 | 2.53E-05 | 8.56E-06 | 2.53E-05 | 1.32E-05 |
| 8/24/2014 | 6.18E-05 | 9.92E-06 | 1.20E-04 | 1.34E-05 |
| 8/25/2014 | 4.01E-05 | 9.39E-06 | 4.21E-05 | 1.54E-05 |
| 8/26/2014 | 5.71E-05 | 9.13E-06 | 9.28E-05 | 1.20E-05 |
| 8/27/2014 | 1.70E-05 | 8.52E-06 | 1.04E-04 | 1.22E-05 |
| 8/28/2014 | 3.41E-05 | 1.03E-05 | 1.06E-04 | 1.27E-05 |
| 8/29/2014 | 1.55E-05 | 7.76E-06 | 1.71E-05 | 1.37E-05 |
| 8/30/2014 | 3.35E-05 | 8.91E-06 | 2.49E-05 | 1.35E-05 |
| 8/31/2014 | 2.53E-05 | 8.05E-06 | 2.77E-05 | 1.45E-05 |
| 9/1/2014 | 3.27E-03 | 8.04E-05 | 3.75E-04 | 2.16E-05 |
| 9/2/2014 | 2.69E-04 | 1.72E-05 | 3.22E-05 | 1.38E-05 |

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014) (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 9/3/2014 | 1.80E-04 | 1.40E-05 | 3.44E-05 | 1.42E-05 |
| 9/4/2014 | 7.17E-05 | 1.01E-05 | 1.32E-04 | 1.32E-05 |
| 9/5/2014 | 5.64E-05 | 9.21E-06 | 1.19E-04 | 1.27E-05 |
| 9/6/2014 | 7.63E-05 | 1.08E-05 | 1.14E-04 | 1.22E-05 |
| 9/7/2014 | 3.79E-05 | 8.68E-06 | 2.13E-05 | 1.36E-05 |
| 9/8/2014 | 1.09E-04 | 1.35E-05 | 5.43E-05 | 1.41E-05 |
| 9/9/2014 | 1.20E-04 | 1.26E-05 | 3.12E-05 | 1.34E-05 |
| 9/10/2014 | 8.56E-05 | 1.11E-05 | 6.96E-05 | 1.49E-05 |
| 9/11/2014 | 1.86E-04 | 1.39E-05 | 4.06E-05 | 1.47E-05 |
| 9/12/2014 | 7.70E-05 | 1.18E-05 | 2.18E-05 | 1.44E-05 |
| 9/13/2014 | 6.70E-05 | 9.99E-06 | 4.29E-05 | 1.41E-05 |
| 9/14/2014 | 5.60E-05 | 1.04E-05 | 2.60E-05 | 1.36E-05 |
| 9/15/2014 | 7.59E-05 | 1.24E-05 | 2.18E-05 | 1.38E-05 |
| 9/16/2014 | 1.01E-05 | 1.11E-05 | 4.64E-05 | 1.40E-05 |
| 9/17/2014 | 1.03E-04 | 1.25E-05 | 5.12E-05 | 1.50E-05 |
| 9/18/2014 | 3.40E-05 | 8.56E-06 | -2.53E-06 | 1.38E-05 |
| 9/19/2014 | 7.89E-05 | 1.04E-05 | 2.72E-05 | 1.52E-05 |
| 9/20/2014 | 8.81E-05 | 1.09E-05 | 9.31E-06 | 1.39E-05 |
| 9/21/2014 | 1.18E-05 | 8.85E-06 | 1.59E-05 | 1.55E-05 |
| 9/22/2014 | 1.06E-04 | 1.36E-05 | 1.01E-05 | 1.44E-05 |
| 9/23/2014 | 3.17E-05 | 1.22E-05 | 7.83E-05 | 1.48E-05 |
| 9/24/2014 | 2.89E-05 | 8.96E-06 | 1.32E-05 | 1.51E-05 |
| 9/25/2014 | 9.53E-05 | 1.23E-05 | 6.40E-05 | 1.46E-05 |
| 9/26/2014 | 2.59E-05 | 9.57E-06 | -9.57E-06 | 1.57E-05 |
| 9/27/2014 | 7.48E-04 | 2.87E-05 | 2.08E-05 | 1.55E-05 |
| 9/28/2014 | 1.17E-04 | 1.21E-05 | 5.76E-06 | 1.50E-05 |
| 9/29/2014 | 1.02E-04 | 1.16E-05 | 8.55E-06 | 1.63E-05 |
| 9/30/2014 | 4.43E-05 | 1.09E-05 | 6.77E-06 | 1.46E-05 |
| 10/1/15 | 5.78E-05 | 1.06E-05 | 1.39E-04 | 1.67E-05 |
| 10/2/2014 | 1.05E-03 | 3.57E-05 | 1.40E-04 | 1.69E-05 |
| 10/3/2014 | 1.06E-03 | 3.58E-05 | 1.41E-04 | 1.82E-05 |
| 10/4/2014 | 1.93E-04 | 1.44E-05 | 4.54E-06 | 1.46E-05 |
| 10/5/2014 | 1.98E-04 | 1.52E-05 | -3.43E-04 | 2.67E-05 |

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014) (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 10/6/2014 | 1.51E-04 | 1.26E-05 | 7.28E-06 | 1.55E-05 |
| 10/7/2014 | 1.53E-04 | 1.43E-05 | 2.69E-05 | 1.47E-05 |
| 10/8/2014 | 1.74E-03 | 5.11E-05 | 2.06E-04 | 1.77E-05 |
| 10/9/2014 | No data | | | |
| 10/10/2014 | 8.28E-05 | 1.07E-05 | -1.33E-05 | 1.43E-05 |
| 10/11/2014 | 3.31E-05 | 8.87E-06 | 4.23E-06 | 1.45E-05 |
| 10/12/2014 | 7.97E-05 | 1.13E-05 | -2.24E-05 | 1.55E-05 |
| 10/13/2014 | 6.08E-05 | 1.20E-05 | 1.42E-05 | 1.32E-05 |
| 10/14/2014 | 6.11E-05 | 9.78E-06 | -1.54E-05 | 1.46E-05 |
| 10/15/2014 | 6.15E-05 | 1.10E-05 | -1.98E-05 | 1.48E-05 |
| 10/16/2014 | 4.75E-04 | 2.18E-05 | 5.30E-05 | 1.54E-05 |
| 10/17/2014 | 1.43E-04 | 1.36E-05 | -2.02E-06 | 1.56E-05 |
| 10/18/2014 | 3.95E-05 | 8.95E-06 | 3.11E-06 | 1.42E-05 |
| 10/19/2014 | 5.79E-05 | 1.16E-05 | -3.25E-06 | 1.46E-05 |
| 10/20/2014 | 5.54E-05 | 9.50E-06 | -1.15E-05 | 1.56E-05 |
| 10/21/2014 | 1.62E-02 | 3.32E-04 | 1.32E-03 | 4.23E-05 |
| 10/22/2014 | 1.60E-03 | 4.61E-05 | 7.09E-05 | 1.61E-05 |
| 10/23/2014 | 5.52E-04 | 2.31E-05 | 2.83E-05 | 1.50E-05 |
| 10/24/2014 | 5.22E-04 | 2.27E-05 | 4.69E-05 | 1.52E-05 |
| 10/25/2014 | 3.69E-04 | 2.06E-05 | 6.08E-05 | 1.46E-05 |
| 10/26/2014 | 4.58E-04 | 2.13E-05 | 5.08E-05 | 1.59E-05 |
| 10/27/2014 | 3.36E-04 | 2.01E-05 | 3.86E-05 | 1.51E-05 |
| 10/28/2014 | 2.97E-04 | 1.73E-05 | 9.83E-06 | 1.55E-05 |
| 10/29/2014 | 2.51E-04 | 1.58E-05 | 3.11E-05 | 1.50E-05 |
| 10/30/2014 | 2.17E-04 | 1.62E-05 | 3.34E-05 | 1.40E-05 |
| 10/31/2014 | 2.42E-04 | 1.57E-05 | 2.66E-05 | 1.45E-05 |
| 11/1/2014 | 2.36E-04 | 1.53E-05 | 3.23E-05 | 1.49E-05 |
| 11/2/2014 | 1.38E-03 | 4.21E-05 | 1.10E-04 | 1.71E-05 |
| 11/3/2014 | 1.93E-03 | 5.31E-05 | 1.13E-04 | 1.71E-05 |
| 11/4/2014 | 6.46E-04 | 2.59E-05 | 1.58E-05 | 1.60E-05 |
| 11/5/2014 | 1.43E-03 | 4.30E-05 | 1.16E-04 | 1.67E-05 |
| 11/6/2014 | 4.33E-04 | 2.05E-05 | 4.78E-05 | 1.54E-05 |
| 11/7/2014 | 3.69E-04 | 1.94E-05 | 2.74E-05 | 1.50E-05 |

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014) (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 11/8/2014 | 2.14E-04 | 1.65E-05 | 6.02E-05 | 1.49E-05 |
| 11/9/2014 | 4.93E-05 | 9.32E-06 | 1.85E-05 | 1.48E-05 |
| 11/10/2014 | 9.00E-05 | 1.26E-05 | 3.54E-05 | 1.56E-05 |
| 11/11/2014 | 8.73E-05 | 1.13E-05 | 2.90E-05 | 1.41E-05 |
| 11/12/2014 | 2.13E-04 | 1.54E-05 | 4.74E-06 | 1.54E-05 |
| 11/13/2014 | 1.76E-04 | 1.62E-05 | 3.46E-05 | 1.69E-05 |
| 11/14/2014 | 1.89E-04 | 1.48E-05 | 1.36E-05 | 1.54E-05 |
| 11/15/2014 | 1.27E-04 | 1.17E-05 | 1.03E-05 | 1.74E-05 |
| 11/16/2014 | 5.95E-05 | 1.10E-05 | 5.28E-05 | 1.48E-05 |
| 11/17/2014 | 6.71E-05 | 1.16E-05 | 2.54E-05 | 1.42E-05 |
| 11/18/2014 | 1.05E-04 | 1.29E-05 | 9.91E-07 | 1.55E-05 |
| 11/19/2014 | 1.67E-04 | 1.39E-05 | -1.37E-06 | 1.51E-05 |
| 11/20/2014 | 1.62E-04 | 1.37E-05 | 2.22E-05 | 1.49E-05 |
| 11/21/2014 | 2.44E-04 | 1.71E-05 | 6.34E-05 | 1.47E-05 |
| 11/22/2014 | 8.15E-05 | 1.08E-05 | 8.82E-06 | 1.51E-05 |
| 11/23/2014 | 5.30E-05 | 1.15E-05 | 5.20E-05 | 1.43E-05 |
| 11/24/2014 | 4.41E-05 | 1.00E-05 | -4.55E-05 | 1.58E-05 |
| 11/25/2014 | 4.65E-05 | 1.02E-05 | 2.17E-06 | 1.46E-05 |
| 11/26/2014 | 3.55E-05 | 1.02E-05 | 1.60E-05 | 1.37E-05 |
| 11/27/2014 | 5.09E-05 | 1.13E-05 | -1.27E-05 | 1.59E-05 |
| 11/28/2014 | 4.10E-05 | 8.61E-06 | -6.53E-05 | 1.78E-05 |
| 11/29/2014 | 1.29E-05 | 8.69E-06 | 8.11E-06 | 1.47E-05 |
| 11/30/2014 | 9.49E-06 | 9.49E-06 | 1.29E-05 | 1.51E-05 |
| 12/1/2014 | 1.85E-05 | 9.85E-06 | -3.86E-07 | 1.51E-05 |
| 12/2/2014 | 1.72E-05 | 9.31E-06 | 4.25E-06 | 1.54E-05 |
| 12/3/2014 | 5.58E-05 | 1.04E-05 | 7.07E-06 | 1.51E-05 |
| 12/4/2014 | 3.54E-05 | 1.02E-05 | 3.80E-05 | 1.46E-05 |
| 12/5/2014 | 4.61E-05 | 1.18E-05 | 2.32E-05 | 1.40E-05 |
| 12/6/2014 | 4.10E-05 | 9.42E-06 | 2.73E-05 | 1.55E-05 |
| 12/7/2014 | 4.72E-05 | 1.13E-05 | 6.92E-05 | 1.42E-05 |
| 12/8/2014 | 4.79E-05 | 1.11E-05 | 2.28E-05 | 1.41E-05 |
| 12/9/2014 | 3.39E-05 | 9.36E-06 | 3.02E-05 | 1.40E-05 |
| 12/10/2014 | 6.98E-05 | 1.32E-05 | 5.00E-06 | 1.48E-05 |

Table B-1: Daily Gross Alpha and Gross Beta concentration (Bq/m$^3$) measured in Station B (Post-HEPA) filter (CEMRC begins collecting data since July, 2014) (continued)

| Sample Date | Gross alpha activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | Gross beta activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ |
|---|---|---|---|---|
| 12/11/2014 | 5.87E-05 | 1.08E-05 | 8.24E-06 | 1.55E-05 |
| 12/12/2014 | 2.49E-05 | 9.68E-06 | -6.68E-05 | 1.66E-05 |
| 12/13/2014 | 4.44E-05 | 9.58E-06 | -1.35E-05 | 1.39E-05 |
| 12/14/2014 | 3.00E-04 | 1.78E-05 | 3.00E-06 | 1.40E-05 |
| 12/15/2014 | 4.30E-04 | 2.11E-05 | 3.70E-05 | 1.49E-05 |
| 12/16/2014 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 12/17/2014 | 1.27E-04 | 1.30E-05 | -5.59E-05 | 1.64E-05 |
| 12/18/2014 | 9.48E-05 | 1.11E-05 | -2.09E-05 | 1.49E-05 |
| 12/19/2014 | 1.13E-04 | 1.27E-05 | -2.35E-05 | 1.49E-05 |
| 12/20/2014 | 7.54E-05 | 1.09E-05 | -2.88E-05 | 1.38E-05 |
| 12/21/2014 | 8.19E-05 | 1.18E-05 | -5.83E-05 | 1.56E-05 |
| 12/22/2014 | 6.20E-05 | 9.45E-06 | -3.62E-05 | 1.77E-05 |
| 12/23/2014 | 5.27E-05 | 1.07E-05 | -1.89E-05 | 1.46E-05 |
| 12/24/2014 | 5.36E-05 | 1.02E-05 | -1.83E-05 | 1.35E-05 |
| 12/25/2014 | 3.43E-05 | 1.08E-05 | 3.47E-05 | 1.39E-05 |
| 12/26/2014 | 1.98E-05 | 8.20E-06 | -4.02E-05 | 1.35E-05 |
| 12/27/2014 | 3.83E-05 | 1.02E-05 | -6.49E-05 | 1.50E-05 |
| 12/28/2014 | 2.05E-05 | 9.56E-06 | 1.75E-05 | 1.35E-05 |
| 12/29/2014 | 4.12E-05 | 1.04E-05 | 1.75E-05 | 1.27E-05 |
| 12/30/2014 | 4.12E-05 | 1.27E-05 | 3.85E-05 | 1.38E-05 |
| 12/31/2014 | 2.68E-05 | 9.20E-06 | 2.17E-05 | 1.46E-05 |

Table B-2: Daily Activity concentrations of $^{137}Cs$ ($Bq/m^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{137}Cs$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 3.63E-04 | 5.77E-04 | 9.72E-04 | Not detected |
| 2/18/2014 | 1.37E-03 | 3.05E-03 | 5.16E-03 | Not detected |
| 2/19/2014 | -4.20E-04 | 2.26E-03 | 3.84E-03 | Not detected |
| 2/20/2014 | -4.11E-03 | 3.95E-03 | 6.78E-03 | Not detected |
| 2/21/2014 | -3.71E-04 | 1.10E-03 | 1.88E-03 | Not detected |
| 2/22/2014 | -2.44E-03 | 1.44E-03 | 2.49E-03 | Not detected |
| 2/23/2014 | 2.19E-03 | 2.53E-03 | 4.24E-03 | Not detected |
| 2/24/2014 | -1.19E-04 | 2.67E-03 | 4.54E-03 | Not detected |
| 2/25/2014 | -9.51E-04 | 1.08E-03 | 1.87E-03 | Not detected |
| 2/26/2014 | -1.10E-03 | 1.32E-03 | 2.26E-03 | Not detected |
| 2/27/2014 | -1.70E-05 | 2.70E-03 | 4.60E-03 | Not detected |
| 3/4/2014 | -2.40E-03 | 1.17E-03 | 2.06E-03 | Not detected |
| 3/5/2014 | -1.22E-03 | 1.33E-03 | 2.29E-03 | Not detected |
| 3/6/2014 | 6.20E-04 | 2.69E-03 | 4.55E-03 | Not detected |
| 3/7/2014 | -1.15E-03 | 1.10E-03 | 1.91E-03 | Not detected |
| 3/8/2014 | -6.32E-04 | 1.32E-03 | 2.26E-03 | Not detected |
| 3/9/2014 | 4.10E-04 | 2.78E-03 | 4.72E-03 | Not detected |
| 3/10/2014 | -1.73E-03 | 1.08E-03 | 1.89E-03 | Not detected |
| 3/11/2014 | 2.11E-05 | 1.33E-03 | 2.26E-03 | Not detected |
| 3/12/2014 | -1.59E-03 | 1.10E-03 | 1.92E-03 | Not detected |
| 3/13/2014 | 1.09E-03 | 2.65E-03 | 4.48E-03 | Not detected |
| 3/14/2014 | -3.39E-04 | 2.71E-03 | 4.63E-03 | Not detected |
| 3/15/2014 | -1.65E-03 | 1.09E-03 | 1.91E-03 | Not detected |
| 3/16/2014 | 6.54E-04 | 2.66E-03 | 4.51E-03 | Not detected |
| 3/20/2014 | -1.54E-03 | 2.69E-03 | 4.62E-03 | Not detected |
| 3/21/2014 | 1.81E-04 | 5.59E-04 | 1.86E-03 | Not detected |
| 3/22/2014 | 8.91E-04 | 1.05E-03 | 3.49E-03 | Not detected |
| 3/23/2014 | -2.15E-04 | 5.60E-04 | 1.87E-03 | Not detected |
| 3/24/2014 | -5.65E-04 | 7.19E-04 | 2.41E-03 | Not detected |
| 3/25/2014 | -7.04E-05 | 5.52E-04 | 1.84E-03 | Not detected |
| 3/26/2014 | -8.33E-04 | 7.10E-04 | 2.63E-03 | Not detected |
| 3/27/2014 | 5.49E-04 | 6.95E-04 | 2.30E-03 | Not detected |
| 3/28/2014 | 1.81E-04 | 5.40E-04 | 1.80E-03 | Not detected |
| 3/29/2014 | 7.59E-04 | 6.81E-04 | 2.25E-03 | Not detected |
| 3/30/2014 | -1.01E-04 | 5.60E-04 | 1.87E-03 | Not detected |
| 3/31/2014 | -3.33E-04 | 7.31E-04 | 2.44E-03 | Not detected |

Table B-3: Weekly Activity concentrations of $^{137}Cs$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{137}Cs$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | -1.31E-04 | 1.05E-04 | 3.51E-04 | Not detected |
| Week 2 Apr. | -6.06E-05 | 9.94E-05 | 3.33E-04 | Not detected |
| Week 3 Apr. | 3.21E-05 | 7.75E-05 | 2.58E-04 | Not detected |
| Week 4 Apr. | 1.45E-04 | 1.44E-04 | 4.78E-04 | Not detected |
| Week 1 May | -4.29E-05 | 1.01E-04 | 3.37E-04 | Not detected |
| Week 2 May | -1.88E-04 | 1.97E-04 | 6.63E-04 | Not detected |
| Week 3 May | -3.72E-05 | 9.63E-05 | 3.22E-04 | Not detected |
| Week 4 May | 2.72E-05 | 1.32E-04 | 4.41E-04 | Not detected |
| Week 1 Jun. | 8.59E-06 | 8.14E-05 | 2.71E-04 | Not detected |
| Week 2 Jun. | -9.28E-06 | 1.02E-04 | 3.41E-04 | Not detected |
| Week 3 Jun. | 1.69E-04 | 1.87E-04 | 6.18E-04 | Not detected |
| Week 4 Jun. | -1.57E-05 | 1.52E-04 | 5.08E-04 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | 1.63E-04 | 2.06E-04 | 6.83E-04 | Not detected |
| Week 3 Jul. | 6.26E-05 | 9.92E-05 | 3.29E-04 | Not detected |
| Week 4 Jul. | 5.30E-05 | 5.37E-05 | 1.78E-04 | Not detected |
| Week 1 Aug. | 9.18E-05 | 7.71E-05 | 2.55E-04 | Not detected |
| Week 2 Aug. | 9.09E-06 | 9.66E-05 | 3.22E-04 | Not detected |
| Week 3 Aug. | -1.58E-04 | 1.01E-04 | 3.39E-04 | Not detected |
| Week 4 Aug. | 4.21E-05 | 5.57E-05 | 1.85E-04 | Not detected |
| Week 1 Sep. | -1.20E-04 | 1.03E-04 | 3.46E-04 | Not detected |
| Week 2 Sep. | -1.11E-04 | 7.74E-05 | 2.61E-04 | Not detected |
| Week 3 Sep. | 3.34E-05 | 9.86E-05 | 3.29E-04 | Not detected |
| Week 4 Sep. | 1.93E-05 | 4.99E-05 | 1.65E-04 | Not detected |
| Week 1 Oct. | 3.27E-05 | 8.23E-05 | 2.72E-04 | Not detected |
| Week 2 Oct. | 1.12E-04 | 9.85E-05 | 3.25E-04 | Not detected |
| Week 3 Oct. | -5.13E-05 | 7.93E-05 | 2.66E-04 | Not detected |
| Week 4 Oct. | -1.15E-05 | 5.40E-05 | 1.80E-04 | Not detected |
| Week 1 Nov. | 1.68E-04 | 9.68E-05 | 3.18E-04 | Not detected |
| Week 2 Nov. | 1.34E-04 | 9.77E-05 | 3.22E-04 | Not detected |
| Week 3 Nov. | 1.46E-04 | 7.57E-05 | 2.52E-04 | Not detected |
| Week 4 Nov. | -1.73E-05 | 6.51E-05 | 2.14E-04 | Not detected |
| Week 1 Dec. | 5.54E-05 | 1.01E-04 | 3.37E-04 | Not detected |
| Week 2 Dec. | -1.76E-04 | 1.60E-04 | 5.37E-04 | Not detected |
| Week 3 Dec. | -7.56E-06 | 7.84E-05 | 2.62E-04 | Not detected |
| Week 4 Dec. | -2.44E-05 | 6.79E-05 | 2.27E-04 | Not detected |

Table B-4: Weekly Activity density of $^{137}Cs$ (Bq/g), in Station B filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{137}Cs$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.52E+01 | 1.28E+01 | 4.23E+01 | Not detected |
| Week 2 Aug. | 1.30E+00 | 1.38E+01 | 4.61E+01 | Not detected |
| Week 3 Aug. | -8.53E+01 | 5.46E+01 | 1.83E+02 | Not detected |
| Week 4 Aug. | 1.37E+01 | 1.81E+01 | 6.02E+01 | Not detected |
| Week 1 Sep. | -1.42E+01 | 1.22E+01 | 4.09E+01 | Not detected |
| Week 2 Sep. | -1.60E+01 | 1.11E+01 | 3.76E+01 | Not detected |
| Week 3 Sep. | 4.57E+00 | 1.35E+01 | 4.50E+01 | Not detected |
| Week 4 Sep. | 2.67E+00 | 6.89E+00 | 2.28E+01 | Not detected |
| Week 1 Oct. | 1.50E+00 | 3.76E+00 | 1.25E+01 | Not detected |
| Week 2 Oct. | 7.45E+00 | 6.56E+00 | 2.16E+01 | Not detected |
| Week 3 Oct. | -3.24E+00 | 5.01E+00 | 1.68E+01 | Not detected |
| Week 4 Oct. | -6.12E+00 | 2.87E+01 | 9.61E+01 | Not detected |
| Week 1 Nov. | 1.59E+01 | 9.16E+00 | 3.01E+01 | Not detected |
| Week 2 Nov. | 4.30E+01 | 3.13E+01 | 1.03E+02 | Not detected |
| Week 3 Nov. | 2.83E+01 | 1.47E+01 | 4.89E+01 | Not detected |
| Week 4 Nov. | -1.70E+00 | 6.38E+00 | 2.10E+01 | Not detected |
| Week 1 Dec. | 4.42E+00 | 8.10E+00 | 2.69E+01 | Not detected |
| Week 2 Dec. | -2.23E+01 | 2.03E+01 | 6.81E+01 | Not detected |
| Week 3 Dec. | -8.38E-01 | 8.69E+00 | 2.90E+01 | Not detected |
| Week 4 Dec. | -8.79E+00 | 2.45E+01 | 8.17E+01 | Not detected |

*Filters collected prior to August were not weighed; no density data is available for this period.

Table B-5: Daily Activity concentrations of $^{60}Co$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{60}Co$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | -5.92E-04 | 6.02E-04 | 1.05E-03 | Not detected |
| 2/18/2014 | -1.46E-03 | 3.16E-03 | 5.47E-03 | Not detected |
| 2/19/2014 | -8.37E-04 | 1.98E-03 | 3.40E-03 | Not detected |
| 2/20/2014 | -3.73E-03 | 3.78E-03 | 6.57E-03 | Not detected |
| 2/21/2014 | -2.21E-04 | 1.11E-03 | 1.90E-03 | Not detected |
| 2/22/2014 | 2.55E-05 | 1.17E-03 | 2.00E-03 | Not detected |
| 2/23/2014 | 1.04E-04 | 2.06E-03 | 3.54E-03 | Not detected |
| 2/24/2014 | -6.09E-04 | 2.28E-03 | 3.95E-03 | Not detected |
| 2/25/2014 | -4.88E-04 | 1.12E-03 | 1.93E-03 | Not detected |
| 2/26/2014 | 3.78E-04 | 1.08E-03 | 1.83E-03 | Not detected |

Table B-5: Daily Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station B (Post–HEPA) filter following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{60}Co$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/27/2014 | -1.44E-03 | 2.33E-03 | 4.07E-03 | Not detected |
| 3/4/2014 | -5.97E-04 | 1.16E-03 | 2.01E-03 | Not detected |
| 3/5/2014 | -6.50E-06 | 1.11E-03 | 1.90E-03 | Not detected |
| 3/6/2014 | 5.87E-05 | 2.23E-03 | 3.83E-03 | Not detected |
| 3/7/2014 | -4.31E-04 | 1.13E-03 | 1.95E-03 | Not detected |
| 3/8/2014 | 5.18E-04 | 1.09E-03 | 1.85E-03 | Not detected |
| 3/9/2014 | 2.54E-03 | 1.81E-03 | 2.96E-03 | Not detected |
| 3/10/2014 | -6.96E-04 | 1.08E-03 | 1.88E-03 | Not detected |
| 3/11/2014 | 7.71E-04 | 1.13E-03 | 1.89E-03 | Not detected |
| 3/12/2014 | 2.51E-05 | 1.08E-03 | 1.85E-03 | Not detected |
| 3/13/2014 | -1.20E-03 | 2.16E-03 | 3.78E-03 | Not detected |
| 3/14/2014 | 9.94E-04 | 2.08E-03 | 3.52E-03 | Not detected |
| 3/15/2014 | -7.39E-04 | 1.10E-03 | 1.91E-03 | Not detected |
| 3/16/2014 | 1.61E-03 | 1.88E-03 | 3.16E-03 | Not detected |
| 3/20/2014 | -3.45E-03 | 2.70E-03 | 4.75E-03 | Not detected |
| 3/21/2014 | -7.11E-04 | 6.39E-04 | 2.17E-03 | Not detected |
| 3/22/2014 | -5.79E-04 | 9.68E-04 | 3.27E-03 | Not detected |
| 3/23/2014 | -1.74E-04 | 6.26E-04 | 2.11E-03 | Not detected |
| 3/24/2014 | -9.99E-04 | 6.45E-04 | 2.20E-03 | Not detected |
| 3/25/2014 | -1.21E-03 | 6.48E-04 | 2.22E-03 | Not detected |
| 3/26/2014 | -5.67E-04 | 6.38E-04 | 2.16E-03 | Not detected |
| 3/27/2014 | -5.82E-04 | 5.50E-04 | 1.87E-03 | Not detected |
| 3/28/2014 | -4.91E-04 | 5.49E-04 | 1.86E-03 | Not detected |
| 3/29/2014 | 4.65E-05 | 5.55E-04 | 1.86E-03 | Not detected |
| 3/30/2014 | -1.31E-04 | 6.04E-04 | 2.03E-03 | Not detected |
| 3/31/2014 | -1.07E-04 | 6.38E-04 | 2.15E-03 | Not detected |

Table B-6: Weekly Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{60}Co$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | 6.77E-05 | 8.83E-05 | 2.93E-04 | Not detected |
| Week 2 Apr. | -1.55E-05 | 8.96E-05 | 3.01E-04 | Not detected |
| Week 3 Apr. | -5.38E-05 | 7.77E-05 | 2.63E-04 | Not detected |
| Week 4 Apr. | -2.80E-05 | 1.53E-04 | 5.15E-04 | Not detected |
| Week 1 May | -1.36E-05 | 9.19E-05 | 3.09E-04 | Not detected |
| Week 2 May | -2.14E-05 | 1.91E-04 | 6.43E-04 | Not detected |
| Week 3 May | -7.14E-05 | 8.61E-05 | 2.92E-04 | Not detected |
| Week 4 May | -1.51E-05 | 1.37E-04 | 4.62E-04 | Not detected |
| Week 1 Jun. | 5.29E-05 | 8.42E-05 | 2.80E-04 | Not detected |
| Week 2 Jun. | -7.08E-05 | 8.90E-05 | 3.01E-04 | Not detected |
| Week 3 Jun. | -1.58E-04 | 2.03E-04 | 6.89E-04 | Not detected |
| Week 4 Jun. | -4.01E-05 | 1.47E-04 | 4.95E-04 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | -1.35E-04 | 1.77E-04 | 5.99E-04 | Not detected |
| Week 3 Jul. | -6.58E-05 | 8.37E-05 | 2.83E-04 | Not detected |
| Week 4 Jul. | -6.88E-05 | 5.52E-05 | 1.88E-04 | Not detected |
| Week 1 Aug. | -3.06E-05 | 7.87E-05 | 2.65E-04 | Not detected |
| Week 2 Aug. | 4.06E-05 | 7.86E-05 | 2.62E-04 | Not detected |
| Week 3 Aug. | -1.09E-04 | 8.17E-05 | 2.78E-04 | Not detected |
| Week 4 Aug. | -3.49E-05 | 5.55E-05 | 1.88E-04 | Not detected |
| Week 1 Sep. | 4.51E-05 | 8.48E-05 | 2.83E-04 | Not detected |
| Week 2 Sep. | 3.21E-05 | 7.29E-05 | 2.43E-04 | Not detected |
| Week 3 Sep. | -3.67E-05 | 8.76E-05 | 2.96E-04 | Not detected |
| Week 4 Sep. | -3.26E-05 | 5.24E-05 | 1.75E-04 | Not detected |
| Week 1 Oct. | -1.48E-05 | 6.89E-05 | 2.30E-04 | Not detected |
| Week 2 Oct. | 4.65E-05 | 8.18E-05 | 2.73E-04 | Not detected |
| Week 3 Oct. | -1.01E-04 | 8.72E-05 | 2.96E-04 | Not detected |
| Week 4 Oct. | -8.11E-07 | 4.77E-05 | 1.60E-04 | Not detected |
| Week 1 Nov. | -1.09E-05 | 8.25E-05 | 2.77E-04 | Not detected |
| Week 2 Nov. | -1.23E-06 | 8.02E-05 | 2.69E-04 | Not detected |
| Week 3 Nov. | -1.36E-05 | 6.84E-05 | 2.30E-04 | Not detected |
| Week 4 Nov. | -3.93E-05 | 6.49E-05 | 2.19E-04 | Not detected |
| Week 1 Dec. | -9.35E-06 | 8.25E-05 | 2.77E-04 | Not detected |
| Week 2 Dec. | 1.28E-03 | 1.11E-03 | 3.68E-03 | Not detected |
| Week 3 Dec. | -5.62E-05 | 7.90E-05 | 2.68E-04 | Not detected |
| Week 4 Dec. | -6.73E-05 | 5.79E-05 | 1.97E-04 | Not detected |

Table B-7: Weekly Activity density of $^{60}Co$ (Bq/g), in Station B (Post–HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{60}Co$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | -5.08E+00 | 1.31E+01 | 4.41E+01 | Not detected |
| Week 2 Aug. | 5.82E+00 | 1.13E+01 | 3.75E+01 | Not detected |
| Week 3 Aug. | -5.88E+01 | 4.41E+01 | 1.50E+02 | Not detected |
| Week 4 Aug. | -1.14E+01 | 1.81E+01 | 6.11E+01 | Not detected |
| Week 1 Sep. | 5.33E+00 | 1.00E+01 | 3.34E+01 | Not detected |
| Week 2 Sep. | 4.62E+00 | 1.05E+01 | 3.50E+01 | Not detected |
| Week 3 Sep. | -5.02E+00 | 1.20E+01 | 4.04E+01 | Not detected |
| Week 4 Sep. | -4.50E+00 | 7.23E+00 | 2.42E+01 | Not detected |
| Week 1 Oct. | -6.77E-01 | 3.15E+00 | 1.05E+01 | Not detected |
| Week 2 Oct. | 3.10E+00 | 5.44E+00 | 1.81E+01 | Not detected |
| Week 3 Oct. | -6.36E+00 | 5.51E+00 | 1.87E+01 | Not detected |
| Week 4 Oct. | -4.32E-01 | 2.54E+01 | 8.54E+01 | Not detected |
| Week 1 Nov. | -1.03E+00 | 7.81E+00 | 2.62E+01 | Not detected |
| Week 2 Nov. | -3.93E-01 | 2.56E+01 | 8.62E+01 | Not detected |
| Week 3 Nov. | -2.63E+00 | 1.33E+01 | 4.46E+01 | Not detected |
| Week 4 Nov. | -3.85E+00 | 6.36E+00 | 2.15E+01 | Not detected |
| Week 1 Dec. | -7.47E-01 | 6.58E+00 | 2.21E+01 | Not detected |
| Week 2 Dec. | 1.62E+02 | 1.41E+02 | 4.67E+02 | Not detected |
| Week 3 Dec. | -6.23E+00 | 8.75E+00 | 2.96E+01 | Not detected |
| Week 4 Dec. | -2.42E+01 | 2.08E+01 | 7.08E+01 | Not detected |

*Filters collected prior to August were not weighed; no density data is available for this period.

Table B-8: Activity concentrations of $^{40}K$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 1.75E-03 | 5.47E-03 | 9.33E-03 | Not detected |
| 2/18/2014 | 2.28E-02 | 3.75E-02 | 6.32E-02 | Not detected |
| 2/19/2014 | 3.38E-03 | 2.38E-02 | 4.06E-02 | Not detected |
| 2/20/2014 | -2.60E-02 | 3.87E-02 | 6.72E-02 | Not detected |
| 2/21/2014 | 1.05E-02 | 1.30E-02 | 2.18E-02 | Not detected |
| 2/22/2014 | -1.04E-02 | 1.33E-02 | 2.31E-02 | Not detected |
| 2/23/2014 | -1.41E-02 | 2.56E-02 | 4.47E-02 | Not detected |
| 2/24/2014 | -8.53E-03 | 2.71E-02 | 4.70E-02 | Not detected |
| 2/25/2014 | -1.17E-02 | 1.29E-02 | 2.25E-02 | Not detected |
| 2/26/2014 | -1.87E-02 | 1.35E-02 | 2.35E-02 | Not detected |
| 2/27/2014 | 1.09E-02 | 2.25E-02 | 3.81E-02 | Not detected |
| 3/4/2014 | -1.77E-02 | 1.37E-02 | 2.41E-02 | Not detected |
| 3/5/2014 | -9.10E-03 | 1.34E-02 | 2.32E-02 | Not detected |
| 3/6/2014 | -2.60E-02 | 2.64E-02 | 4.65E-02 | Not detected |
| 3/7/2014 | -1.60E-02 | 1.33E-02 | 2.33E-02 | Not detected |
| 3/8/2014 | -8.94E-03 | 1.33E-02 | 2.30E-02 | Not detected |
| 3/9/2014 | -2.52E-02 | 2.76E-02 | 4.85E-02 | Not detected |
| 3/10/2014 | -1.57E-02 | 1.27E-02 | 2.23E-02 | Not detected |
| 3/11/2014 | -1.25E-02 | 1.37E-02 | 2.38E-02 | Not detected |
| 3/12/2014 | -2.51E-03 | 1.26E-02 | 2.17E-02 | Not detected |
| 3/13/2014 | 9.09E-04 | 2.43E-02 | 4.19E-02 | Not detected |
| 3/14/2014 | -1.51E-02 | 2.60E-02 | 4.54E-02 | Not detected |
| 3/15/2014 | -2.48E-02 | 1.34E-02 | 2.37E-02 | Not detected |
| 3/16/2014 | -5.02E-03 | 2.46E-02 | 4.26E-02 | Not detected |
| 3/20/2014 | 9.41E-03 | 2.38E-02 | 4.05E-02 | Not detected |
| 3/21/2014 | 3.55E-03 | 6.69E-03 | 2.23E-02 | Not detected |
| 3/22/2014 | 6.40E-03 | 1.02E-02 | 3.40E-02 | Not detected |
| 3/23/2014 | -1.55E-03 | 6.61E-03 | 2.22E-02 | Not detected |
| 3/24/2014 | -9.61E-04 | 6.66E-03 | 2.24E-02 | Not detected |
| 3/25/2014 | -2.05E-04 | 6.45E-03 | 2.17E-02 | Not detected |
| 3/26/2014 | 9.43E-03 | 6.61E-03 | 2.17E-02 | Not detected |
| 3/27/2014 | -2.60E-04 | 7.03E-03 | 2.36E-02 | Not detected |
| 3/28/2014 | 4.91E-03 | 6.56E-03 | 2.18E-02 | Not detected |
| 3/29/2014 | 4.59E-03 | 6.80E-03 | 2.26E-02 | Not detected |
| 3/30/2014 | 4.39E-03 | 6.27E-03 | 2.09E-02 | Not detected |
| 3/31/2014 | 2.17E-04 | 7.28E-03 | 2.44E-02 | Not detected |

Table B-9: Weekly Activity concentrations of $^{40}K$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | -1.03E-04 | 1.01E-03 | 3.40E-03 | Not detected |
| Week 2 Apr. | -8.85E-04 | 1.01E-03 | 3.41E-03 | Not detected |
| Week 3 Apr. | -3.19E-04 | 9.39E-04 | 3.17E-03 | Not detected |
| Week 4 Apr. | 7.07E-04 | 1.37E-03 | 4.58E-03 | Not detected |
| Week 1 May | 2.51E-04 | 9.98E-04 | 3.33E-03 | Not detected |
| Week 2 May | -9.86E-05 | 1.74E-03 | 5.87E-03 | Not detected |
| Week 3 May | 9.44E-04 | 9.12E-04 | 3.02E-03 | Not detected |
| Week 4 May | 7.70E-04 | 1.23E-03 | 4.13E-03 | Not detected |
| Week 1 Jun. | -1.80E-04 | 9.95E-04 | 3.34E-03 | Not detected |
| Week 2 Jun. | 1.76E-03 | 1.00E-03 | 3.27E-03 | Not detected |
| Week 3 Jun. | 1.20E-03 | 1.84E-03 | 6.15E-03 | Not detected |
| Week 4 Jun. | -8.68E-04 | 1.45E-03 | 4.94E-03 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | 5.47E-04 | 1.94E-03 | 6.49E-03 | Not detected |
| Week 3 Jul. | -1.64E-06 | 1.02E-03 | 3.43E-03 | Not detected |
| Week 4 Jul. | -1.46E-04 | 6.87E-04 | 2.31E-03 | Not detected |
| Week 1 Aug. | 7.46E-04 | 9.38E-04 | 3.12E-03 | Not detected |
| Week 2 Aug. | -6.96E-04 | 1.05E-03 | 3.55E-03 | Not detected |
| Week 3 Aug. | 3.06E-04 | 9.83E-04 | 3.28E-03 | Not detected |
| Week 4 Aug. | 1.46E-04 | 6.77E-04 | 2.26E-03 | Not detected |
| Week 1 Sep. | 1.51E-03 | 9.58E-04 | 3.14E-03 | Not detected |
| Week 2 Sep. | 1.17E-03 | 9.05E-04 | 2.99E-03 | Not detected |
| Week 3 Sep. | -4.79E-04 | 1.04E-03 | 3.49E-03 | Not detected |
| Week 4 Sep. | 3.38E-04 | 6.09E-04 | 2.02E-03 | Not detected |
| Week 1 Oct. | 1.10E-03 | 7.93E-04 | 2.61E-03 | Not detected |
| Week 2 Oct. | -8.90E-04 | 1.00E-03 | 3.39E-03 | Not detected |
| Week 3 Oct. | 3.81E-04 | 9.27E-04 | 3.09E-03 | Not detected |
| Week 4 Oct. | -6.39E-04 | 6.75E-04 | 2.29E-03 | Not detected |
| Week 1 Nov. | 1.38E-04 | 1.02E-03 | 3.40E-03 | Not detected |
| Week 2 Nov. | 1.77E-04 | 9.97E-04 | 3.33E-03 | Not detected |
| Week 3 Nov. | -6.44E-04 | 9.95E-04 | 3.36E-03 | Not detected |
| Week 4 Nov. | -4.37E-04 | 7.49E-04 | 2.53E-03 | Not detected |
| Week 1 Dec. | 8.72E-04 | 9.83E-04 | 3.26E-03 | Not detected |
| Week 2 Dec. | 6.68E-04 | 9.19E-04 | 3.05E-03 | Not detected |
| Week 3 Dec. | 9.75E-04 | 8.96E-04 | 2.97E-03 | Not detected |
| Week 4 Dec. | 1.45E-03 | 6.54E-04 | 2.12E-03 | Not detected |

Table B-10: Weekly Activity density of $^{40}K$ (Bq/g), in Station B (Post–HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{40}K$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.24E+02 | 1.56E+02 | 5.18E+02 | Not detected |
| Week 2 Aug. | -9.97E+01 | 1.51E+02 | 5.08E+02 | Not detected |
| Week 3 Aug. | 1.65E+02 | 5.31E+02 | 1.77E+03 | Not detected |
| Week 4 Aug. | 4.76E+01 | 2.20E+02 | 7.37E+02 | Not detected |
| Week 1 Sep. | 1.79E+02 | 1.13E+02 | 3.72E+02 | Not detected |
| Week 2 Sep. | 1.68E+02 | 1.30E+02 | 4.30E+02 | Not detected |
| Week 3 Sep. | -6.55E+01 | 1.42E+02 | 4.77E+02 | Not detected |
| Week 4 Sep. | 4.67E+01 | 8.41E+01 | 2.79E+02 | Not detected |
| Week 1 Oct. | 5.05E+01 | 3.63E+01 | 1.19E+02 | Not detected |
| Week 2 Oct. | -5.92E+01 | 6.67E+01 | 2.25E+02 | Not detected |
| Week 3 Oct. | 2.41E+01 | 5.86E+01 | 1.96E+02 | Not detected |
| Week 4 Oct. | -3.40E+02 | 3.60E+02 | 1.22E+03 | Not detected |
| Week 1 Nov. | 1.31E+01 | 9.63E+01 | 3.22E+02 | Not detected |
| Week 2 Nov. | 5.67E+01 | 3.19E+02 | 1.07E+03 | Not detected |
| Week 3 Nov. | -1.25E+02 | 1.93E+02 | 6.51E+02 | Not detected |
| Week 4 Nov. | -4.29E+01 | 7.34E+01 | 2.48E+02 | Not detected |
| Week 1 Dec. | 6.97E+01 | 7.84E+01 | 2.60E+02 | Not detected |
| Week 1 Dec. | 8.47E+01 | 1.16E+02 | 3.87E+02 | Not detected |
| Week 1 Dec. | 1.08E+02 | 9.93E+01 | 3.29E+02 | Not detected |
| Week 1 Dec. | 5.21E+02 | 2.35E+02 | 7.63E+02 | Not detected |

*Filters collected prior to August were not weighed; no density data is available for this period.

## Appendix C: WIPP Underground Air Station A

Table C-1: Daily Activity concentrations of $^{137}Cs$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP

| Sample Date | $^{137}Cs$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 4.86E-03 | 1.85E-03 | 2.97E-03 | Detected |
| 2/15/2014 | -3.70E-04 | 2.63E-03 | 4.54E-03 | Not detected |
| 2/16/2014 | -4.18E-03 | 2.27E-03 | 3.94E-03 | Not detected |
| 2/17/2014 | -4.97E-03 | 2.26E-03 | 3.93E-03 | Not detected |
| 2/18/2014 | -3.43E-03 | 3.20E-03 | 5.45E-03 | Not detected |
| 2/19/2014 | 1.12E-03 | 3.31E-03 | 5.63E-03 | Not detected |
| 2/20/2014 | -2.04E-03 | 3.23E-03 | 5.52E-03 | Not detected |
| 2/21/2014 | -2.87E-03 | 3.07E-03 | 5.21E-03 | Not detected |
| 2/22/2014 | 1.12E-03 | 2.91E-03 | 4.92E-03 | Not detected |
| 2/23/2014 | -3.00E-04 | 2.75E-03 | 4.70E-03 | Not detected |
| 2/24/2014 | -2.22E-03 | 1.18E-03 | 2.07E-03 | Not detected |
| 2/25/2014 | -5.03E-04 | 1.38E-03 | 2.36E-03 | Not detected |
| 2/26/2014 | 7.68E-04 | 2.81E-03 | 4.75E-03 | Not detected |
| 2/27/2014 | -2.36E-03 | 1.17E-03 | 2.05E-03 | Not detected |
| 3/4/2014 | -1.91E-03 | 1.14E-03 | 2.00E-03 | Not detected |
| 3/5/2014 | -1.48E-03 | 1.14E-03 | 1.98E-03 | Not detected |
| 3/6/2014 | -1.79E-03 | 1.40E-03 | 2.41E-03 | Not detected |
| 3/7/2014 | -1.14E-03 | 2.87E-03 | 4.91E-03 | Not detected |
| 3/8/2014 | -5.12E-04 | 2.73E-03 | 4.66E-03 | Not detected |
| 3/9/2014 | -1.78E-03 | 1.48E-03 | 2.55E-03 | Not detected |
| 3/10/2014 | 7.00E-04 | 2.76E-03 | 4.67E-03 | Not detected |
| 3/11/2014 | -1.64E-03 | 1.43E-03 | 2.47E-03 | Not detected |
| 3/12/2014 | -3.60E-04 | 1.09E-03 | 1.87E-03 | Not detected |
| 3/13/2014 | -1.53E-03 | 1.46E-03 | 2.51E-03 | Not detected |
| 3/14/2014 | -1.68E-03 | 1.15E-03 | 2.00E-03 | Not detected |
| 3/15/2014 | -1.13E-03 | 1.42E-03 | 2.43E-03 | Not detected |
| 3/16/2014 | 6.73E-04 | 2.74E-03 | 4.64E-04 | Not detected |
| 3/17/2014 | -5.33E-06 | 1.13E-03 | 1.92E-03 | Not detected |
| 3/18/2014 | 2.75E-04 | 1.42E-03 | 2.41E-03 | Not detected |
| 3/19/2014 | -5.74E-05 | 2.77E-03 | 4.72E-03 | Not detected |
| 3/20/2014 | -5.80E-05 | 1.12E-03 | 1.90E-03 | Not detected |
| 3/21/2014 | -1.44E-04 | 1.42E-03 | 2.42E-03 | Not detected |
| 3/22/2014 | -1.70E-03 | 2.81E-03 | 4.83E-03 | Not detected |
| 3/23/2014 | 1.07E-03 | 1.10E-03 | 1.84E-03 | Not detected |

Table C-1: Daily Activity concentrations of $^{137}Cs$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{137}Cs$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 3/24/2014 | 3.16E-04 | 1.41E-03 | 2.39E-03 | Not detected |
| 3/25/2014 | -7.27E-04 | 2.34E-03 | 4.03E-03 | Not detected |
| 3/26/2014 | 1.84E-04 | 1.16E-03 | 1.96E-03 | Not detected |
| 3/27/2014 | 6.89E-05 | 1.40E-03 | 2.39E-03 | Not detected |
| 3/28/2014 | -5.44E-04 | 2.82E-03 | 4.82E-03 | Not detected |
| 3/29/2014 | 9.80E-04 | 1.11E-03 | 1.87E-03 | Not detected |
| 3/30/2014 | 3.56E-04 | 2.14E-03 | 3.64E-03 | Not detected |
| 3/31/2014 | 8.84E-04 | 1.13E-03 | 1.91E-03 | Not detected |
| 4/1/2014 | 8.95E-04 | 1.07E-03 | 1.78E-03 | Not detected |
| 4/2/2014 | -8.62E-04 | 1.42E-03 | 2.43E-03 | Not detected |
| 4/3/2014 | -2.53E-04 | 1.48E-03 | 2.52E-03 | Not detected |
| 4/4/2014 | 6.06E-04 | 1.38E-03 | 2.33E-03 | Not detected |
| 4/5/2014 | 4.84E-04 | 1.11E-03 | 1.88E-03 | Not detected |
| 4/6/2014 | 3.83E-04 | 1.39E-03 | 2.35E-03 | Not detected |
| 4/7/2014 | 9.03E-04 | 2.75E-03 | 4.66E-03 | Not detected |
| 4/8/2014 | -4.01E-04 | 1.44E-03 | 2.46E-03 | Not detected |
| 4/9/2014 | -5.53E-05 | 1.09E-03 | 1.86E-03 | Not detected |
| 4/10/2014 | -5.46E-04 | 1.43E-03 | 2.44E-03 | Not detected |
| 4/11/2014 | -4.69E-05 | 2.64E-03 | 4.50E-03 | Not detected |
| 4/12/2014 | -2.53E-05 | 1.09E-03 | 1.86E-03 | Not detected |
| 4/13/2014 | -5.07E-04 | 9.24E-04 | 1.57E-03 | Not detected |
| 4/14/2014 | 3.89E-04 | 1.15E-03 | 1.94E-03 | Not detected |
| 4/15/2014 | 3.41E-06 | 2.20E-03 | 3.73E-03 | Not detected |
| 4/16/2014 | -3.75E-04 | 1.13E-03 | 1.94E-03 | Not detected |
| 4/17/2014 | -5.78E-06 | 1.43E-03 | 2.43E-03 | Not detected |
| 4/18/2014 | -3.20E-04 | 2.71E-03 | 4.63E-03 | Not detected |
| 4/19/2014 | 1.35E-04 | 1.09E-03 | 1.85E-03 | Not detected |
| 4/20/2014 | -2.49E-04 | 1.41E-03 | 2.40E-03 | Not detected |
| 4/21/2014 | 2.14E-04 | 2.67E-03 | 4.54E-03 | Not detected |

Table C-2: Weekly Activity concentrations of $^{137}Cs$ (Bq/m$^3$), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{137}Cs$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 2.05E-04 | 2.83E-04 | 4.76E-04 | Not detected |
| Week 1 May | 1.18E-04 | 3.24E-04 | 5.48E-04 | Not detected |
| Week 2 May | 7.18E-05 | 1.63E-04 | 2.75E-04 | Not detected |
| Week 3 May | 4.92E-05 | 1.54E-04 | 2.61E-04 | Not detected |
| Week 4 May | 6.65E-06 | 1.12E-04 | 1.91E-04 | Not detected |
| Week 1 Jun. | -6.41E-05 | 1.68E-04 | 2.88E-04 | Not detected |
| Week 2 Jun. | -7.11E-05 | 4.15E-04 | 7.08E-04 | Not detected |
| Week 3 Jun. | -1.74E-04 | 3.81E-04 | 6.54E-04 | Not detected |
| Week 4 Jun. | -1.98E-05 | 1.20E-04 | 2.05E-04 | Not detected |
| Week 1 Jul. | 3.14E-05 | 8.37E-05 | 2.79E-04 | Not detected |
| Week 2 Jul. | -1.18E-04 | 1.16E-04 | 3.88E-04 | Not detected |
| Week 3 Jul. | 1.96E-05 | 7.99E-05 | 2.66E-04 | Not detected |
| Week 4 Jul. | -8.02E-05 | 7.24E-05 | 2.43E-04 | Not detected |
| Week 1 Aug. | 1.18E-04 | 7.93E-05 | 2.61E-04 | Not detected |
| Week 2 Aug. | -1.51E-05 | 1.03E-04 | 3.42E-04 | Not detected |
| Week 3 Aug. | 1.07E-05 | 7.96E-05 | 2.62E-04 | Not detected |
| Week 4 Aug. | -1.26E-04 | 7.42E-05 | 2.50E-04 | Not detected |
| Week 1 Sep. | 4.28E-05 | 7.92E-05 | 2.63E-04 | Not detected |
| Week 2 Sep. | 8.67E-05 | 1.04E-04 | 3.43E-04 | Not detected |
| Week 3 Sep. | 1.31E-04 | 9.99E-05 | 3.29E-04 | Not detected |
| Week 4 Sep. | 8.32E-05 | 6.19E-05 | 2.04E-04 | Not detected |
| Week 1 Oct. | -1.85E-04 | 1.07E-04 | 3.60E-04 | Not detected |
| Week 2 Oct. | -4.35E-05 | 8.20E-05 | 2.75E-04 | Not detected |
| Week 3 Oct. | -1.45E-05 | 8.26E-05 | 2.76E-04 | Not detected |
| Week 4 Oct. | 4.30E-05 | 5.62E-05 | 1.86E-04 | Not detected |
| Week 1 Nov. | 1.33E-05 | 8.04E-05 | 2.68E-04 | Not detected |
| Week 2 Nov. | -7.23E-05 | 1.05E-04 | 3.50E-04 | Not detected |
| Week 3 Nov. | 2.69E-06 | 1.01E-04 | 3.36E-04 | Not detected |
| Week 4 Nov. | 2.84E-05 | 7.91E-05 | 2.63E-04 | Not detected |
| Week 1 Dec. | 5.18E-05 | 8.04E-05 | 2.67E-04 | Not detected |
| Week 2 Dec. | 4.52E-05 | 7.66E-05 | 2.54E-04 | Not detected |
| Week 3 Dec. | 2.66E-05 | 1.02E-04 | 3.38E-04 | Not detected |
| Week 4 Dec. | 5.45E-05 | 5.62E-05 | 1.86E-04 | Not detected |

Table C-3: Weekly Activity density of $^{137}Cs$ (Bq/g), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{137}Cs$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | 3.88E-01 | 1.03E+00 | 3.44E+00 | Not detected |
| Week 2 Jul. | -1.84E+00 | 1.80E+00 | 6.02E+00 | Not detected |
| Week 3 Jul. | 2.41E-01 | 9.78E-01 | 3.26E+00 | Not detected |
| Week 4 Jul. | -1.20E+00 | 1.08E+00 | 3.63E+00 | Not detected |
| Week 1 Aug. | 2.35E+00 | 1.58E+00 | 5.20E+00 | Not detected |
| Week 2 Aug. | -2.49E-01 | 1.69E+00 | 5.65E+00 | Not detected |
| Week 3 Aug. | 1.85E-01 | 1.37E+00 | 4.52E+00 | Not detected |
| Week 4 Aug. | -2.51E+00 | 1.48E+00 | 4.97E+00 | Not detected |
| Week 1 Sep. | 9.51E-01 | 1.76E+00 | 5.85E+00 | Not detected |
| Week 2 Sep. | 6.57E-01 | 7.86E-01 | 2.60E+00 | Not detected |
| Week 3 Sep. | 1.59E+00 | 1.21E+00 | 4.00E+00 | Not detected |
| Week 4 Sep. | 1.21E+00 | 9.01E-01 | 2.97E+00 | Not detected |
| Week 1 Oct. | -8.66E+00 | 4.99E+00 | 1.68E+01 | Not detected |
| Week 2 Oct. | -1.50E+00 | 2.83E+00 | 9.51E+00 | Not detected |
| Week 3 Oct. | -3.59E-01 | 2.04E+00 | 6.82E+00 | Not detected |
| Week 4 Oct. | 1.17E+00 | 1.54E+00 | 5.10E+00 | Not detected |
| Week 1 Nov. | 6.79E-01 | 4.10E+00 | 1.37E+01 | Not detected |
| Week 2 Nov. | -2.74E+00 | 3.97E+00 | 1.33E+01 | Not detected |
| Week 3 Nov. | 8.48E-02 | 3.18E+00 | 1.06E+01 | Not detected |
| Week 4 Nov. | 8.72E-01 | 2.43E+00 | 8.06E+00 | Not detected |
| Week 1 Dec. | 8.70E-01 | 1.35E+00 | 4.48E+00 | Not detected |
| Week 2 Dec. | 1.09E+00 | 1.85E+00 | 6.14E+00 | Not detected |
| Week 3 Dec. | 5.91E-01 | 2.26E+00 | 7.52E+00 | Not detected |
| Week 4 Dec. | 2.17E+00 | 2.23E+00 | 7.39E+00 | Not detected |

*Filters collected prior to July, 2014 were not weighed; no density data is available for this period.

Table C-4: Daily Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP

| Sample Date | $^{60}Co$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | -1.16E-03 | 1.86E-03 | 3.28E-03 | Not detected |
| 2/15/2014 | -5.46E-05 | 2.31E-03 | 3.96E-03 | Not detected |
| 2/16/2014 | -4.17E-04 | 2.08E-03 | 3.58E-03 | Not detected |
| 2/17/2014 | -9.00E-04 | 2.05E-03 | 3.50E-03 | Not detected |
| 2/18/2014 | 1.96E-03 | 2.47E-03 | 4.10E-03 | Not detected |
| 2/19/2014 | 3.69E-03 | 2.71E-03 | 4.64E-03 | Not detected |
| 2/20/2014 | -6.07E-04 | 2.62E-03 | 4.47E-03 | Not detected |
| 2/21/2014 | 1.46E-03 | 2.35E-03 | 4.07E-03 | Not detected |
| 2/22/2014 | -9.37E-04 | 2.18E-03 | 3.80E-03 | Not detected |
| 2/23/2014 | 1.47E-03 | 2.03E-03 | 3.41E-03 | Not detected |
| 2/24/2014 | -9.74E-04 | 1.16E-03 | 2.02E-03 | Not detected |
| 2/25/2014 | 8.55E-04 | 1.12E-03 | 1.88E-03 | Not detected |
| 2/26/2014 | 3.47E-04 | 2.09E-03 | 3.59E-03 | Not detected |
| 2/27/2014 | -9.46E-04 | 1.18E-03 | 2.05E-03 | Not detected |
| 3/4/2014 | -1.54E-02 | 1.13E-03 | 1.94E-03 | Not detected |
| 3/5/2014 | -3.84E-04 | 1.15E-03 | 1.98E-03 | Not detected |
| 3/6/2014 | 4.63E-04 | 1.13E-03 | 1.92E-03 | Not detected |
| 3/7/2014 | 1.55E-03 | 2.00E-03 | 3.36E-03 | Not detected |
| 3/8/2014 | 4.32E-04 | 2.14E-03 | 3.66E-03 | Not detected |
| 3/9/2014 | 5.69E-04 | 1.17E-03 | 1.98E-03 | Not detected |
| 3/10/2014 | 7.24E-04 | 2.06E-03 | 3.52E-03 | Not detected |
| 3/11/2014 | -2.79E-04 | 1.19E-03 | 2.05E-03 | Not detected |
| 3/12/2014 | -3.13E-04 | 1.08E-03 | 1.87E-03 | Not detected |
| 3/13/2014 | 1.30E-03 | 1.11E-03 | 1.84E-03 | Not detected |
| 3/14/2014 | -6.08E-04 | 1.14E-03 | 1.97E-03 | Not detected |
| 3/15/2014 | 6.55E-04 | 1.14E-03 | 1.92E-03 | Not detected |
| 3/16/2014 | 1.66E-03 | 1.94E-03 | 3.25E-03 | Not detected |
| 3/17/2014 | -2.99E-04 | 1.16E-03 | 2.00E-03 | Not detected |
| 3/18/2014 | -2.08E-04 | 1.15E-03 | 1.98E-03 | Not detected |
| 3/19/2014 | -1.92E-03 | 2.72E-03 | 4.74E-03 | Not detected |
| 3/20/2014 | -7.41E-04 | 1.16E-03 | 2.02E-03 | Not detected |
| 3/21/2014 | 1.70E-04 | 1.15E-03 | 1.96E-03 | Not detected |
| 3/22/2014 | -5.17E-04 | 2.50E-03 | 4.31E-03 | Not detected |
| 3/23/2014 | -5.59E-04 | 1.14E-03 | 1.97E-03 | Not detected |
| 3/24/2014 | 8.57E-04 | 1.12E-03 | 1.88E-03 | Not detected |
| 3/25/2014 | -1.05E-03 | 2.59E-03 | 4.49E-03 | Not detected |

Table C-4: Daily Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP (continued)

| Sample Date | $^{60}Co$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 3/26/2014 | 9.34E-05 | 1.16E-03 | 1.99E-03 | Not detected |
| 3/27/2014 | 2.81E-04 | 1.11E-03 | 1.88E-03 | Not detected |
| 3/28/2014 | -1.39E-04 | 2.61E-03 | 4.49E-03 | Not detected |
| 3/29/2014 | -2.20E-04 | 1.11E-03 | 1.90E-03 | Not detected |
| 3/30/2014 | -6.32E-03 | 1.42E-02 | 2.46E-02 | Not detected |
| 3/31/2014 | 4.71E-05 | 1.14E-03 | 1.95E-03 | Not detected |
| 4/1/2014 | -3.91E-04 | 1.10E-03 | 1.90E-03 | Not detected |
| 4/2/2014 | -5.76E-05 | 1.14E-03 | 1.96E-03 | Not detected |
| 4/3/2014 | -7.04E-04 | 1.19E-03 | 2.07E-03 | Not detected |
| 4/4/2014 | -1.30E-03 | 1.24E-03 | 2.17E-03 | Not detected |
| 4/5/2014 | -1.58E-04 | 1.11E-03 | 1.91E-03 | Not detected |
| 4/6/2014 | -4.30E-04 | 1.16E-03 | 1.99E-03 | Not detected |
| 4/7/2014 | -8.18E-04 | 2.61E-03 | 4.51E-03 | Not detected |
| 4/8/2014 | 4.03E-04 | 1.15E-03 | 1.94E-03 | Not detected |
| 4/9/2014 | -8.39E-04 | 1.14E-03 | 1.98E-03 | Not detected |
| 4/10/2014 | -1.38E-04 | 1.15E-03 | 1.97E-03 | Not detected |
| 4/11/2014 | -2.84E-03 | 2.78E-03 | 4.87E-03 | Not detected |
| 4/12/2014 | -5.50E-04 | 1.13E-03 | 1.96E-03 | Not detected |
| 4/13/2014 | -1.61E-04 | 9.30E-04 | 1.58E-03 | Not detected |
| 4/14/2014 | -1.07E-04 | 9.34E-04 | 1.59E-03 | Not detected |
| 4/15/2014 | -9.18E-04 | 2.08E-03 | 3.56E-03 | Not detected |
| 4/16/2014 | -2.48E-04 | 1.16E-03 | 2.00E-03 | Not detected |
| 4/17/2014 | -9.89E-05 | 1.15E-03 | 1.97E-03 | Not detected |
| 4/18/2014 | -7.18E-04 | 2.56E-03 | 4.42E-03 | Not detected |
| 4/19/2014 | -2.84E-04 | 1.12E-03 | 1.94E-03 | Not detected |
| 4/20/2014 | 3.95E-05 | 1.14E-03 | 1.95E-03 | Not detected |
| 4/21/2014 | 3.54E-04 | 2.42E-03 | 4.14E-03 | Not detected |

Table C-5: Weekly Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{60}Co$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | 2.52E-04 | 2.57E-04 | 4.29E-04 | Not detected |
| Week 1 May | 3.18E-04 | 2.20E-03 | 3.76E-03 | Not detected |
| Week 2 May | -4.62E-05 | 1.85E-04 | 3.18E-04 | Not detected |
| Week 3 May | -4.04E-05 | 1.54E-04 | 2.66E-04 | Not detected |
| Week 4 May | 3.31E-05 | 1.12E-04 | 1.91E-04 | Not detected |
| Week 1 Jun. | 1.84E-05 | 1.64E-04 | 2.79E-04 | Not detected |
| Week 2 Jun. | -4.70E-05 | 3.87E-04 | 6.67E-04 | Not detected |
| Week 3 Jun. | -8.91E-05 | 3.48E-04 | 6.01E-04 | Not detected |
| Week 4 Jun. | -7.43E-05 | 1.23E-04 | 2.13E-04 | Not detected |
| Week 1 Jul. | -8.11E-05 | 8.67E-05 | 2.95E-04 | Not detected |
| Week 2 Jul. | -1.59E-04 | 9.65E-05 | 3.29E-04 | Not detected |
| Week 3 Jul. | -8.08E-05 | 8.32E-05 | 2.83E-04 | Not detected |
| Week 4 Jul. | -6.89E-05 | 5.86E-05 | 1.99E-04 | Not detected |
| Week 1 Aug. | -6.62E-05 | 8.28E-05 | 2.80E-04 | Not detected |
| Week 2 Aug. | 4.02E-05 | 8.00E-05 | 2.67E-04 | Not detected |
| Week 3 Aug. | -1.07E-04 | 8.34E-05 | 2.84E-04 | Not detected |
| Week 4 Aug. | -4.64E-05 | 5.84E-05 | 1.98E-04 | Not detected |
| Week 1 Sep. | -6.23E-05 | 7.95E-05 | 2.69E-04 | Not detected |
| Week 2 Sep. | 8.54E-05 | 9.01E-05 | 2.99E-04 | Not detected |
| Week 3 Sep. | -1.26E-04 | 8.58E-05 | 2.92E-04 | Not detected |
| Week 4 Sep. | -5.74E-05 | 6.51E-05 | 2.21E-04 | Not detected |
| Week 1 Oct. | 2.48E-05 | 8.50E-05 | 2.84E-04 | Not detected |
| Week 2 Oct. | -4.51E-05 | 8.26E-05 | 2.79E-04 | Not detected |
| Week 3 Oct. | -3.50E-05 | 8.35E-05 | 2.82E-04 | Not detected |
| Week 4 Oct. | -1.95E-05 | 5.74E-05 | 1.94E-04 | Not detected |
| Week 1 Nov. | 5.05E-05 | 7.89E-05 | 2.63E-04 | Not detected |
| Week 2 Nov. | -8.87E-05 | 8.77E-05 | 2.97E-04 | Not detected |
| Week 3 Nov. | -8.46E-05 | 8.55E-05 | 2.90E-04 | Not detected |
| Week 4 Nov. | 1.38E-05 | 6.76E-05 | 2.26E-04 | Not detected |
| Week 1 Dec. | -2.33E-05 | 8.07E-05 | 2.72E-04 | Not detected |
| Week 2 Dec. | -9.75E-05 | 7.40E-05 | 2.52E-04 | Not detected |
| Week 3 Dec. | -1.14E-04 | 8.73E-05 | 2.97E-04 | Not detected |
| Week 4 Dec. | -1.56E-05 | 5.68E-05 | 1.91E-04 | Not detected |

Table C-6: Weekly Activity density of $^{60}Co$ (Bq/g), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{60}Co$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | -1.00E+00 | 1.07E+00 | 3.64E+00 | Not detected |
| Week 2 Jul. | -2.46E+00 | 1.50E+00 | 5.11E+00 | Not detected |
| Week 3 Jul. | -9.90E-01 | 1.02E+00 | 3.46E+00 | Not detected |
| Week 4 Jul. | -1.03E+00 | 8.76E-01 | 2.98E+00 | Not detected |
| Week 1 Aug. | -1.32E+00 | 1.65E+00 | 5.59E+00 | Not detected |
| Week 2 Aug. | 6.65E-01 | 1.32E+00 | 4.41E+00 | Not detected |
| Week 3 Aug. | -1.84E+00 | 1.44E+00 | 4.90E+00 | Not detected |
| Week 4 Aug. | -9.24E-01 | 1.16E+00 | 3.93E+00 | Not detected |
| Week 1 Sep. | -1.39E+00 | 1.77E+00 | 5.99E+00 | Not detected |
| Week 2 Sep. | 6.46E-01 | 6.82E-01 | 2.26E+00 | Not detected |
| Week 3 Sep. | -1.53E+00 | 1.04E+00 | 3.55E+00 | Not detected |
| Week 4 Sep. | -8.35E-01 | 9.47E-01 | 3.21E+00 | Not detected |
| Week 1 Oct. | 1.16E+00 | 3.97E+00 | 1.33E+01 | Not detected |
| Week 2 Oct. | -1.56E+00 | 2.85E+00 | 9.64E+00 | Not detected |
| Week 3 Oct. | -8.65E-01 | 2.06E+00 | 6.96E+00 | Not detected |
| Week 4 Oct. | -5.33E-01 | 1.57E+00 | 5.29E+00 | Not detected |
| Week 1 Nov. | 2.58E+00 | 4.02E+00 | 1.34E+01 | Not detected |
| Week 2 Nov. | -3.36E+00 | 3.32E+00 | 1.13E+01 | Not detected |
| Week 3 Nov. | -2.67E+00 | 2.70E+00 | 9.14E+00 | Not detected |
| Week 4 Nov. | 4.24E-01 | 2.07E+00 | 6.94E+00 | Not detected |
| Week 1 Dec. | -3.92E-01 | 1.36E+00 | 4.57E+00 | Not detected |
| Week 2 Dec. | -2.35E+00 | 1.79E+00 | 6.09E+00 | Not detected |
| Week 3 Dec. | -2.53E+00 | 1.94E+00 | 6.60E+00 | Not detected |
| Week 4 Dec. | -6.22E-01 | 2.26E+00 | 7.61E+00 | Not detected |

*Filters collected prior to July, 2014 were not weighed; no density data is available for this period.

Table C-7: Daily Activity concentrations of $^{40}K$ (Bq/m3), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{40}K$ Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | -5.19E-03 | 1.84E-02 | 3.22E-02 | Not detected |
| 2/15/2014 | -4.28E-02 | 2.77E-02 | 4.85E-02 | Not detected |
| 2/16/2014 | -1.28E-02 | 2.69E-02 | 4.36E-02 | Not detected |
| 2/17/2014 | -6.58E-02 | 2.41E-02 | 4.25E-02 | Not detected |
| 2/18/2014 | -7.11E-02 | 2.55E-02 | 4.47E-02 | Not detected |
| 2/19/2014 | -4.56E-02 | 4.01E-02 | 5.51E-02 | Not detected |
| 2/20/2014 | -3.41E-02 | 3.23E-02 | 5.61E-02 | Not detected |
| 2/21/2014 | -3.12E-02 | 1.90E-02 | 3.33E-02 | Not detected |
| 2/22/2014 | -3.51E-04 | 2.45E-02 | 4.97E-03 | Not detected |
| 2/23/2014 | -1.48E-02 | 2.67E-02 | 4.66E-02 | Not detected |
| 2/24/2014 | -2.53E-02 | 1.44E-02 | 2.55E-02 | Not detected |
| 2/25/2014 | -1.67E-02 | 1.43E-02 | 2.48E-02 | Not detected |
| 2/26/2014 | -1.55E-02 | 2.64E-03 | 5.03E-02 | Not detected |
| 2/27/2014 | -2.68E-02 | 1.47E-02 | 2.59E-02 | Not detected |
| 3/4/2014 | -1.67E-02 | 1.36E-02 | 2.39E-02 | Not detected |
| 3/5/2014 | -2.03E-02 | 1.38E-02 | 2.43E-02 | Not detected |
| 3/6/2014 | -1.90E-02 | 1.42E-02 | 2.46E-02 | Not detected |
| 3/7/2014 | 4.85E-03 | 2.52E-02 | 4.31E-02 | Not detected |
| 3/8/2014 | -1.70E-02 | 2.66E-02 | 4.66E-02 | Not detected |
| 3/9/2014 | -1.02E-02 | 1.42E-02 | 2.46E-02 | Not detected |
| 3/10/2014 | -7.10E-03 | 2.56E-02 | 4.44E-02 | Not detected |
| 3/11/2014 | -1.13E-02 | 1.36E-02 | 2.37E-02 | Not detected |
| 3/12/2014 | -1.16E-02 | 1.43E-02 | 2.49E-02 | Not detected |
| 3/13/2014 | -2.03E-02 | 1.51E-02 | 2.62E-02 | Not detected |
| 3/14/2014 | -2.40E-02 | 1.42E-02 | 2.50E-02 | Not detected |
| 3/15/2014 | -1.68E-02 | 1.45E-02 | 2.52E-02 | Not detected |
| 3/16/2014 | -5.16E-03 | 2.53E-02 | 4.38E-02 | Not detected |
| 3/17/2014 | -3.23E-03 | 1.39E-02 | 2.39E-02 | Not detected |
| 3/18/2014 | 1.43E-02 | 1.31E-02 | 2.17E-02 | Not detected |
| 3/19/2014 | 1.07E-02 | 2.44E-02 | 4.16E-02 | Not detected |
| 3/20/2014 | 5.70E-03 | 1.34E-02 | 2.27E-02 | Not detected |
| 3/21/2014 | 8.33E-03 | 1.35E-02 | 2.28E-02 | Not detected |
| 3/22/2014 | 6.05E-03 | 2.72E-02 | 4.64E-02 | Not detected |

Table C-7: Daily Activity concentrations of $^{40}K$ (Bq/m3), in Station A filters following the February 14 radiological event at WIPP (continued)

| Sample Date 2014 | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 3/23/2014 | -3.77E-03 | 1.33E-02 | 2.29E-02 | Not detected |
| 3/24/2014 | 3.75E-03 | 1.42E-02 | 2.41E-02 | Not detected |
| 3/25/2014 | -9.85E-03 | 2.73E-02 | 4.74E-02 | Not detected |
| 3/26/2014 | 5.01E-03 | 1.39E-02 | 2.36E-02 | Not detected |
| 3/27/2014 | -8.89E-04 | 1.39E-02 | 2.38E-02 | Not detected |
| 3/28/2014 | 5.60E-04 | 2.68E-02 | 4.61E-02 | Not detected |
| 3/29/2014 | 5.22E-03 | 1.31E-02 | 2.23E-02 | Not detected |
| 3/30/2014 | -5.16E-03 | 1.51E-02 | 2.60E-02 | Not detected |
| 3/31/2014 | 4.02E-03 | 1.32E-02 | 2.24E-02 | Not detected |
| 4/1/2014 | 4.16E-03 | 1.31E-02 | 2.22E-02 | Not detected |
| 4/2/2014 | 1.36E-02 | 1.34E-02 | 2.22E-02 | Not detected |
| 4/3/2014 | 1.86E-04 | 1.41E-02 | 2.41E-02 | Not detected |
| 4/4/2014 | -7.65E-03 | 1.46E-02 | 2.53E-02 | Not detected |
| 4/5/2014 | -4.20E-03 | 1.39E-02 | 2.40E-02 | Not detected |
| 4/6/2014 | 2.29E-04 | 1.44E-02 | 2.46E-02 | Not detected |
| 4/7/2014 | 2.10E-02 | 2.34E-02 | 3.91E-02 | Not detected |
| 4/8/2014 | 4.74E-03 | 1.43E-02 | 2.42E-02 | Not detected |
| 4/9/2014 | -9.43E-03 | 1.42E-02 | 2.46E-02 | Not detected |
| 4/10/2014 | 8.98E-03 | 1.35E-02 | 2.27E-02 | Not detected |
| 4/11/2014 | 4.26E-03 | 2.44E-02 | 4.19E-02 | Not detected |
| 4/12/2014 | -9.82E-04 | 1.37E-02 | 2.34E-02 | Not detected |
| 4/13/2014 | 4.50E-03 | 1.10E-02 | 1.86E-02 | Not detected |
| 4/14/2014 | -1.27E-03 | 1.17E-02 | 1.99E-02 | Not detected |
| 4/15/2014 | -2.05E-04 | 2.04E-02 | 3.49E-02 | Not detected |
| 4/16/2014 | 2.45E-03 | 1.36E-02 | 2.32E-02 | Not detected |
| 4/17/2014 | -2.13E-03 | 1.40E-02 | 2.40E-02 | Not detected |
| 4/18/2014 | -2.08E-03 | 2.51E-02 | 4.34E-02 | Not detected |
| 4/19/2014 | 5.51E-03 | 1.37E-02 | 2.32E-02 | Not detected |
| 4/20/2014 | -2.14E-03 | 1.41E-02 | 2.42E-02 | Not detected |
| 4/21/2014 | -6.42E-03 | 2.68E-02 | 5.86E-02 | Not detected |

Table C-8: Weekly Activity concentrations of $^{40}K$ ($Bq/m^3$), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{40}K$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 4 Apr. | -1.51E-04 | 3.17E-03 | 5.42E-03 | Not detected |
| Week 1 May | -1.60E-03 | 2.10E-03 | 3.64E-03 | Not detected |
| Week 2 May | 1.63E-04 | 2.00E-03 | 3.41E-03 | Not detected |
| Week 3 May | 2.50E-04 | 1.97E-03 | 3.36E-03 | Not detected |
| Week 4 May | 1.03E-04 | 1.35E-03 | 2.30E-03 | Not detected |
| Week 1 Jun. | -1.77E-03 | 2.19E-03 | 3.79E-03 | Not detected |
| Week 2 Jun. | 1.82E-03 | 3.73E-03 | 6.32E-03 | Not detected |
| Week 3 Jun. | -5.30E-04 | 3.55E-03 | 6.13E-03 | Not detected |
| Week 4 Jun. | -6.72E-04 | 1.52E-03 | 2.63E-03 | Not detected |
| Week 1 Jul. | -7.13E-04 | 1.06E-03 | 3.57E-03 | Not detected |
| Week 2 Jul. | 1.45E-03 | 1.06E-03 | 3.50E-03 | Not detected |
| Week 3 Jul. | 5.02E-04 | 9.59E-04 | 3.20E-03 | Not detected |
| Week 4 Jul. | 2.37E-04 | 7.05E-04 | 2.35E-03 | Not detected |
| Week 1 Aug. | 6.35E-05 | 9.58E-04 | 3.21E-03 | Not detected |
| Week 2 Aug. | 9.36E-04 | 9.99E-04 | 3.31E-03 | Not detected |
| Week 3 Aug. | 4.23E-04 | 9.35E-04 | 3.12E-03 | Not detected |
| Week 4 Aug. | 5.42E-04 | 7.10E-04 | 2.36E-03 | Not detected |
| Week 1 Sep. | -6.09E-04 | 9.59E-04 | 3.24E-03 | Not detected |
| Week 2 Sep. | 1.38E-03 | 1.03E-03 | 3.39E-03 | Not detected |
| Week 3 Sep. | -1.00E-03 | 1.04E-03 | 3.50E-03 | Not detected |
| Week 4 Sep. | -1.15E-03 | 8.10E-04 | 2.75E-03 | Not detected |
| Week 1 Oct. | 4.65E-04 | 9.90E-04 | 3.30E-03 | Not detected |
| Week 2 Oct. | -4.11E-05 | 9.64E-04 | 3.24E-03 | Not detected |
| Week 3 Oct. | -1.15E-04 | 9.94E-04 | 3.34E-03 | Not detected |
| Week 4 Oct. | -4.70E-04 | 6.79E-04 | 2.29E-03 | Not detected |
| Week 1 Nov. | -3.59E-04 | 9.68E-04 | 3.26E-03 | Not detected |
| Week 2 Nov. | 8.82E-04 | 1.02E-03 | 3.37E-03 | Not detected |
| Week 3 Nov. | 3.19E-04 | 9.92E-04 | 3.31E-03 | Not detected |
| Week 4 Nov. | -8.28E-04 | 8.26E-04 | 2.79E-03 | Not detected |
| Week 1 Dec. | -1.04E-03 | 9.67E-04 | 3.28E-03 | Not detected |
| Week 2 Dec. | 7.12E-04 | 9.65E-04 | 3.21E-03 | Not detected |
| Week 3 Dec. | 4.72E-04 | 1.02E-03 | 3.39E-03 | Not detected |
| Week 4 Dec. | 2.58E-04 | 6.74E-04 | 2.25E-03 | Not detected |

Table C-9: Weekly Activity density of $^{40}K$ (Bq/g), in Station A filters following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{40}K$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Jul. | -8.80E+00 | 1.30E+01 | 4.40E+01 | Not detected |
| Week 2 Jul. | 2.25E+01 | 1.65E+01 | 5.43E+01 | Not detected |
| Week 3 Jul. | 6.15E+00 | 1.18E+01 | 3.92E+01 | Not detected |
| Week 4 Jul. | 3.55E+00 | 1.05E+01 | 3.52E+01 | Not detected |
| Week 1 Aug. | 1.27E+00 | 1.91E+01 | 6.40E+01 | Not detected |
| Week 2 Aug. | 1.55E+01 | 1.65E+01 | 5.47E+01 | Not detected |
| Week 3 Aug. | 7.30E+00 | 1.61E+01 | 5.39E+01 | Not detected |
| Week 4 Aug. | 1.08E+01 | 1.41E+01 | 4.69E+01 | Not detected |
| Week 1 Sep. | -1.35E+01 | 2.13E+01 | 7.20E+01 | Not detected |
| Week 2 Sep. | 1.05E+01 | 7.81E+00 | 2.57E+01 | Not detected |
| Week 3 Sep. | -1.22E+01 | 1.26E+01 | 4.26E+01 | Not detected |
| Week 4 Sep. | -1.67E+01 | 1.18E+01 | 4.01E+01 | Not detected |
| Week 1 Oct. | 2.17E+01 | 4.63E+01 | 1.54E+02 | Not detected |
| Week 2 Oct. | -1.42E+00 | 3.33E+01 | 1.12E+02 | Not detected |
| Week 3 Oct. | -2.83E+00 | 2.46E+01 | 8.24E+01 | Not detected |
| Week 4 Oct. | -1.28E+01 | 1.86E+01 | 6.27E+01 | Not detected |
| Week 1 Nov. | -1.83E+01 | 4.94E+01 | 1.66E+02 | Not detected |
| Week 2 Nov. | 3.34E+01 | 3.85E+01 | 1.28E+02 | Not detected |
| Week 3 Nov. | 1.01E+01 | 3.13E+01 | 1.04E+02 | Not detected |
| Week 4 Nov. | -2.54E+01 | 2.53E+01 | 8.56E+01 | Not detected |
| Week 1 Dec. | -1.74E+01 | 1.62E+01 | 5.51E+01 | Not detected |
| Week 2 Dec. | 1.72E+01 | 2.33E+01 | 7.73E+01 | Not detected |
| Week 3 Dec. | 1.05E+01 | 2.26E+01 | 7.55E+01 | Not detected |
| Week 4 Dec. | 1.03E+01 | 2.68E+01 | 8.95E+01 | Not detected |

*Filters collected prior to July, 2014 were not weighed; no density data is available for this period.

## Appendix D: WIPP Underground Air Station B

Table D-1: Daily Activity concentrations of $^{137}Cs$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{137}Cs$ Activity Bq/m$^3$ | Uncertainty (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 3.63E-04 | 5.77E-04 | 9.72E-04 | Not detected |
| 2/18/2014 | 1.37E-03 | 3.05E-03 | 5.16E-03 | Not detected |
| 2/19/2014 | -4.20E-04 | 2.26E-03 | 3.84E-03 | Not detected |
| 2/20/2014 | -4.11E-03 | 3.95E-03 | 6.78E-03 | Not detected |
| 2/21/2014 | -3.71E-04 | 1.10E-03 | 1.88E-03 | Not detected |
| 2/22/2014 | -2.44E-03 | 1.44E-03 | 2.49E-03 | Not detected |
| 2/23/2014 | 2.19E-03 | 2.53E-03 | 4.24E-03 | Not detected |
| 2/24/2014 | -1.19E-04 | 2.67E-03 | 4.54E-03 | Not detected |
| 2/25/2014 | -9.51E-04 | 1.08E-03 | 1.87E-03 | Not detected |
| 2/26/2014 | -1.10E-03 | 1.32E-03 | 2.26E-03 | Not detected |
| 2/27/2014 | -1.70E-05 | 2.70E-03 | 4.60E-03 | Not detected |
| 3/4/2014 | -2.40E-03 | 1.17E-03 | 2.06E-03 | Not detected |
| 3/5/2014 | -1.22E-03 | 1.33E-03 | 2.29E-03 | Not detected |
| 3/6/2014 | 6.20E-04 | 2.69E-03 | 4.55E-03 | Not detected |
| 3/7/2014 | -1.15E-03 | 1.10E-03 | 1.91E-03 | Not detected |
| 3/8/2014 | -6.32E-04 | 1.32E-03 | 2.26E-03 | Not detected |
| 3/9/2014 | 4.10E-04 | 2.78E-03 | 4.72E-03 | Not detected |
| 3/10/2014 | -1.73E-03 | 1.08E-03 | 1.89E-03 | Not detected |
| 3/11/2014 | 2.11E-05 | 1.33E-03 | 2.26E-03 | Not detected |
| 3/12/2014 | -1.59E-03 | 1.10E-03 | 1.92E-03 | Not detected |
| 3/13/2014 | 1.09E-03 | 2.65E-03 | 4.48E-03 | Not detected |
| 3/14/2014 | -3.39E-04 | 2.71E-03 | 4.63E-03 | Not detected |
| 3/15/2014 | -1.65E-03 | 1.09E-03 | 1.91E-03 | Not detected |
| 3/16/2014 | 6.54E-04 | 2.66E-03 | 4.51E-03 | Not detected |
| 3/20/2014 | -1.54E-03 | 2.69E-03 | 4.62E-03 | Not detected |
| 3/21/2014 | 1.81E-04 | 5.59E-04 | 1.86E-03 | Not detected |
| 3/22/2014 | 8.91E-04 | 1.05E-03 | 3.49E-03 | Not detected |
| 3/23/2014 | -2.15E-04 | 5.60E-04 | 1.87E-03 | Not detected |
| 3/24/2014 | -5.65E-04 | 7.19E-04 | 2.41E-03 | Not detected |
| 3/25/2014 | -7.04E-05 | 5.52E-04 | 1.84E-03 | Not detected |
| 3/26/2014 | -8.33E-04 | 7.10E-04 | 2.63E-03 | Not detected |
| 3/27/2014 | 5.49E-04 | 6.95E-04 | 2.30E-03 | Not detected |
| 3/28/2014 | 1.81E-04 | 5.40E-04 | 1.80E-03 | Not detected |
| 3/29/2014 | 7.59E-04 | 6.81E-04 | 2.25E-03 | Not detected |
| 3/30/2014 | -1.01E-04 | 5.60E-04 | 1.87E-03 | Not detected |
| 3/31/2014 | -3.33E-04 | 7.31E-04 | 2.44E-03 | Not detected |

Table D-2: Weekly Activity concentrations of $^{137}Cs$ ($Bq/m^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{137}Cs$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | -1.31E-04 | 1.05E-04 | 3.51E-04 | Not detected |
| Week 2 Apr. | -6.06E-05 | 9.94E-05 | 3.33E-04 | Not detected |
| Week 3 Apr. | 3.21E-05 | 7.75E-05 | 2.58E-04 | Not detected |
| Week 4 Apr. | 1.45E-04 | 1.44E-04 | 4.78E-04 | Not detected |
| Week 1 May | -4.29E-05 | 1.01E-04 | 3.37E-04 | Not detected |
| Week 2 May | -1.88E-04 | 1.97E-04 | 6.63E-04 | Not detected |
| Week 3 May | -3.72E-05 | 9.63E-05 | 3.22E-04 | Not detected |
| Week 4 May | 2.72E-05 | 1.32E-04 | 4.41E-04 | Not detected |
| Week 1 Jun. | 8.59E-06 | 8.14E-05 | 2.71E-04 | Not detected |
| Week 2 Jun. | -9.28E-06 | 1.02E-04 | 3.41E-04 | Not detected |
| Week 3 Jun. | 1.69E-04 | 1.87E-04 | 6.18E-04 | Not detected |
| Week 4 Jun. | -1.57E-05 | 1.52E-04 | 5.08E-04 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | 1.63E-04 | 2.06E-04 | 6.83E-04 | Not detected |
| Week 3 Jul. | 6.26E-05 | 9.92E-05 | 3.29E-04 | Not detected |
| Week 4 Jul. | 5.30E-05 | 5.37E-05 | 1.78E-04 | Not detected |
| Week 1 Aug. | 9.18E-05 | 7.71E-05 | 2.55E-04 | Not detected |
| Week 2 Aug. | 9.09E-06 | 9.66E-05 | 3.22E-04 | Not detected |
| Week 3 Aug. | -1.58E-04 | 1.01E-04 | 3.39E-04 | Not detected |
| Week 4 Aug. | 4.21E-05 | 5.57E-05 | 1.85E-04 | Not detected |
| Week 1 Sep. | -1.20E-04 | 1.03E-04 | 3.46E-04 | Not detected |
| Week 2 Sep. | -1.11E-04 | 7.74E-05 | 2.61E-04 | Not detected |
| Week 3 Sep. | 3.34E-05 | 9.86E-05 | 3.29E-04 | Not detected |
| Week 4 Sep. | 1.93E-05 | 4.99E-05 | 1.65E-04 | Not detected |
| Week 1 Oct. | 3.27E-05 | 8.23E-05 | 2.72E-04 | Not detected |
| Week 2 Oct. | 1.12E-04 | 9.85E-05 | 3.25E-04 | Not detected |
| Week 3 Oct. | -5.13E-05 | 7.93E-05 | 2.66E-04 | Not detected |
| Week 4 Oct. | -1.15E-05 | 5.40E-05 | 1.80E-04 | Not detected |
| Week 1 Nov. | 1.68E-04 | 9.68E-05 | 3.18E-04 | Not detected |
| Week 2 Nov. | 1.34E-04 | 9.77E-05 | 3.22E-04 | Not detected |
| Week 3 Nov. | 1.46E-04 | 7.57E-05 | 2.52E-04 | Not detected |
| Week 4 Nov. | -1.73E-05 | 6.51E-05 | 2.14E-04 | Not detected |
| Week 1 Dec. | 5.54E-05 | 1.01E-04 | 3.37E-04 | Not detected |
| Week 2 Dec. | -1.76E-04 | 1.60E-04 | 5.37E-04 | Not detected |
| Week 3 Dec. | -7.56E-06 | 7.84E-05 | 2.62E-04 | Not detected |
| Week 4 Dec. | -2.44E-05 | 6.79E-05 | 2.27E-04 | Not detected |

Table D-3: Weekly Activity density of $^{137}Cs$ (Bq/g), in Station B filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{137}Cs$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.52E+01 | 1.28E+01 | 4.23E+01 | Not detected |
| Week 2 Aug. | 1.30E+00 | 1.38E+01 | 4.61E+01 | Not detected |
| Week 3 Aug. | -8.53E+01 | 5.46E+01 | 1.83E+02 | Not detected |
| Week 4 Aug. | 1.37E+01 | 1.81E+01 | 6.02E+01 | Not detected |
| Week 1 Sep. | -1.42E+01 | 1.22E+01 | 4.09E+01 | Not detected |
| Week 2 Sep. | -1.60E+01 | 1.11E+01 | 3.76E+01 | Not detected |
| Week 3 Sep. | 4.57E+00 | 1.35E+01 | 4.50E+01 | Not detected |
| Week 4 Sep. | 2.67E+00 | 6.89E+00 | 2.28E+01 | Not detected |
| Week 1 Oct. | 1.50E+00 | 3.76E+00 | 1.25E+01 | Not detected |
| Week 2 Oct. | 7.45E+00 | 6.56E+00 | 2.16E+01 | Not detected |
| Week 3 Oct. | -3.24E+00 | 5.01E+00 | 1.68E+01 | Not detected |
| Week 4 Oct. | -6.12E+00 | 2.87E+01 | 9.61E+01 | Not detected |
| Week 1 Nov. | 1.59E+01 | 9.16E+00 | 3.01E+01 | Not detected |
| Week 2 Nov. | 4.30E+01 | 3.13E+01 | 1.03E+02 | Not detected |
| Week 3 Nov. | 2.83E+01 | 1.47E+01 | 4.89E+01 | Not detected |
| Week 4 Nov. | -1.70E+00 | 6.38E+00 | 2.10E+01 | Not detected |
| Week 1 Dec. | 4.42E+00 | 8.10E+00 | 2.69E+01 | Not detected |
| Week 2 Dec. | -2.23E+01 | 2.03E+01 | 6.81E+01 | Not detected |
| Week 3 Dec. | -8.38E-01 | 8.69E+00 | 2.90E+01 | Not detected |
| Week 4 Dec. | -8.79E+00 | 2.45E+01 | 8.17E+01 | Not detected |

*Filters collected prior to August, 2014 were not weighed; no density data is available for this period.

Table D-4: Daily Activity concentrations of $^{60}Co$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{60}Co$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | -5.92E-04 | 6.02E-04 | 1.05E-03 | Not detected |
| 2/18/2014 | -1.46E-03 | 3.16E-03 | 5.47E-03 | Not detected |
| 2/19/2014 | -8.37E-04 | 1.98E-03 | 3.40E-03 | Not detected |
| 2/20/2014 | -3.73E-03 | 3.78E-03 | 6.57E-03 | Not detected |
| 2/21/2014 | -2.21E-04 | 1.11E-03 | 1.90E-03 | Not detected |
| 2/22/2014 | 2.55E-05 | 1.17E-03 | 2.00E-03 | Not detected |
| 2/23/2014 | 1.04E-04 | 2.06E-03 | 3.54E-03 | Not detected |
| 2/24/2014 | -6.09E-04 | 2.28E-03 | 3.95E-03 | Not detected |
| 2/25/2014 | -4.88E-04 | 1.12E-03 | 1.93E-03 | Not detected |
| 2/26/2014 | 3.78E-04 | 1.08E-03 | 1.83E-03 | Not detected |
| 2/27/2014 | -1.44E-03 | 2.33E-03 | 4.07E-03 | Not detected |
| 3/4/2014 | -5.97E-04 | 1.16E-03 | 2.01E-03 | Not detected |
| 3/5/2014 | -6.50E-06 | 1.11E-03 | 1.90E-03 | Not detected |
| 3/6/2014 | 5.87E-05 | 2.23E-03 | 3.83E-03 | Not detected |
| 3/7/2014 | -4.31E-04 | 1.13E-03 | 1.95E-03 | Not detected |
| 3/8/2014 | 5.18E-04 | 1.09E-03 | 1.85E-03 | Not detected |
| 3/9/2014 | 2.54E-03 | 1.81E-03 | 2.96E-03 | Not detected |
| 3/10/2014 | -6.96E-04 | 1.08E-03 | 1.88E-03 | Not detected |
| 3/11/2014 | 7.71E-04 | 1.13E-03 | 1.89E-03 | Not detected |
| 3/12/2014 | 2.51E-05 | 1.08E-03 | 1.85E-03 | Not detected |
| 3/13/2014 | -1.20E-03 | 2.16E-03 | 3.78E-03 | Not detected |
| 3/14/2014 | 9.94E-04 | 2.08E-03 | 3.52E-03 | Not detected |
| 3/15/2014 | -7.39E-04 | 1.10E-03 | 1.91E-03 | Not detected |
| 3/16/2014 | 1.61E-03 | 1.88E-03 | 3.16E-03 | Not detected |
| 3/20/2014 | -3.45E-03 | 2.70E-03 | 4.75E-03 | Not detected |
| 3/21/2014 | -7.11E-04 | 6.39E-04 | 2.17E-03 | Not detected |
| 3/22/2014 | -5.79E-04 | 9.68E-04 | 3.27E-03 | Not detected |
| 3/23/2014 | -1.74E-04 | 6.26E-04 | 2.11E-03 | Not detected |
| 3/24/2014 | -9.99E-04 | 6.45E-04 | 2.20E-03 | Not detected |
| 3/25/2014 | -1.21E-03 | 6.48E-04 | 2.22E-03 | Not detected |
| 3/26/2014 | -5.67E-04 | 6.38E-04 | 2.16E-03 | Not detected |
| 3/27/2014 | -5.82E-04 | 5.50E-04 | 1.87E-03 | Not detected |
| 3/28/2014 | -4.91E-04 | 5.49E-04 | 1.86E-03 | Not detected |
| 3/29/2014 | 4.65E-05 | 5.55E-04 | 1.86E-03 | Not detected |
| 3/30/2014 | -1.31E-04 | 6.04E-04 | 2.03E-03 | Not detected |
| 3/31/2014 | -1.07E-04 | 6.38E-04 | 2.15E-03 | Not detected |

Table D-5: Weekly Activity concentrations of $^{60}Co$ ($Bq/m^3$), in Station B (Post–HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{60}Co$ Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | 6.77E-05 | 8.83E-05 | 2.93E-04 | Not detected |
| Week 2 Apr. | -1.55E-05 | 8.96E-05 | 3.01E-04 | Not detected |
| Week 3 Apr. | -5.38E-05 | 7.77E-05 | 2.63E-04 | Not detected |
| Week 4 Apr. | -2.80E-05 | 1.53E-04 | 5.15E-04 | Not detected |
| Week 1 May | -1.36E-05 | 9.19E-05 | 3.09E-04 | Not detected |
| Week 2 May | -2.14E-05 | 1.91E-04 | 6.43E-04 | Not detected |
| Week 3 May | -7.14E-05 | 8.61E-05 | 2.92E-04 | Not detected |
| Week 4 May | -1.51E-05 | 1.37E-04 | 4.62E-04 | Not detected |
| Week 1 Jun. | 5.29E-05 | 8.42E-05 | 2.80E-04 | Not detected |
| Week 2 Jun. | -7.08E-05 | 8.90E-05 | 3.01E-04 | Not detected |
| Week 3 Jun. | -1.58E-04 | 2.03E-04 | 6.89E-04 | Not detected |
| Week 4 Jun. | -4.01E-05 | 1.47E-04 | 4.95E-04 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | -1.35E-04 | 1.77E-04 | 5.99E-04 | Not detected |
| Week 3 Jul. | -6.58E-05 | 8.37E-05 | 2.83E-04 | Not detected |
| Week 4 Jul. | -6.88E-05 | 5.52E-05 | 1.88E-04 | Not detected |
| Week 1 Aug. | -3.06E-05 | 7.87E-05 | 2.65E-04 | Not detected |
| Week 2 Aug. | 4.06E-05 | 7.86E-05 | 2.62E-04 | Not detected |
| Week 3 Aug. | -1.09E-04 | 8.17E-05 | 2.78E-04 | Not detected |
| Week 4 Aug. | -3.49E-05 | 5.55E-05 | 1.88E-04 | Not detected |
| Week 1 Sep. | 4.51E-05 | 8.48E-05 | 2.83E-04 | Not detected |
| Week 2 Sep. | 3.21E-05 | 7.29E-05 | 2.43E-04 | Not detected |
| Week 3 Sep. | -3.67E-05 | 8.76E-05 | 2.96E-04 | Not detected |
| Week 4 Sep. | -3.26E-05 | 5.24E-05 | 1.75E-04 | Not detected |
| Week 1 Oct. | -1.48E-05 | 6.89E-05 | 2.30E-04 | Not detected |
| Week 2 Oct. | 4.65E-05 | 8.18E-05 | 2.73E-04 | Not detected |
| Week 3 Oct. | -1.01E-04 | 8.72E-05 | 2.96E-04 | Not detected |
| Week 4 Oct. | -8.11E-07 | 4.77E-05 | 1.60E-04 | Not detected |
| Week 1 Nov. | -1.09E-05 | 8.25E-05 | 2.77E-04 | Not detected |
| Week 2 Nov. | -1.23E-06 | 8.02E-05 | 2.69E-04 | Not detected |
| Week 3 Nov. | -1.36E-05 | 6.84E-05 | 2.30E-04 | Not detected |
| Week 4 Nov. | -3.93E-05 | 6.49E-05 | 2.19E-04 | Not detected |
| Week 1 Dec. | -9.35E-06 | 8.25E-05 | 2.77E-04 | Not detected |
| Week 2 Dec. | 1.28E-03 | 1.11E-03 | 3.68E-03 | Not detected |
| Week 3 Dec. | -5.62E-05 | 7.90E-05 | 2.68E-04 | Not detected |
| Week 4 Dec. | -6.73E-05 | 5.79E-05 | 1.97E-04 | Not detected |

Table D-6: Weekly Activity density of $^{60}Co$ (Bq/g), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{60}Co$ Activity Bq/g | Unc. ($2\sigma$) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | -5.08E+00 | 1.31E+01 | 4.41E+01 | Not detected |
| Week 2 Aug. | 5.82E+00 | 1.13E+01 | 3.75E+01 | Not detected |
| Week 3 Aug. | -5.88E+01 | 4.41E+01 | 1.50E+02 | Not detected |
| Week 4 Aug. | -1.14E+01 | 1.81E+01 | 6.11E+01 | Not detected |
| Week 1 Sep. | 5.33E+00 | 1.00E+01 | 3.34E+01 | Not detected |
| Week 2 Sep. | 4.62E+00 | 1.05E+01 | 3.50E+01 | Not detected |
| Week 3 Sep. | -5.02E+00 | 1.20E+01 | 4.04E+01 | Not detected |
| Week 4 Sep. | -4.50E+00 | 7.23E+00 | 2.42E+01 | Not detected |
| Week 1 Oct. | -6.77E-01 | 3.15E+00 | 1.05E+01 | Not detected |
| Week 2 Oct. | 3.10E+00 | 5.44E+00 | 1.81E+01 | Not detected |
| Week 3 Oct. | -6.36E+00 | 5.51E+00 | 1.87E+01 | Not detected |
| Week 4 Oct. | -4.32E-01 | 2.54E+01 | 8.54E+01 | Not detected |
| Week 1 Nov. | -1.03E+00 | 7.81E+00 | 2.62E+01 | Not detected |
| Week 2 Nov. | -3.93E-01 | 2.56E+01 | 8.62E+01 | Not detected |
| Week 3 Nov. | -2.63E+00 | 1.33E+01 | 4.46E+01 | Not detected |
| Week 4 Nov. | -3.85E+00 | 6.36E+00 | 2.15E+01 | Not detected |
| Week 1 Dec. | -7.47E-01 | 6.58E+00 | 2.21E+01 | Not detected |
| Week 2 Dec. | 1.62E+02 | 1.41E+02 | 4.67E+02 | Not detected |
| Week 3 Dec. | -6.23E+00 | 8.75E+00 | 2.96E+01 | Not detected |
| Week 4 Dec. | -2.42E+01 | 2.08E+01 | 7.08E+01 | Not detected |

*Filters collected prior to August were not weighed; no density data is available for this period.

Table D-7: Activity concentrations of $^{40}K$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| 2/14/2014 | 1.75E-03 | 5.47E-03 | 9.33E-03 | Not detected |
| 2/18/2014 | 2.28E-02 | 3.75E-02 | 6.32E-02 | Not detected |
| 2/19/2014 | 3.38E-03 | 2.38E-02 | 4.06E-02 | Not detected |
| 2/20/2014 | -2.60E-02 | 3.87E-02 | 6.72E-02 | Not detected |
| 2/21/2014 | 1.05E-02 | 1.30E-02 | 2.18E-02 | Not detected |
| 2/22/2014 | -1.04E-02 | 1.33E-02 | 2.31E-02 | Not detected |
| 2/23/2014 | -1.41E-02 | 2.56E-02 | 4.47E-02 | Not detected |
| 2/24/2014 | -8.53E-03 | 2.71E-02 | 4.70E-02 | Not detected |
| 2/25/2014 | -1.17E-02 | 1.29E-02 | 2.25E-02 | Not detected |
| 2/26/2014 | -1.87E-02 | 1.35E-02 | 2.35E-02 | Not detected |
| 2/27/2014 | 1.09E-02 | 2.25E-02 | 3.81E-02 | Not detected |
| 3/4/2014 | -1.77E-02 | 1.37E-02 | 2.41E-02 | Not detected |
| 3/5/2014 | -9.10E-03 | 1.34E-02 | 2.32E-02 | Not detected |
| 3/6/2014 | -2.60E-02 | 2.64E-02 | 4.65E-02 | Not detected |
| 3/7/2014 | -1.60E-02 | 1.33E-02 | 2.33E-02 | Not detected |
| 3/8/2014 | -8.94E-03 | 1.33E-02 | 2.30E-02 | Not detected |
| 3/9/2014 | -2.52E-02 | 2.76E-02 | 4.85E-02 | Not detected |
| 3/10/2014 | -1.57E-02 | 1.27E-02 | 2.23E-02 | Not detected |
| 3/11/2014 | -1.25E-02 | 1.37E-02 | 2.38E-02 | Not detected |
| 3/12/2014 | -2.51E-03 | 1.26E-02 | 2.17E-02 | Not detected |
| 3/13/2014 | 9.09E-04 | 2.43E-02 | 4.19E-02 | Not detected |
| 3/14/2014 | -1.51E-02 | 2.60E-02 | 4.54E-02 | Not detected |
| 3/15/2014 | -2.48E-02 | 1.34E-02 | 2.37E-02 | Not detected |
| 3/16/2014 | -5.02E-03 | 2.46E-02 | 4.26E-02 | Not detected |
| 3/20/2014 | 9.41E-03 | 2.38E-02 | 4.05E-02 | Not detected |
| 3/21/2014 | 3.55E-03 | 6.69E-03 | 2.23E-02 | Not detected |
| 3/22/2014 | 6.40E-03 | 1.02E-02 | 3.40E-02 | Not detected |
| 3/23/2014 | -1.55E-03 | 6.61E-03 | 2.22E-02 | Not detected |
| 3/24/2014 | -9.61E-04 | 6.66E-03 | 2.24E-02 | Not detected |
| 3/25/2014 | -2.05E-04 | 6.45E-03 | 2.17E-02 | Not detected |
| 3/26/2014 | 9.43E-03 | 6.61E-03 | 2.17E-02 | Not detected |
| 3/27/2014 | -2.60E-04 | 7.03E-03 | 2.36E-02 | Not detected |
| 3/28/2014 | 4.91E-03 | 6.56E-03 | 2.18E-02 | Not detected |
| 3/29/2014 | 4.59E-03 | 6.80E-03 | 2.26E-02 | Not detected |
| 3/30/2014 | 4.39E-03 | 6.27E-03 | 2.09E-02 | Not detected |
| 3/31/2014 | 2.17E-04 | 7.28E-03 | 2.44E-02 | Not detected |

Table D-8: Weekly Activity concentrations of $^{40}K$ (Bq/m$^3$), in Station B (Post-HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014 | $^{40}K$ Activity Bq/m$^3$ | Unc. (2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|
| Week 1 Apr. | -1.03E-04 | 1.01E-03 | 3.40E-03 | Not detected |
| Week 2 Apr. | -8.85E-04 | 1.01E-03 | 3.41E-03 | Not detected |
| Week 3 Apr. | -3.19E-04 | 9.39E-04 | 3.17E-03 | Not detected |
| Week 4 Apr. | 7.07E-04 | 1.37E-03 | 4.58E-03 | Not detected |
| Week 1 May | 2.51E-04 | 9.98E-04 | 3.33E-03 | Not detected |
| Week 2 May | -9.86E-05 | 1.74E-03 | 5.87E-03 | Not detected |
| Week 3 May | 9.44E-04 | 9.12E-04 | 3.02E-03 | Not detected |
| Week 4 May | 7.70E-04 | 1.23E-03 | 4.13E-03 | Not detected |
| Week 1 Jun. | -1.80E-04 | 9.95E-04 | 3.34E-03 | Not detected |
| Week 2 Jun. | 1.76E-03 | 1.00E-03 | 3.27E-03 | Not detected |
| Week 3 Jun. | 1.20E-03 | 1.84E-03 | 6.15E-03 | Not detected |
| Week 4 Jun. | -8.68E-04 | 1.45E-03 | 4.94E-03 | Not detected |
| Week 1 Jul. | No Data | | | |
| Week 2 Jul. | 5.47E-04 | 1.94E-03 | 6.49E-03 | Not detected |
| Week 3 Jul. | -1.64E-06 | 1.02E-03 | 3.43E-03 | Not detected |
| Week 4 Jul. | -1.46E-04 | 6.87E-04 | 2.31E-03 | Not detected |
| Week 1 Aug. | 7.46E-04 | 9.38E-04 | 3.12E-03 | Not detected |
| Week 2 Aug. | -6.96E-04 | 1.05E-03 | 3.55E-03 | Not detected |
| Week 3 Aug. | 3.06E-04 | 9.83E-04 | 3.28E-03 | Not detected |
| Week 4 Aug. | 1.46E-04 | 6.77E-04 | 2.26E-03 | Not detected |
| Week 1 Sep. | 1.51E-03 | 9.58E-04 | 3.14E-03 | Not detected |
| Week 2 Sep. | 1.17E-03 | 9.05E-04 | 2.99E-03 | Not detected |
| Week 3 Sep. | -4.79E-04 | 1.04E-03 | 3.49E-03 | Not detected |
| Week 4 Sep. | 3.38E-04 | 6.09E-04 | 2.02E-03 | Not detected |
| Week 1 Oct. | 1.10E-03 | 7.93E-04 | 2.61E-03 | Not detected |
| Week 2 Oct. | -8.90E-04 | 1.00E-03 | 3.39E-03 | Not detected |
| Week 3 Oct. | 3.81E-04 | 9.27E-04 | 3.09E-03 | Not detected |
| Week 4 Oct. | -6.39E-04 | 6.75E-04 | 2.29E-03 | Not detected |
| Week 1 Nov. | 1.38E-04 | 1.02E-03 | 3.40E-03 | Not detected |
| Week 2 Nov. | 1.77E-04 | 9.97E-04 | 3.33E-03 | Not detected |
| Week 3 Nov. | -6.44E-04 | 9.95E-04 | 3.36E-03 | Not detected |
| Week 4 Nov. | -4.37E-04 | 7.49E-04 | 2.53E-03 | Not detected |
| Week 1 Dec. | 8.72E-04 | 9.83E-04 | 3.26E-03 | Not detected |
| Week 2 Dec. | 6.68E-04 | 9.19E-04 | 3.05E-03 | Not detected |
| Week 3 Dec. | 9.75E-04 | 8.96E-04 | 2.97E-03 | Not detected |
| Week 4 Dec. | 1.45E-03 | 6.54E-04 | 2.12E-03 | Not detected |

Table D-9: Weekly Activity density of $^{40}K$ (Bq/g), in Station B (Post–HEPA) filter following the February 14 radiological event at WIPP

| Sample Date 2014* | $^{40}K$ Activity Bq/g | Unc. (2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|
| Week 1 Aug. | 1.24E+02 | 1.56E+02 | 5.18E+02 | Not detected |
| Week 2 Aug. | -9.97E+01 | 1.51E+02 | 5.08E+02 | Not detected |
| Week 3 Aug. | 1.65E+02 | 5.31E+02 | 1.77E+03 | Not detected |
| Week 4 Aug. | 4.76E+01 | 2.20E+02 | 7.37E+02 | Not detected |
| Week 1 Sep. | 1.79E+02 | 1.13E+02 | 3.72E+02 | Not detected |
| Week 2 Sep. | 1.68E+02 | 1.30E+02 | 4.30E+02 | Not detected |
| Week 3 Sep. | -6.55E+01 | 1.42E+02 | 4.77E+02 | Not detected |
| Week 4 Sep. | 4.67E+01 | 8.41E+01 | 2.79E+02 | Not detected |
| Week 1 Oct. | 5.05E+01 | 3.63E+01 | 1.19E+02 | Not detected |
| Week 2 Oct. | -5.92E+01 | 6.67E+01 | 2.25E+02 | Not detected |
| Week 3 Oct. | 2.41E+01 | 5.86E+01 | 1.96E+02 | Not detected |
| Week 4 Oct. | -3.40E+02 | 3.60E+02 | 1.22E+03 | Not detected |
| Week 1 Nov. | 1.31E+01 | 9.63E+01 | 3.22E+02 | Not detected |
| Week 2 Nov. | 5.67E+01 | 3.19E+02 | 1.07E+03 | Not detected |
| Week 3 Nov. | -1.25E+02 | 1.93E+02 | 6.51E+02 | Not detected |
| Week 4 Nov. | -4.29E+01 | 7.34E+01 | 2.48E+02 | Not detected |
| Week 1 Dec. | 6.97E+01 | 7.84E+01 | 2.60E+02 | Not detected |
| Week 1 Dec. | 8.47E+01 | 1.16E+02 | 3.87E+02 | Not detected |
| Week 1 Dec. | 1.08E+02 | 9.93E+01 | 3.29E+02 | Not detected |
| Week 1 Dec. | 5.21E+02 | 2.35E+02 | 7.63E+02 | Not detected |

*Filters collected prior to August, 2014 were not weighed; no density data is available for this period.

## Appendix E: Ambient Air

Table E-1: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ ($Bq/m^3$), in Onsite station following the February 14 radiological event at WIPP

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{137}Cs$ | Jan. 9-Jan. 29 | 9.69E-08 | 1.47E-06 | 2.48E-06 | Not detected |
| | Jan. 29 – Feb. 11 | 1.09E-06 | 4.31E-06 | 7.28E-06 | Not detected |
| | Feb. 11 – Feb. 18 | -1.38E-05 | 8.40E-06 | 1.47E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | -1.04E-05 | 1.05E-05 | 1.78E-05 | Not detected |
| | Mar. 4 – Mar. 11 | -4.01E-07 | 8.32E-06 | 1.42E-05 | Not detected |
| | Mar. 11 – Mar. 21 | 2.56E-06 | 1.66E-05 | 2.82E-05 | Not detected |
| | Mar. 21 - Mar. 29 | 4.29E-06 | 6.52E-06 | 1.10E-05 | Not detected |
| | Mar. 29 - Apr. 4 | 1.65E-05 | 2.34E-05 | 3.92E-05 | Not detected |
| | Apr. 4 - Apr. 11 | -3.56E-06 | 1.04E-05 | 1.77E-05 | Not detected |
| | Apr. 11 – Apr. 19 | -5.70E-06 | 1.75E-05 | 2.99E-05 | Not detected |
| | Apr. 19 – Apr. 25 | -1.02E-06 | 2.27E-05 | 3.87E-05 | Not detected |
| | Apr. 25 - May 2 | -3.22E-06 | 2.02E-05 | 3.45E-05 | Not detected |
| | May 2 - May 9 | 4.25E-06 | 6.48E-06 | 1.09E-05 | Not detected |
| | May 9 - May 16 | 2.56E-06 | 8.32E-06 | 1.41E-05 | Not detected |
| | May 16 - May 23 | 3.94E-06 | 8.13E-06 | 1.37E-05 | Not detected |
| | May 23 - Jun. 6 | 1.01E-06 | 9.94E-06 | 1.69E-05 | Not detected |
| | Jun. 6 – Jun. 13 | -8.95E-07 | 8.14E-06 | 1.39E-05 | Not detected |
| | Jun. 13 - Jun. 20 | -7.01E-07 | 1.04E-05 | 1.78E-05 | Not detected |
| | Jun. 20 – Jun. 27 | -9.51E-07 | 7.92E-06 | 1.35E-05 | Not detected |
| | Jun. 27 - Jul. 3 | -2.47E-07 | 1.49E-06 | 4.95E-06 | Not detected |
| | Jul. 3 - Jul. 14 | -8.82E-07 | 1.07E-06 | 3.57E-06 | Not detected |
| | Jul. 14 – Jul. 23 | 1.06E-08 | 1.33E-06 | 4.43E-06 | Not detected |
| | Jul. 23 – Aug. 5 | 1.40E-06 | 2.23E-06 | 7.36E-06 | Not detected |
| | Aug. 5 - Aug. 15 | 1.47E-06 | 1.17E-06 | 3.85E-06 | Not detected |
| | Aug. 15 - Aug. 27 | -7.79E-07 | 1.25E-06 | 4.15E-06 | Not detected |
| | Aug. 27 – Sep. 5 | 3.21E-06 | 2.65E-06 | 8.72E-06 | Not detected |
| | Sep. 5 – Sep. 26 | 2.84E-07 | 5.58E-07 | 1.85E-06 | Not detected |
| | Sep. 26 – Oct. 8 | 3.38E-07 | 1.24E-06 | 4.11E-06 | Not detected |
| | Oct. 8 - Oct. 17 | 1.74E-07 | 2.59E-06 | 8.59E-06 | Not detected |
| | Oct. 17 – Oct. 24 | 1.64E-06 | 4.27E-06 | 1.41E-05 | Not detected |
| | Oct. 24 – Nov. 14 | 1.48E-06 | 1.12E-06 | 3.70E-06 | Not detected |
| | Nov. 14 – Dec. 3 | -7.29E-07 | 1.52E-06 | 5.11E-06 | Not detected |

Table E-1: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ ($Bq/m^3$), in Onsite station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc. ($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| | Dec. 3 – Dec. 19 | 1.13E-06 | 7.25E-07 | 2.38E-06 | Not detected |
| | Dec. 19 – Jan. 6 | -7.99E-07 | 6.56E-07 | 2.19E-06 | Not detected |
| | | | | | |
| $^{60}Co$ | Jan. 9 – Jan. 29 | -1.50E-07 | 1.25E-06 | 2.13E-06 | Not detected |
| | Jan. 29 – Feb. 11 | -2.15E-06 | 4.37E-06 | 7.49E-06 | Not detected |
| | Feb. 11 – Feb. 18 | -1.04E-05 | 8.73E-06 | 1.53E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | -3.63E-06 | 8.55E-06 | 1.48E-05 | Not detected |
| | Mar. 4 – Mar. 11 | -1.74E-06 | 8.50E-06 | 1.46E-05 | Not detected |
| | Mar. 11 – Mar. 21 | -6.12E-07 | 1.52E-05 | 2.62E-05 | Not detected |
| | Mar. 21 - Mar. 29 | -5.76E-06 | 7.04E-06 | 1.23E-05 | Not detected |
| | Mar. 29 - Apr. 4 | -3.33E-06 | 2.28E-05 | 3.93E-05 | Not detected |
| | Apr. 4 - Apr. 11 | -1.55E-06 | 8.43E-06 | 1.45E-05 | Not detected |
| | Apr. 11 – Apr. 19 | -2.38E-05 | 1.77E-05 | 3.12E-05 | Not detected |
| | Apr. 19 – Apr. 25 | -2.09E-06 | 2.13E-05 | 3.66E-05 | Not detected |
| | Apr. 25 - May 2 | -2.05E-05 | 1.98E-05 | 3.48E-05 | Not detected |
| | May 2 - May 9 | -6.84E-08 | 6.50E-06 | 1.11E-05 | Not detected |
| | May 9 - May 16 | -1.11E-05 | 8.49E-06 | 1.50E-05 | Not detected |
| | May 16 - May 23 | -1.30E-07 | 8.70E-06 | 1.49E-05 | Not detected |
| | May 23 - Jun. 6 | -8.91E-06 | 9.48E-06 | 1.66E-05 | Not detected |
| | Jun. 6 – Jun. 13 | -4.46E-06 | 8.15E-06 | 1.41E-05 | Not detected |
| | Jun. 13 - Jun. 20 | 4.04E-06 | 8.13E-06 | 1.37E-05 | Not detected |
| | Jun. 20 – Jun. 27 | -4.96E-06 | 8.24E-06 | 1.43E-05 | Not detected |
| | Jun. 27 - Jul. 3 | -1.43E-06 | 1.55E-06 | 5.19E-06 | Not detected |
| | Jul. 3 - Jul. 14 | 9.23E-07 | 1.10E-06 | 3.63E-06 | Not detected |
| | Jul. 14 – Jul. 23 | -1.78E-06 | 1.40E-06 | 4.72E-06 | Not detected |
| | Jul. 23 – Aug. 5 | -7.06E-07 | 2.23E-06 | 7.46E-06 | Not detected |
| | Aug. 5 - Aug. 15 | -8.64E-07 | 1.24E-06 | 4.16E-06 | Not detected |
| | Aug. 15 - Aug. 27 | -1.82E-06 | 1.07E-06 | 3.60E-06 | Not detected |
| | Aug. 27 – Sep. 5 | 2.67E-05 | 2.00E-05 | 6.59E-05 | Not detected |
| | Sep. 5 – Sep. 26 | -3.45E-07 | 5.81E-07 | 1.94E-06 | Not detected |
| | Sep. 26 – Oct. 8 | 5.91E-08 | 1.03E-06 | 3.44E-06 | Not detected |
| | Oct. 8 - Oct. 17 | -3.56E-06 | 2.70E-06 | 9.09E-06 | Not detected |
| | Oct. 17 – Oct. 24 | -4.71E-06 | 3.57E-06 | 1.20E-05 | Not detected |
| | Oct. 24 – Nov. 14 | -3.19E-08 | 1.14E-06 | 3.81E-06 | Not detected |
| | Nov. 14 – Dec. 3 | -1.43E-07 | 1.56E-06 | 5.22E-06 | Not detected |
| | Dec. 3 – Dec. 19 | -3.13E-07 | 7.49E-07 | 2.50E-06 | Not detected |
| | Dec. 19 – Jan. 6 | -7.97E-07 | 6.78E-07 | 2.28E-06 | Not detected |

Table E-1: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ ($Bq/m^3$), in Onsite station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc. (2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{40}K$ | Jan. 9 – Jan. 29 | 4.27E-05 | 1.57E-05 | 2.46E-05 | Detected |
| | Jan. 29 – Feb. 11 | 6.49E-05 | 4.10E-05 | 6.75E-05 | Not detected |
| | Feb. 11 – Feb. 18 | -1.40E-04 | 1.03E-04 | 1.81E-04 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | 1.24E-04 | 1.01E-04 | 1.67E-04 | Not detected |
| | Mar. 4 – Mar. 11 | 5.36E-06 | 1.04E-04 | 1.77E-04 | Not detected |
| | Mar. 11 – Mar. 21 | 2.16E-04 | 1.70E-04 | 2.80E-04 | Not detected |
| | Mar. 21 - Mar. 29 | 4.99E-05 | 8.21E-05 | 1.38E-04 | Not detected |
| | Mar. 29 - Apr. 4 | 1.15E-04 | 2.16E-04 | 3.67E-04 | Not detected |
| | Apr. 4 - Apr. 11 | 1.44E-04 | 1.03E-04 | 1.69E-04 | Not detected |
| | Apr. 11 – Apr. 19 | -9.97E-05 | 1.81E-04 | 3.15E-04 | Not detected |
| | Apr. 19 – Apr. 25 | 1.33E-04 | 2.15E-04 | 3.63E-04 | Not detected |
| | Apr. 25 - May 2 | 1.32E-04 | 1.87E-04 | 3.15E-04 | Not detected |
| | May 2 - May 9 | 1.24E-04 | 7.96E-05 | 1.32E-04 | Not detected |
| | May 9 - May 16 | 1.37E-04 | 1.03E-04 | 1.71E-04 | Detected |
| | May 16 - May 23 | 7.70E-05 | 1.07E-04 | 1.80E-04 | Not detected |
| | May 23 - Jun. 6 | 6.13E-05 | 9.09E-05 | 1.53E-04 | Not detected |
| | Jun. 6 – Jun. 13 | 1.17E-04 | 9.75E-05 | 1.62E-04 | Not detected |
| | Jun. 13 - Jun. 20 | 6.37E-05 | 1.03E-04 | 1.74E-04 | Not detected |
| | Jun. 20 – Jun. 27 | 3.99E-05 | 9.86E-05 | 1.67E-04 | Not detected |
| | Jun. 27 - Jul. 3 | 5.32E-05 | 1.86E-05 | 6.05E-05 | Not detected |
| | Jul. 3 - Jul. 14 | 5.50E-05 | 1.29E-05 | 4.16E-05 | Detected |
| | Jul. 14 – Jul. 23 | 7.31E-05 | 1.61E-05 | 5.18E-05 | Detected |
| | Jul. 23 – Aug. 5 | 1.32E-04 | 2.31E-05 | 7.18E-05 | Detected |
| | Aug. 5 - Aug. 15 | 5.40E-05 | 1.47E-05 | 4.77E-05 | Detected |
| | Aug. 15 - Aug. 27 | 4.22E-05 | 1.29E-05 | 4.14E-05 | Detected |
| | Aug. 27 – Sep. 5 | 9.42E-05 | 1.75E-05 | 5.35E-05 | Detected |
| | Sep. 5 – Sep. 26 | 3.17E-05 | 6.78E-06 | 2.18E-05 | Detected |
| | Sep. 26 – Oct. 8 | 4.03E-05 | 1.31E-05 | 4.19E-05 | Not detected |
| | Oct. 8 - Oct. 17 | 7.06E-05 | 3.20E-05 | 1.05E-04 | Not detected |
| | Oct. 17 – Oct. 24 | 6.71E-05 | 4.32E-05 | 1.42E-04 | Not detected |
| | Oct. 24 – Nov. 14 | 3.66E-05 | 1.37E-05 | 4.47E-05 | Not detected |
| | Nov. 14 – Dec. 3 | -7.29E-07 | 1.52E-06 | 5.11E-06 | Not detected |
| | Dec. 3 – Dec. 19 | 2.50E-05 | 9.33E-06 | 3.05E-05 | Not detected |
| | Dec. 19 – Jan. 6 | 3.37E-05 | 7.99E-06 | 2.56E-05 | Detected |

Table E-2: Activity concentrations of $^{137}$Cs, $^{60}$Co and $^{40}$K (Bq/m$^3$), in Near Field station following the February 14 radiological event at WIPP

| Radionuclides | Sampling Date 2014 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Jan. 9 – Jan. 29 | 3.71E-07 | 2.93E-06 | 4.95E-06 | Not detected |
| | Jan. 29 – Feb. 11 | 7.14E-07 | 1.76E-06 | 2.97E-06 | Not detected |
| | Feb. 11 - Feb. 16 | -1.38E-05 | 1.15E-05 | 1.97E-05 | Not detected |
| | Feb. 16 - Feb. 18 | -4.41E-05 | 2.89E-05 | 5.03E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No data | | | |
| | Feb. 25 – Mar. 4 | 1.25E-05 | 2.07E-05 | 3.49E-05 | Not detected |
| | Mar. 4 - Mar. 11 | -4.69E-06 | 1.08E-05 | 1.84E-05 | Not detected |
| | Mar. 11 – Mar. 21 | 9.26E-06 | 8.24E-06 | 1.37E-05 | Not detected |
| | Mar. 21 - Mar. 29 | -5.88E-06 | 1.73E-05 | 2.96E-05 | Not detected |
| | Mar. 29 - Apr. 4 | -2.63E-05 | 1.23E-05 | 2.10E-05 | Not detected |
| | Apr. 4 - Apr. 11 | 1.25E-05 | 1.96E-05 | 3.30E-05 | Not detected |
| | Apr. 11 – Apr. 19 | -2.36E-06 | 7.42E-06 | 1.27E-05 | Not detected |
| | Apr. 19 – Apr. 25 | 9.26E-06 | 2.24E-05 | 3.79E-05 | Not detected |
| | Apr. 25 - May 2 | -1.46E-06 | 2.02E-05 | 3.44E-05 | Not detected |
| | May 2 - May 9 | -1.06E-06 | 8.69E-06 | 1.47E-05 | Not detected |
| | May 9 - May 16 | 3.03E-06 | 1.06E-05 | 1.80E-05 | Not detected |
| | May 16 - May 23 | -2.62E-06 | 1.06E-05 | 1.80E-05 | Not detected |
| | May 23 - Jun. 6 | 2.63E-06 | 9.70E-06 | 1.64E-05 | Not detected |
| | Jun. 6 – Jun. 13 | 8.57E-06 | 2.06E-05 | 3.48E-05 | Not detected |
| | Jun. 13 - Jun. 20 | -1.71E-06 | 1.79E-05 | 3.05E-05 | Not detected |
| | Jun. 20 – Jun. 27 | -1.94E-06 | 1.04E-05 | 1.77E-05 | Not detected |
| | Jun. 27 - Jul. 3 | 2.22E-07 | 2.48E-06 | 8.22E-06 | Not detected |
| | Jul. 3 - Jul. 14 | 2.40E-07 | 1.42E-06 | 4.70E-06 | Not detected |
| | Jul. 14 – Jul. 23 | 1.69E-07 | 1.73E-06 | 5.72E-06 | Not detected |
| | Jul. 23 – Aug. 5 | 7.32E-07 | 9.68E-07 | 3.20E-06 | Not detected |
| | Aug. 5 - Aug. 15 | -6.82E-08 | 1.59E-06 | 5.27E-06 | Not detected |
| | Aug. 15 - Aug. 27 | 2.15E-07 | 1.01E-06 | 3.33E-06 | Not detected |
| | Aug. 27 – Sep. 5 | 1.60E-06 | 1.77E-06 | 5.84E-06 | Not detected |
| | Sep. 5 – Sep. 26 | 5.74E-07 | 0.00E+00 | 2.38E-06 | Not detected |
| | Sep. 26 – Oct. 8 | -2.02E-08 | 1.03E-06 | 3.42E-06 | Not detected |
| | Oct. 8 - Oct. 17 | -2.63E-06 | 3.40E-06 | 1.13E-05 | Not detected |
| | Oct. 17 – Oct. 24 | -6.64E-07 | 3.36E-06 | 1.12E-05 | Not detected |
| | Oct. 24 – Nov. 14 | -7.91E-08 | 1.44E-06 | 4.79E-06 | Not detected |
| | Nov. 14 – Dec. 3 | 3.09E-07 | 1.97E-06 | 6.54E-06 | Not detected |
| | Dec. 3 – Dec. 19 | 8.21E-08 | 9.39E-07 | 3.11E-06 | Not detected |
| | Dec. 19 – Jan. 6 | 6.51E-07 | 6.43E-07 | 2.12E-06 | Not detected |

Table E-2: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ ($Bq/m^3$), in Near Field station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc.($2\sigma$) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{60}Co$ | Jan. 9 – Jan. 29 | 2.14E-07 | 2.80E-06 | 4.77E-06 | Not detected |
| | Jan. 29 – Feb. 11 | -1.29E-07 | 1.87E-06 | 3.18E-06 | Not detected |
| | Feb. 11 - Feb. 16 | -7.99E-06 | 1.09E-05 | 1.87E-05 | Not detected |
| | Feb. 16 - Feb. 18 | -8.77E-06 | 2.74E-05 | 4.73E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | 1.16E-06 | 1.78E-05 | 3.06E-05 | Not detected |
| | Mar. 4 - Mar. 11 | -2.53E-06 | 8.61E-06 | 1.48E-05 | Not detected |
| | Mar. 11 – Mar. 21 | -1.22E-06 | 6.76E-06 | 1.16E-05 | Not detected |
| | Mar. 21 - Mar. 29 | -8.28E-06 | 1.62E-05 | 2.81E-05 | Not detected |
| | Mar. 29 - Apr. 4 | 2.61E-06 | 9.70E-06 | 1.65E-05 | Not detected |
| | Apr. 4 - Apr. 11 | -9.97E-06 | 2.01E-05 | 3.48E-05 | Not detected |
| | Apr. 11 – Apr. 19 | -2.66E-06 | 7.35E-06 | 1.27E-05 | Not detected |
| | Apr. 19 – Apr. 25 | -7.85E-06 | 2.21E-05 | 3.82E-05 | Not detected |
| | Apr. 25 - May 2 | -7.48E-06 | 1.91E-05 | 3.31E-05 | Not detected |
| | May 2 - May 9 | -2.76E-06 | 7.22E-06 | 1.23E-05 | Not detected |
| | May 9 - May 16 | 7.24E-06 | 8.12E-06 | 1.36E-05 | Not detected |
| | May 16 - May 23 | 1.94E-06 | 8.62E-06 | 1.47E-05 | Not detected |
| | May 23 - Jun. 6 | 9.03E-07 | 7.84E-06 | 1.34E-05 | Not detected |
| | Jun. 6 – Jun. 13 | 6.54E-06 | 1.84E-05 | 3.13E-05 | Not detected |
| | Jun. 13 - Jun. 20 | -1.31E-05 | 1.96E-05 | 3.42E-05 | Not detected |
| | Jun. 20 – Jun. 27 | -1.94E-06 | 1.04E-05 | 1.77E-05 | Not detected |
| | Jun. 27 - Jul. 3 | -2.28E-07 | 2.06E-06 | 6.86E-06 | Not detected |
| | Jul. 3 - Jul. 14 | 3.32E-07 | 1.19E-06 | 3.94E-06 | Not detected |
| | Jul. 14 – Jul. 23 | -1.16E-08 | 1.45E-06 | 4.84E-06 | Not detected |
| | Jul. 23 – Aug. 5 | 3.90E-07 | 1.00E-06 | 3.33E-06 | Not detected |
| | Aug .5 - Aug. 15 | 7.24E-08 | 1.31E-06 | 4.37E-06 | Not detected |
| | Aug .15 - Aug. 27 | -8.45E-08 | 1.05E-06 | 3.52E-06 | Not detected |
| | Aug. 27 – Sep. 5 | -5.04E-07 | 1.50E-06 | 5.02E-06 | Not detected |
| | Sep. 5 – Sep. 26 | 1.23E-07 | 6.08E-07 | 2.02E-06 | Not detected |
| | Sep. 26 – Oct. 8 | -2.47E-06 | 1.07E-06 | 3.63E-06 | Not detected |
| | Oct. 8 - Oct. 17 | -2.35E-06 | 2.80E-06 | 9.37E-06 | Not detected |
| | Oct. 17 – Oct. 24 | 2.06E-06 | 3.37E-06 | 1.12E-05 | Not detected |
| | Oct. 24 – Nov. 14 | 9.25E-07 | 1.15E-06 | 3.80E-06 | Not detected |
| | Nov. 14 – Dec. 3 | -2.72E-06 | 1.74E-06 | 5.90E-06 | Not detected |
| | Dec. 3 – Dec. 19 | -2.04E-07 | 7.79E-07 | 2.60E-06 | Not detected |
| | Dec. 19 – Jan. 6 | 2.12E-08 | 6.68E-07 | 2.22E-06 | Not detected |

Table E-2: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/m$^3$), in Near Field station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{40}K$ | Jan. 9 – Jan. 29 | 3.28E-05 | 2.84E-05 | 4.73E-05 | Not detected |
| | Jan. 29 – Feb. 11 | 4.57E-05 | 2.13E-05 | 3.49E-02 | Not detected |
| | Feb. 11 - Feb. 16 | -4.63E-05 | 1.33E-04 | 2.27E-04 | Not detected |
| | Feb. 16 - Feb. 18 | -6.28E-04 | 3.68E-04 | 6.48E-04 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | 4.94E-05 | 1.89E-04 | 3.22E-04 | Not detected |
| | Mar. 4 - Mar. 11 | 1.00E-05 | 1.05E-04 | 1.79E-04 | Not detected |
| | Mar. 11 – Mar. 21 | 1.92E-04 | 8.97E-05 | 1.42E-04 | Detected |
| | Mar. 21 - Mar. 29 | 1.06E-04 | 1.61E-04 | 2.72E-04 | Not detected |
| | Mar. 29 - Apr. 4 | 2.25E-04 | 1.22E-04 | 1.96E-04 | Detected |
| | Apr. 4 - Apr. 11 | 8.34E-05 | 1.97E-04 | 3.35E-04 | Not detected |
| | Apr. 11 – Apr. 19 | 4.97E-05 | 9.14E-05 | 1.54E-04 | Not detected |
| | Apr. 19 – Apr. 25 | 8.47E-05 | 2.04E-04 | 3.46E-04 | Not detected |
| | Apr. 25 - May 2 | 7.38E-05 | 2.01E-04 | 3.42E-04 | Not detected |
| | May 2 - May 9 | 1.01E-04 | 8.81E-05 | 1.46E-04 | Not detected |
| | May 9 - May 16 | 1.33E-04 | 1.09E-04 | 1.79E-04 | Not detected |
| | May 16 - May 23 | 8.63E-05 | 1.06E-04 | 1.77E-04 | Not detected |
| | May 23 - Jun. 6 | 8.64E-05 | 9.76E-05 | 1.63E-04 | Not detected |
| | Jun. 6 – Jun. 13 | 1.12E-04 | 1.93E-04 | 3.27E-04 | Not detected |
| | Jun. 13 - Jun. 20 | -2.94E-05 | 1.94E-04 | 3.35E-04 | Not detected |
| | Jun. 20 – Jun.27 | 5.07E-05 | 1.02E-04 | 1.73E-04 | Not detected |
| | Jun. 27 - Jul. 3 | 1.27E-04 | 2.65E-05 | 8.22E-05 | Detected |
| | Jul. 3 - Jul. 14 | 6.37E-05 | 1.47E-05 | 4.59E-05 | Detected |
| | Jul. 14 – Jul. 23 | 3.30E-05 | 1.75E-05 | 5.72E-05 | Not detected |
| | Jul. 23 – Aug. 5 | 4.51E-05 | 1.19E-05 | 3.84E-05 | Detected |
| | Aug .5 - Aug. 15 | 7.36E-05 | 1.60E-05 | 4.97E-05 | Detected |
| | Aug .15 - Aug. 27 | 6.07E-05 | 1.24E-05 | 3.98E-05 | Detected |
| | Aug. 27 – Sep. 5 | 9.11E-05 | 1.86E-05 | 5.77E-05 | Detected |
| | Sep. 5 – Sep. 26 | 3.34E-05 | 7.37E-06 | 2.30E-05 | Detected |
| | Sep. 26 – Oct. 8 | 6.70E-05 | 1.27E-05 | 4.05E-05 | Detected |
| | Oct. 8 - Oct. 17 | 6.19E-05 | 3.38E-05 | 1.11E-04 | Not detected |
| | Oct. 17 – Oct. 24 | 2.99E-05 | 4.13E-05 | 1.37E-04 | Not detected |
| | Oct. 24 – Nov. 14 | 3.40E-05 | 1.47E-05 | 4.78E-05 | Not detected |
| | Nov. 14 – Dec. 3 | 2.43E-06 | 2.02E-05 | 6.76E-05 | Not detected |
| | Dec. 3 – Dec. 19 | 5.15E-05 | 9.69E-06 | 2.97E-05 | Detected |
| | Dec. 19 – Jan. 6 | 3.36E-05 | 8.10E-06 | 2.61E-05 | Detected |

Table E-3: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/m3), in Cactus Flats station following the February 14 radiological event at WIPP

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc.(2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{137}Cs$ | Jan. 9 – Jan. 29 | 2.56E-06 | 2.94E-06 | 4.93E-06 | Not detected |
| | Jan. 29 - Feb. 11 | 1.05E-06 | 2.21E-06 | 3.72E-06 | Not detected |
| | Feb. 11 - Feb. 16 | -2.29E-05 | 2.15E-05 | 3.67E-05 | Not detected |
| | Feb. 16 - Feb. 18 | 9.30E-06 | 5.65E-05 | 9.54E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | 3.87E-06 | 8.02E-06 | 1.35E-05 | Not detected |
| | Mar. 4 - Mar. 11 | 3.61E-06 | 1.98E-05 | 3.35E-05 | Not detected |
| | Mar. 11 – Mar. 21 | 3.05E-06 | 1.82E-05 | 3.09E-05 | Not detected |
| | Mar. 21 - Mar. 29 | -2.74E-06 | 8.61E-06 | 1.47E-05 | Not detected |
| | Mar. 29 - Apr. 4 | -1.42E-05 | 2.52E-05 | 4.33E-05 | Not detected |
| | Apr. 4 - Apr. 11 | 1.37E-06 | 1.01E-05 | 1.71E-05 | Not detected |
| | Apr. 11 – Apr. 19 | 2.28E-06 | 5.62E-06 | 9.55E-06 | Not detected |
| | Apr. 19 – Apr. 25 | -9.45E-06 | 2.29E-05 | 3.92E-05 | Not detected |
| | Apr. 25 - May 2 | 1.92E-06 | 2.03E-05 | 3.45E-05 | Not detected |
| | May 2 - May 9 | 8.60E-06 | 1.56E-05 | 2.62E-05 | Not detected |
| | May 9 - May 16 | 1.26E-05 | 1.88E-05 | 3.16E-05 | Not detected |
| | May 16 - May 23 | -8.72E-06 | 2.04E-05 | 3.49E-06 | Not detected |
| | May 23 - Jun. 6 | -2.13E-06 | 1.20E-05 | 2.05E-05 | Not detected |
| | Jun. 6 – Jun. 13 | 8.32E-08 | 1.03E-05 | 1.74E-05 | Not detected |
| | Jun. 13 - Jun. 20 | -3.37E-06 | 1.03E-05 | 1.76E-05 | Not detected |
| | Jun. 20 – Jun. 27 | 5.02E-07 | 2.01E-05 | 3.41E-05 | Not detected |
| | Jun. 27 - Jul. 3 | 3.38E-06 | 4.75E-06 | 1.57E-05 | Not detected |
| | Jul. 3 - Jul. 14 | 1.03E-06 | 2.58E-06 | 8.53E-06 | Not detected |
| | Jul. 14 – Jul. 23 | 1.48E-07 | 1.32E-06 | 4.38E-06 | Not detected |
| | Jul. 23 – Aug. 5 | 5.93E-07 | 1.16E-06 | 3.83E-06 | Not detected |
| | Aug .5 - Aug. 15 | 5.26E-07 | 1.16E-06 | 3.84E-06 | Not detected |
| | Aug .15 - Aug. 27 | 5.30E-07 | 9.53E-07 | 3.15E-06 | Not detected |
| | Aug. 27 – Sep. 5 | 1.81E-06 | 1.31E-06 | 4.36E-06 | Not detected |
| | Sep. 5 – Sep. 26 | 7.35E-08 | 5.71E-07 | 1.89E-06 | Not detected |
| | Sep. 26 – Oct. 8 | -7.20E-07 | 1.26E-06 | 4.19E-06 | Not detected |
| | Oct. 8 - Oct. 17 | 8.95E-07 | 2.59E-06 | 8.59E-06 | Not detected |
| | Oct. 17 – Oct. 24 | -1.12E-06 | 3.35E-06 | 1.11E-05 | Not detected |
| | Oct. 24 – Nov. 14 | 2.19E-06 | 1.33E-06 | 4.36E-06 | Not detected |
| | Nov. 14 – Dec. 3 | 2.42E-06 | 1.47E-06 | 4.82E-06 | Not detected |
| | Dec. 3 – Dec. 19 | 2.10E-07 | 9.37E-07 | 3.10E-06 | Not detected |
| | Dec. 19 – Jan. 6 | -2.59E-07 | 6.57E-07 | 2.18E-06 | Not detected |

Table E-3: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/m3), in Cactus Flats station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity Bq/m$^3$ | Unc.(2σ) Bq/m$^3$ | MDC Bq/m$^3$ | Status |
|---|---|---|---|---|---|
| $^{60}Co$ | Jan. 9 – Jan. 29 | -1.23E-06 | 2.94E-06 | 5.04E-06 | Not detected |
| | Jan. 29 - Feb. 11 | 1.42E-06 | 1.86E-06 | 3.12E-06 | Not detected |
| | Feb. 11 - Feb. 16 | 4.12E-06 | 1.76E-05 | 2.97E-05 | Not detected |
| | Feb. 16 - Feb. 18 | -1.77E-06 | 3.75E-05 | 6.42E-05 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | -7.01E-07 | 8.05E-06 | 1.38E-05 | Not detected |
| | Mar. 4 - Mar. 11 | -3.70E-06 | 1.88E-05 | 3.24E-05 | Not detected |
| | Mar. 11 – Mar. 21 | -6.50E-06 | 1.68E-05 | 2.91E-05 | Not detected |
| | Mar. 21 - Mar. 29 | 1.02E-06 | 6.83E-06 | 1.17E-05 | Not detected |
| | Mar. 29 - Apr. 4 | -1.01E-05 | 2.27E-05 | 3.94E-05 | Not detected |
| | Apr. 4 - Apr. 11 | -9.02E-06 | 8.88E-06 | 1.55E-05 | Not detected |
| | Apr. 11 – Apr. 19 | -1.55E-06 | 7.64E-06 | 1.31E-05 | Not detected |
| | Apr. 19 – Apr. 25 | -1.39E-05 | 2.17E-05 | 3.79E-05 | Not detected |
| | Apr. 25 - May 2 | -1.04E-05 | 1.86E-05 | 3.24E-05 | Not detected |
| | May 2 - May 9 | -6.65E-06 | 1.50E-05 | 2.58E-05 | Not detected |
| | May 9 - May 16 | -9.05E-07 | 1.85E-05 | 3.18E-05 | Not detected |
| | May 16 - May 23 | -1.27E-05 | 1.97E-05 | 3.43E-05 | Not detected |
| | May 23 - Jun. 6 | -4.28E-06 | 1.15E-05 | 1.99E-05 | Not detected |
| | Jun. 6 – Jun. 13 | -2.95E-06 | 8.35E-06 | 1.44E-05 | Not detected |
| | Jun. 13 - Jun. 20 | -3.37E-06 | 1.03E-05 | 1.76E-05 | Not detected |
| | Jun. 20 – Jun.27 | 5.02E-07 | 2.01E-05 | 3.41E-05 | Not detected |
| | Jun. 27 - Jul. 3 | -8.16E-07 | 4.50E-06 | 1.50E-05 | Not detected |
| | Jul. 3 - Jul. 14 | -3.84E-06 | 2.52E-06 | 8.50E-06 | Not detected |
| | Jul. 14 – Jul. 23 | -9.40E-09 | 1.48E-06 | 4.93E-06 | Not detected |
| | Jul. 23 – Aug. 5 | 2.51E-07 | 9.63E-07 | 3.20E-06 | Not detected |
| | Aug .5 - Aug. 15 | -2.53E-07 | 1.22E-06 | 4.07E-06 | Not detected |
| | Aug .15 - Aug. 27 | -7.94E-07 | 1.01E-06 | 3.38E-06 | Not detected |
| | Aug. 27 – Sep. 5 | -2.37E-07 | 1.38E-06 | 4.61E-06 | Not detected |
| | Sep. 5 – Sep. 26 | 2.80E-08 | 5.84E-07 | 1.95E-06 | Not detected |
| | Sep. 26 – Oct. 8 | -1.40E-07 | 1.04E-06 | 3.46E-06 | Not detected |
| | Oct. 8 - Oct. 17 | 1.99E-06 | 2.58E-06 | 8.55E-06 | Not detected |
| | Oct. 17 – Oct. 24 | -1.66E-06 | 3.53E-06 | 1.18E-05 | Not detected |
| | Oct. 24 – Nov. 14 | 3.34E-07 | 1.15E-06 | 3.82E-06 | Not detected |
| | Nov. 14 – Dec. 3 | -9.46E-07 | 1.58E-06 | 5.34E-06 | Not detected |
| | Dec. 3 – Dec. 19 | -5.10E-07 | 7.68E-07 | 5.14E-06 | Not detected |
| | Dec. 19 – Jan. 6 | -1.19E-06 | 6.58E-07 | 4.56E-06 | Not detected |

Table E-3: Activity concentrations of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/m3), in Cactus Flats station following the February 14 radiological event at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity $Bq/m^3$ | Unc.(2σ) $Bq/m^3$ | MDC $Bq/m^3$ | Status |
|---|---|---|---|---|---|
| $^{40}K$ | Jan. 9 – Jan. 29 | 2.60E-05 | 2.99E-05 | 5.00E-05 | Not detected |
| | Jan. 29 - Feb. 11 | 3.31E-05 | 2.31E-05 | 3.81E-05 | Not detected |
| | Feb. 11 - Feb. 16 | 1.67E-04 | 2.16E-04 | 3.62E-04 | Not detected |
| | Feb. 16 - Feb. 18 | -3.94E-04 | 5.48E-04 | 9.45E-04 | Not detected |
| | Feb. 18 - Feb. 25 | No Data | | | |
| | Feb. 25 – Mar. 4 | 5.05E-05 | 9.81E-05 | 1.66E-04 | Not detected |
| | Mar. 4 - Mar. 11 | -1.52E-05 | 1.91E-04 | 3.30E-04 | Not detected |
| | Mar. 11 – Mar. 21 | 2.30E-04 | 1.67E-04 | 2.75E-04 | Not detected |
| | Mar. 21 - Mar. 29 | 9.44E-05 | 8.50E-05 | 1.41E-04 | Not detected |
| | Mar. 29 - Apr. 4 | 2.11E-04 | 2.18E-04 | 3.63E-04 | Not detected |
| | Apr. 4 - Apr. 11 | 1.34E-04 | 9.74E-05 | 1.60E-04 | Not detected |
| | Apr. 11 – Apr. 19 | 8.50E-05 | 8.83E-05 | 1.47E-04 | Not detected |
| | Apr. 19 – Apr. 25 | 1.78E-04 | 2.00E-04 | 3.34E-04 | Not detected |
| | Apr. 25 - May 2 | 1.75E-04 | 1.83E-04 | 3.06E-04 | Not detected |
| | May 2 - May 9 | 1.61E-05 | 1.56E-04 | 8.95E-05 | Not detected |
| | May 9 - May 16 | 4.01E-05 | 1.94E-04 | 3.32E-04 | Not detected |
| | May 16 - May 23 | 1.28E-05 | 1.92E-04 | 3.30E-04 | Not detected |
| | May 23 - Jun. 6 | 2.12E-05 | 1.10E-04 | 1.88E-04 | Not detected |
| | Jun. 6 – Jun. 13 | 4.54E-05 | 1.02E-04 | 1.73E-04 | Not detected |
| | Jun. 13 - Jun. 20 | 2.21E-05 | 1.04E-04 | 1.77E-04 | Not detected |
| | Jun. 20 – Jun.27 | 7.13E-05 | 1.88E-04 | 3.19E-04 | Not detected |
| | Jun. 27 - Jul. 3 | 1.27E-04 | 4.47E-05 | 1.45E-04 | Not detected |
| | Jul. 3 - Jul. 14 | 6.65E-05 | 2.48E-05 | 8.04E-05 | Not detected |
| | Jul. 14 – Jul. 23 | 4.52E-05 | 1.66E-05 | 5.42E-05 | Not detected |
| | Jul. 23 – Aug. 5 | 4.02E-05 | 1.21E-05 | 3.86E-05 | Detected |
| | Aug. 5 - Aug. 15 | 4.71E-05 | 1.42E-05 | 4.61E-05 | Detected |
| | Aug. 15 - Aug. 27 | 2.63E-05 | 1.20E-05 | 3.92E-05 | Not detected |
| | Aug. 27 – Sep. 5 | 5.26E-05 | 1.63E-05 | 5.28E-05 | Not detected |
| | Sep. 5 – Sep. 26 | 1.71E-05 | 7.11E-06 | 2.32E-05 | Not detected |
| | Sep. 26 – Oct. 8 | 4.18E-05 | 1.30E-05 | 4.16E-05 | Not detected |
| | Oct. 8 - Oct. 17 | 7.68E-05 | 3.04E-05 | 9.93E-05 | Not detected |
| | Oct. 17 – Oct. 24 | 6.87E-05 | 4.32E-05 | 1.42E-04 | Not detected |
| | Oct. 24 – Nov. 14 | 3.59E-05 | 1.34E-05 | 4.38E-05 | Not detected |
| | Nov. 14 – Dec. 3 | 2.58E-05 | 1.86E-05 | 6.13E-05 | Not detected |
| | Dec. 3 – Dec. 19 | 2.65E-05 | 9.79E-06 | 3.16E-05 | Not detected |
| | Dec. 19 – Jan. 6 | 4.67E-05 | 7.96E-07 | 2.53E-05 | Detected |

Table E-4: Activity Density of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/g), in On Site station at WIPP

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{137}Cs$ | Jan. 9 – Jan. 29 | 1.98E-03 | 3.00E-02 | 5.07E-02 | Not detected |
| | Jan. 29 - Feb. 11 | 4.15E-02 | 1.65E-01 | 2.78E-01 | Not detected |
| | *Feb. 11 – Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | -2.20E-02 | 2.67E-02 | 8.91E-02 | Not detected |
| | Jul. 14 – Jul. 23 | 2.56E-04 | 3.23E-02 | 1.07E-01 | Not detected |
| | Jul. 23 – Aug. 5 | 3.55E-02 | 5.65E-02 | 1.87E-01 | Not detected |
| | Aug. 5 - Aug. 15 | 4.55E-02 | 3.61E-02 | 1.19E-01 | Not detected |
| | Aug. 15 - Aug. 27 | -2.35E-02 | 3.76E-02 | 1.25E-01 | Not detected |
| | Aug. 27 – Sep. 5 | 8.00E-02 | 6.58E-02 | 2.17E-01 | Not detected |
| | Sep. 5 – Sep. 26 | 1.98E-02 | 3.89E-02 | 1.29E-01 | Not detected |
| | Sep. 26 – Oct. 8 | 1.00E-02 | 3.69E-02 | 1.22E-01 | Not detected |
| | Oct. 8 - Oct. 17 | 4.72E-03 | 7.00E-02 | 2.32E-01 | Not detected |
| | Oct. 17 – Oct. 24 | 5.58E-02 | 1.45E-01 | 4.81E-01 | Not detected |
| | Oct. 24 – Nov. 14 | 4.96E-02 | 3.77E-02 | 1.24E-01 | Not detected |
| | Nov. 14 – Dec. 3 | -2.07E-02 | 4.32E-02 | 1.45E-01 | Not detected |
| | Dec. 3 – Dec. 19 | 4.65E-02 | 2.97E-02 | 9.77E-02 | Not detected |
| | Dec. 19 – Jan. 6 | -5.37E-02 | 4.41E-02 | 1.47E-01 | Not detected |
| | | | | | |
| $^{60}Co$ | Jan. 9 – Jan. 29 | -3.07E-03 | 2.56E-02 | 4.35E-02 | Not detected |
| | Jan. 29-Feb. 11 | -8.23E-02 | 1.67E-01 | 2.86E-01 | Not detected |
| | *Feb. 11 - Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 2.30E-02 | 2.73E-02 | 9.05E-02 | Not detected |
| | Jul. 14 – Jul. 23 | -4.32E-02 | 3.40E-02 | 1.14E-01 | Not detected |
| | Jul. 23 – Aug. 5 | -1.79E-02 | 5.67E-02 | 1.89E-01 | Not detected |
| | Aug. 5 - Aug. 15 | -2.67E-02 | 3.84E-02 | 1.29E-01 | Not detected |
| | Aug. 15 - Aug. 27 | -5.48E-02 | 3.23E-02 | 1.08E-01 | Not detected |
| | Aug. 27 – Sep. 5 | 6.64E-01 | 4.98E-01 | 1.64E+00 | Not detected |
| | Sep. 5 – Sep. 26 | -2.41E-02 | 4.05E-02 | 1.35E-01 | Not detected |
| | Sep. 26 – Oct. 8 | 1.76E-03 | 3.08E-02 | 1.02E-01 | Not detected |
| | Oct. 8 - Oct. 17 | -9.64E-02 | 7.32E-02 | 2.46E-01 | Not detected |
| | Oct. 17 – Oct. 24 | -1.60E-01 | 1.21E-01 | 4.07E-01 | Not detected |
| | Oct. 24 – Nov. 14 | -1.07E-03 | 3.83E-02 | 1.28E-01 | Not detected |
| | Nov. 14 – Dec. 3 | -4.05E-03 | 4.41E-02 | 1.48E-01 | Not detected |
| | Dec. 3 – Dec. 19 | -1.28E-02 | 3.07E-02 | 1.03E-01 | Not detected |
| | Dec. 19 – Jan. 6 | -5.36E-02 | 4.56E-02 | 1.53E-01 | Not detected |
| | | | | | |
| $^{40}K$ | Jan. 9 – Jan. 29 | 8.71E-01 | 3.21E-01 | 5.02E-01 | Detected |
| | Jan. 29 - Feb. 11 | 2.48E+00 | 1.57E+00 | 2.58E+00 | Not detected |

Table E-4: Activity Density of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/g), in On Site station at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| | *Feb. 11 – Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 1.37E+00 | 3.23E-01 | 1.04E+00 | Detected |
| | Jul. 14 – Jul. 23 | 1.77E+00 | 3.90E-01 | 1.25E+00 | Detected |
| | Jul. 23 – Aug. 5 | 3.34E+00 | 5.87E-01 | 1.82E+00 | Detected |
| | Aug. 5 - Aug. 15 | 1.67E+00 | 4.55E-01 | 1.47E+00 | Detected |
| | Aug. 15 - Aug. 27 | 1.27E+00 | 3.89E-01 | 1.25E+00 | Detected |
| | Aug. 27 – Sep. 5 | 2.34E+00 | 4.36E-01 | 1.33E+00 | Detected |
| | Sep. 5 – Sep. 26 | 2.21E+00 | 4.72E-01 | 1.52E+00 | Detected |
| | Sep. 26 – Oct. 8 | 1.20E+00 | 3.89E-01 | 1.25E+00 | Not detected |
| | Oct. 8 - Oct. 17 | 1.91E+00 | 8.66E-01 | 2.84E+00 | Not detected |
| | Oct. 17 – Oct. 24 | 2.28E+00 | 1.47E+00 | 4.82E+00 | Not detected |
| | Oct. 24 – Nov. 14 | 1.23E+00 | 4.59E-01 | 1.50E+00 | Not detected |
| | Nov. 14 – Dec. 3 | -2.07E-02 | 4.32E-02 | 1.45E-01 | Not detected |
| | Dec. 3 – Dec. 19 | 1.02E+00 | 3.83E-01 | 1.25E+00 | Not detected |
| | Dec. 19 – Jan. 6 | 2.27E+00 | 5.37E-01 | 1.72E+00 | Detected |

*Filters collected during these dates were not weighed; no density data is available for this period.

Table E-5: Activity Density of $^{137}$Cs, $^{60}$Co and $^{40}$K (Bq/g), in Near Field station at WIPP

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{137}$Cs | Jan. 9 – Jan. 29 | 8.46E-03 | 6.69E-02 | 1.13E-01 | Not detected |
| | Jan. 29 - Feb. 11 | 2.36E-02 | 5.81E-02 | 9.80E-02 | Not detected |
| | *Feb. 11 - Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 5.11E-03 | 3.03E-02 | 1.00E-01 | Not detected |
| | Jul. 14 – Jul. 23 | 3.93E-03 | 4.02E-02 | 1.33E-01 | Not detected |
| | Jul. 23 – Aug. 5 | 1.70E-02 | 2.24E-02 | 7.42E-02 | Not detected |
| | Aug. 5 - Aug. 15 | -1.83E-03 | 4.26E-02 | 1.41E-01 | Not detected |
| | Aug. 15 - Aug. 27 | 6.09E-03 | 2.85E-02 | 9.46E-02 | Not detected |
| | Aug. 27 – Sep. 5 | 3.90E-02 | 4.32E-02 | 1.43E-01 | Not detected |
| | Sep. 5 – Sep. 26 | 3.35E-02 | 0.00E+00 | 1.39E-01 | Not detected |
| | Sep. 26 – Oct. 8 | -5.10E-04 | 2.60E-02 | 8.62E-02 | Not detected |
| | Oct. 8 - Oct. 17 | -6.37E-02 | 8.25E-02 | 2.74E-01 | Not detected |
| | Oct. 17 – Oct. 24 | -2.04E-02 | 1.03E-01 | 3.43E-01 | Not detected |
| | Oct. 24 – Nov. 14 | -2.36E-03 | 4.31E-02 | 1.43E-01 | Not detected |
| | Nov. 14 – Dec. 3 | 9.15E-03 | 5.82E-02 | 1.94E-01 | Not detected |
| | Dec. 3 – Dec. 19 | 3.01E-03 | 3.44E-02 | 1.14E-01 | Not detected |
| | Dec. 19 – Jan. 6 | 3.76E-02 | 3.72E-02 | 1.23E-01 | Not detected |
| | | | | | |
| $^{60}$Co | Jan. 9 – Jan. 29 | 4.89E-03 | 6.40E-02 | 1.09E-01 | Not detected |
| | Jan. 29 - Feb. 11 | -4.27E-03 | 6.18E-02 | 1.05E-01 | Not detected |
| | *Feb. 11 - Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 7.08E-03 | 2.53E-02 | 8.41E-02 | Not detected |
| | Jul. 14 – Jul. 23 | -2.69E-04 | 3.39E-02 | 1.13E-01 | Not detected |
| | Jul. 23 – Aug. 5 | 9.04E-03 | 2.32E-02 | 7.72E-02 | Not detected |
| | Aug. 5 - Aug. 15 | 1.94E-03 | 3.51E-02 | 1.17E-01 | Not detected |
| | Aug. 15 - Aug. 27 | -2.40E-03 | 2.99E-02 | 9.97E-02 | Not detected |
| | Aug. 27 – Sep. 5 | -1.23E-02 | 3.67E-02 | 1.22E-01 | Not detected |
| | Sep. 5 – Sep. 26 | 7.15E-03 | 3.55E-02 | 1.18E-01 | Not detected |
| | Sep. 26 – Oct. 8 | -6.24E-02 | 2.70E-02 | 9.15E-02 | Not detected |
| | Oct. 8 - Oct. 17 | -5.70E-02 | 6.79E-02 | 2.27E-01 | Not detected |
| | Oct. 17 – Oct. 24 | 6.33E-02 | 1.04E-01 | 3.44E-01 | Not detected |
| | Oct. 24 – Nov. 14 | 2.76E-02 | 3.42E-02 | 1.13E-01 | Not detected |
| | Nov. 14 – Dec. 3 | -8.06E-02 | 5.14E-02 | 1.75E-01 | Not detected |
| | Dec. 3 – Dec. 19 | -7.48E-03 | 2.85E-02 | 9.52E-02 | Not detected |
| | Dec. 19 – Jan. 6 | 1.22E-03 | 3.86E-02 | 1.29E-01 | Not detected |
| | | | | | |
| $^{40}$K | Jan. 9 – Jan. 29 | 7.50E-01 | 6.49E-01 | 1.08E+00 | Not detected |
| | Jan. 29 - Feb. 11 | 1.51E+00 | 7.02E-01 | 1.15E+03 | Not detected |

Table E-5: Activity Density of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/g), in Near Field station at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| | *Feb. 11 – Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 1.36E+00 | 3.12E-01 | 9.79E-01 | Detected |
| | Jul. 14 – Jul. 23 | 7.69E-01 | 4.08E-01 | 1.33E+00 | Not detected |
| | Jul. 23 – Aug. 5 | 1.04E+00 | 2.75E-01 | 8.90E-01 | Detected |
| | Aug. 5 - Aug. 15 | 1.97E+00 | 4.27E-01 | 1.33E+00 | Detected |
| | Aug. 15 - Aug. 27 | 1.72E+00 | 3.52E-01 | 1.13E+00 | Detected |
| | Aug. 27 – Sep. 5 | 2.22E+00 | 4.55E-01 | 1.41E+00 | Detected |
| | Sep. 5 – Sep. 26 | 1.95E+00 | 4.30E-01 | 1.34E+00 | Detected |
| | Sep. 26 – Oct. 8 | 1.69E+00 | 3.19E-01 | 1.02E+00 | Detected |
| | Oct. 8 - Oct. 17 | 1.50E+00 | 8.20E-01 | 2.68E+00 | Not detected |
| | Oct. 17 – Oct. 24 | 9.19E-01 | 1.27E+00 | 4.21E+00 | Not detected |
| | Oct. 24 – Nov. 14 | 1.02E+00 | 4.39E-01 | 1.43E+00 | Not detected |
| | Nov. 14 – Dec. 3 | 7.18E-02 | 5.99E-01 | 2.00E+00 | Not detected |
| | Dec. 3 – Dec. 19 | 1.88E+00 | 3.55E-01 | 1.09E+00 | Not detected |
| | Dec. 19 – Jan. 6 | 1.94E+00 | 4.68E-01 | 1.51E+00 | Detected |

*Filters collected during these dates were not weighed; no density data is available for this period.

Table E-6: Activity Density of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/g), in Cactus Flat station at WIPP

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| $^{137}Cs$ | Jan. 9 – Jan. 29 | 9.40E-02 | 1.08E-01 | 1.81E-01 | Not detected |
| | Jan. 29 - Feb. 11 | 3.75E-02 | 7.93E-02 | 1.33E-01 | Not detected |
| | *Feb. 11 – Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 2.47E-02 | 6.20E-02 | 2.05E-01 | Not detected |
| | Jul. 14 – Jul. 23 | 4.75E-03 | 4.23E-02 | 1.40E-01 | Not detected |
| | Jul. 23 – Aug. 5 | 1.53E-02 | 2.99E-02 | 9.89E-02 | Not detected |
| | Aug. 5 - Aug. 15 | 1.83E-02 | 4.04E-02 | 1.34E-01 | Not detected |
| | Aug. 15 - Aug. 27 | 1.70E-02 | 3.05E-02 | 1.01E-01 | Not detected |
| | Aug. 27 – Sep. 5 | 8.44E-02 | 6.11E-02 | 2.03E-01 | Not detected |
| | Sep. 5 – Sep. 26 | 4.90E-03 | 3.80E-02 | 1.26E-01 | Not detected |
| | Sep. 26 – Oct. 8 | -1.82E-02 | 3.19E-02 | 1.06E-01 | Not detected |
| | Oct. 8 - Oct. 17 | 2.13E-02 | 6.17E-02 | 2.05E-01 | Not detected |
| | Oct. 17 – Oct. 24 | -3.95E-02 | 1.18E-01 | 3.93E-01 | Not detected |
| | Oct. 24 – Nov. 14 | 7.55E-02 | 4.57E-02 | 1.50E-01 | Not detected |
| | Nov. 14 – Dec. 3 | 7.63E-02 | 4.62E-02 | 1.52E-01 | Not detected |
| | Dec. 3 – Dec. 19 | 9.40E-03 | 4.20E-02 | 1.39E-01 | Not detected |

Table E-6: Activity Density of $^{137}Cs$, $^{60}Co$ and $^{40}K$ (Bq/g), in Cactus Flat station at WIPP (continued)

| Radionuclides | Sampling Date 2014 | Activity Bq/g | Unc.(2σ) Bq/g | MDC Bq/g | Status |
|---|---|---|---|---|---|
| | Dec. 19 – Jan. 6 | -1.48E-02 | 3.75E-02 | 1.25E-01 | Not detected |
| | | | | | |
| $^{60}Co$ | Jan. 9 – Jan. 29 | -4.51E-02 | 1.08E-01 | 1.85E-01 | Not detected |
| | Jan. 29 - Feb. 11 | 5.08E-02 | 6.67E-02 | 1.12E-01 | Not detected |
| | *Feb. 11 - Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | -9.24E-02 | 6.07E-02 | 2.05E-01 | Not detected |
| | Jul. 14 – Jul. 23 | -3.01E-04 | 4.74E-02 | 1.58E-01 | Not detected |
| | Jul. 23 – Aug. 5 | 6.47E-03 | 2.49E-02 | 8.26E-02 | Not detected |
| | Aug. 5 - Aug. 15 | -8.81E-03 | 4.25E-02 | 1.42E-01 | Not detected |
| | Aug. 15 – Aug. 27 | -2.54E-02 | 3.23E-02 | 1.08E-01 | Not detected |
| | Aug. 27 – Sep. 5 | -1.10E-02 | 6.43E-02 | 2.15E-01 | Not detected |
| | Sep. 5 – Sep. 26 | 1.87E-03 | 3.90E-02 | 1.30E-01 | Not detected |
| | Sep. 26 – Oct. 8 | -3.53E-03 | 2.62E-02 | 8.74E-02 | Not detected |
| | Oct. 8 - Oct. 17 | 4.73E-02 | 6.15E-02 | 2.04E-01 | Not detected |
| | Oct. 17 – Oct. 24 | -5.85E-02 | 1.25E-01 | 4.16E-01 | Not detected |
| | Oct. 24 – Nov. 14 | 1.15E-02 | 3.95E-02 | 1.31E-01 | Not detected |
| | Nov. 14 – Dec. 3 | -2.98E-02 | 4.99E-02 | 1.68E-01 | Not detected |
| | Dec. 3 – Dec. 19 | -2.28E-02 | 3.44E-02 | 2.30E-01 | Not detected |
| | Dec. 19 – Jan. 6 | -6.80E-02 | 3.76E-02 | 2.61E-01 | Not detected |
| | | | | | |
| $^{40}K$ | Jan. 9 – Jan. 29 | 9.57E-01 | 1.10E+00 | 1.84E+00 | Not detected |
| | Jan. 29 - Feb. 11 | 1.19E+00 | 8.30E-01 | 1.36E+00 | Not detected |
| | *Feb. 11 – Jul. 3 | No density data | | | |
| | Jul. 3 - Jul. 14 | 1.60E+00 | 5.97E-01 | 1.94E+00 | Not detected |
| | Jul. 14 – Jul. 23 | 1.45E+00 | 5.32E-01 | 1.74E+00 | Not detected |
| | Jul. 23 – Aug. 5 | 1.04E+00 | 3.12E-01 | 9.97E-01 | Detected |
| | Aug. 5 - Aug. 15 | 1.64E+00 | 4.94E-01 | 1.61E+00 | Detected |
| | Aug. 15 - Aug. 27 | 8.42E-01 | 3.83E-01 | 1.25E+00 | Not detected |
| | Aug. 27 – Sep. 5 | 2.45E+00 | 7.56E-01 | 2.46E+00 | Not detected |
| | Sep. 5 - Sep. 26 | 1.14E+00 | 4.74E-01 | 1.55E+00 | Not detected |
| | Sep. 26 – Oct. 8 | 1.06E+00 | 3.28E-01 | 1.05E+00 | Detected |
| | Oct. 8 - Oct. 17 | 1.83E+00 | 7.24E-01 | 2.36E+00 | Not detected |
| | Oct. 17 – Oct. 24 | 2.42E+00 | 1.52E+00 | 4.99E+00 | Not detected |
| | Oct. 24 – Nov. 14 | 1.23E+00 | 4.62E-01 | 1.51E+00 | Not detected |
| | Nov. 14 – Dec. 3 | 8.13E-01 | 5.86E-01 | 1.93E+00 | Not detected |
| | Dec. 3 – Dec. 19 | 1.19E+00 | 4.39E-01 | 1.42E+00 | Not detected |
| | Dec. 19 – Jan. 6 | 2.67E+00 | 4.55E-02 | 1.45E+00 | Detected |

*Filters collected during these dates were not weighed; no density data is available for this period.

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