2015 Annual Report

Carlsbad Environmental
Monitoring & Research Center
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Carlsbad Environmental Monitoring & Research Center dedicates this Annual Report in memory of our friend, advisor and colleague

Dr. Abraham Van Luik
(1944-2016)

Executive Summary

The Carlsbad Environmental Monitoring and Research Center (CEMRC) 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 2015. WIPP is a U.S. Department of Energy (DOE) mined deep geologic repository that has been in operation since March, 1999. From the first receipt of waste in March 1999 through the end of 2015, 90,983 cubic meters (m3) of TRU waste have been disposed of at the WIPP facility. Over its lifetime, WIPP is expected to dispose of approximately 175,000 cubic meters of TRU waste from various DOE sites. Therefore, the WIPP is about half full in terms of its legally defined capacity. The primary radionuclides within the disposed waste are plutonium ($^{239+240}$Pu) and americium (^{241}Am), which account for more than 99% of the total TRU radioactivity disposed and/or scheduled for disposal within the repository. After almost fifteen years of successful and safe operations, the WIPP facility was suddenly shutdown in February 2014, due to an accidental underground radiation release event and an unrelated underground fire event. The site is scheduled to reopen by the end of 2016 and begin accepting waste shipments sometime in early 2017. Since the facility was still undergoing a recovery process from the 2014 underground fire and radiation release events, there were no TRU waste disposal activities conducted at the WIPP facility in 2015.

Following the February 2014 underground fire and radiation release events at the WIPP, the CEMRC has continued its efforts to conduct accelerated analyses of the WIPP underground air samples collected from Stations A and B throughout 2015. Rapid analyses were also performed on ambient air samples and on other environmental samples collected from within the vicinity of the WIPP site. The data collected were compared to similar data collected during the monitoring phase of the WIPP prior to the events 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 have been determined to be low and localized, and no negative radiation-related health effects among local workers or the public are expected.

This report summarizes the environmental samples collected and analyzed by the CEMRC during the calendar year 2015 to inform the public that there were no significant adverse impacts on the environment from WIPP facility operations in 2015, as determined from extensive environmental monitoring for both radiological and non-radiological constituents. In summary, the data from this environmental monitoring program shows that the environment around WIPP continues to be safe and that there are no reasons to suspect that there will be any negative environmental impact from the February 2014 underground fire or radiation release events.

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 owned 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 TRU wastes that were generated from research and the production of nuclear weapons at various DOE sites throughout the nation.

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 its environmental monitoring program 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 disposal operations.

CHAPTER 2 | WIPP UNDERGROUND AIR MONITORING

This section summarizes the WIPP's underground air monitoring results for the calendar year 2015. The WIPP facility operates three effluent air monitoring stations known as Stations A, B, and C respectively. Each station is equipped with at least one fixed air sampler collecting particulates from the effluent air stream on a Versapor 47mm filter. Station A samples the unfiltered underground exhaust air whereas Station B samples the underground exhaust air after HEPA filtration and, sometimes, non-filtered air during maintenance activities. 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 actual waste container serves as the primary confinement barrier in the WHB; while negative building pressure and HEPA filtration provide secondary confinement to potential radiological contamination. The effluent studies at Station A and Station B are a major component of the CEMRC WIPP Environmental Monitoring (WIPP-EM) program as they provide a measure of the level of radioactivity present in the air within the repository (Station A) as well as the level of radioactivity present in the air that is released to the environment (Station B). 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.

The weekly monitoring of the air filter samples collected from Station A during 2015 showed frequent detections of ^{241}Am and $^{239+240}$Pu due to residual contamination in the underground from the 2014 radiation release event as well as ongoing cleanup efforts within in the WIPP underground. Results from Station B showed only occasional detection of these two radionuclides during 2015 and the ^{238}Pu level has been below the detection limit for Stations B throughout all of 2015. It is important to note that while still detectable by the CEMRC sophisticate instrumentation, the levels detected in Station B filters are deemed to be very low and are not expected to cause any adverse health to humans nor to the environment.

CHAPTER 3 | AMBIENT AIR MONITORING

This section summarizes the ambient air monitoring results for the calendar year 2015 in the vicinity of the WIPP site. A network of continuously operating ambient air samplers at three locations across the WIPP site were used to determine whether the nuclear waste handling and storage operations at the WIPP have released radionuclides into the environment. Two additional sets of high-volume air samplers were installed following the release event and are located in the two municipalities closest to the WIPP facility, specifically the Village of Loving and the City of Carlsbad. As a result, ambient air samples were collected from 5 separate locations in 2015, representing a total of 93 air particulate filter samples being collected and analyzed during 2015. These filters were collected over a period of 2 to 4 weeks depending on the levels of particulate matter that accumulated on the filters. Except for a few positive detections of Am and Pu in the nearby ambient air samples due to the ongoing cleanup activities occurring within the WIPP facility, there were no increases in radiological contaminants observed during 2015 that could have been attributed to the recent radiation release from the WIPP in the wider region. Additionally, the CEMRC has been monitoring radionuclide concentrations in the ambient air around the WIPP facility since the inception of the WIPP-EM program in 1996. With few exceptions, fallout from atmospheric testing of nuclear weapons has been determined to be the primary source of Pu detected in ambient air prior to the 2014 underground radiation release event. 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 2015. To better assess the radionuclide concentrations following the 2014 radiation release event, soil samples were collected from both Near Field and Cactus Flats locations and analyzed in 2015. Samples were analyzed for radionuclides expected to occur in the areas sampled. Our 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 underground radiation release event specifically or to WIPP related activities in general.

CHAPTER 5 | SURFACE WATER and SEDIMENT MONITORING

This section summarizes the results from surface water and sediment sampling 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 sampled in 2015 were (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 Am and Pu 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, further demonstrating there has not been, and likely will not be, a measureable environmental impact as a result of WIPP-related activities. As for the gamma radionuclides, potassium (^{40}K) was detected in all sediments and two of the surface water samples in 2015 while concentrations of all other gamma radionuclides were typically less than the minimum detectable concentrations.

CHAPTER 6 | DRINKING WATER

This section summarizes public drinking water monitoring results for the calendar year 2015. Public drinking water samples are routinely sampled from six drinking water sources in the region of the WIPP including the City of Carlsbad Sheep Draw and Double Eagle water systems, as well as the Hobbs, Loving, Malaga, and Otis municipal water systems . While it is unlikely that these sampling locations would be affected by any WIPP-related radioactivity releases, the samples are collected and analyzed regularly because water is a primary vector in the food chain and therefore, is important to area constituents. Therefore, 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 monitoring, the absence of WIPP radionuclides in drinking water samples further demonstrates that there has been no adverse impact to the population or to the environment from WIPP-related activities.

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 27, 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, we can conclude that there has been no negative health effect detected on 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

In addition to its WIPP-EM independent environmental monitoring program, the CEMRC also performs additional WIPP-related scientific activities as a contractor to the WIPP management and operations contractor Nuclear Waste Partnership, LLC (NWP). One of those contracted activities involves the analysis of air samples collected at the surface and from the underground of the WIPP facility for the determination of various gases including hydrogen (H), methane (M), and other volatile organic compounds (VOCs). 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 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. This section presents an overview of this activity; however, no sample data are presented as the data are considered to be proprietary to the NWP and DOE and are not subject to release by the CEMRC.

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 is typically verified by a continuing program of internal laboratory quality control, replicate sampling and analysis.

CONCLUSION

It has been almost two years since an accidental underground radiation release and an unrelated underground salt truck fire shut down the WIPP facility in early 2014. After almost fifteen years of successful waste disposal operations, it was the first unambiguous release at the WIPP. The underground radiation event released moderate levels of radioactivity into the underground air with a small portion of the contaminated underground air also escaping to the surface through imperfectly sealing dampers. This contamination was detected by the CEMRC approximately one kilometer away from the facility a few days after the incident. 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 radiation release was caused by a runaway chemical reaction inside a TRU waste drum resulting in 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 predominant radionuclides released were americium (Am) and plutonium (Pu), in a ratio that matches the content of the breached drum.

In the wake of the radiation-release incident of February 14, 2014, the CEMRC conducted an extensive monitoring and measurement campaign to determine to assess the level of risk to anyone as a result of the WIPP radiation release and/or from the on-going WIPP-related activities in general. Moving forward, the CEMRC has continued its efforts to conduct accelerated analyses of the WIPP underground air filters collected from Stations A and B, ambient air samples, and other environmental samples collected in and around the WIPP facility in 2015. Sampling during 2015 was in large part returned to the pre-event schedule, with no detections of radioactivity found to be attributable to WIPP-related operations. Monitoring results continue to be made accessible to the public as soon as they become available. Throughout 2015, town hall meetings were conducted regularly to inform the community of status of the WIPP recovery and restart activities and to provide an opportunity for the public to communicate directly with DOE and WIPP management. Access was also provided via Live-Stream video maintained on the WIPP Recovery Website (http://wipp.energy.gov/wipprecovery/recovery.html). This timely dissemination of information is important in terms of assuring the local public that the potential health impacts of radiation from the WIPP facility are being independently evaluated and to provide the public with a basis for judging the continued acceptability of this facility.

Another capability developed by the CEMRC as part of its service to the southeastern New Mexico region is a program called "Lie Down and Be Counted". This program uses a state of the art whole body counting system that can measure the body burden of radioactive elements at extremely low levels and has operated over the past 15 years with over 1,400 local residents participating to form a baseline. Following the radiation release event, the CEMRC continued to offer this free lung and whole body counting service to adult citizens living within a 100-mile radius of the WIPP facility seven days a week. Concerned citizens were encouraged to be measured to see what radiation might exist in their lungs and whole body. Even though there was not a substantial upsurge in the number of citizens who took advantage of this valuable service, just the mere availability of such a service, provided a sense of security to concerned citizens after the event.

The CEMRC's recent monitoring data show that the concentration levels of the radionuclides of concern present in the environment have returned to normal background levels and in many instances, are not even detectable, demonstrating no long-term environmental impacts of the recent radiation release event at the WIPP. ***Further, an evaluation of 2015 environmental monitoring data indicates that WIPP operations have been safe and that the levels of radiation that escaped to the environment from the 2014 radiation release event 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 release is exceedingly small, approaching zero.

In the past, the CEMRC's independence and its extensive monitoring program and constant public engagement provided a model of how to garner confidence in the local populace with respect to the acceptance of a nearby nuclear facility. Following the radiation release event at WIPP, the CEMRC's independent monitoring program and independent communications effort has continued to prove its value in terms of assuring continued local acceptance of the facility through a timely dissemination of scientific data. ***As a result, the CEMRC independent monitoring and communications model should be considered as part of the infrastructure needed to assure local acceptance of planned repositories elsewhere in the future.***

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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, commonly referred to as the WIPP, is a deep geologic 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 Land Withdrawal Act (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, construction debris, 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. Currently, the WIPP is about half full in terms of its legally defined capacity.

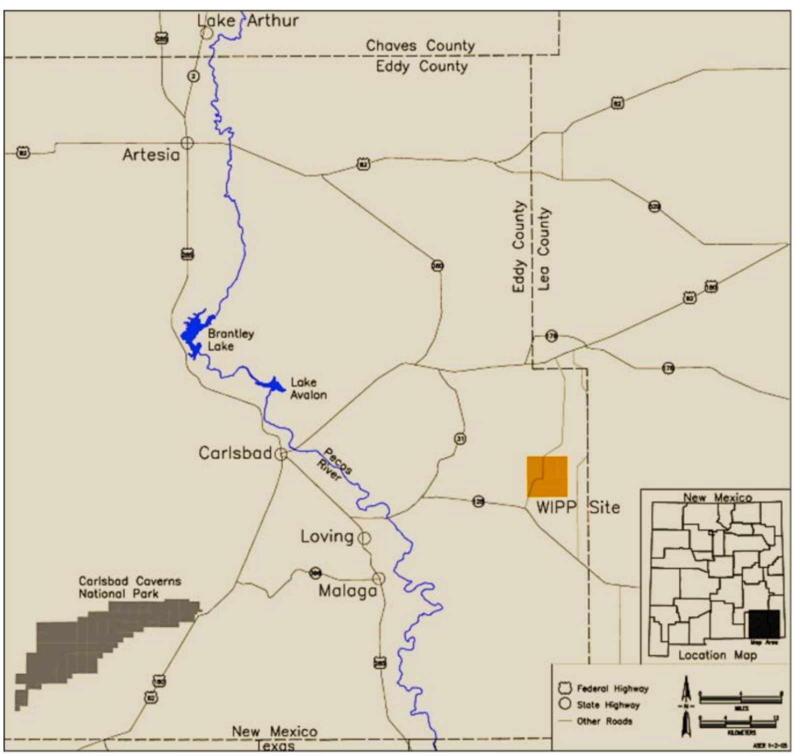


Figure 1-1: Location of the WIPP Site

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" refers to transuranic waste with a surface dose rate not greater than 200 millirem per hour. The term 'remote-handled transuranic waste' refers to transuranic waste with a surface dose rate of 200 millirem per hour or greater" (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. The WIPP facility has remained closed to waste emplacement following an underground fire event that occurred on February 5, 2014 and an unrelated underground radiological release event that occurred nine days later on February 14, 2014. More information about the fire and radiological events can be found in the CEMRC 2014 annual report.

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 ,33 feet (10 meters) wide, and 15 feet (4.5 meters) high. Seven of the panels have been excavated; and the first six have been closed and sealed from ventilation air. Waste disposal was in progress in the seventh panel at the time of the February 14, 2014 underground radiological event. In addition to panel eight, two additional waste storage 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 the presence of HEPA (High Efficiency Particulate Air) filters which are located at the surface. Additionally, 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 or is released directly to the atmosphere. The HEPA filtration system results in the removal of approximately 99.97% of radiological contamination from the underground WIPP exhaust air prior to being released to the environment; however, the major drawback of this system is that it significantly reduces the amount of airflow that is drawn through the repository at any one time. For example, prior to the February 14, 2014 underground radiological event, the amount of air moving through the WIPP underground was approximately 460,000 cubic feet per minute (cfm).

As a result of the February 14, 2014 underground radiological event and the potential for airborne contamination to be present in the WIPP underground air, the air must be directed through the HEPA filtration system before being released to the environment thereby reducing the amount of air moving through the WIPP underground to approximately 60,000 cfm or approximately one seventh of the pre-event level.

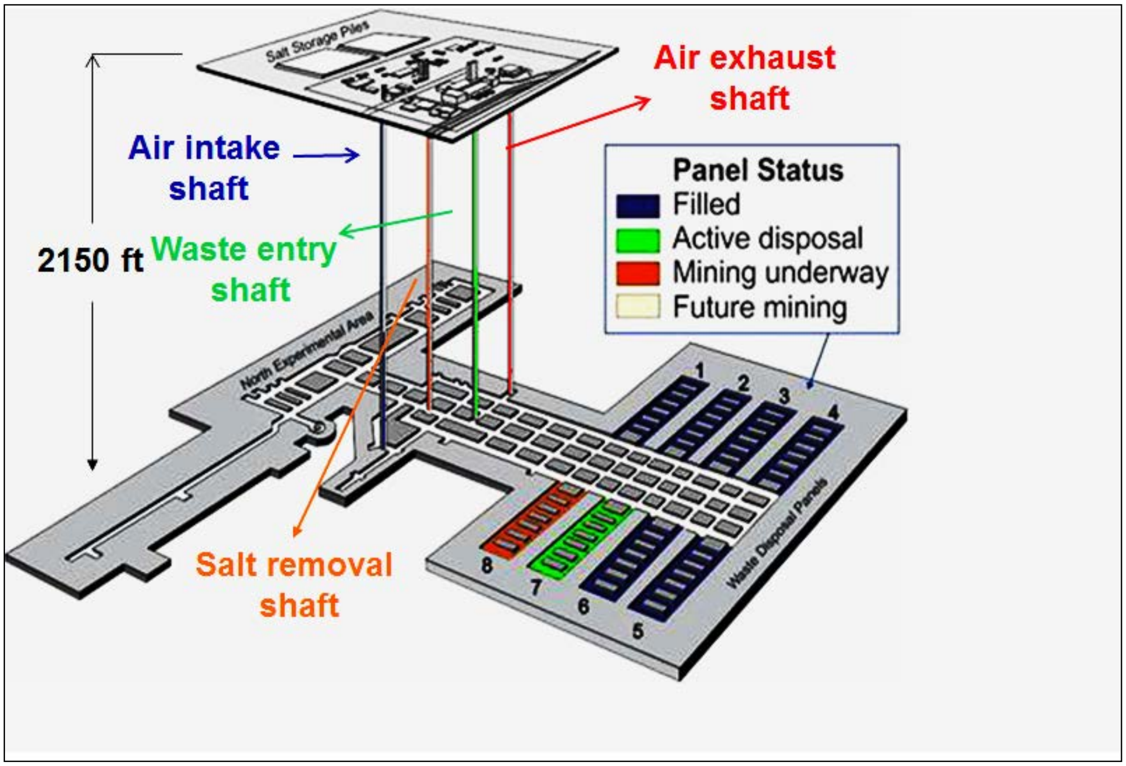


Figure 1-2: WIPP Layout

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 47mm Versapore filter. Representative sampling is assured by system design. Under normal operating conditions (such as those encountered prior to the February 14, 2014 underground radiological 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. The 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 release 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 underground radiological release event, the 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 long-term 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 boreholes 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 current 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 ranchers (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 (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.

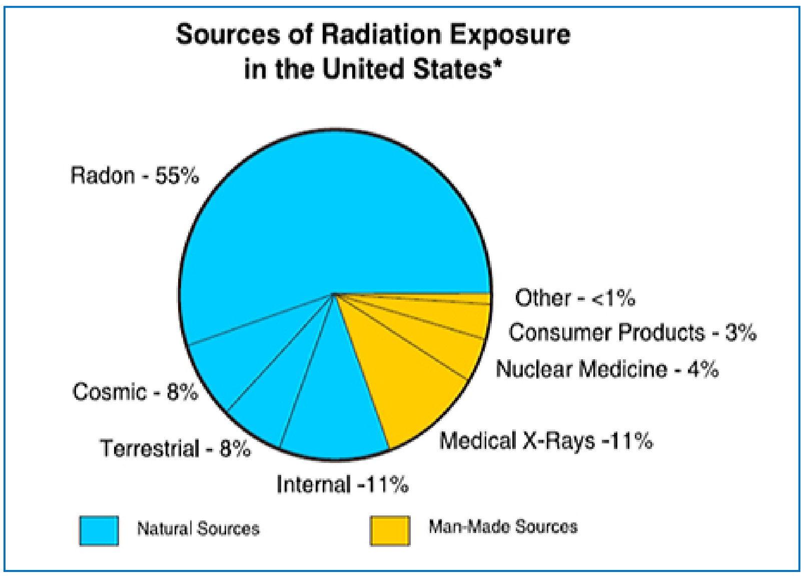


Figure 1-3: Source of Radiation Exposure
Source: National Council on Radiation Protection (ICRP)

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 in the area 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 activities. 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 to 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 and two ambient air samplers in the two closest municipalities nearest the WIPP facility (the Village of Loving and the City of Carlsbad). The ambient air monitoring sites nearest the WIPP facility are located in the most prevalent wind directions from the facility, whereas the ambient air monitoring sites in Loving and Carlsbad are located on Village of Loving owned property and at the CEMRC facility primarily as a matter of convenience and cost. The primary purpose of ambient air monitoring 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 or its two closest municipalities.

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 1997a). 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 likely to be 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 also 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 provided renewed interest on behalf of resident volunteers. Results of the LDBC, both historically and those screened between the February 14, 2014 underground radiation event to December 30, 2015 are reported herein. Also, as a result of the February 14, 2014 radiation release 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 Recovery from the Fire and Radiological Release Events at the Waste Isolation Pilot Plant

After months of investigations into the cause of the underground truck fire and the 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 late 2016 or early 2017. As can be seen in Figure 1-4, decontamination of work areas is a key element of the WIPP Recovery Plan as a portion of the underground area was heavily contaminated by the February 14, 2014, radiation release event. Other parts of the recovery plan include: (1) continued HEPA filtration of underground exhaust air through an expanded interim ventilation system (IVS), (2) expedited closure of Panel 6, where a few hundred suspect waste drums assumed to contain the same type of nitrate salt-bearing waste that led to the underground radiological release event are located, and (3) expedited closure of Room 7 in Panel 7, the location of the ruptured waste drum where the February 14, 2014 radiation release event occurred. During 2015, several notable recovery-related activities were completed at the WIPP facility including the procurement of components for the IVS and the Supplemental Ventilation System (SVS). The IVS is intended to increase the amount of filtered air in the underground from approximately 60,000 cfm to approximately 114,000 cfm. The SVS is intended to act as a booster fan system in the underground that will eventually be used to create a clean circuit for the resumption of mining operations. The SVS was installed in the underground during 2015 but has not been activated at this time as resumption of mining in Panel 8 will not begin for several years. The IVS system will be commissioned and is anticipated to become operational by the summer of 2016. Additional recovery-related activities completed during 2015 included the closure of Panel 6 which occurred on May 13, 2015 and the sealing of Room 7 in Panel 7 which occurred on May 29, 2015. Other notable recovery activities such as decontamination of selected underground areas including the pathway from the Waste Hoist to the entrance of Panel 7 and all areas south of S2520 were completed by September 2015 which served to reduce the level of restrictions for certain areas and lowered the personnel protective equipment (PPE) required in a significant portion of the underground. Lastly, additional recovery activities are on-going including increased safety inspections of underground areas, the cleaning and decontamination of underground vehicles, and re-establishing underground habitability to meet worker safety and health standards.

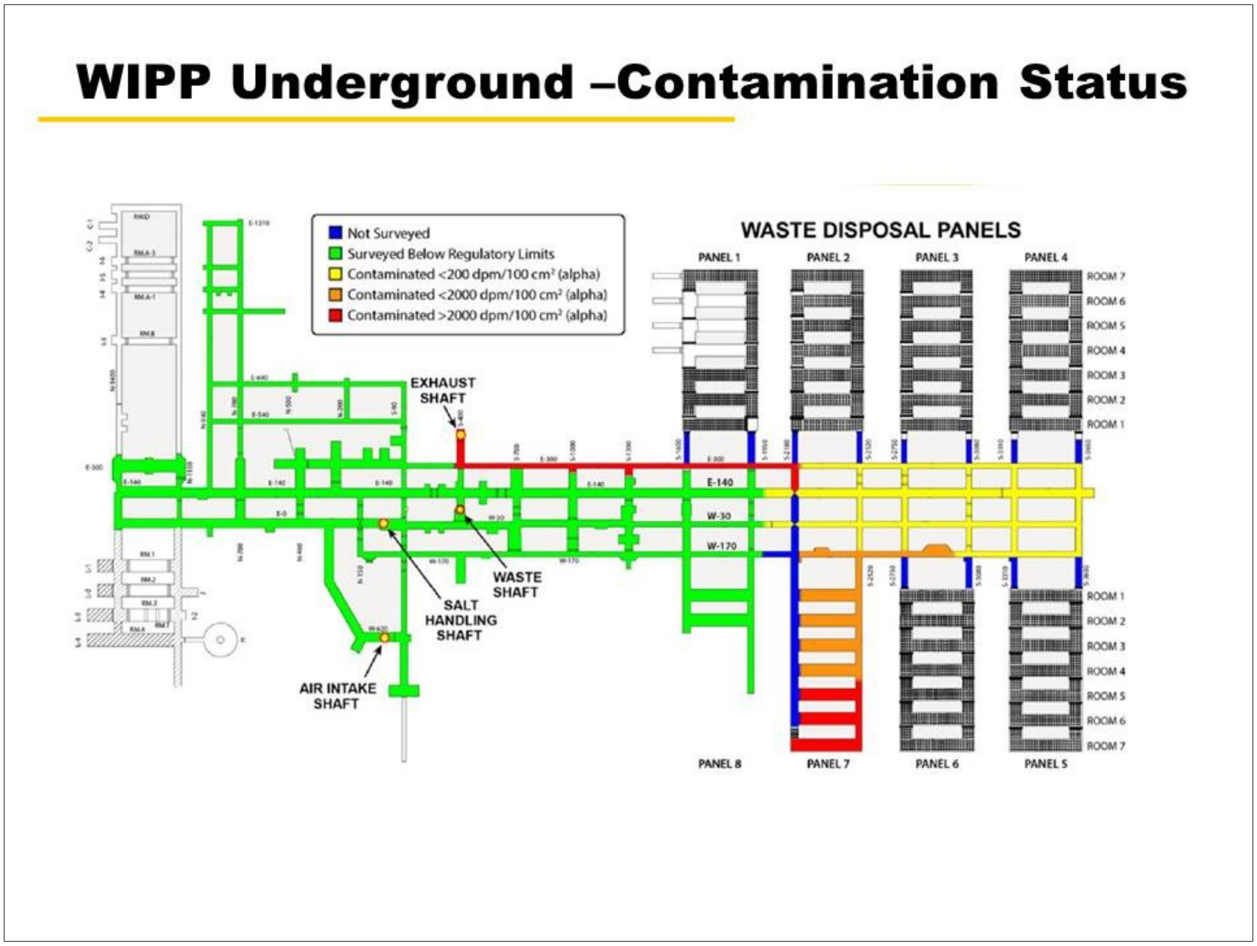


Figure 1-4: Radiological Contamination Map of WIPP Underground
(Source: Department of Energy, Carlsbad Field Office

In response to the February 14, 2014 underground radiological release incident, the CEMRC has continued its efforts to conduct accelerated analyses of the underground filters collected from Stations A and B, surface ambient air samples, and other environmental samples collected in the vicinity of the WIPP site. This report summarizes the samples collected and analyzed during the calendar year 2015 and, in addition, presents an evaluation of two years of environmental monitoring data that informed the public pertaining to the levels of radiation that escaped to the environment from the WIPP underground during the February 14, 2014 event. As reported in the 2014 annual report, the ongoing data from this year's monitoring activities suggest that the 2014 underground radiological release event resulted in the release of very low amounts of contaminants from the WIPP underground and confirms that the escaped contaminants did not harm anyone nor did they pose any long-term consequence to the environment. 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). A second sampling station, referred to as 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

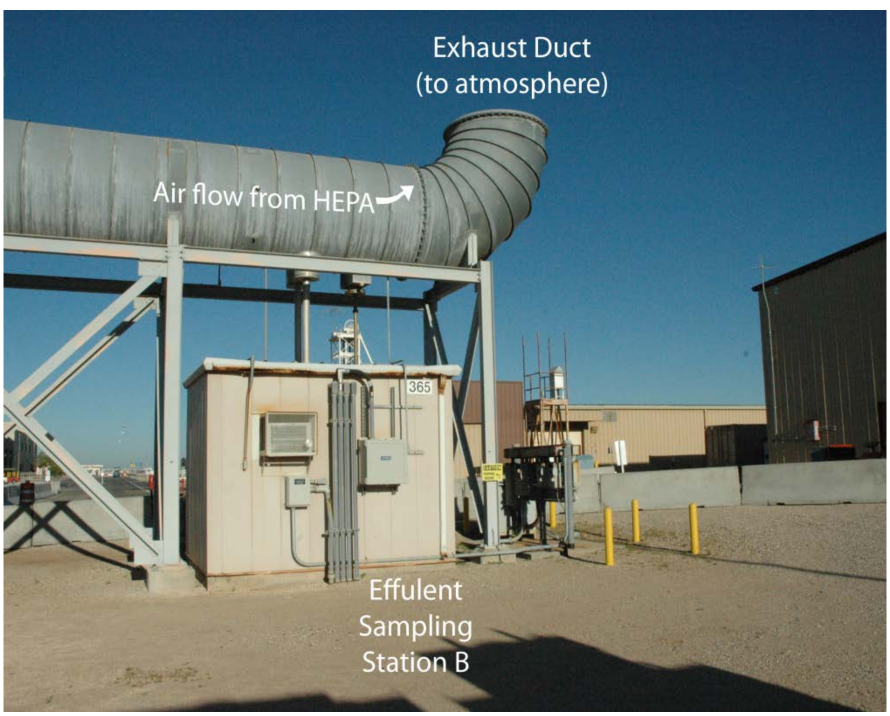


Figure 2-2: Location of Station B

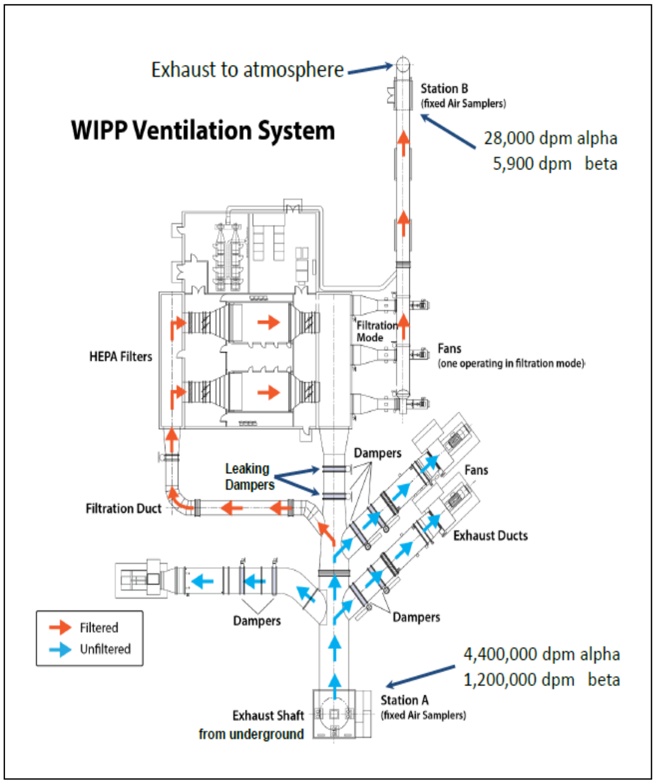


Figure 2-3: Overview of WIPP Ventilation System

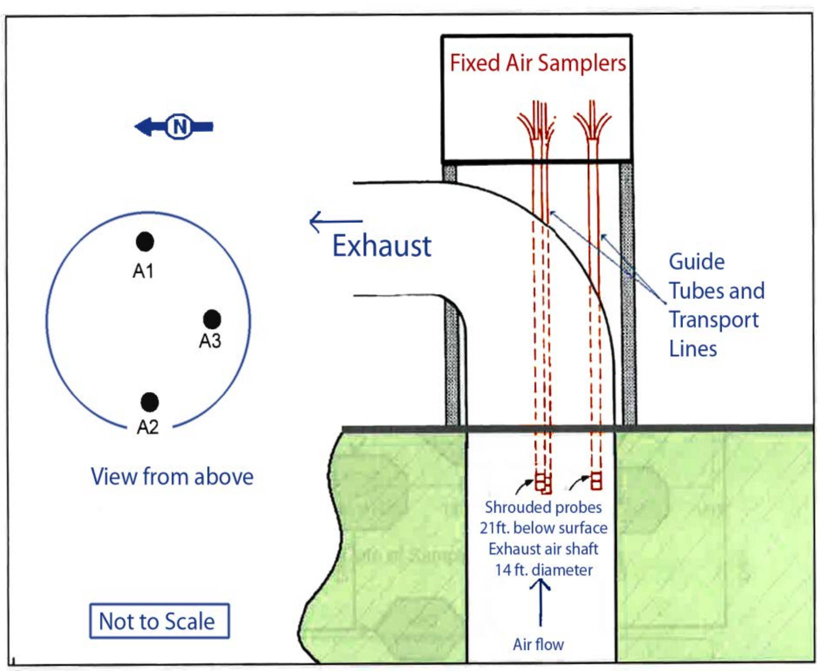


Figure 2-4: Overview of Station A

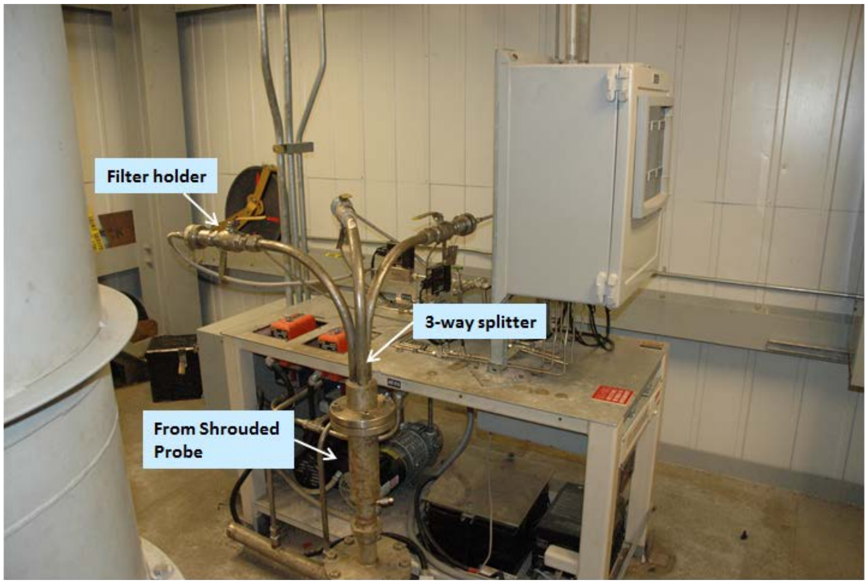


Figure 2-5: Fixed Air Samplers at Station A

Prior to the February 14, 2014 underground radiation event at the WIPP, 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, the frequency of filters collected at station A and station B were reduced to daily, but actinide measurements are performed on weekly composite samples. Since the repository continues to operate in filtration mode, CEMRC technicians continue to collect and analyze Station B samples daily.

Sample Preparation and Analysis

Gross Alpha and Beta Analysis

Once the samples are collected from the site and returned to the laboratory, individual filters are desiccated for a minimum of 48 hours to 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 Stations A and B filters are counted for gross alpha and beta activities on a Protean MPC 9604 low background gas proportional counter for 1200 minutes.

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 (2σ warning and 3σ limits) and ensuring that alpha/beta cross-talk are within limits (≤ 0% α into beta and ≤ 0.1% beta into alpha). Sixty-minute background counts are also recorded daily (count must be within the mean background ±3σ) 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 systems are found to be around 25% for alpha and 38% for beta (see Figures 9-3 and 9-4).

Sample Preparation for Radiochemical Analysis

After gross alpha/beta measurements, individual filters collected over a period of one week are combined into weekly composites. The weekly composite samples are used for the determination of actinide activities. Gamma analysis is performed concurrently on the same weekly composite. Only one half of the sample is used for the determination of the actinide activities. The remaining aliquot is archived.

Filter samples for radiochemical analysis are 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. 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 samples are counted for 5-days for alpha and 48 hours for gamma radionuclides as per CEMRC's standard counting protocol. 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).

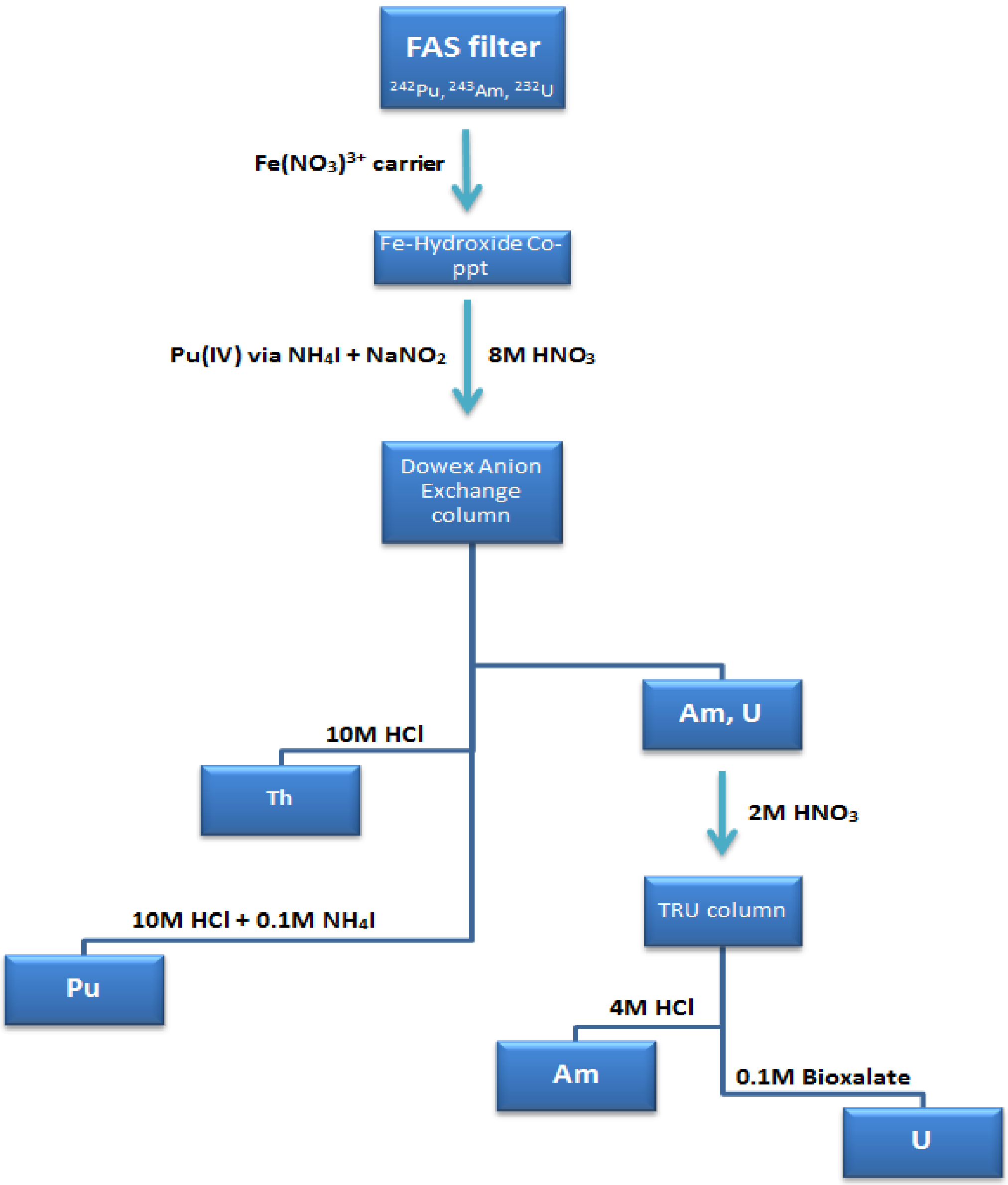


Figure 2-6: Flow Diagram Showing the Analysis of Stations A and B Filters

Results and Discussion

Gross Alpha and Beta concentrations in the WIPP underground Air (Station A, Pre-HEPA Filter)

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. The gross alpha and beta activities appear to have gone back to the pre-release levels in 2015. 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.

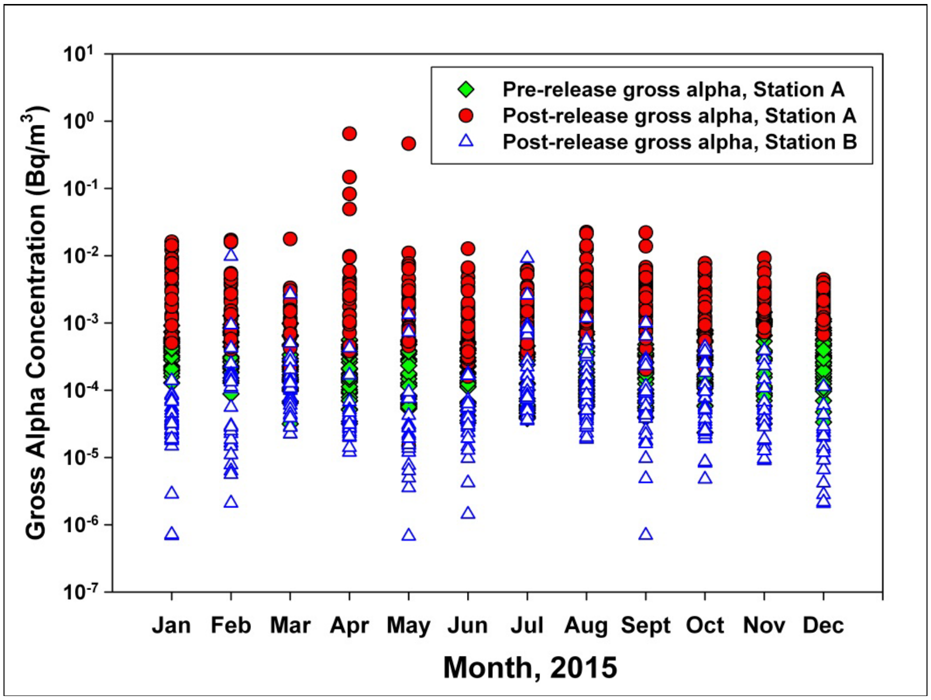


Figure 2-7: The Gross Alpha concentrations in the WIPP exhaust air before (Station A) and after HEPA filtration (Station B) in 2015

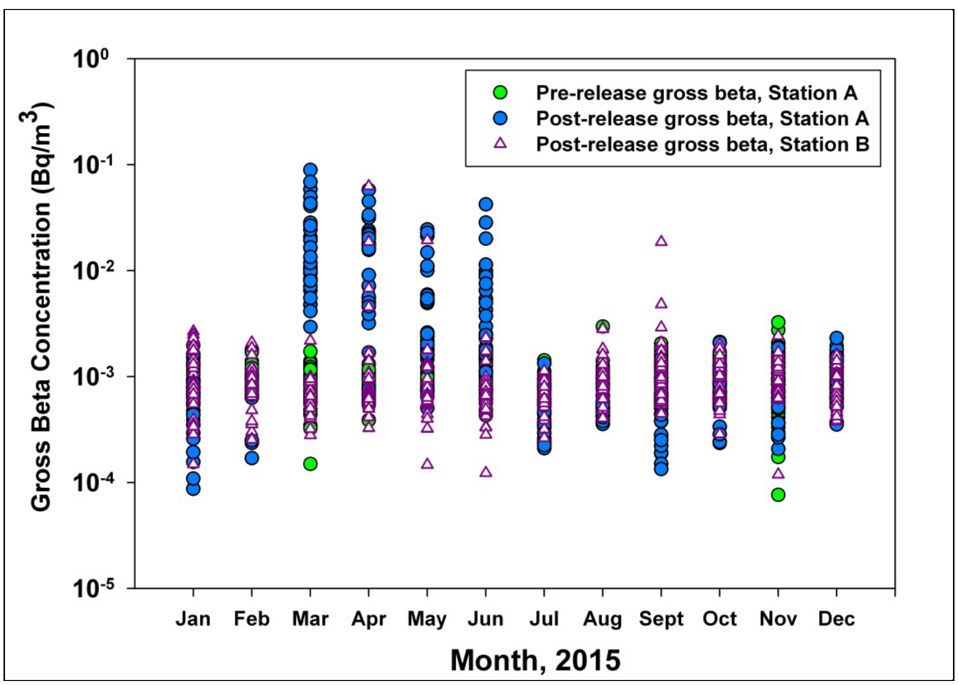


Figure 2-8: The Gross Beta Concentrations in the WIPP exhaust air before (Station A) and after HEPA filtration (Station B) in 2015

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. There is no data for the period between February and June, 2014. This is because gross alpha and beta screening was not performed immediately following the release event 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.

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.

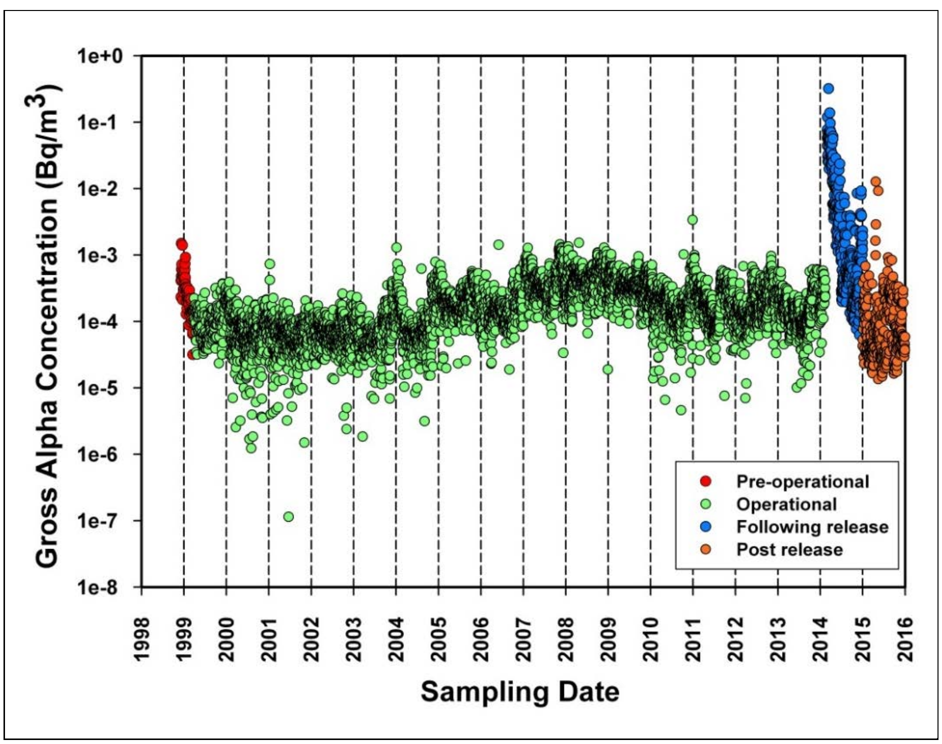


Figure 2-9: Pre- and Post-release Gross Alpha concentration in Station A (Pre-HEPA) filter

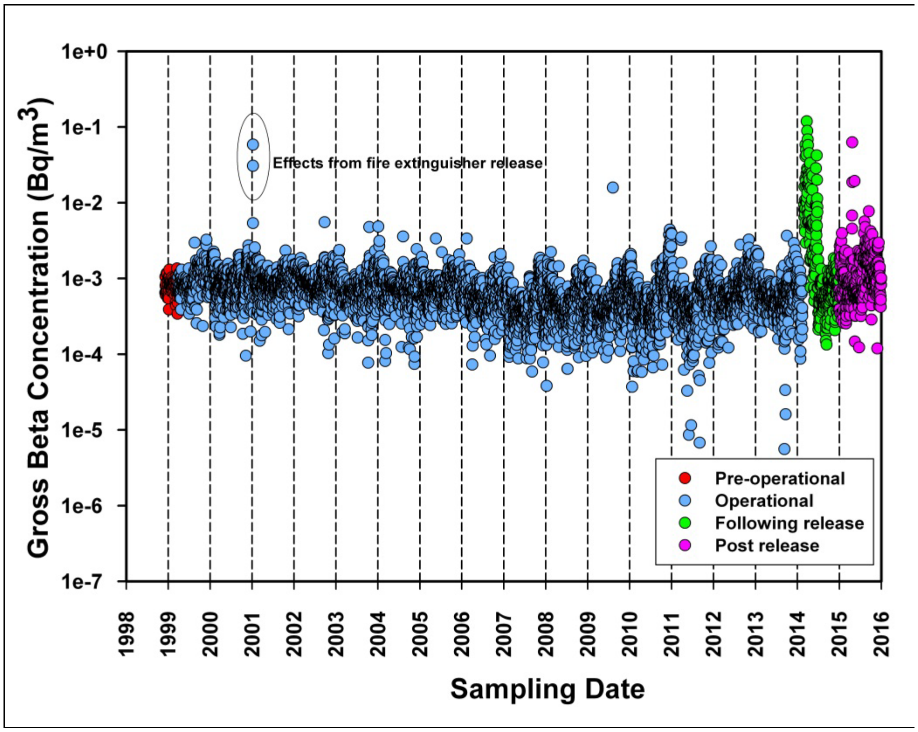


Figure 2-10: Pre- and Post-release Gross Beta concentration in Station A (Pre-HEPA) filter

Similar seasonal trends in gross beta data can also be seen in 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.

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. Since no gravimetric data was collected from the Station A filters following the radiation release event, no data are available for the period between February and July; 2014.CEMRC resumed collecting gravimetric data beginning August, 2014.

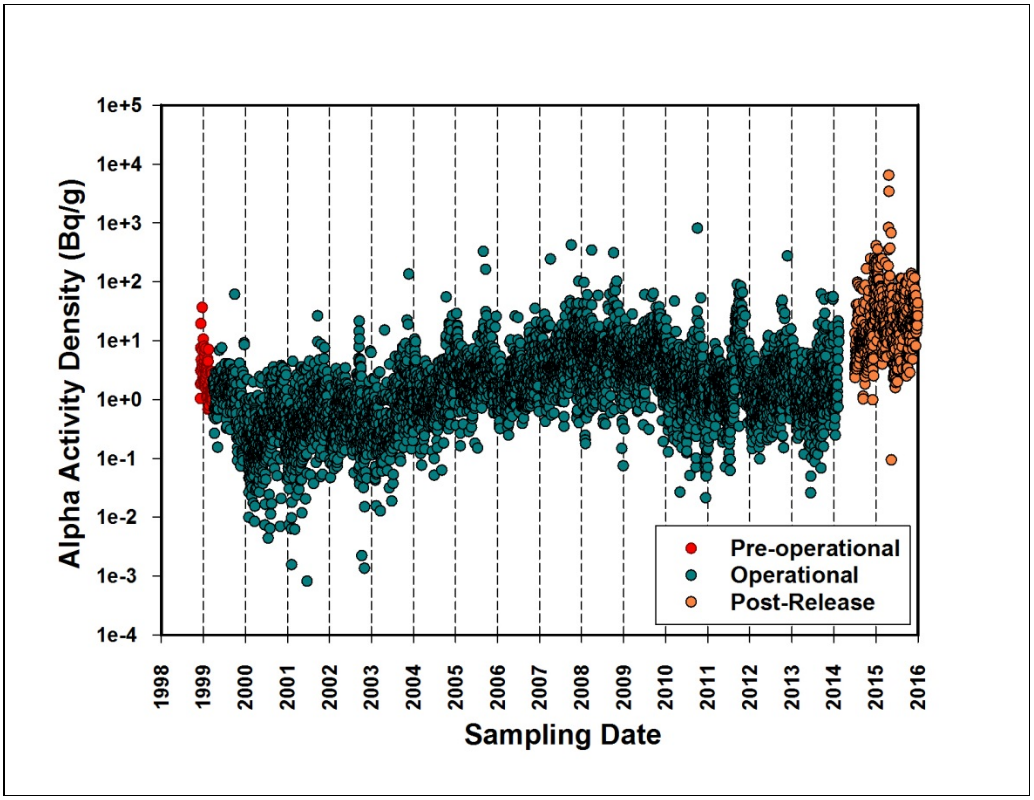


Figure 2-11: Gross Alpha Activity Densities measured in Station A filters

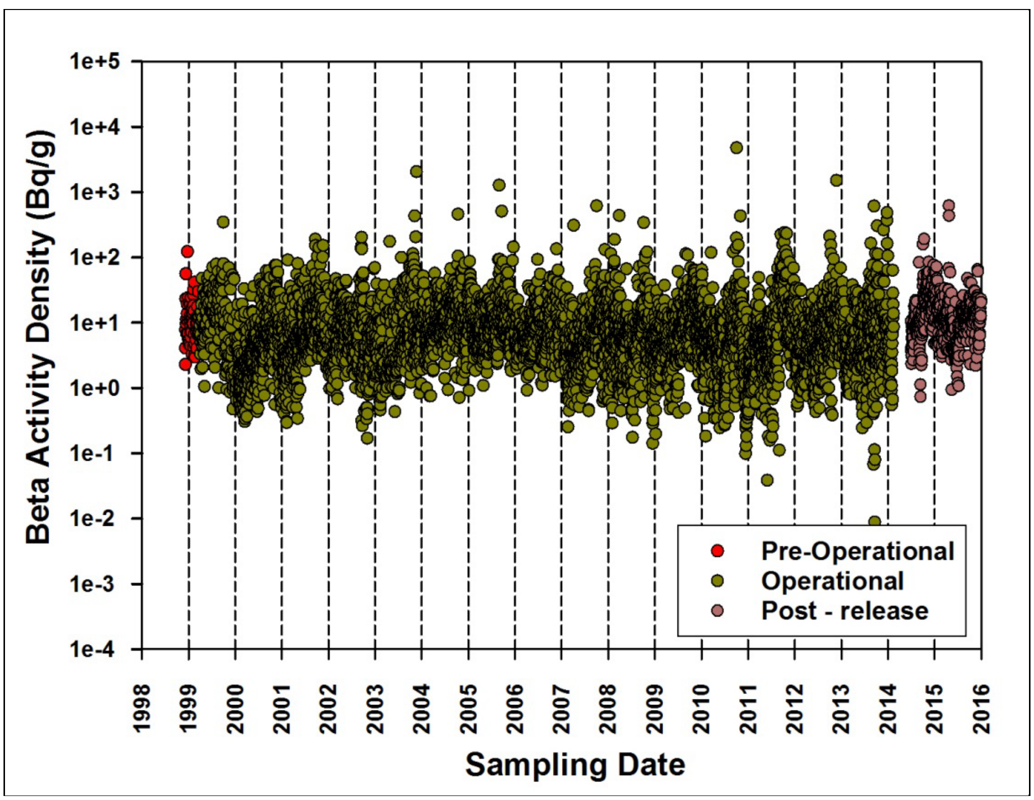


Figure 2-12: Gross Beta Activity Densities measured in Station A filters

Actinide Concentrations in the WIPP's Unfiltered Underground Air (Pre-HEPA, Station A) in 2015

The time series of the activity concentrations of transuranic radionuclides $^{239+240}Pu$ and ^{241}Am measured at Station A (Pre-HEPA filtration) immediately after the release-event are shown in Figures 2-13. The values detected at Station A immediately after the radiation release event were considerably higher than those historically measured for this Station. The maximum air concentrations of americium and plutonium 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. 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.

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 2-1 through 2-3. Trace amounts of ^{241}Am, ^{238}Pu 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 during 2015 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 also 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, 2015. The $^{239+240}Pu$ activity density (activity per unit mass aerosol collected) at Station A was in the range of 0.24-80 Bq/g, while that of ^{241}Am was in the range of 2.05-754 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 2-4 through 2-6.

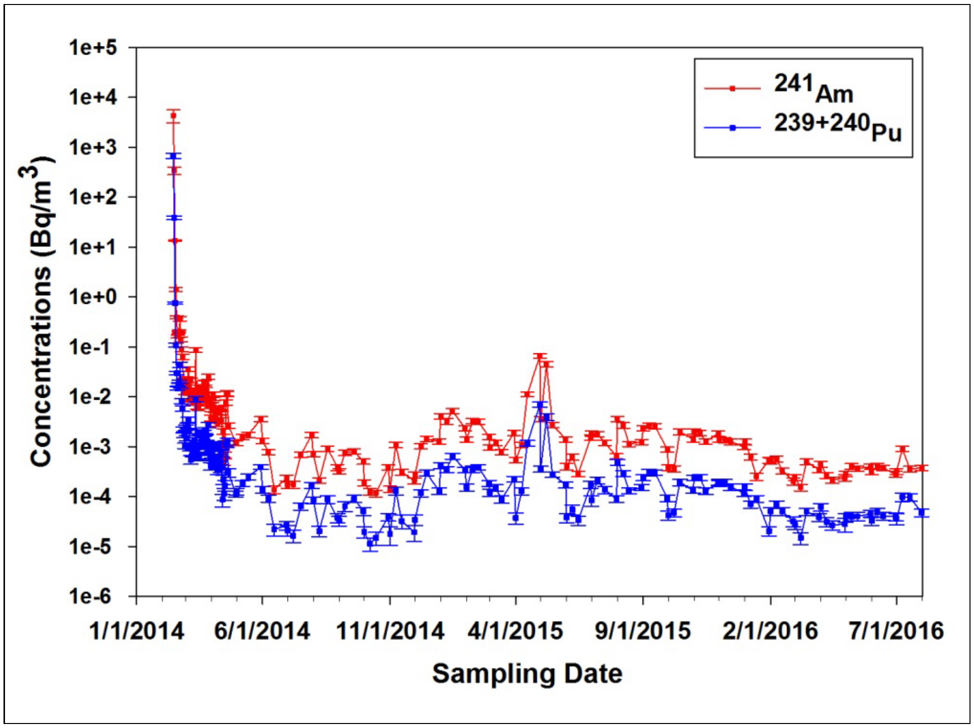


Figure 2-13: Times series of ^{241}Am and $^{239+240}$Pu concentrations in Station A (Pre-HEPA) filters during 2014-2015

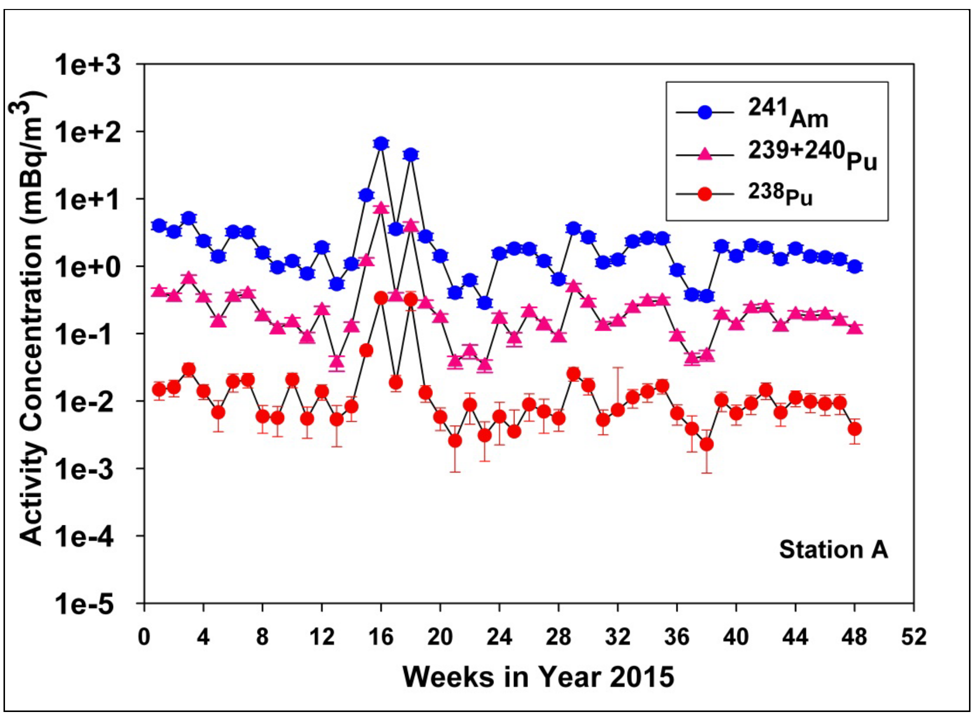


Figure 2-14: The Weekly ^{241}Am, $^{239+240}$Pu and ^{238}Pu concentrations in Station A (Pre-HEPA) filters during 2015

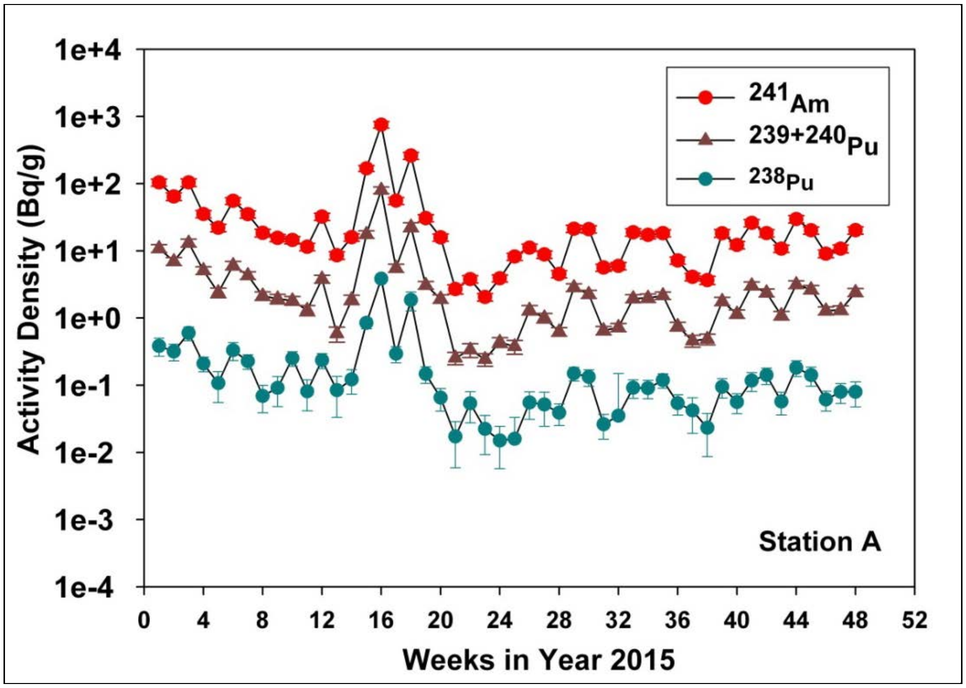


Figure 2-15: The Weekly ^{241}Am, $^{239+240}Pu$ and ^{238}Pu activity density in Station A (Pre-HEPA) filters during 2015.

Gross Alpha and Beta 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, an analysis of Station B filters was performed 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.

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 initially 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, it is expected that 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.

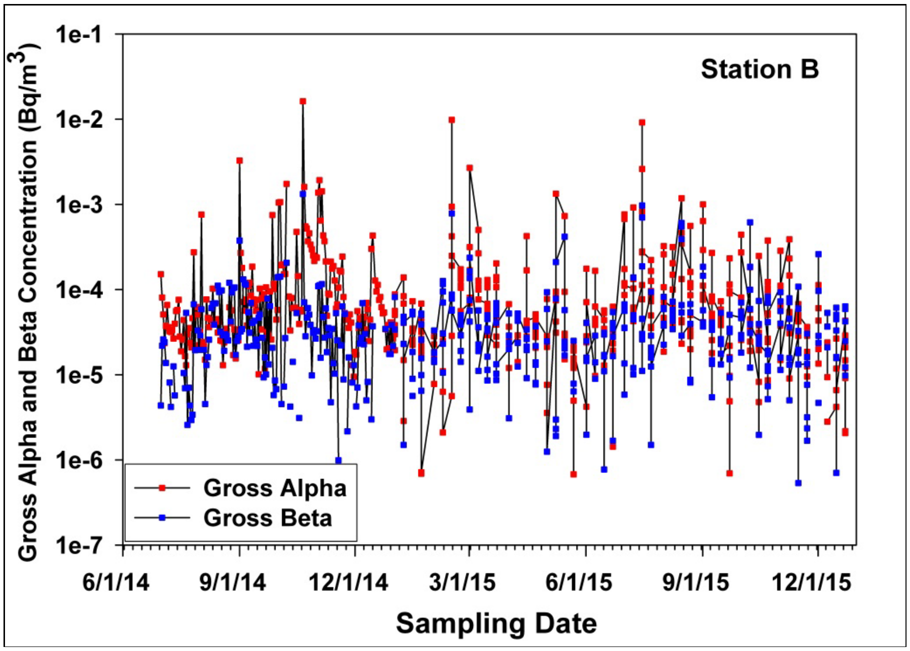


Figure 2-16: Daily Gross Alpha and Gross Beta Activity in the filtered underground air (Station B) during 2014-2015

Actinide concentrations in the WIPP underground Air (Station B, Post-HEPA filter) in 2015

Sampling results from 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, 2014 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, 2014, 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 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 have been performed on weekly composite samples. The activity concentrations of ^{241}Am and $^{239+240}$Pu, in the weekly filters collected from Station B in 2015 is shown in Figure 2-18. The weekly composite filter samples results from Station B are summarized in Tables 2-7 through 2-9.

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 0.082-52.3 Bq/g, while that of ^{241}Am was in the range of 0.83-446 Bq/g. The weekly activity density of ^{241}Am and $^{239+240}Pu$ at Station B are shown in Figure 2-19 and the individual values are summarized in Tables 2-10 through 2-12.

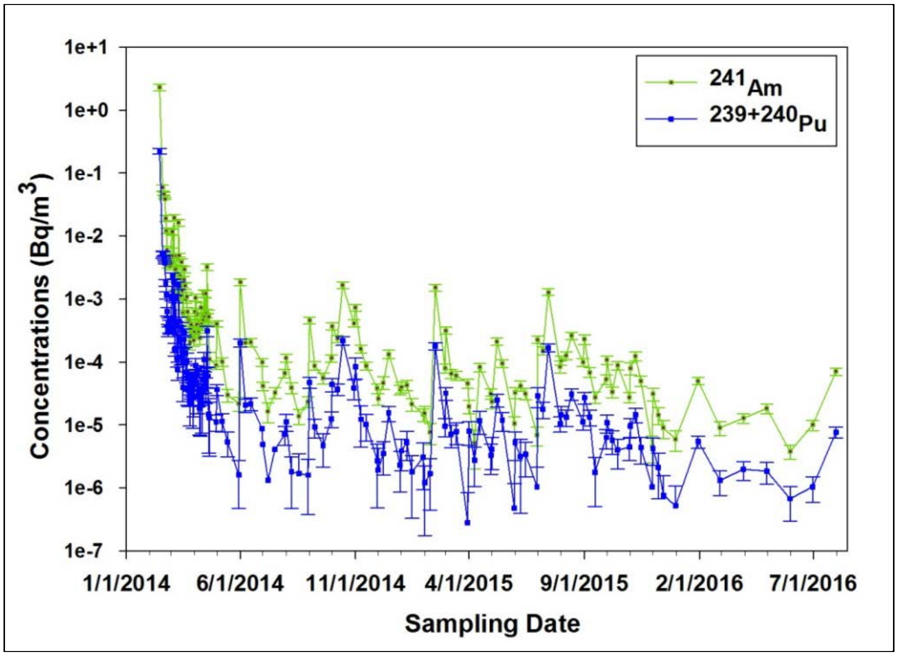


Figure 2-17: Time series of ^{241}Am and $^{239+240}Pu$ concentrations in Station B (Post-HEPA) during 2014-2015

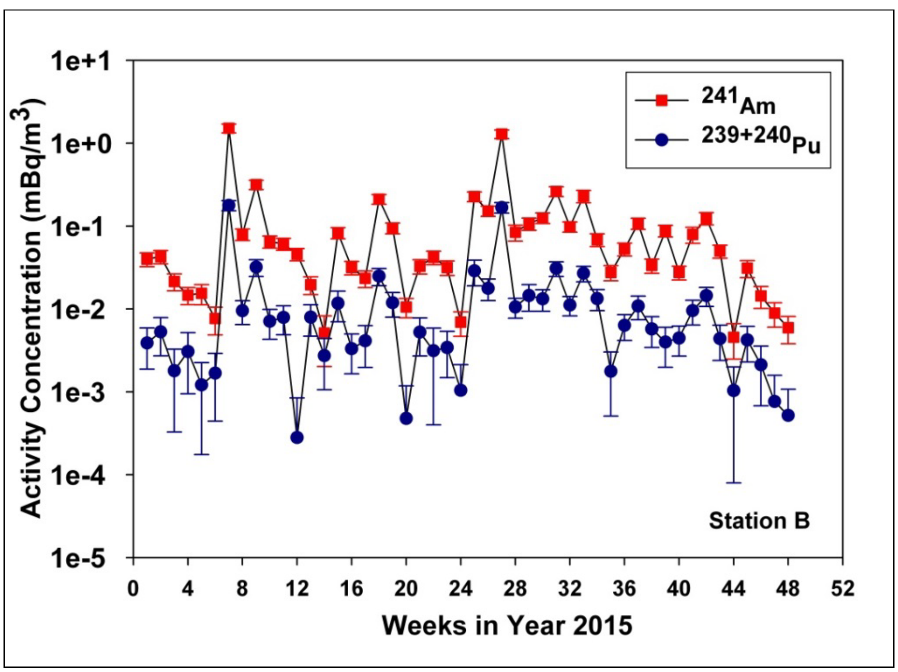


Figure 2-18: The Weekly ^{241}Am and $^{239+240}Pu$ concentrations in Station B (Post-HEPA) filters during 2015

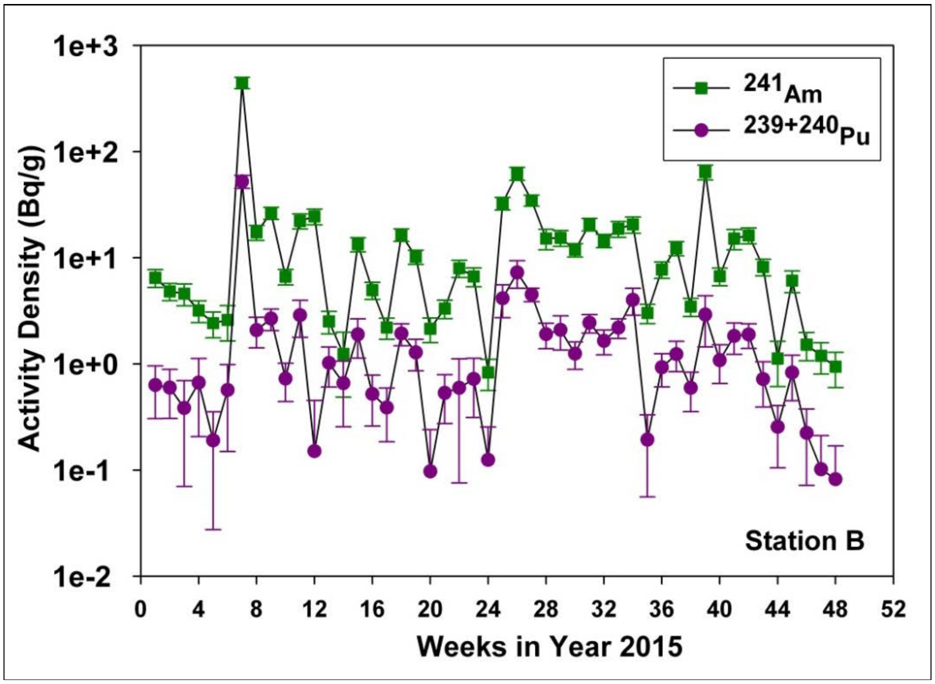


Figure 2-19: The Weekly ^{241}Am, $^{239+240}$Pu and ^{238}Pu activity density in Station B (Post-HEPA) filters during 2015

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.

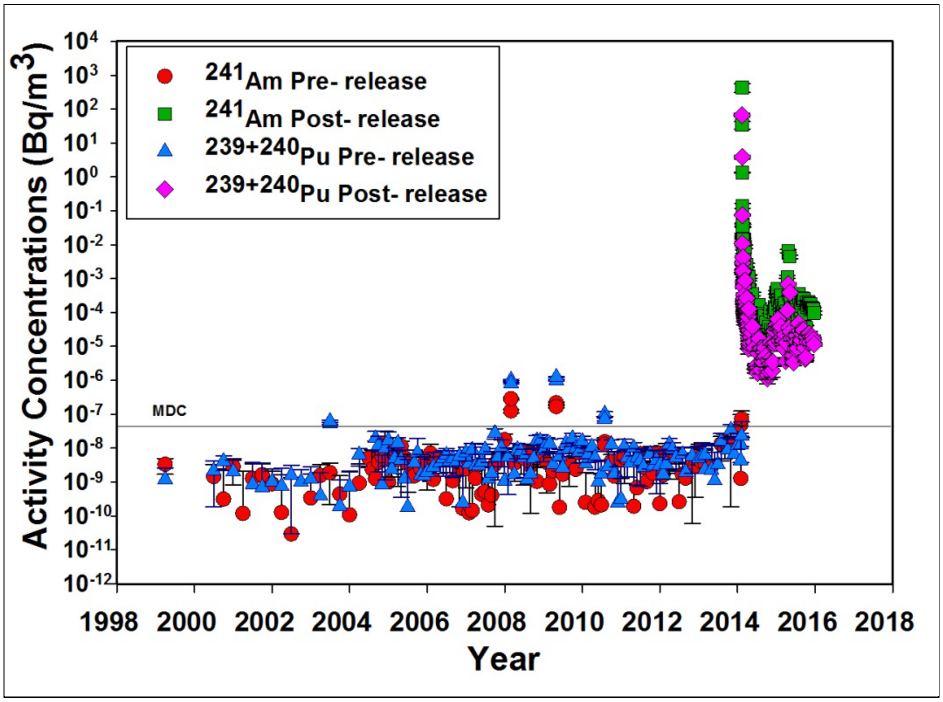


Figure 2-20: Pre- and Post-radiological event of $^{239+240}Pu$ and ^{241}Am concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

Uranium concentrations in the WIPP underground Air (Station A and Station B)

The naturally occurring isotopes of uranium were detected in some monthly composites samples collected from Station A and Station B in 2015. Uranium is naturally occurring radionuclides found in the environment. Thus, the detection of uranium in the WIPP underground air is normal. The highest concentrations detected were 2.91E-6 Bq/m^3 for ^{234}U and 1.13E-6 Bq/m^3 for ^{238}U at Station A and 9.41E-7 Bq/m^3 for ^{234}U and 5.48E-7 Bq/m^3 for ^{238}U at Station B. The ^{235}U was not detected in any of the monthly composite samples in 2015. Where detected, the ^{234}U results were similar to those of ^{238}U for activity concentration and density, indicating secular equilibrium between the two isotopes. These results are consistent with those reported in previous CEMRC reports. The concentrations of uranium isotopes measured in Station A and Station B filter samples are shown in Figures 2-21 through 2-24. The individual concentrations and densities values measured are summarized in Tables 2-13 and 2-14 (Station A) and Tables 2-15 and 2-16 (Station B).

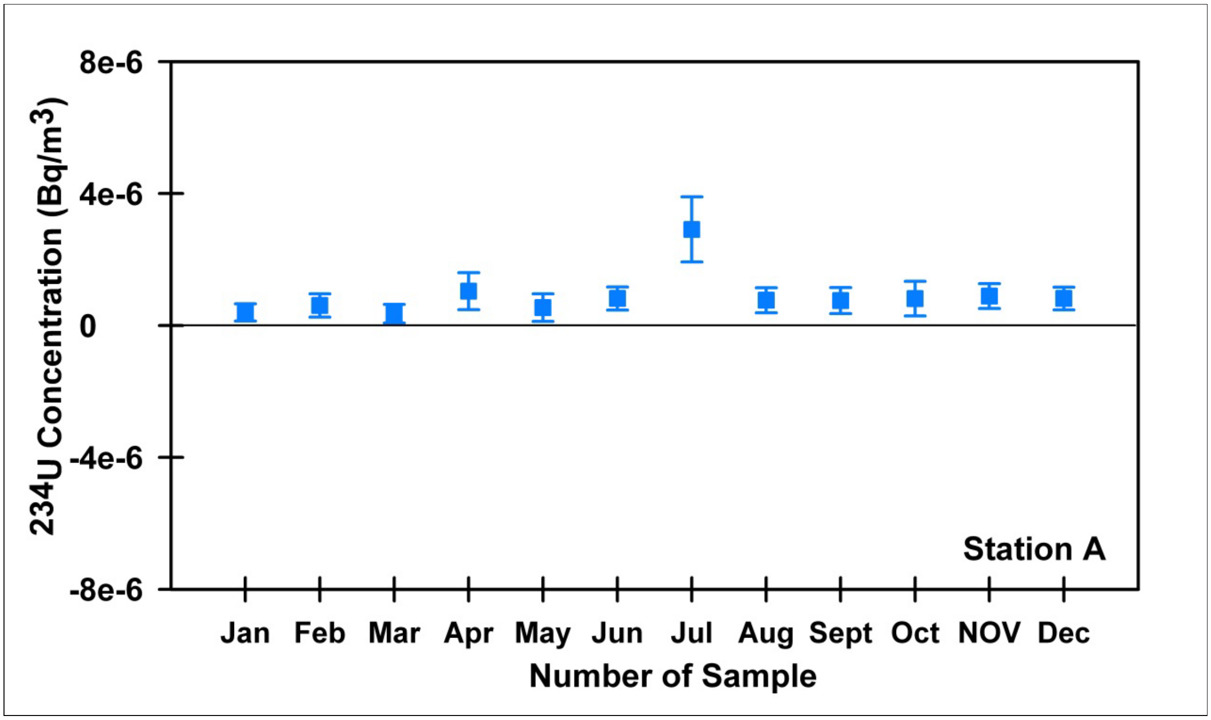


Figure 2-21: The ^{234}U concentrations in the WIPP Exhaust air at Station A (Pre-HEPA) in 2015

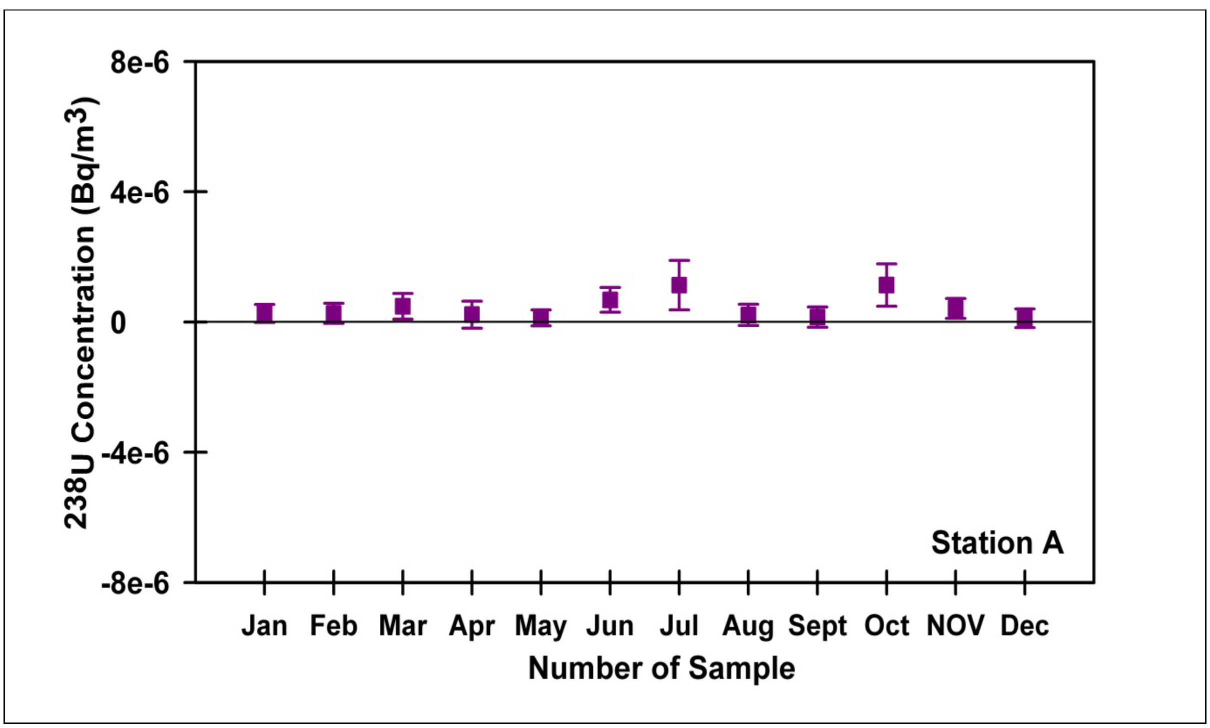


Figure 2-22: The ^{238}U concentrations in the WIPP Exhaust air at Station A (Pre-HEPA) in 2015

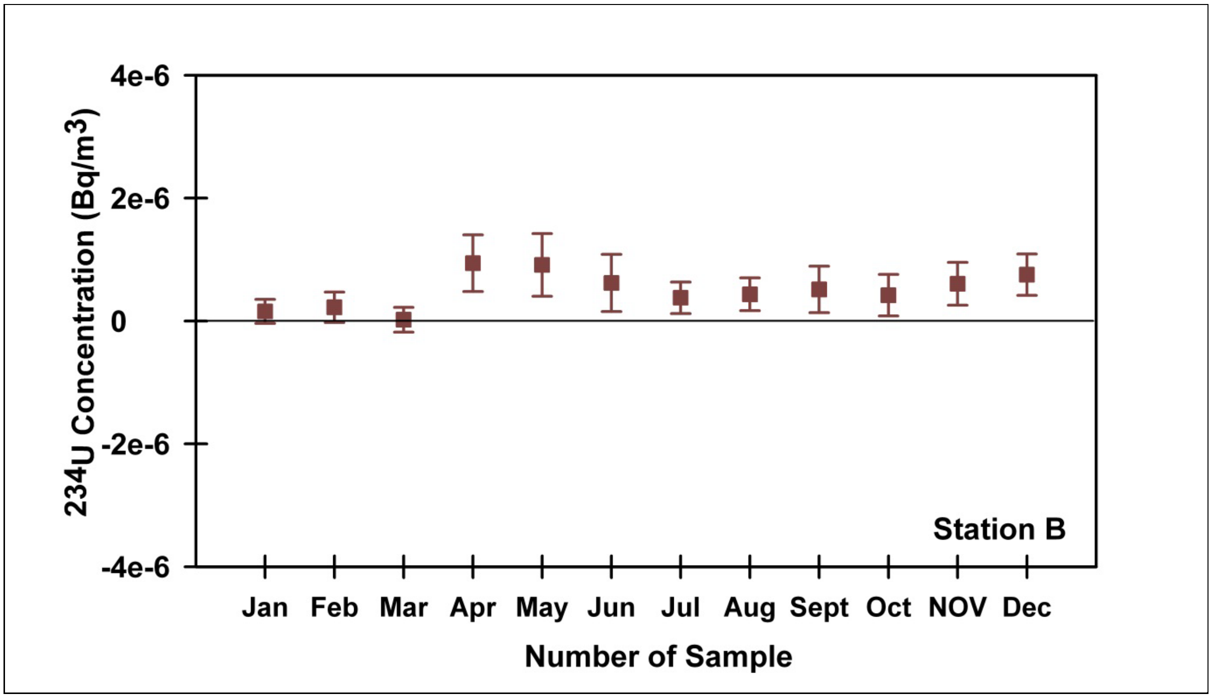


Figure 2-23: The ^{234}U concentrations in the WIPP Exhaust air at Station B (Post-HEPA) in 2015

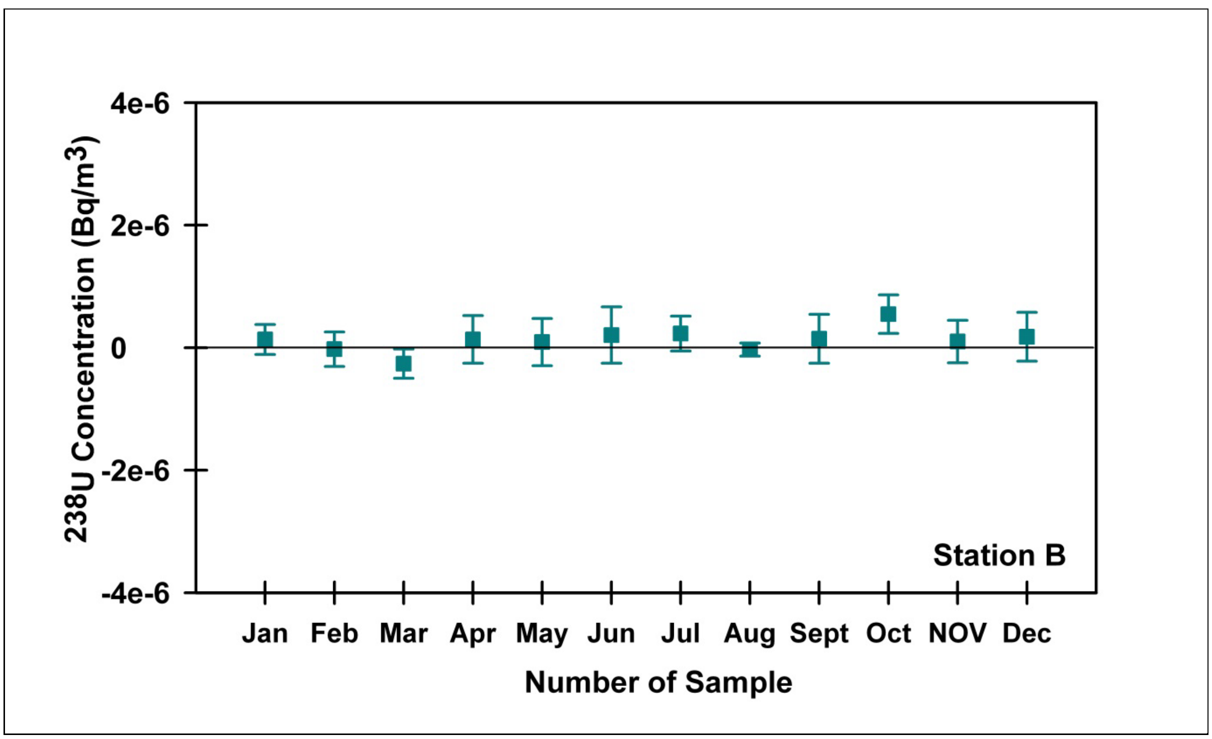


Figure 2-24: The ^{238}U concentrations in the WIPP Exhaust air at Station B (Post-HEPA) in 2015

Gamma radionuclide concentrations in the WIPP underground Air (Station A and Station B)

No detectable gamma-emitting radionuclides were observed in any of the filter samples collected from Station A or Station B in 2015. An analysis of historical operational data indicates detection of ^{137}Cs only once in Station A filter collected on February 14, 2014, 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 2-25 through 2-30. The individual concentrations of these radionuclides measured are summarized in Tables 2-17 through 2-19 (Station A) and Tables 2-20 through 2-22 (Station B). The individual activity densities of these radionuclides are summarized in Tables 2-23 through 2-25 (Station A) and Tables 2-26 through 2-28 (Station B).

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.

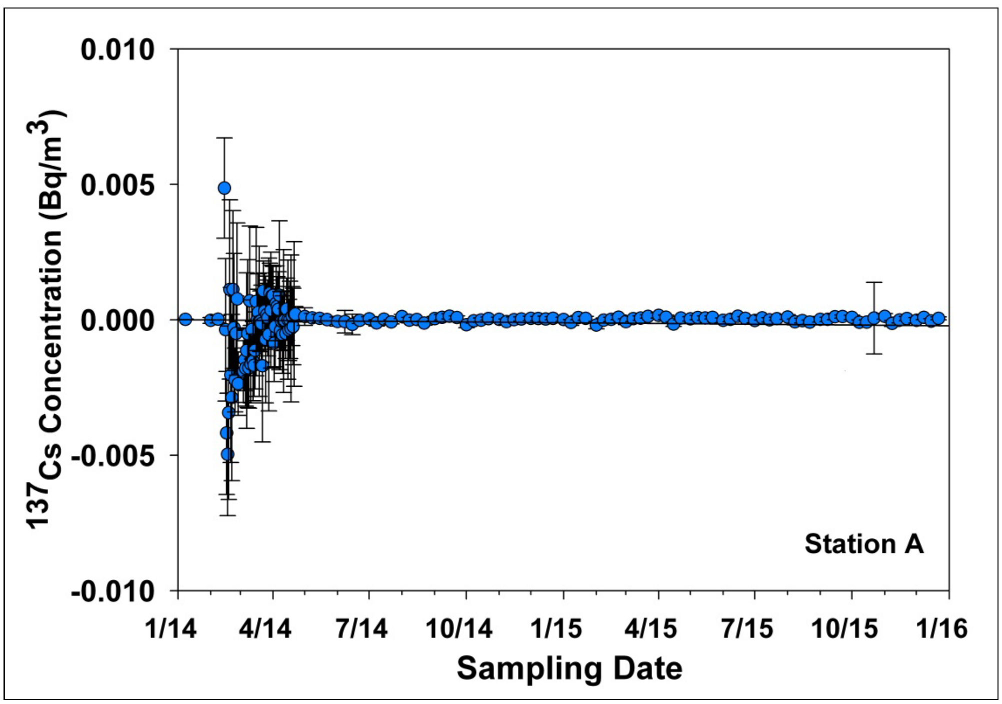


Figure 2-25: The ^{137}Cs concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

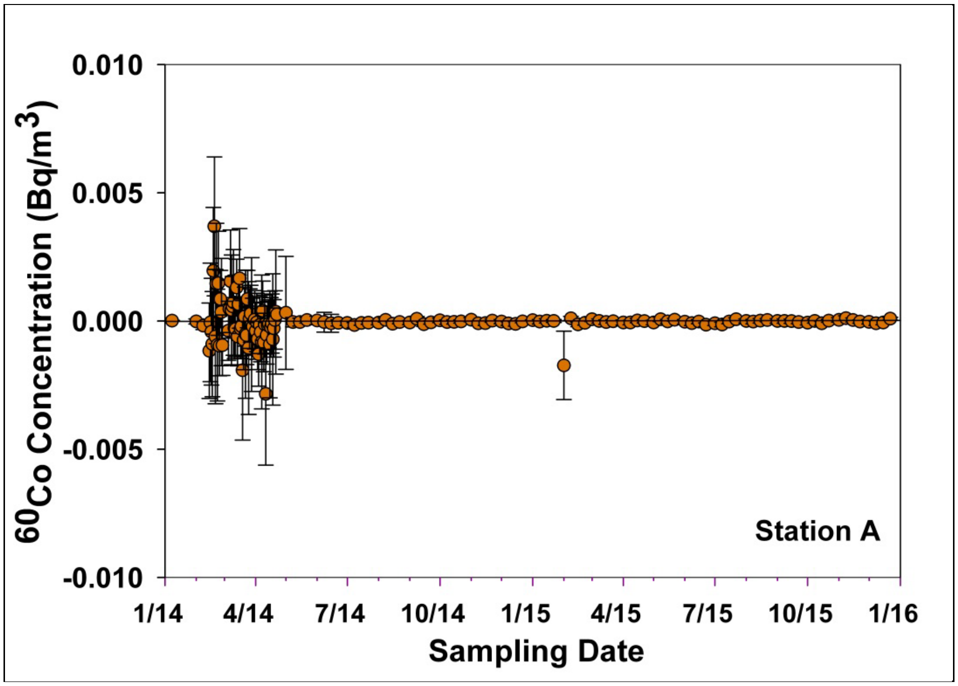


Figure 2-26: The ^{60}Co concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

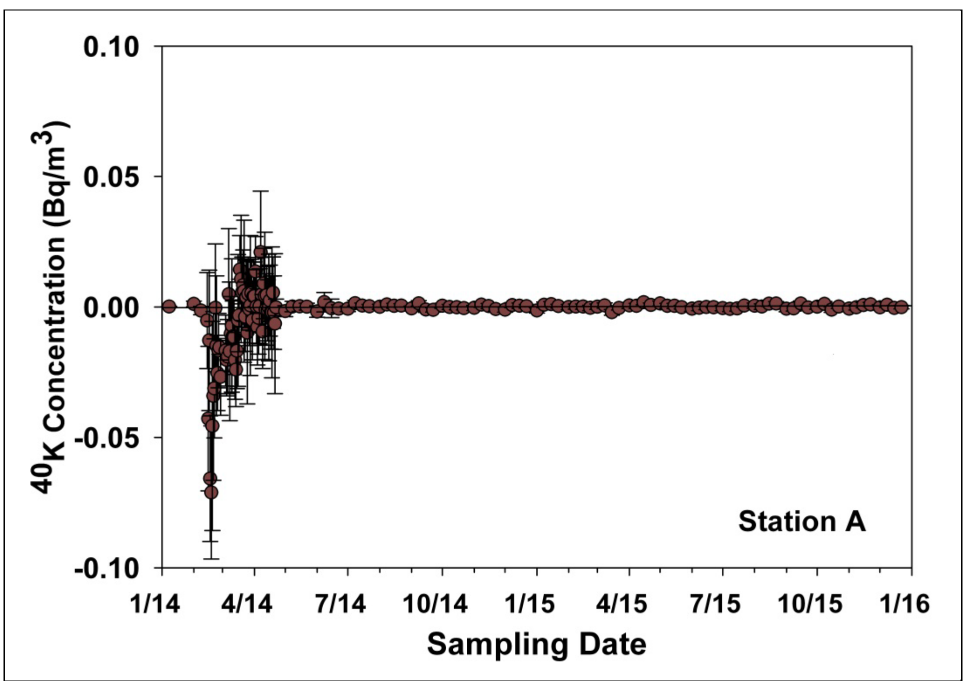


Figure 2-27: The ^{40}K concentrations in the WIPP exhaust air at Station A (Pre-HEPA)

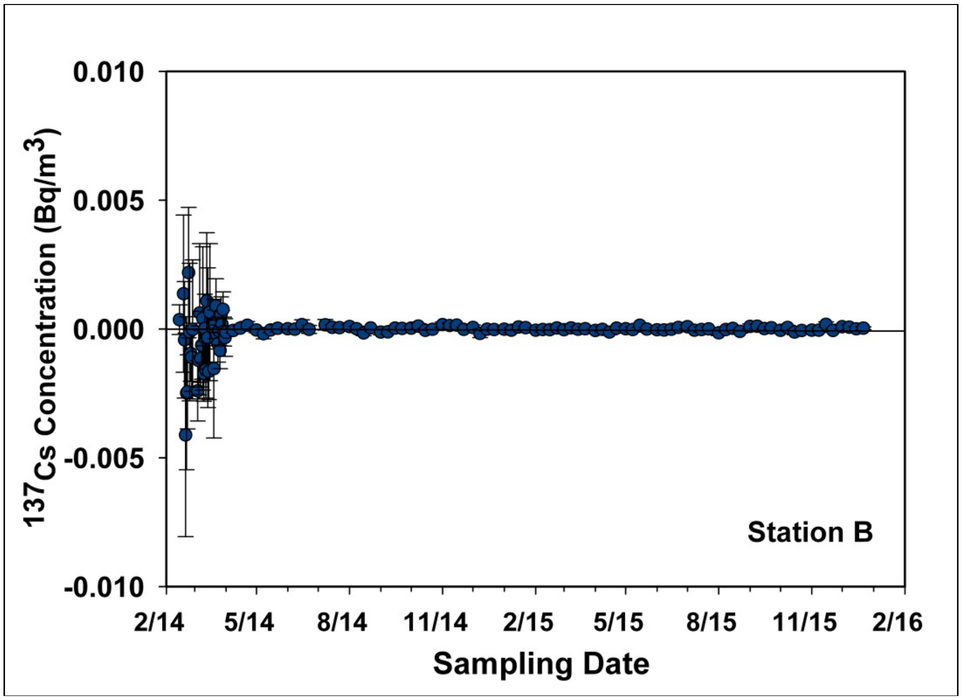


Figure 2-28: The ^{137}Cs concentrations in the WIPP exhaust air at Station B (Post-HEPA)

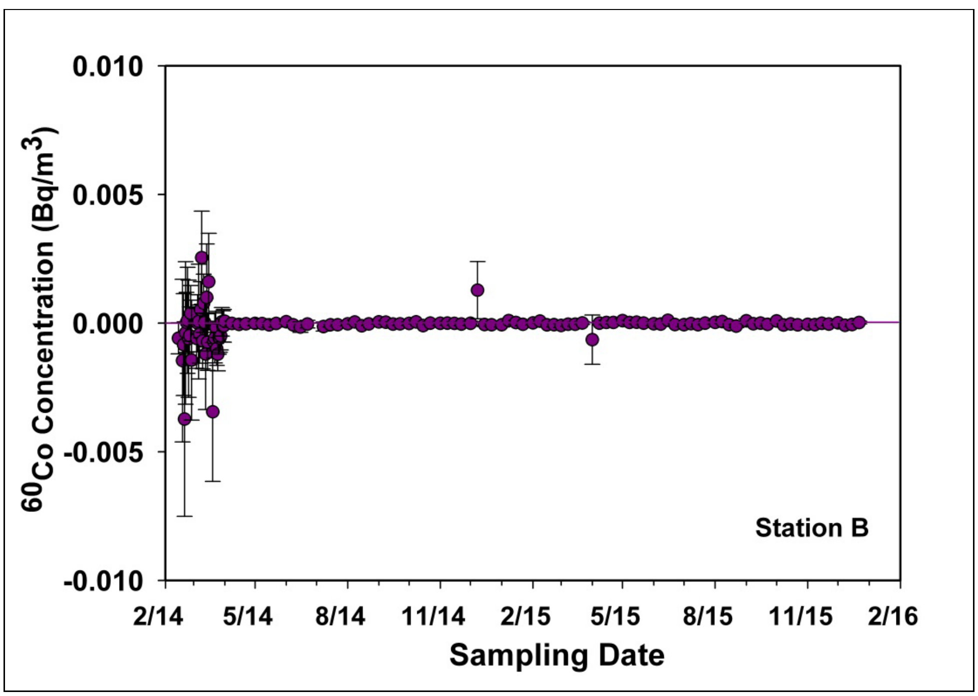


Figure 2-29: The ^{60}Co concentrations in the WIPP exhaust air at Station B (Post-HEPA)

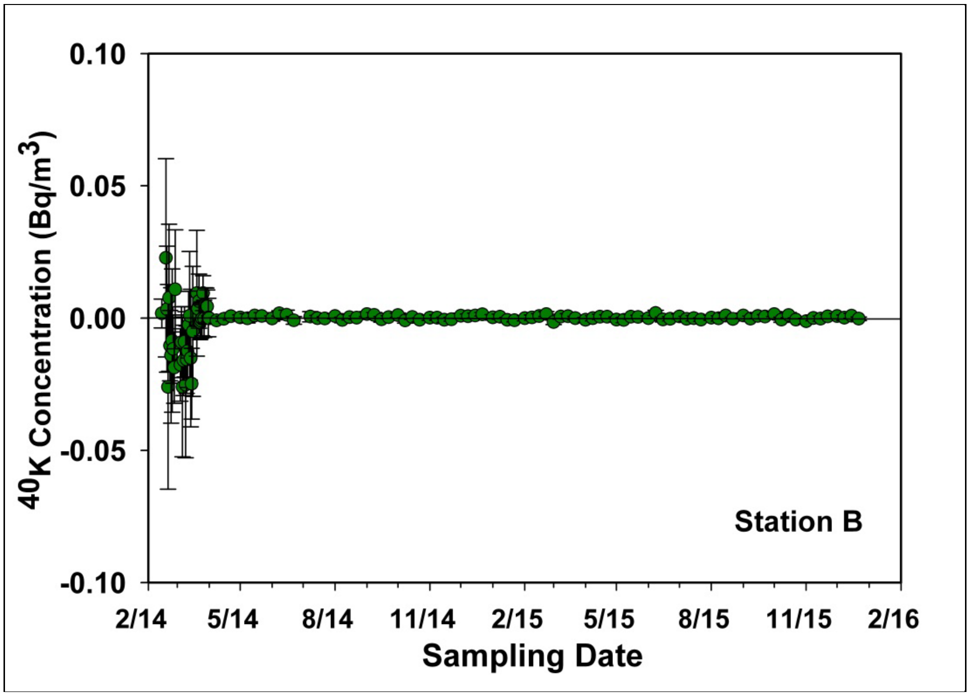


Figure 2-30: The ^{40}K concentrations in the WIPP exhaust air at Station B (Post-HEPA)

Table 2-1: Weekly Activity concentrations of ^{241}Am (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	3.99E-03	4.84E-04	1.36E-06	Detected
2nd week	3.23E-03	4.24E-04	2.71E-06	Detected
3rd week	5.14E-03	6.51E-04	1.83E-06	Detected
4th week	2.36E-03	2.90E-04	1.18E-06	Detected
February 2015				
1st week	1.40E-03	1.82E-04	2.24E-06	Detected
2nd week	3.23E-03	3.86E-04	1.46E-06	Detected
3rd week	3.18E-03	3.82E-04	2.42E-06	Detected
4th week	1.58E-03	2.09E-04	2.87E-06	Detected
March 2015				
1st week	9.63E-04	1.19E-04	1.36E-06	Detected
2nd week	1.19E-03	1.46E-04	1.69E-06	Detected
3rd week	7.78E-04	9.82E-05	1.92E-06	Detected
4th week	1.89E-03	2.36E-04	1.21E-06	Detected

Table 2-1: Weekly Activity concentrations of ^{241}Am (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
April 2015				
1st week	5.43E-04	7.18E-05	2.69E-06	Detected
2nd week	1.08E-03	1.35E-04	1.26E-06	Detected
3rd week	1.13E-02	1.13E-03	1.84E-06	Detected
4th week	6.59E-02	7.37E-03	4.91E-06	Detected
May 2015				
1st week	3.56E-03	4.26E-04	2.01E-06	Detected
2nd week	4.49E-02	5.41E-03	3.62E-05	Detected
3rd week	2.75E-03	3.29E-04	2.10E-06	Detected
4th week	1.41E-03	1.71E-04	1.01E-06	Detected
June 2015				
1st week	4.02E-04	6.24E-05	2.81E-06	Detected
2nd week	6.21E-04	7.86E-05	1.98E-06	Detected
3rd week	2.84E-04	3.69E-05	1.07E-06	Detected
4th week	1.53E-03	1.84E-04	1.01E-06	Detected
July 2015				
1st week	1.82E-03	2.23E-04	1.93E-06	Detected
2nd week	1.80E-03	2.20E-04	1.90E-06	Detected
3rd week	1.20E-03	1.50E-04	1.74E-06	Detected
4th week	6.41E-04	7.93E-05	1.15E-06	Detected
August 2015				
1st week	3.63E-03	4.39E-04	1.82E-06	Detected
2nd week	2.69E-03	3.29E-04	1.99E-06	Detected
3rd week	1.13E-03	1.36E-04	1.23E-06	Detected
4th week	1.25E-03	1.51E-04	7.47E-07	Detected
September 2015				
1st week	2.32E-03	2.90E-04	1.65E-06	Detected
2nd week	2.63E-03	3.31E-04	1.44E-06	Detected
3rd week	2.58E-03	3.11E-04	1.31E-06	Detected
4th week	8.77E-04	1.07E-04	1.53E-06	Detected
October 2015				
1st week	3.78E-04	4.91E-05	1.93E-06	Detected
2nd week	3.60E-04	5.09E-05	1.82E-06	Detected
3rd week	1.97E-03	2.58E-04	3.60E-06	Detected
4th week	1.42E-03	1.78E-04	3.93E-06	Detected

Table 2-1: Weekly Activity concentrations of ^{241}Am (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
November 2015				
1st week	2.03E-03	2.52E-04	2.57E-06	Detected
2nd week	1.88E-03	2.36E-04	2.13E-06	Detected
3rd week	1.27E-03	1.56E-04	1.02E-06	Detected
4th week	1.82E-03	2.30E-04	1.28E-06	Detected
December 2015				
1st week	1.40E-03	1.71E-04	9.30E-07	Detected
2nd week	1.35E-03	1.78E-04	1.38E-06	Detected
3rd week	1.27E-03	1.72E-04	1.84E-06	Detected
4th week	9.86E-04	1.24E-04	9.81E-07	Detected

Table 2-2: Weekly Activity concentrations of $^{239+240}$Pu (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	$^{239+240}$Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	4.17E-04	5.65E-05	1.81E-06	Detected
2nd week	3.50E-04	4.73E-05	1.65E-06	Detected
3rd week	6.48E-04	8.66E-05	2.01E-06	Detected
4th week	3.41E-04	4.39E-05	7.71E-07	Detected
February 2015				
1st week	1.52E-04	2.50E-05	2.61E-06	Detected
2nd week	3.54E-04	5.19E-05	2.25E-06	Detected
3rd week	3.90E-04	5.11E-05	1.65E-06	Detected
4th week	1.84E-04	2.64E-05	1.90E-06	Detected
March 2015				
1st week	1.20E-04	1.95E-05	2.24E-06	Detected
2nd week	1.50E-04	2.20E-05	1.14E-06	Detected
3rd week	8.82E-05	1.53E-05	1.96E-06	Detected
4th week	2.23E-04	3.02E-05	1.14E-06	Detected
April 2015				
1st week	3.69E-05	9.30E-06	2.78E-06	Detected
2nd week	1.28E-04	2.03E-05	1.66E-06	Detected
3rd week	1.18E-03	1.52E-04	1.80E-06	Detected
4th week	6.99E-03	7.84E-04	1.20E-06	Detected

Table 2-2: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
May 2015				
1st week	3.56E-04	4.87E-05	1.80E-06	Detected
2nd week	3.91E-03	5.96E-04	4.26E-05	Detected
3rd week	2.77E-04	3.63E-05	1.21E-06	Detected
4th week	1.72E-04	2.41E-05	8.45E-07	Detected
June 2015				
1st week	3.80E-05	7.97E-06	1.31E-06	Detected
2nd week	5.50E-05	1.27E-05	3.33E-06	Detected
3rd week	3.36E-05	7.06E-06	1.64E-06	Detected
4th week	1.72E-04	2.83E-05	3.75E-06	Detected
July 2015				
1st week	8.36E-05	1.95E-05	6.13E-06	Detected
2nd week	2.12E-04	3.35E-05	2.51E-06	Detected
3rd week	1.37E-04	2.24E-05	2.87E-06	Detected
4th week	8.91E-05	1.31E-05	1.10E-06	Detected
August 2015				
1st week	4.86E-04	6.38E-05	1.18E-06	Detected
2nd week	2.90E-04	4.00E-05	1.49E-06	Detected
3rd week	1.31E-04	1.85E-05	1.13E-06	Detected
4th week	1.52E-04	2.12E-05	9.75E-07	Detected
September 2015				
1st week	2.41E-04	3.28E-05	1.10E-06	Detected
2nd week	3.03E-04	4.31E-05	2.09E-06	Detected
3rd week	3.05E-04	3.90E-05	1.20E-06	Detected
4th week	9.18E-05	1.35E-05	1.16E-06	Detected
October 2015				
1st week	4.24E-05	8.52E-06	1.53E-06	Detected
2nd week	4.77E-05	8.62E-06	1.06E-06	Detected
3rd week	1.93E-04	2.73E-05	1.63E-06	Detected
4th week	1.34E-04	1.89E-05	1.33E-06	Detected
November 2015				
1st week	2.37E-04	3.15E-05	1.68E-06	Detected
2nd week	2.45E-04	3.29E-05	1.31E-06	Detected
3rd week	1.29E-04	1.87E-05	1.20E-06	Detected
4th week	1.93E-04	2.56E-05	9.02E-07	Detected

Table 2-2: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
December 2015				
1st week	1.85E-04	2.58E-05	1.56E-06	Detected
2nd week	1.92E-04	2.66E-05	1.04E-06	Detected
3rd week	1.56E-04	2.24E-05	1.08E-06	Detected
4th week	1.17E-04	1.64E-05	1.03E-06	Detected

Table 2-3: Weekly Activity concentrations of ^{238}Pu (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	1.47E-05	4.45E-06	2.13E-06	Detected
2nd week	1.60E-05	4.45E-06	1.65E-06	Detected
3rd week	2.95E-05	6.83E-06	2.13E-06	Detected
4th week	1.40E-05	3.44E-06	1.64E-06	Detected
February 2015				
1st week	6.80E-06	3.31E-06	2.57E-06	Detected
2nd week	1.94E-05	5.79E-06	2.46E-06	Detected
3rd week	2.06E-05	5.04E-06	1.77E-06	Detected
4th week	5.93E-06	2.60E-06	2.23E-06	Detected
March 2015				
1st week	5.64E-06	2.68E-06	1.70E-06	Detected
2nd week	2.08E-05	5.07E-06	1.66E-06	Detected
3rd week	5.47E-06	2.66E-06	1.74E-06	Detected
4th week	1.38E-05	3.53E-06	8.54E-07	Detected
April 2015				
1st week	5.33E-06	3.23E-06	3.46E-06	Detected
2nd week	8.28E-06	3.30E-06	2.45E-06	Detected
3rd week	5.65E-05	1.03E-05	2.24E-06	Detected
4th week	3.37E-04	4.06E-05	1.22E-06	Detected
May 2015				
1st week	1.88E-05	5.08E-06	1.60E-06	Detected
2nd week	3.20E-04	1.00E-04	4.71E-05	Detected
3rd week	1.32E-05	3.67E-06	1.50E-06	Detected
4th week	5.79E-06	2.14E-06	1.23E-06	Detected

Table 2-3: Weekly Activity concentrations of ^{238}Pu (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
June 2015				
1st week	2.58E-06	1.70E-06	1.31E-06	Detected
2nd week	8.80E-06	4.28E-06	3.33E-06	Detected
3rd week	3.10E-06	1.82E-06	1.46E-06	Detected
4th week	5.90E-06	3.66E-06	3.44E-06	Detected
July 2015				
1st week	3.54E-06	3.86E-06	6.13E-06	Detected
2nd week	8.90E-06	3.89E-06	2.24E-06	Detected
3rd week	6.99E-06	3.67E-06	3.13E-06	Detected
4th week	5.51E-06	1.96E-06	1.10E-06	Detected
August 2015				
1st week	2.55E-05	5.84E-06	1.18E-06	Detected
2nd week	1.70E-05	4.69E-06	1.68E-06	Detected
3rd week	5.26E-06	2.11E-06	1.13E-06	Detected
4th week	7.37E-06	2.39E-05	8.21E-07	Detected
September 2015				
1st week	1.13E-05	3.46E-06	1.46E-06	Detected
2nd week	1.38E-05	4.24E-06	1.59E-06	Detected
3rd week	1.68E-05	4.01E-06	1.07E-06	Detected
4th week	6.59E-06	2.23E-06	1.16E-06	Detected
October 2015				
1st week	3.89E-06	2.12E-06	1.90E-06	Detected
2nd week	2.29E-06	1.43E-06	1.06E-06	Detected
3rd week	1.03E-05	3.31E-06	1.33E-06	Detected
4th week	6.54E-06	2.16E-06	7.60E-07	Detected
November 2015				
1st week	9.17E-06	2.88E-06	9.60E-07	Detected
2nd week	1.45E-05	3.97E-06	1.10E-06	Detected
3rd week	6.74E-06	2.51E-06	1.48E-06	Detected
4th week	1.12E-05	2.94E-06	1.01E-06	Detected
December 2015				
1st week	9.79E-06	3.08E-06	1.56E-06	Detected
2nd week	9.13E-06	3.01E-06	1.62E-06	Detected
3rd week	9.39E-06	3.10E-06	1.44E-06	Detected
4th week	3.86E-06	1.56E-06	8.32E-07	Detected

Table 2-4: Weekly Activity density of ^{241}Am (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	1.04E+02	1.26E+01	3.56E-02	Detected
2nd week	6.44E+01	8.45E+00	5.40E-02	Detected
3rd week	1.04E+02	1.32E+01	3.72E-02	Detected
4th week	3.53E+01	4.34E+00	1.77E-02	Detected
February 2015				
1st week	2.20E+01	2.87E+00	3.54E-02	Detected
2nd week	5.53E+01	6.60E+00	2.49E-02	Detected
3rd week	3.50E+01	4.21E+00	2.67E-02	Detected
4th week	1.85E+01	2.43E+00	3.34E-02	Detected
March 2015				
1st week	1.56E+01	1.93E+00	2.21E-02	Detected
2nd week	1.45E+01	1.76E+00	2.05E-02	Detected
3rd week	1.15E+01	1.45E+00	2.84E-02	Detected
4th week	3.23E+01	4.02E+00	2.07E-02	Detected
April 2015				
1st week	8.59E+00	1.14E+00	4.26E-02	Detected
2nd week	1.59E+01	1.99E+00	1.85E-02	Detected
3rd week	1.69E+02	1.69E+01	2.75E-02	Detected
4th week	7.54E+02	8.43E+01	5.62E-02	Detected
May 2015				
1st week	5.57E+01	6.67E+00	3.15E-02	Detected
2nd week	2.61E+02	3.14E+01	2.11E-01	Detected
3rd week	3.06E+01	3.66E+00	2.33E-02	Detected
4th week	1.59E+01	1.92E+00	1.14E-02	Detected
June 2015				
1st week	2.69E+00	4.18E-01	1.88E-02	Detected
2nd week	3.79E+00	4.80E-01	1.21E-02	Detected
3rd week	2.05E+00	2.66E-01	7.73E-03	Detected
4th week	3.91E+00	4.68E-01	2.58E-03	Detected
July 2015				
1st week	8.21E+00	1.01E+00	8.68E-03	Detected
2nd week	1.12E+01	1.36E+00	1.18E-02	Detected
3rd week	8.82E+00	1.10E+00	1.28E-02	Detected
4th week	4.52E+00	5.59E-01	8.12E-03	Detected

Table 2-4: Weekly Activity density of ^{241}Am (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	2.13E+01	2.58E+00	1.07E-02	Detected
2nd week	2.10E+01	2.58E+00	1.56E-02	Detected
3rd week	5.65E+00	6.77E-01	6.12E-03	Detected
4th week	5.96E+00	7.24E-01	3.57E-03	Detected
September 2015				
1st week	1.88E+01	2.35E+00	1.33E-02	Detected
2nd week	1.72E+01	2.17E+00	9.42E-03	Detected
3rd week	1.83E+01	2.21E+00	9.26E-03	Detected
4th week	7.19E+00	8.80E-01	1.25E-02	Detected
October 2015				
1st week	4.10E+00	5.33E-01	2.09E-02	Detected
2nd week	3.66E+00	5.17E-01	1.85E-02	Detected
3rd week	1.82E+01	2.39E+00	3.33E-02	Detected
4th week	1.22E+01	1.53E+00	3.37E-02	Detected
November 2015				
1st week	2.60E+01	3.22E+00	3.28E-02	Detected
2nd week	1.83E+01	2.30E+00	2.07E-02	Detected
3rd week	1.08E+01	1.33E+00	8.62E-03	Detected
4th week	2.97E+01	3.76E+00	2.08E-02	Detected
December 2015				
1st week	2.02E+01	2.47E+00	1.34E-02	Detected
2nd week	9.08E+00	1.19E+00	9.27E-03	Detected
3rd week	1.08E+01	1.45E+00	1.56E-02	Detected
4th week	2.03E+01	2.54E+00	2.02E-02	Detected

Table 2-5: Weekly Activity density of $^{239+240}Pu$ (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	1.09E+01	1.48E+00	4.73E-02	Detected
2nd week	6.98E+00	9.42E-01	3.29E-02	Detected
3rd week	1.31E+01	1.75E+00	4.07E-02	Detected
4th week	5.11E+00	6.58E-01	1.16E-02	Detected
February 2015				
1st week	2.40E+00	3.95E-01	4.11E-02	Detected
2nd week	6.06E+00	8.89E-01	3.85E-02	Detected
3rd week	4.29E+00	5.63E-01	1.82E-02	Detected
4th week	2.14E+00	3.07E-01	2.21E-02	Detected
March 2015				
1st week	1.94E+00	3.15E-01	3.63E-02	Detected
2nd week	1.81E+00	2.66E-01	1.38E-02	Detected
3rd week	1.30E+00	2.25E-01	2.89E-02	Detected
4th week	3.81E+00	5.15E-01	1.95E-02	Detected
April 2015				
1st week	5.84E-01	1.47E-01	4.40E-02	Detected
2nd week	1.88E+00	2.98E-01	2.44E-02	Detected
3rd week	1.76E+01	2.27E+00	2.68E-02	Detected
4th week	8.00E+01	8.97E+00	1.37E-02	Detected
May 2015				
1st week	5.57E+00	7.63E-01	2.81E-02	Detected
2nd week	2.27E+01	3.47E+00	2.47E-01	Detected
3rd week	3.09E+00	4.05E-01	1.34E-02	Detected
4th week	1.93E+00	2.71E-01	9.49E-03	Detected
June 2015				
1st week	2.54E-01	5.33E-02	8.78E-03	Detected
2nd week	3.36E-01	7.77E-02	2.03E-02	Detected
3rd week	2.42E-01	5.09E-02	1.18E-02	Detected
4th week	4.38E-01	7.20E-02	9.55E-03	Detected
July 2015				
1st week	3.77E-01	8.79E-02	2.76E-02	Detected
2nd week	1.32E+00	2.08E-01	1.56E-02	Detected
3rd week	1.01E+00	1.65E-01	2.12E-02	Detected
4th week	6.27E-01	9.23E-02	7.73E-03	Detected

Table 2-5: Weekly Activity density of $^{239+240}Pu$ (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	2.86E+00	3.75E-01	6.93E-03	Detected
2nd week	2.27E+00	3.13E-01	1.17E-02	Detected
3rd week	6.53E-01	9.22E-02	5.63E-03	Detected
4th week	7.26E-01	1.01E-01	4.66E-03	Detected
September 2015				
1st week	1.95E+00	2.66E-01	8.88E-03	Detected
2nd week	1.98E+00	2.82E-01	1.37E-02	Detected
3rd week	2.16E+00	2.77E-01	8.53E-03	Detected
4th week	7.53E-01	1.11E-01	9.54E-03	Detected
October 2015				
1st week	4.60E-01	9.23E-02	1.66E-02	Detected
2nd week	4.85E-01	8.76E-02	1.07E-02	Detected
3rd week	1.78E+00	2.52E-01	1.51E-02	Detected
4th week	1.15E+00	1.62E-01	1.14E-02	Detected
November 2015				
1st week	3.03E+00	4.03E-01	2.15E-02	Detected
2nd week	2.38E+00	3.21E-01	1.27E-02	Detected
3rd week	1.09E+00	1.59E-01	1.02E-02	Detected
4th week	3.16E+00	4.18E-01	1.47E-02	Detected
December 2015				
1st week	2.67E+00	3.72E-01	2.25E-02	Detected
2nd week	1.29E+00	1.78E-01	6.94E-03	Detected
3rd week	1.32E+00	1.90E-01	9.16E-03	Detected
4th week	2.42E+00	3.37E-01	2.12E-02	Detected

Table 2-6: Weekly Activity density of ^{238}Pu (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	3.85E-01	1.16E-01	5.55E-02	Detected
2nd week	3.18E-01	8.87E-02	3.29E-02	Detected
3rd week	5.98E-01	1.38E-01	4.32E-02	Detected
4th week	2.10E-01	5.15E-02	2.45E-02	Detected
February 2015				
1st week	1.07E-01	5.22E-02	4.06E-02	Detected
2nd week	3.31E-01	9.91E-02	4.21E-02	Detected
3rd week	2.27E-01	5.55E-02	1.95E-02	Detected
4th week	6.91E-02	3.03E-02	2.59E-02	Detected
March 2015				
1st week	9.14E-02	4.33E-02	2.76E-02	Detected
2nd week	2.52E-01	6.15E-02	2.01E-02	Detected
3rd week	8.08E-02	3.94E-02	2.58E-02	Detected
4th week	2.36E-01	6.02E-02	1.46E-02	Detected
April 2015				
1st week	8.43E-02	5.11E-02	5.48E-02	Detected
2nd week	1.22E-01	4.86E-02	3.60E-02	Detected
3rd week	8.44E-01	1.53E-01	3.34E-02	Detected
4th week	3.86E+00	4.64E-01	1.39E-02	Detected
May 2015				
1st week	2.94E-01	7.96E-02	2.51E-02	Detected
2nd week	1.86E+00	5.82E-01	2.74E-01	Detected
3rd week	1.47E-01	4.08E-02	1.67E-02	Detected
4th week	6.50E-02	2.40E-02	1.38E-02	Detected
June 2015				
1st week	1.73E-02	1.14E-02	8.78E-03	Detected
2nd week	5.37E-02	2.61E-02	2.03E-02	Detected
3rd week	2.24E-02	1.31E-02	1.05E-02	Detected
4th week	1.50E-02	9.33E-03	8.75E-03	Detected
July 2015				
1st week	1.60E-02	1.74E-02	2.76E-02	Detected
2nd week	5.52E-02	2.41E-02	1.39E-02	Detected
3rd week	5.16E-02	2.71E-02	2.31E-02	Detected
4th week	3.88E-02	1.38E-02	7.73E-03	Detected

Table 2-6: Weekly Activity density of ^{238}Pu (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	1.50E-01	3.43E-02	6.93E-03	Detected
2nd week	1.33E-01	3.67E-02	1.31E-02	Detected
3rd week	2.62E-02	1.05E-02	5.63E-03	Detected
4th week	3.52E-02	1.14E-01	3.92E-03	Detected
September 2015				
1st week	9.17E-02	2.81E-02	1.19E-02	Detected
2nd week	9.04E-02	2.78E-02	1.04E-02	Detected
3rd week	1.19E-01	2.84E-02	7.61E-03	Detected
4th week	5.40E-02	1.82E-02	9.54E-03	Detected
October 2015				
1st week	4.21E-02	2.30E-02	2.06E-02	Detected
2nd week	2.32E-02	1.46E-02	1.07E-02	Detected
3rd week	9.48E-02	3.06E-02	1.23E-02	Detected
4th week	5.62E-02	1.85E-02	6.53E-03	Detected
November 2015				
1st week	1.17E-01	3.68E-02	1.23E-02	Detected
2nd week	1.41E-01	3.87E-02	1.07E-02	Detected
3rd week	5.72E-02	2.13E-02	1.25E-02	Detected
4th week	1.82E-01	4.81E-02	1.66E-02	Detected
December 2015				
1st week	1.41E-01	4.44E-02	2.25E-02	Detected
2nd week	6.13E-02	2.02E-02	1.09E-02	Detected
3rd week	7.96E-02	2.63E-02	1.22E-02	Detected
4th week	7.95E-02	3.21E-02	1.71E-02	Detected

Table 2-7: Weekly Activity concentrations of ^{241}Am (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	4.00E-05	7.58E-06	1.29E-06	Detected
2nd week	4.29E-05	7.83E-06	1.23E-06	Detected
3rd week	2.15E-05	4.98E-06	1.50E-06	Detected
4th week	1.47E-05	3.40E-06	9.47E-07	Detected
February 2015				
1st week	1.55E-05	4.21E-06	1.62E-06	Detected
2nd week	7.69E-06	2.82E-06	1.63E-06	Detected
3rd week	1.52E-03	1.87E-04	1.53E-06	Detected
4th week	7.96E-05	1.27E-05	1.56E-06	Detected
March 2015				
1st week	3.16E-04	4.08E-05	1.38E-06	Detected
2nd week	6.50E-05	1.08E-05	1.37E-06	Detected
3rd week	6.11E-05	9.90E-06	1.23E-06	Detected
4th week	4.59E-05	7.76E-06	9.13E-07	Detected
April 2015				
1st week	1.96E-05	4.69E-06	1.93E-06	Detected
2nd week	5.15E-06	3.12E-06	3.07E-06	Detected
3rd week	8.29E-05	1.27E-05	1.27E-06	Detected
4th week	3.16E-05	5.85E-06	1.41E-06	Detected
May 2015				
1st week	2.34E-05	5.29E-06	1.54E-06	Detected
2nd week	2.12E-04	2.84E-05	1.68E-06	Detected
3rd week	9.47E-05	1.42E-05	1.42E-06	Detected
4th week	1.06E-05	2.77E-06	7.16E-07	Detected
June 2015				
1st week	3.28E-05	6.48E-06	1.46E-06	Detected
2nd week	4.20E-05	7.74E-06	1.02E-06	Detected
3rd week	3.16E-05	6.34E-06	1.21E-06	Detected
4th week	6.96E-06	2.27E-06	1.16E-06	Detected
July 2015				
1st week	2.27E-04	3.06E-05	1.73E-06	Detected
2nd week	1.52E-04	2.15E-05	1.58E-06	Detected
3rd week	1.29E-03	1.55E-04	1.48E-06	Detected
4th week	8.44E-05	1.85E-05	5.45E-06	Detected

Table 2-7: Weekly Activity concentrations of ^{241}Am (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{241}Am Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	1.07E-04	1.81E-05	2.99E-06	Detected
2nd week	1.26E-04	1.81E-05	1.71E-06	Detected
3rd week	2.62E-04	3.51E-05	1.60E-06	Detected
4th week	9.83E-05	1.39E-05	6.98E-07	Detected
September 2015				
1st week	2.30E-04	3.92E-05	3.23E-06	Detected
2nd week	6.87E-05	1.19E-05	1.61E-06	Detected
3rd week	2.76E-05	5.72E-06	1.30E-06	Detected
4th week	5.30E-05	9.27E-06	9.85E-07	Detected
October 2015				
1st week	1.08E-04	1.65E-05	1.61E-06	Detected
2nd week	3.35E-05	6.56E-06	1.55E-06	Detected
3rd week	8.79E-05	1.40E-05	1.13E-06	Detected
4th week	2.76E-05	5.19E-06	8.43E-07	Detected
November 2015				
1st week	7.94E-05	1.72E-05	4.21E-06	Detected
2nd week	1.24E-04	2.12E-05	2.96E-06	Detected
3rd week	5.01E-05	8.95E-06	1.08E-06	Detected
4th week	4.57E-06	2.08E-06	1.53E-06	Detected
December 2015				
1st week	3.11E-05	7.24E-06	1.91E-06	Detected
2nd week	1.44E-05	4.27E-06	1.70E-06	Detected
3rd week	8.96E-06	2.93E-06	1.02E-06	Detected
4th week	5.96E-06	2.16E-06	8.53E-07	Detected

Table 2-8: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	3.89E-06	2.01E-06	1.57E-06	Detected
2nd week	5.30E-06	2.58E-06	2.05E-06	Detected
3rd week	1.80E-06	1.47E-06	1.62E-06	Detected
4th week	3.07E-06	2.12E-06	2.17E-06	Detected
February 2015				
1st week	1.22E-06	1.04E-06	1.05E-06	Detected
2nd week	1.68E-06	1.24E-06	1.08E-06	Detected
3rd week	1.78E-04	2.46E-05	1.55E-06	Detected
4th week	9.55E-06	3.04E-06	1.21E-06	Detected
March 2015				
1st week	3.20E-05	7.36E-06	2.05E-06	Detected
2nd week	7.11E-06	2.79E-06	1.75E-06	Detected
3rd week	7.90E-06	3.01E-06	1.82E-06	Detected
4th week	2.82E-07	5.65E-07	1.30E-06	Detected
April 2015				
1st week	7.96E-06	3.25E-06	1.93E-06	Detected
2nd week	2.74E-06	1.67E-06	1.40E-06	Detected
3rd week	1.17E-05	4.72E-06	2.97E-06	Detected
4th week	3.32E-06	1.67E-06	1.36E-06	Detected
May 2015				
1st week	4.13E-06	2.17E-06	1.31E-06	Detected
2nd week	2.49E-05	5.85E-06	1.63E-06	Detected
3rd week	1.19E-05	3.93E-06	1.36E-06	Detected
4th week	4.79E-07	7.06E-07	1.32E-06	Not Detected
June 2015				
1st week	5.26E-06	2.55E-06	1.98E-06	Detected
2nd week	3.14E-06	2.74E-06	3.68E-06	Not Detected
3rd week	3.42E-06	1.94E-06	1.80E-06	Detected
4th week	1.04E-06	1.08E-06	1.58E-06	Not Detected
July 2015				
1st week	2.89E-05	9.91E-06	4.23E-06	Detected
2nd week	1.78E-05	5.14E-06	2.11E-06	Detected
3rd week	1.68E-04	2.43E-05	1.75E-06	Detected
4th week	1.06E-05	2.84E-06	7.44E-07	Detected

Table 2-8: Weekly Activity concentrations of $^{239+240}Pu$ (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	1.45E-05	5.17E-06	2.62E-06	Detected
2nd week	1.32E-05	3.84E-06	1.34E-06	Detected
3rd week	3.09E-05	6.18E-06	1.44E-06	Detected
4th week	1.12E-05	2.94E-06	7.46E-07	Detected
September 2015				
1st week	2.70E-05	5.68E-06	1.18E-06	Detected
2nd week	1.34E-05	3.79E-06	1.08E-06	Detected
3rd week	1.77E-06	1.26E-06	1.22E-06	Detected
4th week	6.35E-06	2.19E-06	8.17E-07	Detected
October 2015				
1st week	1.09E-05	3.45E-06	1.16E-06	Detected
2nd week	5.75E-06	2.32E-06	1.24E-06	Detected
3rd week	3.99E-06	2.01E-06	2.09E-06	Detected
4th week	4.46E-06	1.76E-06	1.11E-06	Detected
November 2015				
1st week	9.58E-06	3.16E-06	2.11E-06	Detected
2nd week	1.45E-05	3.77E-06	1.40E-06	Detected
3rd week	4.39E-06	2.00E-06	1.36E-06	Detected
4th week	1.04E-06	9.58E-07	1.28E-06	Not Detected
December 2015				
1st week	4.24E-06	1.94E-06	1.02E-06	Detected
2nd week	2.12E-06	1.44E-06	1.65E-06	Detected
3rd week	7.66E-07	8.17E-07	1.01E-06	Not Detected
4th week	5.20E-07	5.53E-07	6.82E-07	Not Detected

Table 2-9: Weekly Activity concentrations of ^{238}Pu (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	-4.71E-08	4.82E-07	1.18E-06	Not Detected
2nd week	-2.23E-07	6.01E-07	2.03E-06	Not Detected
3rd week	3.27E-07	8.03E-07	1.98E-06	Not Detected
4th week	1.04E-06	1.34E-06	2.36E-06	Not Detected
February 2015				
1st week	0.00E+00	4.58E-07	1.64E-06	Not Detected
2nd week	-8.64E-08	4.88E-07	1.89E-06	Not Detected
3rd week	7.00E-06	2.54E-06	1.44E-06	Not Detected
4th week	6.96E-07	8.36E-07	1.36E-06	Not Detected
March 2015				
1st week	2.15E-06	1.63E-06	1.68E-06	Detected
2nd week	6.64E-07	8.33E-07	1.19E-06	Not Detected
3rd week	8.89E-07	1.00E-06	1.47E-06	Not Detected
4th week	-6.27E-08	3.27E-07	9.30E-07	Not Detected
April 2015				
1st week	5.80E-07	1.04E-06	2.27E-06	Not Detected
2nd week	0.00E+00	6.65E-07	1.73E-06	Not Detected
3rd week	-8.09E-07	9.63E-07	4.01E-06	Not Detected
4th week	3.32E-07	6.67E-07	1.53E-06	Not Detected
May 2015				
1st week	-5.25E-08	5.35E-07	1.31E-06	Not Detected
2nd week	1.42E-06	1.22E-06	1.23E-06	Not Detected
3rd week	1.63E-07	5.65E-07	1.61E-06	Not Detected
4th week	-1.19E-07	4.22E-07	1.32E-06	Not Detected
June 2015				
1st week	4.92E-07	7.84E-07	1.36E-06	Not Detected
2nd week	4.05E-07	1.04E-06	2.52E-06	Not Detected
3rd week	6.34E-07	8.61E-07	1.45E-06	Not Detected
4th week	1.42E-07	4.93E-07	1.41E-06	Not Detected
July 2015				
1st week	7.01E-06	4.61E-06	3.55E-06	Detected
2nd week	3.50E-07	8.57E-07	2.11E-06	Not Detected
3rd week	6.28E-06	2.61E-06	1.74E-06	Detected
4th week	6.87E-07	6.78E-07	8.86E-07	Not Detected

Table 2-9: Weekly Activity concentrations of ^{238}Pu (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{238}Pu Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	-2.58E-08	1.07E-06	3.30E-06	Not Detected
2nd week	3.16E-07	6.58E-07	1.50E-06	Not Detected
3rd week	1.76E-06	1.26E-06	1.44E-06	Detected
4th week	4.18E-07	5.25E-07	7.46E-07	Not Detected
September 2015				
1st week	6.76E-07	8.11E-07	1.32E-06	Not Detected
2nd week	5.62E-07	7.61E-07	1.28E-06	Not Detected
3rd week	1.65E-07	4.20E-07	1.03E-06	Not Detected
4th week	4.93E-07	6.59E-07	1.21E-06	Not Detected
October 2015				
1st week	7.89E-07	9.48E-07	1.54E-06	Not Detected
2nd week	-4.16E-08	4.26E-07	1.04E-06	Not Detected
3rd week	3.79E-07	7.61E-07	1.74E-06	Not Detected
4th week	9.14E-08	4.60E-07	1.33E-06	Not Detected
November 2015				
1st week	-4.24E-08	4.75E-07	1.76E-06	Not Detected
2nd week	6.94E-07	8.87E-07	1.68E-06	Not Detected
3rd week	3.27E-07	5.90E-07	1.21E-06	Not Detected
4th week	3.83E-08	4.12E-07	1.39E-06	Not Detected
December 2015				
1st week	-1.63E-07	4.75E-07	1.95E-06	Not Detected
2nd week	-8.48E-08	4.79E-07	1.85E-06	Not Detected
3rd week	-2.42E-07	4.51E-07	1.68E-06	Not Detected
4th week	-3.55E-07	3.38E-07	1.49E-06	Not Detected

Table 2-10: Weekly Activity density of ^{241}Am (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	6.48E+00	1.23E+00	2.09E-01	Detected
2nd week	4.83E+00	8.82E-01	1.39E-01	Detected
3rd week	4.58E+00	1.06E+00	3.20E-01	Detected
4th week	3.19E+00	7.37E-01	2.05E-01	Detected
February 2015				
1st week	2.42E+00	6.60E-01	2.54E-01	Detected
2nd week	2.59E+00	9.52E-01	5.50E-01	Detected
3rd week	4.46E+02	5.50E+01	4.50E-01	Detected
4th week	1.73E+01	2.77E+00	3.39E-01	Detected
March 2015				
1st week	2.64E+01	3.41E+00	1.16E-01	Detected
2nd week	6.64E+00	1.10E+00	1.40E-01	Detected
3rd week	2.22E+01	3.60E+00	4.47E-01	Detected
4th week	2.46E+01	4.15E+00	4.89E-01	Detected
April 2015				
1st week	2.52E+00	6.02E-01	2.48E-01	Detected
2nd week	1.24E+00	7.51E-01	7.38E-01	Detected
3rd week	1.34E+01	2.06E+00	2.05E-01	Detected
4th week	4.96E+00	9.17E-01	2.21E-01	Detected
May 2015				
1st week	2.20E+00	4.96E-01	1.45E-01	Detected
2nd week	1.64E+01	2.20E+00	1.31E-01	Detected
3rd week	1.02E+01	1.53E+00	1.53E-01	Detected
4th week	2.15E+00	5.63E-01	1.45E-01	Detected
June 2015				
1st week	3.32E+00	6.56E-01	1.48E-01	Detected
2nd week	7.97E+00	1.47E+00	1.93E-01	Detected
3rd week	6.66E+00	1.34E+00	2.56E-01	Detected
4th week	8.31E-01	2.71E-01	1.39E-01	Detected
July 2015				
1st week	3.26E+01	4.38E+00	2.48E-01	Detected
2nd week	6.22E+01	8.79E+00	6.46E-01	Detected
3rd week	3.47E+01	4.16E+00	3.97E-02	Detected
4th week	1.52E+01	3.33E+00	9.81E-01	Detected

Table 2-10: Weekly Activity density of ^{241}Am (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{241}Am Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	1.54E+01	2.61E+00	4.30E-01	Detected
2nd week	1.19E+01	1.71E+00	1.62E-01	Detected
3rd week	2.07E+01	2.77E+00	1.26E-01	Detected
4th week	1.45E+01	2.05E+00	1.03E-01	Detected
September 2015				
1st week	1.88E+01	3.19E+00	2.63E-01	Detected
2nd week	2.06E+01	3.57E+00	4.84E-01	Detected
3rd week	3.02E+00	6.25E-01	1.42E-01	Detected
4th week	7.75E+00	1.36E+00	1.44E-01	Detected
October 2015				
1st week	1.23E+01	1.87E+00	1.83E-01	Detected
2nd week	3.47E+00	6.80E-01	1.60E-01	Detected
3rd week	6.42E+01	1.02E+01	8.22E-01	Detected
4th week	6.70E+00	1.26E+00	2.05E-01	Detected
November 2015				
1st week	1.52E+01	3.29E+00	8.04E-01	Detected
2nd week	1.63E+01	2.77E+00	3.88E-01	Detected
3rd week	8.20E+00	1.47E+00	1.77E-01	Detected
4th week	1.12E+00	5.12E-01	3.77E-01	Detected
December 2015				
1st week	6.09E+00	1.42E+00	3.74E-01	Detected
2nd week	1.52E+00	4.50E-01	1.79E-01	Detected
3rd week	1.19E+00	3.89E-01	1.35E-01	Detected
4th week	9.40E-01	3.41E-01	1.35E-01	Detected

Table 2-11: Weekly Activity density of $^{239+240}Pu$ (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	6.32E-01	3.26E-01	2.55E-01	Detected
2nd week	5.97E-01	2.91E-01	2.31E-01	Detected
3rd week	3.83E-01	3.13E-01	3.44E-01	Detected
4th week	6.65E-01	4.59E-01	4.70E-01	Detected
February 2015				
1st week	1.91E-01	1.63E-01	1.64E-01	Detected
2nd week	5.68E-01	4.18E-01	3.63E-01	Detected
3rd week	5.23E+01	7.25E+00	4.56E-01	Detected
4th week	2.08E+00	6.63E-01	2.64E-01	Detected
March 2015				
1st week	2.67E+00	6.15E-01	1.72E-01	Detected
2nd week	7.27E-01	2.85E-01	1.79E-01	Detected
3rd week	2.88E+00	1.10E+00	6.62E-01	Detected
4th week	1.51E-01	3.03E-01	6.96E-01	Detected
April 2015				
1st week	1.02E+00	4.17E-01	2.48E-01	Detected
2nd week	6.58E-01	4.02E-01	3.36E-01	Detected
3rd week	1.90E+00	7.63E-01	4.81E-01	Detected
4th week	5.21E-01	2.61E-01	2.14E-01	Detected
May 2015				
1st week	3.88E-01	2.03E-01	1.23E-01	Detected
2nd week	1.93E+00	4.54E-01	1.27E-01	Detected
3rd week	1.28E+00	4.23E-01	1.46E-01	Detected
4th week	9.71E-02	1.43E-01	2.69E-01	Not Detected
June 2015				
1st week	5.33E-01	2.58E-01	2.01E-01	Detected
2nd week	5.95E-01	5.20E-01	6.98E-01	Not Detected
3rd week	7.21E-01	4.09E-01	3.79E-01	Detected
4th week	1.25E-01	1.29E-01	1.89E-01	Not Detected
July 2015				
1st week	4.14E+00	1.42E+00	6.06E-01	Detected
2nd week	7.26E+00	2.10E+00	8.63E-01	Detected
3rd week	4.51E+00	6.53E-01	4.70E-02	Detected
4th week	1.90E+00	5.12E-01	1.34E-01	Detected

Table 2-11: Weekly Activity density of $^{239+240}Pu$ (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	$^{239+240}Pu$ Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	2.09E+00	7.43E-01	3.77E-01	Detected
2nd week	1.25E+00	3.62E-01	1.27E-01	Detected
3rd week	2.44E+00	4.87E-01	1.14E-01	Detected
4th week	1.65E+00	4.34E-01	1.10E-01	Detected
September 2015				
1st week	2.20E+00	4.62E-01	9.60E-02	Detected
2nd week	4.01E+00	1.14E+00	3.24E-01	Detected
3rd week	1.93E-01	1.38E-01	1.33E-01	Detected
4th week	9.29E-01	3.20E-01	1.19E-01	Detected
October 2015				
1st week	1.24E+00	3.93E-01	1.32E-01	Detected
2nd week	5.95E-01	2.40E-01	1.28E-01	Detected
3rd week	2.91E+00	1.47E+00	1.52E+00	Detected
4th week	1.08E+00	4.28E-01	2.69E-01	Detected
November 2015				
1st week	1.83E+00	6.03E-01	4.03E-01	Detected
2nd week	1.89E+00	4.93E-01	1.83E-01	Detected
3rd week	7.19E-01	3.27E-01	2.23E-01	Detected
4th week	2.55E-01	2.35E-01	3.14E-01	Not Detected
December 2015				
1st week	8.29E-01	3.81E-01	1.99E-01	Detected
2nd week	2.24E-01	1.52E-01	1.74E-01	Detected
3rd week	1.02E-01	1.09E-01	1.34E-01	Not Detected
4th week	8.20E-02	8.72E-02	1.08E-01	Not Detected

Table 2-12: Weekly Activity density of ^{238}Pu (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	-7.65E-03	7.81E-02	1.91E-01	Not Detected
2nd week	-2.51E-02	6.77E-02	2.28E-01	Not Detected
3rd week	6.97E-02	1.71E-01	4.22E-01	Not Detected
4th week	2.26E-01	2.90E-01	5.12E-01	Not Detected
February 2015				
1st week	0.00E+00	7.18E-02	2.56E-01	Not Detected
2nd week	-2.91E-02	1.65E-01	6.37E-01	Not Detected
3rd week	2.06E+00	7.46E-01	4.25E-01	Not Detected
4th week	1.52E-01	1.82E-01	2.97E-01	Not Detected
March 2015				
1st week	1.79E-01	1.36E-01	1.40E-01	Detected
2nd week	6.78E-02	8.51E-02	1.21E-01	Not Detected
3rd week	3.23E-01	3.65E-01	5.33E-01	Not Detected
4th week	-3.35E-02	1.75E-01	4.97E-01	Not Detected
April 2015				
1st week	7.45E-02	1.34E-01	2.91E-01	Not Detected
2nd week	0.00E+00	1.60E-01	4.17E-01	Not Detected
3rd week	-1.31E-01	1.56E-01	6.49E-01	Not Detected
4th week	5.21E-02	1.05E-01	2.40E-01	Not Detected
May 2015				
1st week	-4.93E-03	5.02E-02	1.23E-01	Not Detected
2nd week	1.11E-01	9.48E-02	9.51E-02	Not Detected
3rd week	1.76E-02	6.08E-02	1.74E-01	Not Detected
4th week	-2.42E-02	8.56E-02	2.69E-01	Not Detected
June 2015				
1st week	4.98E-02	7.94E-02	1.38E-01	Not Detected
2nd week	7.68E-02	1.97E-01	4.78E-01	Not Detected
3rd week	1.34E-01	1.81E-01	3.06E-01	Not Detected
4th week	1.70E-02	5.89E-02	1.68E-01	Not Detected
July 2015				
1st week	1.00E+00	6.61E-01	5.09E-01	Detected
2nd week	1.43E-01	3.50E-01	8.63E-01	Not Detected
3rd week	1.69E-01	7.03E-02	4.68E-02	Detected
4th week	1.24E-01	1.22E-01	1.59E-01	Not Detected

Table 2-12: Weekly Activity concentrations of ^{238}Pu (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{238}Pu Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	-3.72E-03	1.54E-01	4.74E-01	Not Detected
2nd week	2.98E-02	6.21E-02	1.42E-01	Not Detected
3rd week	1.39E-01	9.89E-02	1.14E-01	Detected
4th week	6.16E-02	7.74E-02	1.10E-01	Not Detected
September 2015				
1st week	5.50E-02	6.60E-02	1.08E-01	Not Detected
2nd week	1.69E-01	2.28E-01	3.85E-01	Not Detected
3rd week	1.80E-02	4.58E-02	1.12E-01	Not Detected
4th week	7.21E-02	9.63E-02	1.76E-01	Not Detected
October 2015				
1st week	8.98E-02	1.08E-01	1.76E-01	Not Detected
2nd week	-4.31E-03	4.41E-02	1.08E-01	Not Detected
3rd week	2.77E-01	5.56E-01	1.27E+00	Not Detected
4th week	2.22E-02	1.12E-01	3.23E-01	Not Detected
November 2015				
1st week	-8.10E-03	9.08E-02	3.37E-01	Not Detected
2nd week	9.07E-02	1.16E-01	2.20E-01	Not Detected
3rd week	5.36E-02	9.66E-02	1.99E-01	Not Detected
4th week	9.41E-03	1.01E-01	3.42E-01	Not Detected
December 2015				
1st week	-3.20E-02	9.30E-02	3.81E-01	Not Detected
2nd week	-8.94E-03	5.05E-02	1.95E-01	Not Detected
3rd week	-3.22E-02	6.00E-02	2.23E-01	Not Detected
4th week	-5.60E-02	5.34E-02	2.35E-01	Not Detected

Table 2-13: Monthly Activity concentrations of uranium isotopes in Station A (Pre-HEPA) filters in 2015

Radionuclides	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	January	3.94E-07	2.59E-07	4.67E-07	Not Detected
	February	6.05E-07	3.51E-07	6.19E-07	Not Detected
	March	3.57E-07	2.82E-07	5.43E-07	Not Detected
	April	1.04E-06	5.62E-07	9.07E-07	Detected
	May	5.37E-07	4.18E-07	7.79E-07	Not Detected
	June	8.18E-07	3.48E-07	4.33E-07	Detected
	July	2.91E-06	9.87E-07	6.60E-07	Detected
	August	7.62E-07	3.78E-07	6.10E-07	Detected
	September	7.52E-07	3.94E-07	6.42E-07	Detected
	October	8.13E-07	5.26E-07	8.58E-07	Not Detected
	November	8.92E-07	3.78E-07	4.71E-07	Detected
	December	8.17E-07	3.46E-07	3.98E-07	Detected
^{235}U	January	5.40E-08	1.53E-07	3.81E-07	Not Detected
	February	1.30E-07	1.84E-07	3.91E-07	Not Detected
	March	-3.14E-08	1.89E-07	5.48E-07	Not Detected
	April	5.58E-08	2.49E-07	6.68E-07	Not Detected
	May	1.53E-07	3.06E-07	7.18E-07	Not Detected
	June	6.72E-08	1.35E-07	3.11E-07	Not Detected
	July	1.75E-07	4.95E-07	1.23E-06	Not Detected
	August	1.35E-07	1.65E-07	3.12E-07	Not Detected
	September	7.42E-08	1.49E-07	3.45E-07	Not Detected
	October	2.01E-07	4.43E-07	1.06E-06	Not Detected
	November	0.00E+00	1.04E-07	2.70E-07	Not Detected
	December	3.47E-08	1.85E-07	4.91E-07	Not Detected
^{238}U	January	2.62E-07	2.76E-07	5.95E-07	Not Detected
	February	2.63E-07	3.08E-07	6.68E-07	Not Detected
	March	4.79E-07	3.96E-07	8.51E-07	Not Detected
	April	2.25E-07	4.14E-07	9.59E-07	Not Detected
	May	1.23E-07	2.47E-07	5.79E-07	Not Detected
	June	6.79E-07	3.80E-07	6.65E-07	Detected
	July	1.13E-06	7.58E-07	1.33E-06	Not Detected
	August	2.16E-07	3.26E-07	7.40E-07	Not Detected
	September	1.50E-07	3.12E-07	7.36E-07	Not Detected
	October	1.13E-06	6.51E-07	1.08E-06	Detected
	November	4.15E-07	3.04E-07	5.56E-07	Not Detected
	December	1.12E-07	2.87E-07	6.88E-07	Not Detected

Table 2-14: Monthly Activity density of uranium isotopes in Station A (Pre-HEPA) filters in 2015

Radionuclides	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{234}U	January	7.47E-03	4.91E-03	8.86E-03	Not Detected
	February	8.14E-03	4.73E-03	8.34E-03	Not Detected
	March	5.34E-03	4.22E-03	8.12E-03	Not Detected
	April	1.42E-02	7.71E-03	1.25E-02	Detected
	May	5.26E-03	4.10E-03	7.63E-03	Not Detected
	June	3.66E-03	1.56E-03	1.94E-03	Not Detected
	July	1.79E-02	6.07E-03	4.06E-03	Not Detected
	August	4.23E-03	2.10E-03	3.39E-03	Detected
	September	5.62E-03	2.94E-03	4.80E-03	Not Detected
	October	7.74E-03	5.01E-03	8.17E-03	Not Detected
	November	1.01E-02	4.30E-03	5.35E-03	Detected
	December	8.96E-03	3.79E-03	4.37E-03	Detected
^{235}U	January	1.02E-03	2.90E-03	7.23E-03	Not Detected
	February	1.75E-03	2.47E-03	5.26E-03	Not Detected
	March	-4.71E-04	2.83E-03	8.19E-03	Not Detected
	April	7.66E-04	3.42E-03	9.17E-03	Not Detected
	May	1.50E-03	3.00E-03	7.03E-03	Not Detected
	June	3.01E-04	6.03E-04	1.39E-03	Not Detected
	July	1.08E-03	3.04E-03	7.58E-03	Not Detected
	August	7.48E-04	9.16E-04	1.74E-03	Not Detected
	September	5.55E-04	1.11E-03	2.58E-03	Not Detected
	October	1.91E-03	4.22E-03	1.01E-02	Not Detected
	November	0.00E+00	1.18E-03	3.07E-03	Not Detected
	December	3.81E-04	2.03E-03	5.38E-03	Not Detected
^{238}U	January	4.97E-03	5.24E-03	1.13E-02	Not Detected
	February	3.54E-03	4.14E-03	8.99E-03	Not Detected
	March	7.17E-03	5.92E-03	1.27E-02	Not Detected
	April	3.09E-03	5.69E-03	1.32E-02	Not Detected
	May	1.21E-03	2.42E-03	5.67E-03	Not Detected
	June	3.04E-03	1.70E-03	2.97E-03	Not Detected
	July	6.95E-03	4.66E-03	8.18E-03	Not Detected
	August	1.20E-03	1.81E-03	4.11E-03	Not Detected
	September	1.12E-03	2.33E-03	5.50E-03	Not Detected
	October	1.08E-02	6.19E-03	1.03E-02	Not Detected
	November	4.71E-03	3.46E-03	6.32E-03	Not Detected
	December	1.23E-03	3.14E-03	7.54E-03	Not Detected

Table 2-15: Monthly Activity concentrations of uranium isotopes in Station B (Post-HEPA) filters in 2015

Radionuclides	Sample Date	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	January	1.56E-07	1.96E-07	4.21E-07	Not Detected
	February	2.22E-07	2.47E-07	5.24E-07	Not Detected
	March	2.02E-08	2.02E-07	5.16E-07	Not Detected
	April	9.41E-07	4.61E-07	5.40E-07	Detected
	May	9.12E-07	5.08E-07	7.95E-07	Not Detected
	June	6.18E-07	4.65E-07	8.16E-07	Not Detected
	July	3.78E-07	2.57E-07	4.10E-07	Not Detected
	August	4.33E-07	2.67E-07	3.71E-07	Detected
	September	5.13E-07	3.77E-07	6.90E-07	Not Detected
	October	4.20E-07	3.39E-07	6.50E-07	Not Detected
	November	6.05E-07	3.48E-07	5.33E-07	Detected
	December	7.54E-07	3.36E-07	7.21E-07	Detected
^{235}U	January	-5.51E-08	1.35E-07	4.38E-07	Not Detected
	February	6.06E-08	1.22E-07	2.82E-07	Not Detected
	March	2.49E-08	1.32E-07	3.51E-07	Not Detected
	April	0.00E+00	2.71E-07	7.80E-07	Not Detected
	May	2.25E-07	3.20E-07	6.75E-07	Not Detected
	June	2.54E-07	2.85E-07	4.65E-07	Not Detected
	July	2.86E-07	2.17E-07	2.63E-07	Not Detected
	August	-3.82E-08	1.32E-07	4.59E-07	Not Detected
	September	4.52E-08	2.38E-07	6.38E-07	Not Detected
	October	1.60E-07	2.26E-07	4.79E-07	Not Detected
	November	1.24E-07	1.66E-07	3.05E-07	Not Detected
	December	2.65E-07	2.82E-07	5.32E-07	Not Detected
^{238}U	January	1.33E-07	2.45E-07	5.68E-07	Not Detected
	February	-2.45E-08	2.82E-07	7.31E-07	Not Detected
	March	-2.61E-07	2.40E-07	7.04E-07	Not Detected
	April	1.34E-07	3.88E-07	9.53E-07	Not Detected
	May	9.09E-08	3.85E-07	9.67E-07	Not Detected
	June	2.05E-07	4.59E-07	1.09E-06	Not Detected
	July	2.31E-07	2.85E-07	6.17E-07	Not Detected
	August	-3.08E-08	1.07E-07	3.70E-07	Not Detected
	September	1.46E-07	4.00E-07	9.63E-07	Not Detected
	October	5.48E-07	3.14E-07	4.55E-07	Not Detected
	November	1.00E-07	3.48E-07	8.52E-07	Not Detected
	December	1.79E-07	3.99E-07	9.45E-07	Not Detected

Table 2-16: Monthly Activity density of uranium isotopes in Station B (Post-HEPA) filters in 2015

Radionuclides	Sample Date	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{234}U	January	2.62E-02	3.29E-02	7.07E-02	Not Detected
	February	5.11E-02	5.69E-02	1.21E-01	Not Detected
	March	3.29E-03	3.29E-02	8.41E-02	Not Detected
	April	1.53E-01	7.50E-02	8.78E-02	Detected
	May	1.02E-01	5.67E-02	8.86E-02	Not Detected
	June	8.63E-02	6.50E-02	1.14E-01	Detected
	July	3.07E-02	2.09E-02	3.33E-02	Detected
	August	4.80E-02	2.96E-02	4.12E-02	Detected
	September	6.55E-02	4.82E-02	8.81E-02	Detected
	October	7.24E-02	5.84E-02	1.12E-01	Not Detected
	November	1.07E-01	6.15E-02	9.42E-02	Detected
	December	1.07E-01	4.78E-02	1.03E-01	Detected
^{235}U	January	-9.26E-03	2.27E-02	7.36E-02	Not Detected
	February	1.40E-02	2.80E-02	6.51E-02	Not Detected
	March	4.06E-03	2.15E-02	5.72E-02	Not Detected
	April	0.00E+00	4.41E-02	1.27E-01	Not Detected
	May	2.51E-02	3.57E-02	7.52E-02	Not Detected
	June	3.54E-02	3.98E-02	6.50E-02	Not Detected
	July	2.32E-02	1.77E-02	2.14E-02	Not Detected
	August	-4.24E-03	1.47E-02	5.09E-02	Not Detected
	September	5.77E-03	3.04E-02	8.15E-02	Not Detected
	October	2.76E-02	3.89E-02	8.26E-02	Not Detected
	November	2.19E-02	2.93E-02	5.39E-02	Not Detected
	December	3.77E-02	4.01E-02	7.56E-02	Not Detected
^{238}U	January	2.24E-02	4.12E-02	9.54E-02	Not Detected
	February	-5.65E-03	6.51E-02	1.68E-01	Not Detected
	March	-4.26E-02	3.91E-02	1.15E-01	Not Detected
	April	2.18E-02	6.32E-02	1.55E-01	Not Detected
	May	1.01E-02	4.29E-02	1.08E-01	Not Detected
	June	2.86E-02	6.41E-02	1.52E-01	Detected
	July	1.88E-02	2.31E-02	5.01E-02	Not Detected
	August	-3.42E-03	1.18E-02	4.10E-02	Not Detected
	September	1.86E-02	5.10E-02	1.23E-01	Not Detected
	October	9.45E-02	5.42E-02	7.84E-02	Detected
	November	1.77E-02	6.15E-02	1.51E-01	Not Detected

Table 2-17: Weekly Activity concentrations of ^{137}Cs (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	1.06E-05	8.20E-05	2.73E-04	Not Detected
2nd week	-9.99E-05	1.05E-04	3.53E-04	Not Detected
3rd week	7.80E-05	7.97E-05	2.64E-04	Not Detected
4th week	5.18E-05	7.32E-05	2.42E-04	Not Detected
February 2015				
1st week	-1.98E-04	1.36E-04	4.58E-04	Not Detected
2nd week	-1.67E-05	8.23E-05	2.75E-04	Not Detected
3rd week	1.29E-05	8.52E-05	2.84E-04	Not Detected
4th week	9.10E-05	8.44E-05	2.79E-04	Not Detected
March 2015				
1st week	-7.23E-05	1.07E-04	3.57E-04	Not Detected
2nd week	3.73E-05	1.03E-04	3.42E-04	Not Detected
3rd week	5.87E-05	8.53E-05	2.83E-04	Not Detected
4th week	1.21E-04	5.94E-05	1.95E-04	Not Detected
April 2015				
1st week	1.59E-04	9.87E-05	3.25E-04	Not Detected
2nd week	9.10E-05	8.26E-05	2.73E-04	Not Detected
3rd week	-1.61E-04	8.42E-05	2.85E-04	Not Detected
4th week	6.32E-05	6.38E-05	2.11E-04	Not Detected
May 2015				
1st week	3.41E-05	8.17E-05	2.72E-04	Not Detected
2nd week	8.00E-05	8.20E-05	2.71E-04	Not Detected
3rd week	6.19E-05	8.03E-05	2.66E-04	Not Detected
4th week	8.44E-05	5.76E-05	1.90E-04	Not Detected
June 2015				
1st week	-2.51E-05	8.79E-05	2.94E-04	Not Detected
2nd week	1.62E-05	8.91E-05	2.97E-04	Not Detected
3rd week	1.29E-04	8.25E-05	2.72E-04	Not Detected
4th week	4.84E-05	6.55E-05	2.17E-04	Not Detected
July 2015				
1st week	-2.66E-05	8.38E-05	2.80E-04	Not Detected
2nd week	7.22E-05	8.41E-05	2.78E-04	Not Detected
3rd week	-5.98E-06	8.25E-05	2.76E-04	Not Detected
4th week	3.84E-05	5.84E-05	1.94E-04	Not Detected

Table 2-17: Weekly Activity concentrations of ^{137}Cs (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	1.01E-04	8.33E-05	2.75E-04	Not Detected
2nd week	-7.92E-05	1.07E-04	3.57E-04	Not Detected
3rd week	-3.35E-05	8.60E-05	2.87E-04	Not Detected
4th week	-8.73E-05	7.61E-05	2.55E-04	Not Detected
September 2015				
1st week	1.56E-05	1.05E-04	3.49E-04	Not Detected
2nd week	1.46E-05	8.29E-05	2.76E-04	Not Detected
3rd week	1.09E-04	1.03E-04	2.90E-04	Not Detected
4th week	1.16E-04	6.13E-05	2.01E-04	Not Detected
October 2015				
1st week	8.59E-05	8.10E-05	2.68E-04	Not Detected
2nd week	-9.10E-05	8.30E-05	2.79E-04	Not Detected
3rd week	-8.87E-05	8.29E-05	2.79E-04	Not Detected
4th week	5.85E-05	1.32E-03	2.38E-04	Not Detected
November 2015				
1st week	1.24E-04	1.02E-04	3.36E-04	Not Detected
2nd week	-1.36E-04	1.07E-04	3.60E-04	Not Detected
3rd week	-1.12E-05	1.07E-04	3.56E-04	Not Detected
4th week	4.26E-05	7.85E-05	2.60E-04	Not Detected
December 2015				
1st week	-2.24E-05	1.05E-04	3.49E-04	Not Detected
2nd week	8.64E-05	8.44E-05	2.79E-04	Not Detected
3rd week	-4.78E-05	8.43E-05	2.83E-04	Not Detected
4th week	5.37E-05	5.53E-05	1.83E-04	Not Detected

Table 2-18: Weekly Activity concentrations of ^{40}K (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	-1.36E-03	9.89E-04	3.37E-03	Not Detected
2nd week	8.26E-04	1.02E-03	3.37E-03	Not Detected
3rd week	1.08E-03	9.33E-04	3.09E-03	Not Detected
4th week	3.15E-04	7.18E-04	2.39E-03	Not Detected
February 2015				
1st week	-5.48E-05	1.00E-03	3.37E-03	Not Detected
2nd week	1.28E-04	1.01E-03	3.37E-03	Not Detected
3rd week	1.32E-04	1.01E-03	3.40E-03	Not Detected
4th week	-3.59E-04	1.05E-03	3.52E-03	Not Detected
March 2015				
1st week	9.55E-05	1.02E-03	3.43E-03	Not Detected
2nd week	5.74E-04	1.02E-03	3.40E-03	Not Detected
3rd week	-2.07E-03	1.11E-03	3.80E-03	Not Detected
4th week	-4.35E-04	7.37E-04	2.49E-03	Not Detected
April 2015				
1st week	5.66E-04	1.18E-03	3.94E-03	Not Detected
2nd week	4.15E-04	9.77E-04	3.26E-03	Not Detected
3rd week	1.77E-03	9.38E-04	3.07E-03	Not Detected
4th week	7.37E-04	7.44E-04	2.47E-03	Not Detected
May 2015				
1st week	1.31E-03	9.62E-04	3.18E-03	Not Detected
2nd week	4.24E-04	9.81E-04	3.27E-03	Not Detected
3rd week	4.22E-04	9.72E-04	3.24E-03	Not Detected
4th week	-1.23E-04	6.95E-04	2.34E-03	Not Detected
June 2015				
1st week	-6.69E-04	1.06E-03	3.58E-03	Not Detected
2nd week	-3.15E-04	1.09E-03	3.67E-03	Not Detected
3rd week	-3.43E-05	1.03E-03	3.44E-03	Not Detected
4th week	-1.11E-04	7.32E-05	2.51E-04	Not Detected
July 2015				
1st week	-4.38E-04	1.03E-03	3.46E-03	Not Detected
2nd week	-7.34E-04	1.05E-03	3.56E-03	Not Detected
3rd week	-6.00E-04	9.88E-04	3.34E-03	Not Detected
4th week	5.37E-04	6.89E-04	2.29E-03	Not Detected

Table 2-18: Weekly Activity concentrations of ^{40}K (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	4.59E-04	1.00E-03	3.34E-03	Not Detected
2nd week	1.46E-04	1.07E-03	3.57E-03	Not Detected
3rd week	1.20E-03	9.98E-04	3.30E-03	Not Detected
4th week	1.30E-03	7.18E-04	2.35E-03	Not Detected
September 2015				
1st week	-7.24E-04	1.12E-03	3.76E-03	Not Detected
2nd week	-6.04E-04	1.03E-03	3.46E-03	Not Detected
3rd week	1.28E-03	9.89E-04	3.26E-03	Not Detected
4th week	-2.12E-04	8.06E-04	2.71E-03	Not Detected
October 2015				
1st week	8.92E-05	9.85E-04	3.30E-03	Not Detected
2nd week	1.16E-03	9.57E-04	3.17E-03	Not Detected
3rd week	-1.02E-03	1.06E-03	3.57E-03	Not Detected
4th week	1.60E-04	7.06E-04	2.36E-03	Not Detected
November 2015				
1st week	-6.86E-04	1.07E-03	3.60E-03	Not Detected
2nd week	-1.60E-04	1.03E-03	3.47E-03	Not Detected
3rd week	7.01E-04	1.04E-03	3.45E-03	Not Detected
4th week	9.73E-04	7.68E-04	2.53E-03	Not Detected
December 2015				
1st week	-1.67E-04	1.04E-03	3.50E-03	Not Detected
2nd week	8.21E-04	1.00E-03	3.32E-03	Not Detected
3rd week	-4.22E-04	1.04E-03	3.50E-03	Not Detected
4th week	-8.74E-05	6.74E-04	2.27E-03	Not Detected

Table 2-19: Weekly Activity concentrations of ^{60}Co (Bq/m^3) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{60}Co Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	2.94E-05	8.26E-06	2.76E-04	Not Detected
2nd week	-2.83E-05	8.52E-05	2.87E-04	Not Detected
3rd week	4.85E-06	8.38E-05	2.81E-04	Not Detected
4th week	2.22E-06	5.85E-05	1.96E-04	Not Detected
February 2015				
1st week	-1.73E-03	1.33E-03	4.54E-03	Not Detected
2nd week	1.00E-04	7.96E-05	2.63E-04	Not Detected
3rd week	-1.31E-04	8.97E-05	3.06E-04	Not Detected
4th week	-7.43E-05	8.72E-05	2.96E-04	Not Detected
March 2015				
1st week	6.58E-05	8.46E-05	2.81E-04	Not Detected
2nd week	-5.45E-07	8.46E-05	2.84E-04	Not Detected
3rd week	-4.11E-05	8.65E-05	2.92E-04	Not Detected
4th week	-1.27E-05	6.19E-05	2.08E-04	Not Detected
April 2015				
1st week	-6.04E-05	1.00E-04	3.39E-04	Not Detected
2nd week	-6.35E-05	8.32E-05	2.82E-04	Not Detected
3rd week	1.76E-05	8.32E-05	2.79E-04	Not Detected
4th week	-8.71E-06	6.60E-05	2.22E-04	Not Detected
May 2015				
1st week	-5.94E-05	8.61E-05	4.71E-05	Not Detected
2nd week	6.40E-05	8.30E-05	2.76E-04	Not Detected
3rd week	-1.53E-05	8.36E-05	2.81E-04	Not Detected
4th week	4.92E-05	5.69E-05	1.89E-04	Not Detected
June 2015				
1st week	-3.06E-05	9.01E-05	3.03E-04	Not Detected
2nd week	-8.43E-05	9.54E-05	3.23E-04	Not Detected
3rd week	-2.31E-05	8.24E-05	2.78E-04	Not Detected
4th week	-1.49E-04	7.32E-05	2.51E-04	Not Detected
July 2015				
1st week	-9.34E-05	8.54E-05	2.90E-04	Not Detected
2nd week	-1.39E-04	8.66E-05	2.96E-04	Not Detected
3rd week	-2.50E-05	8.07E-05	2.72E-04	Not Detected
4th week	6.80E-05	5.71E-05	1.89E-04	Not Detected

Table 2-19: Weekly Activity concentrations of ^{60}Co (Bq/m^3) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{60}Co Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	2.40E-06	8.31E-05	2.79E-04	Not Detected
2nd week	-2.41E-05	8.73E-05	2.94E-04	Not Detected
3rd week	7.40E-06	8.57E-05	2.87E-04	Not Detected
4th week	3.49E-05	5.97E-05	1.99E-04	Not Detected
September 2015				
1st week	1.65E-06	8.68E-05	2.91E-04	Not Detected
2nd week	2.70E-07	8.55E-05	2.87E-04	Not Detected
3rd week	-7.67E-06	8.64E-05	2.90E-04	Not Detected
4th week	-4.39E-05	6.50E-05	2.20E-04	Not Detected
October 2015				
1st week	-6.83E-05	8.52E-05	2.89E-04	Not Detected
2nd week	3.06E-07	8.17E-05	2.74E-04	Not Detected
3rd week	-8.81E-05	8.44E-05	2.87E-04	Not Detected
4th week	9.65E-06	5.96E-05	1.99E-04	Not Detected
November 2015				
1st week	4.15E-05	8.67E-05	2.89E-04	Not Detected
2nd week	1.11E-04	9.04E-05	2.99E-04	Not Detected
3rd week	3.69E-05	8.11E-05	2.71E-04	Not Detected
4th week	-2.34E-05	6.39E-05	2.15E-04	Not Detected
December 2015				
1st week	-3.31E-05	8.42E-05	2.84E-04	Not Detected
2nd week	-8.78E-05	8.44E-05	2.87E-04	Not Detected
3rd week	-6.25E-05	8.58E-05	2.90E-04	Not Detected
4th week	8.92E-05	5.60E-05	1.84E-04	Not Detected

Table 2-20: Weekly Activity concentrations of ^{137}Cs (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	-8.60E-06	1.01E-04	3.37E-04	Not Detected
2nd week	-5.05E-05	9.79E-05	3.28E-04	Not Detected
3rd week	7.35E-05	7.87E-05	2.60E-04	Not Detected
4th week	5.11E-05	5.27E-05	1.75E-04	Not Detected
February 2015				
1st week	-4.83E-05	1.02E-04	3.40E-04	Not Detected
2nd week	-2.35E-05	9.93E-05	3.31E-04	Not Detected
3rd week	-2.71E-05	7.63E-05	2.56E-04	Not Detected
4th week	3.88E-05	9.60E-05	3.19E-04	Not Detected
March 2015				
1st week	-2.59E-05	7.75E-05	2.60E-04	Not Detected
2nd week	4.17E-05	1.02E-04	3.36E-04	Not Detected
3rd week	-1.33E-05	1.01E-04	3.35E-04	Not Detected
4th week	1.08E-05	6.93E-05	2.31E-04	Not Detected
April 2015				
1st week	-5.86E-05	7.96E-05	2.70E-04	Not Detected
2nd week	-1.78E-05	1.00E-04	3.35E-04	Not Detected
3rd week	-1.23E-04	1.00E-04	3.37E-04	Not Detected
4th week	3.31E-05	6.12E-05	2.03E-04	Not Detected
May 2015				
1st week	7.54E-06	7.72E-05	2.57E-04	Not Detected
2nd week	-2.10E-05	1.03E-04	3.45E-04	Not Detected
3rd week	1.40E-04	7.60E-05	2.50E-04	Not Detected
4th week	-5.95E-07	5.59E-05	1.87E-04	Not Detected
June 2015				
1st week	-2.99E-05	7.92E-05	2.65E-04	Not Detected
2nd week	-4.08E-05	1.03E-04	3.44E-04	Not Detected
3rd week	-1.13E-05	8.07E-05	2.69E-04	Not Detected
4th week	6.11E-05	7.77E-05	2.57E-04	Not Detected
July 2015				
1st week	8.60E-05	7.72E-05	2.55E-04	Not Detected
2nd week	-5.07E-05	8.02E-05	2.69E-04	Not Detected
3rd week	-2.36E-05	9.92E-05	3.31E-04	Not Detected
4th week	9.72E-07	5.56E-05	1.85E-04	Not Detected

Table 2-20: Weekly Activity concentrations of ^{137}Cs (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{137}Cs Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	-1.53E-04	1.02E-04	3.43E-04	Not Detected
2nd week	-2.35E-05	1.01E-04	3.38E-04	Not Detected
3rd week	2.40E-05	1.01E-04	3.37E-04	Not Detected
4th week	-9.24E-05	7.05E-05	2.37E-04	Not Detected
September 2015				
1st week	1.00E-04	9.82E-05	3.25E-04	Not Detected
2nd week	1.05E-04	7.66E-05	2.52E-04	Not Detected
3rd week	1.15E-05	2.55E-05	8.46E-05	Not Detected
4th week	4.49E-05	6.02E-05	2.00E-04	Not Detected
October 2015				
1st week	-5.24E-05	9.83E-05	3.29E-04	Not Detected
2nd week	5.46E-05	8.02E-05	2.66E-04	Not Detected
3rd week	-1.23E-04	1.03E-04	3.46E-04	Not Detected
4th week	-5.58E-05	5.42E-05	1.82E-04	Not Detected
November 2015				
1st week	-4.41E-05	1.04E-04	3.48E-04	Not Detected
2nd week	-4.47E-05	6.96E-05	2.74E-04	Not Detected
3rd week	1.76E-04	9.78E-05	3.21E-04	Not Detected
4th week	-5.89E-05	7.89E-05	2.64E-04	Not Detected
December 2015				
1st week	8.88E-05	9.83E-05	3.25E-04	Not Detected
2nd week	6.69E-05	9.97E-05	3.30E-04	Not Detected
3rd week	7.07E-06	7.83E-05	2.62E-04	Not Detected
4th week	3.10E-05	5.50E-05	1.83E-04	Not Detected

Table 2-21: Weekly Activity concentrations of ^{40}K (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	2.76E-04	1.01E-03	3.38E-03	Not Detected
2nd week	5.39E-04	9.68E-04	3.22E-03	Not Detected
3rd week	-6.91E-04	9.48E-04	3.21E-03	Not Detected
4th week	-8.05E-04	6.30E-04	2.14E-03	Not Detected
February 2015				
1st week	-4.23E-05	1.01E-03	3.38E-03	Not Detected
2nd week	2.32E-04	9.97E-04	3.34E-03	Not Detected
3rd week	7.32E-04	9.06E-04	3.01E-03	Not Detected
4th week	1.51E-03	9.28E-04	3.04E-03	Not Detected
March 2015				
1st week	-1.46E-03	9.70E-04	3.31E-03	Not Detected
2nd week	5.73E-04	9.53E-04	3.17E-03	Not Detected
3rd week	6.61E-04	9.84E-04	3.27E-03	Not Detected
4th week	-9.92E-06	7.01E-04	2.35E-03	Not Detected
April 2015				
1st week	-6.44E-04	9.57E-04	3.23E-03	Not Detected
2nd week	-6.34E-05	9.76E-04	3.27E-03	Not Detected
3rd week	5.12E-04	1.00E-03	3.33E-03	Not Detected
4th week	5.25E-04	7.31E-04	2.43E-03	Not Detected
May 2015				
1st week	-5.67E-04	9.80E-04	3.30E-03	Not Detected
2nd week	-7.08E-04	1.03E-03	3.46E-04	Not Detected
3rd week	5.36E-04	9.28E-04	3.09E-03	Not Detected
4th week	4.30E-04	6.27E-04	2.09E-03	Not Detected
June 2015				
1st week	-7.26E-05	9.22E-04	3.10E-03	Not Detected
2nd week	1.92E-03	9.92E-04	3.23E-03	Not Detected
3rd week	-5.20E-04	9.52E-04	3.21E-03	Not Detected
4th week	-2.62E-04	7.92E-04	2.66E-03	Not Detected
July 2015				
1st week	6.01E-04	9.28E-04	3.09E-03	Not Detected
2nd week	-3.00E-04	9.39E-04	3.16E-03	Not Detected
3rd week	-6.04E-05	1.01E-03	3.39E-03	Not Detected
4th week	-5.47E-04	6.72E-04	2.27E-03	Not Detected

Table 2-21: Weekly Activity concentrations of ^{40}K (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{40}K Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	1.69E-04	9.54E-04	3.19E-03	Not Detected
2nd week	-1.04E-04	9.87E-04	3.31E-03	Not Detected
3rd week	9.16E-04	9.50E-04	3.15E-03	Not Detected
4th week	-3.32E-04	6.95E-04	2.34E-03	Not Detected
September 2015				
1st week	9.55E-04	9.65E-04	3.19E-03	Not Detected
2nd week	-2.26E-04	9.56E-04	3.21E-03	Not Detected
3rd week	7.80E-04	9.57E-04	3.18E-03	Not Detected
4th week	5.52E-04	7.46E-04	2.48E-03	Not Detected
October 2015				
1st week	1.52E-03	9.16E-04	3.00E-03	Not Detected
2nd week	-6.15E-04	9.52E-04	3.21E-03	Not Detected
3rd week	1.14E-03	9.76E-04	3.22E-03	Not Detected
4th week	-5.66E-04	6.92E-04	2.34E-03	Not Detected
November 2015				
1st week	-1.18E-03	1.09E-03	3.67E-03	Not Detected
2nd week	1.83E-06	9.53E-04	3.19E-03	Not Detected
3rd week	-2.11E-04	9.70E-04	3.26E-03	Not Detected
4th week	6.43E-04	7.73E-04	2.56E-03	Not Detected
December 2015				
1st week	7.43E-04	1.00E-03	3.33E-03	Not Detected
2nd week	1.66E-04	1.03E-03	3.46E-03	Not Detected
3rd week	8.74E-04	9.17E-04	3.04E-03	Not Detected
4th week	-2.51E-04	6.86E-04	2.31E-03	Not Detected

Table 2-22: Weekly Activity concentrations of ^{60}Co (Bq/m^3) in Station B (Post-HEPA) filters in 2015

Sample Date	^{60}Co Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
January 2015				
1st week	-6.63E-05	8.48E-05	2.87E-04	Not Detected
2nd week	9.54E-05	7.49E-05	2.47E-04	Not Detected
3rd week	2.09E-05	7.79E-05	2.61E-04	Not Detected
4th week	-4.95E-05	5.45E-05	1.85E-04	Not Detected
February 2015				
1st week	5.93E-06	7.92E-05	2.66E-04	Not Detected
2nd week	7.37E-05	8.01E-05	2.66E-04	Not Detected
3rd week	-7.21E-05	8.11E-05	2.75E-04	Not Detected
4th week	-6.40E-05	8.26E-05	2.79E-04	Not Detected
March 2015				
1st week	-9.63E-05	8.23E-05	2.80E-04	Not Detected
2nd week	-4.69E-05	8.30E-05	2.80E-04	Not Detected
3rd week	-4.43E-05	8.32E-05	2.81E-04	Not Detected
4th week	3.63E-06	5.74E-05	1.92E-04	Not Detected
April 2015				
1st week	-6.44E-04	9.57E-04	3.23E-03	Not Detected
2nd week	-3.40E-07	7.94E-05	2.67E-04	Not Detected
3rd week	2.54E-05	8.03E-05	2.68E-04	Not Detected
4th week	2.35E-05	5.99E-05	2.00E-04	Not Detected
May 2015				
1st week	9.32E-05	7.84E-05	2.59E-04	Not Detected
2nd week	2.20E-05	8.35E-05	2.79E-04	Not Detected
3rd week	3.59E-05	7.77E-05	2.60E-04	Not Detected
4th week	-3.23E-06	5.74E-05	1.93E-04	Not Detected
June 2015				
1st week	-2.65E-05	7.61E-05	2.57E-04	Not Detected
2nd week	-3.94E-05	8.38E-05	2.83E-04	Not Detected
3rd week	1.06E-04	7.58E-05	2.50E-04	Not Detected
4th week	-5.88E-05	6.42E-05	2.18E-04	Not Detected
July 2015				
1st week	-6.49E-05	7.78E-05	2.82E-04	Not Detected
2nd week	-2.51E-05	7.84E-05	2.62E-04	Not Detected
3rd week	-6.41E-05	8.36E-05	2.83E-04	Not Detected
4th week	-6.17E-06	5.47E-05	1.84E-04	Not Detected

Table 2-22: Weekly Activity concentrations of ^{60}Co (Bq/m^3) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{60}Co Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
August 2015				
1st week	2.79E-05	7.96E-05	2.66E-04	Not Detected
2nd week	5.52E-05	7.64E-05	2.54E-04	Not Detected
3rd week	-6.52E-05	8.49E-05	2.87E-04	Not Detected
4th week	-1.17E-04	6.02E-05	2.05E-04	Not Detected
September 2015				
1st week	8.49E-05	7.92E-05	2.62E-04	Not Detected
2nd week	-2.84E-05	8.05E-05	2.71E-04	Not Detected
3rd week	-1.92E-09	2.16E-09	7.32E-09	Not Detected
4th week	-5.20E-05	6.27E-05	2.13E-04	Not Detected
October 2015				
1st week	8.01E-05	7.96E-05	2.64E-04	Not Detected
2nd week	-7.73E-05	7.82E-05	2.66E-04	Not Detected
3rd week	-3.33E-05	8.26E-05	2.78E-04	Not Detected
4th week	-7.14E-05	5.65E-05	1.93E-04	Not Detected
November 2015				
1st week	-5.32E-05	9.19E-05	3.10E-04	Not Detected
2nd week	-6.33E-05	8.15E-05	2.76E-04	Not Detected
3rd week	-9.15E-06	8.02E-05	2.70E-04	Not Detected
4th week	-4.32E-05	6.58E-05	2.22E-04	Not Detected
December 2015				
1st week	1.01E-05	8.02E-05	2.69E-04	Not Detected
2nd week	-8.75E-05	8.84E-05	2.99E-04	Not Detected
3rd week	-5.49E-05	7.87E-05	2.67E-04	Not Detected
4th week	1.94E-05	5.51E-05	1.84E-04	Not Detected

Table 2-23: Weekly Activity density of ^{137}Cs (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	2.77E-01	2.14E+00	7.13E+00	Not detected
2nd week	-1.99E+00	2.10E+00	7.03E+00	Not detected
3rd week	1.58E+00	1.61E+00	5.34E+00	Not detected
4th week	7.77E-01	1.10E+00	3.63E+00	Not detected
February 2015				
1st week	-3.12E+00	2.14E+00	7.23E+00	-3.12E+00
2nd week	-2.86E-01	1.41E+00	4.71E+00	-2.86E-01
3rd week	1.42E-01	9.39E-01	3.13E+00	1.42E-01
4th week	1.06E+00	9.84E-01	3.25E+00	1.06E+00
March 2015				
1st week	-1.17E+00	1.72E+00	5.77E+00	-1.17E+00
2nd week	4.52E-01	1.25E+00	4.15E+00	4.52E-01
3rd week	8.67E-01	1.26E+00	4.18E+00	8.67E-01
4th week	2.06E+00	1.01E+00	3.33E+00	2.06E+00
April 2015				
1st week	2.52E+00	1.56E+00	5.14E+00	Not detected
2nd week	1.34E+00	1.21E+00	4.02E+00	Not detected
3rd week	-2.41E+00	1.26E+00	4.26E+00	Not detected
4th week	7.23E-01	7.30E-01	2.42E+00	Not detected
May 2015				
1st week	5.34E-01	1.28E+00	4.25E+00	Not detected
2nd week	4.65E-01	4.77E-01	1.58E+00	Not detected
3rd week	6.90E-01	8.94E-01	2.96E+00	Not detected
4th week	9.48E-01	6.47E-01	2.13E+00	Not detected
June 2015				
1st week	-1.68E-01	5.88E-01	1.97E+00	Not detected
2nd week	9.91E-02	5.43E-01	1.81E+00	Not detected
3rd week	9.28E-01	5.96E-01	1.96E+00	Not detected
4th week	1.23E-01	1.67E-01	5.53E-01	Not detected
July 2015				
1st week	-1.20E-01	3.78E-01	1.26E+00	Not detected
2nd week	4.48E-01	5.22E-01	1.73E+00	Not detected
3rd week	-4.41E-02	6.08E-01	2.03E+00	Not detected
4th week	2.70E-01	4.12E-01	1.37E+00	Not detected

Table 2-23: Weekly Activity density of ^{137}Cs (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	5.91E-01	4.90E-01	1.62E+00	Not detected
2nd week	-6.20E-01	8.34E-01	2.79E+00	Not detected
3rd week	-1.67E-01	4.28E-01	1.43E+00	Not detected
4th week	-4.17E-01	3.63E-01	1.22E+00	Not detected
September 2015				
1st week	1.26E-01	8.49E-01	2.83E+00	Not detected
2nd week	9.58E-02	5.43E-01	1.81E+00	Not detected
3rd week	7.75E-01	7.32E-01	2.06E+00	Not detected
4th week	9.55E-01	5.03E-01	1.65E+00	Not detected
October 2015				
1st week	9.32E-01	8.79E-01	2.91E+00	Not detected
2nd week	-9.25E-01	8.43E-01	2.84E+00	Not detected
3rd week	-8.20E-01	7.66E-01	2.58E+00	Not detected
4th week	5.02E-01	1.14E+01	2.05E+00	Not detected
November 2015				
1st week	1.59E+00	1.30E+00	4.29E+00	Not detected
2nd week	-1.32E+00	1.04E+00	3.51E+00	Not detected
3rd week	-9.51E-02	9.08E-01	3.03E+00	Not detected
4th week	6.96E-01	1.28E+00	4.25E+00	Not detected
December 2015				
1st week	-3.24E-01	1.51E+00	5.03E+00	Not detected
2nd week	5.80E-01	5.66E-01	1.87E+00	Not detected
3rd week	-4.05E-01	7.15E-01	2.40E+00	Not detected
4th week	1.10E+00	1.14E+00	3.77E+00	Not detected

Table 2-24: Weekly Activity density of ^{40}K (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	-3.54E+01	2.58E+01	8.78E+01	Not detected
2nd week	1.64E+01	2.02E+01	6.71E+01	Not detected
3rd week	2.20E+01	1.89E+01	6.25E+01	Not detected
4th week	4.72E+00	1.08E+01	3.58E+01	Not detected
February 2015				
1st week	-8.64E-01	1.59E+01	5.32E+01	Not detected
2nd week	2.19E+00	1.72E+01	5.76E+01	Not detected
3rd week	1.46E+00	1.12E+01	3.74E+01	Not detected
4th week	-4.19E+00	1.22E+01	4.10E+01	Not detected
March 2015				
1st week	1.55E+00	1.66E+01	5.55E+01	Not detected
2nd week	6.95E+00	1.24E+01	4.12E+01	Not detected
3rd week	-3.05E+01	1.65E+01	5.62E+01	Not detected
4th week	-7.43E+00	1.26E+01	4.24E+01	Not detected
April 2015				
1st week	8.96E+00	1.87E+01	6.24E+01	Not detected
2nd week	6.10E+00	1.44E+01	4.80E+01	Not detected
3rd week	2.64E+01	1.40E+01	4.59E+01	Not detected
4th week	8.44E+00	8.52E+00	2.82E+01	Not detected
May 2015				
1st week	2.06E+01	1.51E+01	4.97E+01	Not detected
2nd week	2.46E+00	5.70E+00	1.90E+01	Not detected
3rd week	4.69E+00	1.08E+01	3.61E+01	Not detected
4th week	-1.38E+00	7.81E+00	2.62E+01	Not detected
June 2015				
1st week	-4.48E+00	7.10E+00	2.40E+01	Not detected
2nd week	-1.92E+00	6.66E+00	2.24E+01	Not detected
3rd week	-2.48E-01	7.40E+00	2.48E+01	Not detected
4th week	-2.84E-01	1.86E-01	6.39E-01	Not detected
July 2015				
1st week	-1.97E+00	4.62E+00	1.56E+01	Not detected
2nd week	-4.55E+00	6.54E+00	2.21E+01	Not detected
3rd week	-4.42E+00	7.29E+00	2.46E+01	Not detected
4th week	3.79E+00	4.85E+00	1.61E+01	Not detected

Table 2-24: Weekly Activity density of ^{40}K (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	2.70E+00	5.87E+00	1.96E+01	Not detected
2nd week	1.14E+00	8.34E+00	2.79E+01	Not detected
3rd week	5.98E+00	4.97E+00	1.64E+01	Not detected
4th week	6.21E+00	3.43E+00	1.12E+01	Not detected
September 2015				
1st week	-5.86E+00	9.05E+00	3.05E+01	Not detected
2nd week	-3.96E+00	6.72E+00	2.27E+01	Not detected
3rd week	9.04E+00	7.01E+00	2.31E+01	Not detected
4th week	-1.74E+00	6.61E+00	2.22E+01	Not detected
October 2015				
1st week	9.67E-01	1.07E+01	3.58E+01	Not detected
2nd week	1.18E+01	9.73E+00	3.22E+01	Not detected
3rd week	-9.45E+00	9.75E+00	3.30E+01	Not detected
4th week	1.37E+00	6.07E+00	2.03E+01	Not detected
November 2015				
1st week	-8.77E+00	1.36E+01	4.60E+01	Not detected
2nd week	-1.56E+00	1.00E+01	3.38E+01	Not detected
3rd week	5.95E+00	8.82E+00	2.93E+01	Not detected
4th week	1.59E+01	1.25E+01	4.13E+01	Not detected
December 2015				
1st week	-2.41E+00	1.51E+01	5.05E+01	Not detected
2nd week	5.51E+00	6.71E+00	2.23E+01	Not detected
3rd week	-3.58E+00	8.81E+00	2.97E+01	Not detected
4th week	-1.80E+00	1.39E+01	4.66E+01	Not detected

Table 2-25: Weekly Activity density of ^{60}Co (Bq/g) in Station A (Pre-HEPA) filters in 2015

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	7.67E-01	2.15E-01	7.20E+00	Not detected
2nd week	-5.63E-01	1.70E+00	5.72E+00	Not detected
3rd week	9.83E-02	1.70E+00	5.70E+00	Not detected
4th week	3.33E-02	8.76E-01	2.94E+00	Not detected
February 2015				
1st week	-2.73E+01	2.10E+01	7.16E+01	Not detected
2nd week	1.71E+00	1.36E+00	4.50E+00	Not detected
3rd week	-1.45E+00	9.88E-01	3.37E+00	Not detected
4th week	-8.66E-01	1.02E+00	3.45E+00	Not detected
March 2015				
1st week	1.06E+00	1.37E+00	4.55E+00	Not detected
2nd week	-6.61E-03	1.03E+00	3.44E+00	Not detected
3rd week	-6.07E-01	1.28E+00	4.31E+00	Not detected
4th week	-2.18E-01	1.06E+00	3.56E+00	Not detected
April 2015				
1st week	-9.56E-01	1.59E+00	5.36E+00	Not detected
2nd week	-9.35E-01	1.22E+00	4.15E+00	Not detected
3rd week	2.62E-01	1.24E+00	4.16E+00	Not detected
4th week	-9.97E-02	7.55E-01	2.54E+00	Not detected
May 2015				
1st week	-9.31E-01	1.35E+00	7.37E-01	Not detected
2nd week	3.72E-01	4.83E-01	1.61E+00	Not detected
3rd week	-1.70E-01	9.31E-01	3.13E+00	Not detected
4th week	5.52E-01	6.39E-01	2.12E+00	Not detected
June 2015				
1st week	-2.05E-01	6.03E-01	2.03E+00	Not detected
2nd week	-5.14E-01	5.82E-01	1.97E+00	Not detected
3rd week	-1.67E-01	5.95E-01	2.00E+00	Not detected
4th week	-3.79E-01	1.86E-01	6.39E-01	Not detected
July 2015				
1st week	-4.21E-01	3.85E-01	1.31E+00	Not detected
2nd week	-8.63E-01	5.37E-01	1.84E+00	Not detected
3rd week	-1.84E-01	5.95E-01	2.01E+00	Not detected
4th week	4.79E-01	4.02E-01	1.33E+00	Not detected

Table 2-25: Weekly Activity density of ^{60}Co (Bq/g) in Station A (Pre-HEPA) filters in 2015 (continued)

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	1.41E-02	4.88E-01	1.64E+00	Not detected
2nd week	-1.89E-01	6.83E-01	2.30E+00	Not detected
3rd week	3.69E-02	4.27E-01	1.43E+00	Not detected
4th week	1.67E-01	2.85E-01	9.51E-01	Not detected
September 2015				
1st week	1.34E-02	7.04E-01	2.36E+00	Not detected
2nd week	1.77E-03	5.60E-01	1.88E+00	Not detected
3rd week	-5.44E-02	6.13E-01	2.06E+00	Not detected
4th week	-3.60E-01	5.33E-01	1.80E+00	Not detected
October 2015				
1st week	-7.41E-01	9.24E-01	3.13E+00	Not detected
2nd week	3.11E-03	8.30E-01	2.79E+00	Not detected
3rd week	-8.14E-01	7.80E-01	2.65E+00	Not detected
4th week	8.29E-02	5.12E-01	1.71E+00	Not detected
November 2015				
1st week	5.31E-01	1.11E+00	3.69E+00	Not detected
2nd week	1.08E+00	8.81E-01	2.91E+00	Not detected
3rd week	3.13E-01	6.88E-01	2.30E+00	Not detected
4th week	-3.82E-01	1.04E+00	3.52E+00	Not detected
December 2015				
1st week	-4.77E-01	1.21E+00	4.10E+00	Not detected
2nd week	-5.89E-01	5.66E-01	1.92E+00	Not detected
3rd week	-5.30E-01	7.28E-01	2.46E+00	Not detected
4th week	1.84E+00	1.15E+00	3.80E+00	Not detected

Table 2-26: Weekly Activity density of ^{137}Cs (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	-1.40E+00	1.64E+01	5.46E+01	Not detected
2nd week	-5.69E+00	1.10E+01	3.69E+01	Not detected
3rd week	1.57E+01	1.68E+01	5.55E+01	Not detected
4th week	1.11E+01	1.14E+01	3.78E+01	Not detected
February 2015				
1st week	-7.57E+00	1.59E+01	5.33E+01	Not detected
2nd week	-7.92E+00	3.35E+01	1.12E+02	Not detected
3rd week	-7.96E+00	2.24E+01	7.51E+01	Not detected
4th week	8.45E+00	2.09E+01	6.94E+01	Not detected
March 2015				
1st week	-2.17E+00	6.48E+00	2.17E+01	Not detected
2nd week	4.26E+00	1.04E+01	3.44E+01	Not detected
3rd week	-4.84E+00	3.66E+01	1.22E+02	Not detected
4th week	5.80E+00	3.71E+01	1.23E+02	Not detected
April 2015				
1st week	-7.52E+00	1.02E+01	3.46E+01	Not detected
2nd week	-4.27E+00	2.41E+01	8.05E+01	Not detected
3rd week	-1.98E+01	1.62E+01	5.45E+01	Not detected
4th week	5.18E+00	9.59E+00	3.18E+01	Not detected
May 2015				
1st week	7.07E-01	7.24E+00	2.41E+01	Not detected
2nd week	-1.63E+00	8.03E+00	2.68E+01	Not detected
3rd week	1.50E+01	8.18E+00	2.69E+01	Not detected
4th week	-1.21E-01	1.13E+01	3.79E+01	Not detected
June 2015				
1st week	-3.03E+00	8.02E+00	2.68E+01	Not detected
2nd week	-7.75E+00	1.95E+01	6.53E+01	Not detected
3rd week	-1.09E+02	2.01E+02	6.77E+02	Not detected
4th week	-3.13E+01	9.47E+01	3.18E+02	Not detected
July 2015				
1st week	1.23E+01	1.11E+01	3.66E+01	Not detected
2nd week	-2.07E+01	3.27E+01	1.10E+02	Not detected
3rd week	-1.62E+00	2.72E+01	9.12E+01	Not detected
4th week	-9.85E+01	1.21E+02	4.09E+02	Not detected

Table 2-26: Weekly Activity density of ^{137}Cs (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{137}Cs Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	-2.20E+01	1.47E+01	4.94E+01	Not detected
2nd week	-2.22E+00	9.55E+00	3.19E+01	Not detected
3rd week	7.22E+01	7.48E+01	2.48E+02	Not detected
4th week	-4.90E+01	1.03E+02	3.45E+02	Not detected
September 2015				
1st week	8.16E+00	8.00E+00	2.64E+01	Not detected
2nd week	3.16E+01	2.30E+01	7.58E+01	Not detected
3rd week	7.75E+01	1.05E+02	3.48E+02	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected
October 2015				
1st week	-5.96E+00	1.12E+01	3.74E+01	Not detected
2nd week	5.65E+00	8.31E+00	2.76E+01	Not detected
3rd week	-5.92E+02	7.24E+02	2.45E+03	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected
November 2015				
1st week	-8.42E+00	1.99E+01	6.66E+01	Not detected
2nd week	-5.84E+00	9.09E+00	3.58E+01	Not detected
3rd week	1.36E+02	1.63E+02	5.41E+02	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected
December 2015				
1st week	1.74E+01	1.92E+01	6.36E+01	Not detected
2nd week	7.06E+00	1.05E+01	3.48E+01	Not detected
3rd week	-4.78E+01	1.31E+02	4.40E+02	Not detected
4th week	0.00E+00	0.00E+00	0.00E+00	Not detected

Table 2-27: Weekly Activity density of ^{40}K (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	4.48E+01	1.64E+02	5.49E+02	Not detected
2nd week	6.07E+01	1.09E+02	3.63E+02	Not detected
3rd week	-1.47E+02	2.02E+02	6.83E+02	Not detected
4th week	-1.74E+02	1.36E+02	4.64E+02	Not detected
February 2015				
1st week	-6.62E+00	1.58E+02	5.29E+02	Not detected
2nd week	7.81E+01	3.36E+02	1.13E+03	Not detected
3rd week	2.15E+02	2.66E+02	8.85E+02	Not detected
4th week	3.29E+02	2.02E+02	6.62E+02	Not detected
March 2015				
1st week	-1.22E+02	8.11E+01	2.76E+02	Not detected
2nd week	5.86E+01	9.74E+01	3.24E+02	Not detected
3rd week	2.41E+02	3.58E+02	1.19E+03	Not detected
4th week	-5.31E+00	3.75E+02	1.26E+03	Not detected
April 2015				
1st week	-8.26E+01	1.23E+02	4.15E+02	Not detected
2nd week	-1.52E+01	2.35E+02	7.87E+02	Not detected
3rd week	8.29E+01	1.62E+02	5.39E+02	Not detected
4th week	8.22E+01	1.14E+02	3.81E+02	Not detected
May 2015				
1st week	-5.32E+01	9.20E+01	3.10E+02	Not detected
2nd week	-5.50E+01	7.97E+01	2.69E+01	Not detected
3rd week	5.77E+01	9.99E+01	3.33E+02	Not detected
4th week	8.73E+01	1.27E+02	4.23E+02	Not detected
June 2015				
1st week	-7.35E+00	9.34E+01	3.14E+02	Not detected
2nd week	3.64E+02	1.88E+02	6.13E+02	Not detected
3rd week	-1.09E+02	2.01E+02	6.77E+02	Not detected
4th week	-3.13E+01	9.47E+01	3.18E+02	Not detected
July 2015				
1st week	8.62E+01	1.33E+02	4.43E+02	Not detected
2nd week	-1.22E+02	3.83E+02	1.29E+03	Not detected
3rd week	-1.62E+00	2.72E+01	9.12E+01	Not detected
4th week	-9.85E+01	1.21E+02	4.09E+02	Not detected

Table 2-27: Weekly Activity density of ^{40}K (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{40}K Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
1st week	2.43E+01	1.37E+02	4.60E+02	Not detected
2nd week	-9.81E+00	9.32E+01	3.13E+02	Not detected
3rd week	7.22E+01	7.48E+01	2.48E+02	Not detected
4th week	-4.90E+01	1.03E+02	3.45E+02	Not detected
September 2015				
1st week	7.78E+01	7.86E+01	2.60E+02	Not detected
2nd week	-6.79E+01	2.87E+02	9.65E+02	Not detected
3rd week	8.52E+01	1.05E+02	3.47E+02	Not detected
4th week	8.08E+01	1.09E+02	3.63E+02	Not detected
October 2015				
1st week	1.73E+02	1.04E+02	3.42E+02	Not detected
2nd week	-6.37E+01	9.86E+01	3.33E+02	Not detected
3rd week	8.36E+02	7.13E+02	2.35E+03	Not detected
4th week	-1.37E+02	1.68E+02	5.68E+02	Not detected
November 2015				
1st week	-2.26E+02	2.08E+02	7.01E+02	Not detected
2nd week	2.40E-01	1.25E+02	4.18E+02	Not detected
3rd week	-3.46E+01	1.59E+02	5.34E+02	Not detected
4th week	1.58E+02	1.90E+02	6.30E+02	Not detected
December 2015				
1st week	1.46E+02	1.97E+02	6.53E+02	Not detected
2nd week	1.75E+01	1.09E+02	3.65E+02	Not detected
3rd week	1.16E+02	1.22E+02	4.04E+02	Not detected
4th week	-3.95E+01	1.08E+02	3.64E+02	Not detected

Table 2-28: Weekly Activity density of ^{60}Co (Bq/g) in Station B (Post-HEPA) filters in 2015

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
January 2015				
1st week	-1.07E+01	1.38E+01	4.65E+01	Not detected
2nd week	1.08E+01	8.44E+00	2.79E+01	Not detected
3rd week	4.46E+00	1.66E+01	5.56E+01	Not detected
4th week	-1.07E+01	1.18E+01	4.02E+01	Not detected
February 2015				
1st week	9.29E-01	1.24E+01	4.16E+01	Not detected
2nd week	2.49E+01	2.70E+01	8.96E+01	Not detected
3rd week	-2.12E+01	2.39E+01	8.09E+01	Not detected
4th week	-1.39E+01	1.80E+01	6.08E+01	Not detected
March 2015				
1st week	-8.05E+00	6.88E+00	2.34E+01	Not detected
2nd week	-4.79E+00	8.48E+00	2.86E+01	Not detected
3rd week	-1.61E+01	3.03E+01	1.02E+02	Not detected
4th week	1.94E+00	3.07E+01	1.03E+02	Not detected
April 2015				
1st week	-8.26E+01	1.23E+02	4.15E+02	Not detected
2nd week	-8.18E-02	1.91E+01	6.41E+01	Not detected
3rd week	4.10E+00	1.30E+01	4.34E+01	Not detected
4th week	3.69E+00	9.39E+00	3.14E+01	Not detected
May 2015				
1st week	8.74E+00	7.36E+00	2.43E+01	Not detected
2nd week	1.71E+00	6.49E+00	2.17E+01	Not detected
3rd week	3.86E+00	8.37E+00	2.79E+01	Not detected
4th week	-6.54E-01	1.16E+01	3.91E+01	Not detected
June 2015				
Ist week	-2.69E+00	7.71E+00	2.60E+01	Not detected
2nd week	-7.47E+00	1.59E+01	5.36E+01	Not detected
3rd week	2.24E+01	1.60E+01	5.27E+01	Not detected
4th Week	-7.03E+00	7.68E+00	2.60E+01	Not detected
July 2015				
Ist week	-9.31E+00	1.12E+01	4.04E+01	Not detected
2nd week	-1.02E+01	3.20E+01	1.07E+02	Not detected
3rd week	-1.72E+00	2.25E+00	7.60E+00	Not detected
4th Week	-1.11E+00	9.84E+00	3.31E+01	Not detected

Table 2-28: Weekly Activity density of ^{60}Co (Bq/g) in Station B (Post-HEPA) filters in 2015 (continued)

Sample Date	^{60}Co Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
August 2015				
Ist week	4.02E+00	1.15E+01	3.83E+01	Not detected
2nd week	5.21E+00	7.21E+00	2.40E+01	Not detected
3rd week	-5.14E+00	6.68E+00	2.26E+01	Not detected
4th Week	-1.72E+01	8.88E+00	3.03E+01	Not detected
September 2015				
Ist week	6.91E+00	6.44E+00	2.13E+01	Not detected
2nd week	-8.52E+00	2.41E+01	8.14E+01	Not detected
3rd week	-2.10E-04	2.36E-04	7.99E-04	Not detected
4th Week	-7.61E+00	9.18E+00	3.11E+01	Not detected
October 2015				
Ist week	9.11E+00	9.07E+00	3.00E+01	Not detected
2nd week	-8.01E+00	8.11E+00	2.75E+01	Not detected
3rd week	-2.43E+01	6.04E+01	2.03E+02	Not detected
4th Week	-1.73E+01	1.37E+01	4.67E+01	Not detected
November 2015				
Ist week	-1.02E+01	1.76E+01	5.92E+01	Not detected
2nd week	-8.27E+00	1.07E+01	3.61E+01	Not detected
3rd week	-1.50E+00	1.31E+01	4.42E+01	Not detected
4th Week	-1.06E+01	1.62E+01	5.47E+01	Not detected
December 2015				
Ist week	1.97E+00	1.57E+01	5.26E+01	Not detected
2nd week	-9.23E+00	9.32E+00	3.15E+01	Not detected
3rd week	-7.30E+00	1.05E+01	3.54E+01	Not detected
4th Week	3.06E+00	8.69E+00	2.91E+01	Not detected

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 near the repository and two ambient air samplers in the two closest municipalities nearest the WIPP facility (the Village of Loving and the City of Carlsbad). The ambient air monitoring sites nearest the WIPP facility are located in the most prevalent wind directions from the facility, whereas the ambient air monitoring sites in Loving and Carlsbad are located on Village of Loving owned property and at the CEMRC facility primarily as a matter of convenience and cost. 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.

The radionuclides of greatest concern in the WIPP are $^{239+240}$Pu and ^{241}Am, which account for more than 99% of the total radioactivity slated for disposal within the repository. According to current estimates, the WIPP repository will contain approximately 1.20×10^{4} kg of Pu isotopes and 203 kg of ^{241}Am (SOTERM-2014). In this context, the variation in concentrations of these radionuclides in the WIPP environment is important not only because they are the main components of the WIPP wastes, but also because of their global background activity. Transuranic elements are not naturally present in measurable quantities in the ambient air. With few exceptions, nuclear weapon testing was the main source of plutonium in ambient air, but the amount of plutonium still remaining in the atmosphere today from these tests is small because most of the radioactivity has been deposited on the ground as fallout (Harley 1980; Perkins and Thomas 1980). Since the first nuclear test detonation in New Mexico in 1945, approximately 11 PBq of $^{239+240}$Pu has been ejected into the atmosphere (Perkins and Thomas 1980; UNSCEAR, 2000). In addition 0.6 PBq of ^{238}Pu were released over the south Pacific in the high altitude destruction of the SNAP-9A satellite power source in 1964 (Hardy et al., 1973; Krey, 1968). Most of the global fallout was deposited in the northern hemisphere and the majority of the fallout was deposited in the middle latitudes.

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 or oceans. Depending on meteorological conditions, physiochemical properties of soil, and human activity, plutonium can migrate vertically with various rates, can be transported into plants or can become 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™ 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.

Following the radiation release event of 2014, the CEMRC added three additional high-volume sampling stations in order to provide additional information to area residents in the event of a future radiation release event; however, at this time, the third high-volume sampling station has not been deployed as the construction for the concrete base that will eventually hold the sampling tower has been significantly delayed due to the on-going recovery and resumption of waste emplacement activities at the WIPP facility . The new sampling stations are located: (1) in Carlsbad, behind the CEMRC facility, about 56 km northwest of the WIPP site; (2) on the south side of Loving, about 47 km southwest of the WIPP facility, and (3) on the east side of the WIPP facility near the WIPP meteorological station, about 0.3 km east of the WIPP facility. These sampling locations are shown in Figure 3-3. Aerosol samples are currently collected from two sites (Loving and Carlsbad). As mentioned previously, aerosol sampling at third monitoring station located on the east side of the WIPP has not begun at the time this document was prepared.

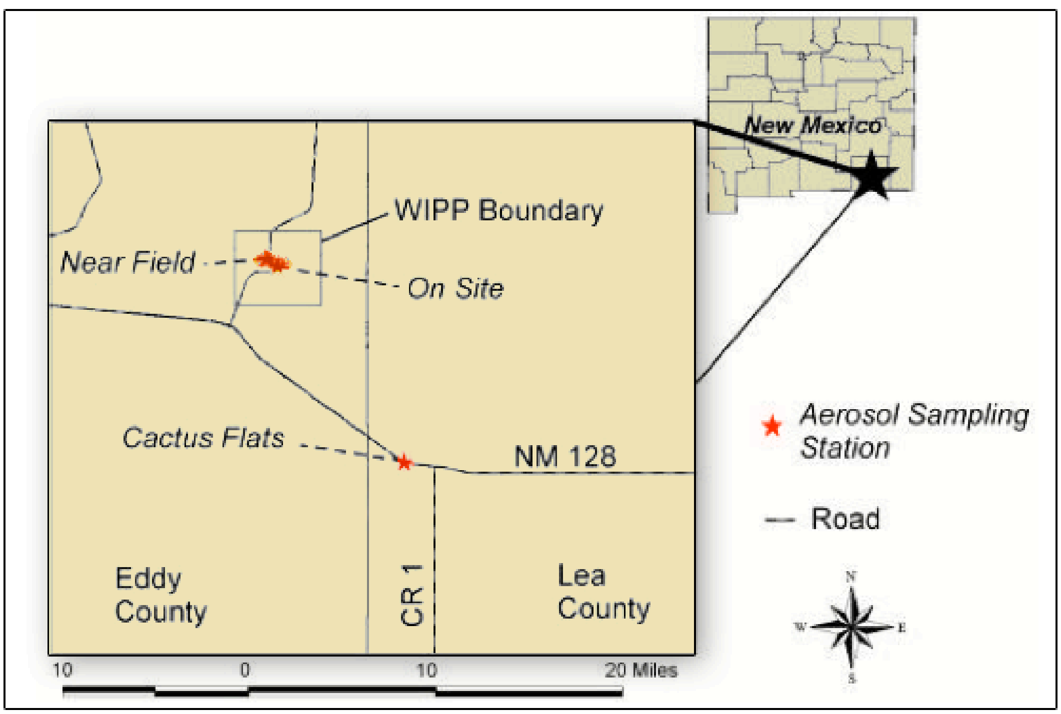


Figure 3-1: Ambient Aerosol Sampling Locations (Prior to Radiation Release 2014)

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

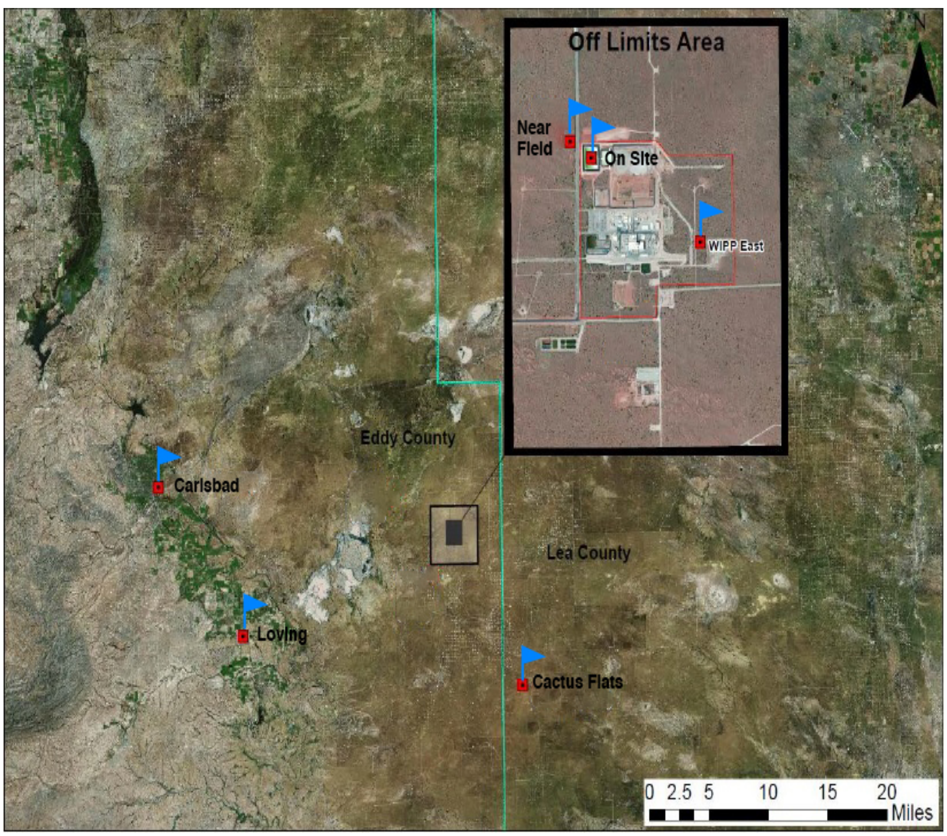


Figure 3-3: Ambient Aerosol Sampling Locations (Post Radiation Release)

Sample Preparation

The high-volume samples were analyzed for selected radionuclides, including ^{238}Pu, $^{239+240}$Pu, ^{241}Am and recently ^{235}U, ^{234}U and ^{238}U following 6 hours of heating in a muffle furnace at 500° C to drive off organics. Once heated in the muffle furnace, each filter was then digested with a strong acid mixture of HCl+HF+$HClO_4$, to aid in the complete decomposition of silica. Samples were then 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 and evaporation was repeated to ensure that all residual HF is removed from the matrix. The residues were then dissolved in 1.0 M HCl for subsequent radionuclide separation and analysis. The acid digestates of the filter composite samples were then 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 were used for the separation of Am. The samples were 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 were 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

CEMRC detected trace levels of ^{241}Am and $^{239+240}$ Pu at two sampling locations (Onsite and Near Field) in February of 2014. No radioactivity was detected at Cactus Flats Station located approximately 19 km southeast of the WIPP facility. The highest concentrations detected were 10.2 µBq/m^3 for $^{239+240}$Pu and 115.2 µBq/m^3 for ^{241}Am at the Onsite sampling Station, and 81.4 µBq/m^3 for ^{241}Am and 5.78 µBq/m^3 for $^{239+240}$Pu at the Near Field Station (shown in Figures 3-4 and 3-5). The levels detected were very low and localized, and no radiation-related health effects among local workers or the public are expected. 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. 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.

Low levels of $^{239+240}$Pu and ^{241}Am in the ambient air were again detected at our onsite and Near Field monitoring locations during 2015. The concentrations of $^{239+240}$Pu, ^{241}Am and ^{238}Pu measured in the ambient air filters during 2015 are listed in Tables 3-1 to 3-3 (Onsite Station), Tables 3-4 to 3-6 (Near Field Station) and Tables 3-7 to 3-9 (Cactus Flats Station). The small level of contamination that was detected in the ambient air was expected and is attributed to the ongoing clean-up efforts in the WIPP underground as clean-up operations tend to dislodge some residual contaminated particles into the underground air. Although these values are above the background levels seen prior to the event, it is important to note that the levels detected were very low and are well below any level of public health or environmental concern. Recent monitoring data show that the concentration levels of these radionuclides have returned to normal background levels and in many instances are not even detectable, further demonstrating the fact that no long-term environmental impacts remain from the 2014 radiation release event at the WIPP.

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 3-4 and 3-5). 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.

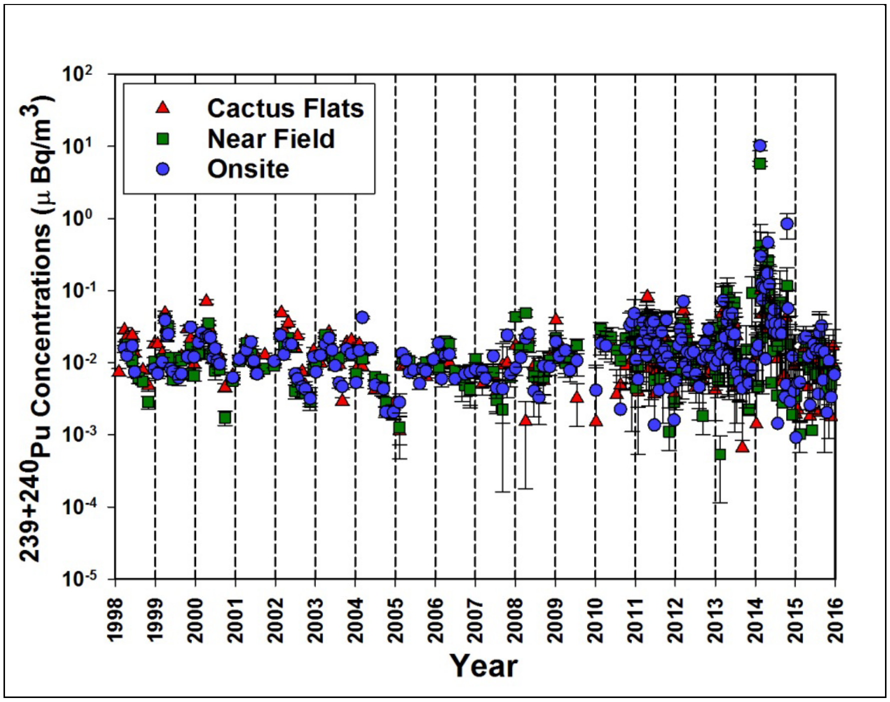


Figure 3-4: The Pre- and Post-radiological event $^{239+240}$Pu concentrations in ambient air at three stations in the vicinity of the WIPP site

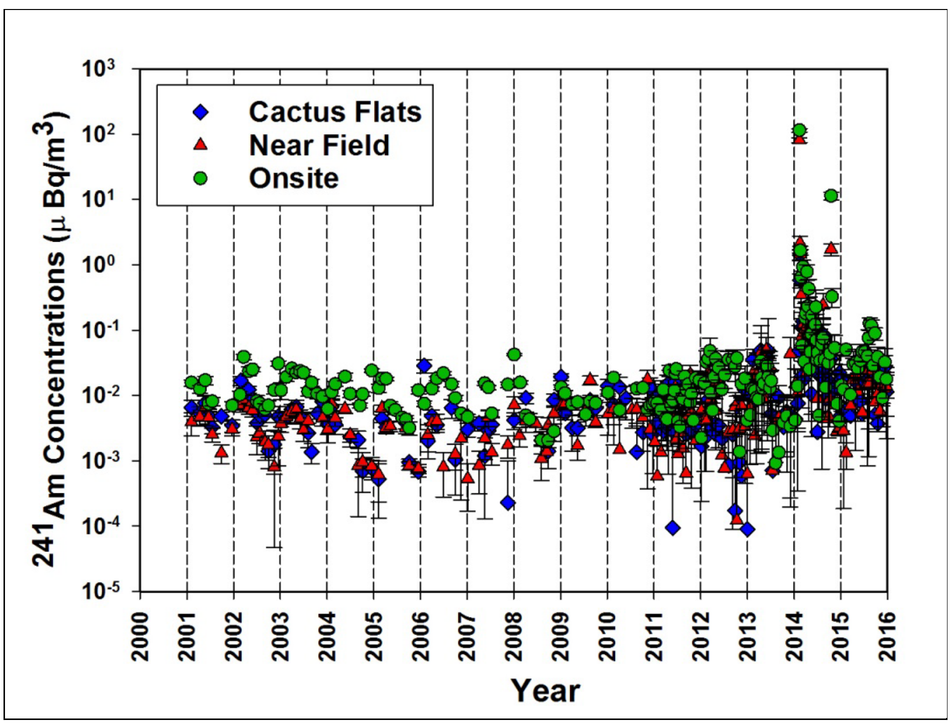


Figure 3-5: The Pre- and Post-radiological event ^{241}Am concentrations in ambient air at three stations in the vicinity of the WIPP site

The $^{239+240}$Pu activity densities (activity per unit mass aerosol collected) were in the range of 0.00-0.91 mBq/g at the Onsite station, 0.00-0.51 mBq/g at the Near Field station and 0.05-

0.51 mBq/g at the Cactus Flats station, while that of ^{241}Am were in the range of 0.27-0.3.29 mBq/g at the Onsite station, 0.12-1.14 mBq/g at the Near Field station and 0.14-0.95 mBq/g at the Cactus Flats station. Furthermore, the mass loadings at all stations tend to track one another remarkably well as shown in Figures 3-6 and 3-7. The activity density of $^{239+240}$Pu, ^{241}Am and ^{238}Pu measured in the ambient air filters during 2015 are listed in Tables 3-10 to 3-12 (Onsite Station), Tables 3-13 to 3-15 (Near Field Station) and Tables 3-16 to 3-18 (Cactus Flats Station).

The highest levels of activity 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 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 (0.33-1.39 g)> Near Field (0.39-1.33 g) > Cactus Flats (0.32-1.28 g).

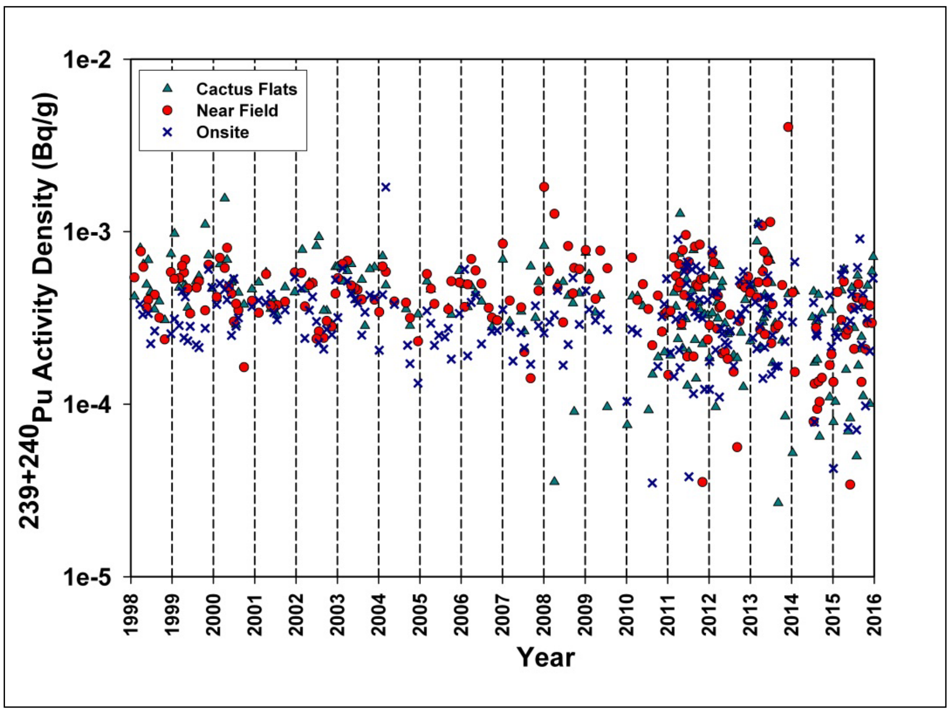


Figure 3-6: The Pre- and Post-radiological event $^{239+240}$Pu densities in ambient air at three stations in the vicinity of the WIPP site

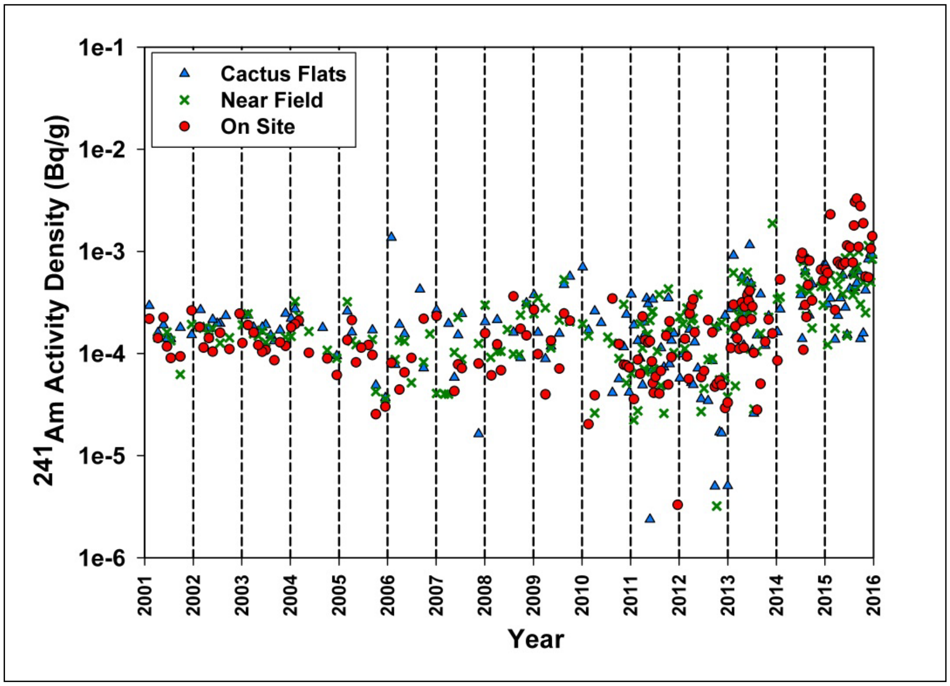


Figure 3-7: The Pre- and Post-radiological event ^{241}Am densities in ambient air at three stations in the vicinity of the WIPP site

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 3-19 (Onsite station), Table 3-20 (Near Field Station) and Table 3-21 (Cactus Flats Station). The isotopes of uranium were detected at all sample locations. The highest concentrations detected were 2.74E-6 Bq/m^3 for ^{234}U and 2.41E-6 Bq/m^3 for ^{238}U measured at the Onsite sampling station. The concentrations detected between the Onsite location and distant locations were not statistically different. The activity density of uranium isotopes measured in the ambient air filters during 2015 are listed in Tables 3-22 (Onsite Station), Tables 3-23 (Near Field Station) and Tables 3-24 (Cactus Flats Station).

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 1.06±0.07 at the Onsite Station, 1.08±0.09 at the Near Field station, and 1.03±0.16 at the 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 3-8 and 3-9.

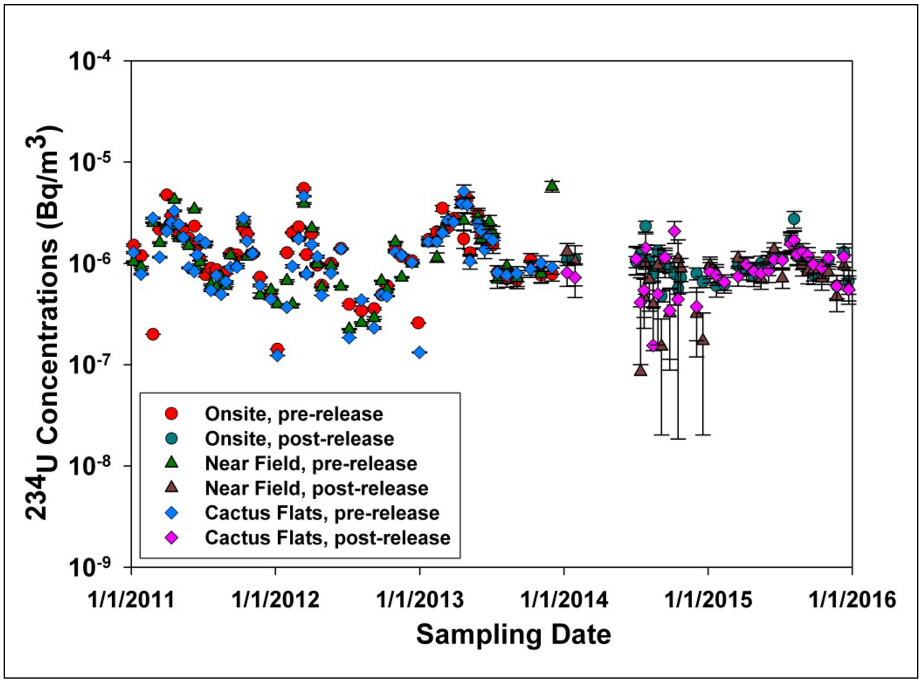


Figure 3-8: The Pre- and Post-radiological event ^{234}U concentrations in ambient air at three stations in the vicinity of the WIPP site

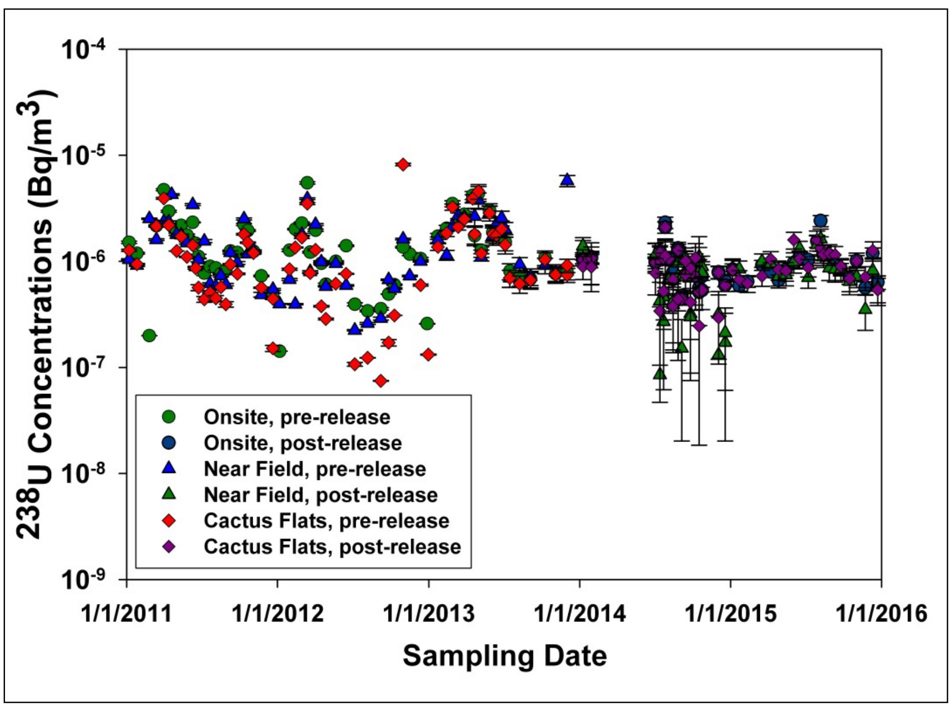


Figure 3-9: The Pre- and Post-radiological event ^{238}U concentrations in ambient air at three stations in the vicinity of the WIPP site

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 3-10 through 3-18.

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 Tables 3-25 (On Site), 3-26 (Near Field) and 3-27 (Cactus Flats). The individual activity densities of these radionuclides in these three monitoring stations are summarized Tables 3-28 (On Site), 3-29 (Near Field) and 3-30 (Cactus Flats).

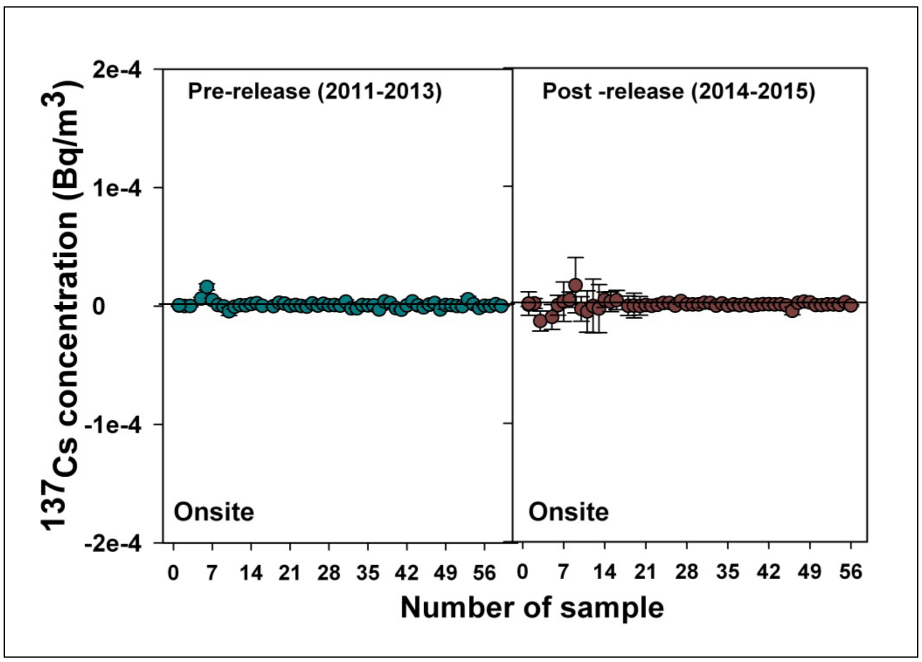


Figure 3-10: The Pre- and Post-radiological event ^{137}Cs concentrations in ambient air at Onsite station

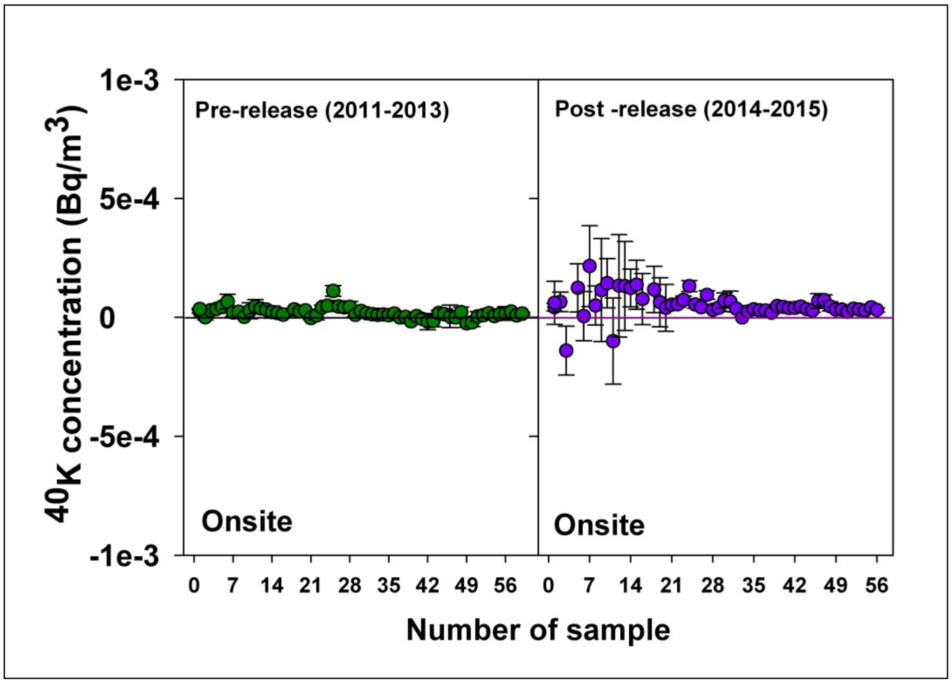


Figure 3-11: The Pre- and Post-radiological event ^{40}K concentrations in ambient air at Onsite station

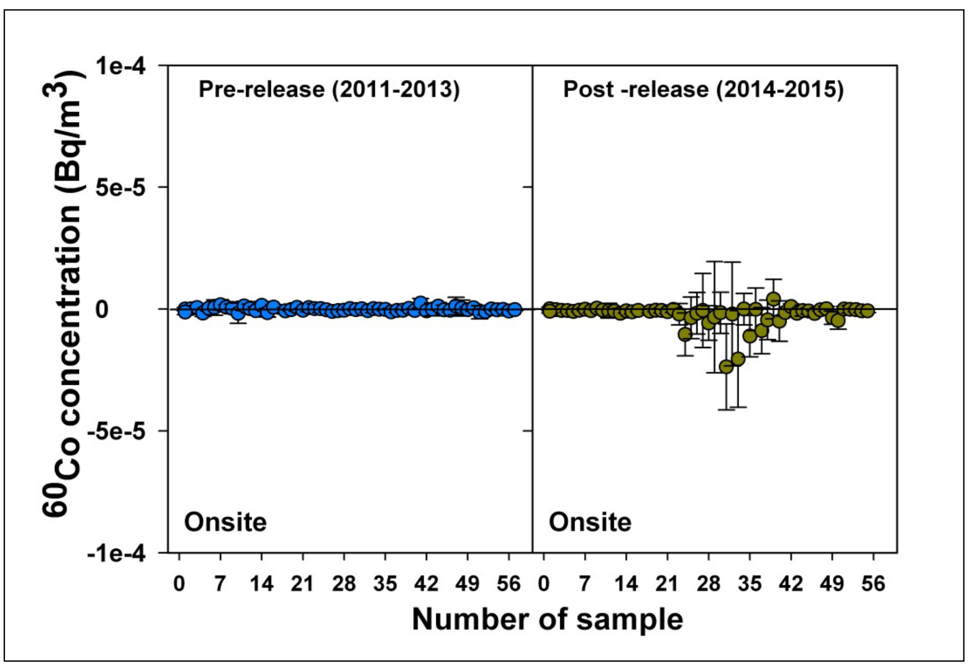


Figure 3-12: The Pre- and Post-radiological event ^{60}Co concentrations in ambient air at Onsite station

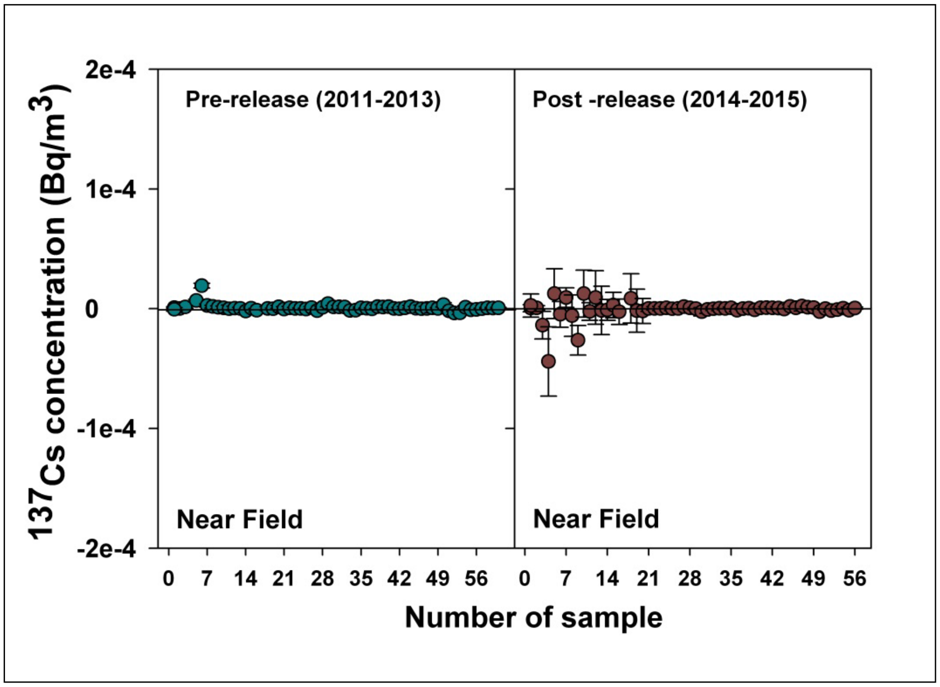


Figure 3-13: The Pre- and Post-radiological event ^{137}Cs concentrations in ambient air at Near Field station

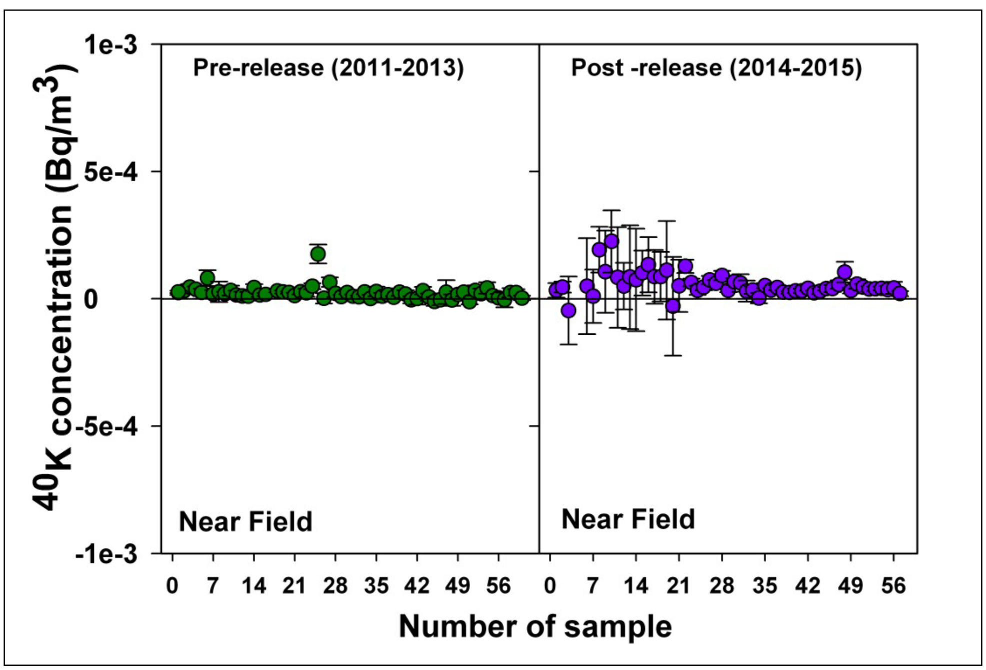


Figure 3-14: The Pre- and Post-radiological event ^{40}K concentrations in ambient air at Near Field station

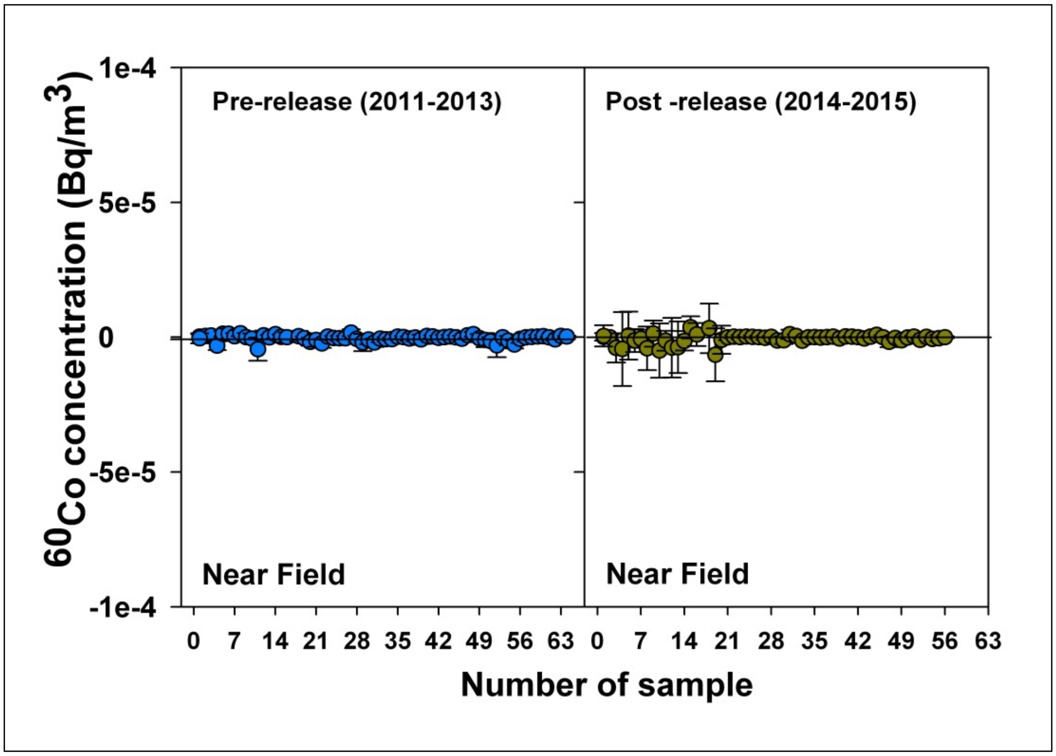


Figure 3-15: The Pre- and Post-radiological event ^{60}Co concentrations in ambient air at Near Field station

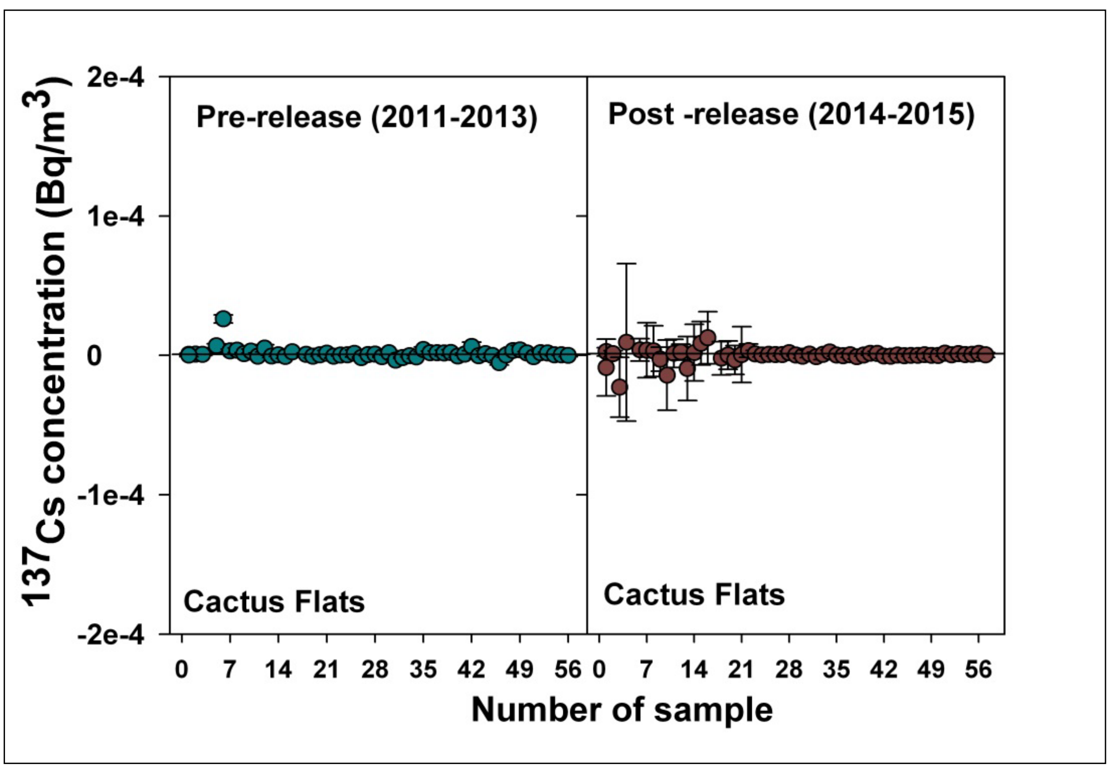


Figure 3-16: The Pre- and Post-radiological event ^{137}Cs concentrations in ambient air at Cactus Flats station

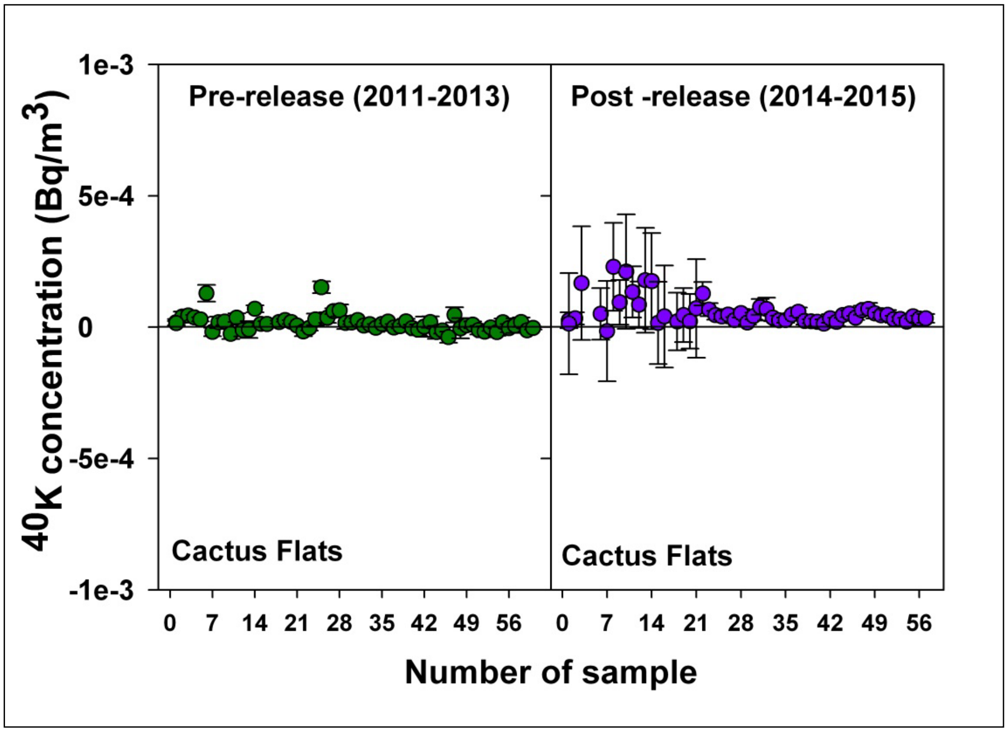


Figure 3-17: The Pre- and Post-radiological event ^{40}K concentrations in ambient air at Cactus Flats station

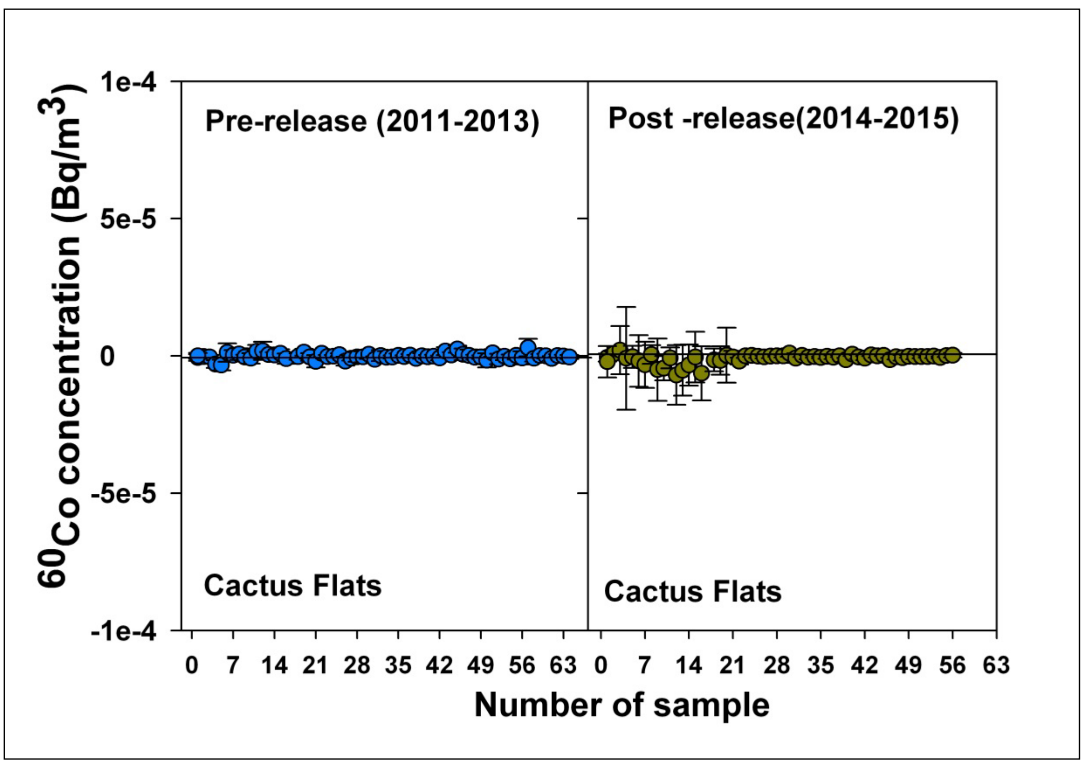


Figure 3-18: The Pre- and Post-radiological event ^{60}Co concentrations in ambient air at Cactus Flats station

Radionuclides concentrations at Carlsbad and Loving Monitoring Stations

The CEMRC began sampling at these two stations in the May of 2015. The concentrations of $^{239+240}Pu$, ^{238}Pu and ^{241}Am measured are listed in Tables 3-31 (Loving) and 3-32 (Carlsbad) and are shown in Figures 3-19 through 3-21 (Loving) and Figures 3-22 through 3-24 (Carlsbad). The levels of $^{239+240}Pu$, ^{238}Pu and ^{241}Am in these monitoring stations are consistent with the normal background levels usually measured in the WIPP vicinity. The corresponding activity densities (activity per gram of dust) are summarized in Tables 3-33 (Loving) and 3-34 (Carlsbad). The isotopes of uranium were detected at both sample locations. The levels detected were similar to those measured at other sample locations around the WIPP. The individual activity concentration of uranium isotopes measured in the ambient air samples collected from Loving and Carlsbad during 2015 are listed in Tables 3-35 (Loving) and 3-36 (Carlsbad). The individual activity density of uranium isotopes measured in the ambient air samples collected from Loving and Carlsbad during 2015 are listed in Tables 3-37 (Loving) and 3-38 (Carlsbad).

Gamma radionuclides (^{137}Cs or ^{60}Co) were not detected in any of the ambient air filter samples collected in 2015. However, ^{40}K was detected in a few ambient air filter samples. The activity concentrations of these gamma radionuclides measured are listed in Tables 3-39 (Loving) and 3-40 (Carlsbad) and shown in Figures 3-25 and 3-26 (Loving) and Figures 3-27 and 3-28 (Carlsbad). The corresponding activity density values are summarized in Tables 3-41 (Loving) and 3-42 (Carlsbad).

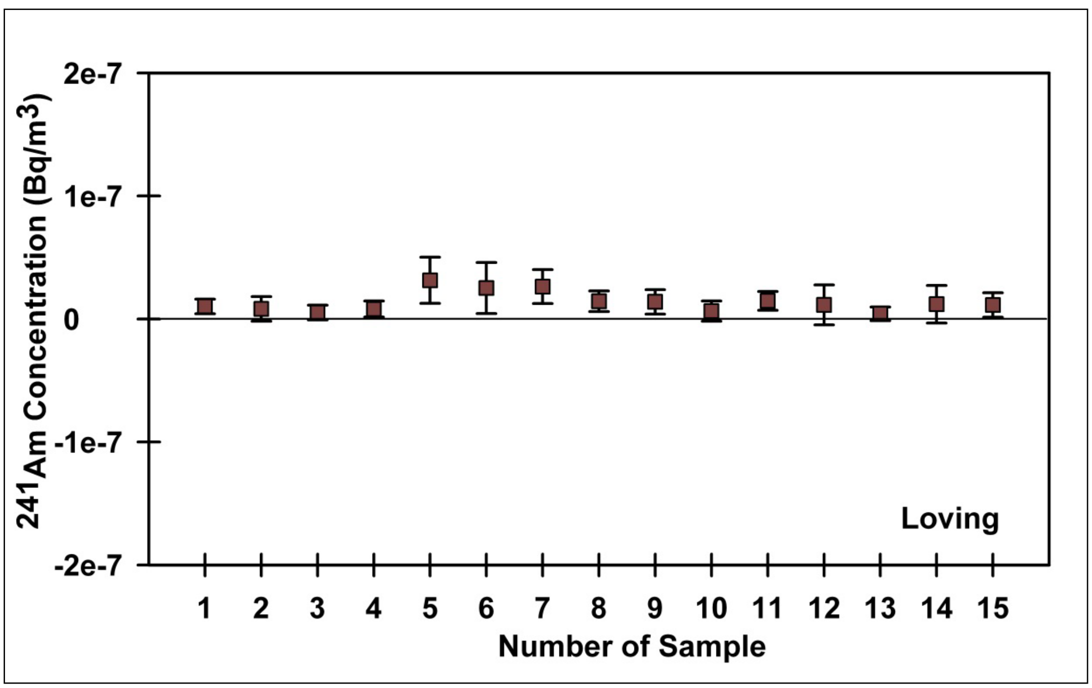


Figure 3-19: The ^{241}Am concentrations in ambient air at Loving station in 2015

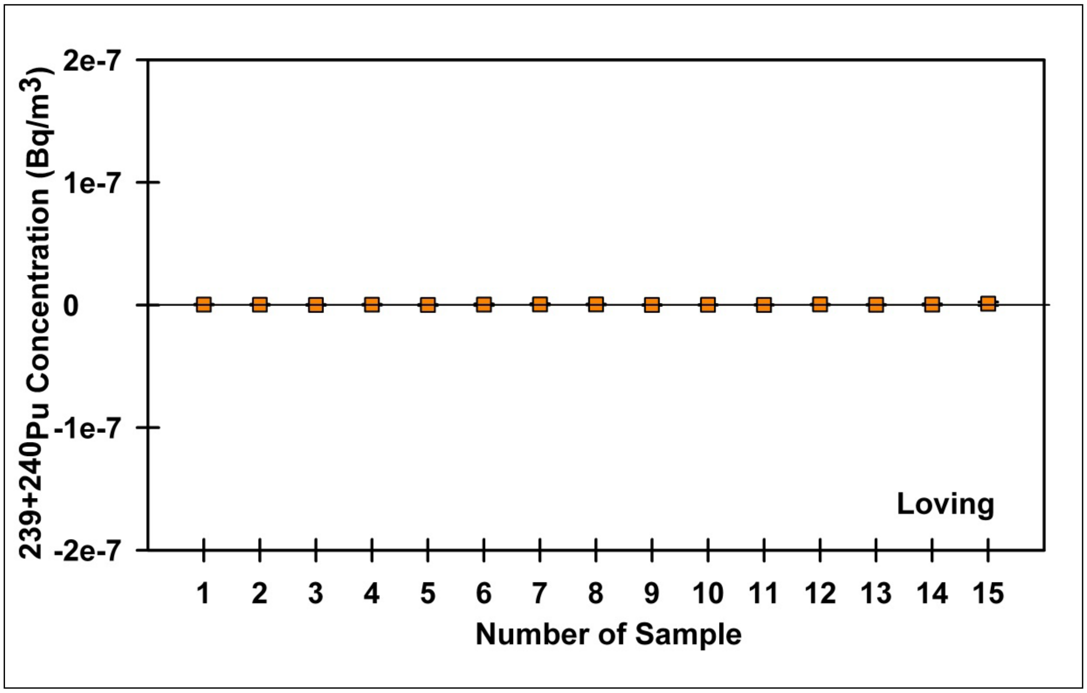


Figure 3-20: The $^{239+240}$Pu concentrations in ambient air at Loving station in 2015

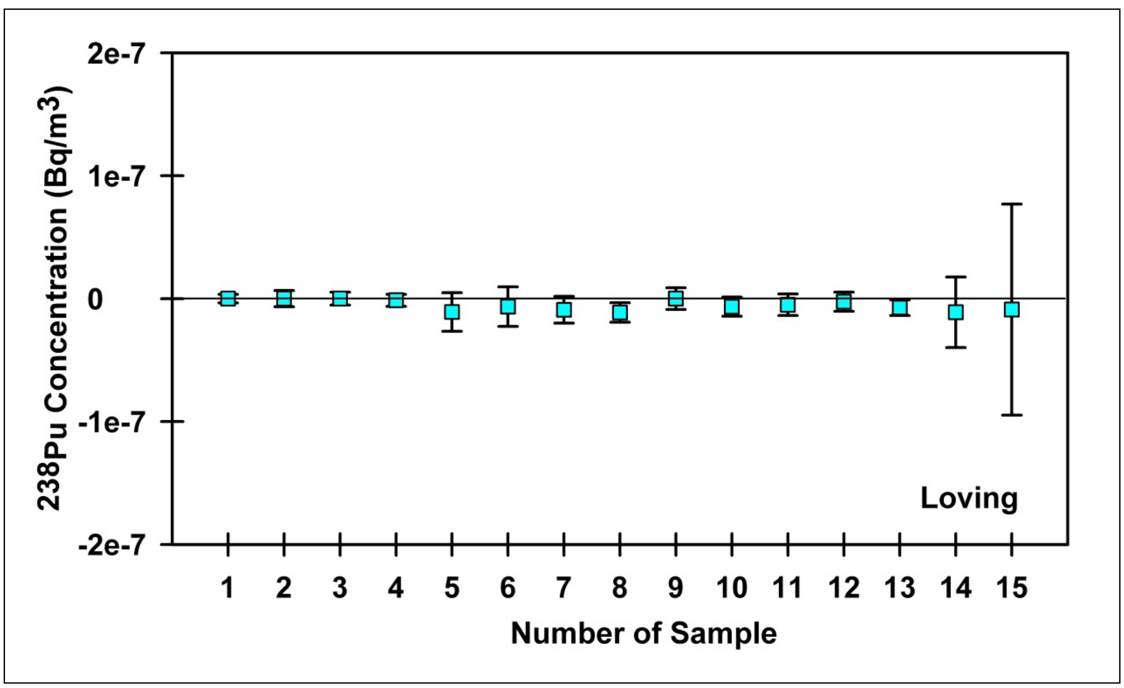


Figure 3-21: The ^{238}Pu concentrations in ambient air at Loving station in 2015

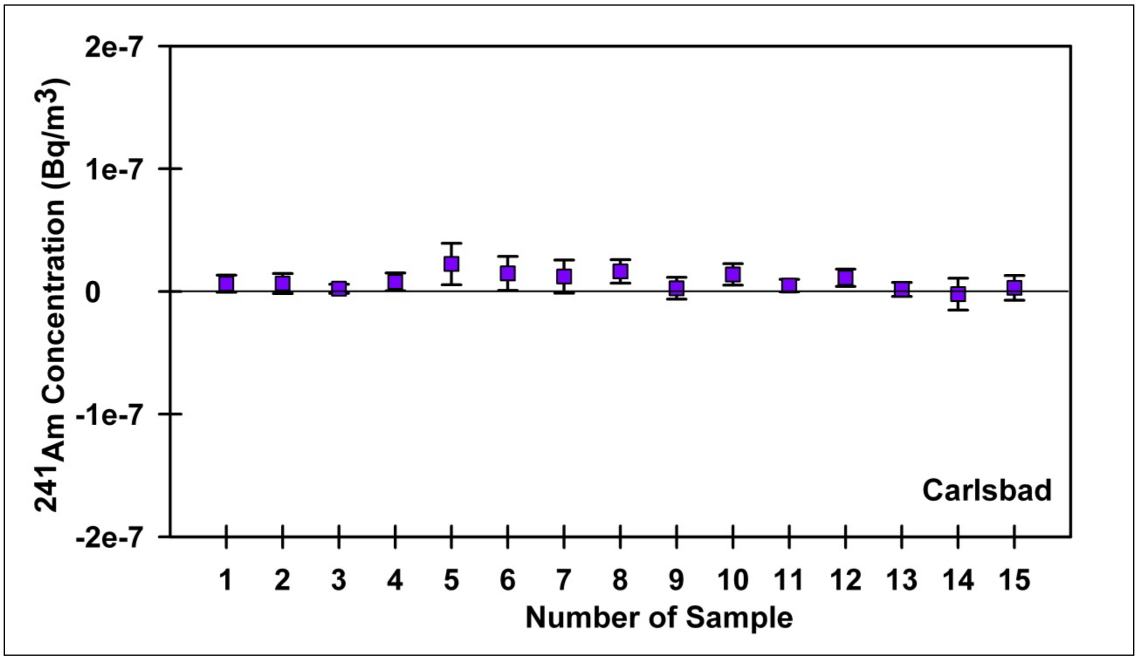


Figure 3-22: The ^{241}Am concentrations in ambient air at Carlsbad station in 2015

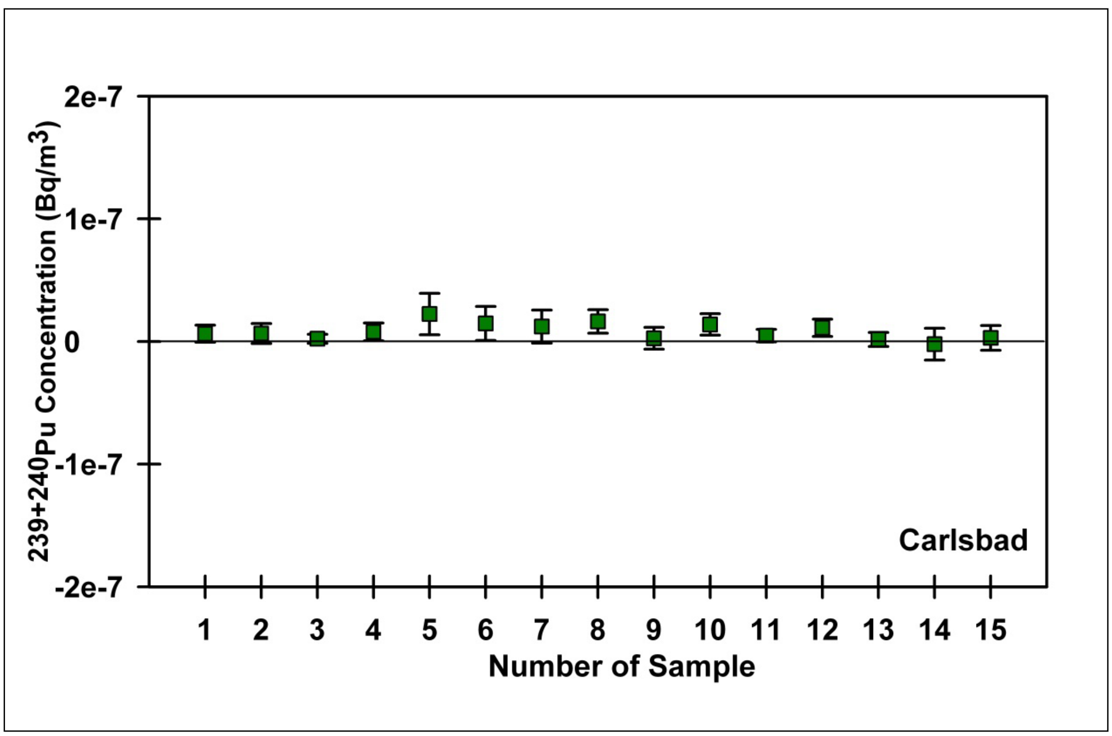


Figure 3-23: The $^{239+240}$Pu concentrations in ambient air at Carlsbad station in 2015

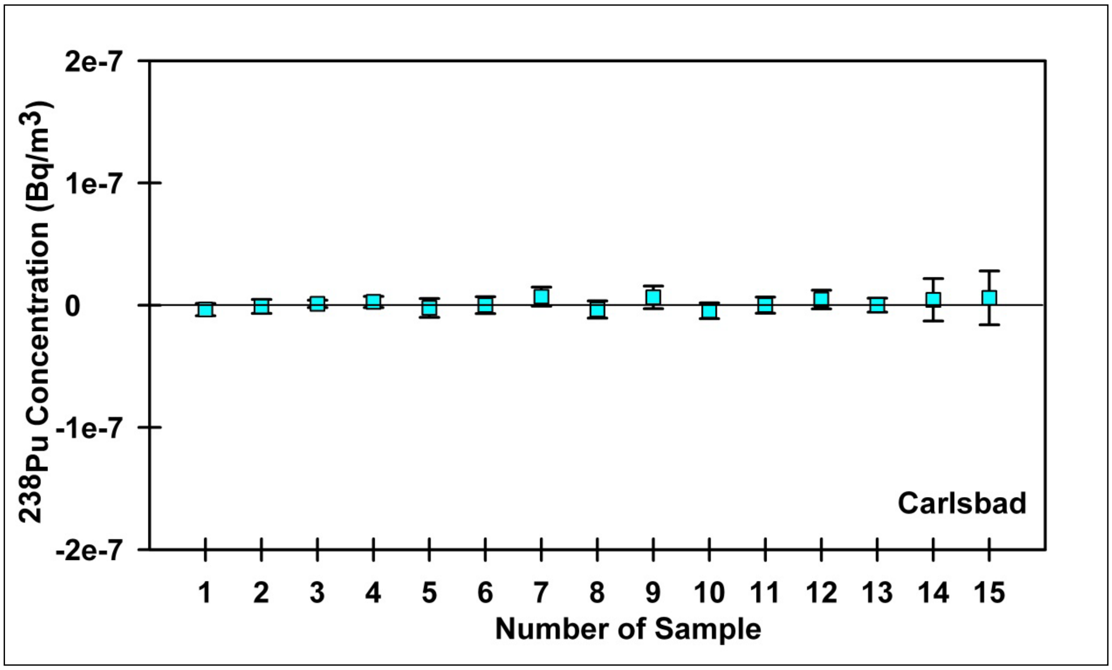


Figure 3-24: The ^{238}Pu concentrations in ambient air at Carlsbad station in 2015

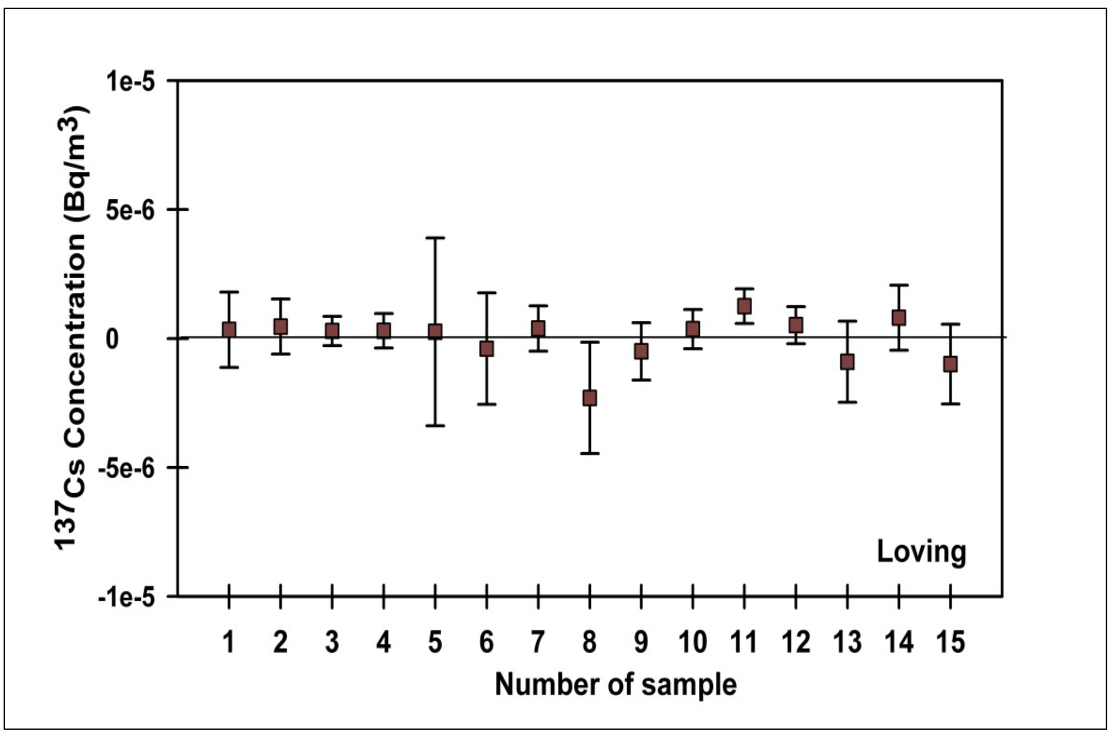


Figure 3-25: The ^{137}Cs concentrations in ambient air at Loving station in 2015

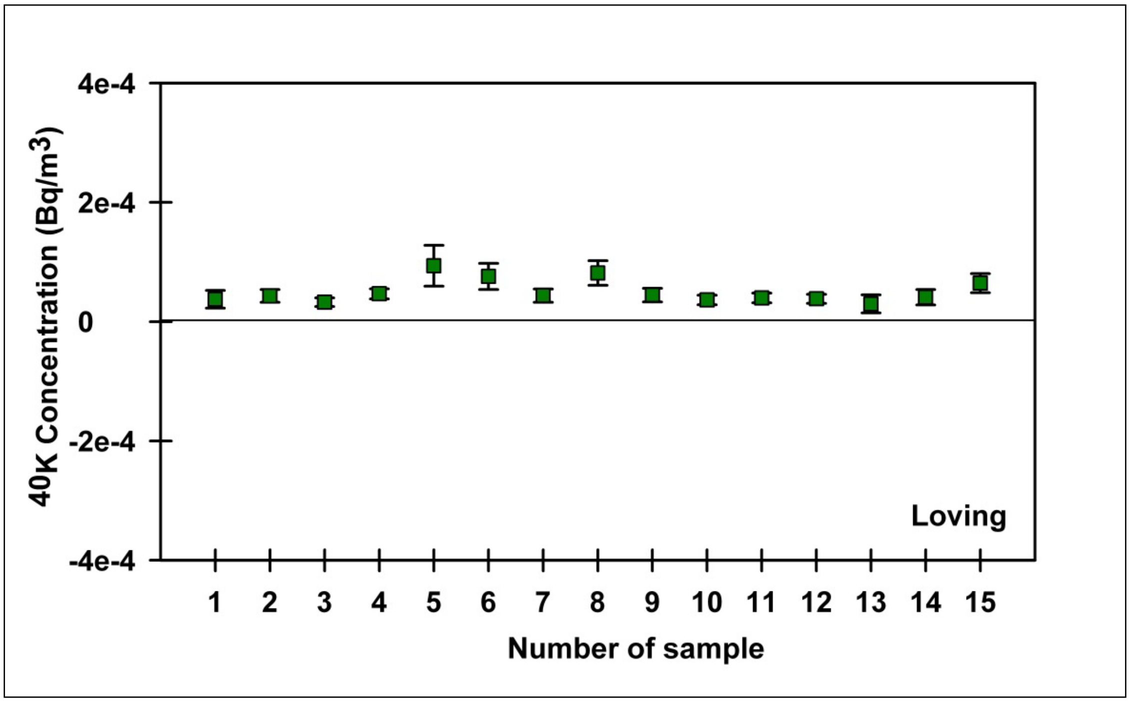


Figure 3-26: The ^{40}K concentrations in ambient air at Loving station in 2015

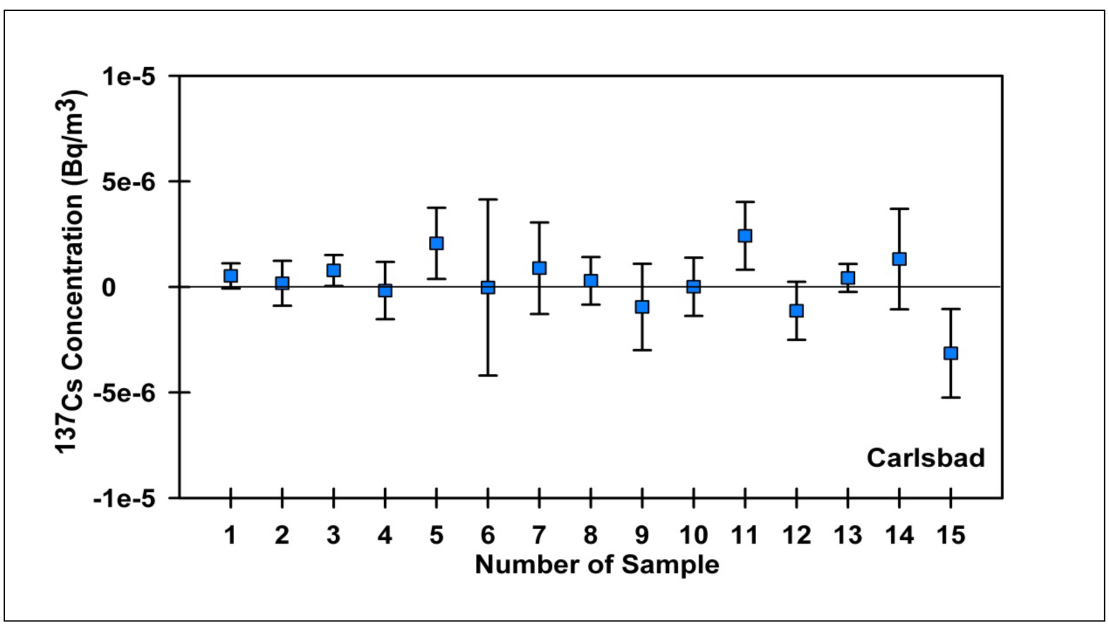


Figure 3-27: The ^{137}Cs concentrations in ambient air at Carlsbad station in 2015

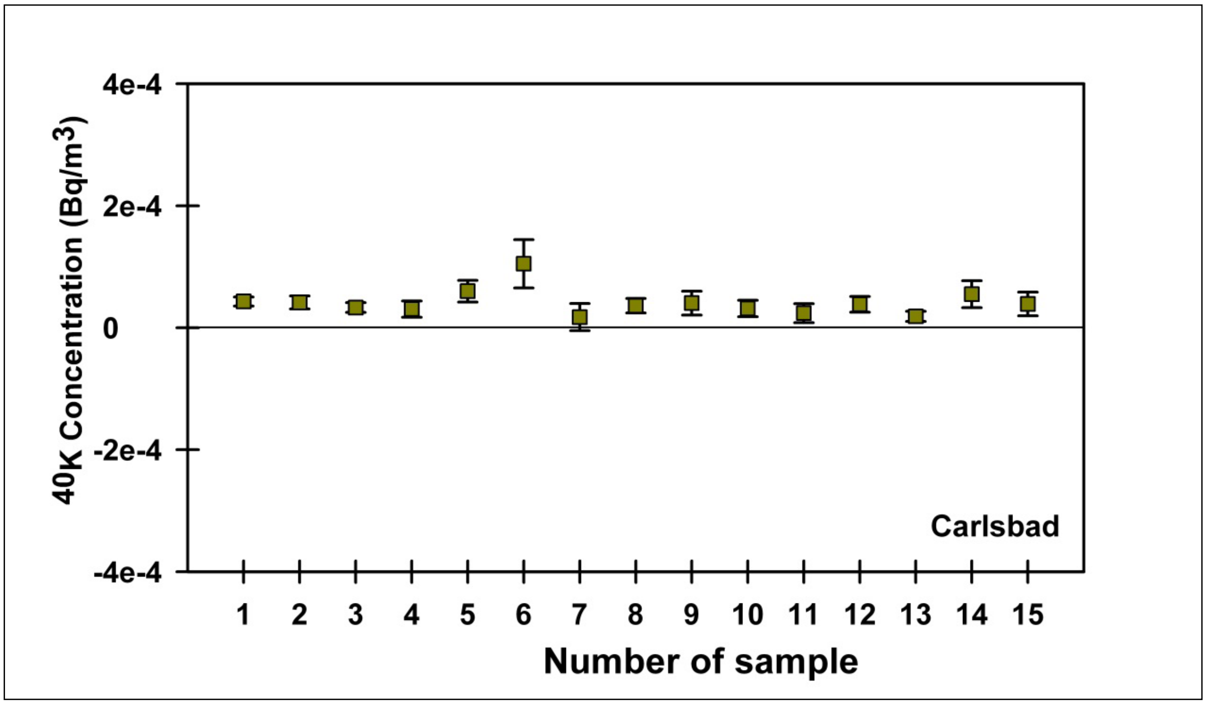


Figure 3-28: The ^{40}K concentrations in ambient air at Carlsbad station in 2015

Table 3-1: Activity concentrations of ^{241}Am in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc.(2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 6 – Jan. 22	1.43E-08	1.03E-08	1.69E-08	Not detected
	Jan. 22 – Feb. 11	1.24E-08	8.42E-09	1.55E-08	Not detected
	Feb. 11 – Mar. 18	5.05E-08	1.08E-08	3.95E-09	Detected
	Mar. 18 – Apr. 8	1.03E-08	1.04E-08	2.19E-08	Not detected
	Apr. 8 – Apr. 27	3.03E-08	1.74E-08	2.52E-08	Detected
	Apr. 27 – May 15	3.17E-08	1.90E-08	3.06E-08	Detected
	May 15 – Jun. 3	2.60E-08	9.18E-09	6.53E-09	Detected
	Jun. 3 – Jun. 17	3.43E-08	1.30E-08	9.92E-09	Detected
	Jun. 17 – Jul. 8	4.69E-08	1.33E-08	1.05E-08	Detected
	Jul. 8 – Jul. 29	4.67E-08	1.38E-08	1.13E-08	Detected
	Jul. 29 – Aug. 7	4.03E-08	1.96E-08	2.81E-08	Detected
	Aug. 7 – Aug. 14	7.58E-08	2.61E-08	1.81E-08	Detected
	Aug. 14 – Aug. 28	1.27E-07	2.80E-08	1.91E-08	Detected
	Aug. 28 – Sep. 11	1.17E-07	2.62E-08	1.80E-08	Detected
	Sep. 11 – Sep. 25	2.88E-08	1.18E-08	1.43E-08	Detected
	Sep. 25 – Oct. 16	8.95E-08	1.89E-08	1.42E-08	Detected
	Oct. 16 – Nov. 2	3.91E-08	1.55E-08	1.82E-08	Detected
	Nov. 2 – Nov. 23	1.93E-08	9.85E-09	1.39E-08	Detected
	Nov. 23 – Dec. 11	9.09E-09	5.75E-09	7.02E-09	Detected
	Dec. 11 – Dec. 23	3.26E-08	2.03E-08	3.65E-08	Not detected
	Dec. 23 – Jan. 8	1.79E-08	8.81E-09	1.14E-08	Detected

Table 3-2: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Onsite Station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}$Pu	Jan. 6 – Jan. 22	9.18E-10	7.11E-09	1.84E-08	Not detected
	Jan. 22 – Feb. 11	5.25E-09	7.44E-09	1.65E-08	Not detected
	Feb. 11 – Mar. 18	5.37E-09	3.84E-09	6.30E-09	Not detected
	Mar. 18 – Apr. 8	2.16E-08	9.91E-09	1.22E-08	Detected
	Apr. 8 – Apr. 27	2.31E-08	9.06E-09	5.88E-09	Detected
	Apr. 27 – May 15	1.21E-08	7.04E-09	8.02E-09	Detected
	May 15 – Jun. 3	2.59E-09	7.50E-09	1.84E-08	Not detected
	Jun. 3 – Jun. 17	1.34E-08	1.01E-08	1.77E-08	Not detected
	Jun. 17 – Jul. 8	1.79E-08	9.25E-09	1.13E-08	Detected
	Jul. 8 – Jul. 29	1.52E-08	1.13E-08	1.56E-08	Not detected
	Jul. 29 – Aug. 7	3.67E-09	1.04E-08	2.59E-08	Not detected

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

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Aug. 7 – Aug. 14	2.63E-08	2.09E-08	3.05E-08	Not detected
	Aug. 14 – Aug. 28	1.51E-08	1.31E-08	2.26E-08	Not detected
	Aug. 28 – Sep. 11	3.25E-08	1.37E-08	1.16E-08	Detected
	Sep. 11 – Sep. 25	5.76E-09	8.18E-09	1.73E-08	Not detected
	Sep. 25 – Oct. 16	1.41E-08	2.04E-08	4.47E-08	Not detected
	Oct. 16 – Nov. 2	2.03E-09	6.43E-09	1.61E-08	Not detected
	Nov. 2 – Nov. 23	1.07E-08	8.07E-09	1.42E-08	Not detected
	Nov. 23 – Dec. 11	3.32E-09	5.76E-09	1.31E-08	Not detected
	Dec. 11 – Dec. 23	-4.09E-09	1.15E-08	3.55E-08	Not detected
	Dec. 23 – Jan. 8	6.84E-09	1.19E-08	2.71E-08	Not detected

Table 3-3: Activity concentrations of ^{238}Pu in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 6 – Jan. 22	-9.18E-10	4.86E-09	1.46E-08	Not detected
	Jan. 22 – Feb. 11	-7.87E-09	5.87E-09	2.06E-08	Not detected
	Feb. 11 – Mar. 18	1.34E-09	2.01E-09	4.16E-09	Not detected
	Mar. 18 – Apr. 8	8.68E-10	5.20E-09	1.37E-08	Not detected
	Apr. 8 – Apr. 27	-2.40E-09	5.76E-09	1.70E-08	Not detected
	Apr. 27 – May 15	-5.19E-09	6.97E-09	2.12E-08	Not detected
	May 15 – Jun. 3	0.00E+00	4.87E-09	1.36E-08	Not detected
	Jun. 3 – Jun. 17	-2.23E-09	5.48E-09	1.77E-08	Not detected
	Jun. 17 – Jul. 8	9.43E-10	4.22E-09	1.13E-08	Not detected
	Jul. 8 – Jul. 29	-5.06E-09	8.97E-09	2.93E-08	Not detected
	Jul. 29 – Aug. 7	-3.67E-09	1.16E-08	3.45E-08	Not detected
	Aug. 7 – Aug. 14	-7.81E-16	1.61E-08	4.61E-08	Not detected
	Aug. 14 – Aug. 28	1.88E-09	1.13E-08	2.99E-08	Not detected
	Aug. 28 – Sep. 11	3.74E-09	1.37E-08	1.16E-08	Not detected
	Sep. 11 – Sep. 25	5.76E-09	8.18E-09	1.73E-08	Not detected
	Sep. 25 – Oct. 16	2.81E-09	9.78E-09	2.62E-08	Not detected
	Oct. 16 – Nov. 2	4.06E-09	5.00E-09	9.40E-09	Not detected
	Nov. 2 – Nov. 23	1.06E-16	2.52E-09	8.28E-09	Not detected
	Nov. 23 – Dec. 11	2.49E-09	3.72E-09	7.71E-09	Not detected
	Dec. 11 – Dec. 23	-8.17E-09	1.01E-08	3.55E-08	Not detected
	Dec. 23 – Jan. 8	5.13E-09	7.66E-09	1.59E-08	Not detected

Table 3-4: Activity concentrations of ^{241}Am in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 6 – Jan. 22	1.16E-08	8.79E-09	1.49E-08	Not detected
	Jan. 22 – Feb. 11	2.88E-09	7.07E-09	1.69E-08	Not detected
	Feb. 11 – Mar. 18	1.33E-09	5.80E-10	8.08E-10	Detected
	Mar. 18 – Apr. 8	6.99E-09	1.23E-08	2.85E-08	Not detected
	Apr. 8 – Apr. 27	1.76E-08	1.98E-08	4.14E-08	Not detected
	Apr. 27 – May 15	2.08E-08	1.05E-08	1.25E-08	Detected
	May 15 – Jun. 3	1.15E-08	7.46E-09	1.07E-08	Detected
	Jun. 3 – Jun. 17	2.93E-08	1.17E-08	7.71E-09	Detected
	Jun. 17 – Jul. 8	5.55E-09	6.54E-09	1.40E-08	Not detected
	Jul. 8 – Jul. 29	3.22E-08	1.12E-08	1.18E-08	Detected
	Jul. 29 – Aug. 7	1.52E-08	1.44E-08	2.86E-08	Not detected
	Aug. 7 – Aug. 14	2.42E-08	2.12E-08	4.15E-08	Not detected
	Aug. 14 – Aug. 28	1.52E-08	1.07E-08	1.89E-08	Not detected
	Aug. 28 – Sep. 11	2.40E-08	1.07E-08	9.71E-09	Detected
	Sep. 11 – Sep. 25	2.71E-08	1.38E-08	1.40E-08	Detected
	Sep. 25 – Oct. 16	8.00E-09	1.05E-08	2.29E-08	Not detected
	Oct. 16 – Nov. 2	1.07E-08	7.98E-09	1.43E-08	Not detected
	Nov. 2 – Nov. 23	5.78E-09	6.81E-09	1.43E-08	Not detected
	Nov. 23 – Dec. 11	1.55E-08	7.88E-09	8.02E-09	Detected
	Dec. 11 – Dec. 23	1.25E-08	1.66E-08	3.62E-08	Not detected
	Dec. 23 – Jan. 8	1.37E-08	8.84E-09	1.45E-08	Not detected

Table 3-5: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Jan. 6 – Jan. 22	3.44E-09	5.97E-09	1.36E-08	Not detected
	Jan. 22 – Feb. 11	0.00E+00	5.84E-09	1.61E-08	Not detected
	Feb. 11 – Mar. 18	1.02E-09	4.59E-10	5.55E-10	Detected
	Mar. 18 – Apr. 8	1.22E-08	7.11E-09	8.07E-09	Detected
	Apr. 8 – Apr. 27	1.90E-08	9.19E-09	1.26E-08	Detected
	Apr. 27 – May 15	9.27E-09	7.04E-09	1.19E-08	Not detected
	May 15 – Jun. 3	8.13E-09	6.14E-09	9.80E-09	Not detected
	Jun. 3 – Jun. 17	1.16E-09	6.17E-09	1.64E-08	Not detected
	Jun. 17 – Jul. 8	1.34E-08	8.27E-09	1.15E-08	Detected

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

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Jul. 8 – Jul. 29	6.92E-09	7.16E-09	1.47E-08	Not detected
	Jul. 29 – Aug. 7	1.69E-08	1.47E-08	2.54E-08	Not detected
	Aug. 7 – Aug. 14	1.70E-08	3.41E-08	8.00E-08	Not detected
	Aug. 14 – Aug. 28	1.84E-08	1.48E-08	2.59E-08	Not detected
	Aug. 28 – Sep. 11	0.00E+00	8.52E-09	2.34E-08	Not detected
	Sep. 11 – Sep. 25	3.66E-09	8.10E-09	1.93E-08	Not detected
	Sep. 25 – Oct. 16	1.04E-08	9.85E-09	1.84E-08	Not detected
	Oct. 16 – Nov. 2	4.50E-09	7.12E-09	1.59E-08	Not detected
	Nov. 2 – Nov. 23	6.81E-09	5.93E-09	1.07E-08	Not detected
	Nov. 23 – Dec. 11	5.07E-09	5.88E-09	1.19E-08	Not detected
	Dec. 11 – Dec. 23	7.43E-09	9.14E-09	2.63E-08	Not detected
	Dec. 23 – Jan. 8	4.84E-16	9.84E-09	2.83E-08	Not detected

Table 3-6: Activity concentrations of ^{238}Pu in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 6 – Jan. 22	-3.44E-09	3.86E-09	1.36E-08	Not detected
	Jan. 22 – Feb. 11	-2.77E-09	5.55E-09	1.73E-08	Not detected
	Feb. 11 – Mar. 18	-1.97E-10	2.09E-10	7.40E-10	Not detected
	Mar. 18 – Apr. 8	8.73E-10	4.62E-09	1.23E-08	Not detected
	Apr. 8 – Apr. 27	2.38E-09	3.18E-09	5.84E-09	Not detected
	Apr. 27 – May 15	3.38E-09	7.60E-09	1.80E-08	Not detected
	May 15 – Jun. 3	4.06E-09	5.41E-09	1.15E-08	Not detected
	Jun. 3 – Jun. 17	-1.16E-09	6.17E-09	1.85E-08	Not detected
	Jun. 17 – Jul. 8	9.58E-10	3.33E-09	8.92E-09	Not detected
	Jul. 8 – Jul. 29	-3.37E-09	6.73E-09	1.98E-08	Not detected
	Jul. 29 – Aug. 7	0.00E+00	1.19E-08	3.34E-08	Not detected
	Aug. 7 – Aug. 14	-5.67E-09	2.55E-08	8.00E-08	Not detected
	Aug. 14 – Aug. 28	-1.84E-09	8.20E-09	2.59E-08	Not detected
	Aug. 28 – Sep. 11	6.73E-09	9.00E-09	1.90E-08	Not detected
	Sep. 11 – Sep. 25	4.88E-09	7.73E-09	1.72E-08	Not detected
	Sep. 25 – Oct. 16	3.91E-09	8.63E-09	2.07E-08	Not detected
	Oct. 16 – Nov. 2	-2.24E-09	5.51E-09	1.78E-08	Not detected
	Nov. 2 – Nov. 23	-1.52E-09	3.72E-09	1.20E-08	Not detected
	Nov. 23 – Dec. 11	-1.69E-09	4.14E-09	1.34E-08	Not detected
	Dec. 11 – Dec. 23	1.86E-09	9.84E-09	2.63E-08	Not detected
	Dec. 23 – Jan. 8	-4.01E-09	9.84E-09	3.18E-08	Not detected

Table 3-7: Activity concentrations of ^{241}Am in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	Jan. 6 – Jan. 22	1.78E-08	1.20E-08	2.07E-08	Not detected
	Jan. 22 – Feb. 11	6.54E-09	6.35E-09	1.26E-08	Not detected
	Feb. 11 – Mar. 18	6.10E-09	4.23E-09	8.22E-09	Not detected
	Mar. 18 – Apr. 8	4.86E-09	1.42E-08	3.46E-08	Not detected
	Apr. 8 – Apr. 27	7.27E-09	1.29E-08	2.92E-08	Not detected
	Apr. 27 – May 15	1.00E-08	8.57E-09	1.59E-08	Not detected
	May 15 – Jun. 3	1.52E-08	7.09E-09	5.57E-09	Detected
	Jun. 3 – Jun. 17	8.14E-09	9.11E-09	1.91E-08	Not detected
	Jun. 17 – Jul. 8	5.20E-09	5.23E-09	1.03E-08	Not detected
	Jul. 8 – Jul. 29	1.61E-08	7.17E-09	8.23E-09	Detected
	Jul. 29 – Aug. 7	2.48E-08	1.66E-08	2.92E-08	Not detected
	Aug. 7 – Aug. 14	2.38E-08	2.27E-08	4.61E-08	Not detected
	Aug. 14 – Aug. 28	1.58E-08	1.12E-08	1.96E-08	Not detected
	Aug. 28 – Sep. 11	1.94E-08	1.00E-08	1.22E-08	Detected
	Sep. 11 – Sep. 25	1.89E-08	1.17E-08	1.98E-08	Not detected
	Sep. 25 – Oct. 16	5.02E-09	6.25E-09	1.35E-08	Not detected
	Oct. 16 – Nov. 2	3.75E-09	5.94E-09	1.32E-08	Not detected
	Nov. 2 – Nov. 23	1.36E-08	8.09E-09	1.20E-08	Detected
	Nov. 23 – Dec. 11	1.48E-08	7.86E-09	9.86E-09	Detected
	Dec. 11 – Dec. 23	2.75E-08	1.30E-08	1.01E-08	Detected
	Dec. 23 – Jan. 8	1.13E-08	9.16E-09	1.75E-08	Not detected

Table 3-8: Activity concentrations of $^{239+240}$Pu in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}$Pu	Jan. 6 – Jan. 22	1.92E-09	7.18E-09	1.80E-08	Not detected
	Jan. 22 – Feb. 11	2.23E-09	3.93E-09	8.88E-09	Not detected
	Feb. 11 – Mar. 18	4.83E-09	3.27E-09	4.83E-09	Not detected
	Mar. 18 – Apr. 8	1.62E-08	8.29E-09	7.00E-09	Detected
	Apr. 8 – Apr. 27	1.88E-08	8.70E-09	9.80E-09	Detected
	Apr. 27 – May 15	4.55E-09	6.05E-09	1.28E-08	Not detected
	May 15 – Jun. 3	1.81E-09	7.22E-09	1.82E-08	Not detected
	Jun. 3 – Jun. 17	2.39E-09	8.93E-09	2.25E-08	Not detected
	Jun. 17 – Jul. 8	1.62E-08	8.74E-09	9.38E-09	Detected
	Jul. 8 – Jul. 29	1.04E-08	1.22E-08	2.61E-08	Not detected
	Jul. 29 – Aug. 7	2.02E-09	1.07E-08	2.85E-08	Not detected

Table 3-8: Activity concentrations of $^{239+240}Pu$ in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}Pu$	Aug. 7 – Aug. 14	2.25E-08	2.38E-08	4.51E-08	Not detected
	Aug. 14 – Aug. 28	5.99E-09	1.32E-08	3.16E-08	Not detected
	Aug. 28 – Sep. 11	8.29E-09	1.35E-08	3.10E-08	Not detected
	Sep. 11 – Sep. 25	7.30E-09	7.73E-09	1.46E-08	Not detected
	Sep. 25 – Oct. 16	4.02E-09	4.51E-09	7.37E-09	Not detected
	Oct. 16 – Nov. 2	8.83E-09	7.19E-09	9.26E-09	Not detected
	Nov. 2 – Nov. 23	1.59E-08	7.89E-09	6.53E-09	Detected
	Nov. 23 – Dec. 11	1.78E-09	3.09E-09	6.55E-09	Not detected
	Dec. 11 – Dec. 23	1.70E-08	1.20E-08	1.39E-08	Detected
	Dec. 23 – Jan. 8	8.85E-09	9.93E-09	1.62E-08	Not detected

Table 3-9: Activity concentrations of ^{238}Pu in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Jan. 6 – Jan. 22	-5.75E-09	5.46E-09	1.93E-08	Not detected
	Jan. 22 – Feb. 11	-7.40E-10	3.32E-09	1.04E-08	Not detected
	Feb. 11 – Mar. 18	-1.62E-09	2.56E-09	8.11E-09	Not detected
	Mar. 18 – Apr. 8	3.81E-09	5.40E-09	7.00E-09	Not detected
	Apr. 8 – Apr. 27	3.26E-09	5.17E-09	1.15E-08	Not detected
	Apr. 27 – May 15	3.63E-09	6.31E-09	1.44E-08	Not detected
	May 15 – Jun. 3	-3.63E-09	5.14E-09	1.71E-08	Not detected
	Jun. 3 – Jun. 17	0.00E+00	8.93E-09	2.40E-08	Not detected
	Jun. 17 – Jul. 8	1.01E-09	5.35E-09	1.43E-08	Not detected
	Jul. 8 – Jul. 29	-2.60E-09	7.35E-09	2.26E-08	Not detected
	Jul. 29 – Aug. 7	2.02E-09	9.04E-09	2.42E-08	Not detected
	Aug. 7 – Aug. 14	-1.79E-15	1.50E-08	4.51E-08	Not detected
	Aug. 14 – Aug. 28	0.00E+00	7.60E-09	2.39E-08	Not detected
	Aug. 28 – Sep. 11	9.66E-09	1.27E-08	2.77E-08	Not detected
	Sep. 11 – Sep. 25	-2.43E-09	5.97E-09	1.93E-08	Not detected
	Sep. 25 – Oct. 16	-6.01E-09	6.37E-09	2.14E-08	Not detected
	Oct. 16 – Nov. 2	1.26E-09	1.04E-08	2.68E-08	Not detected
	Nov. 2 – Nov. 23	8.86E-10	7.31E-09	1.88E-08	Not detected
	Nov. 23 – Dec. 11	-5.34E-09	5.66E-09	1.90E-08	Not detected
	Dec. 11 – Dec. 23	-1.35E-15	7.56E-09	2.27E-08	Not detected
	Dec. 23 – Jan. 8	-6.63E-09	1.59E-08	4.70E-08	Not detected

Table 3-10: Activity density of ^{241}Am in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc.(2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 6 – Jan. 22	6.63E-04	4.74E-04	7.81E-04	Not detected
	Jan. 22 – Feb. 11	6.15E-04	4.19E-04	7.71E-04	Not detected
	Feb. 11 – Mar. 18	2.30E-03	4.91E-04	1.80E-04	Detected
	Mar. 18 – Apr. 8	2.67E-04	2.71E-04	5.70E-04	Not detected
	Apr. 8 – Apr. 27	7.92E-04	4.55E-04	6.58E-04	Detected
	Apr. 27 – May 15	7.44E-04	4.45E-04	7.19E-04	Detected
	May 15 – Jun. 3	7.37E-04	2.60E-04	1.85E-04	Detected
	Jun. 3 – Jun. 17	7.77E-04	2.96E-04	2.25E-04	Detected
	Jun. 17 – Jul. 8	1.14E-03	3.24E-04	2.55E-04	Detected
	Jul. 8 – Jul. 29	1.09E-03	3.24E-04	2.65E-04	Detected
	Jul. 29 – Aug. 7	7.79E-04	3.79E-04	5.43E-04	Detected
	Aug. 7 – Aug. 14	1.79E-03	6.16E-04	4.28E-04	Detected
	Aug. 14 – Aug. 28	3.06E-03	6.76E-04	4.61E-04	Detected
	Aug. 28 – Sep. 11	3.29E-03	7.34E-04	5.04E-04	Detected
	Sep. 11 – Sep. 25	1.10E-03	4.52E-04	5.46E-04	Detected
	Sep. 25 – Oct. 16	2.78E-03	5.87E-04	4.40E-04	Detected
	Oct. 16 – Nov. 2	1.88E-03	7.44E-04	8.77E-04	Detected
	Nov. 2 – Nov. 23	5.66E-04	2.89E-04	4.07E-04	Detected
	Nov. 23 – Dec. 11	5.56E-04	3.52E-04	4.29E-04	Detected
	Dec. 11 – Dec. 23	1.06E-03	6.62E-04	1.19E-03	Not detected
	Dec. 23 – Jan. 8	1.40E-03	6.93E-04	8.98E-04	Detected

Table 3-11: Activity density of $^{239+240}$Pu in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}$Pu	Jan. 6 – Jan. 22	4.24E-05	3.29E-04	8.52E-04	Not detected
	Jan. 22 – Feb. 11	2.61E-04	3.70E-04	8.20E-04	Not detected
	Feb. 11 – Mar. 18	2.45E-04	1.75E-04	2.87E-04	Not detected
	Mar. 18 – Apr. 8	5.63E-04	2.58E-04	3.17E-04	Detected
	Apr. 8 – Apr. 27	6.04E-04	2.37E-04	1.53E-04	Detected
	Apr. 27 – May 15	2.85E-04	1.65E-04	1.88E-04	Detected
	May 15 – Jun. 3	7.33E-05	2.13E-04	5.21E-04	Not detected
	Jun. 3 – Jun. 17	3.04E-04	2.29E-04	4.01E-04	Not detected
	Jun. 17 – Jul. 8	4.35E-04	2.25E-04	2.75E-04	Detected
	Jul. 8 – Jul. 29	3.54E-04	2.65E-04	3.66E-04	Not detected
	Jul. 29 – Aug. 7	7.10E-05	2.01E-04	5.01E-04	Not detected

Table 3-11: Activity density of $^{239+240}Pu$ in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Aug. 7 – Aug. 14	6.21E-04	4.95E-04	7.21E-04	Not detected
	Aug. 14 – Aug. 28	3.63E-04	3.17E-04	5.46E-04	Not detected
	Aug. 28 – Sep. 11	9.10E-04	3.83E-04	3.24E-04	Detected
	Sep. 11 – Sep. 25	2.21E-04	3.13E-04	6.61E-04	Not detected
	Sep. 25 – Oct. 16	4.38E-04	6.33E-04	1.39E-03	Not detected
	Oct. 16 – Nov. 2	9.77E-05	3.09E-04	7.76E-04	Not detected
	Nov. 2 – Nov. 23	3.13E-04	2.37E-04	4.15E-04	Not detected
	Nov. 23 – Dec. 11	2.03E-04	3.52E-04	8.04E-04	Not detected
	Dec. 11 – Dec. 23	-1.33E-04	3.76E-04	1.16E-03	Not detected
	Dec. 23 – Jan. 8	5.37E-04	9.34E-04	2.13E-03	Not detected

Table 3-12: Activity density of ^{238}Pu in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 6 – Jan. 22	-4.24E-05	2.25E-04	6.74E-04	Not detected
	Jan. 22 – Feb. 11	-3.91E-04	2.92E-04	1.02E-03	Not detected
	Feb. 11 – Mar. 18	6.12E-05	9.15E-05	1.90E-04	Not detected
	Mar. 18 – Apr. 8	2.26E-05	1.35E-04	3.57E-04	Not detected
	Apr. 8 – Apr. 27	-6.25E-05	1.50E-04	4.44E-04	Not detected
	Apr. 27 – May 15	-1.22E-04	1.64E-04	4.99E-04	Not detected
	May 15 – Jun. 3	0.00E+00	1.38E-04	3.87E-04	Not detected
	Jun. 3 – Jun. 17	-5.06E-05	1.24E-04	4.01E-04	Not detected
	Jun. 17 – Jul. 8	2.29E-05	1.02E-04	2.75E-04	Not detected
	Jul. 8 – Jul. 29	-1.18E-04	2.10E-04	6.86E-04	Not detected
	Jul. 29 – Aug. 7	-7.10E-05	2.24E-04	6.68E-04	Not detected
	Aug. 7 – Aug. 14	-1.84E-11	3.79E-04	1.09E-03	Not detected
	Aug. 14 – Aug. 28	4.55E-05	2.72E-04	7.21E-04	Not detected
	Aug. 28 – Sep. 11	1.05E-04	3.83E-04	3.24E-04	Not detected
	Sep. 11 – Sep. 25	2.21E-04	3.13E-04	6.61E-04	Not detected
	Sep. 25 – Oct. 16	8.74E-05	3.04E-04	8.13E-04	Not detected
	Oct. 16 – Nov. 2	1.95E-04	2.40E-04	4.52E-04	Not detected
	Nov. 2 – Nov. 23	3.11E-12	7.38E-05	2.43E-04	Not detected
	Nov. 23 – Dec. 11	1.52E-04	2.28E-04	4.72E-04	Not detected
	Dec. 11 – Dec. 23	-2.67E-04	3.28E-04	1.16E-03	Not detected
	Dec. 23 – Jan. 8	4.03E-04	6.02E-04	1.25E-03	Not detected

Table 3-13: Activity density of ^{241}Am in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 6 – Jan. 22	4.56E-04	3.44E-04	5.82E-04	Not detected
	Jan. 22 – Feb. 11	1.22E-04	2.99E-04	7.14E-04	Not detected
	Feb. 11 – Mar. 18	5.78E-04	2.53E-04	3.52E-04	Detected
	Mar. 18 – Apr. 8	1.76E-04	3.11E-04	7.18E-04	Not detected
	Apr. 8 – Apr. 27	4.74E-04	5.33E-04	1.11E-03	Not detected
	Apr. 27 – May 15	5.68E-04	2.86E-04	3.41E-04	Detected
	May 15 – Jun. 3	3.83E-04	2.48E-04	3.54E-04	Detected
	Jun. 3 – Jun. 17	8.62E-04	3.45E-04	2.27E-04	Detected
	Jun. 17 – Jul. 8	1.50E-04	1.77E-04	3.77E-04	Not detected
	Jul. 8 – Jul. 29	9.72E-04	3.39E-04	3.58E-04	Detected
	Jul. 29 – Aug. 7	3.73E-04	3.52E-04	7.01E-04	Not detected
	Aug. 7 – Aug. 14	5.90E-04	5.15E-04	1.01E-03	Not detected
	Aug. 14 – Aug. 28	4.12E-04	2.91E-04	5.12E-04	Not detected
	Aug. 28 – Sep. 11	7.04E-04	3.14E-04	2.85E-04	Detected
	Sep. 11 – Sep. 25	9.98E-04	5.09E-04	5.15E-04	Detected
	Sep. 25 – Oct. 16	3.04E-04	3.99E-04	8.72E-04	Not detected
	Oct. 16 – Nov. 2	4.98E-04	3.70E-04	6.64E-04	Not detected
	Nov. 2 – Nov. 23	2.51E-04	2.96E-04	6.23E-04	Not detected
	Nov. 23 – Dec. 11	1.14E-03	5.80E-04	5.90E-04	Detected
	Dec. 11 – Dec. 23	4.99E-04	6.58E-04	1.44E-03	Not detected
	Dec. 23 – Jan. 8	8.40E-04	5.42E-04	8.87E-04	Not detected

Table 3-14: Activity density of $^{239+240}$Pu in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}$Pu	Jan. 6 – Jan. 22	1.35E-04	2.33E-04	5.34E-04	Not detected
	Jan. 22 – Feb. 11	0.00E+00	2.47E-04	6.80E-04	Not detected
	Feb. 11 – Mar. 18	4.47E-04	2.00E-04	2.42E-04	Detected
	Mar. 18 – Apr. 8	3.08E-04	1.79E-04	2.04E-04	Detected
	Apr. 8 – Apr. 27	5.13E-04	2.48E-04	3.39E-04	Detected
	Apr. 27 – May 15	2.52E-04	1.92E-04	3.25E-04	Not detected
	May 15 – Jun. 3	2.70E-04	2.04E-04	3.25E-04	Not detected
	Jun. 3 – Jun. 17	3.42E-05	1.81E-04	4.83E-04	Not detected
	Jun. 17 – Jul. 8	3.63E-04	2.23E-04	3.11E-04	Detected
	Jul. 8 – Jul. 29	2.09E-04	2.17E-04	4.44E-04	Not detected
	Jul. 29 – Aug. 7	4.15E-04	3.59E-04	6.22E-04	Not detected
	Aug. 7 – Aug. 14	4.14E-04	8.30E-04	1.95E-03	Not detected

Table 3-14: Activity density of $^{239+240}Pu$ in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Aug. 14 – Aug. 28	4.97E-04	4.00E-04	7.01E-04	Not detected
	Aug. 28 – Sep. 11	0.00E+00	2.50E-04	6.88E-04	Not detected
	Sep. 11 – Sep. 25	1.35E-04	2.98E-04	7.12E-04	Not detected
	Sep. 25 – Oct. 16	3.96E-04	3.74E-04	6.99E-04	Not detected
	Oct. 16 – Nov. 2	2.09E-04	3.30E-04	7.37E-04	Not detected
	Nov. 2 – Nov. 23	2.96E-04	2.57E-04	4.66E-04	Not detected
	Nov. 23 – Dec. 11	3.73E-04	4.33E-04	8.75E-04	Not detected
	Dec. 11 – Dec. 23	2.96E-04	3.64E-04	1.04E-03	Not detected
	Dec. 23 – Jan. 8	2.97E-11	6.04E-04	1.74E-03	Not detected

Table 3-15: Activity density of ^{238}Pu in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 6 – Jan. 22	-1.35E-04	1.51E-04	5.34E-04	Not detected
	Jan. 22 – Feb. 11	-1.17E-04	2.34E-04	7.33E-04	Not detected
	Feb. 11 – Mar. 18	-8.57E-05	9.12E-05	3.22E-04	Not detected
	Mar. 18 – Apr. 8	2.20E-05	1.16E-04	3.11E-04	Not detected
	Apr. 8 – Apr. 27	6.41E-05	8.58E-05	1.57E-04	Not detected
	Apr. 27 – May 15	9.21E-05	2.07E-04	4.91E-04	Not detected
	May 15 – Jun. 3	1.35E-04	1.80E-04	3.81E-04	Not detected
	Jun. 3 – Jun. 17	-3.42E-05	1.81E-04	5.44E-04	Not detected
	Jun. 17 – Jul. 8	2.58E-05	8.97E-05	2.41E-04	Not detected
	Jul. 8 – Jul. 29	-1.02E-04	2.04E-04	5.98E-04	Not detected
	Jul. 29 – Aug. 7	0.00E+00	2.92E-04	8.19E-04	Not detected
	Aug. 7 – Aug. 14	-1.38E-04	6.20E-04	1.95E-03	Not detected
	Aug. 14 – Aug. 28	-4.97E-05	2.22E-04	7.01E-04	Not detected
	Aug. 28 – Sep. 11	1.98E-04	2.64E-04	5.58E-04	Not detected
	Sep. 11 – Sep. 25	1.79E-04	2.84E-04	6.31E-04	Not detected
	Sep. 25 – Oct. 16	1.49E-04	3.28E-04	7.85E-04	Not detected
	Oct. 16 – Nov. 2	-1.04E-04	2.56E-04	8.27E-04	Not detected
	Nov. 2 – Nov. 23	-6.59E-05	1.62E-04	5.23E-04	Not detected
	Nov. 23 – Dec. 11	-1.24E-04	3.05E-04	9.87E-04	Not detected
	Dec. 11 – Dec. 23	7.38E-05	3.91E-04	1.04E-03	Not detected
	Dec. 23 – Jan. 8	-2.46E-04	6.04E-04	1.95E-03	Not detected

Table 3-16: Activity density of ^{241}Am in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Jan. 6 – Jan. 22	7.32E-04	4.95E-04	8.50E-04	Not detected
	Jan. 22 – Feb. 11	3.03E-04	2.95E-04	5.87E-04	Not detected
	Feb. 11 – Mar. 18	3.46E-04	2.40E-04	4.66E-04	Not detected
	Mar. 18 – Apr. 8	1.37E-04	4.00E-04	9.76E-04	Not detected
	Apr. 8 – Apr. 27	2.35E-04	4.17E-04	9.42E-04	Not detected
	Apr. 27 – May 15	3.48E-04	2.98E-04	5.54E-04	Not detected
	May 15 – Jun. 3	5.84E-04	2.73E-04	2.14E-04	Detected
	Jun. 3 – Jun. 17	2.83E-04	3.16E-04	6.64E-04	Not detected
	Jun. 17 – Jul. 8	1.52E-04	1.53E-04	3.02E-04	Not detected
	Jul. 8 – Jul. 29	4.29E-04	1.91E-04	2.19E-04	Detected
	Jul. 29 – Aug. 7	6.11E-04	4.11E-04	7.20E-04	Not detected
	Aug. 7 – Aug. 14	5.90E-04	5.61E-04	1.14E-03	Not detected
	Aug. 14 – Aug. 28	4.41E-04	3.12E-04	5.49E-04	Not detected
	Aug. 28 – Sep. 11	4.88E-04	2.52E-04	3.07E-04	Detected
	Sep. 11 – Sep. 25	6.37E-04	3.93E-04	6.67E-04	Not detected
	Sep. 25 – Oct. 16	1.39E-04	1.73E-04	3.74E-04	Not detected
	Oct. 16 – Nov. 2	1.58E-04	2.50E-04	5.58E-04	Not detected
	Nov. 2 – Nov. 23	4.16E-04	2.48E-04	3.66E-04	Detected
	Nov. 23 – Dec. 11	8.38E-04	4.44E-04	5.58E-04	Detected
	Dec. 11 – Dec. 23	9.52E-04	4.49E-04	3.50E-04	Detected
	Dec. 23 – Jan. 8	9.13E-04	7.39E-04	1.42E-03	Not detected

Table 3-17: Activity density of $^{239+240}$Pu in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}$Pu	Jan. 6 – Jan. 22	7.89E-05	2.95E-04	7.41E-04	Not detected
	Jan. 22 – Feb. 11	1.03E-04	1.82E-04	4.12E-04	Not detected
	Feb. 11 – Mar. 18	2.74E-04	1.85E-04	2.74E-04	Not detected
	Mar. 18 – Apr. 8	4.56E-04	2.34E-04	1.98E-04	Detected
	Apr. 8 – Apr. 27	6.05E-04	2.81E-04	3.16E-04	Detected
	Apr. 27 – May 15	1.58E-04	2.11E-04	4.46E-04	Not detected
	May 15 – Jun. 3	6.98E-05	2.78E-04	7.00E-04	Not detected
	Jun. 3 – Jun. 17	8.29E-05	3.10E-04	7.80E-04	Not detected
	Jun. 17 – Jul. 8	4.73E-04	2.56E-04	2.74E-04	Detected
	Jul. 8 – Jul. 29	2.77E-04	3.26E-04	6.95E-04	Not detected
	Jul. 29 – Aug. 7	4.99E-05	2.64E-04	7.03E-04	Not detected
	Aug. 7 – Aug. 14	5.56E-04	5.90E-04	1.12E-03	Not detected

Table 3-17: Activity density of $^{239+240}Pu$ in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
$^{239+240}Pu$	Aug. 14 – Aug. 28	1.67E-04	3.70E-04	8.85E-04	Not detected
	Aug. 28 – Sep. 11	2.08E-04	3.40E-04	7.79E-04	Not detected
	Sep. 11 – Sep. 25	2.46E-04	2.60E-04	4.91E-04	Not detected
	Sep. 25 – Oct. 16	1.11E-04	1.25E-04	2.04E-04	Not detected
	Oct. 16 – Nov. 2	3.72E-04	3.03E-04	3.90E-04	Not detected
	Nov. 2 – Nov. 23	4.87E-04	2.42E-04	2.00E-04	Detected
	Nov. 23 – Dec. 11	1.01E-04	1.75E-04	3.70E-04	Not detected
	Dec. 11 – Dec. 23	5.88E-04	4.17E-04	4.81E-04	Detected
	Dec. 23 – Jan. 8	7.14E-04	8.01E-04	1.31E-03	Not detected

Table 3-18: Activity density of ^{238}Pu in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}Pu	Jan. 6 – Jan. 22	-2.36E-04	2.25E-04	7.92E-04	Not detected
	Jan. 22 – Feb. 11	-3.43E-05	1.54E-04	4.84E-04	Not detected
	Feb. 11 – Mar. 18	-9.16E-05	1.45E-04	4.60E-04	Not detected
	Mar. 18 – Apr. 8	1.07E-04	1.52E-04	1.98E-04	Not detected
	Apr. 8 – Apr. 27	1.05E-04	1.67E-04	3.71E-04	Not detected
	Apr. 27 – May 15	1.26E-04	2.20E-04	5.01E-04	Not detected
	May 15 – Jun. 3	-1.40E-04	1.98E-04	6.57E-04	Not detected
	Jun. 3 – Jun. 17	0.00E+00	3.10E-04	8.33E-04	Not detected
	Jun. 17 – Jul. 8	2.95E-05	1.56E-04	4.17E-04	Not detected
	Jul. 8 – Jul. 29	-6.92E-05	1.96E-04	6.03E-04	Not detected
	Jul. 29 – Aug. 7	4.99E-05	2.23E-04	5.98E-04	Not detected
	Aug. 7 – Aug. 14	-4.43E-11	3.72E-04	1.12E-03	Not detected
	Aug. 14 – Aug. 28	0.00E+00	2.13E-04	6.69E-04	Not detected
	Aug. 28 – Sep. 11	2.43E-04	3.20E-04	6.98E-04	Not detected
	Sep. 11 – Sep. 25	-8.18E-05	2.01E-04	6.49E-04	Not detected
	Sep. 25 – Oct. 16	-1.67E-04	1.76E-04	5.93E-04	Not detected
	Oct. 16 – Nov. 2	5.30E-05	4.39E-04	1.13E-03	Not detected
	Nov. 2 – Nov. 23	2.71E-05	2.24E-04	5.76E-04	Not detected
	Nov. 23 – Dec. 11	-3.02E-04	3.20E-04	1.07E-03	Not detected
	Dec. 11 – Dec. 23	-4.67E-11	2.62E-04	7.84E-04	Not detected
	Dec. 23 – Jan. 8	-5.35E-04	1.29E-03	3.80E-03	Not detected

Table 3-19: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 6 – Jan. 22	8.98E-07	1.95E-07	2.83E-08	Detected
	Jan. 22 – Feb. 11	5.99E-07	1.35E-07	1.08E-08	Detected
	Feb. 11 – Mar. 18	6.17E-07	1.09E-07	1.17E-08	Detected
	Mar. 18 – Apr. 8	9.47E-07	1.65E-07	1.36E-08	Detected
	Apr. 8 – Apr. 27	8.54E-07	1.69E-07	2.02E-08	Detected
	Apr. 27 – May 15	7.46E-07	1.55E-07	1.56E-08	Detected
	May 15 – Jun. 3	9.98E-07	1.82E-07	1.51E-08	Detected
	Jun. 3 – Jun. 17	9.78E-07	2.21E-07	3.95E-08	Detected
	Jun. 17 – Jul. 8	1.21E-06	2.15E-07	2.83E-08	Detected
	Jul. 8 – Jul. 29	1.10E-06	1.98E-07	2.12E-08	Detected
	Jul. 29 – Aug. 7	1.69E-06	3.52E-07	4.98E-08	Detected
	Aug. 7 – Aug. 14	2.74E-06	5.15E-07	5.80E-08	Detected
	Aug. 14 – Aug. 28	1.17E-06	2.27E-07	2.32E-08	Detected
	Aug. 28 – Sep. 11	1.08E-06	2.15E-07	2.21E-08	Detected
	Sep. 11 – Sep. 25	1.05E-06	2.23E-07	3.00E-08	Detected
	Sep. 25 – Oct. 16	7.73E-07	1.56E-07	1.48E-08	Detected
	Oct. 16 – Nov. 2	7.91E-07	1.73E-07	2.91E-08	Detected
	Nov. 2 – Nov. 23	1.08E-06	2.00E-07	2.35E-08	Detected
	Nov. 23 – Dec. 11	6.02E-07	1.54E-07	1.32E-08	Detected
	Dec. 11 – Dec. 23	1.29E-06	2.62E-07	2.66E-08	Detected
	Dec. 23 – Jan. 8	6.70E-07	1.76E-07	3.76E-08	Detected
^{235}U	Jan. 6 – Jan. 22	9.13E-07	2.94E-08	2.23E-08	Detected
	Jan. 22 – Feb. 11	4.76E-08	1.60E-08	1.33E-08	Detected
	Feb. 11 – Mar. 18	6.76E-08	1.56E-08	6.30E-09	Detected
	Mar. 18 – Apr. 8	6.51E-08	1.71E-08	1.07E-08	Detected
	Apr. 8 – Apr. 27	6.77E-08	1.95E-08	1.08E-08	Detected
	Apr. 27 – May 15	4.60E-08	1.65E-08	1.45E-08	Detected
	May 15 – Jun. 3	7.50E-08	2.20E-08	2.20E-08	Detected
	Jun. 3 – Jun. 17	8.91E-08	3.02E-08	2.02E-08	Detected
	Jun. 17 – Jul. 8	2.43E-07	4.75E-08	1.79E-08	Detected
	Jul. 8 – Jul. 29	7.86E-08	2.17E-08	1.14E-08	Detected
	Jul. 29 – Aug. 7	1.41E-07	4.76E-08	4.85E-08	Detected
	Aug. 7 – Aug. 14	2.06E-07	6.12E-08	3.53E-08	Detected
	Aug. 14 – Aug. 28	8.49E-08	2.52E-08	1.82E-08	Detected
	Aug. 28 – Sep. 11	1.04E-07	2.76E-08	1.74E-08	Detected
	Sep. 11 – Sep. 25	8.43E-08	2.79E-08	1.82E-08	Detected

Table 3-19: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{235}U	Sep. 25 – Oct. 16	5.56E-08	1.83E-08	9.54E-09	Detected
	Oct. 16 – Nov. 2	8.97E-08	2.60E-08	1.18E-08	Detected
	Nov. 2 – Nov. 23	1.17E-07	2.96E-08	1.74E-08	Detected
	Nov. 23 – Dec. 11	6.84E-08	2.47E-08	2.47E-08	Detected
	Dec. 11 – Dec. 23	1.78E-07	4.38E-08	2.48E-08	Detected
	Dec. 23 – Jan. 8	1.22E-07	3.69E-08	3.07E-08	Detected
^{238}U	Jan. 6 – Jan. 22	8.39E-07	1.07E-07	1.92E-08	Detected
	Jan. 22 – Feb. 11	5.89E-07	6.87E-08	6.29E-09	Detected
	Feb. 11 – Mar. 18	6.43E-07	7.40E-08	8.91E-09	Detected
	Mar. 18 – Apr. 8	9.20E-07	1.00E-07	7.47E-09	Detected
	Apr. 8 – Apr. 27	7.95E-07	9.05E-08	1.74E-08	Detected
	Apr. 27 – May 15	6.63E-07	7.81E-08	1.04E-08	Detected
	May 15 – Jun. 3	8.32E-07	9.62E-08	5.58E-09	Detected
	Jun. 3 – Jun. 17	9.72E-07	1.26E-07	4.83E-08	Detected
	Jun. 17 – Jul. 8	1.08E-06	1.37E-07	2.95E-08	Detected
	Jul. 8 – Jul. 29	1.03E-06	1.17E-07	8.85E-09	Detected
	Jul. 29 – Aug. 7	1.55E-06	1.93E-07	5.25E-08	Detected
	Aug. 7 – Aug. 14	2.41E-06	2.93E-07	4.69E-08	Detected
	Aug. 14 – Aug. 28	1.14E-06	1.31E-07	1.05E-08	Detected
	Aug. 28 – Sep. 11	1.14E-06	1.28E-07	9.12E-09	Detected
	Sep. 11 – Sep. 25	9.06E-07	1.14E-07	2.50E-08	Detected
	Sep. 25 – Oct. 16	8.52E-07	1.03E-07	9.97E-09	Detected
	Oct. 16 – Nov. 2	6.93E-07	8.60E-08	2.03E-08	Detected
	Nov. 2 – Nov. 23	1.01E-06	1.21E-07	6.11E-09	Detected
	Nov. 23 – Dec. 11	5.63E-07	7.70E-08	2.04E-08	Detected
	Dec. 11 – Dec. 23	1.19E-06	1.42E-07	2.85E-08	Detected
	Dec. 23 – Jan. 8	6.34E-07	9.11E-08	2.54E-08	Detected

Table 3-20: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 6 – Jan. 22	9.51E-07	2.01E-07	2.43E-08	Detected
	Jan. 22 – Feb. 11	8.10E-07	1.60E-07	1.95E-08	Detected
	Feb. 11 – Mar. 18	5.96E-08	1.06E-08	1.41E-09	Detected
	Mar. 18 – Apr. 8	1.12E-06	1.90E-07	1.24E-08	Detected

Table 3-20: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Apr. 8 – Apr. 27	9.49E-07	1.80E-07	2.58E-08	Detected
	Apr. 27 – May 15	8.43E-07	1.73E-07	1.48E-08	Detected
	May 15 – Jun. 3	7.09E-07	1.54E-07	1.75E-08	Detected
	Jun. 3 – Jun. 17	1.08E-06	2.24E-07	3.52E-08	Detected
	Jun. 17 – Jul. 8	1.36E-06	2.25E-07	2.20E-08	Detected
	Jul. 8 – Jul. 29	7.12E-07	1.46E-07	1.42E-08	Detected
	Jul. 29 – Aug. 7	1.64E-06	3.46E-07	5.18E-08	Detected
	Aug. 7 – Aug. 14	1.68E-06	3.93E-07	5.60E-08	Detected
	Aug. 14 – Aug. 28	1.22E-06	2.46E-07	2.86E-08	Detected
	Aug. 28 – Sep. 11	9.66E-07	2.15E-07	2.82E-08	Detected
	Sep. 11 – Sep. 25	8.27E-07	2.00E-07	3.43E-08	Detected
	Sep. 25 – Oct. 16	8.58E-07	1.87E-07	1.49E-08	Detected
	Oct. 16 – Nov. 2	7.12E-07	1.69E-07	2.24E-08	Detected
	Nov. 2 – Nov. 23	8.14E-07	1.61E-07	1.96E-08	Detected
	Nov. 23 – Dec. 11	4.73E-07	1.41E-07	2.11E-08	Detected
	Dec. 11 – Dec. 23	9.43E-07	2.67E-07	7.20E-08	Detected
	Dec. 23 – Jan. 8	5.88E-07	1.62E-07	2.55E-08	Detected
^{235}U	Jan. 6 – Jan. 22	6.78E-08	3.21E-08	3.00E-08	Detected
	Jan. 22 – Feb. 11	3.38E-08	1.91E-08	1.11E-08	Detected
	Feb. 11 – Mar. 18	5.62E-09	1.65E-09	9.61E-10	Detected
	Mar. 18 – Apr. 8	1.01E-07	2.76E-08	1.00E-08	Detected
	Apr. 8 – Apr. 27	5.59E-08	2.32E-08	1.16E-08	Detected
	Apr. 27 – May 15	3.32E-08	2.06E-08	1.55E-08	Detected
	May 15 – Jun. 3	6.33E-08	2.41E-08	9.13E-09	Detected
	Jun. 3 – Jun. 17	3.51E-08	2.59E-08	1.71E-08	Detected
	Jun. 17 – Jul. 8	5.71E-08	2.43E-08	2.22E-08	Detected
	Jul. 8 – Jul. 29	2.89E-08	1.77E-08	1.32E-08	Detected
	Jul. 29 – Aug. 7	1.13E-07	5.05E-08	3.41E-08	Detected
	Aug. 7 – Aug. 14	3.25E-08	4.43E-08	4.13E-08	Not detected
	Aug. 14 – Aug. 28	6.15E-08	3.35E-08	3.21E-08	Detected
	Aug. 28 – Sep. 11	6.77E-08	3.39E-08	3.17E-08	Detected
	Sep. 11 – Sep. 25	5.17E-08	3.09E-08	2.53E-08	Detected
	Sep. 25 – Oct. 16	4.13E-08	2.44E-08	1.84E-08	Detected
	Oct. 16 – Nov. 2	5.59E-08	2.83E-08	2.46E-08	Detected
	Nov. 2 – Nov. 23	4.56E-08	2.23E-08	2.04E-08	Detected
	Nov. 23 – Dec. 11	4.49E-08	2.57E-08	1.36E-08	Detected
	Dec. 11 – Dec. 23	1.30E-08	3.89E-08	5.87E-08	Not detected
	Dec. 23 – Jan. 8	3.12E-08	2.46E-08	1.46E-08	Detected

Table 3-20: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Jan. 6 – Jan. 22	8.62E-07	1.91E-07	2.42E-08	Detected
	Jan. 22 – Feb. 11	8.44E-07	1.65E-07	2.17E-08	Detected
	Feb. 11 – Mar. 18	6.08E-08	1.08E-08	1.92E-09	Detected
	Mar. 18 – Apr. 8	9.97E-07	1.76E-07	1.96E-08	Detected
	Apr. 8 – Apr. 27	9.51E-07	1.80E-08	2.37E-08	Detected
	Apr. 27 – May 15	7.22E-07	1.62E-07	2.56E-08	Detected
	May 15 – Jun. 3	7.45E-07	1.57E-07	1.89E-08	Detected
	Jun. 3 – Jun. 17	9.90E-07	2.15E-07	4.32E-08	Detected
	Jun. 17 – Jul. 8	1.32E-06	2.21E-07	2.62E-08	Detected
	Jul. 8 – Jul. 29	7.02E-07	1.46E-07	2.51E-08	Detected
	Jul. 29 – Aug. 7	1.44E-06	3.25E-07	7.38E-08	Detected
	Aug. 7 – Aug. 14	1.63E-06	3.88E-07	5.58E-08	Detected
	Aug. 14 – Aug. 28	1.11E-06	2.35E-07	2.35E-07	Detected
	Aug. 28 – Sep. 11	8.62E-07	2.04E-07	3.62E-08	Detected
	Sep. 11 – Sep. 25	8.38E-07	2.02E-07	3.41E-08	Detected
	Sep. 25 – Oct. 16	8.45E-07	1.86E-07	2.32E-08	Detected
	Oct. 16 – Nov. 2	6.47E-07	1.63E-07	5.28E-08	Detected
	Nov. 2 – Nov. 23	7.16E-07	1.51E-07	2.33E-08	Detected
	Nov. 23 – Dec. 11	3.51E-07	1.28E-07	3.66E-08	Detected
	Dec. 11 – Dec. 23	8.20E-07	2.56E-07	1.32E-07	Detected
	Dec. 23 – Jan. 8	5.67E-07	1.61E-07	3.41E-08	Detected

Table 3-21: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Jan. 6 – Jan. 22	8.27E-07	1.89E-07	2.53E-08	Detected
	Jan. 22 – Feb. 11	7.61E-07	1.55E-07	2.20E-08	Detected
	Feb. 11 – Mar. 18	6.54E-07	1.15E-07	1.27E-08	Detected
	Mar. 18 – Apr. 8	7.44E-07	1.49E-07	1.49E-08	Detected
	Apr. 8 – Apr. 27	9.77E-07	1.81E-07	2.11E-08	Detected
	Apr. 27 – May 15	8.32E-07	1.70E-07	1.91E-08	Detected
	May 15 – Jun. 3	7.97E-07	1.61E-07	1.16E-08	Detected
	Jun. 3 – Jun. 17	8.44E-07	1.96E-07	3.08E-08	Detected
	Jun. 17 – Jul. 8	1.09E-06	1.93E-07	1.21E-08	Detected
	Jul. 8 – Jul. 29	1.07E-06	1.83E-07	2.10E-08	Detected
	Jul. 29 – Aug. 7	1.56E-06	3.36E-07	4.54E-08	Detected

Table 3-21: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Aug. 7 – Aug. 14	1.69E-06	4.09E-07	7.47E-08	Detected
	Aug. 14 – Aug. 28	1.22E-06	2.56E-07	3.10E-08	Detected
	Aug. 28 – Sep. 11	1.31E-06	2.49E-07	2.42E-08	Detected
	Sep. 11 – Sep. 25	1.20E-06	2.35E-07	3.62E-08	Detected
	Sep. 25 – Oct. 16	9.75E-07	1.74E-07	1.09E-08	Detected
	Oct. 16 – Nov. 2	9.00E-07	1.91E-07	3.44E-08	Detected
	Nov. 2 – Nov. 23	1.13E-06	1.98E-07	9.32E-09	Detected
	Nov. 23 – Dec. 11	5.96E-07	1.66E-07	2.86E-08	Detected
	Dec. 11 – Dec. 23	1.17E-06	2.52E-07	3.90E-08	Detected
	Dec. 23 – Jan. 8	5.50E-07	1.54E-07	1.54E-07	Detected
^{235}U	Jan. 6 – Jan. 22	2.82E-08	2.49E-08	2.36E-08	Detected
	Jan. 22 – Feb. 11	2.44E-08	1.91E-08	2.28E-08	Detected
	Feb. 11 – Mar. 18	4.97E-08	1.69E-08	1.36E-08	Detected
	Mar. 18 – Apr. 8	4.06E-08	1.95E-08	8.53E-09	Detected
	Apr. 8 – Apr. 27	3.43E-08	1.97E-08	1.47E-08	Detected
	Apr. 27 – May 15	2.87E-08	2.01E-08	1.62E-08	Detected
	May 15 – Jun. 3	3.01E-08	1.92E-08	1.69E-08	Detected
	Jun. 3 – Jun. 17	1.57E-07	4.52E-08	2.26E-08	Detected
	Jun. 17 – Jul. 8	1.04E-07	3.00E-08	1.50E-08	Detected
	Jul. 8 – Jul. 29	3.82E-08	1.89E-08	1.49E-08	Detected
	Jul. 29 – Aug. 7	9.63E-08	4.79E-08	2.77E-08	Detected
	Aug. 7 – Aug. 14	9.33E-08	5.63E-08	3.35E-08	Detected
	Aug. 14 – Aug. 28	1.61E-08	2.60E-08	2.24E-08	Not detected
	Aug. 28 – Sep. 11	4.55E-08	2.78E-08	1.76E-08	Detected
	Sep. 11 – Sep. 25	1.03E-07	3.58E-08	1.63E-08	Detected
	Sep. 25 – Oct. 16	4.66E-08	2.01E-08	8.25E-09	Detected
	Oct. 16 – Nov. 2	6.44E-08	3.21E-08	3.55E-08	Detected
	Nov. 2 – Nov. 23	6.99E-08	2.56E-08	1.75E-08	Detected
	Nov. 23 – Dec. 11	1.50E-08	2.56E-08	3.52E-08	Not detected
	Dec. 11 – Dec. 23	9.37E-08	3.84E-08	1.58E-08	Detected
	Dec. 23 – Jan. 8	5.62E-08	2.82E-08	2.09E-08	Detected
^{238}U	Jan. 6 – Jan. 22	8.30E-07	1.90E-07	2.51E-08	Detected
	Jan. 22 – Feb. 11	6.71E-07	1.46E-07	4.02E-08	Detected
	Feb. 11 – Mar. 18	6.20E-07	1.11E-07	1.77E-08	Detected
	Mar. 18 – Apr. 8	7.28E-07	1.48E-07	1.76E-08	Detected
	Apr. 8 – Apr. 27	1.04E-06	1.89E-07	2.51E-08	Detected

Table 3-21: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}U	Apr. 27 – May 15	8.35E-07	1.72E-07	3.26E-08	Detected
	May 15 – Jun. 3	8.13E-07	1.64E-07	1.68E-08	Detected
	Jun. 3 – Jun. 17	1.59E-06	2.87E-07	5.08E-08	Detected
	Jun. 17 – Jul. 8	1.05E-06	1.90E-07	3.37E-08	Detected
	Jul. 8 – Jul. 29	8.74E-07	1.62E-07	2.75E-08	Detected
	Jul. 29 – Aug. 7	1.59E-06	3.41E-07	7.15E-08	Detected
	Aug. 7 – Aug. 14	1.33E-06	3.70E-07	8.69E-08	Detected
	Aug. 14 – Aug. 28	1.16E-06	2.50E-07	3.66E-08	Detected
	Aug. 28 – Sep. 11	1.19E-06	2.38E-07	2.86E-08	Detected
	Sep. 11 – Sep. 25	1.15E-06	2.30E-07	4.22E-08	Detected
	Sep. 25 – Oct. 16	8.95E-07	1.66E-07	1.70E-08	Detected
	Oct. 16 – Nov. 2	6.86E-07	1.68E-07	4.30E-08	Detected
	Nov. 2 – Nov. 23	1.01E-06	1.86E-07	2.45E-08	Detected
	Nov. 23 – Dec. 11	7.09E-07	1.81E-07	5.33E-08	Detected
	Dec. 11 – Dec. 23	1.26E-06	2.63E-07	4.73E-08	Detected
	Dec. 23 – Jan. 8	5.37E-07	1.54E-07	4.61E-08	Detected

Table 3-22: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 6 – Jan. 22	4.15E-02	9.02E-03	1.31E-03	Detected
	Jan. 22 – Feb. 11	2.98E-02	6.70E-03	5.35E-04	Detected
	Feb. 11 – Mar. 18	2.81E-02	4.95E-03	5.34E-04	Detected
	Mar. 18 – Apr. 8	2.46E-02	4.28E-03	3.54E-04	Detected
	Apr. 8 – Apr. 27	2.23E-02	4.41E-03	5.27E-04	Detected
	Apr. 27 – May 15	1.75E-02	3.64E-03	3.66E-04	Detected
	May 15 – Jun. 3	2.83E-02	5.15E-03	4.27E-04	Detected
	Jun. 3 – Jun. 17	2.21E-02	5.00E-03	8.95E-04	Detected
	Jun. 17 – Jul. 8	2.95E-02	5.22E-03	6.87E-04	Detected
	Jul. 8 – Jul. 29	2.58E-02	4.63E-03	4.96E-04	Detected
	Jul. 29 – Aug. 7	3.27E-02	6.81E-03	9.62E-04	Detected
	Aug. 7 – Aug. 14	6.47E-02	1.22E-02	1.37E-03	Detected
	Aug. 14 – Aug. 28	2.84E-02	5.48E-03	5.59E-04	Detected
	Aug. 28 – Sep. 11	3.03E-02	6.03E-03	6.18E-04	Detected
	Sep. 11 – Sep. 25	4.03E-02	8.53E-03	1.15E-03	Detected
	Sep. 25 – Oct. 16	2.40E-02	4.84E-03	4.60E-04	Detected

Table 3-22: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Oct. 16 – Nov. 2	3.81E-02	8.31E-03	1.40E-03	Detected
	Nov. 2 – Nov. 23	3.16E-02	5.88E-03	6.90E-04	Detected
	Nov. 23 – Dec. 11	3.68E-02	9.43E-03	8.08E-04	Detected
	Dec. 11 – Dec. 23	4.22E-02	8.54E-03	8.67E-04	Detected
	Dec. 23 – Jan. 8	5.27E-02	1.39E-02	2.96E-03	Detected
^{235}U	Jan. 6 – Jan. 22	4.22E-02	1.36E-03	1.03E-03	Detected
	Jan. 22 – Feb. 11	2.37E-03	7.98E-04	6.61E-04	Detected
	Feb. 11 – Mar. 18	3.08E-03	7.09E-04	2.87E-04	Detected
	Mar. 18 – Apr. 8	1.69E-03	4.44E-04	2.77E-04	Detected
	Apr. 8 – Apr. 27	1.77E-03	5.09E-04	2.83E-04	Detected
	Apr. 27 – May 15	1.08E-03	3.87E-04	3.41E-04	Detected
	May 15 – Jun. 3	2.13E-03	6.23E-04	6.25E-04	Detected
	Jun. 3 – Jun. 17	2.02E-03	6.84E-04	4.57E-04	Detected
	Jun. 17 – Jul. 8	5.91E-03	1.15E-03	4.34E-04	Detected
	Jul. 8 – Jul. 29	1.84E-03	5.07E-04	2.67E-04	Detected
	Jul. 29 – Aug. 7	2.73E-03	9.19E-04	9.38E-04	Detected
	Aug. 7 – Aug. 14	4.86E-03	1.45E-03	8.34E-04	Detected
	Aug. 14 – Aug. 28	2.05E-03	6.08E-04	4.40E-04	Detected
	Aug. 28 – Sep. 11	2.92E-03	7.74E-04	4.87E-04	Detected
	Sep. 11 – Sep. 25	3.23E-03	1.07E-03	6.98E-04	Detected
	Sep. 25 – Oct. 16	1.73E-03	5.67E-04	2.96E-04	Detected
	Oct. 16 – Nov. 2	4.31E-03	1.25E-03	5.67E-04	Detected
	Nov. 2 – Nov. 23	3.43E-03	8.67E-04	5.10E-04	Detected
	Nov. 23 – Dec. 11	4.18E-03	1.51E-03	1.51E-03	Detected
	Dec. 11 – Dec. 23	5.82E-03	1.43E-03	8.10E-04	Detected
	Dec. 23 – Jan. 8	9.58E-03	2.90E-03	2.42E-03	Detected
^{238}U	Jan. 6 – Jan. 22	3.88E-02	4.95E-03	8.85E-04	Detected
	Jan. 22 – Feb. 11	2.93E-02	3.42E-03	3.13E-04	Detected
	Feb. 11 – Mar. 18	2.93E-02	3.37E-03	4.06E-04	Detected
	Mar. 18 – Apr. 8	2.39E-02	2.60E-03	1.94E-04	Detected
	Apr. 8 – Apr. 27	2.07E-02	2.36E-03	4.54E-04	Detected
	Apr. 27 – May 15	1.56E-02	1.83E-03	2.45E-04	Detected
	May 15 – Jun. 3	2.36E-02	2.73E-03	1.58E-04	Detected
	Jun. 3 – Jun. 17	2.20E-02	2.85E-03	1.09E-03	Detected
	Jun. 17 – Jul. 8	2.62E-02	3.33E-03	7.17E-04	Detected
	Jul. 8 – Jul. 29	2.42E-02	2.75E-03	2.07E-04	Detected

Table 3-22: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Jul. 29 – Aug. 7	2.99E-02	3.73E-03	1.02E-03	Detected
	Aug. 7 – Aug. 14	5.69E-02	6.91E-03	1.11E-03	Detected
	Aug. 14 – Aug. 28	2.76E-02	3.16E-03	2.54E-04	Detected
	Aug. 28 – Sep. 11	3.18E-02	3.58E-03	2.55E-04	Detected
	Sep. 11 – Sep. 25	3.47E-02	4.38E-03	9.56E-04	Detected
	Sep. 25 – Oct. 16	2.65E-02	3.20E-03	3.10E-04	Detected
	Oct. 16 – Nov. 2	3.33E-02	4.13E-03	9.75E-04	Detected
	Nov. 2 – Nov. 23	2.96E-02	3.55E-03	1.79E-04	Detected
	Nov. 23 – Dec. 11	3.44E-02	4.71E-03	1.25E-03	Detected
	Dec. 11 – Dec. 23	3.89E-02	4.63E-03	9.29E-04	Detected
	Dec. 23 – Jan. 8	4.99E-02	7.16E-03	2.00E-03	Detected

Table 3-23: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 6 – Jan. 22	3.72E-02	7.87E-03	9.50E-04	Detected
	Jan. 22 – Feb. 11	3.42E-02	6.77E-03	8.25E-04	Detected
	Feb. 11 – Mar. 18	2.60E-02	4.64E-03	6.12E-04	Detected
	Mar. 18 – Apr. 8	2.83E-02	4.78E-03	3.12E-04	Detected
	Apr. 8 – Apr. 27	2.56E-02	4.85E-03	6.97E-04	Detected
	Apr. 27 – May 15	2.30E-02	4.71E-03	4.02E-04	Detected
	May 15 – Jun. 3	2.35E-02	5.11E-03	5.82E-04	Detected
	Jun. 3 – Jun. 17	3.17E-02	6.60E-03	1.03E-03	Detected
	Jun. 17 – Jul. 8	3.68E-02	6.08E-03	5.94E-04	Detected
	Jul. 8 – Jul. 29	2.15E-02	4.42E-03	4.29E-04	Detected
	Jul. 29 – Aug. 7	4.02E-02	8.46E-03	1.27E-03	Detected
	Aug. 7 – Aug. 14	4.08E-02	9.56E-03	1.36E-03	Detected
	Aug. 14 – Aug. 28	3.29E-02	6.66E-03	7.73E-04	Detected
	Aug. 28 – Sep. 11	2.84E-02	6.31E-03	8.30E-04	Detected
	Sep. 11 – Sep. 25	3.04E-02	7.38E-03	1.26E-03	Detected
	Sep. 25 – Oct. 16	3.26E-02	7.11E-03	5.66E-04	Detected
	Oct. 16 – Nov. 2	3.30E-02	7.82E-03	1.04E-03	Detected
	Nov. 2 – Nov. 23	3.54E-02	6.98E-03	8.52E-04	Detected
	Nov. 23 – Dec. 11	3.48E-02	1.04E-02	1.55E-03	Detected
	Dec. 11 – Dec. 23	3.75E-02	1.06E-02	2.86E-03	Detected
	Dec. 23 – Jan. 8	3.60E-02	9.95E-03	1.56E-03	Detected

Table 3-23: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{235}U	Jan. 6 – Jan. 22	2.65E-03	1.26E-03	1.17E-03	Detected
	Jan. 22 – Feb. 11	1.43E-03	8.07E-04	4.71E-04	Detected
	Feb. 11 – Mar. 18	2.45E-03	7.19E-04	4.19E-04	Detected
	Mar. 18 – Apr. 8	2.55E-03	6.97E-04	2.53E-04	Detected
	Apr. 8 – Apr. 27	1.51E-03	6.27E-04	3.12E-04	Detected
	Apr. 27 – May 15	9.03E-04	5.62E-04	4.22E-04	Detected
	May 15 – Jun. 3	2.10E-03	8.01E-04	3.03E-04	Detected
	Jun. 3 – Jun. 17	1.03E-03	7.61E-04	5.04E-04	Detected
	Jun. 17 – Jul. 8	1.54E-03	6.55E-04	5.99E-04	Detected
	Jul. 8 – Jul. 29	8.73E-04	5.34E-04	4.00E-04	Detected
	Jul. 29 – Aug. 7	2.76E-03	1.24E-03	8.36E-04	Detected
	Aug. 7 – Aug. 14	7.91E-04	1.08E-03	1.00E-03	Not detected
	Aug. 14 – Aug. 28	1.66E-03	9.07E-04	8.67E-04	Detected
	Aug. 28 – Sep. 11	1.99E-03	9.97E-04	9.32E-04	Detected
	Sep. 11 – Sep. 25	1.90E-03	1.14E-03	9.31E-04	Detected
	Sep. 25 – Oct. 16	1.57E-03	9.27E-04	6.99E-04	Detected
	Oct. 16 – Nov. 2	2.60E-03	1.31E-03	1.14E-03	Detected
	Nov. 2 – Nov. 23	1.98E-03	9.68E-04	8.88E-04	Detected
	Nov. 23 – Dec. 11	3.31E-03	1.89E-03	1.00E-03	Detected
	Dec. 11 – Dec. 23	5.16E-04	1.55E-03	2.34E-03	Not detected
	Dec. 23 – Jan. 8	1.92E-03	1.51E-03	8.96E-04	Detected
^{238}U	Jan. 6 – Jan. 22	3.37E-02	7.48E-03	9.47E-04	Detected
	Jan. 22 – Feb. 11	3.57E-02	6.96E-03	9.18E-04	Detected
	Feb. 11 – Mar. 18	2.65E-02	4.70E-03	8.36E-04	Detected
	Mar. 18 – Apr. 8	2.52E-02	4.45E-03	4.95E-04	Detected
	Apr. 8 – Apr. 27	2.56E-02	4.87E-04	6.39E-04	Detected
	Apr. 27 – May 15	1.97E-02	4.42E-03	6.96E-04	Detected
	May 15 – Jun. 3	2.47E-02	5.22E-03	6.26E-04	Detected
	Jun. 3 – Jun. 17	2.91E-02	6.34E-03	1.27E-03	Detected
	Jun. 17 – Jul. 8	3.56E-02	5.96E-03	7.06E-04	Detected
	Jul. 8 – Jul. 29	2.12E-02	4.40E-03	7.60E-04	Detected
	Jul. 29 – Aug. 7	3.52E-02	7.94E-03	1.81E-03	Detected
	Aug. 7 – Aug. 14	3.96E-02	9.43E-03	1.36E-03	Detected
	Aug. 14 – Aug. 28	3.00E-02	6.36E-03	6.36E-03	Detected
	Aug. 28 – Sep. 11	2.53E-02	5.99E-03	1.06E-03	Detected
	Sep. 11 – Sep. 25	3.08E-02	7.44E-03	1.26E-03	Detected
	Sep. 25 – Oct. 16	3.21E-02	7.05E-03	8.81E-04	Detected

Table 3-23: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Oct. 16 – Nov. 2	3.00E-02	7.58E-03	2.45E-03	Detected
	Nov. 2 – Nov. 23	3.11E-02	6.54E-03	1.01E-03	Detected
	Nov. 23 – Dec. 11	2.58E-02	9.41E-03	2.69E-03	Detected
	Dec. 11 – Dec. 23	3.26E-02	1.02E-02	5.24E-03	Detected
	Dec. 23 – Jan. 8	3.48E-02	9.86E-03	2.09E-03	Detected

Table 3-24: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Jan. 6 – Jan. 22	3.40E-02	7.76E-03	1.04E-03	Detected
	Jan. 22 – Feb. 11	3.53E-02	7.18E-03	1.02E-03	Detected
	Feb. 11 – Mar. 18	3.71E-02	6.50E-03	7.20E-04	Detected
	Mar. 18 – Apr. 8	2.10E-02	4.22E-03	4.22E-04	Detected
	Apr. 8 – Apr. 27	3.15E-02	5.84E-03	6.81E-04	Detected
	Apr. 27 – May 15	2.90E-02	5.92E-03	6.66E-04	Detected
	May 15 – Jun. 3	3.07E-02	6.19E-03	4.48E-04	Detected
	Jun. 3 – Jun. 17	2.93E-02	6.82E-03	1.07E-03	Detected
	Jun. 17 – Jul. 8	3.18E-02	5.64E-03	3.53E-04	Detected
	Jul. 8 – Jul. 29	2.85E-02	4.88E-03	5.60E-04	Detected
	Jul. 29 – Aug. 7	3.85E-02	8.29E-03	1.12E-03	Detected
	Aug. 7 – Aug. 14	4.19E-02	1.01E-02	1.85E-03	Detected
	Aug. 14 – Aug. 28	3.42E-02	7.17E-03	8.66E-04	Detected
	Aug. 28 – Sep. 11	3.30E-02	6.27E-03	6.09E-04	Detected
	Sep. 11 – Sep. 25	4.03E-02	7.92E-03	1.22E-03	Detected
	Sep. 25 – Oct. 16	2.70E-02	4.83E-03	3.02E-04	Detected
	Oct. 16 – Nov. 2	3.79E-02	8.05E-03	1.45E-03	Detected
	Nov. 2 – Nov. 23	3.45E-02	6.06E-03	2.85E-04	Detected
	Nov. 23 – Dec. 11	3.37E-02	9.40E-03	1.61E-03	Detected
	Dec. 11 – Dec. 23	4.04E-02	8.73E-03	1.35E-03	Detected
	Dec. 23 – Jan. 8	4.44E-02	1.24E-02	1.24E-02	Detected
^{235}U	Jan. 6 – Jan. 22	1.16E-03	1.03E-03	9.68E-04	Detected
	Jan. 22 – Feb. 11	1.13E-03	8.84E-04	1.06E-03	Detected
	Feb. 11 – Mar. 18	2.82E-03	9.56E-04	7.70E-04	Detected
	Mar. 18 – Apr. 8	1.15E-03	5.49E-04	2.41E-04	Detected
	Apr. 8 – Apr. 27	1.11E-03	6.37E-04	4.73E-04	Detected

Table 3-24: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{235}U	Apr. 27 – May 15	1.00E-03	6.99E-04	5.66E-04	Detected
	May 15 – Jun. 3	1.16E-03	7.41E-04	6.50E-04	Detected
	Jun. 3 – Jun. 17	5.47E-03	1.57E-03	7.83E-04	Detected
	Jun. 17 – Jul. 8	3.05E-03	8.77E-04	4.37E-04	Detected
	Jul. 8 – Jul. 29	1.02E-03	5.02E-04	3.97E-04	Detected
	Jul. 29 – Aug. 7	2.38E-03	1.18E-03	6.83E-04	Detected
	Aug. 7 – Aug. 14	2.31E-03	1.40E-03	8.30E-04	Detected
	Aug. 14 – Aug. 28	4.52E-04	7.27E-04	6.27E-04	Not detected
	Aug. 28 – Sep. 11	1.14E-03	7.00E-04	4.42E-04	Detected
	Sep. 11 – Sep. 25	3.45E-03	1.21E-03	5.48E-04	Detected
	Sep. 25 – Oct. 16	1.29E-03	5.57E-04	2.29E-04	Detected
	Oct. 16 – Nov. 2	2.71E-03	1.35E-03	1.50E-03	Detected
	Nov. 2 – Nov. 23	2.14E-03	7.82E-04	5.35E-04	Detected
	Nov. 23 – Dec. 11	8.46E-04	1.45E-03	1.99E-03	Not detected
	Dec. 11 – Dec. 23	3.24E-03	1.33E-03	5.45E-04	Detected
	Dec. 23 – Jan. 8	4.53E-03	2.27E-03	1.69E-03	Detected
^{238}U	Jan. 6 – Jan. 22	3.41E-02	7.80E-03	1.03E-03	Detected
	Jan. 22 – Feb. 11	3.11E-02	6.78E-03	1.86E-03	Detected
	Feb. 11 – Mar. 18	3.52E-02	6.30E-03	1.01E-03	Detected
	Mar. 18 – Apr. 8	2.05E-02	4.18E-03	4.98E-04	Detected
	Apr. 8 – Apr. 27	3.37E-02	6.09E-03	8.10E-04	Detected
	Apr. 27 – May 15	2.91E-02	5.99E-03	1.14E-03	Detected
	May 15 – Jun. 3	3.13E-02	6.30E-03	6.47E-04	Detected
	Jun. 3 – Jun. 17	5.52E-02	9.95E-03	1.76E-03	Detected
	Jun. 17 – Jul. 8	3.08E-02	5.56E-03	9.85E-04	Detected
	Jul. 8 – Jul. 29	2.33E-02	4.32E-03	7.32E-04	Detected
	Jul. 29 – Aug. 7	3.93E-02	8.42E-03	1.77E-03	Detected
	Aug. 7 – Aug. 14	3.30E-02	9.16E-03	2.15E-03	Detected
	Aug. 14 – Aug. 28	3.25E-02	6.98E-03	1.02E-03	Detected
	Aug. 28 – Sep. 11	3.00E-02	5.98E-03	7.20E-04	Detected
	Sep. 11 – Sep. 25	3.86E-02	7.74E-03	1.42E-03	Detected
	Sep. 25 – Oct. 16	2.48E-02	4.60E-03	4.72E-04	Detected
	Oct. 16 – Nov. 2	2.89E-02	7.07E-03	1.81E-03	Detected
	Nov. 2 – Nov. 23	3.08E-02	5.68E-03	7.50E-04	Detected
	Nov. 23 – Dec. 11	4.01E-02	1.03E-02	3.01E-03	Detected
	Dec. 11 – Dec. 23	4.38E-02	9.09E-03	1.64E-03	Detected
	Dec. 23 – Jan. 8	4.33E-02	1.24E-02	3.72E-03	Detected

Table 3-25: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 6 – Jan. 22	3.30E-07	7.29E-07	2.41E-06	Not Detected
	Jan. 22 – Feb. 11	-3.72E-07	5.87E-07	1.96E-06	Not Detected
	Feb. 11 – Mar. 18	3.95E-07	3.37E-07	1.11E-06	Not Detected
	Mar. 18 – Apr. 8	-6.65E-07	5.72E-07	1.91E-06	Not Detected
	Apr. 8 – Apr. 27	-1.35E-10	6.26E-07	2.08E-06	Not Detected
	Apr. 27 – May 15	4.59E-07	6.42E-07	2.12E-06	Not Detected
	May 15 – Jun. 3	3.63E-07	6.17E-07	2.07E-06	Not Detected
	Jun. 3 – Jun. 17	2.84E-07	8.57E-07	2.84E-06	Not Detected
	Jun. 17 – Jul. 8	4.29E-07	5.68E-07	1.88E-06	Not Detected
	Jul. 8 – Jul. 29	-5.84E-07	8.45E-07	2.81E-06	Not Detected
	Jul. 29 – Aug. 7	-5.19E-06	3.23E-06	1.08E-05	Not Detected
	Aug. 7 – Aug. 14	1.61E-06	2.13E-06	7.03E-06	Not Detected
	Aug. 14 – Aug. 28	2.69E-06	1.96E-06	6.44E-06	Not Detected
	Aug. 28 – Sep. 11	1.89E-06	1.05E-06	3.44E-06	Not Detected
	Sep. 11 – Sep. 25	-3.31E-07	8.43E-07	2.80E-06	Not Detected
	Sep. 25 – Oct. 16	-2.75E-07	5.71E-07	1.90E-06	Not Detected
	Oct. 16 – Nov. 2	2.88E-07	6.86E-07	2.27E-06	Not Detected
	Nov. 2 – Nov. 23	3.45E-07	6.56E-07	2.17E-06	Not Detected
	Nov. 23 – Dec. 11	7.27E-09	8.38E-07	2.78E-06	Not Detected
	Dec. 11 – Dec. 23	2.22E-06	1.25E-06	4.10E-06	Not Detected
	Dec. 23 – Jan. 8	-5.94E-07	7.27E-07	2.42E-06	Not Detected
^{60}Co	Jan. 6 – Jan. 22	9.98E-08	7.50E-07	2.49E-06	Not Detected
	Jan. 22 – Feb. 11	-2.92E-07	6.00E-07	2.01E-06	Not Detected
	Feb. 11 – Mar. 18	-5.88E-07	3.50E-07	1.18E-06	Not Detected
	Mar. 18 – Apr. 8	-6.40E-07	5.87E-07	1.97E-06	Not Detected
	Apr. 8 – Apr. 27	-9.79E-07	6.48E-07	2.18E-06	Not Detected
	Apr. 27 – May 15	-4.76E-07	6.63E-07	2.22E-06	Not Detected
	May 15 – Jun. 3	-8.54E-08	6.23E-07	2.08E-06	Not Detected
	Jun. 3 – Jun. 17	-6.97E-07	8.88E-07	2.97E-06	Not Detected
	Jun. 17 – Jul. 8	2.96E-07	5.74E-07	1.91E-06	Not Detected
	Jul. 8 – Jul. 29	-4.86E-07	6.94E-07	2.32E-06	Not Detected
	Jul. 29 – Aug. 7	-7.28E-07	3.00E-06	1.00E-05	Not Detected
	Aug. 7 – Aug. 14	-8.20E-07	1.75E-06	5.86E-06	Not Detected
	Aug. 14 – Aug. 28	-1.72E-06	1.97E-06	6.70E-06	Not Detected
	Aug. 28 – Sep. 11	-7.50E-07	8.77E-07	2.94E-06	Not Detected
	Sep. 11 – Sep. 25	-1.17E-06	8.58E-07	2.89E-06	Not Detected

Table 3-25: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{60}Co	Sep. 25 – Oct. 16	-5.91E-07	5.86E-07	1.96E-06	Not detected
	Oct. 16 – Nov. 2	-9.31E-07	7.20E-07	2.42E-06	Not detected
	Nov. 2 – Nov. 23	-9.46E-07	6.86E-07	2.31E-06	Not detected
	Nov. 23 – Dec. 11	-5.16E-07	6.96E-07	2.33E-06	Not Detected
	Dec. 11 – Dec. 23	-5.82E-07	1.05E-06	3.49E-06	Not Detected
	Dec. 23 – Jan. 8	-1.14E-06	7.40E-07	2.49E-06	Not Detected
^{40}K	Jan. 6 – Jan. 22	2.96E-05	9.34E-06	3.04E-05	Not Detected
	Jan. 22 – Feb. 11	2.86E-05	7.37E-07	2.38E-05	Detected
	Feb. 11 – Mar. 18	1.88E-05	4.23E-06	1.36E-05	Detected
	Mar. 18 – Apr. 8	4.75E-05	7.10E-06	2.24E-05	Detected
	Apr. 8 – Apr. 27	4.37E-05	7.71E-06	2.45E-05	Detected
	Apr. 27 – May 15	3.86E-05	8.01E-06	2.57E-05	Detected
	May 15 – Jun. 3	3.98E-05	7.45E-06	2.38E-05	Detected
	Jun. 3 – Jun. 17	4.51E-05	1.04E-05	3.34E-05	Detected
	Jun. 17 – Jul. 8	3.50E-05	7.06E-06	2.26E-05	Detected
	Jul. 8 – Jul. 29	2.96E-05	8.86E-06	2.83E-05	Detected
	Jul. 29 – Aug. 7	6.91E-05	3.06E-05	9.98E-05	Not detected
	Aug. 7 – Aug. 14	7.26E-05	2.18E-05	6.96E-05	Detected
	Aug. 14 – Aug. 28	4.64E-05	1.93E-05	6.29E-05	Not detected
	Aug. 28 – Sep. 11	3.30E-05	1.10E-05	3.52E-05	Not detected
	Sep. 11 – Sep. 25	3.30E-05	1.04E-05	3.38E-05	Not detected
	Sep. 25 – Oct. 16	2.31E-05	7.11E-06	2.31E-05	Detected
	Oct. 16 – Nov. 2	3.63E-05	8.40E-06	2.71E-05	Detected
	Nov. 2 – Nov. 23	3.28E-05	8.20E-06	2.65E-05	Detected
	Nov. 23 – Dec. 11	2.90E-05	8.54E-06	2.73E-05	Detected
	Dec. 11 – Dec. 23	4.16E-05	1.30E-05	4.16E-05	Not detected
	Dec. 23 – Jan. 8	3.13E-05	8.94E-06	2.89E-05	Detected

Table 3-26: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 6 – Jan. 22	-1.44E-06	9.51E-07	3.17E-06	Not detected
	Jan. 22 – Feb. 11	-4.12E-08	7.54E-07	2.50E-06	Not detected
	Feb. 11 – Mar. 18	2.52E-07	4.38E-07	1.45E-06	Not detected
	Mar. 18 – Apr. 8	-9.79E-07	6.07E-07	2.04E-06	Not detected

Table 3-26: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Apr. 8 – Apr. 27	6.07E-07	7.97E-07	2.63E-06	Not detected
	Apr. 27 – May 15	8.26E-07	8.70E-07	2.87E-06	Not detected
	May 15 – Jun. 3	6.86E-07	8.02E-07	2.65E-06	Not detected
	Jun. 3 – Jun. 17	4.63E-07	1.09E-06	3.60E-06	Not detected
	Jun. 17 – Jul. 8	-3.91E-07	7.31E-07	2.43E-06	Not detected
	Jul. 8 – Jul. 29	1.88E-06	1.37E-06	4.52E-06	Not detected
	Jul. 29 – Aug. 7	6.55E-07	1.34E-06	4.43E-06	Not detected
	Aug. 7 – Aug. 14	2.12E-06	4.14E-06	1.37E-05	Not detected
	Aug. 14 – Aug. 28	1.04E-06	8.63E-07	2.85E-06	Not detected
	Aug. 28 – Sep. 11	8.94E-07	1.99E-06	6.60E-06	Not detected
	Sep. 11 – Sep. 25	-2.53E-06	1.49E-06	4.95E-06	Not detected
	Sep. 25 – Oct. 16	-3.03E-09	9.93E-07	3.29E-06	Not detected
	Oct. 16 – Nov. 2	-1.67E-06	9.22E-07	3.08E-06	Not detected
	Nov. 2 – Nov. 23	-8.47E-07	7.40E-07	2.46E-06	Not detected
	Nov. 23 – Dec. 11	4.28E-07	1.56E-06	5.17E-06	Not detected
	Dec. 11 – Dec. 23	-1.26E-06	2.46E-06	8.18E-06	Not detected
	Dec. 23 – Jan. 8	4.49E-07	9.28E-07	3.07E-06	Not detected
^{60}Co	Jan. 6 – Jan. 22	-4.41E-07	7.59E-07	2.54E-06	Not detected
	Jan. 22 – Feb. 11	-3.64E-08	6.25E-07	2.08E-06	Not detected
	Feb. 11 – Mar. 18	2.72E-07	3.55E-07	1.18E-06	Not detected
	Mar. 18 – Apr. 8	-9.79E-07	6.07E-07	2.04E-06	Not detected
	Apr. 8 – Apr. 27	4.54E-07	6.57E-07	2.17E-06	Not detected
	Apr. 27 – May 15	3.03E-07	7.19E-07	2.39E-06	Not detected
	May 15 – Jun. 3	-6.93E-08	6.69E-07	2.23E-06	Not detected
	Jun. 3 – Jun. 17	-1.03E-06	9.11E-07	3.06E-06	Not detected
	Jun. 17 – Jul. 8	3.14E-07	5.90E-07	1.96E-06	Not detected
	Jul. 8 – Jul. 29	1.55E-06	1.26E-06	4.17E-06	Not detected
	Jul. 29 – Aug. 7	-5.31E-08	1.35E-06	4.50E-06	Not detected
	Aug. 7 – Aug. 14	-3.56E-06	3.90E-06	1.31E-05	Not detected
	Aug. 14 – Aug. 28	-7.11E-07	8.90E-07	2.98E-06	Not detected
	Aug. 28 – Sep. 11	-2.28E-06	1.96E-06	6.58E-06	Not detected
	Sep. 11 – Sep. 25	-4.03E-07	1.22E-06	4.04E-06	Not detected
	Sep. 25 – Oct. 16	3.72E-07	8.23E-07	2.73E-06	Not detected
	Oct. 16 – Nov. 2	-2.07E-06	7.72E-07	2.60E-06	Not detected
	Nov. 2 – Nov. 23	2.48E-07	5.95E-07	1.98E-06	Not detected
	Nov. 23 – Dec. 11	-1.43E-06	1.54E-06	5.16E-06	Not detected
	Dec. 11 – Dec. 23	-8.39E-07	2.31E-06	7.73E-06	Not detected
	Dec. 23 – Jan. 8	-6.83E-08	7.65E-07	2.55E-06	Not detected

Table 3-26: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Jan. 6 – Jan. 22	4.37E-05	9.74E-06	3.04E-05	Detected
	Jan. 22 – Feb. 11	2.59E-05	8.04E-06	2.58E-05	Detected
	Feb. 11 – Mar. 18	2.44E-05	4.69E-06	1.44E-05	Detected
	Mar. 18 – Apr. 8	3.08E-05	7.83E-06	2.48E-05	Detected
	Apr. 8 – Apr. 27	3.09E-05	8.57E-06	2.73E-05	Detected
	Apr. 27 – May 15	4.03E-05	9.27E-06	2.91E-05	Detected
	May 15 – Jun. 3	2.31E-05	8.59E-06	2.77E-05	Not detected
	Jun. 3 – Jun. 17	2.91E-05	1.14E-05	3.70E-05	Not detected
	Jun. 17 – Jul. 8	3.97E-05	7.56E-06	2.32E-05	Detected
	Jul. 8 – Jul. 29	3.99E-05	1.36E-05	4.39E-05	Not detected
	Jul. 29 – Aug. 7	5.56E-05	1.65E-05	5.35E-05	Detected
	Aug. 7 – Aug. 14	1.04E-04	4.04E-05	1.31E-04	Not detected
	Aug. 14 – Aug. 28	3.19E-05	1.09E-05	3.54E-05	Not detected
	Aug. 28 – Sep. 11	5.73E-05	1.86E-05	5.98E-05	Not detected
	Sep. 11 – Sep. 25	4.56E-05	1.25E-05	3.98E-05	Detected
	Sep. 25 – Oct. 16	3.84E-05	1.03E-05	3.25E-05	Detected
	Oct. 16 – Nov. 2	3.89E-05	9.34E-06	2.94E-05	Detected
	Nov. 2 – Nov. 23	4.08E-05	7.40E-06	2.25E-05	Detected
	Nov. 23 – Dec. 11	3.56E-05	1.47E-05	4.77E-05	Not detected
	Dec. 11 – Dec. 23	4.24E-05	2.38E-05	7.80E-05	Not detected
	Dec. 23 – Jan. 8	2.04E-05	9.79E-06	3.19E-05	Not detected

Table 3-27: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Jan. 6 – Jan. 22	3.41E-07	1.78E-06	5.90E-06	Not detected
	Jan. 22 – Feb. 11	-1.13E-06	1.42E-06	4.74E-06	Not detected
	Feb. 11 – Mar. 18	1.84E-07	8.17E-07	2.71E-06	Not detected
	Mar. 18 – Apr. 8	1.36E-06	1.33E-06	4.40E-06	Not detected
	Apr. 8 – Apr. 27	1.31E-06	1.49E-06	4.92E-06	Not detected
	Apr. 27 – May 15	-5.81E-07	1.60E-06	5.31E-06	Not detected
	May 15 – Jun. 3	-7.17E-07	1.53E-06	5.09E-06	Not detected
	Jun. 3 – Jun. 17	5.55E-08	8.37E-07	2.78E-06	Not detected
	Jun. 17 – Jul. 8	-4.28E-07	1.34E-06	4.47E-06	Not detected
	Jul. 8 – Jul. 29	-1.07E-07	7.21E-07	2.39E-06	Not detected
	Jul. 29 – Aug. 7	-6.16E-08	1.66E-06	5.50E-06	Not detected

Table 3-27: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Aug. 7 – Aug. 14	4.23E-07	1.83E-06	6.07E-06	Not detected
	Aug. 14 – Aug. 28	-1.21E-07	2.14E-06	7.11E-06	Not detected
	Aug. 28 – Sep. 11	-2.24E-07	1.10E-06	3.64E-06	Not detected
	Sep. 11 – Sep. 25	1.51E-06	2.07E-06	6.88E-06	Not detected
	Sep. 25 – Oct. 16	3.03E-07	1.38E-06	4.58E-06	Not detected
	Oct. 16 – Nov. 2	1.15E-06	8.60E-07	2.83E-06	Not detected
	Nov. 2 – Nov. 23	4.50E-07	1.49E-06	4.94E-06	Not detected
	Nov. 23 – Dec. 11	5.73E-07	8.29E-07	2.74E-06	Not detected
	Dec. 11 – Dec. 23	1.32E-06	9.73E-07	3.21E-06	Not detected
	Dec. 23 – Jan. 8	3.03E-07	1.77E-06	5.88E-06	Not detected
^{60}Co	Jan. 6 – Jan. 22	-4.41E-07	1.67E-06	5.57E-06	Not detected
	Jan. 22 – Feb. 11	-9.71E-07	1.37E-06	4.61E-06	Not detected
	Feb. 11 – Mar. 18	-4.72E-08	7.83E-07	2.61E-06	Not detected
	Mar. 18 – Apr. 8	-2.88E-06	1.36E-06	4.60E-06	Not detected
	Apr. 8 – Apr. 27	1.23E-06	1.40E-06	4.64E-06	Not detected
	Apr. 27 – May 15	-8.58E-07	1.50E-06	5.04E-06	Not detected
	May 15 – Jun. 3	-1.65E-06	1.48E-06	4.98E-06	Not detected
	Jun. 3 – Jun. 17	6.12E-07	8.55E-07	2.83E-06	Not detected
	Jun. 17 – Jul. 8	-9.01E-08	1.29E-06	4.30E-06	Not detected
	Jul. 8 – Jul. 29	3.32E-07	5.81E-07	1.92E-06	Not detected
	Jul. 29 – Aug. 7	-2.86E-06	1.40E-06	4.71E-06	Not detected
	Aug. 7 – Aug. 14	-7.30E-07	1.86E-06	6.20E-06	Not detected
	Aug. 14 – Aug. 28	-1.44E-06	2.08E-06	6.97E-06	Not detected
	Aug. 28 – Sep. 11	-4.33E-07	8.98E-07	3.00E-06	Not detected
	Sep. 11 – Sep. 25	-5.57E-07	1.93E-06	6.44E-06	Not detected
	Sep. 25 – Oct. 16	-6.01E-07	1.33E-06	4.46E-06	Not detected
	Oct. 16 – Nov. 2	-5.74E-07	7.32E-07	2.45E-06	Not detected
	Nov. 2 – Nov. 23	-1.59E-07	1.42E-06	4.75E-06	Not detected
	Nov. 23 – Dec. 11	-1.19E-06	7.03E-07	2.36E-06	Not detected
	Dec. 11 – Dec. 23	1.80E-07	1.00E-06	3.34E-06	Not detected
	Dec. 23 – Jan. 8	4.59E-07	1.64E-06	5.43E-06	Not detected
^{40}K	Jan. 6 – Jan. 22	5.78E-05	1.66E-05	5.32E-05	Detected
	Jan. 22 – Feb. 11	2.26E-05	1.38E-05	4.54E-05	Not detected
	Feb. 11 – Mar. 18	2.18E-05	7.79E-06	2.52E-05	Not detected
	Mar. 18 – Apr. 8	1.97E-05	1.33E-05	4.37E-05	Not detected
	Apr. 8 – Apr. 27	1.33E-05	1.54E-05	5.10E-05	Not detected

Table 3-27: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Apr. 27 – May 15	3.28E-05	1.58E-05	5.18E-05	Not detected
	May 15 – Jun. 3	1.98E-05	1.53E-05	5.04E-05	Not detected
	Jun. 3 – Jun. 17	4.52E-05	1.03E-05	3.31E-05	Detected
	Jun. 17 – Jul. 8	5.10E-05	1.28E-05	4.07E-05	Detected
	Jul. 8 – Jul. 29	3.51E-05	7.51E-06	2.34E-05	Detected
	Jul. 29 – Aug. 7	6.37E-05	1.73E-05	5.49E-05	Detected
	Aug. 7 – Aug. 14	6.89E-05	2.30E-05	7.50E-05	Not detected
	Aug. 14 – Aug. 28	5.23E-05	2.01E-05	6.51E-05	Not detected
	Aug. 28 – Sep. 11	4.48E-05	1.12E-05	3.55E-05	Detected
	Sep. 11 – Sep. 25	4.64E-05	1.89E-05	6.16E-05	Not detected
	Sep. 25 – Oct. 16	2.99E-05	1.32E-05	4.30E-05	Not detected
	Oct. 16 – Nov. 2	3.05E-05	8.93E-06	2.85E-05	Detected
	Nov. 2 – Nov. 23	2.02E-05	1.49E-05	4.75E-06	Detected
	Nov. 23 – Dec. 11	4.09E-05	8.60E-06	2.67E-05	Detected
	Dec. 11 – Dec. 23	3.21E-05	1.23E-05	4.01E-05	Not detected
	Dec. 23 – Jan. 8	3.29E-05	1.66E-05	5.42E-05	Not detected

Table 3-28: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Onsite station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 6 – Jan. 22	1.53E-02	3.37E-02	1.12E-01	Not detected
	Jan. 22 – Feb. 11	-1.85E-02	2.91E-02	9.69E-02	Not detected
	Feb. 11 – Mar. 18	1.81E-02	1.55E-02	5.11E-02	Not detected
	Mar. 18 – Apr. 8	-1.73E-02	1.49E-02	4.97E-02	Not detected
	Apr. 8 – Apr. 27	-3.17E-06	1.47E-02	4.88E-02	Not detected
	Apr. 27 – May 15	1.20E-02	1.68E-02	5.55E-02	Not detected
	May 15 – Jun. 3	1.03E-02	1.75E-02	5.86E-02	Not detected
	Jun. 3 – Jun. 17	6.43E-03	1.94E-02	6.43E-02	Not detected
	Jun. 17 – Jul. 8	1.04E-02	1.38E-02	4.56E-02	Not detected
	Jul. 8 – Jul. 29	-1.36E-02	1.98E-02	6.57E-02	Not detected
	Jul. 29 – Aug. 7	-1.00E-01	6.24E-02	2.08E-01	Not detected
	Aug. 7 – Aug. 14	3.80E-02	5.03E-02	1.66E-01	Not detected
	Aug. 14 – Aug. 28	6.50E-02	4.74E-02	1.56E-01	Not detected
	Aug. 28 – Sep. 11	5.30E-02	2.94E-02	9.63E-02	Not detected
	Sep. 11 – Sep. 25	-1.27E-02	3.23E-02	1.07E-01	Not detected
	Sep. 25 – Oct. 16	-8.58E-03	1.78E-02	5.93E-02	Not detected

Table 3-28: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Oct. 16 – Nov. 2	1.38E-02	3.30E-02	1.09E-01	Not detected
	Nov. 2 – Nov. 23	1.01E-02	1.92E-02	6.36E-02	Not detected
	Nov. 23 – Dec. 11	4.44E-04	5.13E-02	1.70E-01	Not detected
	Dec. 11 – Dec. 23	7.25E-02	4.08E-02	1.34E-01	Not detected
	Dec. 23 – Jan. 8	-4.67E-02	5.71E-02	1.90E-01	Not detected
^{60}Co	Jan. 6 – Jan. 22	4.61E-03	3.46E-02	1.15E-01	Not detected
	Jan. 22 – Feb. 11	-1.45E-02	2.98E-02	9.95E-02	Not detected
	Feb. 11 – Mar. 18	-2.70E-02	1.61E-02	5.42E-02	Not detected
	Mar. 18 – Apr. 8	-1.66E-02	1.53E-02	5.12E-02	Not detected
	Apr. 8 – Apr. 27	-2.30E-02	1.52E-02	5.12E-02	Not detected
	Apr. 27 – May 15	-1.24E-02	1.73E-02	5.79E-02	Not detected
	May 15 – Jun. 3	-2.42E-03	1.77E-02	5.89E-02	Not detected
	Jun. 3 – Jun. 17	-1.58E-02	2.01E-02	6.73E-02	Not detected
	Jun. 17 – Jul. 8	7.18E-03	1.40E-02	4.63E-02	Not detected
	Jul. 8 – Jul. 29	-1.14E-02	1.62E-02	5.43E-02	Not detected
	Jul. 29 – Aug. 7	-1.41E-02	5.80E-02	1.94E-01	Not detected
	Aug. 7 – Aug. 14	-1.94E-02	4.14E-02	1.38E-01	Not detected
	Aug. 14 – Aug. 28	-4.16E-02	4.76E-02	1.62E-01	Not detected
	Aug. 28 – Sep. 11	-2.10E-02	2.46E-02	8.22E-02	Not detected
	Sep. 11 – Sep. 25	-4.50E-02	3.28E-02	1.11E-01	Not detected
	Sep. 25 – Oct. 16	-1.85E-02	1.83E-02	6.13E-02	Not detected
	Oct. 16 – Nov. 2	-4.47E-02	3.46E-02	1.16E-01	Not detected
	Nov. 2 – Nov. 23	-2.77E-02	2.01E-02	6.76E-02	Not detected
	Nov. 23 – Dec. 11	-3.16E-02	4.26E-02	1.42E-01	Not detected
	Dec. 11 – Dec. 23	-1.90E-02	3.41E-02	1.14E-01	Not detected
	Dec. 23 – Jan. 8	-8.98E-02	5.82E-02	1.96E-01	Not detected
^{40}K	Jan. 6 – Jan. 22	1.37E+00	4.32E-01	1.40E+00	not detected
	Jan. 22 – Feb. 11	1.42E+00	3.65E-02	1.18E+00	Detected
	Feb. 11 – Mar. 18	8.62E-01	1.94E-01	6.26E-01	Detected
	Mar. 18 – Apr. 8	1.23E+00	1.85E-01	5.83E-01	Detected
	Apr. 8 – Apr. 27	1.03E+00	1.81E-01	5.76E-01	Detected
	Apr. 27 – May 15	1.01E+00	2.09E-01	6.70E-01	Detected
	May 15 – Jun. 3	1.13E+00	2.11E-01	6.74E-01	Detected
	Jun. 3 – Jun. 17	1.02E+00	2.35E-01	7.57E-01	Detected
	Jun. 17 – Jul. 8	8.50E-01	1.72E-01	5.50E-01	Detected

Table 3-28: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Onsite station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Jul. 8 – Jul. 29	6.91E-01	2.07E-01	6.62E-01	Detected
	Jul. 29 – Aug. 7	1.34E+00	5.92E-01	1.93E+00	Not detected
	Aug. 7 – Aug. 14	1.72E+00	5.15E-01	1.64E+00	Detected
	Aug. 14 – Aug. 28	1.12E+00	4.67E-01	1.52E+00	Not detected
	Aug. 28 – Sep. 11	9.24E-01	3.07E-01	9.85E-01	Not detected
	Sep. 11 – Sep. 25	1.26E+00	3.98E-01	1.29E+00	Not detected
	Sep. 25 – Oct. 16	7.21E-01	2.22E-01	7.21E-01	Detected
	Oct. 16 – Nov. 2	1.75E+00	4.04E-01	1.30E+00	Detected
	Nov. 2 – Nov. 23	9.63E-01	2.41E-01	7.77E-01	Detected
	Nov. 23 – Dec. 11	1.78E+00	5.22E-01	1.67E+00	Detected
	Dec. 11 – Dec. 23	1.36E+00	4.23E-01	1.36E+00	Not detected
	Dec. 23 – Jan. 8	2.46E+00	7.03E-01	2.28E+00	Detected

Table 3-29: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 6 – Jan. 22	-5.63E-02	3.72E-02	1.24E-01	Not detected
	Jan. 22 – Feb. 11	-1.74E-03	3.19E-02	1.06E-01	Not detected
	Feb. 11 – Mar. 18	1.08E-02	1.87E-02	6.19E-02	Not detected
	Mar. 18 – Apr. 8	-2.47E-02	1.53E-02	5.15E-02	Not detected
	Apr. 8 – Apr. 27	1.64E-02	2.15E-02	7.10E-02	Not detected
	Apr. 27 – May 15	2.25E-02	2.37E-02	7.82E-02	Not detected
	May 15 – Jun. 3	2.28E-02	2.66E-02	8.79E-02	Not detected
	Jun. 3 – Jun. 17	1.36E-02	3.20E-02	1.06E-01	Not detected
	Jun. 17 – Jul. 8	-1.06E-02	1.97E-02	6.56E-02	Not detected
	Jul. 8 – Jul. 29	5.69E-02	4.15E-02	1.37E-01	Not detected
	Jul. 29 – Aug. 7	1.60E-02	3.28E-02	1.08E-01	Not detected
	Aug. 7 – Aug. 14	5.16E-02	1.01E-01	3.34E-01	Not detected
	Aug. 14 – Aug. 28	2.82E-02	2.33E-02	7.70E-02	Not detected
	Aug. 28 – Sep. 11	2.63E-02	5.86E-02	1.94E-01	Not detected
	Sep. 11 – Sep. 25	-9.29E-02	5.48E-02	1.82E-01	Not detected
	Sep. 25 – Oct. 16	-1.15E-04	3.77E-02	1.25E-01	Not detected
	Oct. 16 – Nov. 2	-7.74E-02	4.28E-02	1.43E-01	Not detected
	Nov. 2 – Nov. 23	-3.68E-02	3.21E-02	1.07E-01	Not detected
	Nov. 23 – Dec. 11	3.15E-02	1.15E-01	3.80E-01	Not detected
	Dec. 11 – Dec. 23	-5.02E-02	9.78E-02	3.25E-01	Not detected
	Dec. 23 – Jan. 8	2.75E-02	5.69E-02	1.88E-01	Not detected

Table 3-29: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{60}Co	Jan. 6 – Jan. 22	-1.72E-02	2.97E-02	9.93E-02	Not detected
	Jan. 22 – Feb. 11	-1.54E-03	2.64E-02	8.79E-02	Not detected
	Feb. 11 – Mar. 18	1.16E-02	1.52E-02	5.03E-02	Not detected
	Mar. 18 – Apr. 8	-2.47E-02	1.53E-02	5.15E-02	Not detected
	Apr. 8 – Apr. 27	1.22E-02	1.77E-02	5.86E-02	Not detected
	Apr. 27 – May 15	8.26E-03	1.96E-02	6.50E-02	Not detected
	May 15 – Jun. 3	-2.30E-03	2.22E-02	7.40E-02	Not detected
	Jun. 3 – Jun. 17	-3.02E-02	2.68E-02	8.99E-02	Not detected
	Jun. 17 – Jul. 8	8.47E-03	1.59E-02	5.28E-02	Not detected
	Jul. 8 – Jul. 29	4.68E-02	3.82E-02	1.26E-01	Not detected
	Jul. 29 – Aug. 7	-1.30E-03	3.31E-02	1.10E-01	Not detected
	Aug. 7 – Aug. 14	-8.65E-02	9.50E-02	3.19E-01	Not detected
	Aug. 14 – Aug. 28	-1.92E-02	2.41E-02	8.07E-02	Not detected
	Aug. 28 – Sep. 11	-6.69E-02	5.75E-02	1.93E-01	Not detected
	Sep. 11 – Sep. 25	-1.48E-02	4.47E-02	1.49E-01	Not detected
	Sep. 25 – Oct. 16	1.41E-02	3.13E-02	1.04E-01	Not detected
	Oct. 16 – Nov. 2	-9.59E-02	3.58E-02	1.21E-01	Not detected
	Nov. 2 – Nov. 23	1.08E-02	2.59E-02	8.58E-02	Not detected
	Nov. 23 – Dec. 11	-1.05E-01	1.13E-01	3.80E-01	Not detected
	Dec. 11 – Dec. 23	-3.33E-02	9.19E-02	3.07E-01	Not detected
	Dec. 23 – Jan. 8	-4.19E-03	4.69E-02	1.56E-01	Not detected
^{40}K	Jan. 6 – Jan. 22	1.71E+00	3.81E-01	1.19E+00	Detected
	Jan. 22 – Feb. 11	1.09E+00	3.40E-01	1.09E+00	Detected
	Feb. 11 – Mar. 18	1.04E+00	2.01E-01	6.17E-01	Detected
	Mar. 18 – Apr. 8	7.77E-01	1.97E-01	6.25E-01	Detected
	Apr. 8 – Apr. 27	8.32E-01	2.31E-01	7.35E-01	Detected
	Apr. 27 – May 15	1.10E+00	2.53E-01	7.92E-01	Detected
	May 15 – Jun. 3	7.66E-01	2.85E-01	9.21E-01	Not detected
	Jun. 3 – Jun. 17	8.56E-01	3.36E-01	1.09E+00	Not detected
	Jun. 17 – Jul. 8	1.07E+00	2.04E-01	6.26E-01	Detected
	Jul. 8 – Jul. 29	1.21E+00	4.11E-01	1.33E+00	Not detected
	Jul. 29 – Aug. 7	1.36E+00	4.04E-01	1.31E+00	Detected
	Aug. 7 – Aug. 14	2.54E+00	9.83E-01	3.19E+00	Not detected
	Aug. 14 – Aug. 28	8.62E-01	2.94E-01	9.58E-01	Not detected
	Aug. 28 – Sep. 11	1.68E+00	5.45E-01	1.76E+00	Not detected
	Sep. 11 – Sep. 25	1.68E+00	4.60E-01	1.46E+00	Detected

Table 3-29: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Near Field station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{40}K	Sep. 25 – Oct. 16	1.46E+00	3.90E-01	1.24E+00	Detected
	Oct. 16 – Nov. 2	1.81E+00	4.34E-01	1.36E+00	Detected
	Nov. 2 – Nov. 23	1.77E+00	3.22E-01	9.79E-01	Detected
	Nov. 23 – Dec. 11	2.62E+00	1.08E+00	3.51E+00	Not detected
	Dec. 11 – Dec. 23	1.69E+00	9.46E-01	3.10E+00	Not detected
	Dec. 23 – Jan. 8	1.25E+00	6.00E-01	1.96E+00	Not detected

Table 3-30: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Cactus Flats station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Jan. 6 – Jan. 22	1.40E-02	7.32E-02	2.43E-01	Not detected
	Jan. 22 – Feb. 11	-5.27E-02	6.62E-02	2.21E-01	Not detected
	Feb. 11 – Mar. 18	1.04E-02	4.59E-02	1.52E-01	Not detected
	Mar. 18 – Apr. 8	3.83E-02	3.76E-02	1.24E-01	Not detected
	Apr. 8 – Apr. 27	4.22E-02	4.81E-02	1.59E-01	Not detected
	Apr. 27 – May 15	-2.02E-02	5.56E-02	1.85E-01	Not detected
	May 15 – Jun. 3	-2.76E-02	5.89E-02	1.96E-01	Not detected
	Jun. 3 – Jun. 17	1.93E-03	2.91E-02	9.65E-02	Not detected
	Jun. 17 – Jul. 8	-1.25E-02	3.93E-02	1.31E-01	Not detected
	Jul. 8 – Jul. 29	-2.84E-03	1.92E-02	6.37E-02	Not detected
	Jul. 29 – Aug. 7	-1.52E-03	4.09E-02	1.36E-01	Not detected
	Aug. 7 – Aug. 14	1.05E-02	4.54E-02	1.50E-01	Not detected
	Aug. 14 – Aug. 28	-3.38E-03	5.99E-02	1.99E-01	Not detected
	Aug. 28 – Sep. 11	-5.62E-03	2.76E-02	9.15E-02	Not detected
	Sep. 11 – Sep. 25	5.07E-02	6.95E-02	2.32E-01	Not detected
	Sep. 25 – Oct. 16	8.34E-03	3.80E-02	1.26E-01	Not detected
	Oct. 16 – Nov. 2	4.83E-02	3.63E-02	1.19E-01	Not detected
	Nov. 2 – Nov. 23	1.38E-02	4.57E-02	1.51E-01	Not detected
	Nov. 23 – Dec. 11	3.24E-02	4.68E-02	1.55E-01	Not detected
	Dec. 11 – Dec. 23	4.56E-02	3.37E-02	1.11E-01	Not detected
	Dec. 23 – Jan. 8	2.45E-02	1.43E-01	4.74E-01	Not detected
^{60}Co	Jan. 6 – Jan. 22	-1.81E-02	6.85E-02	2.29E-01	Not detected
	Jan. 22 – Feb. 11	-4.52E-02	6.40E-02	2.15E-01	Not detected
	Feb. 11 – Mar. 18	-2.65E-03	4.40E-02	1.47E-01	Not detected
	Mar. 18 – Apr. 8	-8.13E-02	3.83E-02	1.30E-01	Not detected

Table 3-30: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Cactus Flats station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{60}Co	Apr. 8 – Apr. 27	3.98E-02	4.52E-02	1.50E-01	Not detected
	Apr. 27 – May 15	-2.99E-02	5.24E-02	1.75E-01	Not detected
	May 15 – Jun. 3	-6.36E-02	5.70E-02	1.92E-01	Not detected
	Jun. 3 – Jun. 17	2.13E-02	2.97E-02	9.83E-02	Not detected
	Jun. 17 – Jul. 8	-2.64E-03	3.77E-02	1.26E-01	Not detected
	Jul. 8 – Jul. 29	8.85E-03	1.55E-02	5.13E-02	Not detected
	Jul. 29 – Aug. 7	-7.06E-02	3.45E-02	1.16E-01	Not detected
	Aug. 7 – Aug. 14	-1.81E-02	4.60E-02	1.54E-01	Not detected
	Aug. 14 – Aug. 28	-4.02E-02	5.81E-02	1.95E-01	Not detected
	Aug. 28 – Sep. 11	-1.09E-02	2.26E-02	7.54E-02	Not detected
	Sep. 11 – Sep. 25	-1.88E-02	6.49E-02	2.17E-01	Not detected
	Sep. 25 – Oct. 16	-1.66E-02	3.67E-02	1.23E-01	Not detected
	Oct. 16 – Nov. 2	-2.42E-02	3.09E-02	1.03E-01	Not detected
	Nov. 2 – Nov. 23	-4.86E-03	4.36E-02	1.46E-01	Not detected
	Nov. 23 – Dec. 11	-6.70E-02	3.98E-02	1.34E-01	Not detected
	Dec. 11 – Dec. 23	6.22E-03	3.48E-02	1.16E-01	Not detected
	Dec. 23 – Jan. 8	3.70E-02	1.32E-01	4.38E-01	Not detected
^{40}K	Jan. 6 – Jan. 22	2.38E+00	6.82E-01	2.19E+00	Detected
	Jan. 22 – Feb. 11	1.05E+00	6.43E-01	2.11E+00	Not detected
	Feb. 11 – Mar. 18	1.23E+00	4.38E-01	1.42E+00	Not detected
	Mar. 18 – Apr. 8	5.55E-01	3.75E-01	1.23E+00	Not detected
	Apr. 8 – Apr. 27	4.31E-01	4.96E-01	1.64E+00	Not detected
	Apr. 27 – May 15	1.14E+00	5.52E-01	1.80E+00	Not detected
	May 15 – Jun. 3	7.64E-01	5.89E-01	1.94E+00	Not detected
	Jun. 3 – Jun. 17	1.57E+00	3.57E-01	1.15E+00	Detected
	Jun. 17 – Jul. 8	1.49E+00	3.74E-01	1.19E+00	Detected
	Jul. 8 – Jul. 29	9.34E-01	2.00E-01	6.22E-01	Detected
	Jul. 29 – Aug. 7	1.57E+00	4.26E-01	1.35E+00	Detected
	Aug. 7 – Aug. 14	1.71E+00	5.71E-01	1.86E+00	Not detected
	Aug. 14 – Aug. 28	1.46E+00	5.61E-01	1.82E+00	Not detected
	Aug. 28 – Sep. 11	1.13E+00	2.83E-01	8.93E-01	Detected
	Sep. 11 – Sep. 25	1.56E+00	6.38E-01	2.07E+00	Not detected
	Sep. 25 – Oct. 16	8.24E-01	3.64E-01	1.19E+00	Not detected
	Oct. 16 – Nov. 2	1.28E+00	3.76E-01	1.20E+00	Detected
	Nov. 2 – Nov. 23	6.17E-01	4.56E-01	1.46E-01	Detected
	Nov. 23 – Dec. 11	2.31E+00	4.86E-01	1.51E+00	Detected
	Dec. 11 – Dec. 23	1.11E+00	4.25E-01	1.39E+00	Not detected
	Dec. 23 – Jan. 8	2.65E+00	1.34E+00	4.37E+00	Not detected

Table 3-31: Activity concentrations of ^{241}Am, $^{239+240}Pu$ and ^{238}Pu in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	May 15 – Jun. 3	1.02E-08	5.99E-09	8.10E-09	Detected
	Jun. 3 – Jun. 17	8.15E-09	1.00E-08	2.17E-08	Not detected
	Jun. 17 – Jul. 8	5.21E-09	6.02E-09	1.23E-08	Not detected
	Jul. 8 – Jul. 29	8.09E-09	6.53E-09	1.14E-08	Not detected
	Jul. 29 – Aug. 7	3.14E-08	1.87E-08	3.03E-08	Detected
	Aug. 7 – Aug. 14	2.51E-08	2.08E-08	4.09E-08	Not detected
	Aug. 14 – Aug. 28	2.63E-08	1.38E-08	2.21E-08	Detected
	Aug. 28 – Sep. 11	1.44E-08	8.38E-09	9.60E-09	Detected
	Sep. 11 – Sep. 25	1.39E-08	9.91E-09	1.69E-08	Not detected
	Sep. 25 – Oct. 16	6.40E-09	8.22E-09	1.82E-08	Not detected
	Oct. 16 – Nov. 2	1.47E-08	7.70E-09	8.06E-09	Detected
	Nov. 2 – Nov. 23	1.14E-08	1.62E-08	3.43E-08	Not detected
	Nov. 23 – Dec. 11	4.15E-09	5.52E-09	1.17E-08	Not detected
	Dec. 11 – Dec. 23	1.20E-08	1.53E-08	3.34E-08	Not detected
	Dec. 23 – Jan. 8	1.13E-08	9.88E-09	1.70E-08	Not detected
$^{239+240}Pu$	May 15 – Jun. 3	3.20E-10	1.95E-10	2.29E-10	Detected
	Jun. 3 – Jun. 17	2.29E-10	2.54E-10	5.20E-10	Not detected
	Jun. 17 – Jul. 8	3.68E-11	2.45E-10	6.41E-10	Not detected
	Jul. 8 – Jul. 29	2.37E-10	2.75E-10	5.58E-10	Not detected
	Jul. 29 – Aug. 7	0.00E+00	3.02E-10	8.71E-10	Not detected
	Aug. 7 – Aug. 14	2.79E-10	5.59E-10	1.31E-09	Not detected
	Aug. 14 – Aug. 28	5.15E-10	4.41E-10	8.17E-10	Not detected
	Aug. 28 – Sep. 11	4.18E-10	2.82E-10	4.52E-10	Not detected
	Sep. 11 – Sep. 25	0.00E+00	2.48E-10	6.73E-10	Not detected
	Sep. 25 – Oct. 16	1.07E-10	1.52E-10	3.21E-10	Not detected
	Oct. 16 – Nov. 2	5.68E-11	1.39E-10	3.42E-10	Not detected
	Nov. 2 – Nov. 23	3.62E-10	2.13E-10	2.89E-10	Detected
	Nov. 23 – Dec. 11	1.39E-10	1.47E-10	2.78E-10	Not detected
	Dec. 11 – Dec. 23	3.15E-10	4.70E-10	9.72E-10	Not detected
	Dec. 23 – Jan. 8	1.01E-09	1.44E-09	3.05E-09	Not detected
^{238}Pu	May 15 – Jun. 3	0.00E+00	3.49E-09	1.05E-08	Not detected
	Jun. 3 – Jun. 17	0.00E+00	6.54E-09	1.84E-08	Not detected
	Jun. 17 – Jul. 8	-6.20E-16	5.20E-09	1.56E-08	Not detected
	Jul. 8 – Jul. 29	-1.40E-09	4.84E-09	1.67E-08	Not detected
	Jul. 29 – Aug. 7	-1.09E-08	1.57E-08	4.89E-08	Not detected
	Aug. 7 – Aug. 14	-6.57E-09	1.61E-08	5.21E-08	Not detected

Table 3-31: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Loving station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{238}Pu	Aug. 14 – Aug. 28	-9.09E-09	1.09E-08	3.65E-08	Not detected
	Aug. 28 – Sep. 11	-1.13E-08	7.95E-09	2.78E-08	Not detected
	Sep. 11 – Sep. 25	0.00E+00	8.75E-09	2.38E-08	Not detected
	Sep. 25 – Oct. 16	-6.59E-09	7.78E-09	2.40E-08	Not detected
	Oct. 16 – Nov. 2	-5.01E-09	8.78E-09	2.56E-08	Not detected
	Nov. 2 – Nov. 23	-2.56E-09	7.82E-09	2.17E-08	Not detected
	Nov. 23 – Dec. 11	-7.34E-09	6.38E-09	2.08E-08	Not detected
	Dec. 11 – Dec. 23	-1.11E-08	2.87E-08	8.31E-08	Not detected
	Dec. 23 – Jan. 8	-8.95E-09	8.59E-08	2.29E-07	Not detected

Table 3-32: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{241}Am	May 15 – Jun. 3	9.64E-09	7.19E-09	1.30E-08	Not detected
	Jun. 3 – Jun. 17	6.37E-09	9.99E-09	2.26E-08	Not detected
	Jun. 17 – Jul. 8	8.19E-09	1.16E-08	2.56E-08	Not detected
	Jul. 8 – Jul. 29	5.94E-09	5.50E-09	1.05E-08	Not detected
	Jul. 29 – Aug. 7	1.29E-08	1.45E-08	3.03E-08	Not detected
	Aug. 7 – Aug. 14	2.08E-08	1.47E-08	1.94E-08	Detected
	Aug. 14 – Aug. 28	1.28E-08	1.46E-08	3.14E-08	Not detected
	Aug. 28 – Sep. 11	2.32E-08	1.38E-08	2.04E-08	Detected
	Sep. 11 – Sep. 25	8.48E-09	9.49E-09	1.99E-08	Not detected
	Sep. 25 – Oct. 16	5.35E-09	7.01E-09	1.54E-08	Not detected
	Oct. 16 – Nov. 2	2.00E-08	9.19E-09	1.13E-08	Detected
	Nov. 2 – Nov. 23	1.00E-08	7.52E-09	1.42E-08	Not detected
	Nov. 23 – Dec. 11	2.51E-09	8.02E-09	1.96E-08	Not detected
	Dec. 11 – Dec. 23	7.88E-09	1.23E-08	2.74E-08	Not detected
	Dec. 23 – Jan. 8	1.13E-08	1.04E-08	2.07E-08	Not detected
$^{239+240}$Pu	May 15 – Jun. 3	6.24E-09	6.94E-09	1.41E-08	Not detected
	Jun. 3 – Jun. 17	6.48E-09	8.11E-09	1.71E-08	Not detected
	Jun. 17 – Jul. 8	2.16E-09	3.75E-09	7.95E-09	Not detected
	Jul. 8 – Jul. 29	7.82E-09	7.24E-09	1.38E-08	Not detected
	Jul. 29 – Aug. 7	2.24E-08	1.69E-08	2.68E-08	Not detected
	Aug. 7 – Aug. 14	1.47E-08	1.39E-08	2.27E-08	Not detected
	Aug. 14 – Aug. 28	1.21E-08	1.35E-08	2.74E-08	Not detected

Table 3-32: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
$^{239+240}$Pu	Aug. 28 – Sep. 11	1.63E-08	9.55E-09	1.08E-08	Detected
	Sep. 11 – Sep. 25	2.55E-09	8.87E-09	2.22E-08	Not detected
	Sep. 25 – Oct. 16	1.38E-08	8.72E-09	1.07E-08	Detected
	Oct. 16 – Nov. 2	4.79E-09	5.10E-09	8.90E-09	Not detected
	Nov. 2 – Nov. 23	1.11E-08	6.99E-09	8.57E-09	Detected
	Nov. 23 – Dec. 11	1.64E-09	5.68E-09	1.54E-08	Not detected
	Dec. 11 – Dec. 23	-2.16E-09	1.30E-08	3.76E-08	Not detected
	Dec. 23 – Jan. 8	2.93E-09	1.01E-08	2.73E-08	Not detected
^{238}Pu	May 15 – Jun. 3	-3.57E-09	5.06E-09	1.68E-08	Not detected
	Jun. 3 – Jun. 17	-1.08E-09	5.72E-09	1.71E-08	Not detected
	Jun. 17 – Jul. 8	1.06E-09	3.06E-09	7.95E-09	Not detected
	Jul. 8 – Jul. 29	2.61E-09	4.62E-09	1.05E-08	Detected
	Jul. 29 – Aug. 7	-2.24E-09	7.74E-09	2.68E-08	Not detected
	Aug. 7 – Aug. 14	0.00E+00	6.91E-09	2.27E-08	Not detected
	Aug. 14 – Aug. 28	6.92E-09	7.77E-09	1.27E-08	Not detected
	Aug. 28 – Sep. 11	-3.50E-09	7.02E-09	2.20E-08	Not detected
	Sep. 11 – Sep. 25	6.37E-09	9.22E-09	2.02E-08	Not detected
	Sep. 25 – Oct. 16	-4.58E-09	6.48E-09	2.16E-08	Not detected
	Oct. 16 – Nov. 2	2.74E-15	6.64E-09	1.80E-08	Not detected
	Nov. 2 – Nov. 23	4.60E-09	7.63E-09	1.73E-08	Not detected
	Nov. 23 – Dec. 11	1.17E-15	5.68E-09	1.54E-08	Not detected
	Dec. 11 – Dec. 23	4.32E-09	1.73E-08	4.34E-08	Not detected
	Dec. 23 – Jan. 8	5.88E-09	2.20E-08	5.53E-08	Not detected

Table 3-33: Activity density of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	May 15 – Jun. 3	4.13E-04	3.08E-04	5.56E-04	Detected
	Jun. 3 – Jun. 17	2.01E-04	3.14E-04	7.12E-04	Not detected
	Jun. 17 – Jul. 8	2.22E-04	3.14E-04	6.94E-04	Not detected
	Jul. 8 – Jul. 29	2.02E-04	1.87E-04	3.58E-04	Not detected
	Jul. 29 – Aug. 7	3.46E-04	3.90E-04	8.14E-04	Detected
	Aug. 7 – Aug. 14	4.46E-04	3.14E-04	4.15E-04	Not detected
	Aug. 14 – Aug. 28	2.53E-04	2.88E-04	6.20E-04	Detected
	Aug. 28 – Sep. 11	4.79E-04	2.86E-04	4.22E-04	Detected

Table 3-33: Activity density of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Loving station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Sep. 11 – Sep. 25	2.77E-04	3.09E-04	6.50E-04	Not detected
	Sep. 25 – Oct. 16	1.58E-04	2.07E-04	4.54E-04	Not detected
	Oct. 16 – Nov. 2	8.37E-04	3.84E-04	4.71E-04	Detected
	Nov. 2 – Nov. 23	3.76E-04	2.82E-04	5.34E-04	Not detected
	Nov. 23 – Dec. 11	1.55E-04	4.97E-04	1.21E-03	Not detected
	Dec. 11 – Dec. 23	3.38E-04	5.27E-04	1.18E-03	Not detected
	Dec. 23 – Jan. 8	8.47E-04	7.80E-04	1.55E-03	Not detected
$^{239+240}$Pu	May 15 – Jun. 3	3.79E-04	2.30E-04	2.71E-04	Detected
	Jun. 3 – Jun. 17	2.32E-04	2.57E-04	5.26E-04	Not detected
	Jun. 17 – Jul. 8	2.91E-05	1.93E-04	5.07E-04	Not detected
	Jul. 8 – Jul. 29	1.74E-04	2.02E-04	4.10E-04	Not detected
	Jul. 29 – Aug. 7	0.00E+00	2.10E-04	6.05E-04	Not detected
	Aug. 7 – Aug. 14	1.76E-04	3.52E-04	8.29E-04	Not detected
	Aug. 14 – Aug. 28	2.80E-04	2.40E-04	4.44E-04	Not detected
	Aug. 28 – Sep. 11	1.57E-04	1.06E-04	1.70E-04	Not detected
	Sep. 11 – Sep. 25	0.00E+00	1.85E-04	5.03E-04	Not detected
	Sep. 25 – Oct. 16	9.22E-05	1.31E-04	2.78E-04	Not detected
	Oct. 16 – Nov. 2	6.64E-05	1.63E-04	4.00E-04	Not detected
	Nov. 2 – Nov. 23	2.71E-04	1.60E-04	2.17E-04	Detected
	Nov. 23 – Dec. 11	2.02E-04	2.14E-04	4.04E-04	Not detected
	Dec. 11 – Dec. 23	2.65E-04	3.95E-04	8.17E-04	Not detected
	Dec. 23 – Jan. 8	1.33E-03	1.89E-03	3.99E-03	Not detected
^{238}Pu	May 15 – Jun. 3	0.00E+00	1.17E-04	3.51E-04	Not detected
	Jun. 3 – Jun. 17	0.00E+00	1.87E-04	5.26E-04	Not detected
	Jun. 17 – Jul. 8	-1.39E-11	1.16E-04	3.49E-04	Not detected
	Jul. 8 – Jul. 29	-2.90E-05	1.01E-04	3.48E-04	Not detected
	Jul. 29 – Aug. 7	-2.14E-04	3.09E-04	9.63E-04	Not detected
	Aug. 7 – Aug. 14	-1.17E-04	2.88E-04	9.30E-04	Not detected
	Aug. 14 – Aug. 28	-1.40E-04	1.68E-04	5.62E-04	Not detected
	Aug. 28 – Sep. 11	-1.21E-04	8.46E-05	2.96E-04	Not detected
	Sep. 11 – Sep. 25	0.00E+00	1.85E-04	5.03E-04	Not detected
	Sep. 25 – Oct. 16	-1.61E-04	1.90E-04	5.87E-04	Not detected
	Oct. 16 – Nov. 2	-1.66E-04	2.90E-04	8.48E-04	Not detected
	Nov. 2 – Nov. 23	-5.42E-05	1.66E-04	4.61E-04	Not detected
	Nov. 23 – Dec. 11	-3.02E-04	2.63E-04	8.59E-04	Not detected
	Dec. 11 – Dec. 23	-2.65E-04	6.82E-04	1.98E-03	Not detected
	Dec. 23 – Jan. 8	-3.32E-04	3.19E-03	8.48E-03	Not detected

Table 3-34: Activity density of ^{241}Am, $^{239+240}$Pu and ^{238}Pu in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	May 15 – Jun. 3	4.13E-04	3.08E-04	5.56E-04	Not detected
	Jun. 3 – Jun. 17	2.01E-04	3.14E-04	7.12E-04	Not detected
	Jun. 17 – Jul. 8	2.22E-04	3.14E-04	6.94E-04	Not detected
	Jul. 8 – Jul. 29	2.02E-04	1.87E-04	3.58E-04	Not detected
	Jul. 29 – Aug. 7	3.46E-04	3.90E-04	8.14E-04	Not detected
	Aug. 7 – Aug. 14	4.46E-04	3.14E-04	4.15E-04	Detected
	Aug. 14 – Aug. 28	2.53E-04	2.88E-04	6.20E-04	Not detected
	Aug. 28 – Sep. 11	4.79E-04	2.86E-04	4.22E-04	Detected
	Sep. 11 – Sep. 25	2.77E-04	3.09E-02	6.50E-03	Not detected
	Sep. 25 – Oct. 16	1.58E-04	2.07E-04	4.54E-04	Not detected
	Oct. 16 – Nov. 2	8.37E-04	3.84E-04	4.71E-04	Detected
	Nov. 2 – Nov. 23	3.76E-04	2.82E-04	5.34E-04	Not detected
	Nov. 23 – Dec. 11	1.55E-04	4.97E-04	1.21E-03	Not detected
	Dec. 11 – Dec. 23	3.38E-04	5.27E-04	1.18E-03	Not detected
	Dec. 23 – Jan. 8	8.47E-04	7.80E-04	1.55E-03	Not detected
$^{239+240}$Pu	May 15 – Jun. 3	2.67E-04	2.97E-04	6.05E-04	Not detected
	Jun. 3 – Jun. 17	2.04E-04	2.55E-04	5.38E-04	Not detected
	Jun. 17 – Jul. 8	5.85E-05	1.02E-04	2.15E-04	Not detected
	Jul. 8 – Jul. 29	2.66E-04	2.46E-04	4.70E-04	Not detected
	Jul. 29 – Aug. 7	6.00E-04	4.54E-04	7.20E-04	Not detected
	Aug. 7 – Aug. 14	3.14E-04	2.98E-04	4.85E-04	Not detected
	Aug. 14 – Aug. 28	2.39E-04	2.66E-04	5.41E-04	Not detected
	Aug. 28 – Sep. 11	3.37E-04	1.98E-04	2.24E-04	Detected
	Sep. 11 – Sep. 25	8.31E-05	2.89E-04	7.25E-04	Not detected
	Sep. 25 – Oct. 16	4.07E-04	2.57E-04	3.15E-04	Detected
	Oct. 16 – Nov. 2	2.00E-04	2.13E-04	3.72E-04	Not detected
	Nov. 2 – Nov. 23	4.16E-04	2.63E-04	3.22E-04	Detected
	Nov. 23 – Dec. 11	1.01E-04	3.52E-04	9.55E-04	Not detected
	Dec. 11 – Dec. 23	-9.27E-05	5.58E-04	1.61E-03	Not detected
	Dec. 23 – Jan. 8	2.20E-04	7.59E-04	2.04E-03	Not detected
^{238}Pu	May 15 – Jun. 3	-1.53E-04	2.17E-04	7.18E-04	Not detected
	Jun. 3 – Jun. 17	-3.39E-05	1.80E-04	5.38E-04	Not detected
	Jun. 17 – Jul. 8	2.88E-05	8.28E-05	2.15E-04	Not detected
	Jul. 8 – Jul. 29	8.89E-05	1.57E-04	3.56E-04	Detected
	Jul. 29 – Aug. 7	-6.00E-05	2.08E-04	7.20E-04	Not detected
	Aug. 7 – Aug. 14	0.00E+00	1.48E-04	4.85E-04	Not detected

Table 3-34: Activity density of ^{241}Am, $^{239+240}Pu$ and ^{238}Pu in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
	Aug. 14 – Aug. 28	1.36E-04	1.53E-04	2.51E-04	Not detected
	Aug. 28 – Sep. 11	-7.25E-05	1.45E-04	4.54E-04	Not detected
	Sep. 11 – Sep. 25	2.08E-04	3.01E-04	6.59E-04	Not detected
	Sep. 25 – Oct. 16	-1.35E-04	1.91E-04	6.36E-04	Not detected
	Oct. 16 – Nov. 2	1.15E-10	2.77E-04	7.53E-04	Not detected
	Nov. 2 – Nov. 23	1.73E-04	2.87E-04	6.50E-04	Not detected
	Nov. 23 – Dec. 11	7.26E-11	3.52E-04	9.55E-04	Not detected
	Dec. 11 – Dec. 23	1.85E-04	7.43E-04	1.86E-03	Not detected
	Dec. 23 – Jan. 8	4.40E-04	1.65E-03	4.14E-03	Not detected

Table 3-35: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	May 15 – Jun. 3	7.93E-07	1.57E-07	1.60E-08	Detected
	Jun. 3 – Jun. 17	8.21E-07	1.93E-07	2.26E-08	Detected
	Jun. 17 – Jul. 8	1.43E-06	2.42E-07	2.19E-08	Detected
	Jul. 8 – Jul. 29	1.21E-06	2.09E-07	2.04E-08	Detected
	Jul. 29 – Aug. 7	1.89E-06	4.00E-07	5.43E-08	Detected
	Aug. 7 – Aug. 14	2.39E-06	4.64E-07	4.55E-08	Detected
	Aug. 14 – Aug. 28	1.64E-06	2.86E-07	2.40E-08	Detected
	Aug. 28 – Sep. 11	2.65E-06	4.00E-07	2.67E-08	Detected
	Sep. 11 – Sep. 25	1.49E-06	2.72E-07	2.69E-08	Detected
	Sep. 25 – Oct. 16	1.00E-06	1.81E-07	1.14E-08	Detected
	Oct. 16 – Nov. 2	8.37E-07	1.75E-07	2.39E-08	Detected
	Nov. 2 – Nov. 23	1.50E-06	2.52E-07	2.16E-08	Detected
	Nov. 23 – Dec. 11	8.74E-07	1.87E-07	2.67E-08	Detected
	Dec. 11 – Dec. 23	1.44E-06	2.98E-07	3.71E-08	Detected
	Dec. 23 – Jan. 8	1.48E-06	3.30E-07	5.15E-08	Detected
^{235}U	May 15 – Jun. 3	3.60E-08	1.84E-08	9.77E-09	Detected
	Jun. 3 – Jun. 17	1.67E-08	2.15E-08	1.29E-08	Detected
	Jun. 17 – Jul. 8	6.20E-08	2.72E-08	2.46E-08	Detected
	Jul. 8 – Jul. 29	3.16E-08	2.00E-08	1.87E-08	Detected
	Jul. 29 – Aug. 7	1.82E-07	6.89E-08	5.02E-08	Detected
	Aug. 7 – Aug. 14	1.94E-07	6.72E-08	2.36E-08	Detected
	Aug. 14 – Aug. 28	7.42E-08	3.18E-08	2.05E-08	Detected

Table 3-35: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{235}U	Aug. 28 – Sep. 11	1.57E-07	4.52E-08	2.27E-08	Detected
	Sep. 11 – Sep. 25	8.20E-08	3.39E-08	1.40E-08	Detected
	Sep. 25 – Oct. 16	5.39E-08	2.20E-08	1.66E-08	Detected
	Oct. 16 – Nov. 2	2.19E-08	1.99E-08	1.76E-08	Detected
	Nov. 2 – Nov. 23	7.30E-08	3.01E-08	1.39E-08	Detected
	Nov. 23 – Dec. 11	6.03E-08	2.94E-08	2.27E-08	Detected
	Dec. 11 – Dec. 23	4.39E-08	3.71E-08	4.07E-08	Detected
	Dec. 23 – Jan. 8	6.13E-08	4.38E-08	3.13E-08	Detected
^{238}U	May 15 – Jun. 3	6.67E-07	1.43E-07	1.99E-08	Detected
	Jun. 3 – Jun. 17	8.07E-07	1.92E-07	2.86E-08	Detected
	Jun. 17 – Jul. 8	1.26E-06	2.22E-07	4.20E-08	Detected
	Jul. 8 – Jul. 29	1.17E-06	2.06E-07	2.34E-08	Detected
	Jul. 29 – Aug. 7	1.99E-06	4.09E-07	6.12E-08	Detected
	Aug. 7 – Aug. 14	2.32E-06	4.58E-07	6.11E-08	Detected
	Aug. 14 – Aug. 28	1.56E-06	2.77E-07	3.09E-08	Detected
	Aug. 28 – Sep. 11	2.48E-06	3.81E-07	3.43E-08	Detected
	Sep. 11 – Sep. 25	1.48E-06	2.72E-07	3.62E-08	Detected
	Sep. 25 – Oct. 16	9.83E-07	1.80E-07	1.65E-08	Detected
	Oct. 16 – Nov. 2	7.82E-07	1.70E-07	3.62E-08	Detected
	Nov. 2 – Nov. 23	1.40E-06	2.41E-07	3.74E-08	Detected
	Nov. 23 – Dec. 11	8.76E-07	1.88E-07	3.58E-08	Detected
	Dec. 11 – Dec. 23	1.32E-06	2.87E-07	8.74E-08	Detected
	Dec. 23 – Jan. 8	1.31E-06	3.12E-07	8.55E-08	Detected

Table 3-36: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	May 15 – Jun. 3	5.62E-07	1.36E-07	2.68E-08	Detected
	Jun. 3 – Jun. 17	8.10E-07	1.97E-07	1.53E-08	Detected
	Jun. 17 – Jul. 8	1.19E-06	2.06E-07	1.78E-08	Detected
	Jul. 8 – Jul. 29	6.67E-07	1.37E-07	1.89E-08	Detected
	Jul. 29 – Aug. 7	1.40E-06	3.28E-07	3.88E-08	Detected
	Aug. 7 – Aug. 14	2.07E-06	4.53E-07	5.30E-08	Detected
	Aug. 14 – Aug. 28	1.16E-06	2.47E-07	1.71E-08	Detected
	Aug. 28 – Sep. 11	1.66E-06	2.93E-07	1.45E-08	Detected

Table 3-36: Activity concentrations of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{234}U	Sep. 11 – Sep. 25	9.44E-07	2.10E-07	2.87E-08	Detected
	Sep. 25 – Oct. 16	8.51E-07	1.66E-07	1.52E-08	Detected
	Oct. 16 – Nov. 2	6.70E-07	1.63E-07	2.99E-08	Detected
	Nov. 2 – Nov. 23	8.65E-07	1.63E-07	1.35E-08	Detected
	Nov. 23 – Dec. 11	6.06E-07	1.51E-07	2.66E-08	Detected
	Dec. 11 – Dec. 23	9.05E-07	2.22E-07	3.82E-08	Detected
	Dec. 23 – Jan. 8	5.74E-07	1.78E-07	2.70E-08	Detected
^{235}U	May 15 – Jun. 3	4.75E-08	2.28E-08	2.29E-08	Detected
	Jun. 3 – Jun. 17	3.82E-08	2.73E-08	1.50E-08	Detected
	Jun. 17 – Jul. 8	8.62E-08	2.75E-08	1.17E-08	Detected
	Jul. 8 – Jul. 29	2.38E-08	1.60E-08	1.51E-08	Detected
	Jul. 29 – Aug. 7	1.65E-07	6.39E-08	4.79E-08	Detected
	Aug. 7 – Aug. 14	1.04E-07	5.85E-08	4.90E-08	Detected
	Aug. 14 – Aug. 28	5.73E-08	3.38E-08	2.73E-08	Detected
	Aug. 28 – Sep. 11	8.80E-08	3.59E-08	2.32E-08	Detected
	Sep. 11 – Sep. 25	8.34E-08	3.48E-08	2.66E-08	Detected
	Sep. 25 – Oct. 16	3.77E-08	2.10E-08	1.87E-08	Detected
	Oct. 16 – Nov. 2	7.46E-08	3.15E-08	2.20E-08	Detected
	Nov. 2 – Nov. 23	2.90E-08	1.84E-08	1.65E-08	Detected
	Nov. 23 – Dec. 11	2.17E-08	2.08E-08	1.96E-08	Detected
	Dec. 11 – Dec. 23	4.00E-08	3.23E-08	3.95E-08	Detected
	Dec. 23 – Jan. 8	1.88E-08	2.76E-08	3.33E-08	Not detected
^{238}U	May 15 – Jun. 3	5.45E-07	1.34E-07	2.92E-08	Detected
	Jun. 3 – Jun. 17	7.17E-07	1.88E-07	4.35E-08	Detected
	Jun. 17 – Jul. 8	1.17E-06	2.04E-07	3.04E-08	Detected
	Jul. 8 – Jul. 29	6.22E-07	1.33E-07	3.41E-08	Detected
	Jul. 29 – Aug. 7	1.25E-06	3.14E-07	8.17E-08	Detected
	Aug. 7 – Aug. 14	1.97E-06	4.44E-07	7.41E-08	Detected
	Aug. 14 – Aug. 28	1.16E-06	2.48E-07	3.20E-08	Detected
	Aug. 28 – Sep. 11	1.55E-06	2.82E-07	2.72E-08	Detected
	Sep. 11 – Sep. 25	1.10E-06	2.27E-07	4.02E-08	Detected
	Sep. 25 – Oct. 16	9.47E-07	1.77E-07	2.63E-08	Detected
	Oct. 16 – Nov. 2	7.38E-07	1.71E-07	2.58E-08	Detected
	Nov. 2 – Nov. 23	7.39E-07	1.49E-07	2.51E-08	Detected
	Nov. 23 – Dec. 11	6.29E-07	1.55E-07	2.81E-08	Detected
	Dec. 11 – Dec. 23	9.50E-07	2.27E-07	4.77E-08	Detected
	Dec. 23 – Jan. 8	4.15E-07	1.60E-07	4.07E-08	Detected

Table 3-37: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	May 15 – Jun. 3	2.66E-02	5.25E-03	5.36E-04	Detected
	Jun. 3 – Jun. 17	2.35E-02	5.52E-03	6.47E-04	Detected
	Jun. 17 – Jul. 8	3.21E-02	5.41E-03	4.89E-04	Detected
	Jul. 8 – Jul. 29	2.51E-02	4.35E-03	4.24E-04	Detected
	Jul. 29 – Aug. 7	3.72E-02	7.87E-03	1.07E-03	Detected
	Aug. 7 – Aug. 14	4.27E-02	8.29E-03	8.13E-04	Detected
	Aug. 14 – Aug. 28	2.53E-02	4.41E-03	3.70E-04	Detected
	Aug. 28 – Sep. 11	2.82E-02	4.25E-03	2.84E-04	Detected
	Sep. 11 – Sep. 25	3.15E-02	5.75E-03	5.70E-04	Detected
	Sep. 25 – Oct. 16	2.45E-02	4.42E-03	2.79E-04	Detected
	Oct. 16 – Nov. 2	2.77E-02	5.79E-03	7.90E-04	Detected
	Nov. 2 – Nov. 23	3.18E-02	5.34E-03	4.58E-04	Detected
	Nov. 23 – Dec. 11	3.60E-02	7.71E-03	1.10E-03	Detected
	Dec. 11 – Dec. 23	3.42E-02	7.09E-03	8.83E-04	Detected
	Dec. 23 – Jan. 8	5.50E-02	1.22E-02	1.91E-03	Detected
^{235}U	May 15 – Jun. 3	1.21E-03	6.16E-04	3.27E-04	Detected
	Jun. 3 – Jun. 17	4.79E-04	6.15E-04	3.70E-04	Detected
	Jun. 17 – Jul. 8	1.39E-03	6.08E-04	5.49E-04	Detected
	Jul. 8 – Jul. 29	6.57E-04	4.16E-04	3.89E-04	Detected
	Jul. 29 – Aug. 7	3.58E-03	1.35E-03	9.88E-04	Detected
	Aug. 7 – Aug. 14	3.46E-03	1.20E-03	4.22E-04	Detected
	Aug. 14 – Aug. 28	1.14E-03	4.90E-04	3.15E-04	Detected
	Aug. 28 – Sep. 11	1.67E-03	4.81E-04	2.42E-04	Detected
	Sep. 11 – Sep. 25	1.73E-03	7.16E-04	2.97E-04	Detected
	Sep. 25 – Oct. 16	1.32E-03	5.37E-04	4.05E-04	Detected
	Oct. 16 – Nov. 2	7.24E-04	6.60E-04	5.83E-04	Detected
	Nov. 2 – Nov. 23	1.55E-03	6.38E-04	2.95E-04	Detected
	Nov. 23 – Dec. 11	2.49E-03	1.21E-03	9.35E-04	Detected
	Dec. 11 – Dec. 23	1.05E-03	8.83E-04	9.69E-04	Detected
	Dec. 23 – Jan. 8	2.27E-03	1.62E-03	1.16E-03	Detected
^{238}U	May 15 – Jun. 3	2.23E-02	4.80E-03	6.67E-04	Detected
	Jun. 3 – Jun. 17	2.31E-02	5.49E-03	8.19E-04	Detected
	Jun. 17 – Jul. 8	2.81E-02	4.97E-03	9.39E-04	Detected
	Jul. 8 – Jul. 29	2.43E-02	4.27E-03	4.86E-04	Detected
	Jul. 29 – Aug. 7	3.91E-02	8.06E-03	1.20E-03	Detected
	Aug. 7 – Aug. 14	4.15E-02	8.19E-03	1.09E-03	Detected

Table 3-37: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Loving station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{238}U	Aug. 14 – Aug. 28	2.40E-02	4.27E-03	4.75E-04	Detected
	Aug. 28 – Sep. 11	2.64E-02	4.06E-03	3.65E-04	Detected
	Sep. 11 – Sep. 25	3.14E-02	5.75E-03	7.66E-04	Detected
	Sep. 25 – Oct. 16	2.40E-02	4.40E-03	4.03E-04	Detected
	Oct. 16 – Nov. 2	2.59E-02	5.62E-03	1.20E-03	Detected
	Nov. 2 – Nov. 23	2.97E-02	5.11E-03	7.94E-04	Detected
	Nov. 23 – Dec. 11	3.61E-02	7.74E-03	1.47E-03	Detected
	Dec. 11 – Dec. 23	3.14E-02	6.82E-03	2.08E-03	Detected
	Dec. 23 – Jan. 8	4.85E-02	1.16E-02	3.17E-03	Detected

Table 3-38: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	May 15 – Jun. 3	2.40E-02	5.80E-03	1.15E-03	Detected
	Jun. 3 – Jun. 17	2.55E-02	6.21E-03	4.83E-04	Detected
	Jun. 17 – Jul. 8	3.23E-02	5.59E-03	4.83E-04	Detected
	Jul. 8 – Jul. 29	2.27E-02	4.66E-03	6.45E-04	Detected
	Jul. 29 – Aug. 7	3.77E-02	8.82E-03	1.04E-03	Detected
	Aug. 7 – Aug. 14	4.44E-02	9.71E-03	1.14E-03	Detected
	Aug. 14 – Aug. 28	2.29E-02	4.88E-03	3.37E-04	Detected
	Aug. 28 – Sep. 11	3.44E-02	6.06E-03	3.01E-04	Detected
	Sep. 11 – Sep. 25	3.08E-02	6.85E-03	9.37E-04	Detected
	Sep. 25 – Oct. 16	2.51E-02	4.88E-03	4.48E-04	Detected
	Oct. 16 – Nov. 2	2.80E-02	6.81E-03	1.25E-03	Detected
	Nov. 2 – Nov. 23	3.25E-02	6.11E-03	5.05E-04	Detected
	Nov. 23 – Dec. 11	3.75E-02	9.38E-03	1.65E-03	Detected
	Dec. 11 – Dec. 23	3.89E-02	9.54E-03	1.64E-03	Detected
	Dec. 23 – Jan. 8	4.30E-02	1.34E-02	2.02E-03	Detected
^{235}U	May 15 – Jun. 3	2.04E-03	9.77E-04	9.79E-04	Detected
	Jun. 3 – Jun. 17	1.20E-03	8.58E-04	4.72E-04	Detected
	Jun. 17 – Jul. 8	2.33E-03	7.46E-04	3.17E-04	Detected
	Jul. 8 – Jul. 29	8.11E-04	5.45E-04	5.15E-04	Detected
	Jul. 29 – Aug. 7	4.43E-03	1.71E-03	1.29E-03	Detected
	Aug. 7 – Aug. 14	2.23E-03	1.25E-03	1.05E-03	Detected
	Aug. 14 – Aug. 28	1.13E-03	6.67E-04	5.39E-04	Detected

Table 3-38: Activity density of uranium isotopes (^{234}U, ^{235}U and ^{238}U) in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{235}U	Aug. 28 – Sep. 11	1.82E-03	7.42E-04	4.79E-04	Detected
	Sep. 11 – Sep. 25	2.72E-03	1.13E-03	8.68E-04	Detected
	Sep. 25 – Oct. 16	1.11E-03	6.19E-04	5.53E-04	Detected
	Oct. 16 – Nov. 2	3.12E-03	1.32E-03	9.21E-04	Detected
	Nov. 2 – Nov. 23	1.09E-03	6.89E-04	6.21E-04	Detected
	Nov. 23 – Dec. 11	1.34E-03	1.29E-03	1.21E-03	Detected
	Dec. 11 – Dec. 23	1.72E-03	1.39E-03	1.70E-03	Detected
	Dec. 23 – Jan. 8	1.41E-03	2.07E-03	2.49E-03	Not detected
^{238}U	May 15 – Jun. 3	2.33E-02	5.72E-03	1.25E-03	Detected
	Jun. 3 – Jun. 17	2.26E-02	5.90E-03	1.37E-03	Detected
	Jun. 17 – Jul. 8	3.17E-02	5.54E-03	8.23E-04	Detected
	Jul. 8 – Jul. 29	2.12E-02	4.52E-03	1.16E-03	Detected
	Jul. 29 – Aug. 7	3.37E-02	8.44E-03	2.20E-03	Detected
	Aug. 7 – Aug. 14	4.22E-02	9.51E-03	1.59E-03	Detected
	Aug. 14 – Aug. 28	2.30E-02	4.90E-03	6.31E-04	Detected
	Aug. 28 – Sep. 11	3.22E-02	5.83E-03	5.62E-04	Detected
	Sep. 11 – Sep. 25	3.58E-02	7.39E-03	1.31E-03	Detected
	Sep. 25 – Oct. 16	2.79E-02	5.21E-03	7.77E-04	Detected
	Oct. 16 – Nov. 2	3.08E-02	7.14E-03	1.08E-03	Detected
	Nov. 2 – Nov. 23	2.77E-02	5.60E-03	9.41E-04	Detected
	Nov. 23 – Dec. 11	3.90E-02	9.60E-03	1.74E-03	Detected
	Dec. 11 – Dec. 23	4.08E-02	9.76E-03	2.05E-03	Detected
	Dec. 23 – Jan. 8	3.10E-02	1.20E-02	3.04E-03	Detected

Table 3-39: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	May 15 – Jun. 3	3.33E-07	1.46E-06	4.85E-06	Not detected
	Jun. 3 – Jun. 17	4.62E-07	1.06E-06	3.52E-06	Not detected
	Jun. 17 – Jul. 8	2.90E-07	5.68E-07	1.88E-06	Not detected
	Jul. 8 – Jul. 29	2.97E-07	6.69E-07	2.21E-06	Not detected
	Jul. 29 – Aug. 7	2.54E-07	3.64E-06	1.21E-05	Not detected
	Aug. 7 – Aug. 14	-3.96E-07	2.16E-06	7.17E-06	Not detected
	Aug. 14 – Aug. 28	3.87E-07	8.78E-07	2.91E-06	Not detected
	Aug. 28 – Sep. 11	-2.31E-06	2.16E-06	7.20E-06	Not detected

Table 3-39: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Loving station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	Sep. 11 – Sep. 25	-5.02E-07	1.11E-06	3.69E-06	Not detected
	Sep. 25 – Oct. 16	3.63E-07	7.61E-07	2.52E-06	Not detected
	Oct. 16 – Nov. 2	1.25E-06	6.71E-07	2.21E-06	Not detected
	Nov. 2 – Nov. 23	5.17E-07	7.18E-07	2.37E-06	Not detected
	Nov. 23 – Dec. 11	-9.05E-07	1.57E-06	5.23E-06	Not detected
	Dec. 11 – Dec. 23	8.02E-07	1.26E-06	4.16E-06	Not detected
	Dec. 23 – Jan. 8	-9.95E-07	1.55E-06	5.15E-06	Not detected
^{60}Co	May 15 – Jun. 3	-7.46E-07	1.42E-06	4.76E-06	Not detected
	Jun. 3 – Jun. 17	-9.05E-07	9.07E-07	3.04E-06	Not detected
	Jun. 17 – Jul. 8	2.39E-07	5.88E-07	1.95E-06	Not detected
	Jul. 8 – Jul. 29	-7.90E-07	7.01E-07	2.35E-06	Not detected
	Jul. 29 – Aug. 7	3.63E-07	3.33E-06	1.11E-05	Not detected
	Aug. 7 – Aug. 14	7.15E-07	1.73E-06	5.74E-06	Not detected
	Aug. 14 – Aug. 28	-1.11E-06	9.07E-07	3.05E-06	Not detected
	Aug. 28 – Sep. 11	-1.64E-06	2.04E-06	6.84E-06	Not detected
	Sep. 11 – Sep. 25	-7.65E-07	9.11E-07	3.05E-06	Not detected
	Sep. 25 – Oct. 16	-9.22E-07	6.53E-07	2.19E-06	Not detected
	Oct. 16 – Nov. 2	-3.95E-07	6.90E-07	2.31E-06	Not detected
	Nov. 2 – Nov. 23	-1.15E-06	6.11E-07	2.05E-06	Not detected
	Nov. 23 – Dec. 11	-1.54E-06	1.52E-06	5.10E-06	Not detected
	Dec. 11 – Dec. 23	-1.13E-06	1.05E-06	3.52E-06	Not detected
	Dec. 23 – Jan. 8	4.13E-07	1.27E-06	4.24E-06	Not detected
^{40}K	May 15 – Jun. 3	3.75E-05	1.47E-05	4.77E-05	Not detected
	Jun. 3 – Jun. 17	4.30E-05	1.08E-05	3.40E-05	detected
	Jun. 17 – Jul. 8	3.26E-05	7.25E-06	2.33E-05	detected
	Jul. 8 – Jul. 29	4.66E-05	8.45E-06	2.69E-05	detected
	Jul. 29 – Aug. 7	9.36E-05	3.42E-05	1.11E-04	Not detected
	Aug. 7 – Aug. 14	7.58E-05	2.19E-05	6.99E-05	detected
	Aug. 14 – Aug. 28	4.36E-05	1.12E-05	3.61E-05	detected
	Aug. 28 – Sep. 11	8.15E-05	2.05E-05	6.53E-05	detected
	Sep. 11 – Sep. 25	4.45E-05	1.15E-05	3.64E-05	detected
	Sep. 25 – Oct. 16	3.63E-05	7.99E-06	2.49E-05	detected
	Oct. 16 – Nov. 2	3.97E-05	8.30E-06	2.66E-05	detected
	Nov. 2 – Nov. 23	3.83E-05	7.52E-06	2.32E-05	detected
	Nov. 23 – Dec. 11	2.97E-05	1.52E-05	4.96E-05	Not detected
	Dec. 11 – Dec. 23	4.08E-05	1.30E-05	4.16E-05	Not detected
	Dec. 23 – Jan. 8	6.45E-05	1.60E-05	5.05E-05	detected

Table 3-40: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{137}Cs	May 15 – Jun. 3	5.17E-07	5.95E-07	1.97E-06	Not detected
	Jun. 3 – Jun. 17	1.71E-07	1.07E-06	3.53E-06	Not detected
	Jun. 17 – Jul. 8	7.75E-07	7.32E-07	2.41E-06	Not detected
	Jul. 8 – Jul. 29	-1.74E-07	1.36E-06	4.51E-06	Not detected
	Jul. 29 – Aug. 7	2.06E-06	1.69E-06	5.56E-06	Not detected
	Aug. 7 – Aug. 14	-2.85E-08	4.17E-06	1.38E-05	Not detected
	Aug. 14 – Aug. 28	8.86E-07	2.17E-06	7.18E-06	Not detected
	Aug. 28 – Sep. 11	2.86E-07	1.13E-06	3.74E-06	Not detected
	Sep. 11 – Sep. 25	-9.51E-07	2.04E-06	6.80E-06	Not detected
	Sep. 25 – Oct. 16	4.74E-09	1.38E-06	4.58E-06	Not detected
	Oct. 16 – Nov. 2	2.42E-06	1.61E-06	5.29E-06	Not detected
	Nov. 2 – Nov. 23	-1.14E-06	1.38E-06	4.59E-06	Not detected
	Nov. 23 – Dec. 11	4.23E-07	6.61E-07	2.19E-06	Not detected
	Dec. 11 – Dec. 23	1.32E-06	2.38E-06	7.88E-06	Not detected
	Dec. 23 – Jan. 8	-3.15E-06	2.10E-06	7.01E-06	Not detected
^{60}Co	May 15 – Jun. 3	-2.85E-07	6.19E-07	2.07E-06	Not detected
	Jun. 3 – Jun. 17	-7.37E-07	8.84E-07	2.96E-06	Not detected
	Jun. 17 – Jul. 8	-1.24E-06	6.24E-07	2.10E-06	Not detected
	Jul. 8 – Jul. 29	-1.77E-06	1.35E-06	4.55E-06	Not detected
	Jul. 29 – Aug. 7	-5.40E-07	1.38E-06	4.62E-06	Not detected
	Aug. 7 – Aug. 14	2.17E-06	3.87E-06	1.29E-05	Not detected
	Aug. 14 – Aug. 28	-4.22E-06	2.18E-06	7.37E-06	Not detected
	Aug. 28 – Sep. 11	-9.06E-08	9.09E-07	3.03E-06	Not detected
	Sep. 11 – Sep. 25	-2.37E-06	1.96E-06	6.59E-06	Not detected
	Sep. 25 – Oct. 16	-1.94E-06	1.35E-06	4.56E-06	Not detected
	Oct. 16 – Nov. 2	2.10E-07	1.53E-06	5.09E-06	Not detected
	Nov. 2 – Nov. 23	-7.91E-07	1.34E-06	4.50E-06	Not detected
	Nov. 23 – Dec. 11	-4.34E-08	6.65E-07	2.21E-06	Not detected
	Dec. 11 – Dec. 23	-4.31E-06	2.37E-06	7.99E-06	Not detected
	Dec. 23 – Jan. 8	4.54E-07	1.96E-06	6.53E-06	Not detected
^{40}K	May 15 – Jun. 3	4.30E-05	7.38E-06	2.35E-05	Detected
	Jun. 3 – Jun. 17	4.14E-05	1.08E-05	3.42E-05	Detected
	Jun. 17 – Jul. 8	3.31E-05	7.87E-06	2.47E-05	Detected
	Jul. 8 – Jul. 29	3.05E-05	1.33E-05	4.33E-05	Not detected
	Jul. 29 – Aug. 7	5.98E-05	1.76E-05	5.63E-05	Detected
	Aug. 7 – Aug. 14	1.05E-04	3.95E-05	1.28E-04	Not detected

Table 3-40: Activity concentrations of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/m^3	Unc. (2σ) Bq/m^3	MDC Bq/m^3	Status
^{40}K	Aug. 14 – Aug. 28	1.74E-05	2.21E-05	7.34E-05	Not detected
	Aug. 28 – Sep. 11	3.60E-05	1.20E-05	3.85E-05	Not detected
	Sep. 11 – Sep. 25	4.03E-05	1.95E-05	6.38E-05	Not detected
	Sep. 25 – Oct. 16	3.15E-05	1.34E-05	4.37E-05	Not detected
	Oct. 16 – Nov. 2	2.39E-05	1.56E-05	5.14E-05	Not detected
	Nov. 2 – Nov. 23	3.84E-05	1.28E-05	4.14E-05	Not detected
	Nov. 23 – Dec. 11	1.87E-05	8.16E-06	2.67E-05	Not detected
	Dec. 11 – Dec. 23	5.49E-05	2.22E-05	7.21E-05	Not detected
	Dec. 23 – Jan. 8	3.89E-05	1.95E-05	6.37E-05	Not detected

Table 3-41: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Loving station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	May 15 – Jun. 3	1.11E-02	4.90E-02	1.62E-01	Not detected
	Jun. 3 – Jun. 17	1.32E-02	3.05E-02	1.01E-01	Not detected
	Jun. 17 – Jul. 8	6.48E-03	1.27E-02	4.21E-02	Not detected
	Jul. 8 – Jul. 29	6.17E-03	1.39E-02	4.60E-02	Not detected
	Jul. 29 – Aug. 7	5.00E-03	7.16E-02	2.38E-01	Not detected
	Aug. 7 – Aug. 14	-7.08E-03	3.86E-02	1.28E-01	Not detected
	Aug. 14 – Aug. 28	5.95E-03	1.35E-02	4.48E-02	Not detected
	Aug. 28 – Sep. 11	-2.45E-02	2.30E-02	7.66E-02	Not detected
	Sep. 11 – Sep. 25	-1.01E-02	2.23E-02	7.42E-02	Not detected
	Sep. 25 – Oct. 16	8.87E-03	1.86E-02	6.15E-02	Not detected
	Oct. 16 – Nov. 2	4.14E-02	2.22E-02	7.30E-02	Not detected
	Nov. 2 – Nov. 23	1.10E-02	1.52E-02	5.03E-02	Not detected
	Nov. 23 – Dec. 11	-3.73E-02	6.48E-02	2.16E-01	Not detected
	Dec. 11 – Dec. 23	1.91E-02	3.00E-02	9.90E-02	Not detected
	Dec. 23 – Jan. 8	-3.69E-02	5.74E-02	1.91E-01	Not detected
^{60}Co	May 15 – Jun. 3	-2.50E-02	4.76E-02	1.59E-01	Not detected
	Jun. 3 – Jun. 17	-2.59E-02	2.60E-02	8.71E-02	Not detected
	Jun. 17 – Jul. 8	5.35E-03	1.32E-02	4.37E-02	Not detected
	Jul. 8 – Jul. 29	-1.64E-02	1.46E-02	4.89E-02	Not detected
	Jul. 29 – Aug. 7	7.14E-03	6.55E-02	2.18E-01	Not detected
	Aug. 7 – Aug. 14	1.28E-02	3.09E-02	1.03E-01	Not detected
	Aug. 14 – Aug. 28	-1.70E-02	1.40E-02	4.69E-02	Not detected

Table 3-41: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Loving station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{60}Co	Aug. 28 – Sep. 11	-1.75E-02	2.17E-02	7.28E-02	Not detected
	Sep. 11 – Sep. 25	-1.54E-02	1.83E-02	6.13E-02	Not detected
	Sep. 25 – Oct. 16	-2.25E-02	1.60E-02	5.36E-02	Not detected
	Oct. 16 – Nov. 2	-1.31E-02	2.28E-02	7.64E-02	Not detected
	Nov. 2 – Nov. 23	-2.43E-02	1.30E-02	4.36E-02	Not detected
	Nov. 23 – Dec. 11	-6.34E-02	6.24E-02	2.10E-01	Not detected
	Dec. 11 – Dec. 23	-2.70E-02	2.50E-02	8.37E-02	Not detected
	Dec. 23 – Jan. 8	1.53E-02	4.72E-02	1.57E-01	Not detected
^{40}K	May 15 – Jun. 3	1.25E+00	4.92E-01	1.60E+00	Not detected
	Jun. 3 – Jun. 17	1.23E+00	3.09E-01	9.74E-01	Detected
	Jun. 17 – Jul. 8	7.30E-01	1.62E-01	5.22E-01	Detected
	Jul. 8 – Jul. 29	9.69E-01	1.76E-01	5.60E-01	Detected
	Jul. 29 – Aug. 7	1.84E+00	6.74E-01	2.18E+00	Not detected
	Aug. 7 – Aug. 14	1.35E+00	3.92E-01	1.25E+00	Detected
	Aug. 14 – Aug. 28	6.72E-01	1.72E-01	5.56E-01	Detected
	Aug. 28 – Sep. 11	8.67E-01	2.18E-01	6.95E-01	Detected
	Sep. 11 – Sep. 25	8.95E-01	2.31E-01	7.32E-01	Detected
	Sep. 25 – Oct. 16	8.89E-01	1.95E-01	6.10E-01	Detected
	Oct. 16 – Nov. 2	1.31E+00	2.75E-01	8.81E-01	Detected
	Nov. 2 – Nov. 23	8.13E-01	1.60E-01	4.92E-01	Detected
	Nov. 23 – Dec. 11	1.22E+00	6.24E-01	2.04E+00	Not detected
	Dec. 11 – Dec. 23	9.71E-01	3.09E-01	9.91E-01	Not detected
	Dec. 23 – Jan. 8	2.39E+00	5.94E-01	1.87E+00	Detected

Table 3-42: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Carlsbad station

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	May 15 – Jun. 3	2.21E-02	2.55E-02	8.42E-02	Not detected
	Jun. 3 – Jun. 17	5.37E-03	3.35E-02	1.11E-01	Not detected
	Jun. 17 – Jul. 8	2.10E-02	1.98E-02	6.54E-02	Not detected
	Jul. 8 – Jul. 29	-5.91E-03	4.62E-02	1.53E-01	Not detected
	Jul. 29 – Aug. 7	5.53E-02	4.53E-02	1.49E-01	Not detected
	Aug. 7 – Aug. 14	-6.10E-04	8.92E-02	2.96E-01	Not detected
	Aug. 14 – Aug. 28	1.75E-02	4.28E-02	1.42E-01	Not detected
	Aug. 28 – Sep. 11	5.92E-03	2.33E-02	7.73E-02	Not detected

Table 3-42: Activity density of gamma emitting isotopes (^{137}Cs, ^{60}Co and ^{40}K) in the filter samples collected from Carlsbad station (continued)

Radionuclides	Sample Date 2015	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Sep. 11 – Sep. 25	-3.10E-02	6.67E-02	2.22E-01	Not detected
	Sep. 25 – Oct. 16	1.40E-04	4.07E-02	1.35E-01	Not detected
	Oct. 16 – Nov. 2	1.01E-01	6.71E-02	2.21E-01	Not detected
	Nov. 2 – Nov. 23	-4.26E-02	5.17E-02	1.72E-01	Not detected
	Nov. 23 – Dec. 11	2.62E-02	4.10E-02	1.35E-01	Not detected
	Dec. 11 – Dec. 23	5.66E-02	1.02E-01	3.38E-01	Not detected
	Dec. 23 – Jan. 8	-2.36E-01	1.57E-01	5.25E-01	Not detected
^{60}Co	May 15 – Jun. 3	-1.22E-02	2.65E-02	8.86E-02	Not detected
	Jun. 3 – Jun. 17	-2.32E-02	2.78E-02	9.31E-02	Not detected
	Jun. 17 – Jul. 8	-3.37E-02	1.69E-02	5.68E-02	Not detected
	Jul. 8 – Jul. 29	-6.01E-02	4.60E-02	1.55E-01	Not detected
	Jul. 29 – Aug. 7	-1.45E-02	3.71E-02	1.24E-01	Not detected
	Aug. 7 – Aug. 14	4.65E-02	8.29E-02	2.75E-01	Not detected
	Aug. 14 – Aug. 28	-8.33E-02	4.30E-02	1.45E-01	Not detected
	Aug. 28 – Sep. 11	-1.87E-03	1.88E-02	6.27E-02	Not detected
	Sep. 11 – Sep. 25	-7.72E-02	6.39E-02	2.15E-01	Not detected
	Sep. 25 – Oct. 16	-5.72E-02	3.99E-02	1.35E-01	Not detected
	Oct. 16 – Nov. 2	8.75E-03	6.38E-02	2.13E-01	Not detected
	Nov. 2 – Nov. 23	-2.97E-02	5.05E-02	1.69E-01	Not detected
	Nov. 23 – Dec. 11	-2.69E-03	4.12E-02	1.37E-01	Not detected
	Dec. 11 – Dec. 23	-1.85E-01	1.02E-01	3.43E-01	Not detected
	Dec. 23 – Jan. 8	3.40E-02	1.47E-01	4.89E-01	Not detected
^{40}K	May 15 – Jun. 3	1.84E+00	3.16E-01	1.00E+00	Detected
	Jun. 3 – Jun. 17	1.30E+00	3.40E-01	1.08E+00	Detected
	Jun. 17 – Jul. 8	8.96E-01	2.13E-01	6.70E-01	Detected
	Jul. 8 – Jul. 29	1.04E+00	4.52E-01	1.47E+00	Not detected
	Jul. 29 – Aug. 7	1.61E+00	4.74E-01	1.51E+00	Detected
	Aug. 7 – Aug. 14	2.24E+00	8.47E-01	2.75E+00	Not detected
	Aug. 14 – Aug. 28	3.43E-01	4.37E-01	1.45E+00	Not detected
	Aug. 28 – Sep. 11	7.45E-01	2.48E-01	7.97E-01	Not detected
	Sep. 11 – Sep. 25	1.31E+00	6.36E-01	2.08E+00	Not detected
	Sep. 25 – Oct. 16	9.30E-01	3.96E-01	1.29E+00	Not detected
	Oct. 16 – Nov. 2	9.97E-01	6.53E-01	2.15E+00	Not detected
	Nov. 2 – Nov. 23	1.44E+00	4.82E-01	1.56E+00	Not detected
	Nov. 23 – Dec. 11	1.16E+00	5.06E-01	1.66E+00	Not detected
	Dec. 11 – Dec. 23	2.36E+00	9.53E-01	3.10E+00	Not detected
	Dec. 23 – Jan. 8	2.91E+00	1.46E+00	4.77E+00	Not 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 are of high interest to the CEMRC environmental monitoring program because aerosol releases of contaminants from within the repository could eventually be deposited into surface soils, which then can serve as a source for continuing contaminant exposure and uptake via direct contact, food chain pathways, and re-suspension. Additionally, 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 located near the WIPP facility, and the regional fallout from the above-ground testing at the Nevada Test Site (NTS) or 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 resulted from WIPP operations. These samples have been analyzed for transuranic actinides and gamma-emitting radionuclides. Following the radiological event at WIPP on February 14, 2014, several soil samples were collected from within a 10-mile radius of WIPP to assess the regional impact of the February 14 radiation release event to the local environment, if any. The measured data show, as expected, that no detectable increases above those typical of previously measured natural variation occurred as a result of the February 14, 2014 underground radiation event.

Sample Collection

In 2015, a total of 32 soil samples were collected from the two locations where the high-volume air samplers are stationed around the WIPP site: Site 107 (Near Field) and Site 109 (Cactus Flats). Soil samples at the depth of (0-2 cm) were collected at random short distances and orientations from both locations. The sampling location of soil is shown in Figure 4-1. Individual sampling sites were selected on the basis of relatively flat topography, minimum surface erosion, and minimum surface disturbance by human or livestock activity. Approximately 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 ground with a ball mill and homogenized by mixing.

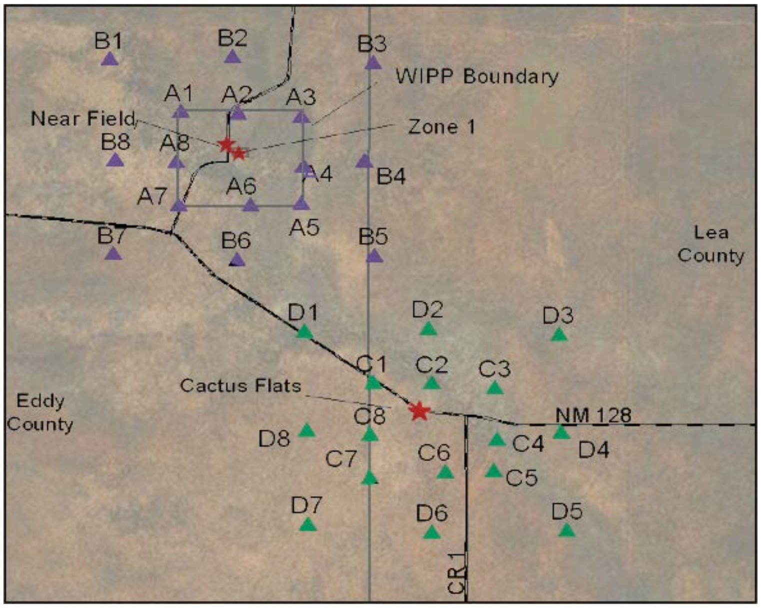


Figure 4-1: Soil Sampling locations in the vicinity of the WIPP Site

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

Sample Preparation

Soil samples were dried at 110^{o}C and blended prior to sampling. For actinides analyses, 5-10 g of sample were heated in a muffle furnace at 500^{o}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^{o}C for at least 2 hours; 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 was 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) and counted 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 and Cactus Flats are presented in Tables 4-1 and 4-2. The $^{239+240}$Pu concentrations in the Near Field ranged from 0.021 to 0.15 Bq/kg, with a mean value of 0.071 Bq/kg, while that for ^{241}Am ranged from 0.029 to 0.12 Bq/kg, with a mean value of 0.060 Bq/kg. For Cactus Flats, the $^{239+240}$Pu concentrations varied in the range from 0.038 to 0.40 Bq/kg, with a mean value of 0.14 Bq/kg, while that for ^{241}Am ranged from 0.035 to 0.24 Bq/kg, with a mean value of 0.01 Bq/kg. The ^{238}Pu was not detected in any of the soil samples collected in 2015. All detected concentration of $^{239+240}$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 the arrival of TRU wastes in the WIPP and are typical of "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 to 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 4-3.

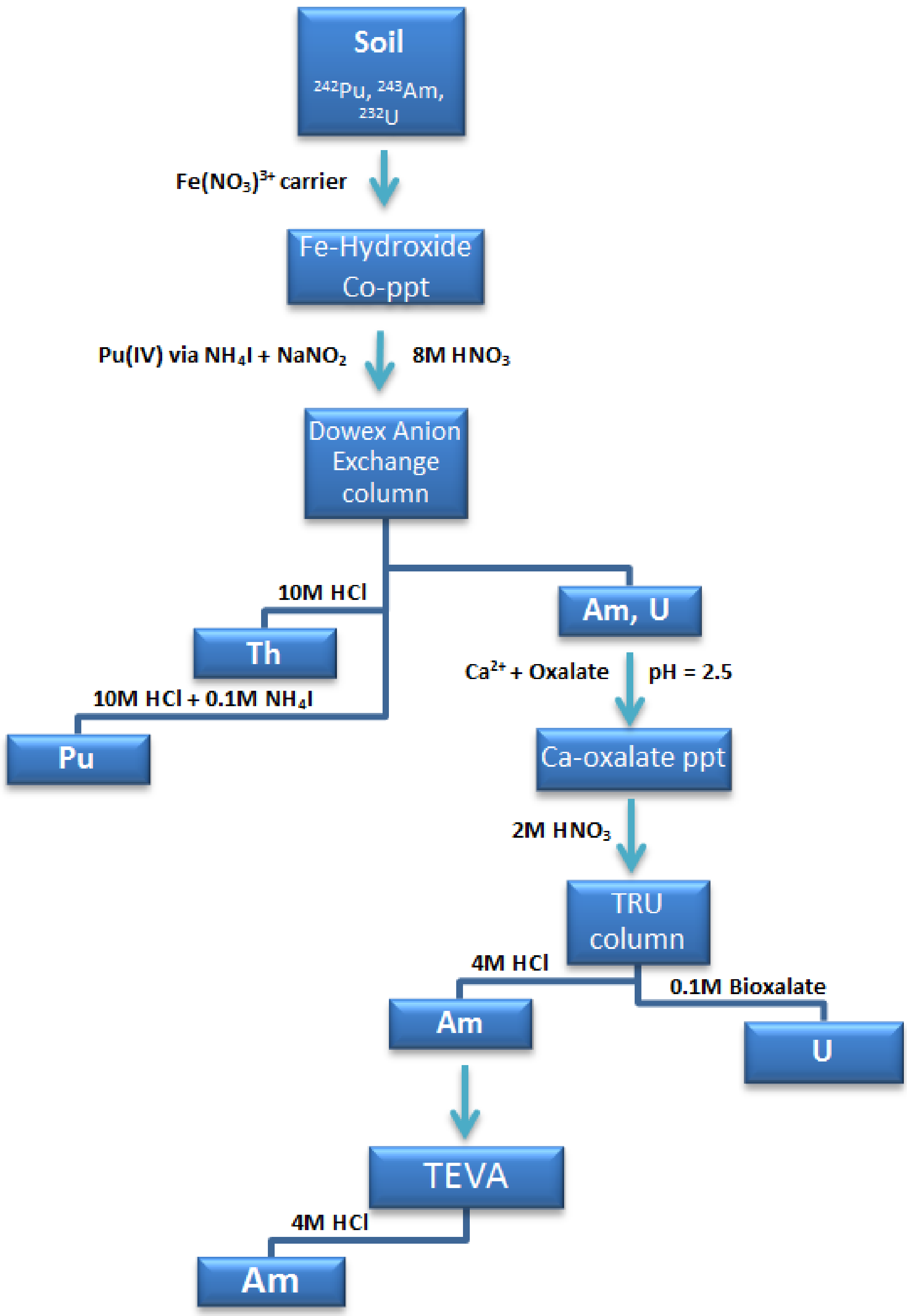


Figure 4-3: Radiochemical separation of Soil Samples

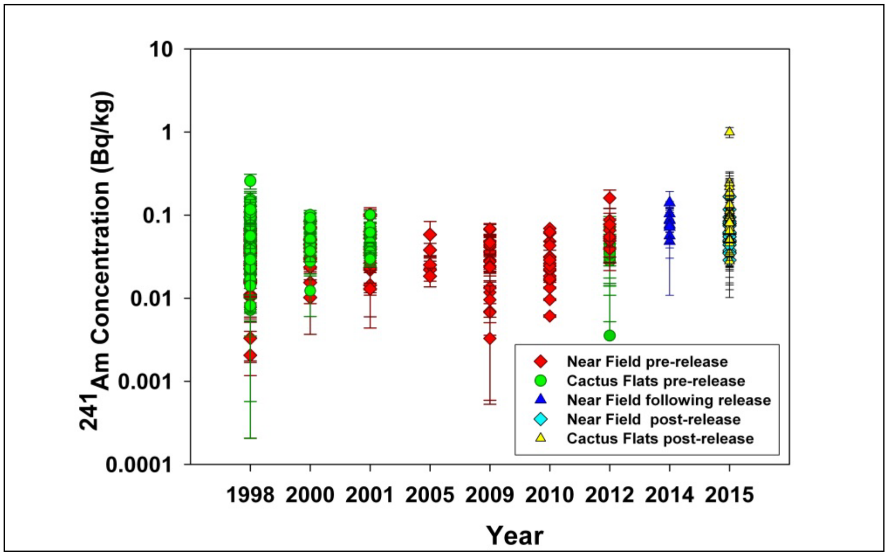


Figure 4-4: The Pre- and Post-radiological event soil concentrations of ^{241}Am in the vicinity of the WIPP site

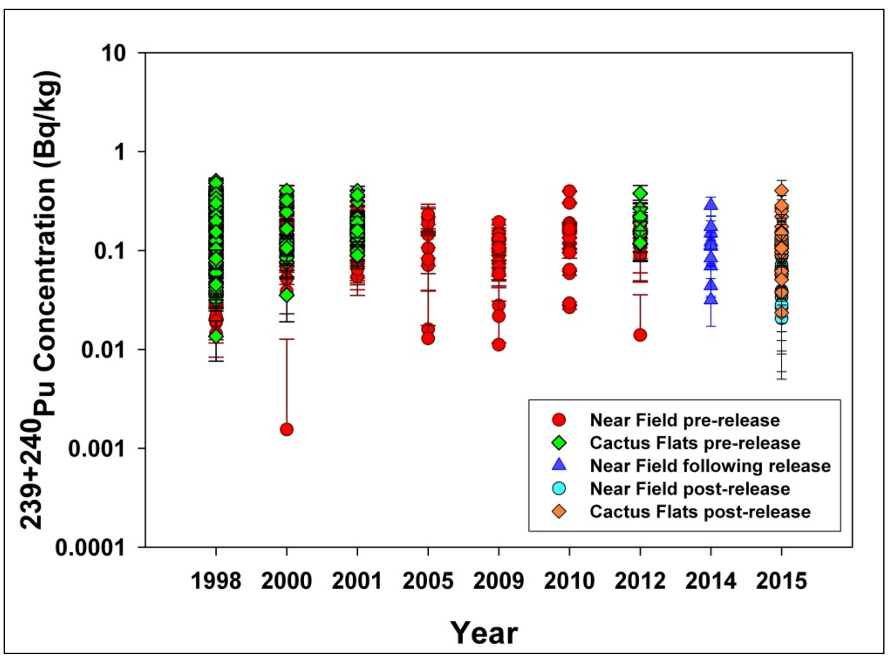


Figure 4-5: The Pre- and Post-radiological event soil concentrations of $^{239+240}$Pu in the vicinity of the WIPP site

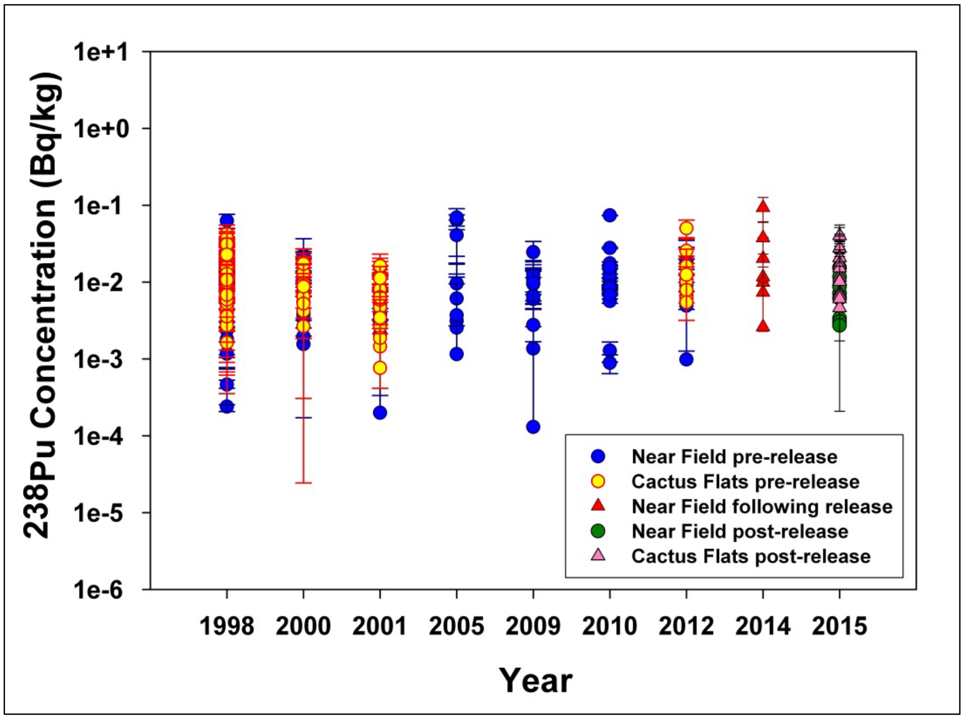


Figure 4-6: The Pre- and post-radiological event soil concentrations of ^{238}Pu in the vicinity of the WIPP site

Concentrations of uranium Isotopes in the WIPP soil

The naturally occurring isotopes of U were detected in all soil samples collected in 2015. Tables 4-4 and 4-5 presents the uranium isotope analysis data for the soil samples collected in 2015. The highest concentrations of ^{234}U and ^{238}U detected in Near Field soil were 8.13 Bq/kg and 7.89 Bq/kg, while that at Cactus Flats soils were 10.3 Bq/kg and 11.1 Bq/kg, respectively. The concentration of uranium in soil varies widely, but typically contains about 3 parts per million (ppm), or about 0.074 (Bq/g) picocuries per gram (pCi/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 0.92 to 1.11 with an average value of 0.98±0.04 for the Near Field soils and between 0.91 to 1.08 with an average value of 0.97±0.04 for the Cactus Flats soils indicating the presence of natural uranium . The Figures 4-10 and 4-11 show 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.

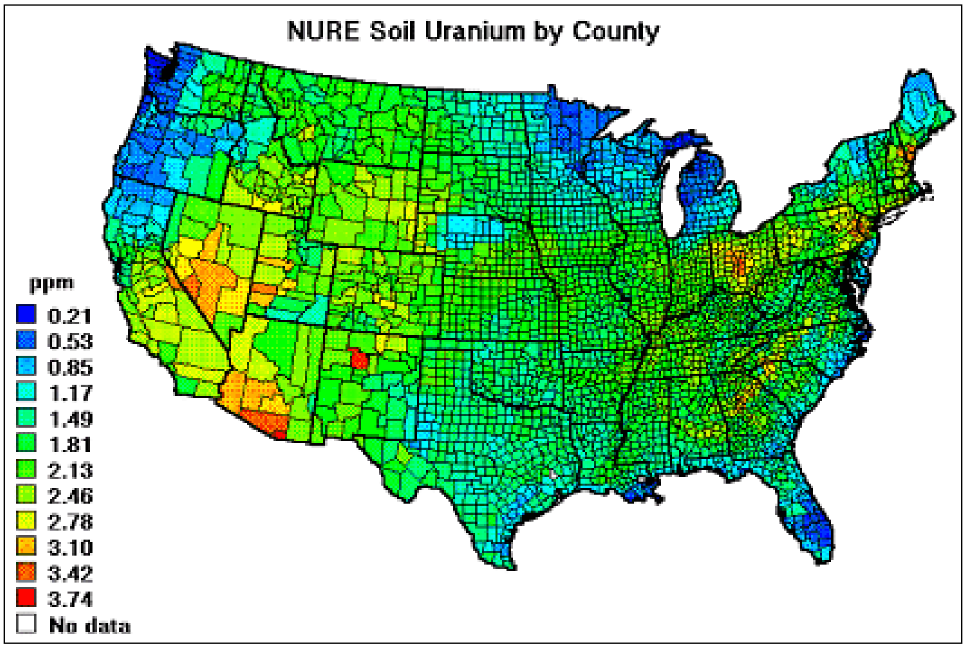


Figure 4-7: Soil uranium concentration levels in the United States
Courtesy: USGS.gov

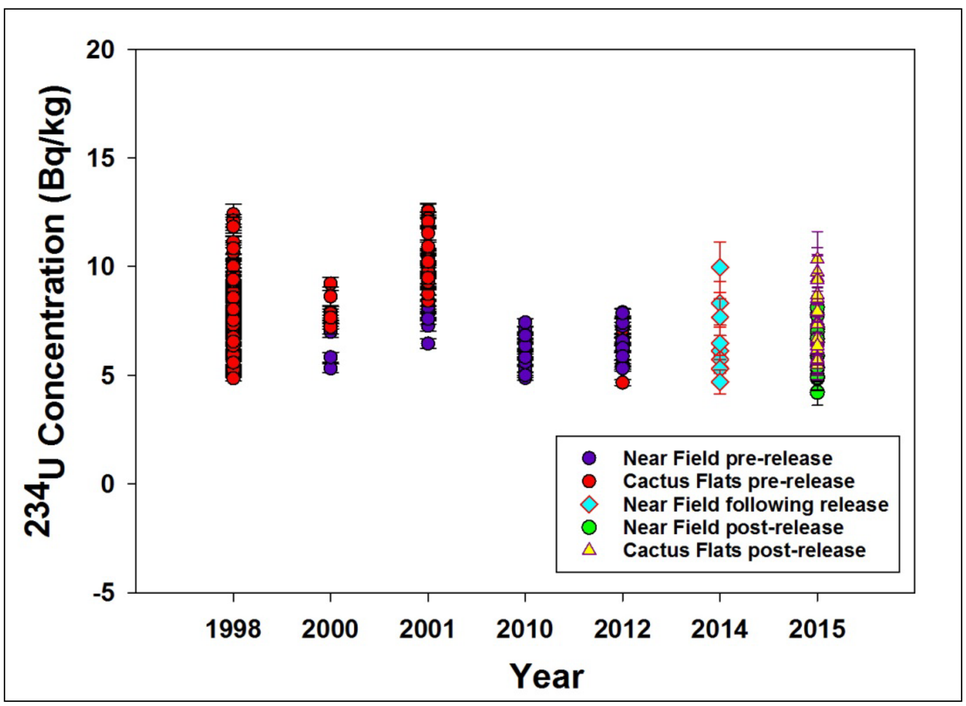


Figure 4-8: The Pre- and post-radiological event soil concentrations of ^{234}U in the vicinity of the WIPP site

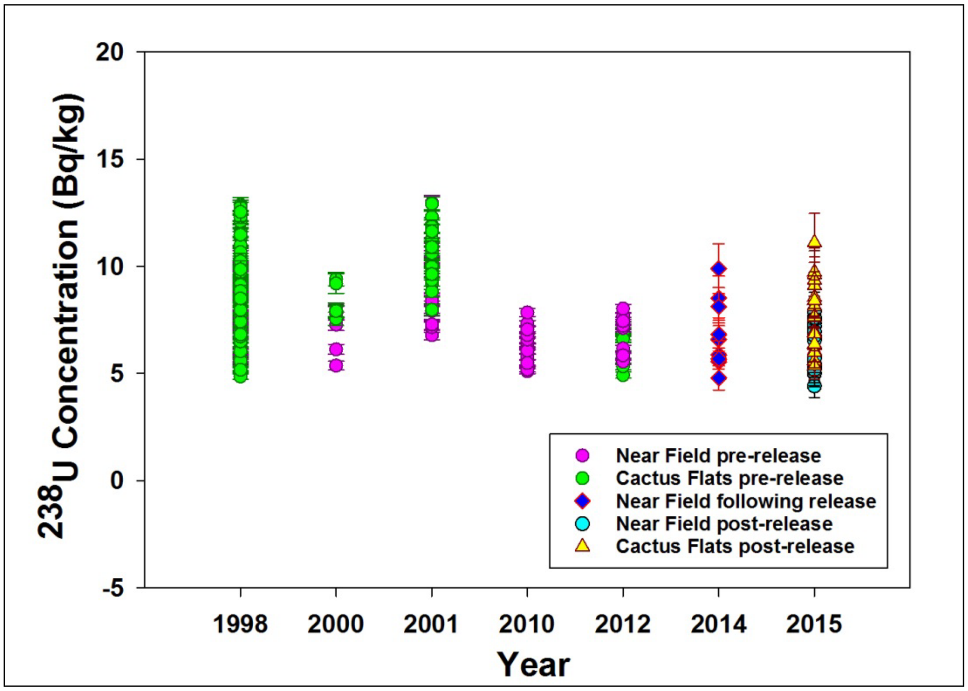


Figure 4-9: The Pre- and post-radiological event soil concentrations of ^{238}U in the vicinity of the WIPP site

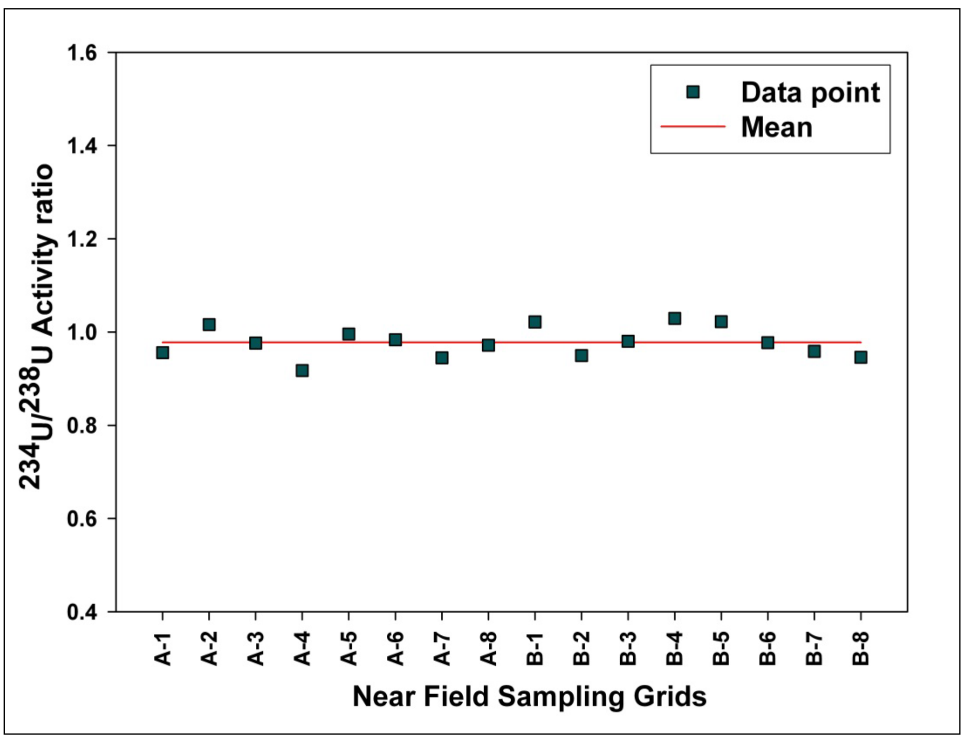


Figure 4-10: The $^{234}U/^{238}U$ activity ratio in the soil samples collected from Near Field grid in the vicinity of the WIPP site

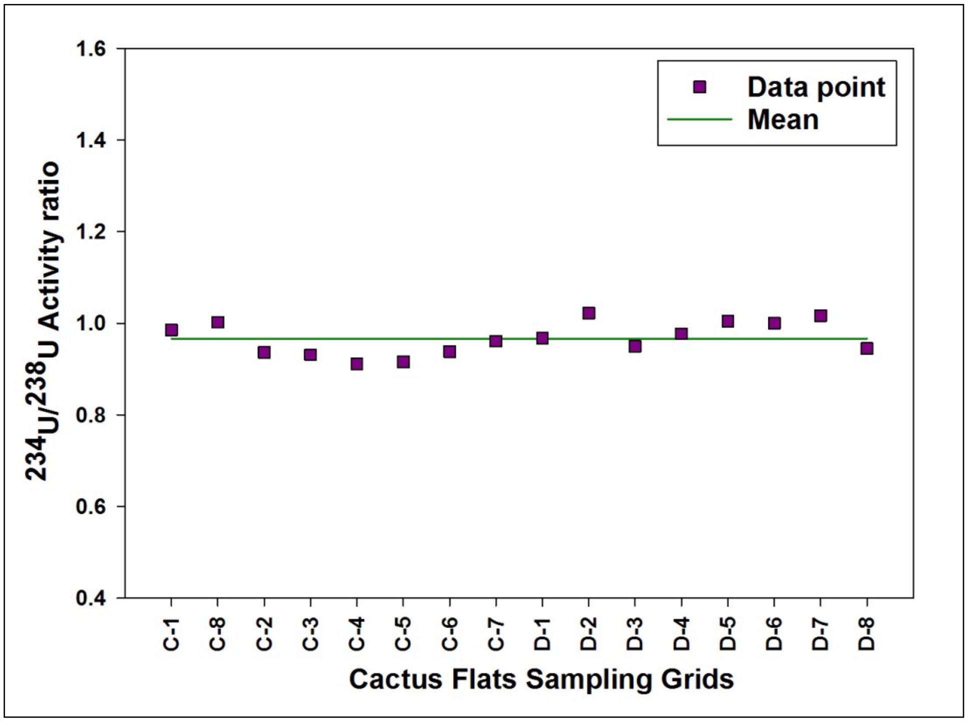


Figure 4-11: The $^{234}U/^{238}U$ activity ratio in the soil samples collected from Cactus Flats grid in the vicinity of the WIPP site

Concentrations of Gamma Radionuclides in the WIPP soil

The ^{137}Cs was detected in all soil samples (Tables 4-6 and 4-7). The activity concentration of ^{137}Cs in the Near Field surface soil ranged from 0.25 to 2.91 Bq/kg, with a mean value of 1.40 Bq/kg, while the activity concentration of ^{137}Cs in the Cactus Flats soil ranged from 0.27 to 5.84 Bq/kg, with a mean value of 2.22 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 (Tables 4-6 and 4-7). 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 4-12 and 4-13. 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.

The concentration of ^{137}Cs in the surface soil at Cactus Flats is approximately 2 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. However, there is no apparent difference between the radionuclides concentration in soil collected before and after WIPP started receiving TRU waste. The Cactus Flats soil radionuclide concentrations are higher than those measured in the soil samples collected following the radiological event at the WIPP.

One 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 addition, 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 (5.84 Bq/kg) seen in the WIPP surface soil samples in 2015. The monitoring results indicate that there is no evidence of increase in soil radionuclide concentrations that can be attributed to the recent radiological event at the WIPP.

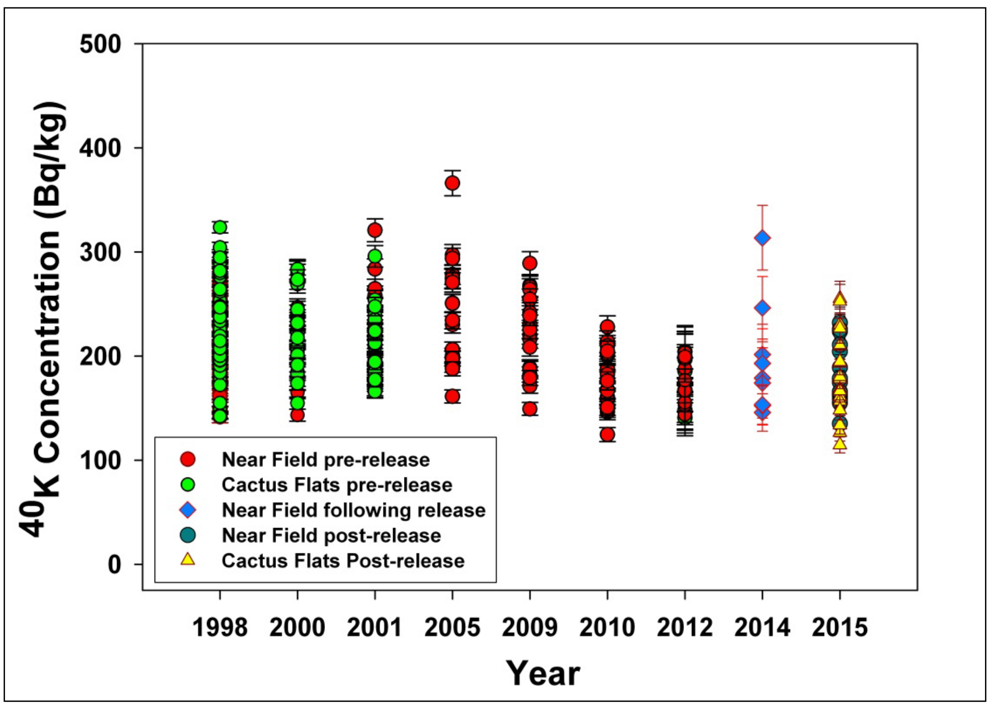


Figure 4-12: The Pre- and Post-radiological event soil concentrations of ^{40}K in the vicinity of the WIPP site

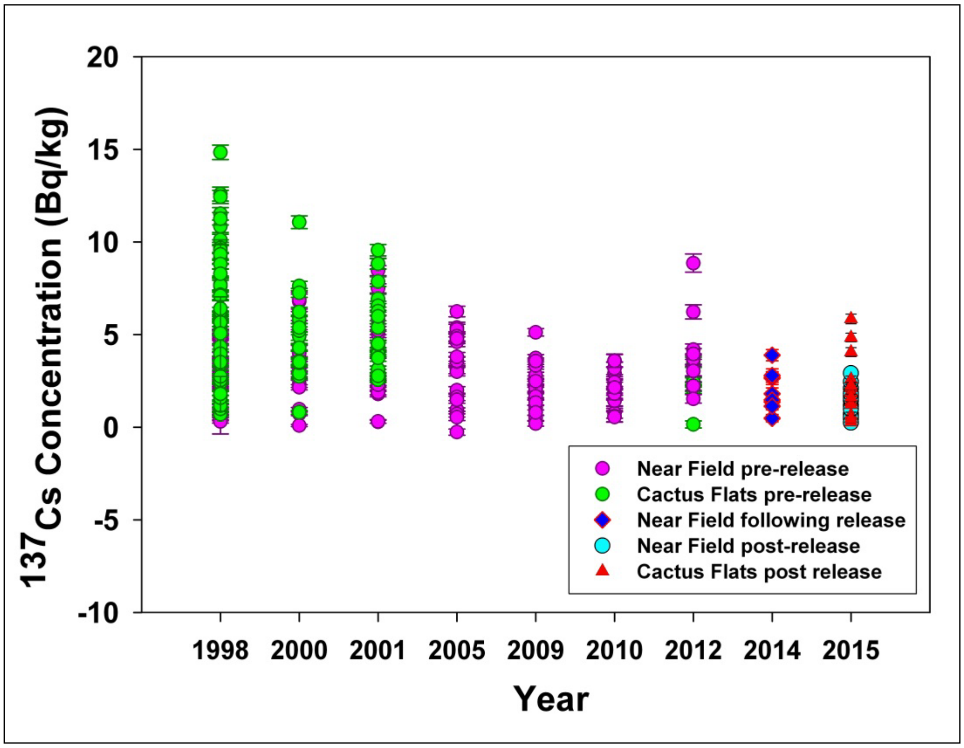


Figure 4-13: The Pre- and Post-radiological event soil concentrations of ^{137}Cs in the vicinity of the WIPP site

Table 4-1: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu (Bq/kg) in soil samples collected at Near Field

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{241}Am	Near field	A-2	4/23/15	7.43E-02	2.76E-02	3.11E-02	Detected
	Near field	A-1	4/23/15	3.55E-02	2.03E-02	2.67E-02	Detected
	Near field	A-3	4/23/15	5.89E-02	2.39E-02	1.96E-02	Detected
	Near field	A-4	4/23/15	4.72E-02	2.27E-02	1.83E-02	Detected
	Near field	A-5	4/23/15	3.75E-02	2.31E-02	3.22E-02	Detected
	Near field	A-6	4/23/15	8.45E-02	3.26E-02	2.54E-02	Detected
	Near field	A-7	4/23/15	4.81E-02	2.69E-02	4.19E-02	Detected
	Near field	A-7 (Dup)	4/23/15	6.10E-02	2.57E-02	1.80E-02	Detected
	Near field	A-8	4/23/15	1.17E-01	4.33E-02	4.45E-02	Detected
	Near field	B-1	6/1/15	6.07E-02	2.73E-02	2.03E-02	Detected
	Near field	B-2	6/1/15	2.87E-02	2.72E-02	5.39E-02	Not Detected
	Near field	B-3	6/1/15	4.98E-02	2.52E-02	3.35E-02	Detected
	Near field	B-4	6/1/15	7.82E-02	3.31E-02	3.82E-02	Detected
	Near field	B-5	6/1/15	4.37E-02	2.15E-02	2.13E-02	Detected
	Near field	B-6	6/3/15	5.47E-02	2.43E-02	2.63E-02	Detected
	Near field	B-7	6/3/15	8.00E-02	3.90E-02	2.13E-02	Detected
	Near field	B-7 (Dup)	6/3/15	5.51E-02	2.37E-02	1.69E-02	Detected
	Near field	B-8	6/3/15	6.19E-02	2.82E-02	3.10E-02	Detected
$^{239+240}$Pu	Near field	A-1	4/23/15	2.07E-02	1.47E-02	1.69E-02	Detected
	Near field	A-2	4/23/15	3.37E-02	2.41E-02	3.96E-02	Not Detected
	Near field	A-3	4/23/15	1.11E-01	3.84E-02	2.65E-02	Detected
	Near field	A-4	4/23/15	6.82E-02	3.49E-02	5.16E-02	Detected
	Near field	A-5	4/23/15	3.92E-02	2.42E-02	3.69E-02	Detected
	Near field	A-6	4/23/15	9.58E-02	3.68E-02	3.48E-02	Detected
	Near field	A-7	4/23/15	2.65E-02	3.06E-02	6.21E-02	Not Detected
	Near field	A-7 (Dup)	4/23/15	7.15E-02	3.90E-02	3.51E-02	Detected
	Near field	A-8	4/23/15	2.85E-02	2.69E-02	5.03E-02	Not Detected
	Near field	B-1	6/1/15	1.25E-01	4.40E-02	4.28E-02	Detected
	Near field	B-2	6/1/15	-1.07E-02	2.59E-02	7.62E-02	Not Detected
	Near field	B-3	6/1/15	9.01E-02	3.63E-02	4.33E-02	Detected
	Near field	B-4	6/1/15	1.38E-01	5.65E-02	7.72E-02	Detected

Table 4-1: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu (Bq/kg) in soil samples collected at Near Field (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
	Near field	B-5	6/1/15	1.52E-01	5.39E-02	4.68E-02	Detected
	Near field	B-6	6/3/15	9.08E-02	3.55E-02	3.41E-02	Detected
	Near field	B-7	6/3/15	1.11E-01	4.17E-02	4.34E-02	Detected
	Near field	B-7 (Dup)	6/3/15	2.82E-02	4.22E-02	9.49E-02	Not Detected
	Near field	B-8	6/3/15	6.43E-02	2.94E-02	2.71E-02	Detected
^{238}Pu	Near field	A-1	4/23/15	-6.91E-03	1.66E-02	4.91E-02	Not Detected
	Near field	A-2	4/23/15	-1.40E-02	1.49E-02	5.27E-02	Not Detected
	Near field	A-3	4/23/15	-5.72E-03	1.98E-02	5.75E-02	Not Detected
	Near field	A-4	4/23/15	8.90E-03	2.44E-02	5.96E-02	Not Detected
	Near field	A-5	4/23/15	6.21E-10	1.04E-02	3.14E-02	Not Detected
	Near field	A-6	4/23/15	2.90E-03	1.54E-02	4.08E-02	Not Detected
	Near field	A-7	4/23/15	-3.42E-03	2.05E-02	5.96E-02	Not Detected
	Near field	A-7 (Dup)	4/23/15	-3.15E-03	2.29E-02	6.36E-02	Not Detected
	Near field	A-8	4/23/15	-4.99E-03	3.31E-02	9.36E-02	Not Detected
	Near field	B-1	6/1/15	3.04E-03	2.02E-02	5.30E-02	Not Detected
	Near field	B-2	6/1/15	7.15E-03	1.43E-02	3.33E-02	Not Detected
	Near field	B-3	6/1/15	2.73E-03	1.22E-02	3.27E-02	Not Detected
	Near field	B-4	6/1/15	1.53E-02	1.89E-02	3.56E-02	Not Detected
	Near field	B-5	6/1/15	1.17E-02	1.74E-02	3.62E-02	Not Detected
	Near field	B-6	6/3/15	-5.67E-03	1.39E-02	4.49E-02	Not Detected
	Near field	B-7	6/3/15	6.14E-03	1.74E-02	4.34E-02	Not Detected
	Near field	B-7 (Dup)	6/3/15	-1.21E-02	2.42E-02	7.58E-02	Not Detected
	Near field	B-8	6/3/15	8.77E-03	1.55E-02	3.52E-02	Not Detected

Table 4-2: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu (Bq/kg) in soil samples collected from Cactus Flats

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{241}Am	Cactus Flats	C-1	5/20/15	1.72E-01	5.31E-02	5.86E-02	Detected
	Cactus Flats	C-2	5/20/15	3.48E-02	2.46E-02	4.33E-02	Not Detected
	Cactus Flats	C-2 (Dup)	5/20/15	5.12E-02	3.86E-02	6.76E-02	Not Detected
	Cactus Flats	C-3	5/27/15	2.42E-01	8.98E-02	9.22E-02	Detected

Table 4-2: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu (Bq/kg) in soil samples collected from Cactus Flats (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{241}Am	Cactus Flats	C-4	5/27/15	8.51E-02	4.71E-02	7.88E-02	Detected
	Cactus Flats	C-5	5/27/15	9.87E-02	5.48E-02	7.73E-02	Detected
	Cactus Flats	C-6	5/27/15	2.44E-01	7.42E-02	6.27E-02	Detected
	Cactus Flats	C-7	5/27/15	1.33E-01	6.05E-02	6.65E-02	Detected
	Cactus Flats	C-8	5/27/15	1.88E-01	8.73E-02	1.30E-01	Detected
	Cactus Flats	D-1	6/8/15	6.99E-02	2.63E-02	2.74E-02	Detected
	Cactus Flats	D-2	6/8/15	6.33E-02	2.79E-02	2.46E-02	Detected
	Cactus Flats	D-3	6/8/15	7.10E-02	4.25E-02	6.63E-02	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	5.22E-02	2.87E-02	3.69E-02	Detected
	Cactus Flats	D-4	6/8/15	4.59E-02	5.45E-02	1.14E-01	Not Detected
	Cactus Flats	D-5	6/9/15	5.01E-02	2.62E-02	3.52E-02	Detected
	Cactus Flats	D-6	6/9/15	6.48E-02	3.09E-02	3.54E-02	Detected
	Cactus Flats	D-7	6/9/15	8.16E-02	3.45E-02	4.98E-02	Detected
	Cactus Flats	D-8	6/9/15	8.03E-02	3.38E-02	4.75E-02	Detected
$^{239+240}$Pu	Cactus Flats	C-1	5/20/15	1.13E-01	5.05E-02	7.11E-02	Detected
	Cactus Flats	C-2	5/20/15	3.77E-02	3.27E-02	5.90E-02	Not Detected
	Cactus Flats	C-2 (Dup)	5/20/15	6.37E-02	3.15E-02	3.11E-02	Detected
	Cactus Flats	C-3	5/27/15	4.03E-01	1.08E-01	6.91E-02	Detected
	Cactus Flats	C-4	5/27/15	8.86E-02	4.67E-02	4.09E-02	Detected
	Cactus Flats	C-5	5/27/15	1.31E-01	5.46E-02	5.61E-02	Detected
	Cactus Flats	C-6	5/27/15	2.69E-01	8.86E-02	8.07E-02	Detected
	Cactus Flats	C-7	5/27/15	9.60E-02	4.69E-02	5.49E-02	Detected
	Cactus Flats	C-8	5/20/15	2.85E-01	7.31E-02	2.79E-02	Detected
	Cactus Flats	D-1	6/8/15	1.54E-01	4.57E-02	2.61E-02	Detected
	Cactus Flats	D-2	6/8/15	1.24E-01	4.21E-02	4.59E-02	Detected
	Cactus Flats	D-3	6/8/15	117E-01	3.41E-02	1.93E-02	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	6.16E-02	3.07E-02	4.77E-02	Detected
	Cactus Flats	D-4	6/8/15	1.37E-01	4.61E-02	4.30E-02	Detected
	Cactus Flats	D-5	6/9/15	5.08E-02	2.28E-02	1.70E-02	Detected
	Cactus Flats	D-6	6/9/15	1.09E-01	3.93E-02	2.82E-02	Detected
	Cactus Flats	D-7	6/9/15	1.50E-01	4.29E-02	2.36E-02	Detected
	Cactus Flats	D-8	6/9/15	1.05E-01	3.75E-02	4.27E-02	Detected

Table 4-2: Activity concentrations of ^{241}Am, $^{239+240}$Pu and ^{238}Pu (Bq/kg) in soil samples collected from Cactus Flats (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{238}Pu	Cactus Flats	C-1	5/20/15	7.54E-03	2.83E-02	8.04E-02	Not Detected
	Cactus Flats	C-2	5/20/15	0.00E+00	2.90E-02	7.87E-02	Not Detected
	Cactus Flats	C-2 (Dup)	5/20/15	6.69E-03	1.34E-02	3.11E-02	Not Detected
	Cactus Flats	C-3	5/27/15	4.00E-02	6.91E-02	6.58E+00	Not Detected
	Cactus Flats	C-4	5/27/15	2.76E-02	2.74E-02	4.09E-02	Not Detected
	Cactus Flats	C-5	5/27/15	-4.67E-03	2.81E-02	8.12E-02	Not Detected
	Cactus Flats	C-6	5/27/15	1.15E-02	3.97E-02	9.98E-02	Not Detected
	Cactus Flats	C-7	5/27/15	-1.37E-02	3.03E-02	9.20E-02	Not Detected
	Cactus Flats	C-8	5/20/15	-1.14E-02	2.75E-02	8.10E-02	Not Detected
	Cactus Flats	D-1	6/8/15	0.00E+00	1.77E-02	4.89E-02	Not Detected
	Cactus Flats	D-2	6/8/15	-1.84E-02	1.92E-02	6.20E-02	Not Detected
	Cactus Flats	D-3	6/8/15	1.04E-02	1.11E-02	1.93E-02	Not Detected
	Cactus Flats	D-3 (Dup)	6/8/15	4.74E-03	1.34E-02	4.11E-02	Not Detected
	Cactus Flats	D-4	6/8/15	1.52E-02	1.62E-02	2.83E-02	Not Detected
	Cactus Flats	D-5	6/9/15	4.62E-03	1.13E-02	2.78E-02	Not Detected
	Cactus Flats	D-6	6/9/15	6.07E-03	1.72E-02	4.29E-02	Not Detected
	Cactus Flats	D-7	6/9/15	1.02E-02	1.61E-02	3.59E-02	Not Detected
	Cactus Flats	D-8	6/9/15	-7.36E-03	1.10E-02	3.88E-02	Not Detected

Table 4-3: 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 4-4: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected at Near Field

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{234}U	Near field	A-1	4/23/15	4.21E+00	5.89E-01	4.73E-02	Detected
	Near field	A-2	4/23/15	5.89E+00	7.05E-01	8.01E-02	Detected
	Near field	A-3	4/23/15	4.90E+00	5.82E-01	5.70E-02	Detected
	Near field	A-4	4/23/15	4.86E+00	5.70E-01	5.87E-02	Detected
	Near field	A-5	4/23/15	4.96E+00	6.17E-01	6.86E-02	Detected
	Near field	A-6	4/23/15	7.22E+00	8.45E-01	5.53E-02	Detected
	Near field	A-7	4/23/15	7.13E+00	8.33E-01	4.40E-02	Detected
	Near field	A-7 (Dup)	4/23/15	5.91E+00	7.00E-01	4.11E-02	Detected
	Near field	A-8	4/23/15	7.00E+00	8.30E-01	6.92E-02	Detected
	Near field	B-1	6/1/15	7.77E+00	8.77E-01	2.44E-02	Detected
	Near field	B-2	6/1/15	4.91E+00	5.74E-01	3.20E-02	Detected
	Near field	B-3	6/1/15	6.52E+00	7.52E-01	3.96E-02	Detected
	Near field	B-4	6/1/15	8.13E+00	9.14E-01	2.48E-02	Detected
	Near field	B-5	6/1/15	6.69E+00	7.64E-01	5.15E-02	Detected
	Near field	B-6	6/3/15	5.33E+00	6.27E-01	4.40E-02	Detected
	Near field	B-7	6/3/15	6.66E+00	7.72E-01	6.60E-02	Detected
	Near field	B-7 (Dup)	6/3/15	6.51E+00	7.25E-01	3.30E-02	Detected
	Near field	B-8	6/3/15	5.38E+00	6.26E-01	3.07E-02	Detected
^{235}U	Near field	A-1	4/23/15	2.08E-01	5.82E-02	3.11E-02	Detected
	Near field	A-2	4/23/15	3.26E-01	8.03E-02	3.59E-02	Detected
	Near field	A-3	4/23/15	2.87E-01	7.03E-02	3.96E-02	Detected
	Near field	A-4	4/23/15	3.39E-01	7.68E-02	5.37E-02	Detected
	Near field	A-5	4/23/15	3.69E-01	9.70E-02	6.84E-02	Detected
	Near field	A-6	4/23/15	4.08E-01	9.28E-02	4.71E-02	Detected
	Near field	A-7	4/23/15	4.02E-01	9.04E-02	2.83E-02	Detected
	Near field	A-7 (Dup)	4/23/15	2.76E-01	7.13E-02	4.32E-02	Detected
	Near field	A-8	4/23/15	3.41E-01	8.73E-02	3.33E-02	Detected
	Near field	B-1	6/1/15	4.15E-01	8.65E-02	3.91E-02	Detected
	Near field	B-2	6/1/15	2.26E-01	6.11E-02	3.93E-02	Detected
	Near field	B-3	6/1/15	4.46E-01	9.35E-02	4.87E-02	Detected
	Near field	B-4	6/1/15	4.21E-01	8.80E-02	3.96E-02	Detected
	Near field	B-5	6/1/15	3.45E-01	7.76E-02	5.02E-02	Detected
	Near field	B-6	6/3/15	2.52E-01	6.57E-02	3.18E-02	Detected
	Near field	B-7	6/3/15	3.36E -01	7.93E-02	4.89E-02	Detected

Table 4-4: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples Collected at Near Field (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{235}U	Near field	B-7 (Dup)	6/3/15	3.21E-01	6.47E-02	2.17E-02	Detected
	Near field	B-8	6/3/15	3.05E-01	7.15E-02	3.79E-02	Detected
^{238}U	Near field	A-1	4/23/15	4.41E+00	5.33E-01	9.07E-02	Detected
	Near field	A-2	4/23/15	5.80E+00	6.94E-01	7.35E-02	Detected
	Near field	A-3	4/23/15	5.02E+00	5.94E-01	6.79E-02	Detected
	Near field	A-4	4/23/15	5.30E+00	6.15E-01	8.51E-02	Detected
	Near field	A-5	4/23/15	4.98E+00	6.19E-01	8.37E-02	Detected
	Near field	A-6	4/23/15	7.34E+00	8.59E-01	9.44E-02	Detected
	Near field	A-7	4/23/15	7.54E+00	8.81E-01	4.38E-02	Detected
	Near field	A-7 (Dup)	4/23/15	5.31E+00	6.27E-01	4.71E-02	Detected
	Near field	A-8	4/23/15	7.20E+00	8.50E-01	6.39E-02	Detected
	Near field	B-1	6/1/15	7.61E+00	8.58E-01	6.71E-02	Detected
	Near field	B-2	6/1/15	5.17E+00	6.02E-01	6.74E-02	Detected
	Near field	B-3	6/1/15	6.65E+00	7.65E-01	8.30E-02	Detected
	Near field	B-4	6/1/15	7.89E+00	8.91E-01	6.25E-02	Detected
	Near field	B-5	6/1/15	6.55E+00	7.49E-01	8.37E-02	Detected
	Near field	B-6	6/3/15	5.45E+00	6.43E-01	6.48E-02	Detected
	Near field	B-7	6/3/15	6.95E+00	8.02E-01	5.62E-02	Detected
	Near field	B-7 (Dup)	6/3/15	6.75E+00	7.51E-01	3.56E-02	Detected
	Near field	B-8	6/3/15	5.69E+00	6.59E-01	6.48E-02	Detected

Table 4-5: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected at Cactus Flats

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{234}U	Cactus Flats	C-1	5/20/15	9.49E+00	1.08E+00	4.89E-02	Detected
	Cactus Flats	C-2	5/20/15	6.51E+00	7.91E-01	5.73E-02	Detected
	Cactus Flats	C-2 (Dup)	5/20/15	5.48E+00	6.65E-01	4.01E-02	Detected
	Cactus Flats	C-3	5/27/15	1.03E+01	1.28E+00	1.02E-01	Detected
	Cactus Flats	C-4	5/27/15	5.75E+00	7.20E-01	5.27E-02	Detected
	Cactus Flats	C-5	5/27/15	7.45E+00	9.08E-01	7.56E-02	Detected
	Cactus Flats	C-6	5/27/15	8.54E+00	1.02E+00	5.92E-02	Detected
	Cactus Flats	C-7	5/27/15	7.35E+00	8.94E-01	5.69E-02	Detected
	Cactus Flats	C-8	5/20/15	9.75E+00	1.12E+00	6.25E-02	Detected

Table 4-5: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected at Cactus Flats (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{234}U	Cactus Flats	D-1	6/8/15	6.68E+00	7.51E-01	2.58E-02	Detected
	Cactus Flats	D-2	6/8/15	6.18E+00	7.12E-01	4.65E-02	Detected
	Cactus Flats	D-3	6/8/15	5.69E+00	6.99E-01	7.90E-02	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	5.78E+00	6.70E-01	3.39E-02	Detected
	Cactus Flats	D-4	6/8/15	6.69E+00	7.90E-01	6.57E-02	Detected
	Cactus Flats	D-5	6/9/15	9.39E+00	1.09E+00	6.39E-02	Detected
	Cactus Flats	D-6	6/9/15	6.37E+00	8.15E-01	1.18E-01	Detected
	Cactus Flats	D-7	6/9/15	8.70E+00	1.00E+00	6.41E-02	Detected
	Cactus Flats	D-8	6/9/15	7.93E+00	9.25E-01	5.15E-02	Detected
^{235}U	Cactus Flats	C-1	5/20/15	5.23E-01	1.04E-01	5.49E-02	Detected
	Cactus Flats	C-2	5/20/15	2.75E-01	7.76E-02	4.14E-02	Detected
	Cactus Flats	C-2 (Dup)	5/20/15	2.52E-01	7.21E-02	4.95E-02	Detected
	Cactus Flats	C-3	5/27/15	9.87E-01	2.00E-01	8.05E-02	Detected
	Cactus Flats	C-4	5/27/15	3.94E-01	1.04E-01	5.02E-02	Detected
	Cactus Flats	C-5	5/27/15	6.06E-01	1.33E-01	3.94E-02	Detected
	Cactus Flats	C-6	5/27/15	7.51E-01	1.20E-01	3.81E-02	Detected
	Cactus Flats	C-7	5/27/15	5.97E-01	1.29E-01	5.97E-02	Detected
	Cactus Flats	C-8	5/20/15	4.52E-01	9.79E-02	4.60E-02	Detected
	Cactus Flats	D-1	6/8/15	4.43E-01	7.96E-02	2.71E-02	Detected
	Cactus Flats	D-2	6/8/15	2.67E-01	6.33E-02	3.42E-02	Detected
	Cactus Flats	D-3	6/8/15	3.30E-01	8.97E-02	7.25E-02	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	2.54E-01	6.22E-02	2.75E-02	Detected
	Cactus Flats	D-4	6/8/15	3.62E-01	8.93E-02	6.40E-02	Detected
	Cactus Flats	D-5	6/9/15	5.21E-01	1.08E-01	3.65E-02	Detected
	Cactus Flats	D-6	6/9/15	1.98E-01	8.37E-02	9.62E-02	Detected
	Cactus Flats	D-7	6/9/15	4.13E-01	8.88E-02	2.59E-02	Detected
	Cactus Flats	D-8	6/9/15	4.98E-01	1.07E-01	5.66E-02	Detected
^{238}U	Cactus Flats	C-1	5/20/15	9.62E+00	1.10E+00	7.13E-02	Detected
	Cactus Flats	C-2	5/20/15	6.95E+00	8.41E-01	7.65E-02	Detected
	Cactus Flats	C-2 (Dup)	5/20/15	5.59E+00	6.78E-01	8.17E-02	Detected
	Cactus Flats	C-3	5/27/15	1.11E+01	1.37E+00	1.02E-01	Detected
	Cactus Flats	C-4	5/27/15	6.31E+00	7.84E-01	9.29E-02	Detected
	Cactus Flats	C-5	5/27/15	8.14E+00	9.87E-01	8.14E-02	Detected

Table 4-5: Activity concentrations of isotopes of uranium (Bq/kg) in soil samples collected at Cactus Flats (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{238}U	Cactus Flats	C-6	5/27/15	9.10E+00	1.08E+00	5.87E-02	Detected
	Cactus Flats	C-7	5/27/15	7.66E+00	9.26E-01	9.02E-02	Detected
	Cactus Flats	C-8	5/20/15	9.73E+00	1.12E+00	4.90E-02	Detected
	Cactus Flats	D-1	6/8/15	6.91E+00	7.75E-01	3.16E-02	Detected
	Cactus Flats	D-2	6/8/15	6.05E+00	6.97E-01	6.85E-02	Detected
	Cactus Flats	D-3	6/8/15	5.99E+00	7.34E-01	1.24E-01	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	5.34E+00	6.23E-01	5.87E-02	Detected
	Cactus Flats	D-4	6/8/15	6.85E+00	8.08E-01	9.45E-02	Detected
	Cactus Flats	D-5	6/9/15	9.36E+00	1.09E+00	7.75E-02	Detected
	Cactus Flats	D-6	6/9/15	6.37E+00	8.19E-01	2.17E-01	Detected
	Cactus Flats	D-7	6/9/15	8.55E+00	9.86E-01	7.77E-02	Detected
	Cactus Flats	D-8	6/9/15	8.40E+00	9.79E-01	1.21E-01	Detected

Table 4-6: Activity concentrations of ^{137}Cs, ^{40}K and ^{60}Co (Bq/kg) in soil samples collected at Near Field

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{137}Cs	Near Field	A-1	4/23/15	1.83E+00	1.71E-01	5.13E-01	Detected
	Near Field	A-2	4/23/15	6.89E-01	1.55E-01	4.99E-01	Detected
	Near Field	A-3	4/23/15	1.18E+00	1.69E-01	5.31E-01	Detected
	Near Field	A-4	4/23/15	1.46E+00	1.64E-01	5.05E-01	Detected
	Near Field	A-5	4/23/15	7.14E-01	1.55E-01	4.98E-01	Detected
	Near Field	A-6	4/23/15	4.70E-01	1.49E-01	4.86E-01	Not Detected
	Near Field	A-7	4/23/15	5.32E-01	1.61E-01	5.22E-01	Detected
	Near Field	A-7 (Dup)	4/23/15	2.09E+00	1.83E-01	5.47E-01	Detected
	Near Field	A-8	4/23/15	9.77E-01	1.67E-01	5.33E-01	Detected
	Near Field	B-1	6/1/15	2.45E+00	1.91E-01	5.59E-01	Detected
	Near Field	B-2	6/1/15	2.50E-01	1.57E-01	5.17E-01	Not Detected
	Near Field	B-3	6/1/15	1.46E+00	1.70E-01	5.26E-01	Detected
	Near Field	B-4	6/1/15	2.91E+00	2.01E-01	5.72E-01	Detected
	Near Field	B-5	6/1/15	1.70E+00	1.65E-01	5.02E-01	Detected
	Near Field	B-6	6/3/15	1.74E+00	1.75E-01	5.34E-01	Detected
	Near Field	B-7	6/3/15	1.53E+00	1.83E-01	5.70E-01	Detected
	Near Field	B-7 (Dup)	6/3/15	1.44E+00	1.66E-01	5.14E-01	Detected
	Near Field	B-8	6/3/15	1.80E+00	1.70E-01	5.13E-01	Detected

Table 4-6: Activity concentrations of ^{137}Cs, ^{40}K and ^{60}Co (Bq/kg) in soil samples collected at Near Field (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{40}K	Near Field	A-1	4/23/15	2.04E+02	1.33E+01	4.74E+00	Detected
	Near Field	A-2	4/23/15	1.62E+02	1.06E+01	4.80E+00	Detected
	Near Field	A-3	4/23/15	1.66E+02	1.08E+01	4.88E+00	Detected
	Near Field	A-4	4/23/15	1.55E+02	1.01E+01	4.55E+00	Detected
	Near Field	A-5	4/23/15	1.35E+02	8.90E+00	4.88E+00	Detected
	Near Field	A-6	4/23/15	1.61E+02	1.05E+01	4.30E+00	Detected
	Near Field	A-7	4/23/15	1.78E+02	1.16E+01	4.81E+00	Detected
	Near Field	A-7 (Dup)	4/23/15	1.89E+02	1.23E+01	4.62E+00	Detected
	Near Field	A-8	4/23/15	2.24E+01	1.45E+01	4.74E+00	Detected
	Near Field	B-1	6/1/15	2.32E+02	1.50E+01	5.46E+00	Detected
	Near Field	B-2	6/1/15	1.58E+02	1.03E+01	5.09E+00	Detected
	Near Field	B-3	6/1/15	1.75E+02	1.13E+01	4.79E+00	Detected
	Near Field	B-4	6/1/15	2.25E+02	1.46E+01	5.36E+00	Detected
	Near Field	B-5	6/1/15	1.63E+02	1.06E+01	4.80E+00	Detected
	Near Field	B-6	6/3/15	1.65E+02	1.08E+01	5.24E+00	Detected
	Near Field	B-7	6/3/15	2.11E+02	1.36E+01	5.44E+00	Detected
	Near Field	B-7 (Dup)	6/3/15	1.64E+02	1.07E+01	4.93E+00	Detected
	Near Field	B-8	6/3/15	1.78E+02	1.16E+01	4.85E+00	Detected
^{60}Co	Near Field	A-1	4/23/15	9.10E-02	1.65E-01	5.45E-01	Not Detected
	Near Field	A-2	4/23/15	8.31E-02	1.51E-01	4.99E-01	Not Detected
	Near Field	A-3	4/23/15	-1.34E-01	1.61E-01	5.39E-01	Not Detected
	Near Field	A-4	4/23/15	9.04E-02	1.57E-01	5.19E-01	Not Detected
	Near Field	A-5	4/23/15	9.58E-02	1.50E-01	4.97E-01	Not Detected
	Near Field	A-6	4/23/15	8.00E-02	1.54E-01	5.09E-01	Not Detected
	Near Field	A-7	4/23/15	5.63E-02	1.62E-01	5.38E-01	Not Detected
	Near Field	A-7 (Dup)	4/23/15	3.86E-01	1.58E-01	5.16E-01	Not Detected
	Near Field	A-8	4/23/15	1.10E-01	1.72E-01	5.68E-01	Not Detected
	Near Field	B-1	6/1/15	1.49E-01	1.73E-01	5.71E-01	Not Detected
	Near Field	B-2	6/1/15	-1.40E-01	1.68E-01	5.61E-01	Not Detected
	Near Field	B-3	6/1/15	7.50E-02	1.63E-01	5.39E-01	Not Detected
	Near Field	B-4	6/1/15	-7.82E-02	1.77E-01	5.88E-01	Not Detected
	Near Field	B-5	6/1/15	1.30E-01	1.54E-01	5.16E-01	Not Detected
	Near Field	B-6	6/3/15	2.69E-01	1.63E-01	5.37E-01	Not Detected
	Near Field	B-7	6/3/15	-3.36E-02	1.75E-01	5.80E-01	Not Detected
	Near Field	B-7 (Dup)	6/3/15	-6.00E-02	1.60E-01	5.32E-01	Not Detected
	Near Field	B-8	6/3/15	1.47E-01	1.60E-01	5.28E-01	Not Detected

Table 4-7: Activity concentrations of ^{137}Cs, ^{40}K and ^{60}Co (Bq/kg) in soil samples collected at Cactus Flats

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{137}Cs	Cactus Flats	C-1	5/20/15	2.24E+00	1.88E-01	5.54E-01	Detected
	Cactus Flats	C-2	5/20/15	2.73E-01	1.54E-01	5.06E-01	Not Detected
	Cactus Flats	C-2 (Dup)	5/20/15	6.44E-01	1.59E-01	5.15E-01	Detected
	Cactus Flats	C-3	5/27/15	5.84E+00	2.64E-01	6.16E-01	Detected
	Cactus Flats	C-4	5/27/15	1.36E+00	1.70E-01	5.31E-01	Detected
	Cactus Flats	C-5	5/27/15	1.92E+00	1.76E-01	5.29E-01	Detected
	Cactus Flats	C-6	5/27/15	4.84E+00	2.35E-01	5.74E-01	Detected
	Cactus Flats	C-7	5/27/15	2.13E+00	1.81E-01	5.36E-01	Detected
	Cactus Flats	C-8	5/20/15	4.05E+00	2.40E-01	6.50E-01	Detected
	Cactus Flats	D-1	6/8/15	2.29E+00	1.80E-01	5.28E-01	Detected
	Cactus Flats	D-2	6/8/15	2.26E+00	1.79E-01	5.23E-01	Detected
	Cactus Flats	D-3	6/8/15	2.13E+00	1.78E-01	5.27E-01	Detected
	Cactus Flats	D-3 (Dup)	6/8/15	1.21E+00	1.65E-01	5.20E-01	Detected
	Cactus Flats	D-4	6/8/15	2.58E+00	1.83E-01	5.21E-01	Detected
	Cactus Flats	D-5	6/9/15	4.52E-01	1.83E-01	5.97E-01	Not Detected
	Cactus Flats	D-6	6/9/15	1.84E+00	1.79E-01	5.47E-01	Detected
	Cactus Flats	D-7	6/9/15	2.23E+00	1.87E-01	5.56E-01	Detected
	Cactus Flats	D-8	6/9/15	1.60E+00	1.78E-01	5.49E-01	Detected
^{40}K	Cactus Flats	C-1	5/20/15	1.94E+02	1.27E+01	5.35E+00	Detected
	Cactus Flats	C-2	5/20/15	1.26E+02	8.32E+00	4.72E+00	Detected
	Cactus Flats	C-2 (Dup)	5/20/15	1.15E+02	7.58E+00	4.82E+00	Detected
	Cactus Flats	C-3	5/27/15	2.53E+01	1.63E+01	5.58E+00	Detected
	Cactus Flats	C-4	5/27/15	1.34E+02	8.79E+00	4.97E+00	Detected
	Cactus Flats	C-5	5/27/15	1.69E+02	1.10E+01	5.21E+00	Detected
	Cactus Flats	C-6	5/27/15	1.93E+02	1.25E+01	5.30E+00	Detected
	Cactus Flats	C-7	5/27/15	2.10E+02	1.36E+01	5.26E+00	Detected
	Cactus Flats	C-8	5/20/15	2.55E+02	1.65E+01	6.16E+00	Detected
	Cactus Flats	D-1	6/8/15	1.78E+02	1.16E+01	4.91E+00	Detected
	Cactus Flats	D-2	6/8/15	1.61E+02	1.05E+01	4.82E+00	Detected
	Cactus Flats	D-3	6/8/15	1.67E+02	1.09E+01	5.17E+00	Detected

Table 4-7: Activity concentrations of ^{137}Cs, ^{40}K and ^{60}Co (Bq/kg) in soil samples collected at Cactus Flats (continued)

Radionuclides	Location	Grid Nodes	Sampling Date	Activity Bq/kg	Unc. (2σ) Bq/kg	MDC Bq/kg	Status
^{40}K	Cactus Flats	D-3 (Dup)	6/8/15	1.57E+02	1.02E+01	4.86E+00	Detected
	Cactus Flats	D-4	6/8/15	1.48E+02	9.68E+00	4.89E+00	Detected
	Cactus Flats	D-5	6/9/15	2.30E+02	1.49E+01	5.57E+00	Detected
	Cactus Flats	D-6	6/9/15	1.80E+02	1.17E+01	5.25E+00	Detected
	Cactus Flats	D-7	6/9/15	2.27E+02	1.47E+01	5.16E+00	Detected
	Cactus Flats	D-8	6/9/15	1.94E+02	1.26E+01	5.11E+00	Detected
^{60}Co	Cactus Flats	C-1	5/20/15	2.74E-01	1.68E-01	5.52E-01	Not Detected
	Cactus Flats	C-2	5/20/15	-9.34E-02	1.56E-01	5.19E-01	Not Detected
	Cactus Flats	C-2 (Dup)	5/20/15	2.55E-02	1.51E-01	5.01E-01	Not Detected
	Cactus Flats	C-3	5/27/15	-2.78E-02	1.87E-01	6.20E-01	Not Detected
	Cactus Flats	C-4	5/27/15	1.72E-02	1.55E-01	5.16E-01	Not Detected
	Cactus Flats	C-5	5/27/15	2.00E-01	1.60E-01	5.28E-01	Not Detected
	Cactus Flats	C-6	5/27/15	5.61E-02	1.76E-01	5.83E-01	Not Detected
	Cactus Flats	C-7	5/27/15	9.52E-02	1.68E-01	5.57E-01	Not Detected
	Cactus Flats	C-8	5/20/15	-3.80E-02	2.01E-01	6.68E-01	Not Detected
	Cactus Flats	D-1	6/8/15	3.30E-01	1.58E-01	5.18E-01	Not Detected
	Cactus Flats	D-2	6/8/15	6.57E-02	1.62E-01	5.35E-01	Not Detected
	Cactus Flats	D-3	6/8/15	-7.61E-02	1.64E-01	5.45E-01	Not Detected
	Cactus Flats	D-3 (Dup)	6/8/15	1.24E-01	1.58E-01	5.24E-01	Not Detected
	Cactus Flats	D-4	6/8/15	3.02E-01	1.57E-01	5.14E-01	Not Detected
	Cactus Flats	D-5	6/9/15	1.78E-01	1.79E-01	5.91E-01	Not Detected
	Cactus Flats	D-6	6/9/15	1.25E-02	1.71E-01	5.67E-01	Not Detected
	Cactus Flats	D-7	6/9/15	-1.20E-01	1.75E-01	5.84E-01	Not Detected
	Cactus Flats	D-8	6/9/15	8.62E-02	1.72E-01	5.69E-01	Not 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 into 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. Radiochemical analyses were performed to assess if there is any evidence of an increase in radionuclide activity concentrations in the region that could be attributed to releases from WIPP or to the February, 2014 radiation release from the WIPP. ***The 2015 monitoring results show no evidence of any release from the WIPP contributing to radionuclide concentrations in the 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).

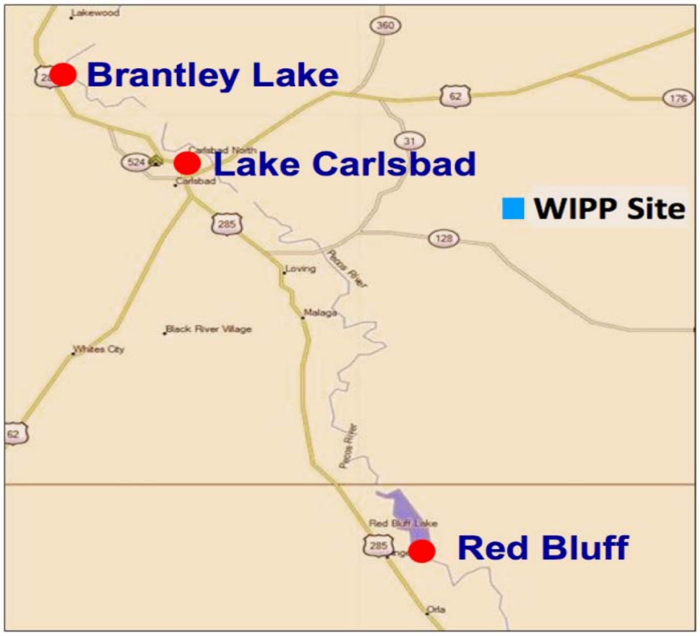


Figure 5-1: Surface Water and Sediment Sampling locations in the vicinity of the WIPP Site

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 plutonium was adjusted by adding 1 ml of 1.0M NH_4I with a 10 min wait step, followed by 2 ml of 2M $NaNO_2$. Plutonium isotopes were then separated and purified using a two-column anion exchange resin (Dowex 1-× 8, 100-200 mesh), while TRU chromatography columns were used for the separation of Am and U. The samples were then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for 5-days.

Data Reporting

The activities of the actinides and gamma radionuclides were 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 individual values of ^{241}Am, ^{238}Pu, and $^{239+240}Pu$ measured in the three reservoirs are listed in Table 5-1 and are shown in Figures 5-3 through 5-5. Since 1998, neither $^{239+240}Pu$, ^{238}Pu nor ^{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 indicates no impact of WIPP related activities to the regional reservoirs.

The analysis results for the uranium isotopes in the surface water samples are shown in Table 5-2. Uranium isotopes (^{234}U, ^{235}U and ^{238}U) were detected in all the surface water samples collected in 2015. The concentrations range of these radionuclides measured in three reservoirs in 2015 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 concentrations of the uranium isotopes were also compared between 2015 and 2014 and between sampling locations. There was no significant variation in the concentrations of the uranium isotopes in the surface water between 2015 and 2014. These observations further support our conclusion that there is no evidence of increases in radiological contaminants in the region that could be attributed to releases from WIPP.

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 1.85 to 2.14 (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.

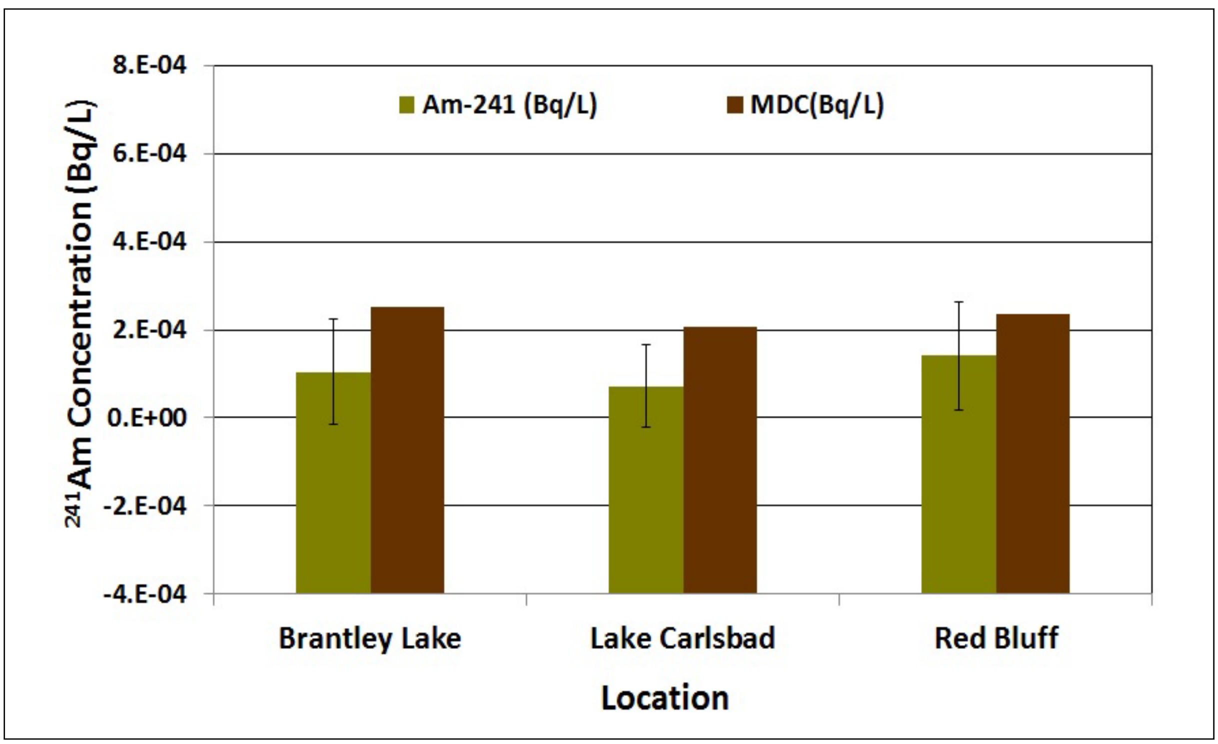


Figure 5-3: ^{241}Am concentration in surface water samples in three regional reservoirs in 2015

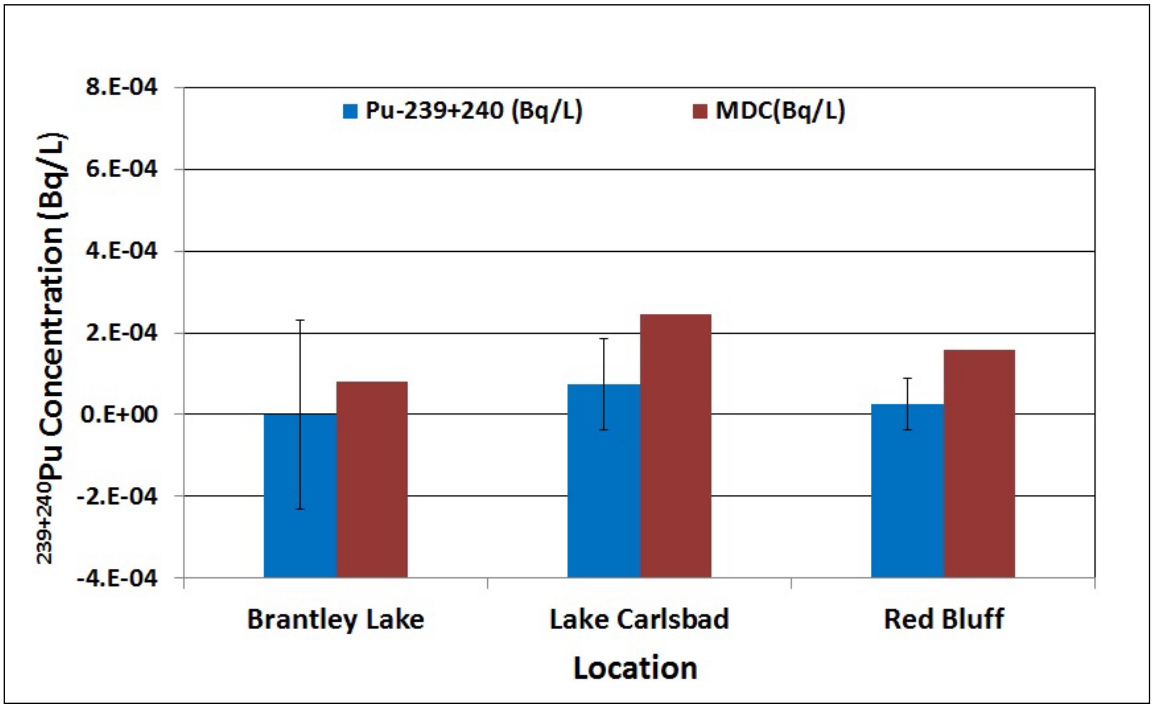


Figure 5-4: $^{239+240}$Pu concentration in surface water samples in three regional reservoirs in 2015

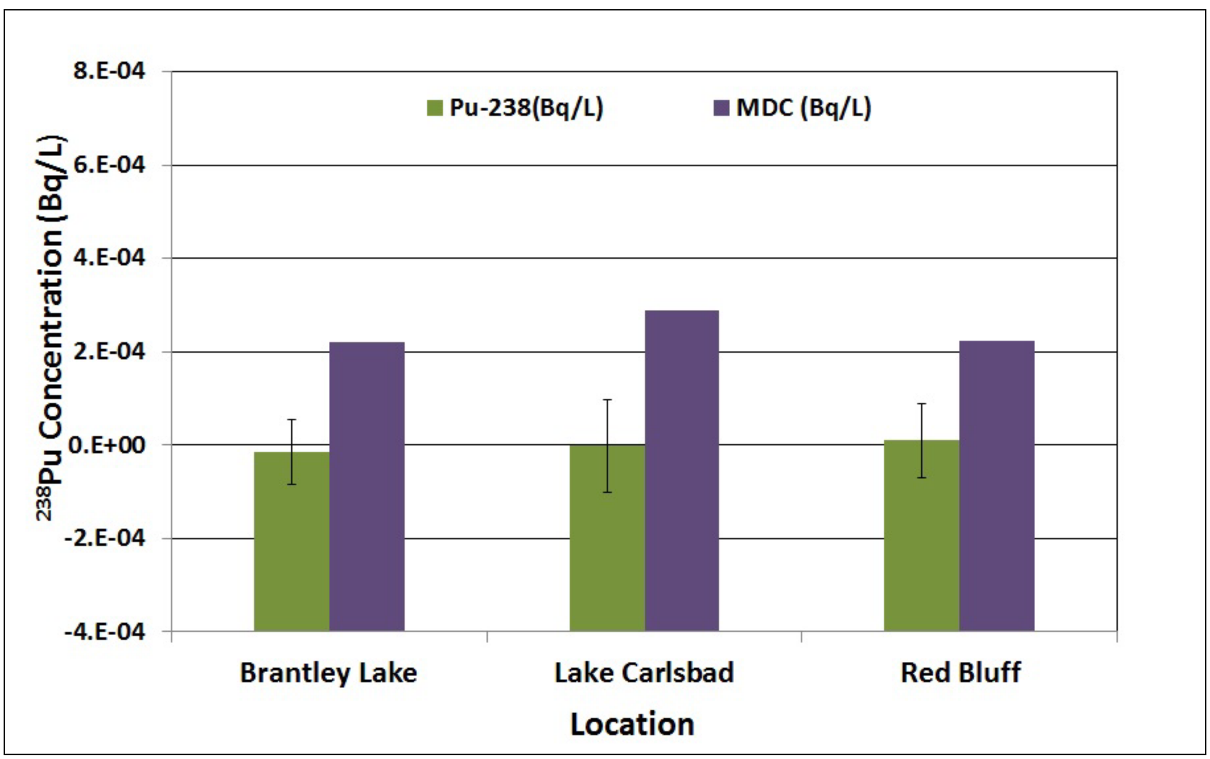


Figure 5-5: ^{238}Pu concentration in surface water samples in three regional reservoirs in 2015

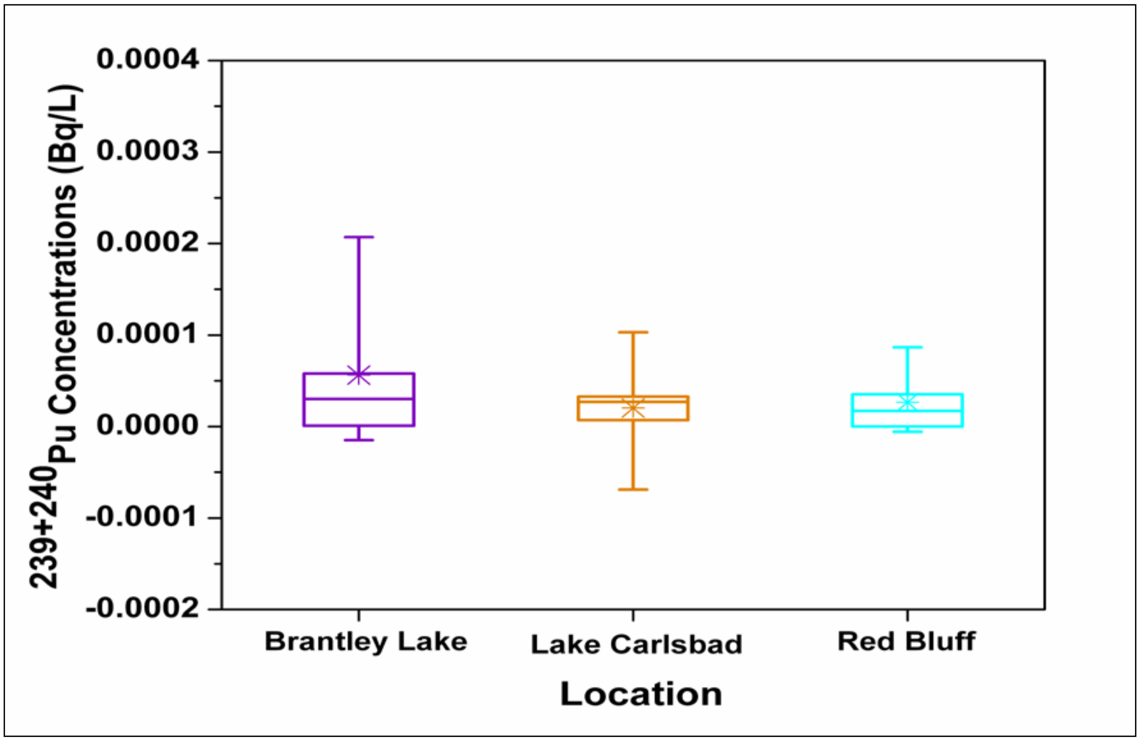


Figure 5-6: $^{239+240}Pu$ activity in regional surface water in three regional reservoirs from 1998 to 2015 (All samples are below MDC)

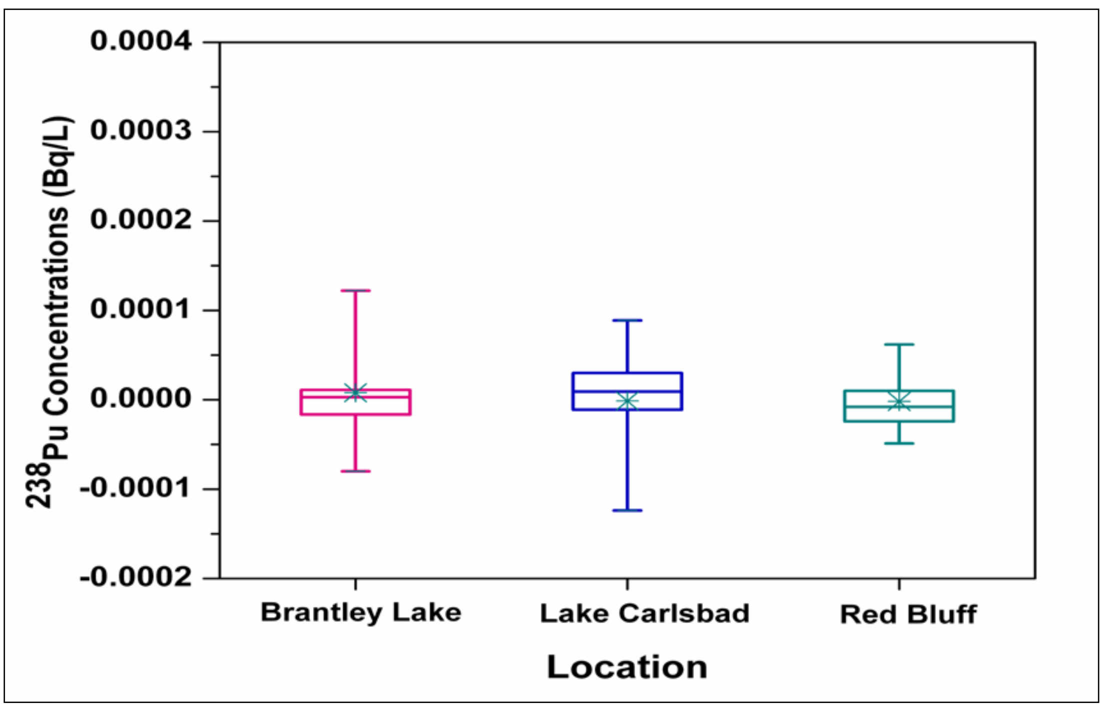


Figure 5-7: ^{238}Pu activity in regional surface water in three regional reservoirs from 1998 to 2015 (All samples are below MDC)

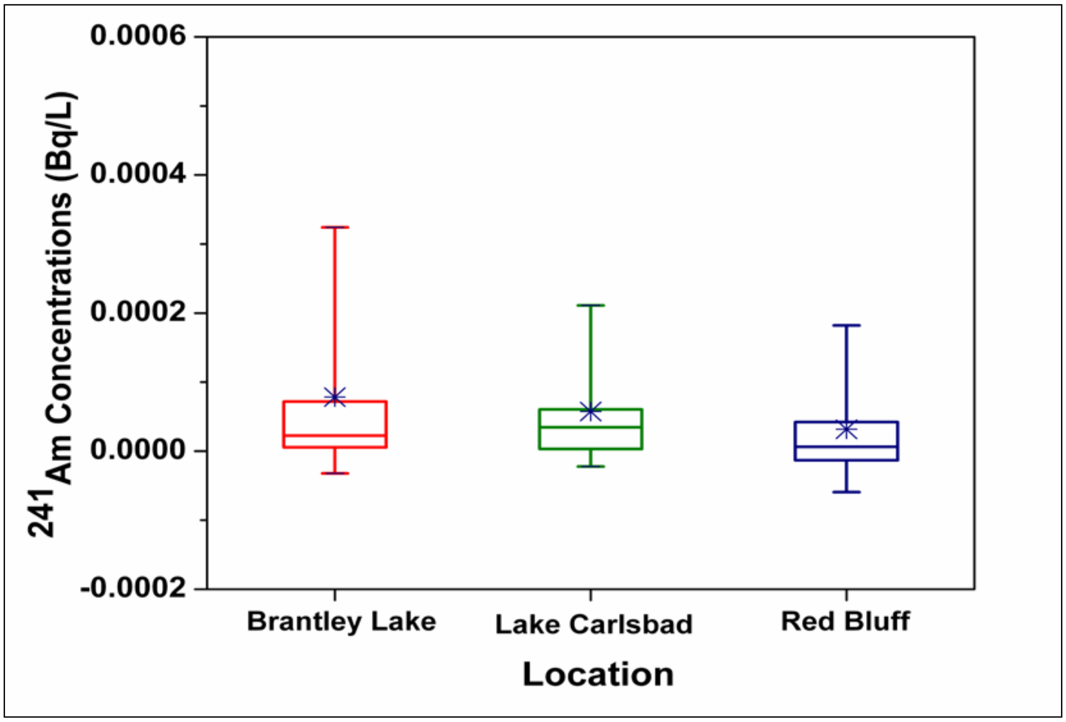


Figure 5-8: ^{241}Am activity in regional surface water in three regional reservoirs from 1998 to 2015 (All samples are below MDC)

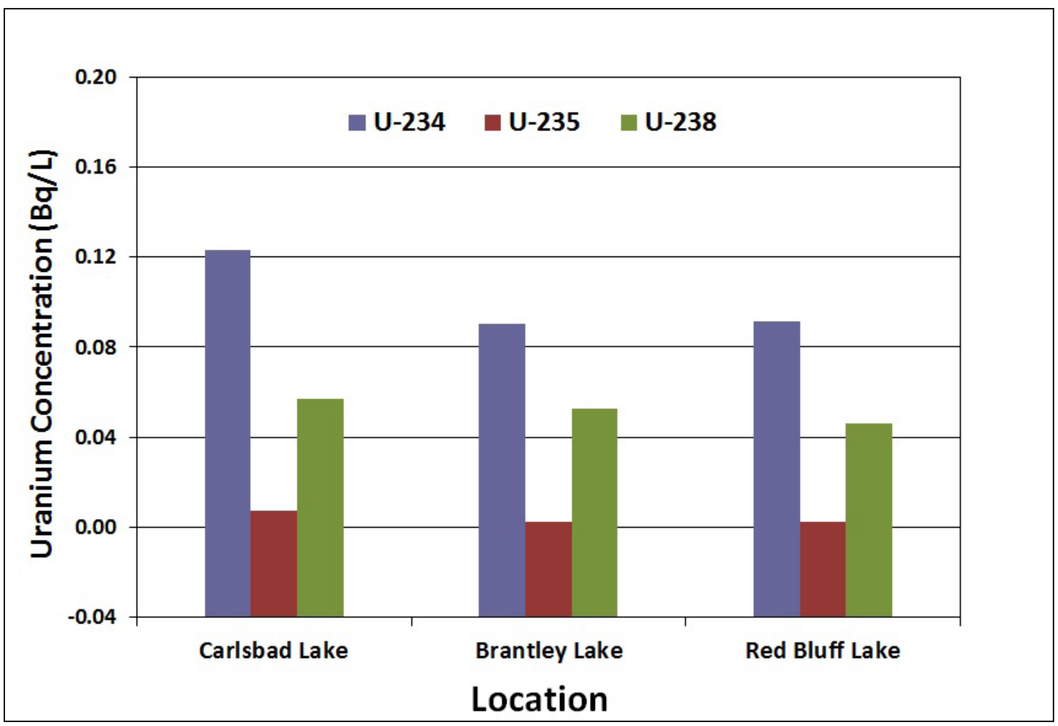


Figure 5-9: Uranium concentrations in surface water samples in three regional reservoirs in 2015

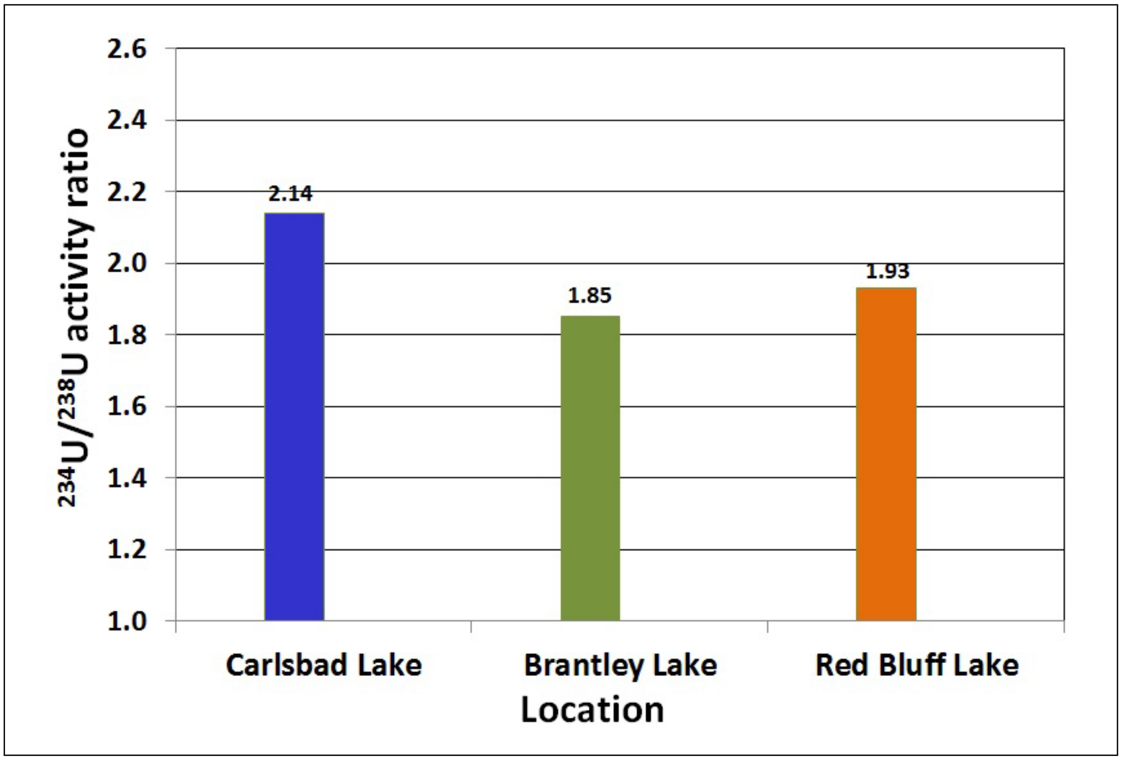


Figure 5-10: The $^{234}U/^{238}U$ Activity Ratio in surface water samples of three reservoirs in the vicinity of the WIPP site.

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 5-4, ***gamma radionuclides were not detected in any of the surface water samples collected in 2015***. However, ^{40}K was detected in 1998, 2000, and 2012 (CEMRC Annual Report, 1998, 2000, 2012) in surface water samples collected from Red Bluff Reservoir. 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. Since these isotopes were not regularly detected, no comparisons between years or among locations were performed.

Table 5-1: 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

Radionuclides	Location	Sample Date	Activity Bq/L	Unc. (2σ) Bq/L	MDC Bq/L	Status
^{241}Am	Red Bluff (shallow)	10/27/15	1.82E-04	1.45E-04	2.63E-04	Not Detected
	Red Bluff (deep)	10/27/15	9.96E-05	1.02E-04	2.08E-04	Not Detected
	Brantley (shallow)	10/22/15	7.17E-05	1.31E-04	3.05E-04	Not Detected
	Brantley (deep)	10/22/15	1.38E-04	1.09E-04	1.98E-04	Not Detected
	Carlsbad (Shallow)	10/21/15	9.34E-05	8.61E-05	1.64E-04	Not Detected
	Carlsbad (Deep)	10/21/15	1.71E-04	1.25E-04	2.29E-04	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/15	-2.22E-05	5.44E-05	1.76E-04	Not Detected
	Carlsbad (Deep) Duplicate	10/21/15	4.81E-05	1.08E-04	2.56E-04	Not Detected
	Blank	10/27/15	4.57E-05	7.93E-05	1.81E-04	Not Detected
$^{239+240}$Pu	Red Bluff (shallow)	10/27/15	3.51E-05	7.03E-05	1.63E-04	Not Detected
	Red Bluff (deep)	10/27/15	1.68E-05	5.84E-05	1.56E-04	Not Detected
	Brantley (shallow)	10/22/15	-1.50E-05	6.69E-05	2.10E-04	Not Detected
	Brantley (deep)	10/22/15	3.93E-12	8.07E-05	2.32E-04	Not Detected
	Carlsbad (Shallow)	10/21/15	4.40E-05	7.78E-05	1.76E-04	Not Detected
	Carlsbad (Deep)	10/21/15	2.97E-05	9.41E-05	2.35E-04	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/15	3.04E-05	7.47E-05	1.83E-04	Not Detected
	Carlsbad (Deep) Duplicate	10/21/15	1.90E-04	2.02E-04	3.82E-04	Not Detected
	Blank	10/27/15	-5.18E-05	9.16E-05	3.01E-04	Not Detected
^{238}Pu	Red Bluff (shallow)	10/27/15	3.51E-05	8.61E-05	2.11E-04	Not Detected
	Red Bluff (deep)	10/27/15	-1.68E-05	7.53E-05	2.37E-04	Not Detected
	Brantley (shallow)	10/22/15	-1.50E-05	5.18E-05	1.79E-04	Not Detected
	Brantley (deep)	10/22/15	-1.65E-05	8.72E-05	2.62E-04	Not Detected
	Carlsbad (Shallow)	10/21/15	5.87E-05	1.02E-04	2.33E-04	Not Detected
	Carlsbad (Deep)	10/21/15	2.97E-05	9.41E-05	2.35E-04	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/15	-3.04E-05	7.47E-05	2.42E-04	Not Detected
	Carlsbad (Deep) Duplicate	10/21/15	-6.35E-05	1.28E-04	4.47E-04	Not Detected
	Blank	10/27/15	6.91E-05	7.76E-05	1.27E-04	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

Radionuclides	Location	Sample Date	Activity Bq/L	Unc. (2σ) Bq/L	MDC Bq/L	Status
^{234}U	Red Bluff (shallow)	10/27/15	8.67E-02	1.00E-02	2.99E-04	Detected
	Red Bluff (deep)	10/27/15	9.14E-02	1.05E-02	3.09E-04	Detected
	Brantley (shallow)	10/22/15	9.02E-02	1.04E-02	4.34E-04	Detected
	Brantley (deep)	10/22/15	9.79E-02	1.17E-02	5.74E-04	Detected
	Carlsbad (Shallow)	10/21/15	1.13E-01	1.27E-02	2.88E-04	Detected
	Carlsbad (Deep)	10/21/15	1.23E-01	1.39E-02	2.36E-04	Detected
	Carlsbad (Shallow) Duplicate	10/21/15	1.06E-01	1.23E-02	4.07E-04	Detected
	Carlsbad (Deep) Duplicate	10/21/15	1.24E-01	1.40E-02	3.05E-04	Detected
	Blank	10/27/15	5.97E-04	2.27E-04	2.74E-04	Detected
^{235}U	Red Bluff (shallow)	10/27/15	2.10E-03	4.93E-04	2.99E-04	Detected
	Red Bluff (deep)	10/27/15	4.61E-02	5.43E-03	4.98E-04	Detected
	Brantley (shallow)	10/22/15	2.87E-03	6.08E-04	2.12E-04	Detected
	Brantley (deep)	10/22/15	2.50E-03	6.48E-04	5.25E-04	Detected
	Carlsbad (Shallow)	10/21/15	2.55E-03	5.26E-04	2.26E-04	Detected
	Carlsbad (Deep)	10/21/15	3.81E-03	7.11E-04	3.28E-04	Detected
	Carlsbad (Shallow) Duplicate	10/21/15	4.78E-03	8.68E-04	3.32E-04	Detected
	Carlsbad (Deep) Duplicate	10/21/15	7.13E-03	1.09E-03	2.82E-04	Detected
	Blank	10/27/15	-3.88E-05	1.34E-04	3.90E-04	Not Detected
^{238}U	Red Bluff (shallow)	10/27/15	4.61E-02	5.43E-03	5.73E-04	Detected
	Red Bluff (deep)	10/27/15	4.61E-02	5.43E-03	4.98E-04	Detected
	Brantley (shallow)	10/22/15	4.88E-02	5.79E-03	5.19E-04	Detected
	Brantley (deep)	10/22/15	5.29E-02	6.49E-03	9.27E-04	Detected
	Carlsbad (Shallow)	10/21/15	5.17E-02	5.97E-03	4.42E-04	Detected
	Carlsbad (Deep)	10/21/15	5.79E-02	6.70E-03	5.94E-04	Detected
	Carlsbad (Shallow) Duplicate	10/21/15	5.14E-02	6.11E-03	4.47E-04	Detected
	Carlsbad (Deep) Duplicate	10/21/15	5.72E-02	6.62E-03	4.40E-04	Detected
	Blank	10/27/15	3.13E-05	1.77E-04	4.41E-04	Not 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

Radionuclides	Location	Sample Date	Activity Bq/L	Unc. (2σ) Bq/L	MDC Bq/L	Status
^{137}Cs	Red Bluff (shallow)	10/27/2015	4.45E-02	2.86E-02	9.40E-02	Not Detected
	Red Bluff (deep)	10/27/2015	8.07E-03	2.87E-02	9.52E-02	Not Detected
	Brantley (shallow)	10/22/2015	3.41E-02	2.85E-02	9.40E-02	Not Detected
	Brantley (deep)	10/22/2015	-5.64E-03	2.87E-02	9.53E-02	Not Detected
	Carlsbad (Shallow)	10/21/2015	3.70E-02	2.82E-02	9.27E-02	Not Detected
	Carlsbad (Deep)	10/21/2015	3.33E-02	2.79E-02	9.19E-02	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/2015	2.37E-02	2.86E-02	9.43E-02	Not Detected
	Carlsbad (Deep) Duplicate	10/21/2015	-2.23E-03	2.87E-02	9.54E-02	Not Detected
	Blank	10/27/15	3.36E-02	2.86E-02	9.42E-02	Not Detected
^{40}K	Red Bluff (shallow)	10/27/2015	7.33E-01	3.40E-01	1.11E+00	Not Detected
	Red Bluff (deep)	10/27/2015	7.09E-01	3.37E-01	1.10E+00	Not Detected
	Brantley (shallow)	10/22/2015	7.35E-01	3.35E-01	1.10E+00	Not Detected
	Brantley (deep)	10/22/2015	2.09E-01	3.38E-01	1.12E+00	Not Detected
	Carlsbad (Shallow)	10/21/2015	6.76E-01	3.31E-01	1.08E+00	Not Detected
	Carlsbad (Deep)	10/21/2015	-1.67E-01	3.37E-01	1.12E+00	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/2015	2.46E-01	3.36E-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 (continued)

Radionuclides	Location	Sample Date	Activity Bq/L	Unc. (2σ) Bq/L	MDC Bq/L	Status
^{40}K	Carlsbad (Deep) Duplicate	10/21/2015	1.08E-01	3.43E-01	1.14E+00	Not Detected
	Blank	10/27/15	2.15E-01	3.33E-01	1.10E+00	Not Detected
^{60}Co	Red Bluff (shallow)	10/27/2015	5.15E-02	2.61E-02	8.55E-02	Not Detected
	Red Bluff (deep)	10/27/2015	2.17E-02	2.64E-02	8.72E-02	Not Detected
	Brantley (shallow)	10/22/2015	1.61E-02	2.68E-02	8.86E-02	Not Detected
	Brantley (deep)	10/22/2015	3.07E-03	2.66E-02	8.84E-02	Not Detected
	Carlsbad (Shallow)	10/21/2015	1.81E-02	2.65E-02	8.78E-02	Not Detected
	Carlsbad (Deep)	10/21/2015	9.75E-03	2.66E-02	8.83E-02	Not Detected
	Carlsbad (Shallow) Duplicate	10/21/2015	3.65E-02	2.67E-02	8.80E-02	Not Detected
	Carlsbad (Deep) Duplicate	10/21/2015	-2.87E-02	2.77E-02	9.28E-02	Not Detected
	Blank	10/27/15	3.28E-02	2.66E-02	8.76E-02	Not Detected

Inorganic Analysis of Surface Water Samples

Surface water samples from the three previously mentioned reservoirs were also analyzed in 2015 for inorganic constituents that are likely to be found in the waste emplaced within the WIPP facility. Each 1L sample collected for anion analysis was refrigerated immediately upon arrival at the CEMRC laboratory and analyzed within 48 hours of collection. All samples were filtered prior to analysis. Due to the high salt content, all samples were diluted prior to analysis. Sample results were blank-corrected if applicable. Only concentrations above laboratory MDC values were reported.

For mercury analysis, the samples collected in 500mL containers were preserved with a bromomonochloride solution upon receipt by the CEMRC laboratory. All samples were filtered prior to direct analysis (no sample dilution was necessary). For inorganic analysis, all samples were diluted using a similar nitric acid matrix and then filtered prior to analysis by ICP-MS. For both mercury and inorganic analyses, aliquots were blank-corrected after the application of dilution factors (if dilutions were used). As per the CEMRC procedure, only concentrations above laboratory MDC values were reported.

Results and Discussion (Inorganic Analysis of Surface Water)

The 2015 inorganic results and how they compare to past data are summarized in Tables **5-5, 5-6, and 5-7** for the three regional water sources. The results exhibited in these Tables are not used in assessing regulatory compliance. Tables presenting the surface water data summarized herein (and also previous years) are available on the CEMRC web site at http://www.cemrc.org.

Minerals are a natural part of all water sources. The amount of elemental and inorganic materials in surface water is determined primarily by local geology and topography, but it can be influenced by urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, and/or farming, etc. The elemental constituents, As, Ba, Cr, Cu, Pb, Sb, and U are naturally found in water sources of the southwest. (http://www.midlandtexas.gov/ArchiveCenter/ViewFile/Item/152).

The majority of all analytes measured were detected in each of the samples with the exceptions of Silver (Ag), Tin (Sn), bromide, and phosphate which have never been detected in the 3 surface water locations. Mercury (Hg) was not detected in any of the surface water samples this year, although it has been detected in all three water reservoirs in the past. The high salt load could be explained by intersection of the salt-bed outcrops of the Salado formation by the Pecos River upstream from Red Bluff Reservoir and downstream from Brantley Lake and Lake Carlsbad. It could also be attributed to drier weather.

Present results, as well as the results of previous analyses for surface water, are consistent for each source across sampling periods. No noticeable increases in the elemental or inorganic levels have been observed in the regional surface water following the WIPP site's acceptance of mixed waste in August of 2000. More importantly, no noticeable increases in the elemental or inorganic levels have been observed following the February 2014 WIPP underground fire and radiation events either.

Table 5-5: Range of Concentrations for Inorganic Constituents in Lake Carlsbad Surface Water Samples Collected from 1999 – 2015

Lake Carlsbad							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
Ag	12	0	N/A	N/A	4.45e-001	<MDC	<MDC
Al	12	12	5.69e+001	5.03e+002	8.20e+000	1.14e+002	1.33e+002
As	12	7	1.23e+000	1.22e+001	2.15e+001	<MDC	<MDC
B	2	2	1.97e+002	2.25e+002	N/A	N/A	N/A
Ba	12	12	1.73e+001	3.30e+001	4.20e+000	2.18e+001	2.15e+001
Be	12	4	1.51e-002	1.47e-001	2.20e+000	<MDC	<MDC
Bromide	1	0	N/A	N/A	3.65e+002	<MDC	4.10e+002
Ca	10	10	3.03e+005	4.19e+005	6.40e+002	3.91e+005	3.90e+005
Cd	10	1	9.00e-002	9.00e-002	6.50e+000	<MDC	<MDC
Ce	12	8	8.08e-002	4.87e-001	N/A	N/A	N/A
Chloride	8	8	4.14e+005	1.06e+006	6.40e+002	8.26e+005	8.65e+005
Co	12	10	6.58e-001	5.22e+000	3.45e-001	7.06e-001	6.91e-001
Cr	10	6	3.02e-001	4.42e+000	5.00e+000	<MDC	<MDC
Cu	10	8	2.63e+000	1.13e+001	4.25e+000	<MDC	<MDC
Dy	12	5	6.67e-003	1.00e-001	N/A	N/A	N/A
Er	12	5	1.17e-003	1.16e-001	8.00e-002	4.25e-001	<MDC
Eu	12	4	6.54e-003	1.81e-002	1.70e-001	4.30e-001	<MDC

Table 5-5: Range of Concentrations for Inorganic Constituents in Lake Carlsbad Surface Water Samples Collected from 1999 – 2015 (continued)

Lake Carlsbad							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
Fe	12	12	7.60e+001	3.96e+003	9.00e+001	1.14e+003	1.29e+003
Fluoride	5	4	5.48e+002	1.05e+003	6.50e+001	9.10e+002	9.05e+002
Gd	12	6	9.10e-003	1.03e-001	1.65e-001	3.64e-001	<MDC
Hg	8	3	2.82e-002	4.24e-001	3.00e-002	<MDC	<MDC
K	12	12	4.41e+003	1.24e+004	5.35e+002	5.55e+003	5.80e+003
La	12	7	4.29e-002	2.21e-001	1.35e-001	5.17e-001	<MDC
Li	8	8	3.95e+001	7.75e+001	1.35e+000	4.26e+001	4.42e+001
Mg	12	12	9.05e+004	1.51e+005	7.00e+000	1.22e+005	1.22e+005
Mn	8	7	8.47e+000	6.65e+001	8.00e-001	2.82e+001	3.20e+001
Mo	12	12	2.65e+000	5.17e+000	1.45e+000	2.81e+000	2.32e+000
Na	10	10	3.17e+005	5.06e+005	2.50e+001	4.02e+005	4.02e+005
Nd	12	8	3.79e-002	2.31e-001	2.60e-001	6.65e-001	<MDC
Ni	12	12	2.33e+000	2.29e+001	3.80e+000	1.37e+001	1.35e+001
Nitrate	4	2	3.16e+003	6.28e+003	4.95e+002	5.40e+003	5.70e+003
Nitrite	3	2	4.38e+004	6.41e+004	1.85e+002	<MDC	<MDC
P	6	6	8.35e+001	1.39e+003	2.95e+002	5.65e+002	4.35e+002
Pb	12	10	1.73e-001	2.65e+000	2.05e-001	4.01e+000	1.34e+000
Phosphate	2	0	N/A	N/A	5.50e+002	<MDC	<MDC
Pr	10	5	1.11e-002	8.35e-002	1.25e-001	4.71e-001	<MDC
Sb	12	1	1.17e-001	1.17e-001	1.25e+000	<MDC	<MDC
Sc	6	4	2.81e+000	4.72e+000	2.90e+000	3.15e+000	<MDC
Se	10	3	5.54e-001	3.56e+001	6.00e+001	<MDC	<MDC
Si	4	4	7.15e+003	8.08e+003	3.85e+002	9.53e+003	8.95e+003
Sm	8	3	1.51e-002	5.94e-002	N/A	N/A	N/A
Sn	4	0	N/A	N/A	N/A	N/A	N/A
Sr	12	12	4.16e+003	6.15e+003	2.40e+000	5.32e+003	5.55e+003
Sulfate	8	8	7.54e+005	2.01e+006	1.50e+003	1.29e+006	1.33e+006
Th	12	9	9.10e-003	1.85e-001	1.10e-001	5.01e-001	<MDC
Ti	2	2	8.56e+000	1.40e+001	N/A	N/A	N/A
Tl	12	6	1.20e-001	1.99e-001	1.50e-001	2.47e-001	1.63e-001
U	12	12	3.56e+000	9.17e+000	2.85e-001	3.99e+000	4.13e+000
V	10	10	6.13e+000	9.31e+000	9.00e-001	5.05e+000	5.87e+000
Zn	10	6	5.93e+000	2.78e+002	2.55e+002	<MDC	<MDC

[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]For Lake Carlsbad, "Shallow" measurements were taken at 0.5m from the surface while "Deep" measurements were taken at 2.35m from the sediment bed;
[6]Concentrations below the MDC are reported as <MDC;
N/A = Not Applicable

Table 5-6: Range of Concentrations for Inorganic Constituents in Brantley Lake Surface Water Samples Collected from 1999 – 2015

Brantley Lake							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
Ag	12	1	1.03e-002	1.03e-002	4.45e-001	<MDC	<MDC
Al	12	11	2.62e+001	4.90e+002	1.02e+001	4.78e+001	7.11e+002
As	13	10	1.21e+000	5.86e+001	2.15e+001	<MDC	<MDC
B	2	2	2.09e+002	2.18e+002	N/A	N/A	N/A
Ba	12	12	3.03e+001	9.23e+001	4.20e+000	8.05e+001	9.03e+001
Be	12	3	1.92e-002	1.43e-001	2.20e+000	<MDC	<MDC
Bromide	1	0	N/A	N/A	7.30e+002	<MDC	<MDC
Ca	10	10	3.46e+005	6.67e+005	6.40e+002	3.67e+005	3.72e+005
Cd	10	0	N/A	N/A	6.50e+000	<MDC	<MDC
Ce	12	9	5.71e-002	4.90e-001	N/A	N/A	N/A
Chloride	11	11	5.10e+005	2.20e+006	3.20e+002	7.67e+005	7.56e+005
Co	12	10	8.68e-001	6.76e+000	3.45e-001	7.31e-001	9.70e-001
Cr	10	6	3.17e-001	1.80e+001	5.00e+000	<MDC	<MDC
Cu	10	7	3.10e+000	8.07e+000	4.25e+000	<MDC	<MDC
Dy	12	6	5.79e-003	1.55e-001	N/A	N/A	N/A
Er	12	3	3.52e-003	2.16e-002	8.00e-002	<MDC	2.21e-001
Eu	12	5	1.55e-002	3.35e-002	1.70e-001	<MDC	2.29e-001
Fe	12	12	5.30e+001	2.26e+003	9.00e+001	1.13e+003	1.77e+003
Fluoride	6	5	5.30e+002	1.98e+003	1.30e+002	5.20e+002	5.30e+002
Gd	12	5	7.34e-003	1.91e-001	1.65e-001	<MDC	3.25e-001
Hg	8	1	1.77e-001	1.77e-001	3.00e-002	<MDC	<MDC
K	12	12	4.67e+003	1.51e+004	5.35e+002	7.66e+003	8.07e+003
La	12	8	3.38e-002	2.92e-001	1.35e-001	<MDC	6.36e-001
Li	8	8	3.50e+001	7.77e+001	1.35e+000	3.68e+001	3.76e+001
Mg	12	12	9.31e+004	2.01e+005	7.00e+000	9.58e+004	9.59e+004
Mn	8	7	8.98e+000	7.53e+002	8.00e-001	9.43e+001	1.37e+002
Mo	12	12	2.41e+000	5.01e+000	1.45e+000	3.34e+000	3.97e+000
Na	10	10	3.50e+005	1.25e+006	2.50e+001	4.11e+005	4.06e+005
Nd	12	8	3.34e-002	4.24e-001	2.60e-001	<MDC	5.34e-001
Ni	12	12	3.65e+000	2.91e+001	3.80e+000	1.34e+001	1.40e+001
Nitrate	4	2	1.02e+004	9.54e+004	9.90e+002	<MDC	<MDC
Nitrite	3	2	6.96e+004	1.20e+005	3.70e+002	<MDC	<MDC

Table 5-6: Range of Concentrations for Inorganic Constituents in Brantley Lake Surface Water Samples Collected from 1999 – 2015 (continued)

Brantley Lake							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
P	6	6	1.27e+002	5.13e+003	2.95e+002	8.21e+002	6.08e+002
Pb	12	8	2.64e-001	1.00e+000	2.05e-001	8.58e-001	1.37e+000
Phosphate	2	0	N/A	N/A	1.10e+003	<MDC	<MDC
Pr	10	5	1.08e-002	1.92e-001	1.25e-001	<MDC	3.40e-001
Sb	12	4	2.54e-001	3.01e-001	1.25e+000	<MDC	<MDC
Sc	6	2	9.33e-001	1.56e+000	2.90e+000	<MDC	<MDC
Se	10	3	2.82e+001	1.86e+002	6.00e+001	<MDC	<MDC
Si	4	3	3.01e+003	5.13e+003	3.85e+002	6.42e+003	8.13e+003
Sm	8	4	2.00e-002	5.67e-002	N/A	N/A	N/A
Sn	4	0	N/A	N/A	N/A	N/A	N/A
Sr	12	12	5.00e+003	1.02e+004	2.40e+000	5.79e+003	5.90e+003
Sulfate	11	11	1.02e+006	2.61e+006	3.75e+003	1.22e+006	1.25e+006
Th	12	7	1.67e-002	4.07e-001	1.10e-001	<MDC	2.29e-001
Ti	2	0	N/A	N/A	N/A	N/A	N/A
Tl	12	1	4.81e-002	4.81e-002	1.50e-001	<MDC	<MDC
U	12	12	3.32e+000	7.94e+000	2.85e-001	3.86e+000	3.70e+000
V	10	10	3.47e+000	7.02e+000	9.00e-001	6.09e+000	7.14e+000
Zn	10	6	1.07e+001	3.75e+002	2.55e+002	<MDC	<MDC
Ag	12	1	1.03e-002	1.03e-002	4.45e-001	<MDC	<MDC

[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]For Brantley Lake, "Shallow" measurements were taken at 0.5m from the surface while "Deep" measurements were taken at 9.36m from the sediment bed;

[6]Concentrations below the MDC are reported as <MDC;

N/A = Not Applicable

Table 5-7: Range of Concentrations for Inorganic Constituents in Red Bluff Surface Water Samples Collected from 1999 – 2015

Red Bluff							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
Ag	11	0	N/A	N/A	4.45e-001	<MDC	<MDC
Al	11	8	1.65e+001	3.96e+002	4.10e+001	<MDC	<MDC
As	12	10	1.96e+000	1.69e+002	2.15e+001	<MDC	<MDC
B	2	2	3.72e+002	3.76e+002	N/A	N/A	N/A
Ba	11	11	6.83e+001	1.37e+002	4.20e+000	8.06e+001	8.31e+001
Be	11	4	3.28e-002	2.68e-001	2.20e+000	<MDC	<MDC
Bromide	1	0	N/A	N/A	1.46e+003	<MDC	<MDC
Ca	10	10	4.19e+005	8.99e+005	6.40e+002	4.24e+005	4.20e+005
Cd	9	4	4.11e-001	7.73e+001	6.50e+000	<MDC	<MDC
Ce	11	7	3.93e-002	5.71e-001	N/A	N/A	N/A
Chloride	10	10	1.52e+006	4.71e+006	6.40e+002	1.14e+006	1.13e+006
Co	11	11	8.16e-001	6.01e+000	3.45e-001	7.66e-001	8.42e-001
Cr	9	4	1.86e+000	3.86e+001	5.00e+000	<MDC	<MDC
Cu	9	5	6.73e+000	8.87e+000	4.25e+000	<MDC	<MDC
Dy	11	3	2.99e-003	4.24e-002	N/A	N/A	N/A
Er	11	2	2.08e-003	8.34e-003	8.00e-002	<MDC	<MDC
Eu	11	6	2.36e-002	6.86e-002	1.70e-001	<MDC	<MDC
Fe	11	11	3.38e+001	3.29e+003	9.00e+001	1.19e+003	1.27e+003
Fluoride	7	4	6.67e+002	3.77e+003	2.60e+002	6.40e+002	6.40e+002
Gd	11	4	1.44e-002	8.33e-002	1.65e-001	<MDC	<MDC
Hg	7	2	6.12e-002	2.14e-001	3.00e-002	<MDC	<MDC
K	12	12	1.92e+004	8.39e+004	5.35e+002	1.60e+004	1.60e+004
La	11	6	3.51e-002	4.47e-001	1.35e-001	<MDC	<MDC
Li	6	6	6.19e+001	1.34e+002	1.35e+000	4.43e+001	4.30e+001
Mg	12	12	1.24e+005	4.10e+005	7.00e+000	1.20e+005	1.20e+005
Mn	8	8	3.85e+001	2.97e+002	8.00e-001	6.47e+001	7.14e+001
Mo	11	7	3.44e+000	5.82e+000	1.45e+000	3.16e+000	3.46e+000
Na	10	10	7.21e+005	2.65e+006	2.50e+002	5.88e+005	5.79e+005
Nd	11	3	2.06e-002	6.47e-002	2.60e-001	<MDC	<MDC
Ni	11	11	1.24e+001	3.25e+001	3.80e+000	1.48e+001	1.46e+001
Nitrate	5	3	2.38e+003	1.20e+005	1.98e+003	<MDC	<MDC
Nitrite	3	2	1.57e+005	2.48e+005	7.40e+002	<MDC	<MDC
P	6	6	1.33e+002	1.16e+004	2.95e+002	<MDC	5.92e+002
Pb	11	8	2.62e-001	3.24e+000	2.05e-001	2.84e+000	5.63e-001
Phosphate	3	1	5.68e+003	5.68e+003	2.20e+003	<MDC	<MDC
Pr	9	3	7.11e-003	7.55e-002	1.25e-001	<MDC	<MDC
Sb	11	7	2.47e-001	4.83e-001	1.25e+000	<MDC	<MDC

Table 5-7: Range of Concentrations for Inorganic Constituents in Red Bluff Surface Water Samples Collected from 1999 – 2015 (continued)

Red Bluff							
1999 - 2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Shallow[5] Sample Conc. (µg/L)[6]	Deep[5] Sample Conc. (µg/L)[6]
Sc	6	1	5.93e-001	5.93e-001	2.90e+000	<MDC	<MDC
Se	10	4	8.37e+001	5.29e+002	6.00e+001	<MDC	<MDC
Si	4	0	N/A	N/A	3.85e+002	5.63e+003	5.90e+003
Sm	7	3	3.80e-002	4.71e-002	N/A	N/A	N/A
Sn	3	0	N/A	N/A	N/A	N/A	N/A
Sr	12	12	5.76e+003	1.50e+004	6.00e+000	6.38e+003	6.46e+003
Sulfate	10	10	1.77e+006	3.23e+006	1.50e+003	1.37e+006	1.35e+006
Th	11	6	4.68e-003	4.77e-001	1.10e-001	<MDC	<MDC
Ti	2	2	9.92e+000	1.30e+001	N/A	N/A	N/A
Tl	11	0	N/A	N/A	1.50e-001	<MDC	<MDC
U	11	11	4.70e+000	1.23e+001	2.85e-001	3.28e+000	3.41e+000
V	9	9	3.37e+000	2.07e+001	9.00e-001	2.42e+000	3.08e+000
Zn	9	5	6.21e+000	1.30e+003	2.55e+002	<MDC	<MDC
Ag	11	0	N/A	N/A	4.45e-001	<MDC	<MDC

[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]For Red Bluff, "Shallow" measurements were taken at 0.5m from the surface while "Deep" measurements were taken at 3.26m from the sediment bed;
[6]Concentrations below the MDC are reported as <MDC;
N/A = Not Applicable

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. Assuming measured activities were high enough, 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 in October, 2015. 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. 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 WIPP related activities or to the February, 2014 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.

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

Four site locations at each lake were identified using sonar and a combination of triangulation to known shoreline locations and GPS coordinates established during the 1998 and 1999 sampling seasons. These locations fall within the deep basins of each reservoir. Deep basins were chosen for sampling to minimize the disturbance and particle mixing effects of current and wave action that occur at shallower depths. Also, many of the analytes of interest tend to concentrate 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, approximately 5g 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 were 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 were then separated and purified using a two-column anion exchange resin (Dowex1-× 8, 100-200 mesh), while TRU chromatography columns were used for the separation of Am and U. The Am fraction was subsequently purified from lanthanides using a TEVA column. The samples were then micro-co-precipitated using an Nd-carrier and counted on the alpha spectrometer for five days.

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 5-10. 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 <MDC -0.16 mBq/g, while that of $^{239+240}$Pu varied from 0.097-0.28 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 in 2015 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 in 2015 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 Lake Carlsbad (0.19 mBq/g) and lowest in Red Bluff reservoir (0.063 mBq/g). 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 in 2015 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 2015. The concentrations of uranium isotopes measured in the sediment samples are summarized in Table 5-9. The concentrations range of uranium isotopes measured in the sediment samples collected from all three reservoirs for 2015 are shown in Figure 5-15 and historically in Figures 5-16 and 5-17. 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 were lowest in Lake Carlsbad, and highest in Red Bluff reservoir, while that of ^{234}U were lowest in Brantley Lake and highest in Red Bluff. 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 1.26 to 1.67 (Figure 5-18).

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 5-10. The ^{137}Cs was detected in all sediment samples collected (Table 5-10). Variability among the ^{137}Cs concentrations was not very significant. Maximum activity concentrations for ^{137}Cs (5.56 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 5-10). 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 5-10, the ^{60}Co were not detected at any sampling location. Comparison of activity concentrations of ^{137}Cs and ^{40}K determined in 2015 to that of the baseline and monitoring phase activities reflects no increase in radionuclide concentrations (Figures 5-19 and 5-20).

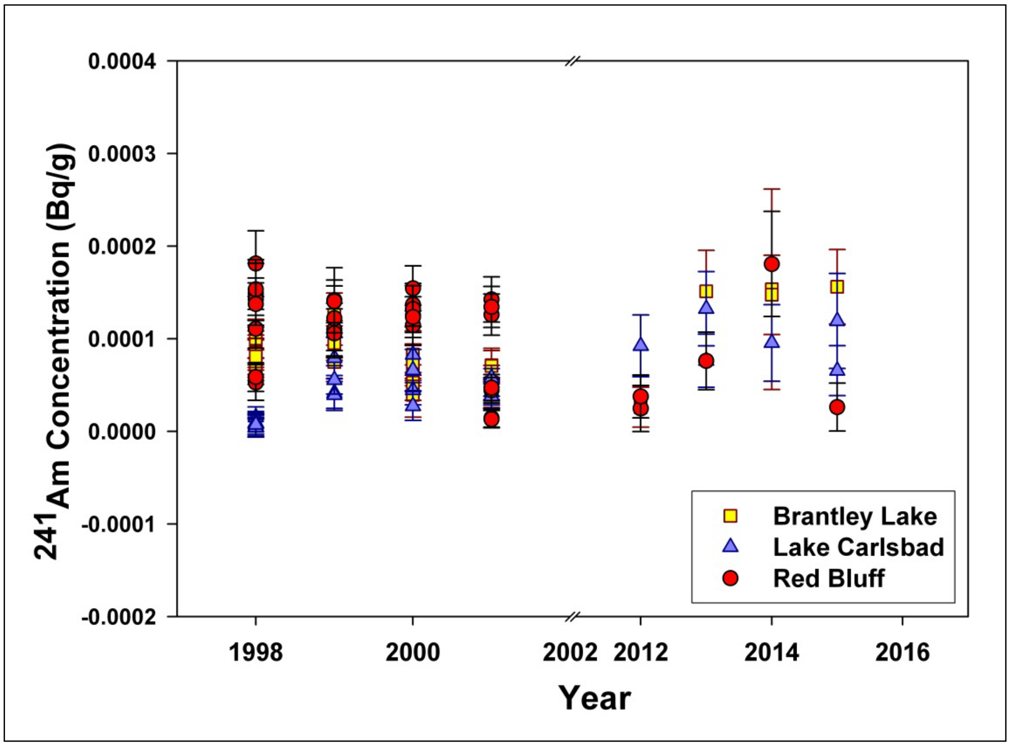


Figure 5-12: The Pre- and Post-radiological event sediment concentrations of ^{241}Am from the three reservoirs in the vicinity of the WIPP site

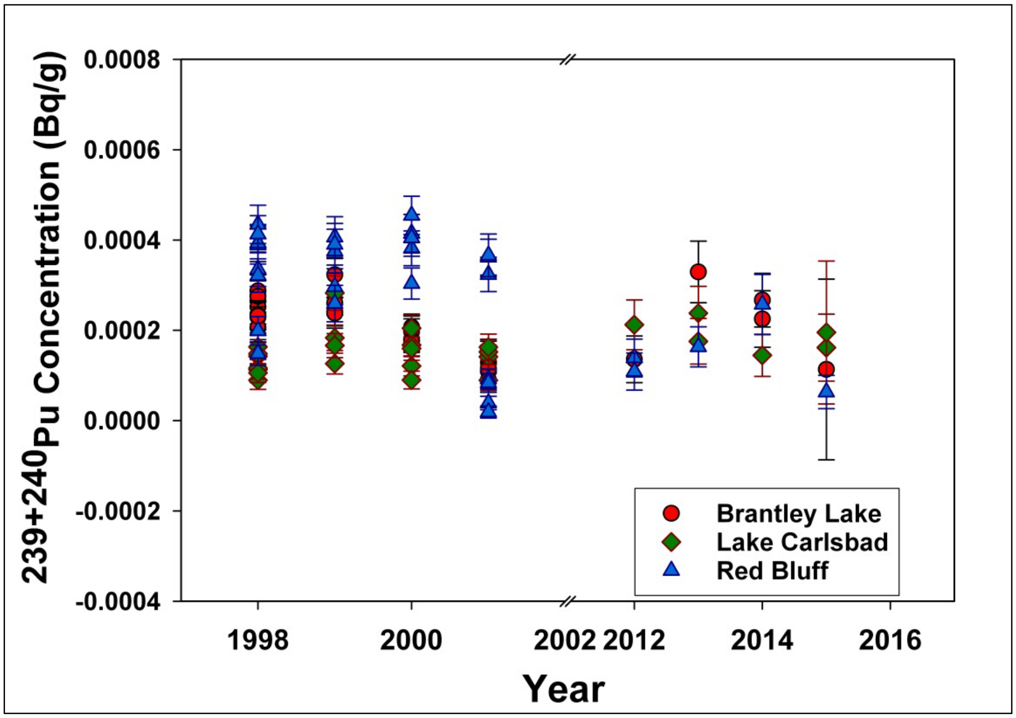


Figure 5-13: The Pre- and Post-radiological event sediment concentrations of $^{239+240}$Pu from the three reservoirs in the vicinity of the WIPP site

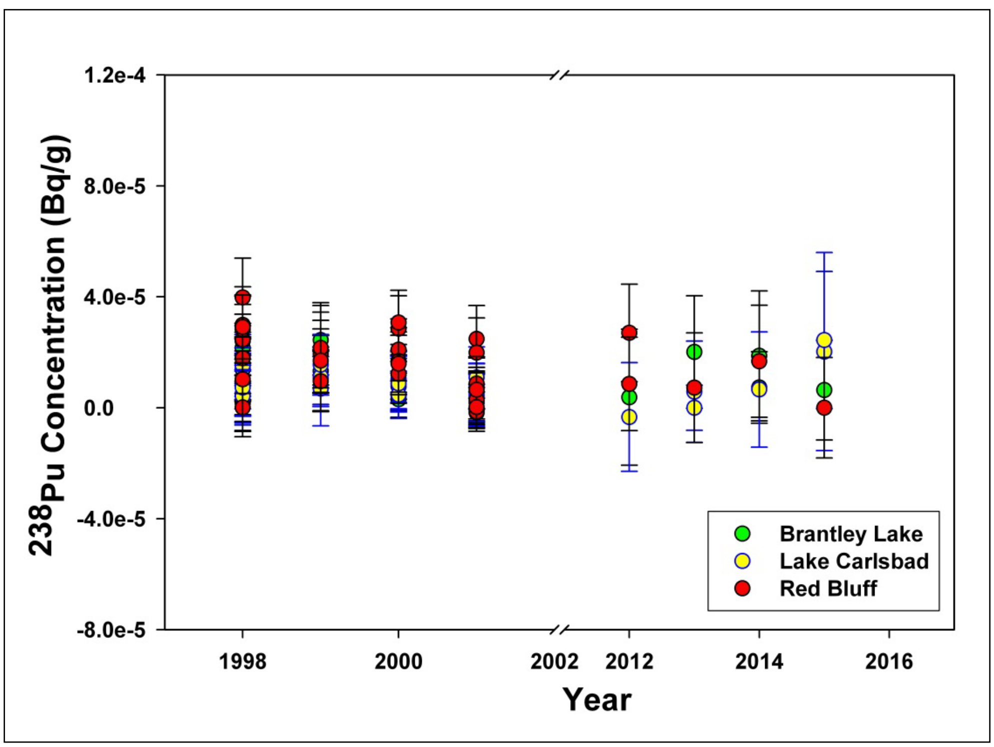


Figure 5-14: The Pre- and Post-radiological event sediment concentrations of ^{238}Pu from the three reservoirs in the vicinity of the WIPP site

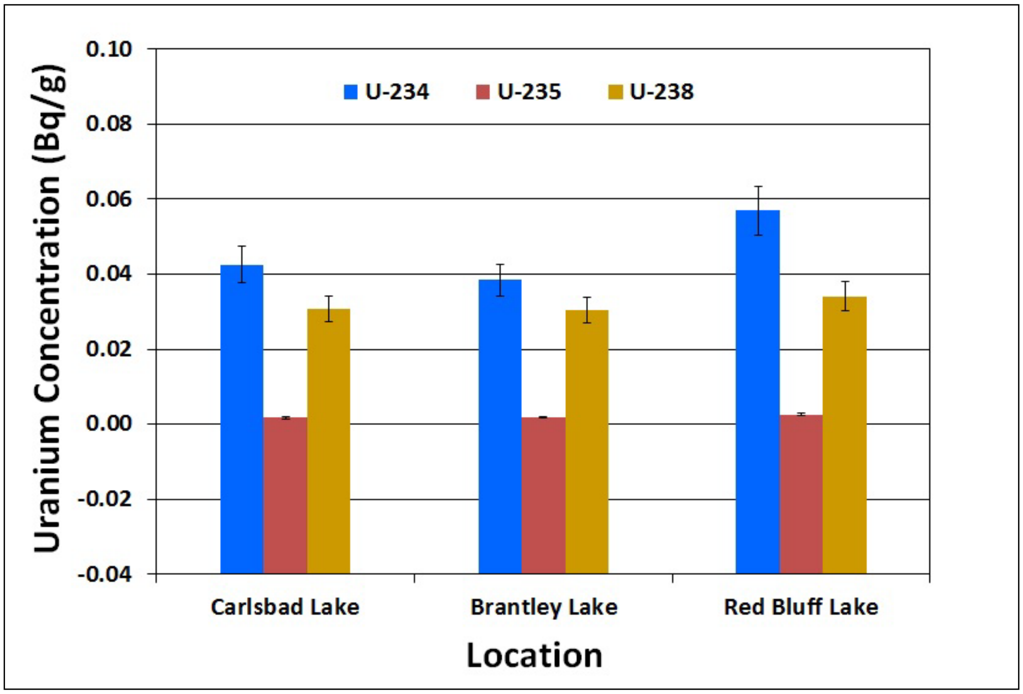


Figure 5-15: Uranium concentrations in sediment samples in three regional reservoirs in 2015

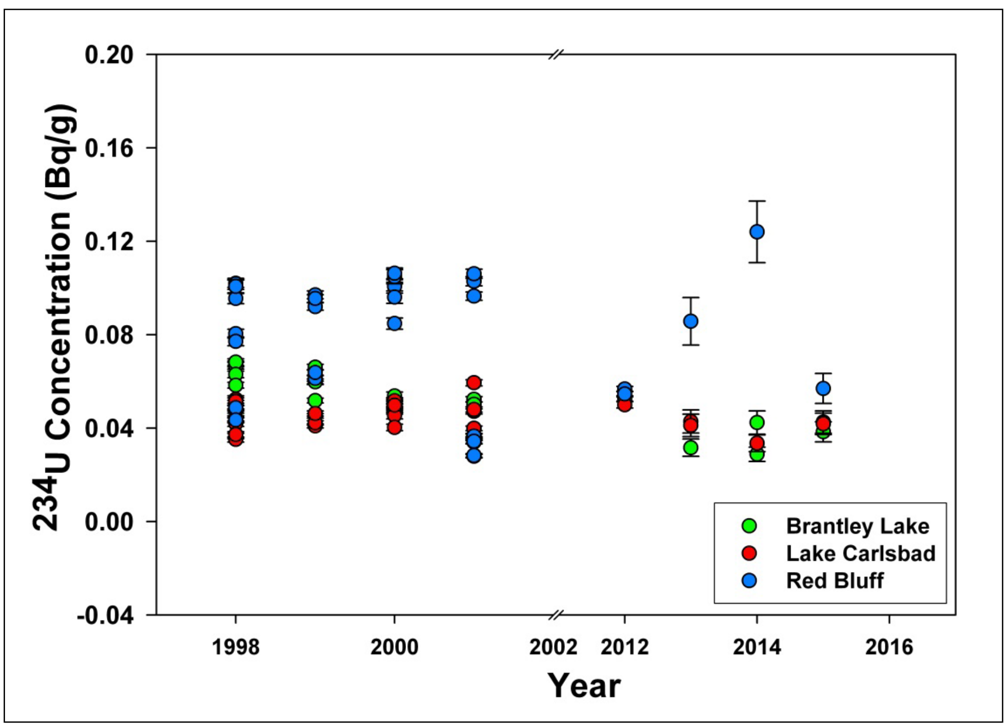


Figure 5-16: The Pre- and Post-radiological event sediment concentrations of ^{234}U from the three reservoirs in the vicinity of the WIPP site

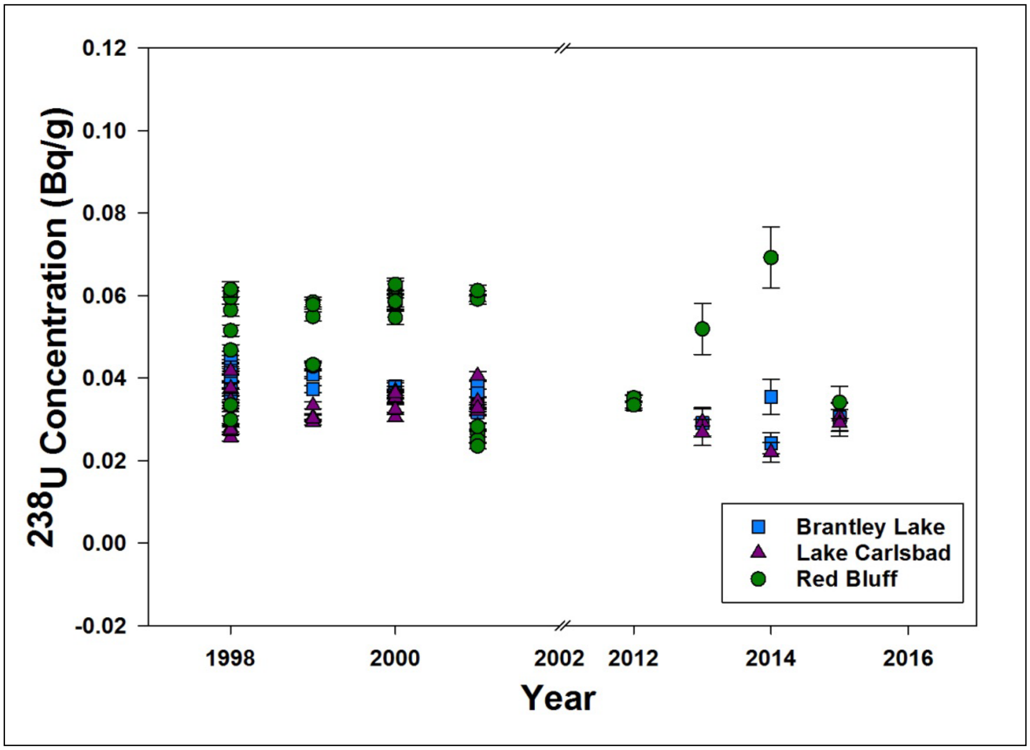


Figure 5-17: The Pre- and Post-radiological event sediment concentrations of ^{238}U from the three reservoirs in the vicinity of the WIPP site

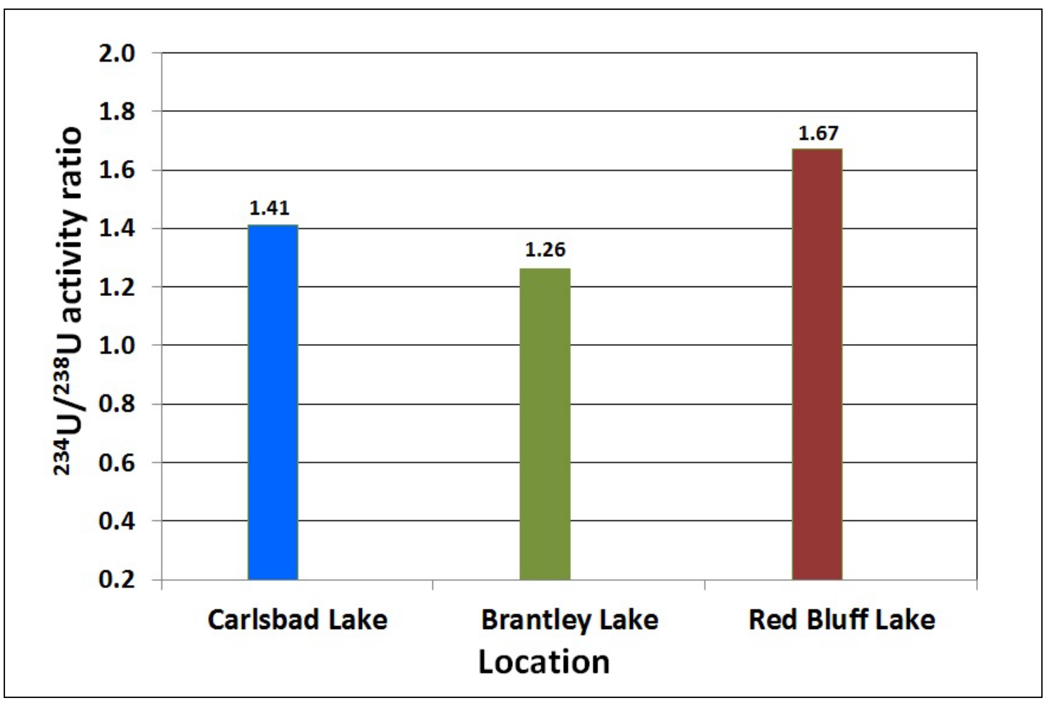


Figure 5-18: The $^{234}U/^{238}U$ Activity Ratio in sediment samples of three reservoirs in the vicinity of the WIPP site

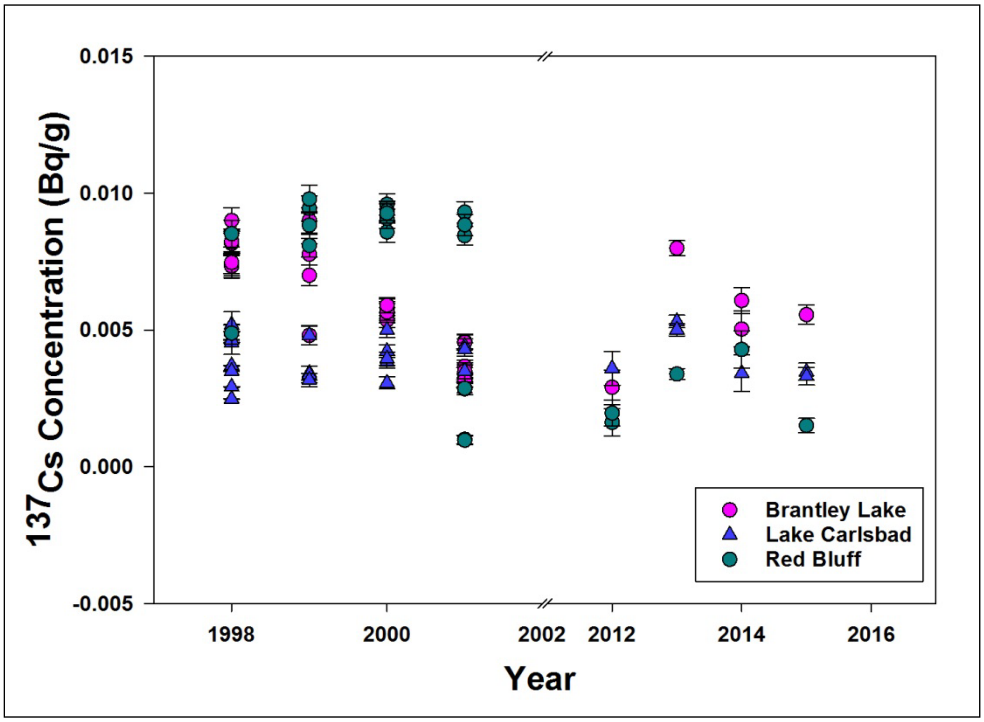


Figure 5-19: The Pre- and Post-radiological event sediment concentrations of ^{137}Cs from the three reservoirs in the vicinity of the WIPP site

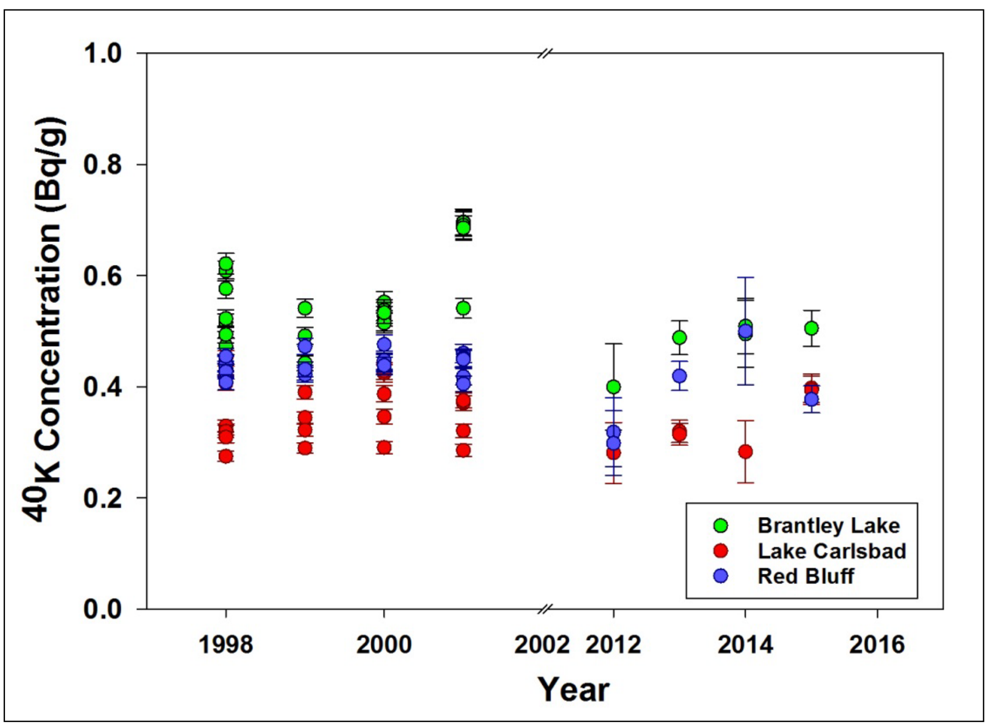


Figure 5-20: The Pre- and Post-radiological event sediment concentrations of ^{40}K from the three reservoirs in the vicinity of the WIPP site

Table 5-8: Activity concentrations of ^{241}Am, $^{239+240}Pu$ and ^{238}Pu (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{241}Am	Lake Carlsbad	10/21/15	1.19E-04	5.13E-05	7.64E-05	Detected
	Lake Carlsbad (Dup)	10/21/15	8.15E-05	3.38E-05	4.51E-05	Detected
	Brantley	10/27/15	1.56E-04	4.02E-05	1.94E-05	Detected
	Red Bluff	10/28/15	2.62E-05	2.59E-05	5.36E-05	Not Detected
$^{239+240}Pu$	Lake Carlsbad	10/21/15	1.97E-04	5.38E-05	3.50E-05	Detected
	Lake Carlsbad (Dup)	10/21/15	2.23E-04	6.64E-05	3.77E-05	Detected
	Brantley	10/27/15	2.81E-04	7.09E-05	5.99E-05	Detected
	Red Bluff	10/28/15	9.66E-05	3.82E-05	4.13E-05	Detected
^{238}Pu	Lake Carlsbad	10/21/15	1.16E-05	2.48E-05	5.86E-05	Not Detected
	Lake Carlsbad (Dup)	10/21/15	8.13E-06	3.05E-05	7.66E-05	Not Detected
	Brantley	10/27/15	6.37E-06	1.79E-05	4.48E-05	Not Detected
	Red Bluff	10/28/15	-1.82E-13	8.29E-06	2.72E-05	Not Detected

Table 5-9: Activity concentrations of ^{234}U, ^{235}U and ^{238}U (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{234}U	Lake Carlsbad	10/21/15	4.26E-02	4.79E-03	5.84E-05	Detected
	Lake Carlsbad (Dup)	10/21/15	4.18E-02	4.61E-03	4.80E-05	Detected
	Brantley	10/27/15	3.84E-02	4.30E-03	3.89E-05	Detected
	Red Bluff	10/28/15	5.69E-02	6.44E-03	6.70E-05	Detected
^{235}U	Lake Carlsbad	10/21/15	1.76E-03	2.66E-04	7.22E-05	Detected
	Lake Carlsbad (Dup)	10/21/15	1.45E-03	2.17E-04	2.75E-05	Detected
	Brantley	10/27/15	1.85E-03	2.65E-04	2.94E-05	Detected
	Red Bluff	10/28/15	2.59E-03	3.65E-04	4.40E-05	Detected
^{238}U	Lake Carlsbad	10/21/15	3.06E-02	3.45E-03	7.38E-05	Detected
	Lake Carlsbad (Dup)	10/21/15	2.91E-02	3.24E-03	5.68E-05	Detected
	Brantley	10/27/15	3.05E-02	3.42E-03	4.55E-05	Detected
	Red Bluff	10/28/15	3.41E-02	3.89E-03	8.58E-05	Detected

Table 5-10: Activity concentrations of ^{137}Cs, ^{40}K and ^{60}Co (Bq/g) in sediment samples collected from the three reservoirs in the vicinity of the WIPP site

Radionuclides	Location	Sample Date	Activity Bq/g	Unc. (2σ) Bq/g	MDC Bq/g	Status
^{137}Cs	Lake Carlsbad	10/21/15	3.47E-03	3.15E-04	9.51E-04	Detected
	Lake Carlsbad (Dup)	10/21/15	3.31E-03	3.23E-04	9.84E-04	Detected
	Brantley	10/27/15	5.56E-03	3.47E-04	9.65E-04	Detected
	Red Bluff	10/28/15	1.50E-03	2.61E-04	8.34E-04	Detected
^{40}K	Lake Carlsbad	10/21/15	3.98E-01	2.57E-02	8.45E-03	Detected
	Lake Carlsbad (Dup)	10/21/15	3.94E-01	2.55E-02	8.71E-03	Detected
	Brantley	10/27/15	5.05E-01	3.25E-02	8.88E-03	Detected
	Red Bluff	10/28/15	3.77E-01	2.44E-02	7.61E-03	Detected
^{60}Co	Lake Carlsbad	10/21/15	-7.04E-05	2.91E-04	9.68E-04	Not Detected
	Lake Carlsbad (Dup)	10/21/15	1.48E-04	2.98E-04	9.88E-04	Not Detected
	Brantley	10/27/15	1.06E-04	2.95E-04	9.77E-04	Not Detected
	Red Bluff	10/28/15	2.68E-05	2.70E-04	8.94E-04	Not Detected

CHAPTER 6

Drinking Water Monitoring

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. For this reason, 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 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). MCLs 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 (not including radon and uranium), 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 30 μg/L. 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 water sources also.

During 2015, the CEMRC 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), Carlsbad (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. While the CEMRC sampling locations are not likely to be affected by any WIPP radioactivity releases, the samples are collected and analyzed by the CEMRC annually because water is a primary vector in the food chain,. As with community air sampling, the verification of the absence of WIPP-related radionuclides from CEMRC 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 and the Malaga water system was added to the CEMRC sampling sites in 2011. 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 sampling sites around the WIPP site. Although uranium has been detected above the MDC, the observed activity indicates its presence in regional drinking water samples 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.**

Drinking water monitoring following the 2014 WIPP Radiation Release Event

Drinking water samples collected from the same locations following the radiation release event at the WIPP had uranium concentrations in the range from 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 detailed monitoring results are published in CEMRC Annual Report 2014 and are available at (www.cemrc.org/Annual Report). The levels detected were consistent with those measured previously from these locations. These sampling locations are not likely to be affected by any WIPP-related radiation releases; however, the verification of no WIPP radionuclides in drinking waters continues to demonstrate the absence of adverse effects to the local and wider public or to the environment from the February 14, radiation release at the WIPP. Further, the isotopes of plutonium (^{238}Pu and $^{239+240}$Pu) and ^{241}Am, the main radionuclides released from the WIPP repository, were not detected in any of the drinking water samples collected in 2014.

Analyses reported herein for are for 2015 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 2015 monitoring results for drinking water analyses continue to show no increase in the levels of radionuclides or inorganics that could be attributed to the 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 July of 2015. 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 were separated and purified using a two-column anion exchange resin (Dowex1× 8, Eichrom, 100-200 mesh), while TRU chromatography columns were used for the separation of Am and U. The samples were then micro-co-precipitated using neodymium fluoride (NdF_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. Due to the elevated calcium (Ca) and sodium (Na) levels in all of the 2015 samples, they were diluted using a similar nitric acid matrix prior to analysis by Inductively-Coupled Plasma Mass Spectrometer (ICP-MS). For Mercury analysis, the 500mL samples were preserved with a bromomonochloride solution and analyzed directly by ICP-MS.

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.

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 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 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-}	4.3-83.0 µg/L **
Mercury (EPA 200.8)	Hg	0.043 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*[2]	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 mg/L	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*2	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

* U.S. EPA: United States Environmental Protection Agency (2012), Drinking Water Contaminants
*2 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 drinking water in *liters* (L). The non-radiological data has been reported as (µg/L).

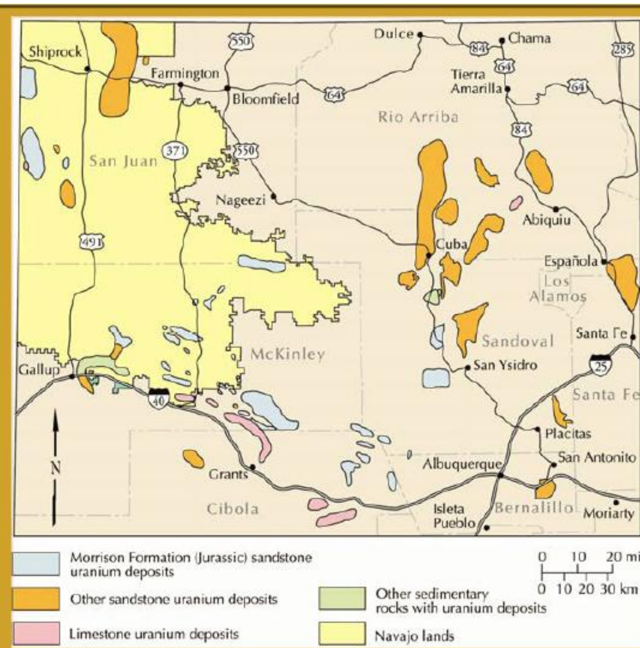
For each type of inorganic analysis (elemental, mercury, and anions), aliquots were blank-corrected after the application of dilution factors. As per the CEMRC procedure, only concentrations above laboratory MDC values are reported. Results for all inorganic analyses are reported in units of parts per billion (ppb).

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 of the drinking water samples in 2015 as shown in Table 6-3. Uranium in the environment occurs naturally as three radioactive isotopes: 238U (99.27%), 235U (0.72%) and 234U (0.005%). They have long half-lives ($t_{1/2}$) that allow them to be transported to water supplies. The isotopes of uranium are also found in the earth's crust with a natural abundance of about 4 ×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 may be used for drinking purposes. Thus it is expected that some drinking and surface waters sources will contain concentrations of uranium. 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. The average phosphate fertilizers contains about 100µg/g (or 24.8 Bq/g), if it is naturally occurring uranium (Cothern, and Lappenbusch, 1983), which can leach from the soil to nearby rivers and lakes (Fleischer, 1980; UNSCEAR, 1982). Additionally, contamination may be caused by catalysts, staining pigments, burning of fossil fuel (oil and coal) and the manufacture and use of phosphate fertilizers that contain uranium (WHO, 2004).

Despite its widespread abundance, uranium has not been shown to be an essential element for humans (Hursh et. al, 1973). The major health effect of uranium is its chemical toxicity rather than its radiological hazard. The chemical toxicity of uranium is considered to be similar to lead. The primary target organ from chronic (long-term) ingestion of uranium is kidney damage; however, liver and thyroid damage can also result. Regardless, radiological impacts from the ingestion of uranium continues to be the subject of ongoing research and debate.



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

Uranium levels are naturally high in many areas in the USA. Uranium contaminated drinking water is a common problem, particularly in the Western United States, including New Mexico. 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 present in their groundwater. According to the EPA, the MCL for uranium in drinking Water is 30 ug/L. 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. Prior to 1980, uranium in drinking water was measured only when contamination from industrial sources was suspected. However, concerns over the radiological quality of drinking water have led to an increased demand for real data assessment. Further, considering the importance of water for human consumption, its quality has to be assured and regularly controlled; however, bathing in water with elevated levels of uranium is not considered to be a health risk. Cothern and Lappenbusch, 1983, conducted an extensive investigation of radioactivity in drinking water in the US. Of the 59,812 community drinking water supplies in the US, a projected 25 to 650 exceeded a uranium concentration of 0.74 Bq/L; 100 to 2,000 exceeded 0.37 Bq/L; and 2,500 to 5,000 exceeded 0.185 Bq/L. A survey conducted by European Food safety Authority (EFSA) found average uranium concentrations in the 5,474 tap water samples collected from various European countries to be about 0.055 Bq/L.

Measured values for the drinking water samples collected in the vicinity of the WIPP site ranged from 7.8-66.1 mBq/L for for 238U, 0.34-4.99 mBq/L for 235U, and 20.9-170 mBq/L for 234U. **These uranium activity concentrations are well below the EPA recommended level of 746 mBq/L and are within the range expected in waters from this region.** According to the United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR, 2008, ^{238}U concentrations in drinking water is about 0.5-149 mBq/L in the US, 0.74-1190 mBq/L in Germany, and 0.25-1389 mBq/L in China. The worldwide reference value for ^{238}U in drinking water is about 2 mBq/L. The levels detected in these drinking water sources were also within the range expected in the US. For comparison purposes, the variation of uranium concentrations in drinking water sources around the World is summarized in Table 6-4.

The activity concentrations of ^{234}U, ^{235}U, and ^{238}U in drinking water collected from the six sources in 2015 are presented in Figure 6-9. The greatest variations appear in the amounts of ^{235}U. The low activity concentration of ^{235}U in the water samples is consistent with the lower activity concentration of ^{235}U in the natural environment as compared to the activity concentrations of ^{234}U and ^{238}U. The highest activity concentrations were found in Malaga and Otis waters. Figure 6-10 shows the total uranium activity concentration at each location.

It has been reported that the activity of uranium in 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 for ^{234}U, ^{235}U, and ^{238}U are 48.9, 2.2, and 48.9 %, respectively. In radiochemical equilibrium, natural activity ratios are typically unity (1.0) for $^{234}U/^{238}U$ and 0.045 for $^{235}U/^{238}U$ (Pimple et al, 1992). However, many studies looking at ^{238}U and ^{234}U in natural bodies of water indicate that these isotopes do not occur in equilibrium and that, with a few exceptions, waters typically contain more ^{234}U than ^{238}U (Cothern et al, 1983; Skwarzec et al, 2002). Higher activity of ^{234}U in water is the result of the ^{234}U atom displacement from the crystal lattice. The recoil atom, ^{234}U, is liable to be oxidized to the hexavalent stage and can be leached into the water phase more easily than its parent nuclide ^{238}U. The oxidation of U(IV) to U(VI) is an important step in leaching, because compounds containing U(VI) have a higher solubility due to the formation of strong complexes between uranyl and carbonate ions (UNSCEAR, 2000). All U(IV) compounds of uranium are practically insoluble.

The average activity ratio of $^{235}U/^{238}U$ in the water samples collected around the WIPP site ranged from 0.043-0.059. 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 6-5. The calculated $^{234}U/^{238}U$ activity ratio varies between 2.32 to 3.22 which means that two isotopes are not in radioactive equilibrium. The $^{234}U/^{238}U$ activity ratio measured in regional drinking water since 1998 are shown in Figure 6-11. The historical activity concentrations of ^{234}U, ^{235}U and ^{238}U measured at each sites in the regional drinking water are summarized in Tables 6-6 through 6-11.

Gamma Radionuclides in the Drinking Water

The analysis data for the gamma isotopes are presented in Table 6-12. As shown in the table 6-12, the naturally occurring gamma-emitting radionuclide, ^{40}K is not detected in any of the drinking water samples collected in 2015. In 2014, CEMRC had detected ^{40}K in Hobbs drinking water sample at a level of (1.35 Bq/L). The ^{40}K was also detected in drinking water samples collected from Carlsbad, Malaga and Otis in 2013. This naturally occurring gamma-emitting radionuclide is ubiquitous in nature; therefore an occasional detection of ^{40}K in drinking water is not unusual. There was no significant difference between concentrations of ^{40}K among sampling locations 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 drinking water samples (Table 6-12). Since these isotopes were not detected, no comparisons between years or among locations were performed.

Radiation Dose Estimation

Given the natural uranium activity found within the drinking waters studied, it is necessary to provide context and values for these low but traceable quantities. Assuming that a person drinks about 2.5 liters of water per day, the annual effect dose (D) resulting from consumption of the water investigated in the present study can be calculated using the following formula:

$$D = K*G*C*T$$

where D is the dose via ingestion (in Sv); K is the ingestion dose conversion factor of the specific radionuclide (Sv/Bq); G is the water consumption per day per person; C is the concentration of the specific radionuclide (Bq/L) and T is the duration of consumption, here it is one year (365 days). Ingestion dose conversion factors (Sv/Bq) for adults (20-70 years) used in the calculations were taken from the International Commission on Radiological Protection (ICRP) publication and were equal to 4.5×10^{-8} for ^{238}U, 4.7×10^{-8} for ^{235}U and 4.9×10^{-8} for ^{234}U. The calculated effective doses for the analyzed drinking water samples were in the range of 2.1-2.9 μSv/Bq for Carlsbad, 2.3-6.3 μSv/Bq for Double Eagle, 4.2- 11.3 μSv/Bq for Hobbs, 10.1-14.0 μSv/Bq for Otis, and 6.2-8.1 μSv/Bq for Loving as shown in Figure 6-12. The overall annual effective dose contributions due to intake of uranium isotopes were below the WHO and IAEA reference value (100 μSv/y) for drinking water (WHO, 2004). For most people in the world, the intake of uranium through food is around 1 g/day. The worldwide average of dietary uranium is estimated at 1.3 g/day from which the portion from drinking water is 0.2 g/day. Thus drinking water is not usually the main source of ingested uranium.

Table 6-3: Actinide Concentrations Measured in Drinking Water in 2015

Radionuclide	Location	Activity Bq/L	Unc (2-sig) (Bq/L)	MDC (Bq/L)	Status
^{241}Am	Carlsbad	1.87E-04	1.34E-04	2.05E-04	Not detected
	Otis	5.62E-05	1.13E-04	2.64E-04	Not detected
	Otis (Dup)	8.26E-05	7.13E-05	1.10E-04	Not detected
	Loving	1.15E-04	1.16E-04	2.27E-04	Not detected
	Hobbs	1.61E-04	1.57E-04	3.12E-04	Not detected
	Double Eagle	1.18E-04	1.01E-04	1.87E-04	Not detected
	Malaga	5.07E-05	7.58E-05	1.57E-04	Not detected
	Blank	1.22E-04	1.13E-04	2.24E-04	Not detected
$^{239+240}$Pu	Carlsbad	4.50E-05	9.97E-05	2.38E-04	Not detected
	Otis	-6.76E-05	1.35E-04	3.97E-04	Not detected
	Otis (Dup)	-2.32E-05	1.22E-04	3.67E-04	Not detected
	Loving	3.61E-05	8.68E-05	2.09E-04	Not detected
	Hobbs	-4.01E-05	8.04E-05	2.52E-04	Not detected

Table 6-3: Actinide Concentrations Measured in Drinking Water in 2015 (continued)

Radionuclide	Location	Activity Bq/L	Unc (2-sig) (Bq/L)	MDC (Bq/L)	Status
$^{239+240}Pu$	Double Eagle	-4.63E-05	5.19E-05	8.51E-05	Not detected
	Malaga	1.56E-05	8.25E-05	2.20E-04	Not detected
	Blank	-2.17E-05	4.35E-05	1.01E-04	Not detected
^{238}Pu	Carlsbad	4.50E-05	1.31E-04	3.20E-04	Not detected
	Otis	-5.07E-05	1.02E-04	3.18E-04	Not detected
	Otis (Dup)	-1.16E-04	1.39E-04	4.66E-04	Not detected
	Loving	-1.20E-05	6.36E-05	1.91E-04	Not detected
	Hobbs	-5.35E-05	9.29E-05	2.85E-04	Not detected
	Double Eagle	-4.63E-05	8.02E-05	2.46E-04	Not detected
	Malaga	0.00E+00	1.08E-04	2.94E-04	Not detected
	Blank	-3.26E-05	6.53E-05	2.05E-04	Not detected
^{234}U	Carlsbad	2.09E-02	2.52E-03	2.30E-04	Detected
	Otis	1.70E-01	1.94E-02	3.85E-04	Detected
	Otis (Dup)	1.69E-01	1.86E-02	2.30E-04	Detected
	Loving	7.42E-02	8.27E-03	2.45E-04	Detected
	Hobbs	9.67E-02	1.11E-02	3.34E-04	Detected
	Double Eagle	4.55E-02	5.39E-03	3.03E-04	Detected
	Malaga	1.57E-01	1.75E-02	2.43E-04	Detected
	Blank	1.82E-04	1.65E-04	3.18E-04	Not detected
^{235}U	Carlsbad	3.39E-04	1.68E-04	1.66E-04	Detected
	Otis	2.95E-03	6.57E-04	4.39E-04	Detected
	Otis (Dup)	3.37E-03	6.16E-04	2.15E-04	Detected
	Loving	1.26E-03	3.33E-04	2.08E-04	Detected
	Hobbs	2.17E-03	5.36E-04	4.12E-04	Detected
	Double Eagle	9.19E-04	3.18E-04	2.19E-04	Detected
	Malaga	4.99E-03	8.21E-04	1.39E-04	Detected
	Blank	2.25E-05	1.01E-04	2.71E-04	Not detected
^{238}U	Carlsbad	7.80E-03	1.08E-03	3.07E-04	Detected
	Otis	6.61E-02	7.72E-03	5.74E-04	Detected
	Otis (Dup)	6.55E-02	7.36E-03	3.67E-04	Detected
	Loving	2.30E-02	2.74E-03	2.98E-04	Detected
	Hobbs	4.17E-02	4.95E-03	5.22E-04	Detected
	Double Eagle	1.57E-02	2.06E-03	3.02E-04	Detected
	Malaga	6.07E-02	6.91E-03	3.24E-04	Detected
	Blank	1.81E-05	1.96E-04	4.97E-04	Not detected

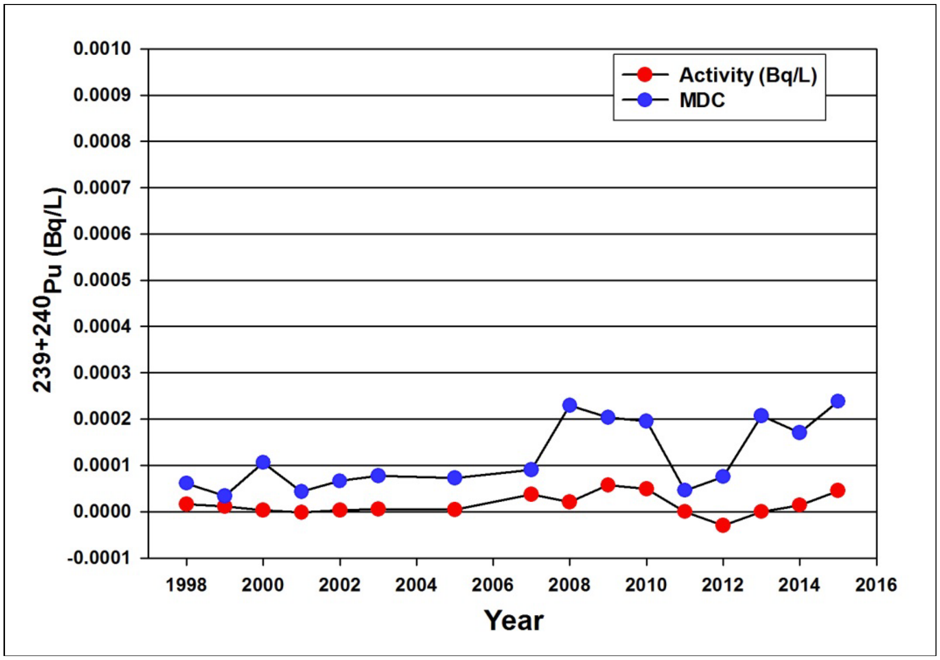


Figure 6-1: $^{239+240}$Pu in Carlsbad Drinking Water from 1998 – 2015

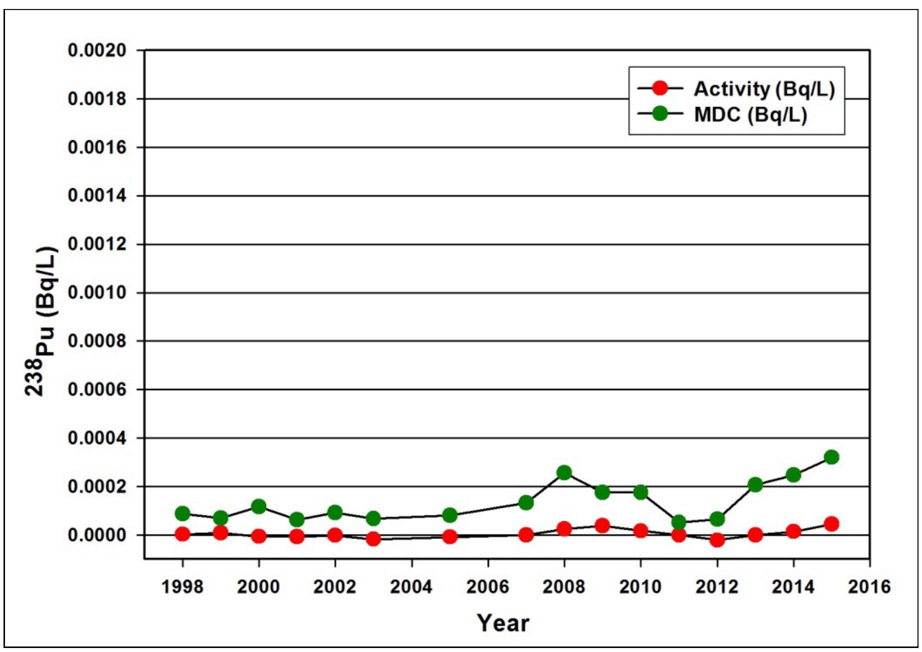


Figure 6-2: ^{238}Pu in Carlsbad Drinking Water from 1998 – 2015

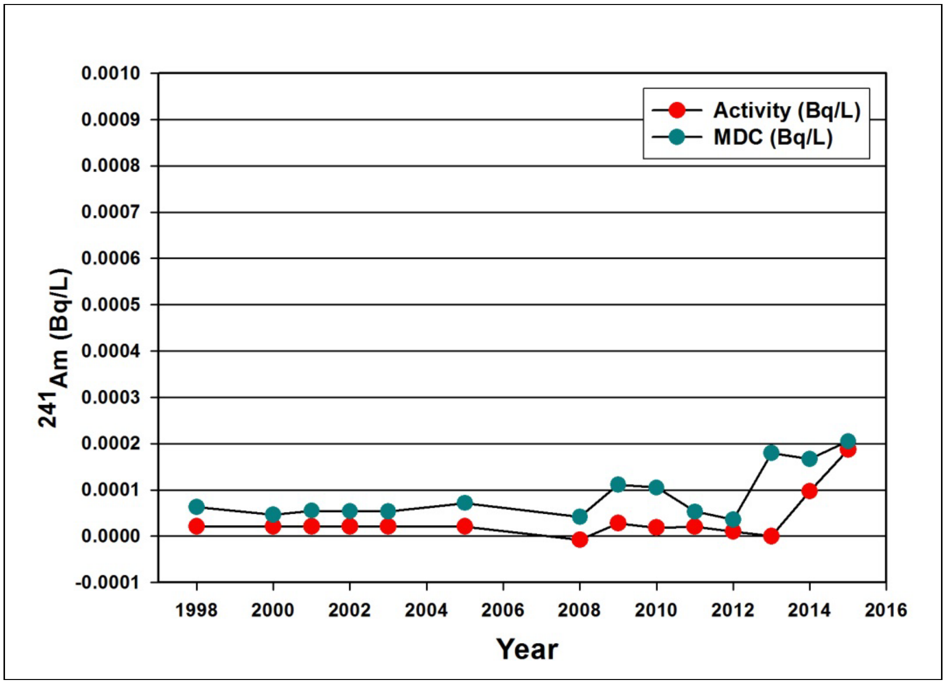


Figure 6-3: ^{241}Am in Carlsbad Drinking Water from 1998 – 2015

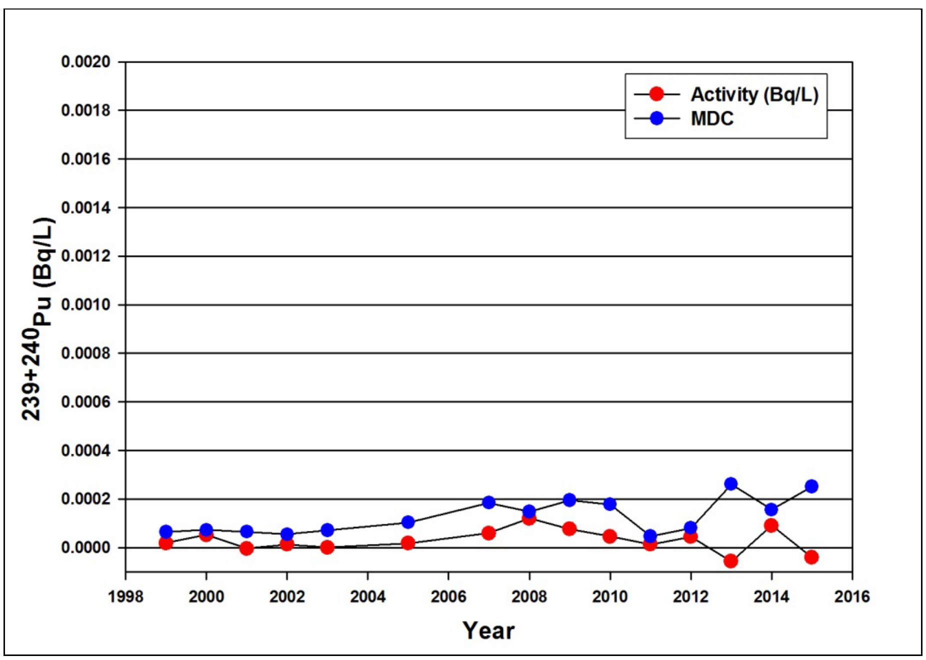


Figure 6-4: $^{239+240}$Pu in Hobbs Drinking Water from 1999 – 2015

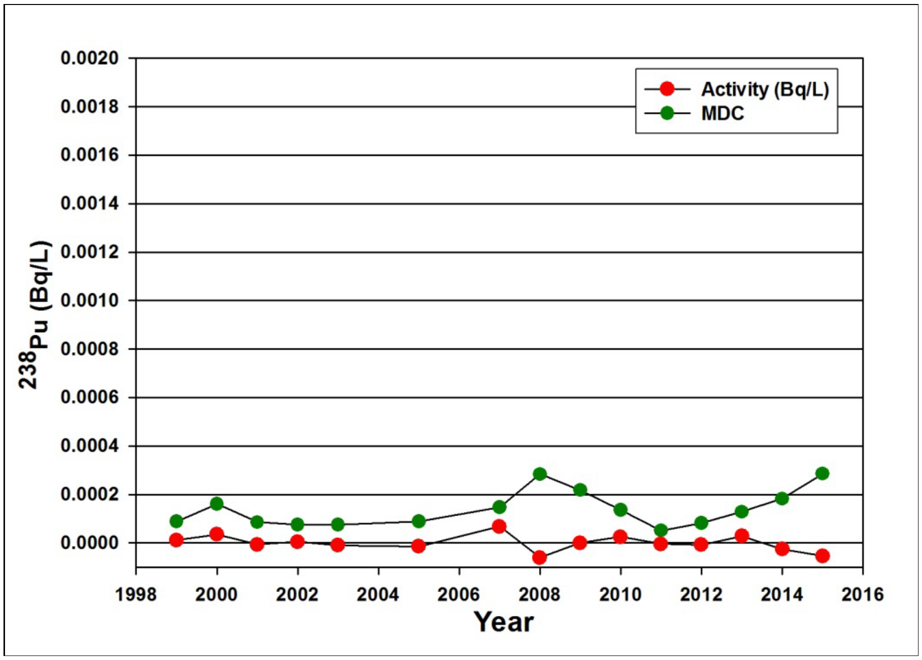


Figure 6-5: ^{238}Pu in Hobbs Drinking Water from 1999 – 2015

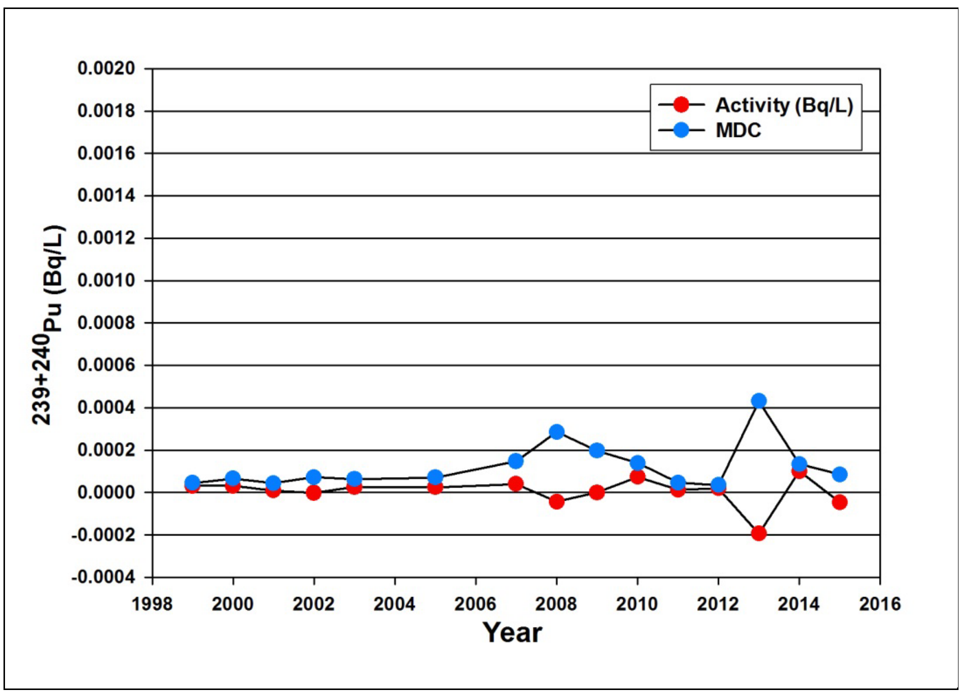


Figure 6-6: $^{239+240}$Pu in Double Eagle Drinking Water from 1999 -2015

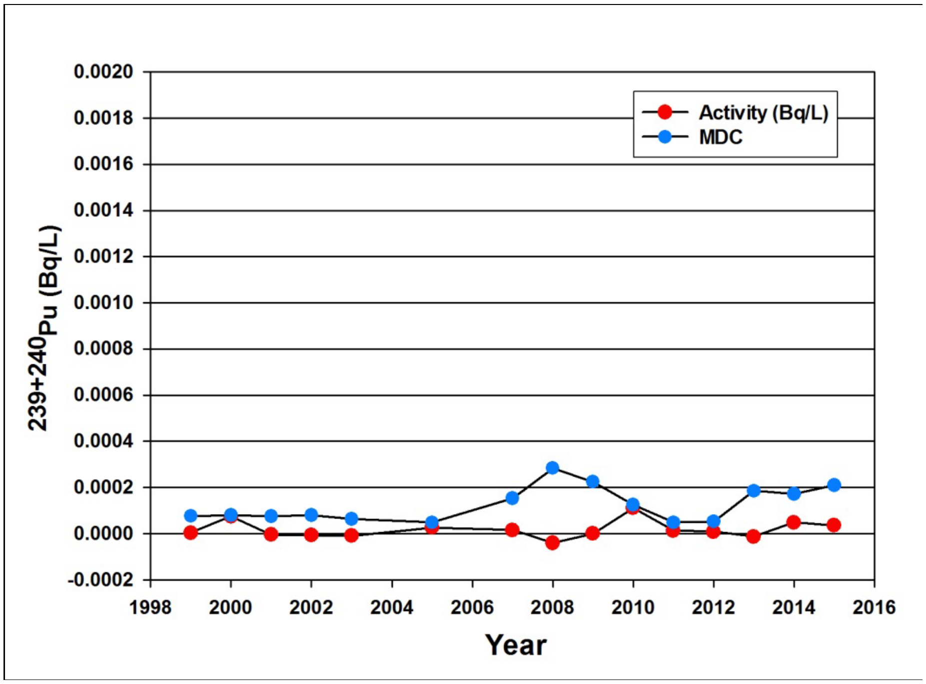


Figure 6-7: $^{239+240}$Pu in Loving Drinking Water from 1999 – 2015

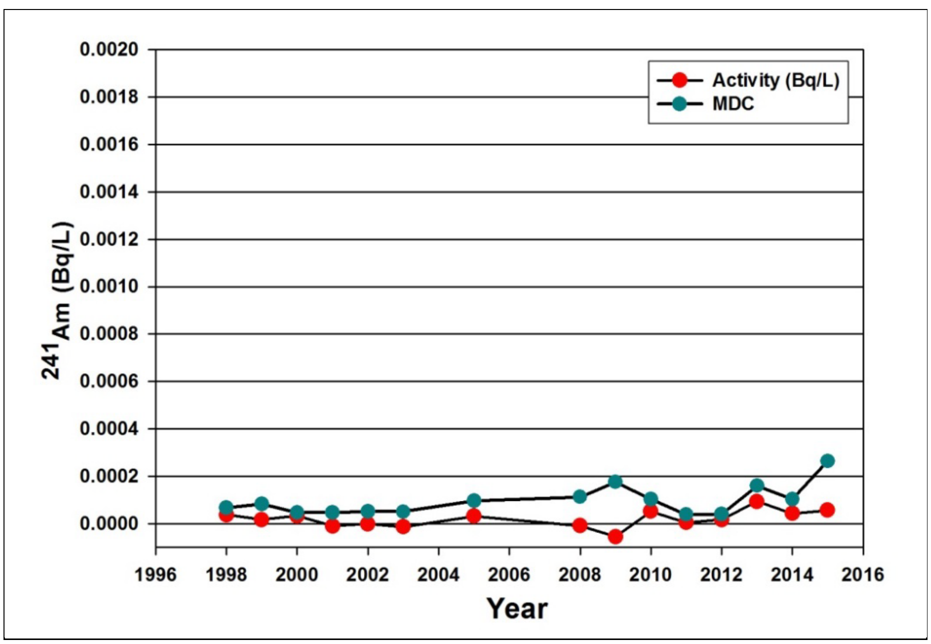


Figure 6-8: ^{241}Am in Otis Drinking Water from 1998 - 2015

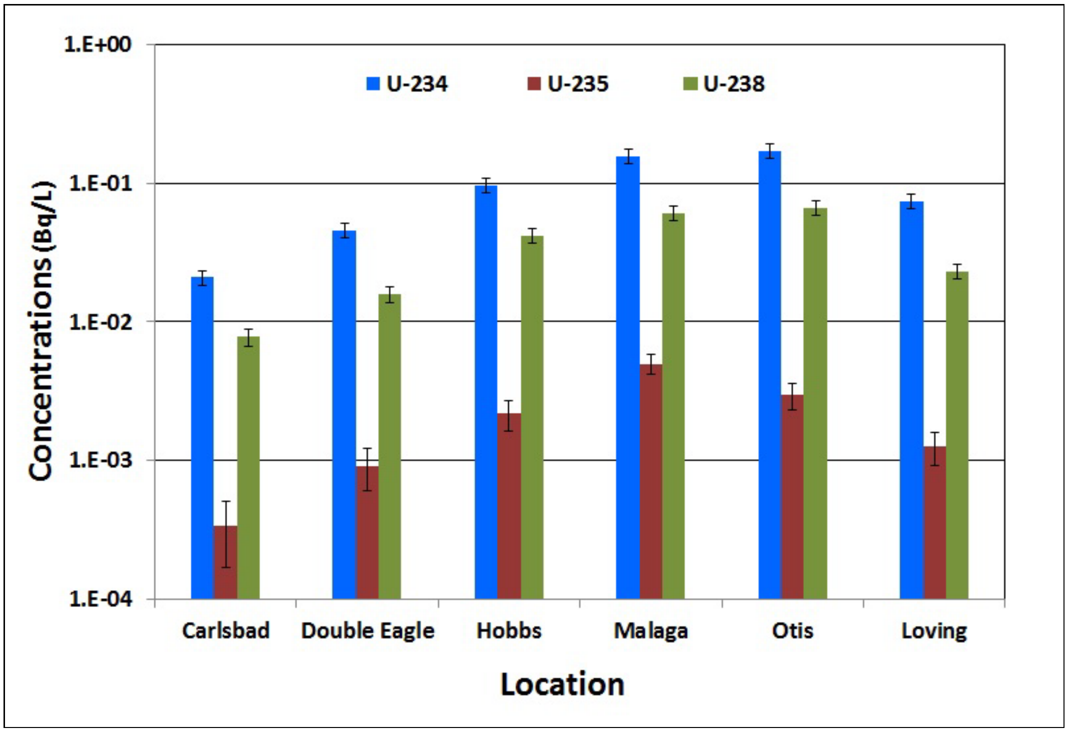


Figure 6-9: The ^{234}U, ^{235}U, and ^{238}U concentrations (Bq/L) in Regional Drinking Water in 2015

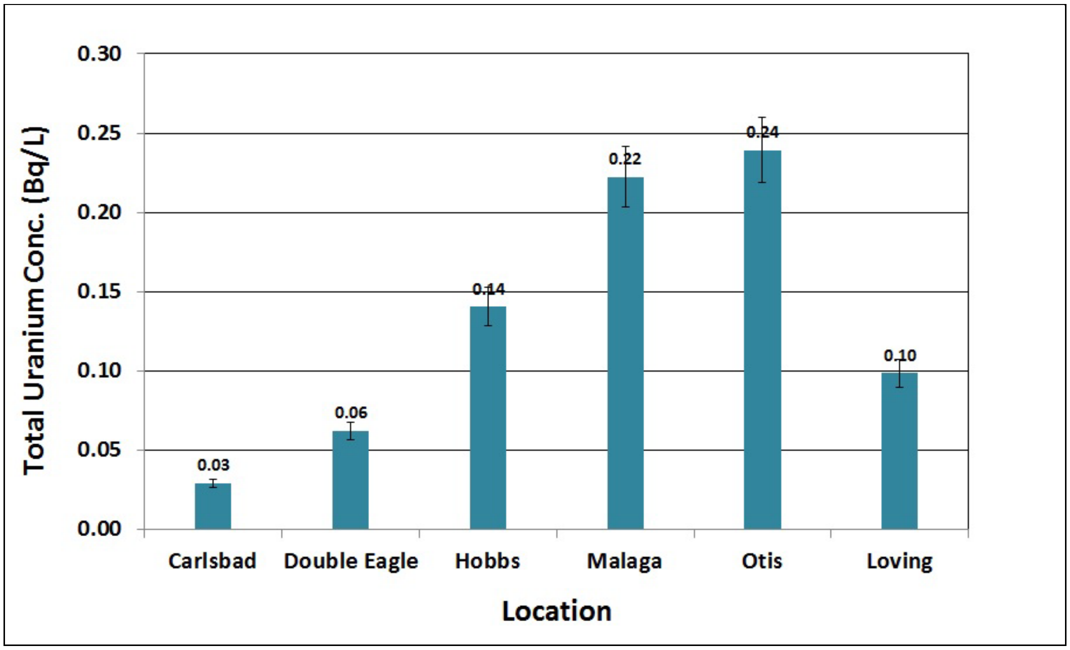


Figure 6-10: Total Uranium Concentrations in Bq/L in Regional Drinking Water collected in 2015

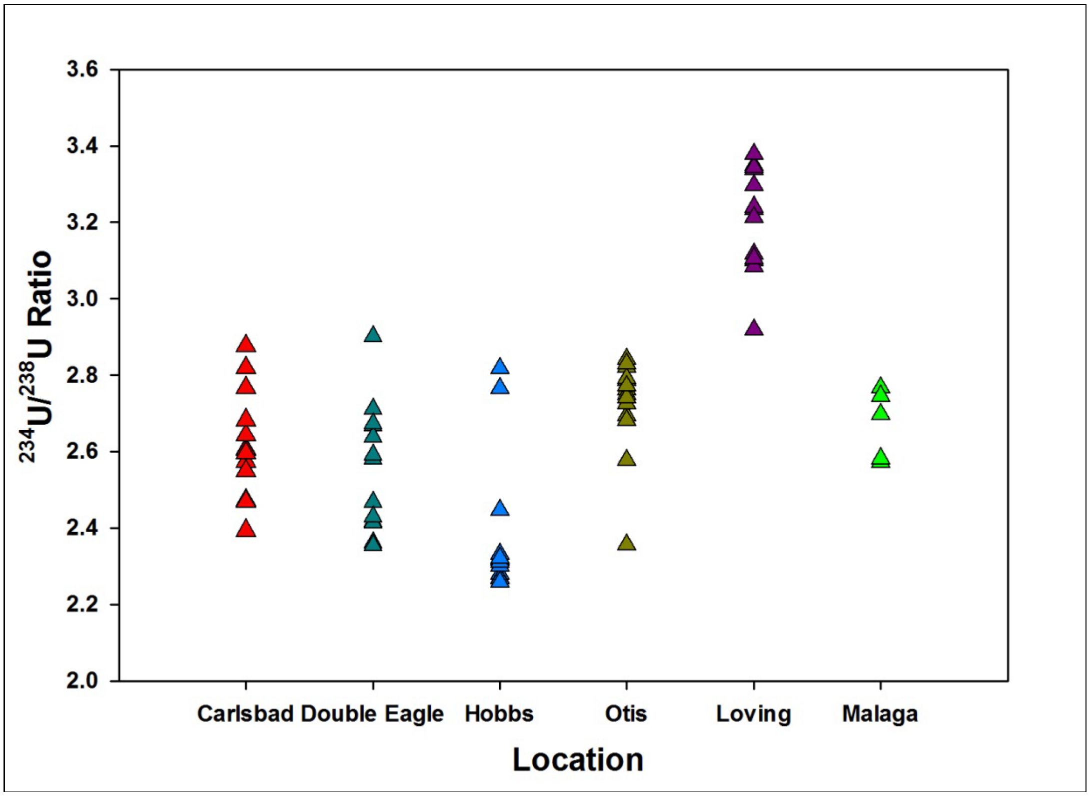


Figure 6-11: Variation in $^{234}U/^{238}U$ Activity Ratio in Regional Drinking Water from 1998 – 2015

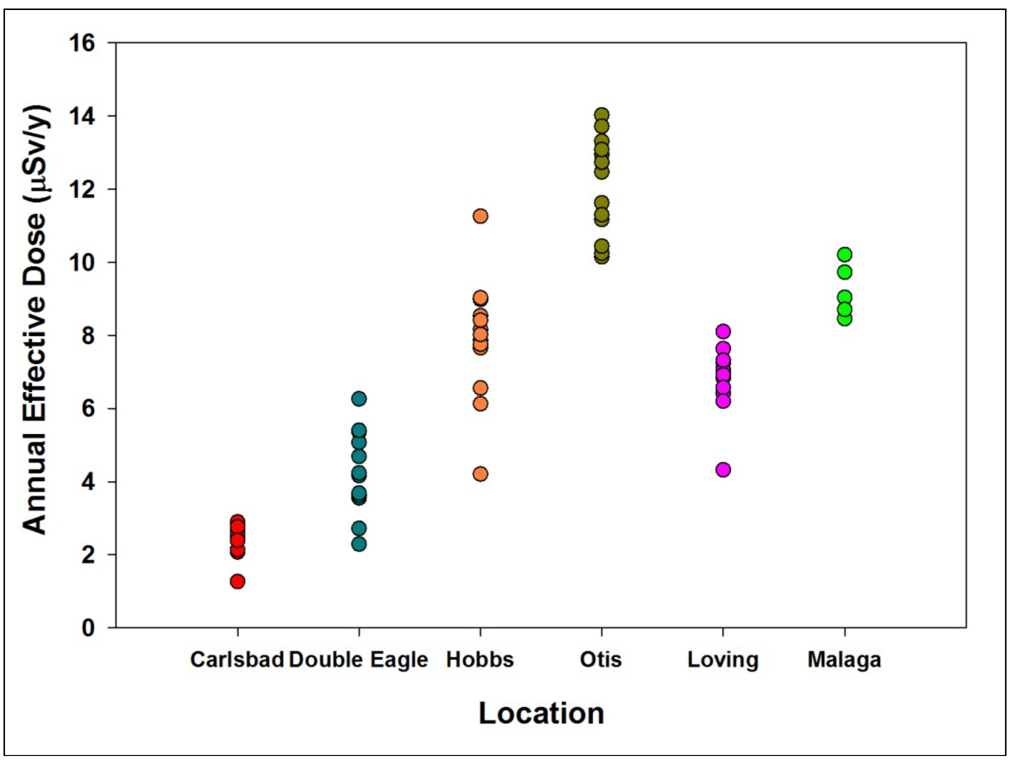


Figure 6-12: Annual effective dose (µSv/y) due to ingestion of uranium in drinking water in the vicinity of the WIPP site.

Table 6-4: Variability of natural uranium concentrations in the drinking water Around the World

Country	Uranium Conc. (mBq/l)	Reference
Ontario, Canada	1.24-104.5	OMEE, 1996
Jordan	0.996-348.3	Gedeon, et al., 1994
Kuwait	0.498-62.19	Bou-Rabee, 1995
South Greenland	12.4-24.9	Brown et al., 1983
Turkey	4.98-437.9	Kumru, 1995
China	0.0996-696.6	UNSCEAR, 2008,
Iran	24.9-271.2	Alirezazadeh and Garshasbi, 2003
Norway	<0.498-4229	Banks et al., 1995
Sweden	< 4.98-11,693	Selden et al., 2000
Argentina	0.5-5000	UNSCEAR, 2008
Brazil	0.4-400	Geraldo et al., 1979
China	0.09-950	UNSCEAR, 2008
Czech Republic	3-1100	UNSCEAR, 2008
Finland	0.8-120,000	UNSCEAR, 2008
France	8-1000	UNSCEAR, 2008
Germany	0.5-900	UNSCEAR, 2008
Greece	0.2-30	UNSCEAR, 2008
Hungary	1-1000	UNSCEAR, 2008
India	0.09-2	UNSCEAR, 2008
Italy	0.3-400	UNSCEAR, 2008
Morocco	0.8-700	UNSCEAR, 2008
Romania	0.6-90	UNSCEAR, 2008
Spain	0.05-9	UNSCEAR, 2008
Switzerland	8-800	UNSCEAR, 2008
United States	0.5-90	Cothern and Lappenbusch, 1983
Poland	1.0-56	Kozlowska et al., 2007
Austria	2.5-2226	Gegner and Irweck, 2005

Table 6-5: 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	2.68	0.043	Present work
Double Eagle	Drinking water	2.9	0.059	Present work
Hobbs	Drinking water	2.32	0.052	Present work
Otis	Drinking water	2.58	0.045	Present work
Loving	Drinking water	3.22	0.055	Present work
Malaga	Drinking water	2.59	0.082	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 6-6: 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
2015	2.09E-02	3.39E-04	7.80E-03

NR = not reported

Table 6-7: 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
2015	4.55E-02	9.19E-04	1.57E-02

NR = not reported

Table 6-8: 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
2015	9.67E-02	2.17E-03	4.17E-02

NR = not reported

Table 6-9: 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
2015	1.70E-01	2.95E-03	6.61E-02

NR = not reported

Table 6-10: 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
2015	7.42E-02	1.26E-03	2.30E-02

NR = not reported

Table 6-11: 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
2015	1.57E-01	4.99E-03	6.07E-02

*Collection started in 2011

Table 6-12: Gamma Emitting Radionuclides measured in Drinking Water in 2015

Radionuclide	Location	Activity Bq/L	Unc(2-sig) (Bq/L)	MDC (Bq/L)	Status
^{137}Cs	Carlsbad	4.35E-03	2.88E-02	9.54E-02	Not detected
	Otis	6.70E-03	2.86E-02	9.48E-02	Not detected
	Otis (Dup)	4.38E-02	2.86E-02	9.42E-02	Not detected
	Loving	1.54E-02	2.85E-02	9.43E-02	Not detected
	Hobbs	-7.26E-03	2.84E-02	9.44E-02	Not detected
	Double Eagle	2.82E-02	2.85E-02	9.40E-02	Not detected
	Malaga	2.45E-02	2.82E-02	9.30E-02	Not detected
	Blank	2.22E-02	2.87E-02	9.48E-02	Not detected
^{60}Co	Carlsbad	3.78E-02	2.68E-02	8.82E-02	Not detected
	Otis	5.06E-03	2.70E-02	8.96E-02	Not detected
	Otis (Dup)	4.12E-02	2.66E-02	8.74E-02	Not detected
	Loving	2.31E-02	2.63E-02	8.69E-02	Not detected
	Hobbs	4.81E-02	2.61E-02	8.57E-02	Not detected
	Double Eagle	3.00E-02	2.62E-02	8.64E-02	Not detected
	Malaga	-1.15E-03	2.66E-02	8.84E-02	Not detected
	Blank	4.27E-02	2.65E-02	8.70E-02	Not detected
^{40}K	Carlsbad	3.70E-01	3.29E-01	1.08E+00	Not detected
	Otis	-2.14E-02	3.35E-01	1.11E+00	Not detected
	Otis (Dup)	8.34E-02	3.41E-01	1.13E+00	Not detected
	Loving	1.24E-01	3.35E-01	1.11E+00	Not detected
	Hobbs	-6.65E-01	3.47E-01	1.16E+00	Not detected
	Double Eagle	2.27E-01	3.33E-01	1.10E+00	Not detected
	Malaga	-6.46E-02	3.36E-01	1.12E+00	Not detected
	Blank	3.36E-02	3.38E-01	1.12E+00	Not detected

Non-Radiological Monitoring Results

Samples collected by the CEMRC from each location were analyzed for Inorganics, consisting of elemental analyses, anion analyses, and analysis for mercury. Each analysis was performed separately. Current methods used for the various analyses performed on each samples are summarized in Table 6-1. Present results, as well as the results of previous analyses for drinking water, are consistent for each source across sampling periods, and are below levels specified under the EPA Safe Drinking Water Act (U.S. EPA: 2012). Previous results published by the CEMRC can be found on the CEMRC website (www.cemrc.org). General information about inorganic contaminants in drinking water is listed in Table 6-2. The 2015 monitoring results show no increase in the levels of inorganics that could be attributed to WIPP-related activities or the February 2014 WIPP event.

The CEMRC has the ability to analyze drinking water samples for seven different inorganic anions and over 30 different inorganic metals. The 2015 metal results and how they compare to past results are summarized in Tables 6-13 through 6-18 for the six regional drinking water sources. The results exhibited in these tables are not used in assessing regulatory compliance; however, 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 6-13 through 6-18 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 (Conca, J., T. Kirchner, J. Monk, S. Sage 2008).

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). The 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. Indeed the concentrations of As 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 6-14 and 6-16 respectively. A comparison of the different sites for select metals is shown in Figure 6-19 and 6-20. However, the levels determined for Double Eagle and Hobbs are still below the EPA limit of 10µg/L (0.01mg/L) as listed in Table 6-2. (Conca, J., T. Kirchner, J. Monk, S. Sage, 2008).

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 (Kerr, Richard A., 1999; Weeks, Jennifer 2011). The Permian Basin is now a major source of potassium salts (potash), which are mined from bedded deposits of sylvite and langbeinite (Alto, B.R., R.S. Fulton, 1965). 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 (Mereiter, K., 1979; Palache, C., H. Berman, and C. Frondel, 1951). 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 6-20 summarizes the concentrations of metals in common salts measured in the areas surrounding the WIPP site. Currently there are no EPA regulations for salt-containing components like K, Mg, and Na in drinking water.

By far, the highest concentration of the measured inorganic elements found in the drinking water of this area is Calcium (Ca) for each of the sites sampled around the WIPP (Figure 6-20). 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 National Park, located approximately 18 miles southwest of Carlsbad, NM and is a likely source of Calcium (Ca) in the drinking water of the area.

Inorganic anion analysis results are shown separately in Tables 6-19 through 6-24 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 6-21 through 6-24 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 (250,000µg/L) for Carlsbad, Double Eagle, Hobbs, and Loving since 1998. However, this anion has frequently been detected above the EPA limit for the Otis and Malaga drinking water (See Figure 6-21). 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 (4,000µg/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 hovers 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 fall just 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 6-23 for nitrate concentrations at all of the sites. All reported nitrate concentrations are below the EPA limit for nitrate (measured as nitrogen = 10mg/L or approximately 44,200µg/L nitrate ion). According to the EPA (2012), 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 6-24) 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 (250,000µg/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. This year is the first time that bromide has been observed in the drinking water collected at the Malaga and Carlsbad locations; however, the amount of bromide measured at the Malaga site are in the same range as concentrations observed in the other sites for 2015. The EPA (see Table 6-2) does not list regulatory information about bromide.

Table 6-13: Measured Concentration of Selected Inorganic Elements in Carlsbad Drinking Water from 1998 - 2015

Carlsbad							
1998-2014					2015		
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	12	1	1.75E-02	1.75E-02	8.60E-03	-2.70E-04	2.88E-02
Al	13	6	1.83E+00	4.11E+01	1.70E-01	2.20E-01	4.35E+00
As	15	11	2.97E-01	1.42E+00	4.50E-01	9.41E-01	<MDC
B	3	3	2.89E+01	4.44E+01	N/A	N/A	N/A
Ba	11	11	6.64E+01	8.19E+01	1.80E-02	8.27E-04	7.68E+01
Be	12	N/A	N/A	N/A	1.90E-02	2.52E-03	<MDC
Ca	8	8	5.90E+04	7.30E+04	7.40E+01	5.08E+00	6.43E+04
Cd	11	N/A	N/A	N/A	6.70E-02	2.60E-03	<MDC
Ce	12	5	5.81E-03	3.42E-02	1.40E-03	-3.36E-04	<MDC
Co	13	11	8.80E-02	3.41E-01	1.70E-03	4.44E-03	1.03E-01
Cr	14	12	5.14E-01	1.02E+01	1.40E-01	1.08E-01	1.14E+00
Cu	13	12	1.30E+00	1.67E+01	1.50E-02	8.72E-03	9.55E+00
Dy	13	1	3.56E-03	3.56E-03	1.50E-03	-4.48E-04	<MDC
Er	13	2	3.32E-03	3.38E-03	2.30E-03	-1.13E-03	<MDC
Eu	12	9	1.35E-02	2.42E-02	5.70E-03	2.78E-04	1.04E-02
Fe	10	7	7.10E-01	6.52E+02	1.90E+00	2.47E+00	6.47E+02
Ga	1	1	3.25E+00	3.25E+00	N/A	N/A	N/A
Gd	11	3	1.96E-03	3.91E-03	1.50E-03	1.75E-03	<MDC
Hg	7	2	2.26E-02	3.14E-02	4.30E-02	1.16E-02	<MDC
K	12	12	1.02E+03	3.56E+03	8.50E+00	9.72E+00	1.09E+03
La	12	6	5.81E-03	4.42E-02	3.90E-03	-1.09E-04	<MDC
Li	11	11	5.14E+00	8.86E+00	N/A	N/A	N/A
Mg	11	11	2.73E+04	3.47E+04	2.80E+00	1.93E-01	2.89E+04
Mn	14	9	5.50E-02	8.71E+00	1.50E-02	2.32E-02	2.93E+01
Mo	10	9	8.93E-01	1.37E+00	2.30E-02	-3.37E-02	1.05E+00
Na	13	13	8.16E+03	4.55E+04	2.80E+00	1.56E-01	1.20E+04
Nd	13	2	8.50E-03	9.35E-03	1.10E-03	5.93E-04	<MDC
Ni	13	12	1.46E+00	3.14E+00	1.70E-02	7.51E-03	1.46E+00
P	7	6	1.61E+01	4.09E+01	3.40E+00	5.11E+00	4.95E+01
Pb	12	10	1.01E-01	2.07E+00	4.30E-03	1.04E-03	1.73E+00
Pr	13	2	1.93E-03	3.72E-03	5.20E-04	-5.12E-04	<MDC
Sb	12	7	3.14E-02	1.99E-01	7.90E-03	1.13E-03	8.00E-02
Sc	11	10	1.18E+00	3.03E+00	1.90E-01	4.92E-03	1.19E+00

Table 6-13: Measured Concentration of Selected Inorganic Elements in Carlsbad Drinking Water from 1998 – 2015 (continued)

Carlsbad							
1998-2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Blank Conc. (µg/L)	Sample Conc. (µg/L)[5]
Se	12	7	-8.83E-02	1.93E+00	1.20E+00	2.74E+00	<MDC
Si	9	9	5.39E+03	6.87E+03	4.10E+00	2.14E+00	5.35E+03
Sr	12	12	2.61E+02	3.62E+02	6.00E-02	3.04E-03	3.24E+02
Th	10	3	6.32E-03	1.76E-02	4.70E-03	7.92E-04	<MDC
Tl	12	12	8.97E-02	3.47E-01	3.40E-03	-3.06E-04	1.30E+00
U	13	13	8.21E-01	1.05E+00	3.00E-03	5.49E-04	7.36E-01
V	14	14	3.54E+00	6.57E+00	2.90E-02	2.36E-02	3.07E+00
Zn	13	12	2.13E+00	1.52E+01	1.60E-01	-4.28E-02	1.57E+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 6-14: Measured Concentration of Selected Inorganic Elements in Double Eagle Drinking Water from 1998 - 2015

Double Eagle							
1998-2014					2015		
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	2	3.62E-03	1.78E-01	8.60E-03	-2.70E-04	<MDC
Al	15	9	1.93E+00	7.22E+01	1.70E-01	2.20E-01	6.62E+00
As	14	13	4.48E+00	9.11E+00	4.50E-01	9.41E-01	7.70E+00
B	3	3	2.98E+01	8.55E+01	N/A	N/A	N/A
Ba	12	12	3.82E+01	1.25E+02	1.80E-01	8.27E-04	1.26E+02
Be	13	2	3.63E-02	6.76E-02	1.90E-02	2.52E-03	<MDC
Ca	8	8	4.15E+04	5.94E+04	7.40E+01	5.08E+00	4.65E+04
Cd	12	1	1.87E-02	1.87E-02	6.70E-02	2.60E-03	<MDC
Ce	13	3	3.63E-03	3.22E-02	1.40E-03	-3.36E-04	<MDC
Co	14	11	6.48E-02	1.12E+00	1.70E-03	4.44E-03	5.73E-02
Cr	15	14	9.11E-01	3.25E+01	1.40E-01	1.08E-01	8.38E-01
Cu	14	13	8.09E-01	5.69E+00	1.50E-02	8.72E-03	9.82E-01
Dy	14	N/A	N/A	N/A	1.50E-03	-4.48E-04	<MDC
Er	14	N/A	N/A	N/A	2.30E-03	-1.13E-03	<MDC

Table 6-14: Measured Concentration of Selected Inorganic Elements in Double Eagle Drinking Water from 1998 – 2015 (continued)

Double Eagle							
1998-2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Blank Conc. (µg/L)	Sample Conc. (µg/L)[5]
Eu	13	10	1.68E-02	2.86E-02	5.70E-03	2.78E-04	1.95E-02
Fe	11	9	3.01E-02	9.32E+02	1.90E+00	2.47E+00	1.59E+02
Ga	1	1	4.46E+00	4.46E+00	N/A	N/A	N/A
Gd	13	N/A	N/A	N/A	1.50E-03	1.75E-03	<MDC
Hg	6	N/A	N/A	N/A	4.30E-02	1.16E-02	<MDC
K	13	13	2.22E+03	2.94E+04	8.50E+00	9.72E+00	2.75E+03
La	13	5	1.19E-02	6.26E-02	3.90E-03	-1.09E-04	<MDC
Li	12	12	9.97E+00	1.95E+01	N/A	N/A	N/A
Mg	11	11	8.51E+03	1.25E+04	2.80E-01	1.93E-01	9.34E+03
Mn	15	12	2.22E-01	6.04E+00	1.50E-02	2.32E-02	1.88E+00
Mo	11	11	1.42E+00	6.70E+00	2.30E-02	-3.37E-02	1.97E+00
Na	14	14	3.84E+03	4.04E+04	2.80E+00	1.56E-01	2.55E+04
Nd	14	N/A	N/A	N/A	1.10E-03	5.93E-04	2.35E-03
Ni	14	13	1.16E+00	4.03E+00	1.70E-02	7.51E-03	7.68E-01
P	7	4	6.38E+00	1.95E+01	3.40E+00	5.11E+00	2.35E+01
Pb	13	12	2.56E-01	5.32E+00	4.30E-03	1.04E-03	1.19E+00
Pr	14	1	9.05E-04	9.05E-04	5.20E-04	-5.12E-04	<MDC
Sb	13	9	2.41E-02	1.39E-01	7.90E-03	1.13E-03	3.21E-02
Sc	11	10	1.40E+00	6.59E+00	1.90E-01	4.92E-03	3.30E+00
Se	12	10	-4.16E-02	5.30E+00	1.20E+00	2.74E+00	<MDC
Si	9	9	7.37E+03	1.81E+04	4.10E+00	2.14E+00	1.48E+04
Sr	13	13	5.06E+01	5.82E+02	6.00E-02	3.04E-03	5.57E+02
Th	12	4	2.07E-03	8.38E-02	4.70E-03	7.92E-04	<MDC
Tl	13	1	-1.23E-02	-1.23E-02	3.40E-03	-3.06E-04	<MDC
U	14	14	1.17E+00	2.38E+00	3.00E-03	5.49E-04	1.57E+00
V	15	15	7.71E+00	3.26E+01	2.90E-02	2.36E-02	4.06E+01
Zn	14	13	1.46E+00	1.25E+01	1.60E-01	-4.28E-02	1.68E+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 6-15: Measured Concentration of Selected Inorganic Elements in Hobbs Drinking Water from 1998 - 2015

Hobbs							
1998-2014					2015		
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	2	3.86E-03	1.04E-01	1.72E-02	-2.70E-04	<MDC
Al	15	12	3.03E+00	1.14E+02	3.40E-01	2.20E-01	8.25E+00
As	14	13	4.55E+00	8.56E+00	9.00E-01	9.41E-01	5.85E+00
B	3	3	1.41E+02	1.97E+02	N/A	N/A	N/A
Ba	12	12	5.63E+01	6.79E+01	3.60E-02	8.27E-04	5.83E+01
Be	13	1	5.39E-02	5.39E-02	3.80E-02	2.52E-03	<MDC
Ca	8	8	7.63E+04	1.10E+05	1.48E+02	5.08E+00	9.07E+04
Cd	12	N/A	N/A	N/A	1.34E-01	2.60E-03	<MDC
Ce	13	10	5.10E-03	3.56E-02	2.80E-03	-3.36E-04	<MDC
Co	14	12	9.78E-02	3.61E-01	3.40E-03	4.44E-03	1.28E-01
Cr	15	14	6.44E-01	1.13E+01	2.80E-01	1.08E-01	1.48E+00
Cu	14	13	1.06E+00	6.93E+00	3.00E-02	8.72E-03	1.08E+00
Dy	14	1	4.18E-03	4.18E-03	3.00E-03	-4.48E-04	<MDC
Er	14	N/A	N/A	N/A	4.60E-03	-1.13E-03	<MDC
Eu	13	10	1.12E-02	1.97E-02	1.14E-02	2.78E-04	<MDC
Fe	11	9	3.64E+01	4.44E+02	3.80E+00	2.47E+00	1.59E+02
Ga	1	1	2.56E+00	2.56E+00	N/A	N/A	N/A
Gd	13	N/A	N/A	N/A	3.00E-03	1.75E-03	<MDC
Hg	6	N/A	N/A	N/A	4.30E-02	1.16E-02	<MDC
K	13	13	2.11E+03	2.52E+04	1.70E+01	9.72E+00	2.24E+03
La	13	5	1.25E-02	5.01E-02	7.80E-03	-1.09E-04	<MDC
Li	12	12	2.65E+01	3.89E+01	N/A	N/A	N/A
Mg	11	11	1.90E+04	2.67E+04	5.60E+00	1.93E-01	2.25E+04
Mn	15	14	3.79E-01	3.62E+00	3.00E-02	2.32E-02	1.66E+00
Mo	11	11	2.46E+00	3.31E+00	4.60E-02	-3.37E-02	2.36E+00
Na	14	14	4.97E+03	5.80E+04	5.60E+00	1.56E-01	3.96E+04
Nd	14	5	3.01E-03	1.44E-02	2.20E-03	5.93E-04	<MDC
Ni	14	14	1.67E+00	4.78E+00	3.40E-02	7.51E-03	1.71E+00
P	7	6	1.74E+01	5.65E+01	6.80E+00	5.11E+00	8.31E+01
Pb	13	11	9.44E-02	1.19E+00	8.60E-03	1.04E-03	3.20E-01
Pr	14	2	1.57E-03	1.88E-03	1.04E-03	-5.12E-04	<MDC

Table 6-15: Measured Concentration of Selected Inorganic Elements in Hobbs Drinking Water from 1998 – 2015 (continued)

Hobbs							
1998-2014					2015		
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	13	9	3.88E-02	8.53E-02	1.58E-02	1.13E-03	5.78E-02
Sc	11	11	3.06E+00	1.05E+01	3.80E-01	4.92E-03	5.25E+00
Se	12	10	-1.70E-01	1.23E+01	2.40E+00	2.74E+00	5.15E+00
Si	9	9	2.41E+04	2.86E+04	8.20E+00	2.14E+00	2.30E+04
Sr	13	13	7.89E+01	1.14E+03	1.20E-01	3.04E-03	1.12E+03
Th	12	3	2.29E-03	1.36E-01	9.40E-03	7.92E-04	1.08E-02
Tl	12	2	9.45E-03	2.24E-02	6.80E-03	-3.06E-04	<MDC
U	14	14	2.90E+00	4.30E+00	6.00E-03	5.49E-04	4.03E+00
V	15	15	3.11E+01	3.79E+01	5.80E-02	2.36E-02	3.55E+01
Zn	14	11	8.44E-01	4.37E+00	3.20E-01	-4.28E-02	1.41E+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 6-16: Measured Concentration of Selected Inorganic Elements in Loving Drinking Water from 1998 – 2015

Loving							
1998-2014					2015		
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	15	4	2.55E-03	2.17E-01	8.60E-03	-2.70E-04	<MDC
Al	15	10	1.43E+00	3.76E+02	1.70E-01	2.20E-01	3.21E+00
As	14	11	7.89E-01	2.22E+00	4.50E-01	9.41E-01	1.02E+00
B	3	3	7.55E+01	1.12E+02	N/A	N/A	N/A
Ba	12	12	2.96E+01	3.47E+01	1.80E-02	8.27E-04	3.44E+01
Be	13	1	9.35E-02	9.35E-02	1.90E-02	2.52E-03	<MDC
Ca	8	8	6.71E+04	1.00E+05	7.40E+01	5.08E+00	7.61E+04
Cd	13	N/A	N/A	N/A	6.70E-02	2.60E-03	<MDC
Ce	14	6	9.74E-04	2.53E-01	1.40E-03	-3.36E-04	<MDC
Co	14	12	1.02E-01	4.04E-01	1.70E-03	4.44E-03	8.42E-02
Cr	15	13	1.12E+00	1.12E+01	1.40E-01	1.08E-01	1.91E+00
Cu	14	12	8.06E-01	5.59E+00	1.50E-02	8.72E-03	1.22E+00
Dy	14	N/A	N/A	N/A	1.50E-03	-4.48E-04	<MDC

Table 6-16: Measured Concentration of Selected Inorganic Elements in Loving Drinking Water from 1998 – 2015 (continued)

Loving							
1998-2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Blank Conc. (µg/L)	Sample Conc. (µg/L)[5]
Er	15	N/A	N/A	N/A	2.30E-03	-1.13E-03	<MDC
Eu	14	10	7.00E-03	1.04E-02	5.70E-03	2.78E-04	<MDC
Fe	11	8	3.60E+00	2.57E+02	1.90E+00	2.47E+00	1.45E+02
Ga	1	1	1.26E+00	1.26E+00	N/A	N/A	N/A
Gd	14	2	2.15E-03	1.04E-02	1.50E-03	1.75E-03	<MDC
Hg	6	N/A	N/A	N/A	4.30E-02	1.16E-02	<MDC
K	13	13	1.69E+03	1.98E+04	8.50E+00	9.72E+00	1.69E+03
La	14	4	6.66E-03	2.22E-02	3.90E-03	-1.09E-04	<MDC
Li	12	12	1.50E+01	2.24E+01	N/A	N/A	N/A
Mg	11	11	3.02E+04	4.21E+04	2.80E+00	1.93E-01	3.36E+04
Mn	15	9	1.43E-02	1.77E+00	1.50E-02	2.32E-02	7.90E-02
Mo	11	10	1.28E+00	1.72E+00	2.30E-02	-3.37E-02	1.51E+00
Na	14	14	2.33E+03	2.82E+04	2.80E+00	1.56E-01	1.79E+04
Nd	15	2	3.37E-03	7.68E-03	1.10E-03	5.93E-04	<MDC
Ni	14	13	1.91E+00	3.38E+00	1.70E-02	7.51E-03	1.41E+00
P	7	6	2.46E+01	4.73E+01	3.40E+00	5.11E+00	7.32E+01
Pb	13	9	8.03E-02	1.67E+00	4.30E-03	1.04E-03	1.04E-01
Pr	15	N/A	N/A	N/A	5.20E-04	-5.12E-04	<MDC
Sb	13	8	3.46E-02	1.84E-01	7.90E-03	1.13E-03	3.43E-02
Sc	11	10	1.50E+00	4.72E+00	1.90E-01	4.92E-03	2.26E+00
Se	12	6	-2.89E+00	1.53E+00	1.20E+00	2.74E+00	<MDC
Si	9	9	9.10E+03	1.09E+04	4.10E+00	2.14E+00	8.91E+03
Sr	13	13	7.60E+01	9.37E+02	6.00E-02	3.04E-03	7.73E+02
Th	13	2	5.69E-03	7.38E-03	4.70E-03	7.92E-04	<MDC
Tl	14	2	2.24E-03	4.32E-02	3.40E-03	-3.06E-04	<MDC
U	14	14	1.90E+00	2.30E+00	3.00E-03	5.49E-04	2.20E+00
V	15	15	1.11E+01	1.61E+01	2.90E-02	2.36E-02	1.36E+01
Zn	14	13	4.79E+00	2.01E+01	1.60E-01	-4.28E-02	8.92E+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 Otis Drinking Water from 1998 - 2015

Otis							
1998-2014					2015		
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	12	1	2.63E-02	2.63E-02	4.30E-02	-2.70E-04	<MDC
Al	13	4	2.69E+00	1.06E+03	8.50E-01	2.20E-01	1.10E+01
As	14	7	6.53E-01	2.34E+00	2.25E+00	9.41E-01	<MDC
B	3	3	1.46E+02	2.39E+02	N/A	N/A	N/A
Ba	11	10	1.39E+01	1.75E+01	9.00E-02	8.27E-04	1.97E+01
Be	12	N/A	N/A	N/A	9.50E-02	2.52E-03	<MDC
Ca	8	8	1.89E+05	3.57E+05	7.40E+02	5.08E+00	3.25E+05
Cd	11	N/A	N/A	N/A	3.35E-01	2.60E-03	<MDC
Ce	12	1	2.75E-02	2.75E-02	7.00E-03	-3.36E-04	<MDC
Co	13	11	2.44E-01	9.51E-01	8.50E-03	4.44E-03	3.65E-01
Cr	14	12	8.12E-01	8.72E+00	7.00E-01	1.08E-01	1.93E+00
Cu	13	12	2.43E+00	6.02E+00	7.50E-02	8.72E-03	3.40E+00
Dy	13	1	3.39E-03	3.39E-03	7.50E-03	-4.48E-04	<MDC
Er	13	N/A	N/A	N/A	1.15E-02	-1.13E-03	<MDC
Eu	12	3	3.42E-03	9.48E-03	2.85E-02	2.78E-04	<MDC
Fe	11	10	2.87E+00	1.02E+03	9.50E+00	2.47E+00	7.94E+02
Ga	1	1	6.54E-01	6.54E-01	N/A	N/A	N/A
Gd	12	N/A	N/A	N/A	7.50E-03	1.75E-03	<MDC
Hg	6	1	3.23E-02	3.23E-02	4.30E-02	1.16E-02	<MDC
K	12	12	2.41E+03	4.01E+03	4.25E+01	9.72E+00	3.11E+03
La	12	2	3.36E-03	6.30E-03	1.95E-02	-1.09E-04	<MDC
Li	11	11	3.37E+01	6.79E+01	N/A	N/A	N/A
Mg	11	11	5.16E+04	1.08E+05	2.80E+01	1.93E-01	8.76E+04
Mn	13	5	1.98E-01	2.32E+00	7.50E-02	2.32E-02	4.91E+00
Mo	10	10	2.25E+00	4.68E+00	1.15E-01	-3.37E-02	4.11E+00
Na	12	12	5.35E+04	1.97E+05	2.80E+01	1.56E-01	9.12E+04
Nd	13	3	4.80E-03	3.97E-02	5.50E-03	5.93E-04	<MDC
Ni	13	12	2.62E+00	1.11E+01	8.50E-02	7.51E-03	5.98E+00
P	7	7	4.54E+01	2.59E+02	1.70E+01	5.11E+00	3.68E+02
Pb	12	7	1.08E-01	5.98E-01	2.15E-02	1.04E-03	3.29E-01
Pr	13	N/A	N/A	N/A	2.60E-03	-5.12E-04	<MDC

Table 6-17: Measured Concentration of Selected Inorganic Elements in Otis Drinking Water from 1998 – 2015 (continued)

Otis							
1998-2014					2015		
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	3.66E-02	4.10E-01	3.95E-02	1.13E-03	<MDC
Sc	11	9	6.55E-01	5.35E+00	9.50E-01	4.92E-03	2.93E+00
Se	12	6	-2.43E-02	1.19E+00	6.00E+00	2.74E+00	<MDC
Si	9	9	9.30E+03	1.39E+04	2.05E+01	2.14E+00	9.83E+03
Sr	11	11	2.20E+03	4.62E+03	6.00E-01	3.04E-03	4.50E+03
Th	10	3	1.19E-03	5.11E-02	2.35E-02	7.92E-04	<MDC
Tl	12	1	-6.30E-03	-6.30E-03	1.70E-02	-3.06E-04	<MDC
U	13	13	3.73E+00	5.88E+00	1.50E-02	5.49E-04	6.06E+00
V	14	13	7.87E+00	1.29E+01	1.45E-01	2.36E-02	9.71E+00
Zn	12	9	1.54E+00	1.16E+01	8.00E-01	-4.28E-02	5.56E+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 6-18: Measured Concentration of Selected Inorganic Elements in Malaga Drinking Water from 2011 - 2015

Malaga							
2011-2014					2015		
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	4	N/A	N/A	N/A	4.30E-02	-2.70E-04	<MDC
Al	4	1	2.39E+00	2.39E+00	8.50E-01	2.20E-01	2.66E+00
As	4	1	5.44E+00	5.44E+00	2.25E+00	9.41E-01	<MDC
B	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ba	4	4	1.44E+01	1.66E+01	9.00E-02	8.27E-04	1.48E+01
Be	4	1	3.04E-01	3.04E-01	9.50E-02	2.52E-03	<MDC
Ca	4	4	2.41E+05	3.51E+05	7.40E+02	5.08E+00	3.04E+05
Cd	4	N/A	N/A	N/A	3.35E-01	2.60E-03	<MDC
Ce	4	N/A	N/A	N/A	7.00E-03	-3.36E-04	<MDC
Co	4	4	3.54E-01	8.57E-01	8.50E-03	4.44E-03	3.39E-01
Cr	4	4	5.80E-01	1.00E+01	7.00E-01	1.08E-01	1.82E+00
Cu	4	3	2.62E+00	3.66E+00	7.50E-02	8.72E-03	1.57E+00
Dy	4	N/A	N/A	N/A	7.50E-03	-4.48E-04	<MDC

Table 6-18: Measured Concentration of Selected Inorganic Elements in Malaga Drinking Water from 2011 – 2015 (continued)

Malaga							
2011-2014					2015		
EL[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Blank Conc. (µg/L)	Sample Conc. (µg/L)[5]
Er	4	N/A	N/A	N/A	1.15E-02	-1.13E-03	<MDC
Eu	4	N/A	N/A	N/A	2.85E-02	2.78E-04	<MDC
Fe	4	4	5.90E+02	1.02E+03	9.50E+00	2.47E+00	6.52E+02
Ga	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gd	4	N/A	N/A	N/A	7.50E-03	1.75E-03	<MDC
Hg	4	N/A	N/A	N/A	4.30E-02	1.16E-02	<MDC
K	4	4	2.57E+03	3.38E+03	4.25E+01	9.72E+00	3.05E+03
La	4	N/A	N/A	N/A	1.95E-02	-1.09E-04	<MDC
Li	4	4	3.72E+01	5.40E+01	N/A	N/A	N/A
Mg	4	4	6.98E+04	9.90E+04	2.80E+01	1.93E-01	9.06E+04
Mn	4	1	8.34E-01	8.34E-01	7.50E-02	2.32E-02	2.84E-01
Mo	3	3	3.54E+00	3.99E+00	1.15E-01	-3.37E-02	3.23E+00
Na	4	4	7.53E+04	1.11E+05	2.80E+01	1.56E-01	8.91E+04
Nd	4	N/A	N/A	N/A	5.50E-03	5.93E-04	<MDC
Ni	4	4	6.84E+00	1.06E+01	8.50E-02	7.51E-03	5.66E+00
P	4	4	5.64E+01	2.25E+02	1.70E+01	5.11E+00	4.45E+02
Pb	4	3	3.68E-01	1.75E+00	2.15E-02	1.04E-03	1.46E-01
Pr	4	N/A	N/A	N/A	2.60E-03	-5.12E-04	<MDC
Sb	4	2	3.95E-02	6.38E-02	3.95E-02	1.13E-03	<MDC
Sc	3	3	1.54E+00	2.41E+00	9.50E-01	4.92E-03	2.40E+00
Se	4	1	1.65E+01	1.65E+01	6.00E+00	2.74E+00	<MDC
Si	4	4	9.12E+03	1.04E+04	2.05E+01	2.14E+00	9.22E+03
Sr	4	4	3.71E+03	3.87E+03	6.00E-01	3.04E-03	4.13E+03
Th	3	N/A	N/A	N/A	2.35E-02	7.92E-04	<MDC
Tl	4	N/A	N/A	N/A	1.70E-02	-3.06E-04	<MDC
U	4	4	4.38E+00	5.38E+00	1.50E-02	5.49E-04	5.61E+00
V	4	4	8.30E+00	1.20E+01	1.45E-01	2.36E-02	9.49E+00
Zn	4	4	1.52E+01	4.64E+01	8.00E-01	-4.28E-02	2.19E+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 6-19: Measured Concentration of Select Anions in Carlsbad Drinking Water from 1998 - 2015

Carlsbad							
1998-2014					2015		
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	8	0	N/A	N/A	2.50E+01	0.00E+00	8.40E+01
Chloride	14	13	7.83E+03	7.88E+04	4.30E+00	0.00E+00	2.07E+04
Fluoride	11	10	1.23E+02	8.62E+02	1.30E+01	0.00E+00	3.32E+02
Nitrate	15	15	3.52E+03	5.91E+03	2.50E+01	0.00E+00	1.57E+03
Nitrite	7	0	N/A	N/A	3.10E+01	0.00E+00	<MDC
Phosphate	15	0	N/A	N/A	8.30E+01	0.00E+00	<MDC
Sulfate	14	14	7.61E+04	1.17E+05	3.10E+01	0.00E+00	7.96E+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 Double Eagle Drinking Water from 1998 - 2015

Double Eagle							
1998-2014					2015		
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	8	3	9.49E+01	2.39E+02	2.50E+01	0.00E+00	2.78E+02
Chloride	15	15	2.23E+04	4.59E+04	4.30E+00	0.00E+00	3.52E+04
Fluoride	11	11	4.40E+02	1.36E+03	1.30E+01	0.00E+00	8.37E+02
Nitrate	14	14	6.98E+03	1.46E+04	2.50E+01	0.00E+00	1.05E+04
Nitrite	8	0	N/A	N/A	3.10E+01	0.00E+00	<MDC
Phosphate	15	0	N/A	N/A	8.30E+01	0.00E+00	<MDC
Sulfate	15	15	3.81E+04	5.69E+04	3.10E+01	0.00E+00	3.83E+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 6-21: Measured Concentration of Select Anions in Hobbs Drinking Water from 1998 - 2015

Hobbs							
1998-2014					2015		
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	8	2	8.27E+01	1.84E+02	2.50E+01	0.00E+00	3.94E+02
Chloride	15	15	6.32E+04	1.07E+05	4.30E+00	0.00E+00	1.03E+05
Fluoride	12	12	4.91E+02	2.88E+03	1.30E+01	0.00E+00	1.20E+03
Nitrate	15	15	1.56E+04	2.21E+04	2.50E+01	0.00E+00	2.08E+04
Nitrite	8	0	N/A	N/A	3.10E+01	0.00E+00	<MDC
Phosphate	14	0	N/A	N/A	8.30E+01	0.00E+00	<MDC
Sulfate	15	15	9.60E+04	1.51E+05	1.55E+02	0.00E+00	1.33E+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 Loving Drinking Water from 1998 - 2015

Loving							
1998-2014					2015		
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	3.58E+01	3.58E+01	2.50E+01	0.00E+00	<MDC
Chloride	14	14	1.59E+04	3.62E+04	4.30E+00	0.00E+00	3.26E+04
Fluoride	11	8	1.31E+02	2.34E+03	1.30E+01	0.00E+00	5.15E+02
Nitrate	14	14	1.59E+04	2.91E+04	2.50E+01	0.00E+00	2.12E+04
Nitrite	6	0	N/A	N/A	3.10E+01	0.00E+00	<MDC
Phosphate	14	1	5.28E+01	5.28E+01	8.30E+01	0.00E+00	<MDC
Sulfate	13	13	1.27E+05	2.05E+05	1.55E+02	0.00E+00	1.18E+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 Malaga Drinking Water from 1998 - 2015

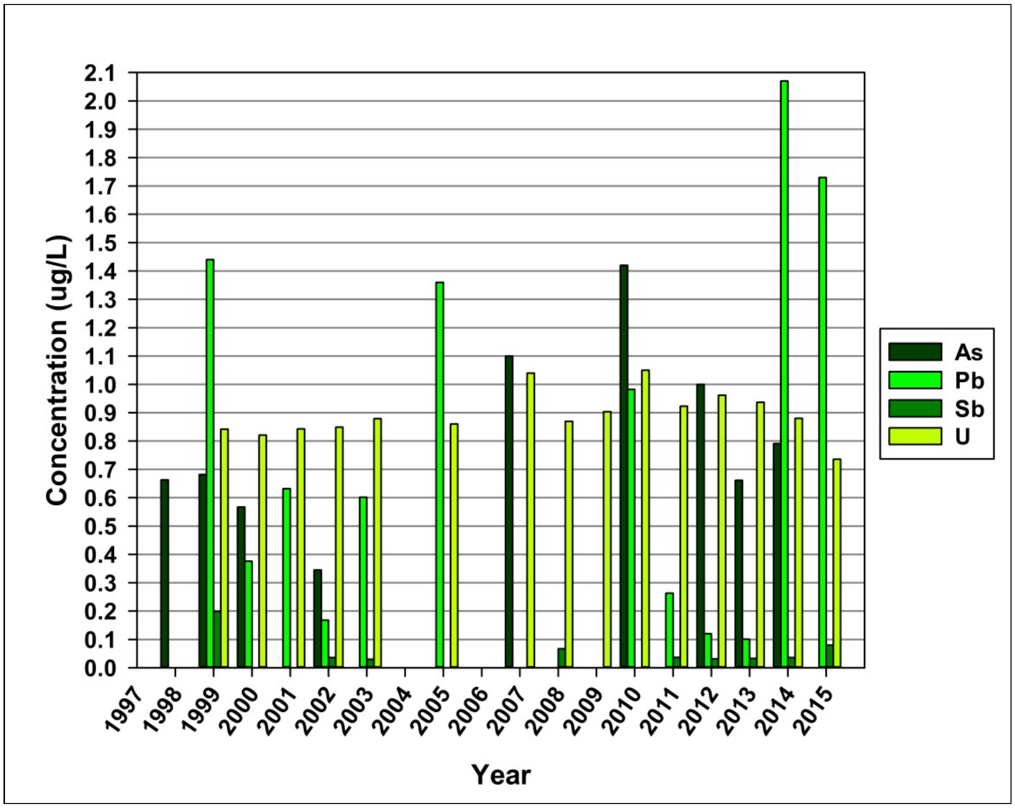
Malaga							
1998-2014					2015		
Anion[1]	N[2]	N_{DET}[2]	Min[3]	Max[3]	MDC[4] (µg/L)	Blank Conc. (µg/L)	Sample Conc. (µg/L)[5]
Bromide	4	0	N/A	N/A	1.25E+02	0.00E+00	2.40E+02
Chloride	4	4	3.63E+05	4.30E+05	2.15E+01	0.00E+00	4.22E+05
Fluoride	4	0	N/A	N/A	6.50E+01	0.00E+00	8.55E+02
Nitrate	4	4	1.07E+04	2.41E+04	1.25E+02	0.00E+00	1.82E+04
Nitrite	4	0	N/A	N/A	1.55E+02	0.00E+00	<MDC
Phosphate	4	0	N/A	N/A	4.15E+02	0.00E+00	<MDC
Sulfate	4	4	6.73E+05	7.98E+05	3.10E+02	0.00E+00	7.58E+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 6-24: Measured Concentration of Select Anions in Otis Drinking Water from 1998 - 2015

Otis							
1998-2014					2015		
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	1.25E+02	0.00E+00	3.00E+02
Chloride	14	14	1.26E+05	4.21E+05	2.15E+01	0.00E+00	4.12E+05
Fluoride	12	7	4.70E+02	1.53E+03	6.50E+01	0.00E+00	8.85E+02
Nitrate	15	15	9.59E+03	2.53E+04	1.25E+02	0.00E+00	1.81E+04
Nitrite	7	0	N/A	N/A	1.55E+02	0.00E+00	<MDC
Phosphate	15	0	N/A	N/A	4.15E+02	0.00E+00	<MDC
Sulfate	13	13	3.27E+05	8.94E+05	3.10E+02	0.00E+00	7.73E+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



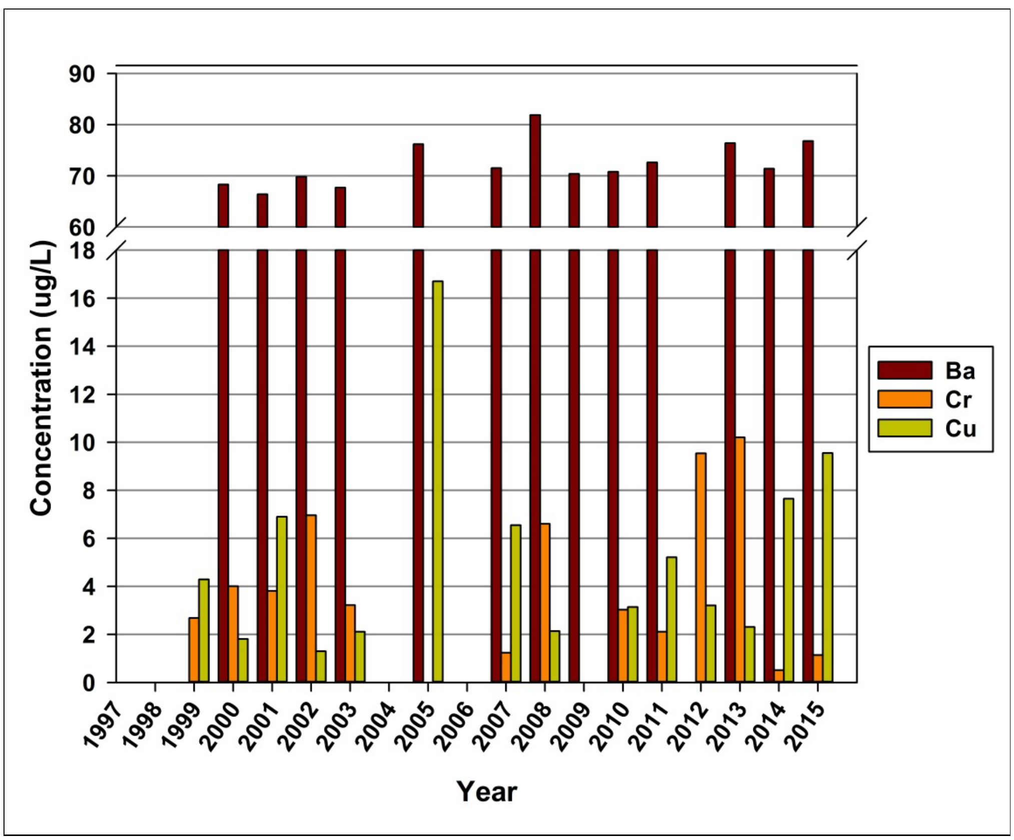


Figure 6-13: Concentrations (µg/L) of Select Inorganic Analytes Measured in Carlsbad Drinking Water from 1998 - 2015

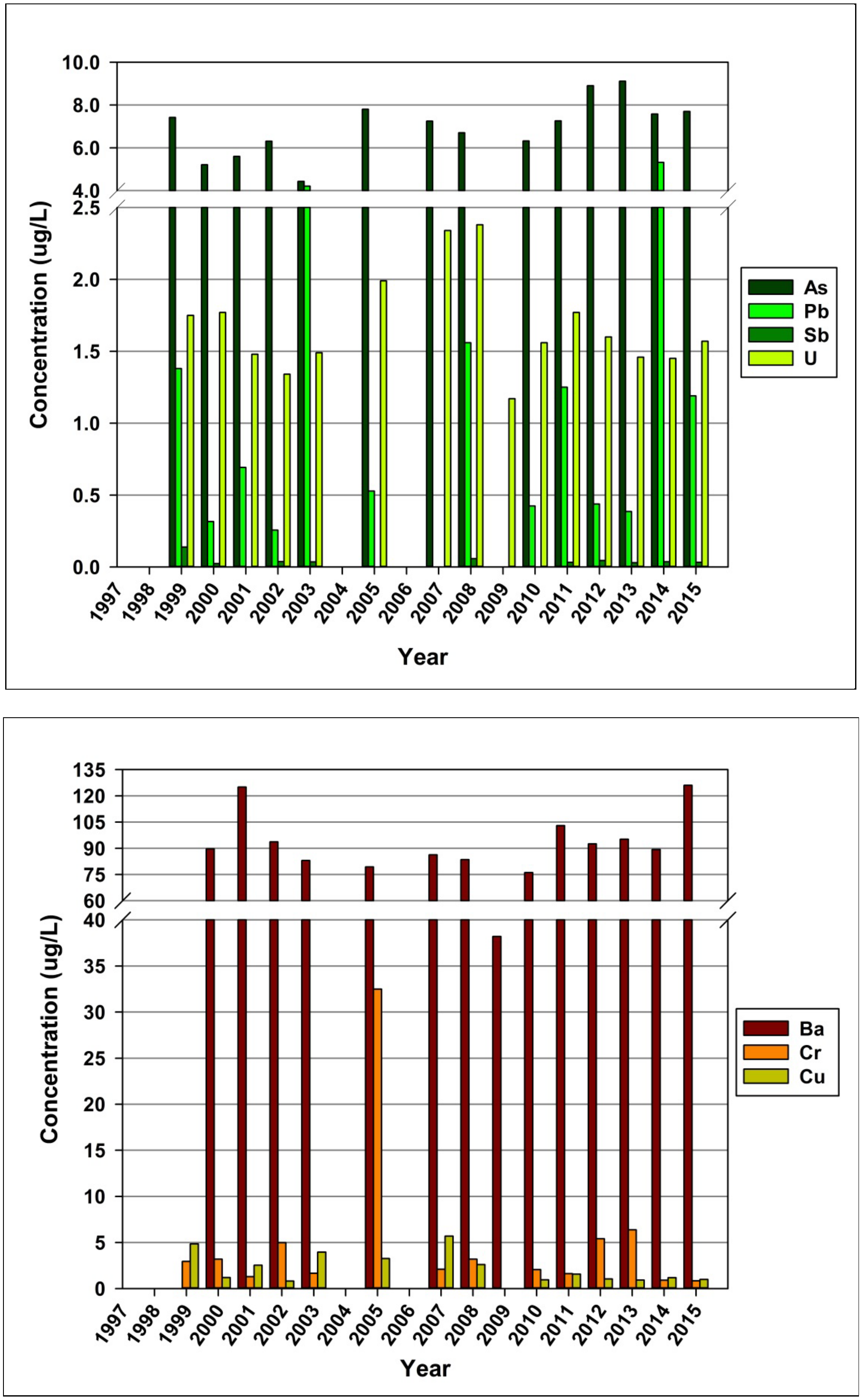
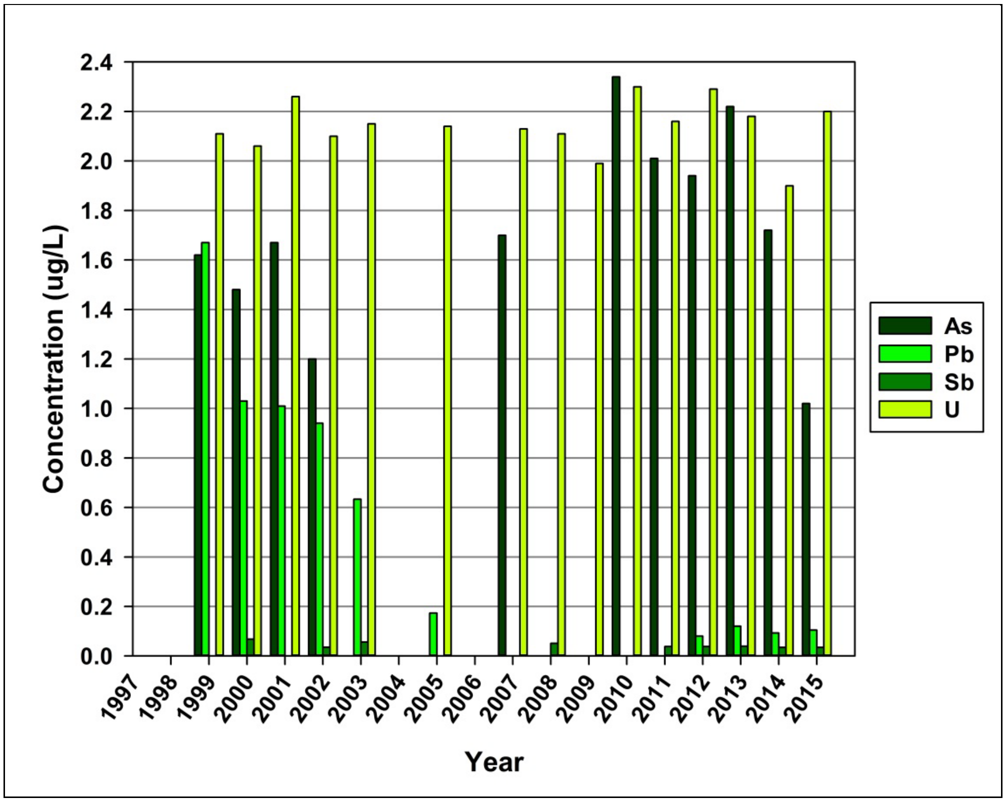


Figure 6-14: Concentrations (µg/L) of Select Inorganic Analytes Measured Near the WIPP site (Double Eagle) from 1998 - 2015



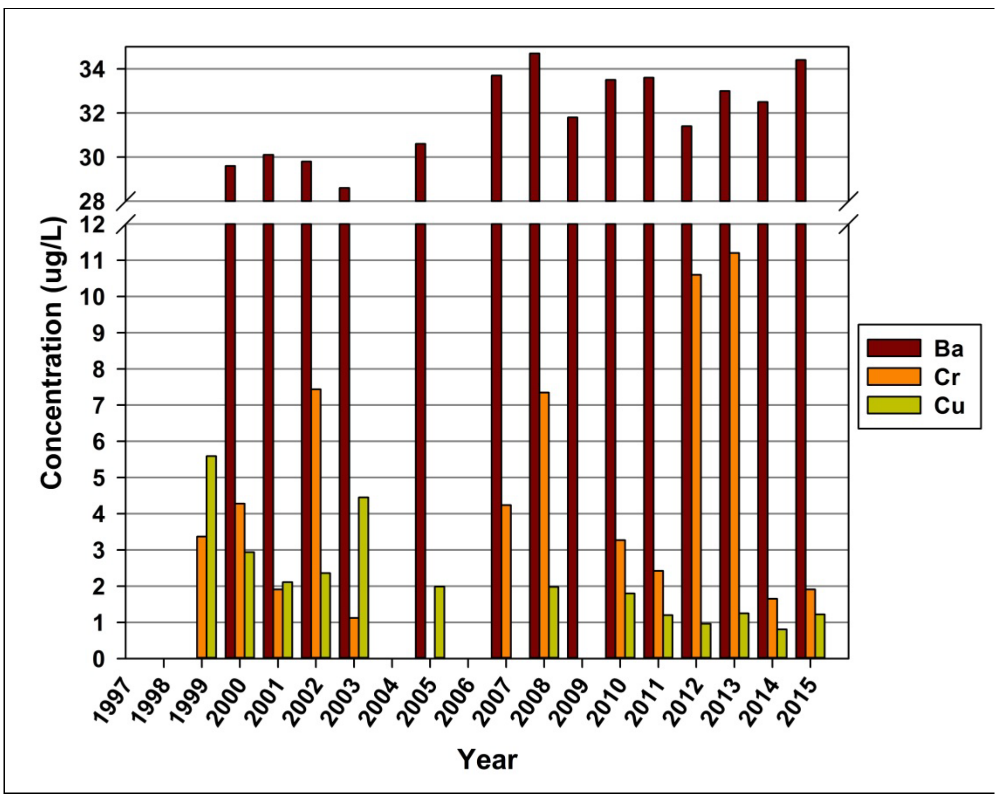
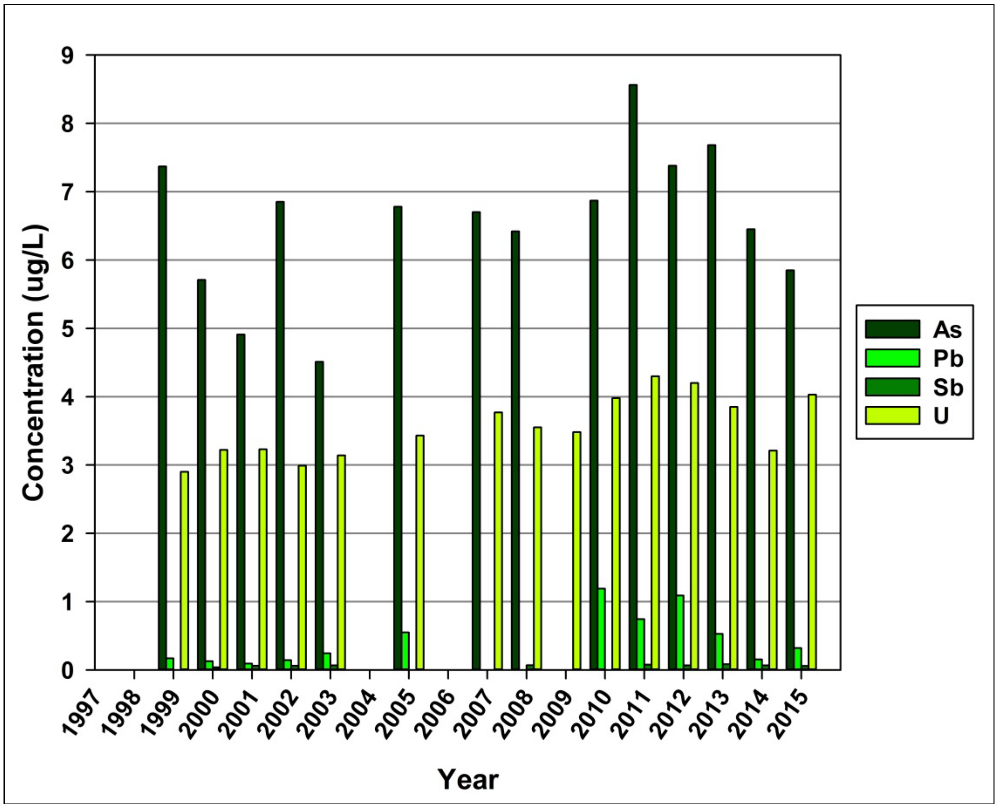


Figure 6-15: Concentrations (µg/L) of Select Inorganic Analytes Measured in Loving Drinking Water from 1998 - 2015



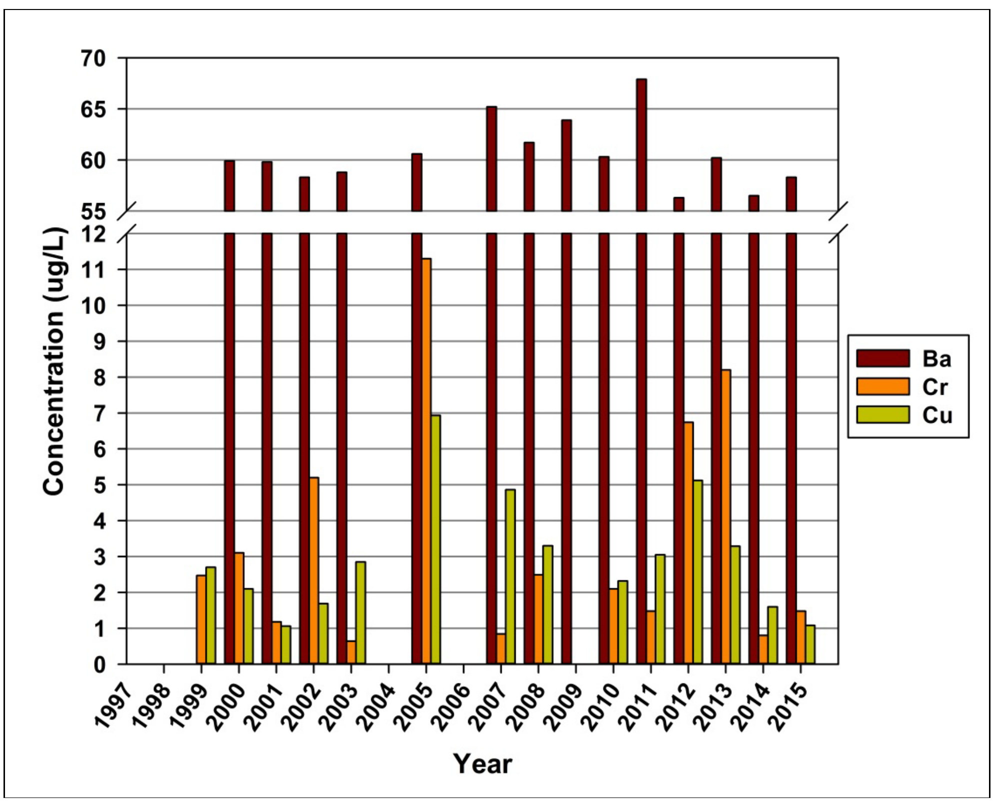
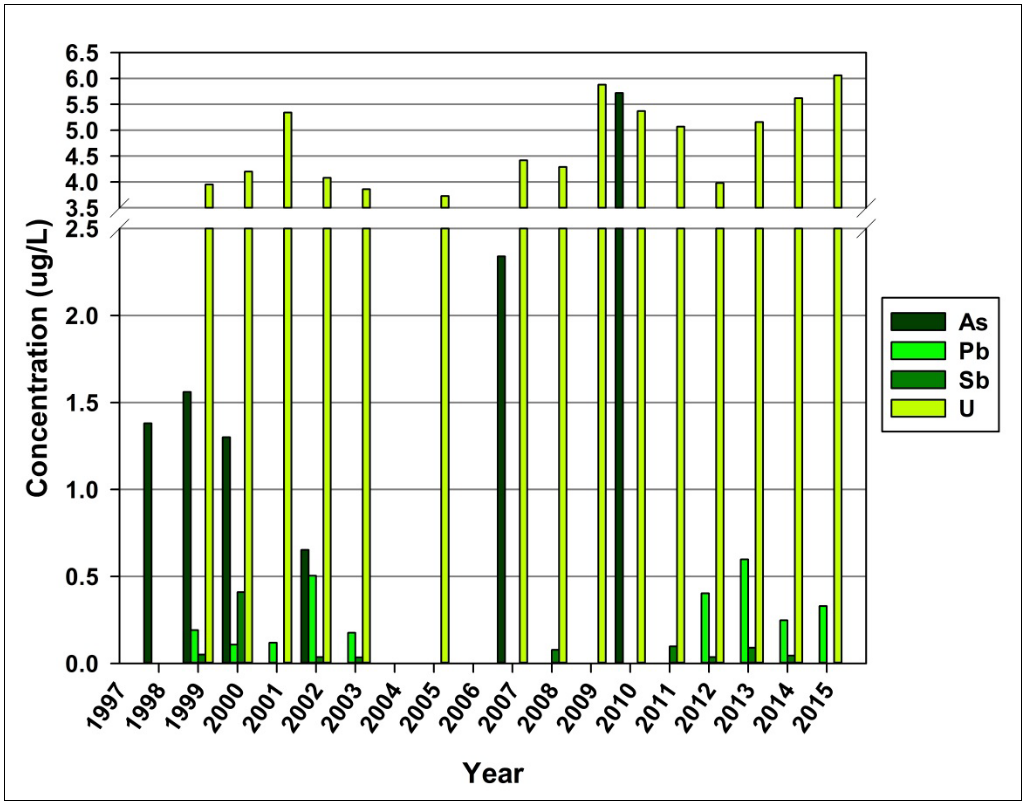


Figure 6-16: Concentrations (µg/L) of Select Inorganic Analytes Measured in Hobbs Drinking Water from 1998 - 2015



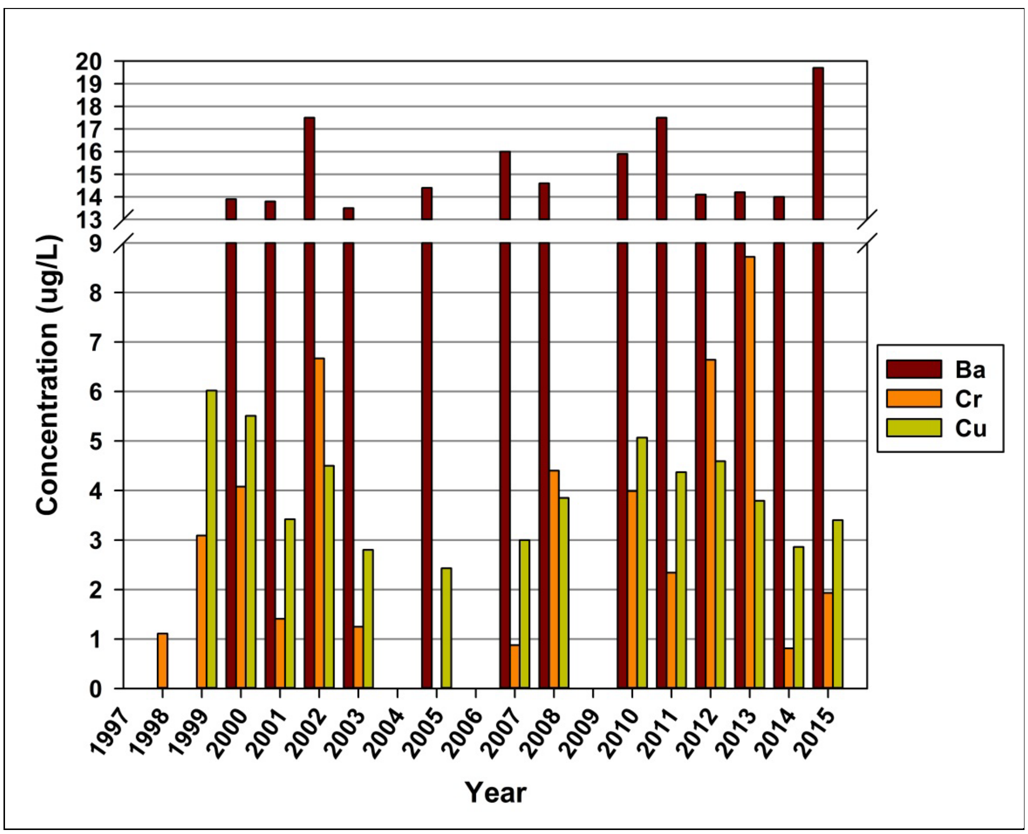
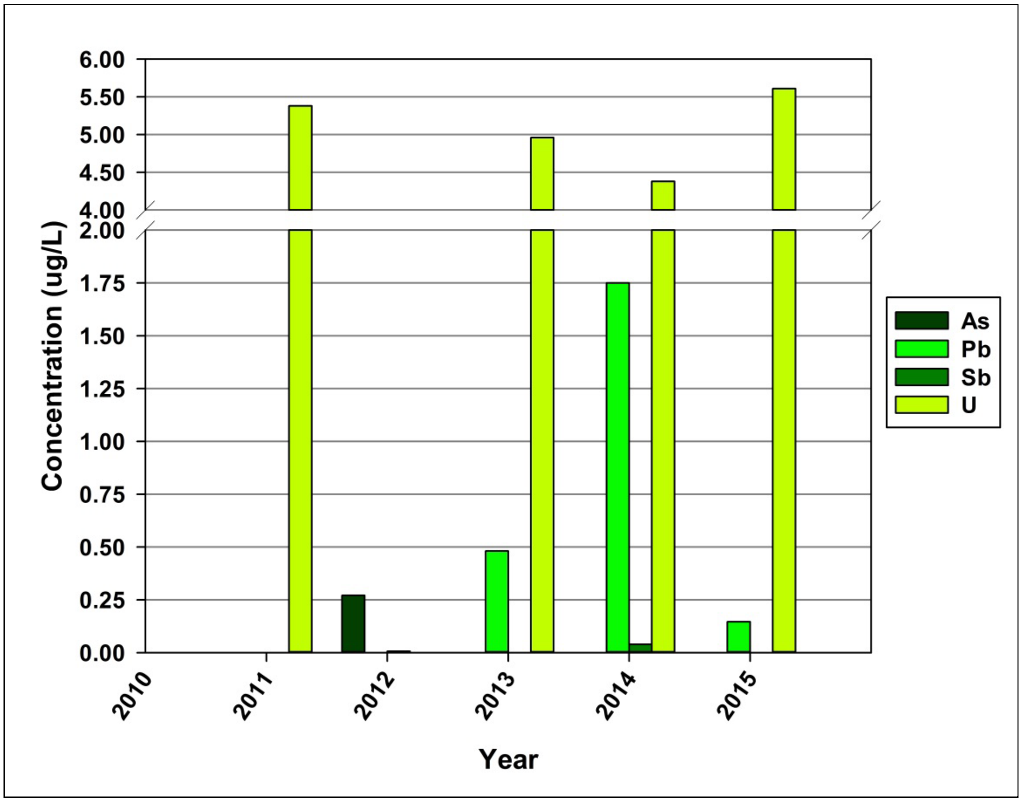


Figure 6-17: Concentrations (µg/L) of Select Inorganic Analytes Measured in Otis Drinking Water from 1998 - 2015



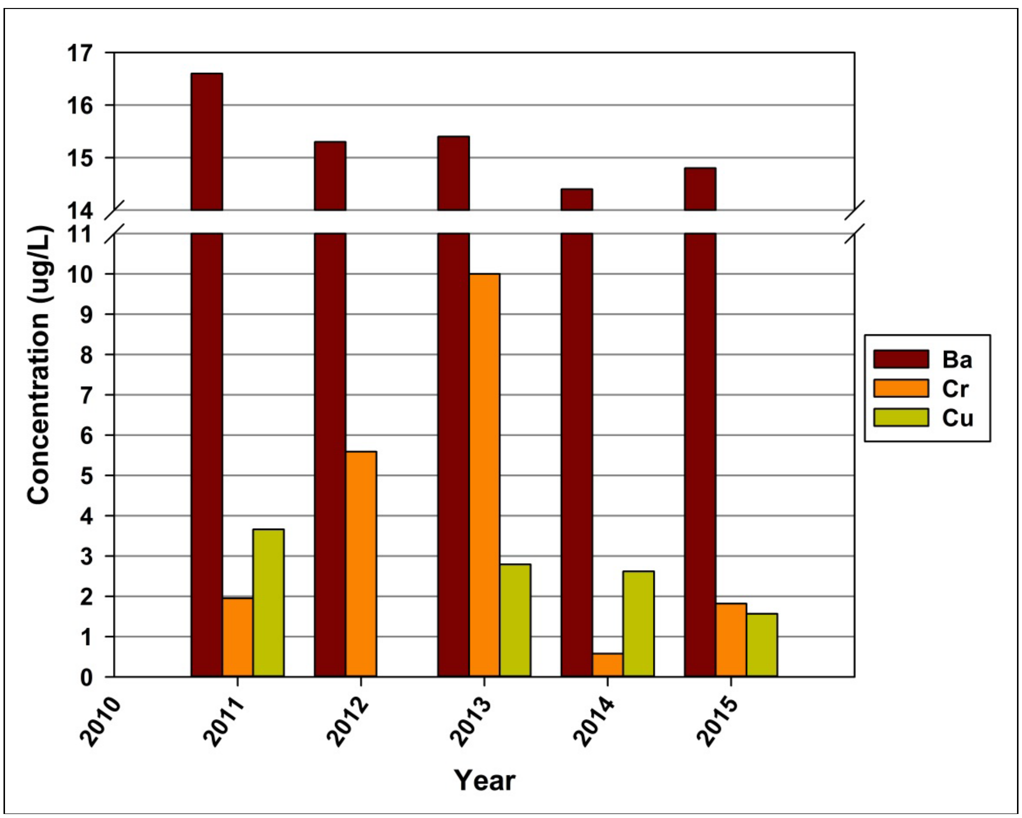


Figure 6-18: Concentrations (µg/L) of Select Inorganic Analytes Measured in Malaga Drinking Water from 2011 – 2015

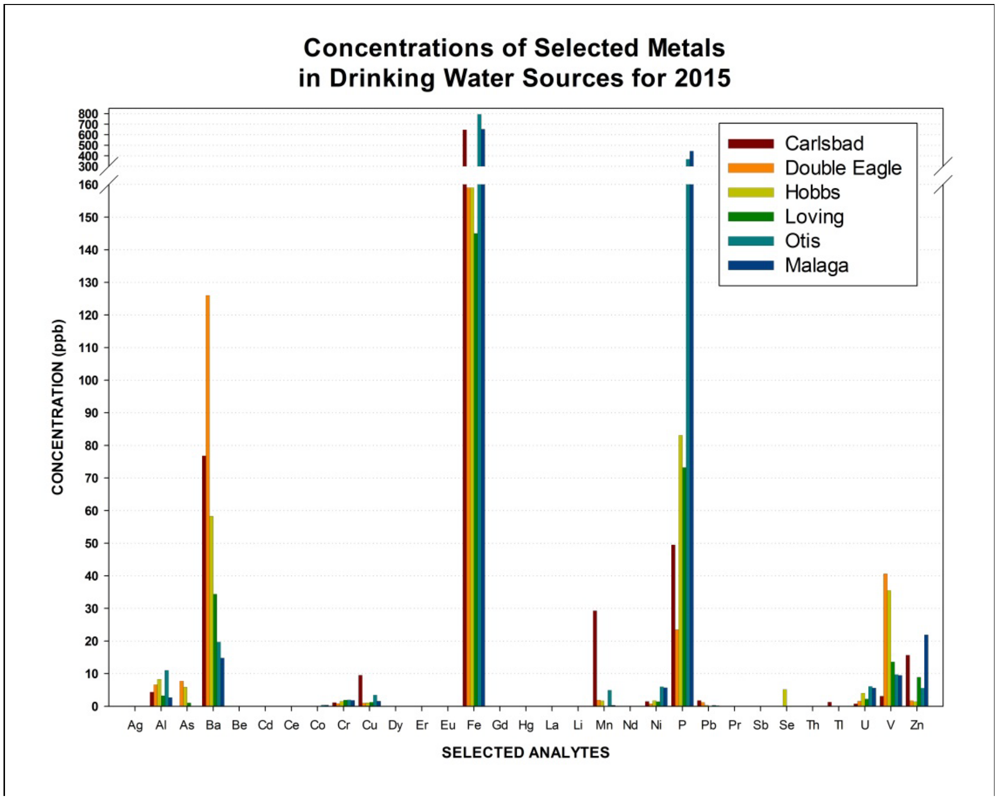


Figure 6-19: Select Metals in 2015 Drinking Water

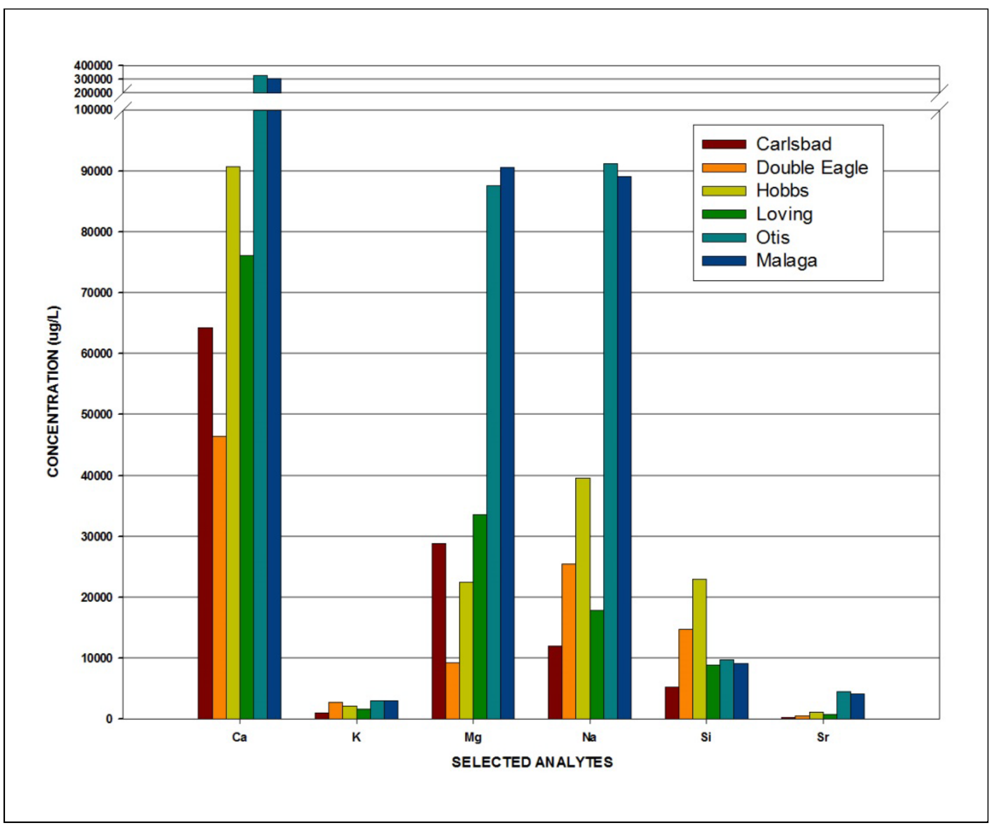


Figure 6-20: Concentrations of Select Metals in Common Salts for 2015 Drinking Water

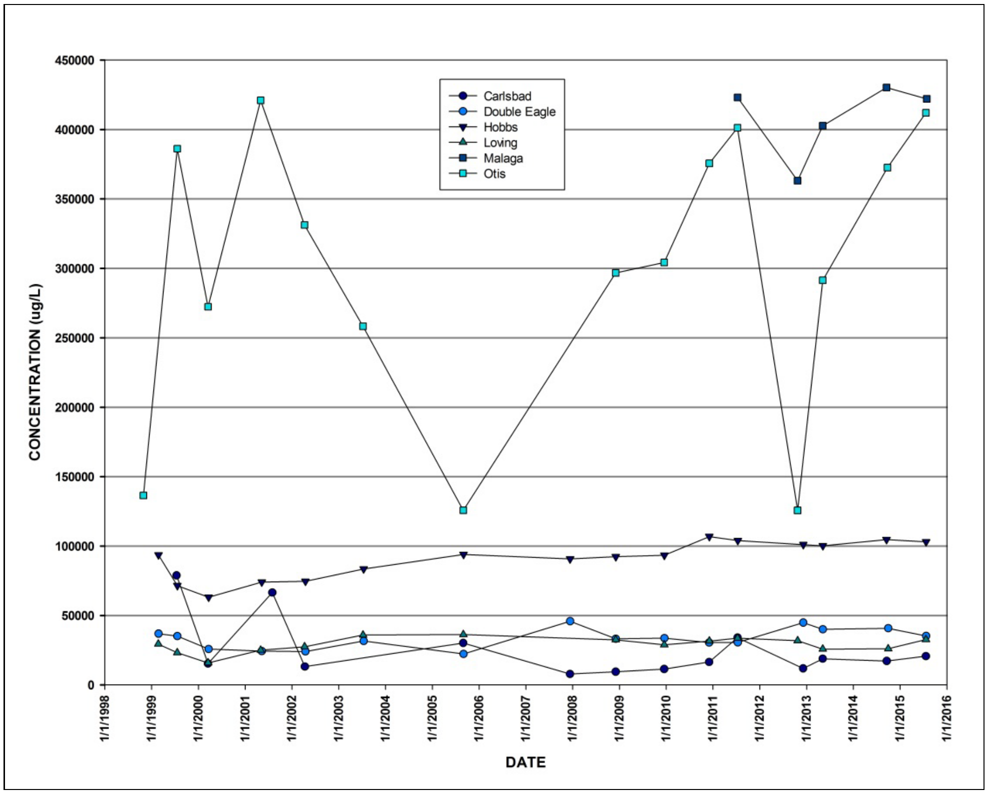


Figure 6-21: Measured Concentrations of Chloride in Drinking Water from 1998 – 2015

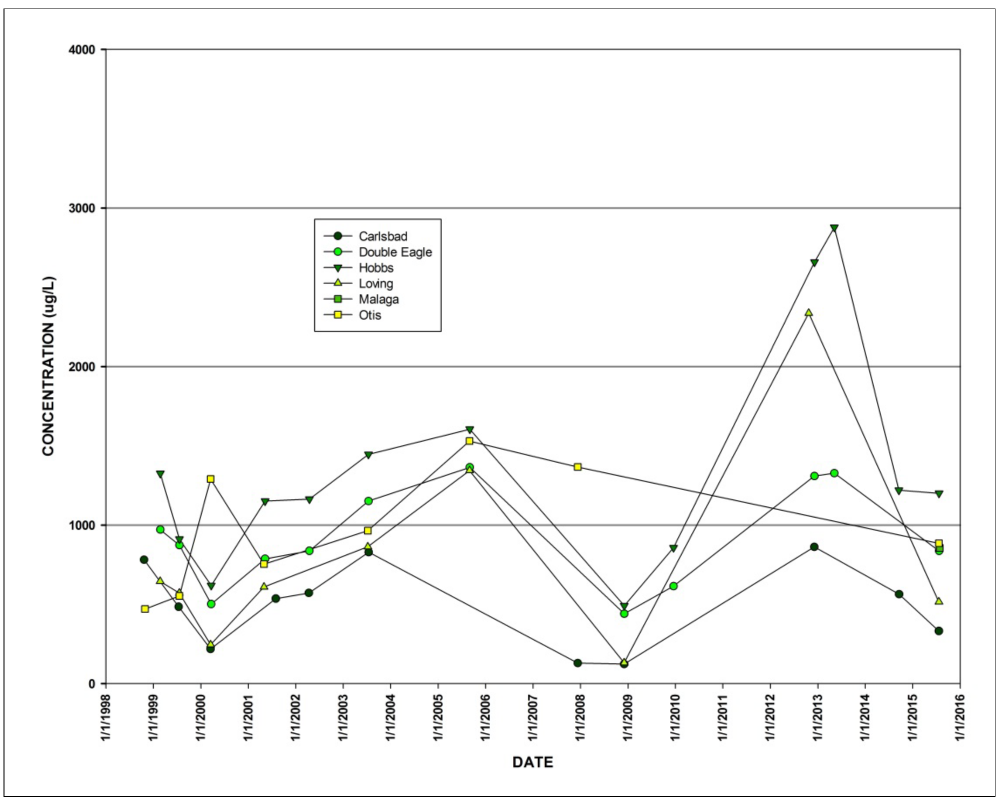


Figure 6-22: Measured Concentrations of Fluoride in Drinking Water from 1998 – 2015

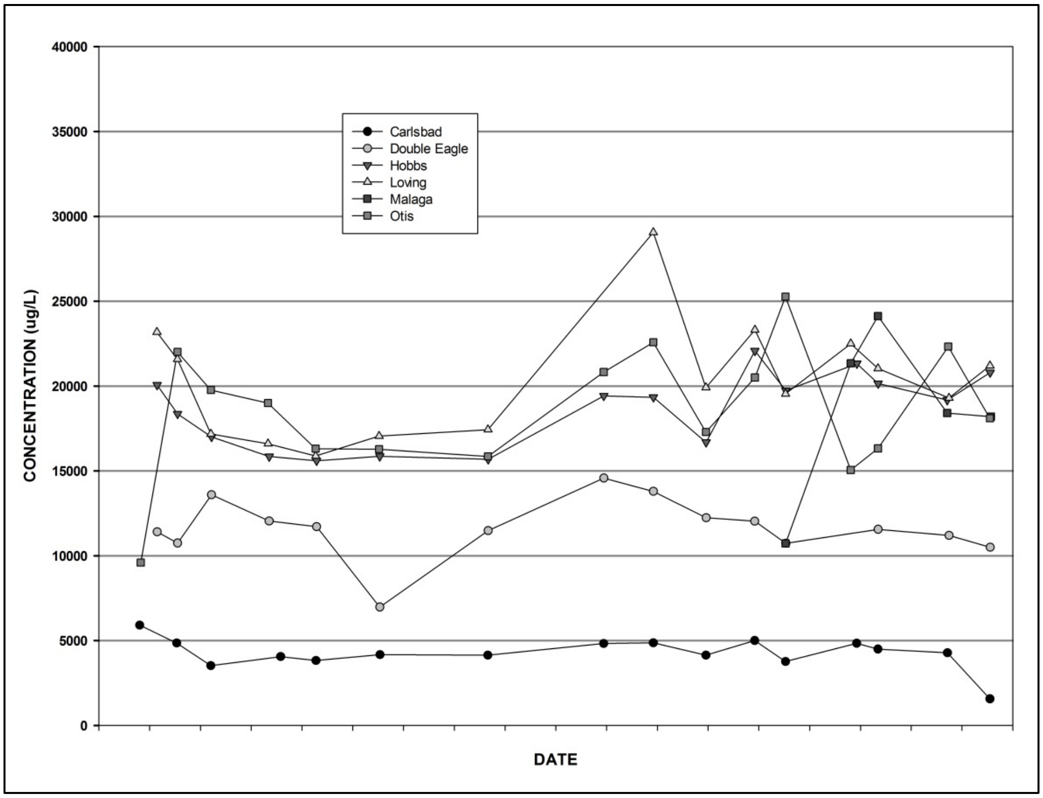


Figure 6-23: Measured Concentrations of Nitrate in Drinking Water from 1998 – 2015

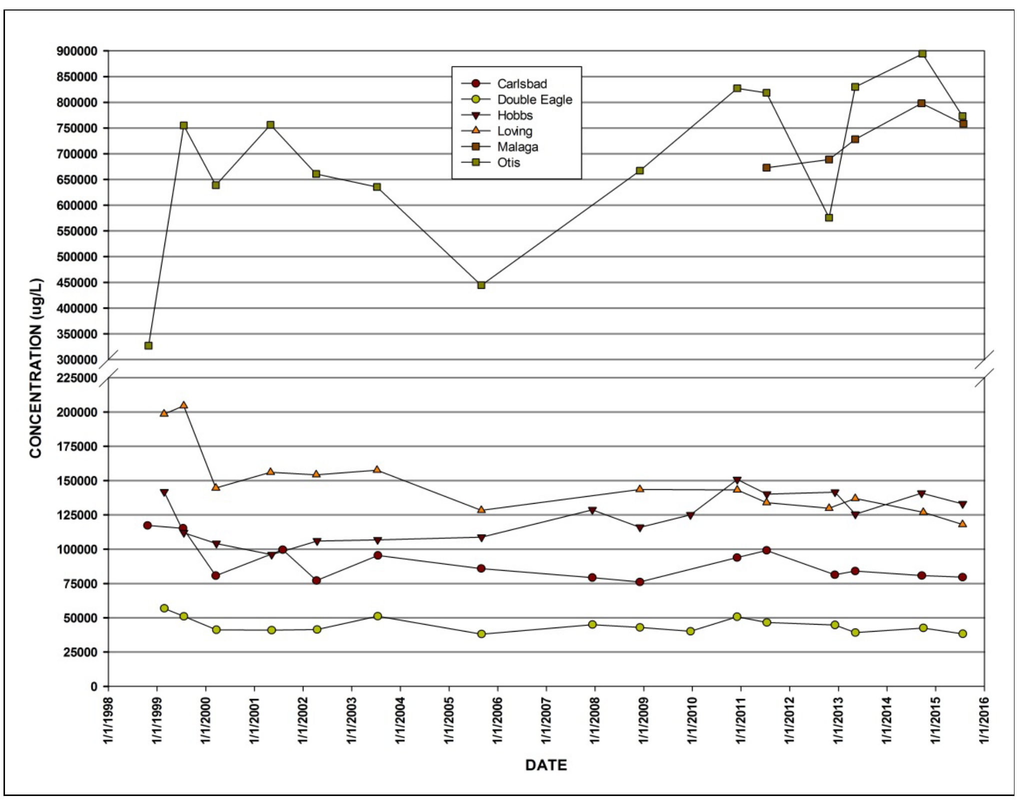


Figure 6-24: Measured Concentrations of Sulfate in Drinking Water from 1998 - 2015

CHAPTER 7

Whole Body and Lung *In Vivo* Measurement of Occurrence of Radionuclides in Residents of the Carlsbad, New Mexico Area and Further Potential Uses

The "Lie Down and Be Counted" (LDBC) project monitors internally deposited radionuclides by a non-invasive in-vivo radiobioassay of lungs and whole body. The LDBC project provides a scientific understanding of how low-level nuclear waste disposed in the Waste Isolation Pilot Plant (WIPP) repository may impact the residents living near the facility. This valuable service is provided free of charge to adult residents and children aged 13 and older living within a 100-mile radius of the WIPP site as an outreach service to the public and to support education about naturally occurring and man-made radioactivity present in people, especially those who live 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 55-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, 2015) of an ongoing study.

Participating in the LDBC consists of having a lung and whole body count, also referred to as 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 conduct presentations to local community groups and businesses and solicit volunteers via community events such as the New Mexico State Park's March for Parks and Earth Day events. The entire measurement process takes approximately one hour and culminates with the volunteer receiving a detailed report showing the results from the whole body count. A technical staff member gives a brief lecture explaining 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 of 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. 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, 2015, 1131 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 3-1 shows the yearly number of male, female and total number of voluntary participants counted thus far in the program period (7/21/1997 to 12/31/2015).

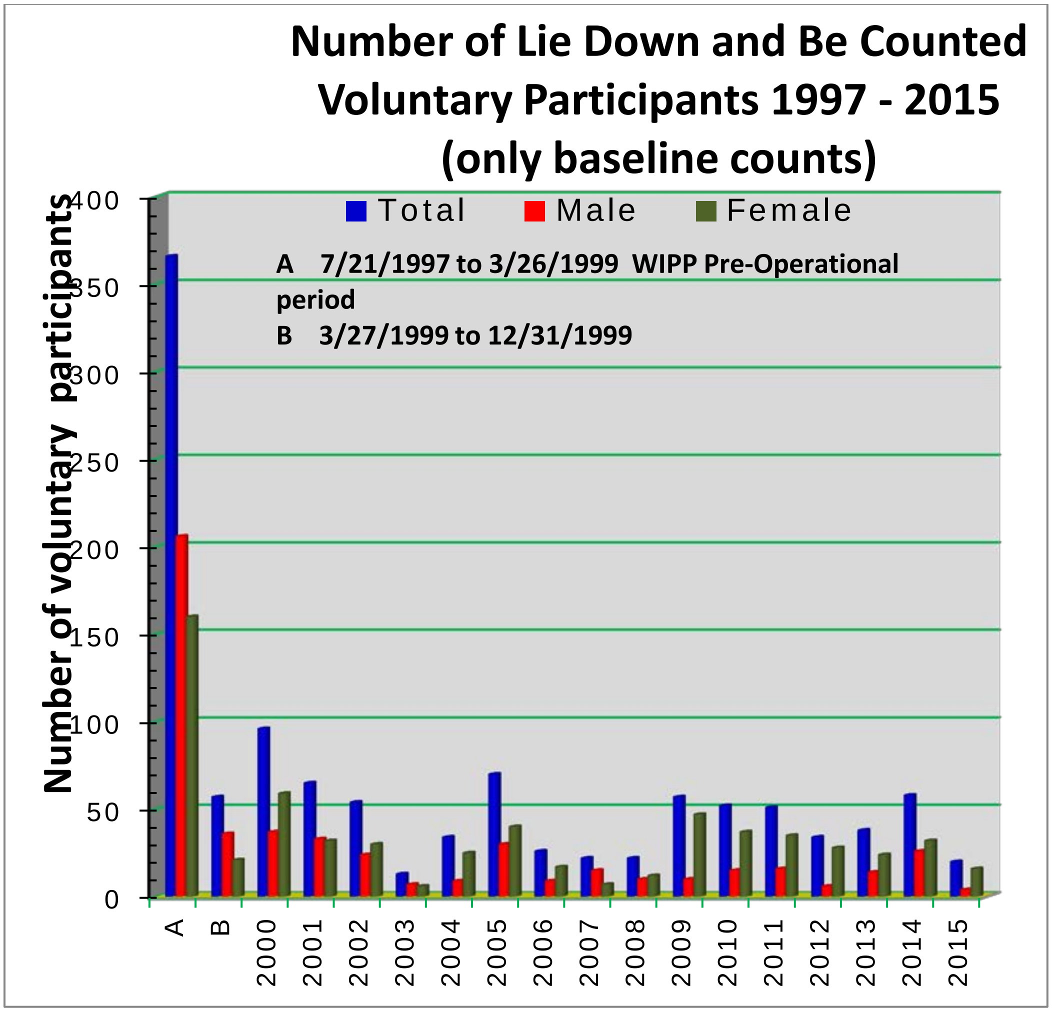


Figure 7-1: Number of LDBC voluntary participants (total and by gender) counted during the period 1997 – 2015

As was mentioned in the introduction chapter of this report, on February 14, 2014 there was an underground radiation incidence at the WIPP site resulting in a small release of radioactive

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

contamination into the environment. In this context, the LDBC program's valuable information of 17 years has been divided into four categories, shown pictorially in Figure 3-1, and described as:

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 the WIPP radiation incidence from February 14, to June 30, 2014
4) *In vivo* analyses performed on public and contract personnel after the WIPP radiation incidence from July 1, 2014 to present (currently December 31, 2015).

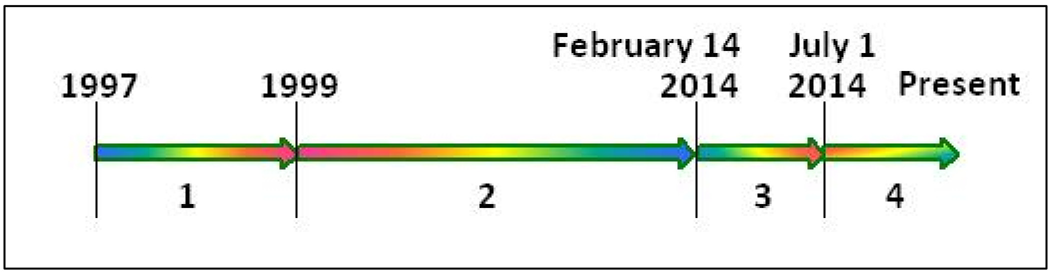


Figure 7-2: Time periods (not drawn to scale) of the LDBC *in vivo* radio-bioassay measurements of the public volunteers

The release event report providing the evaluation of the LDBC results is available on-line:

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 4744 counts which include baseline (in this context baseline refers to the first time a participant is counted at the 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; 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 2015 census estimated for citizens living in Carlsbad. The largest deviation

[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.

between the LDBC cohort and population estimated by the 2015 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.

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 program and their minimum detectable activities are listed in Tables 7-2A through 7-2F for the 2013-2016 time frame 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 Table 7-2). 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 = 1071), 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 were positive for all participants through December 2015, and ranged from 868 to 5559 Bq per person with an overall average (± Std. Err.) of 2433 (± 21) 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 3036 (± 26) Bq per person for males, which was significantly greater ($p < 0.0001$) than that of females, which was 1875 (± 16) 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 17.7% (with margin of error 16.6% to 18.9%) for operational monitoring counts for the period march 27, 1999 through December 31, 2015; 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). 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 was also 10.5(± 1.3) Bq for females 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.

K-40 and Cs-137 results of LDBC voluntary participants through December 2015 are shown in Figures 7-3 through 7-6.

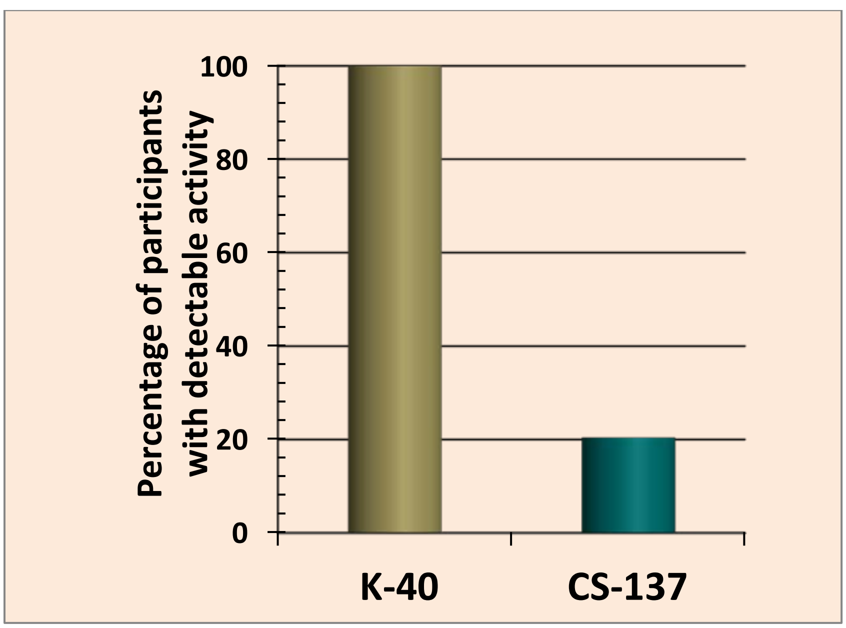


Figure 7-3: Percentage of voluntary participants with detectable ^{40}K and ^{137}Cs activities through December 2015

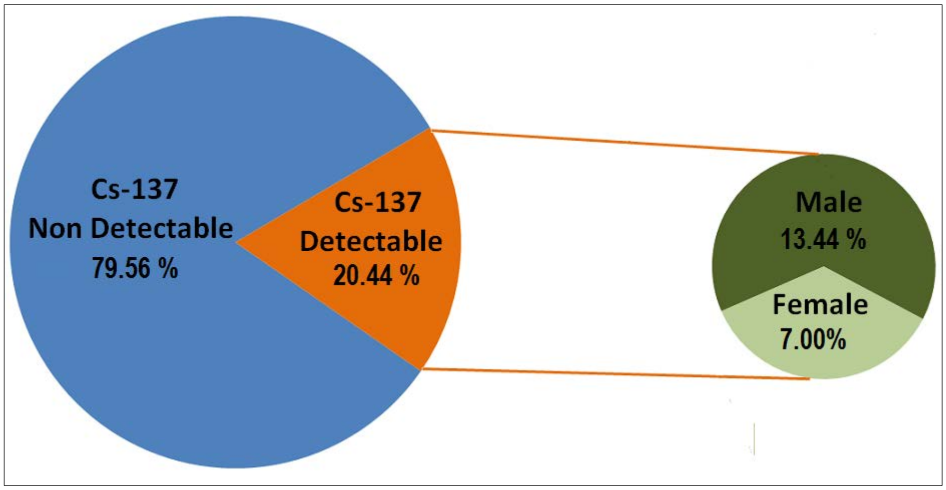


Figure 7-4: Percentage of voluntary participants with detectable ^{137}Cs activity through December 2015. (This figure displays the total percentage of participants with detectable ^{137}Cs activity and the percentage of participants with detectable ^{137}Cs activity by gender).

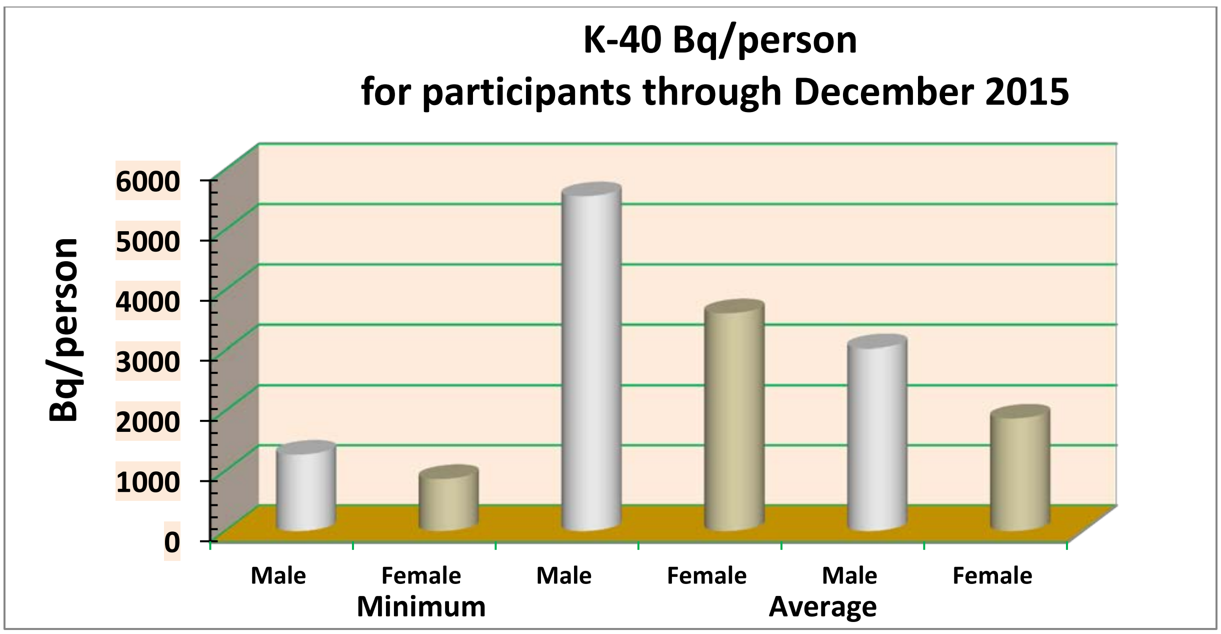


Figure 7-5: Minimum, average, and maximum ^{40}K activity for participants, separated by gender, through December 2015

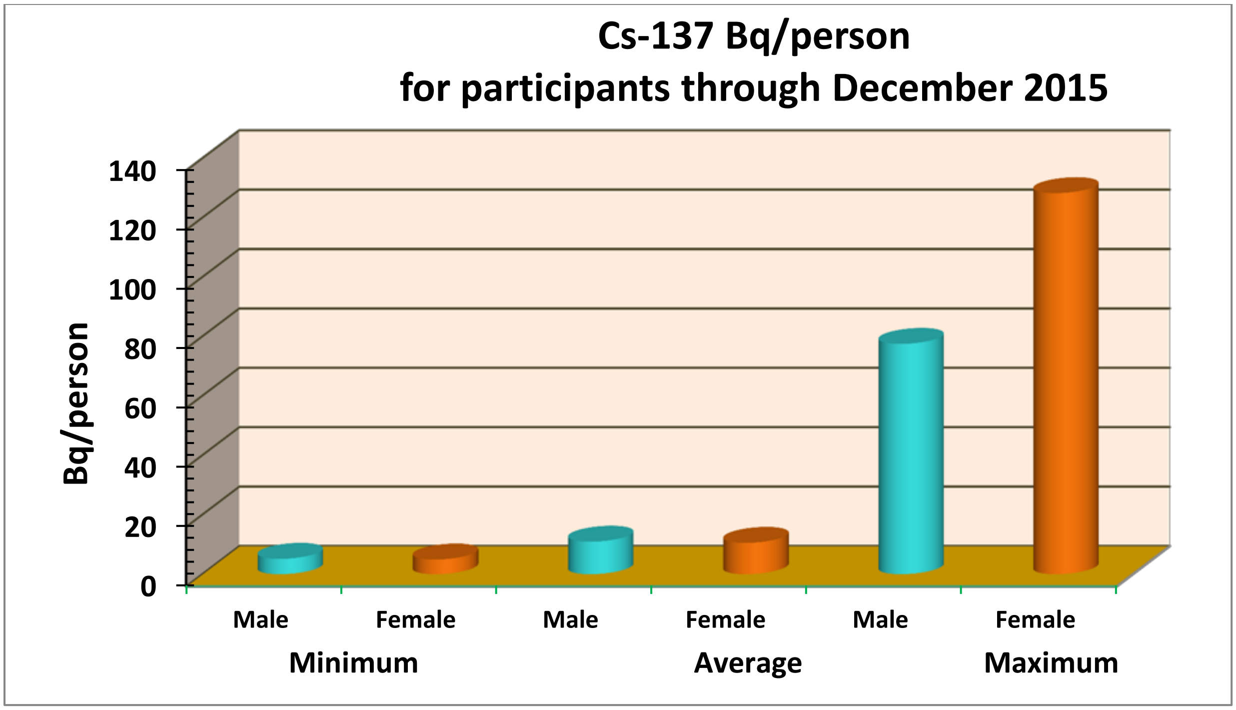


Figure 7-6: Minimum, average, and maximum ^{137}Cs activity for participants, separated by gender, through December 2015

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, 2015

Characteristic		2015 Sample Group[a] (margin of error)	Census 2010[b,c]		Census 2015[d] Estimates	
			NM	US	NM	US
Gender	Male	44.7% (43.2 to 46.1%)	49.4%	49.1%	49.6%	49.2%
	Female	55.3 (53.9 to 56.8%)	50.6%	50.9%	50.4%	50.8%
Ethnicity	Latino	22.5% (21.3 to 23.8%)	46.3%	16.3%	48.0%	17.6%
	Non-Latino	77.5% (76.2 to 78.7%)	53.7%	83.7%	52.0%	82.4%
Age 65 years or over		31.1% (29.8 to 32.5%)	13.2%	13.0%	15.8%	14.9%
Currently or previously classified as a radiation worker		8.0% (7.3 to 8.8%)	NA	NA	NA	NA
Consumption of wild game within 3 months prior to count		21.0% (19.8 to 22.1%)	NA	NA	NA	NA
Medical treatment other than X-rays using radionuclides		6.5% (5.7 to 7.2%)	NA	NA	NA	NA
European/Japan travel within 2 years prior to the count		3.9% (3.3 to 4.5%)	NA	NA	NA	NA
Current smoker		15.4% (14.3 to 16.4%)	N/A	NA	16+%-19%[e]	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. (Web site accessed October 31, 2016.
[d] 2015 Population Estimates, http://quickfacts.census.gov/qfd/states/35000.html, (Web site accessed October 31, 2016.
[e] http://www.cdc.gov/vitalsigns/tobaccouse/smoking/infographic.html, US Center for Disease Control, 2011, US. (Web site accessed October 31, 2016).

Table 7-2A: Minimum Detectable Activities
2013-2014 Calibration
(Using 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 7-2B: Minimum Detectable Activities
2013-2014 Calibration
(Using 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 7-2C: Minimum Detectable Activities
2014-2015 Calibration
(Using 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 7-2D: Minimum Detectable Activities
2014-2015 Calibration
(Using 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 7-2E: Minimum Detectable Activities
2015-2016 Calibration
(Using 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	0.15	0.19	0.25	0.28	0.38	0.53	0.74
Ce-144	133.5	0.41	0.49	0.62	0.68	0.87	1.15	1.50
Cf-252	19.2	15.1	30.4	74.2	107	279	790	2188
Cm-244	18.1	13.3	28.6	76.1	113	323	1006	3071
Eu-155	105.3	0.23	0.28	0.36	0.40	0.52	0.70	0.93
Np-237	86.5	0.41	0.50	0.65	0.73	0.96	1.30	1.75
Pu-238	17.1	15.5	36.0	105	162	513	1780	6024
Pu-239	17.1	38.7	89.6	260	403	1275	4429	14988
Pu-240	17.1	15.2	35.2	102	158	501	1740	5888
Pu-242	17.1	18.3	42.5	123	191	604	2099	7103
Ra-226	186.1	1.39	1.64	2.03	2.21	2.78	3.57	4.56
Th-232 via Pb-212	238.6	0.12	0.14	0.17	0.19	0.24	0.30	0.38
Th-232	59	24.3	30.4	40.4	45.3	61.4	85.4	118
Th-232 via Th-228	84.3	3.72	4.56	5.94	6.60	8.75	11.9	15.9
U-233	440.3	0.57	0.66	0.80	0.87	1.07	1.33	1.65
U-235	185.7	0.09	0.10	0.13	0.14	0.17	0.22	0.28
Nat U via Th-234	63.3	1.30	1.61	2.14	2.39	3.23	4.46	6.11

Table 7-2F: Minimum Detectable Activities
2015-2016 Calibration
(Using Whole Body detectors)

Radionuclides Deposited in the Whole Body		
Nuclide	**Energy (keV)**	**MDA (nCi)**
Ba-133	356	0.81
Ba-140	537	1.58
Ce-141	145	1.67
Co-58	811	0.38
Co-60	1333	0.37
Cr-51	320	4.73
Cs-134	604	0.37
Cs-137	662	0.43
Eu-152	344	1.69
Eu-154	1275	0.99
Eu-155	105	3.88
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	3.44
Sb-125	428	1.40
Th-232 via Ac-228	911	1.30
Y-88	898	0.39
Zn-65	1116	1.14
Zr-95	757	0.61

Table 7-3: "Lie Down and Be Counted"
Results through December 31, 2015

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 2015) N = 1071
		% of Results ≥ [b]L_C	% of Results ≥ [b]L_C
^{241}Am	Lung	5.2 (4.0 to 6.4)	4.30 (3.69 to 4.90)
^{144}Ce	Lung	4.6 (3.5 to 5.7)	4.39 (3.78 to 5.00)
^{252}Cf	Lung	4.1 (3.1 to 5.1)	5.70 (5.00 to 6.39)
^{244}Cm	Lung	5.7 (4.5 to 7.0)	5.04 (4.39 to 5.70)
^{155}Eu	Lung	7.1 (5.8 to 8.4)	5.14 (4.47 to 5.8)
^{237}Np	Lung	3.6 (2.6 to 4.5)	3.64 (3.08 to 4.20)
^{210}Pb	Lung	4.4 (3.3 to 5.4)	6.54 (5.80 to 7.28)
Plutonium Isotope	Lung	5.7 (4.5 to 7.0)	5.32 (4.65 to 5.99)
[d] ^{232}Th via ^{212}Pb	Lung	34.2 (31.7 to 36.6)	31.56 (30.17 to 32.95)
^{232}Th	Lung	4.9 (3.8 to 6.0)	5.51 (4.83 to 6.19)
^{232}Th via ^{228}Th	Lung	4.1 (3.1 to 5.1)	4.48 (3.86 to 5.10)
^{233}U	Lung	5.7 (4.5 to 7.0)	9.24 (8.38 to 10.11)
$^{235}U/^{226}Ra$	Lung	10.7 (9.0 to 12.3)	10.92 (9.99 to 11.86)
Natural Uranium via ^{234}Th	Lung	5.2 (4.0 to 6.4)	5.7 (5.00 to 6.39)
^{133}Ba	Whole Body	3.6 (2.6 to 4.5)	3.17 (2.65 to 3.7)
^{140}Ba	Whole Body	5.2 (4.0 to 6.4)	4.01 (3.43 to 4.60)
^{141}Ce	Whole Body	3.6 (2.6 to 4.5)	4.76 (4.12 to 5.40)
^{58}Co	Whole Body	4.4 (3.3 to 5.4)	3.36 (2.82 to 3.90)
[d] ^{60}Co	Whole Body	54.6 (52.0 to 57.2)	23.34 (22.08 to 24.61)
^{51}Cr	Whole Body	5.7 (4.5 to 7.0)	4.20 (3.60 to 4.80)
^{134}Cs	Whole Body	1.6 (1.0 to 2.3)	2.52 (2.05 to 2.99)
^{137}Cs	Whole Body	28.4 (26.1 to 30.8)	17.74 (16.60 to 18.88)
^{152}Eu	Whole Body	7.4 (6.0 to 8.7)	5.70 (5.00 to 6.39)
^{154}Eu	Whole Body	3.8 (2.8 to 4.8)	3.36 (2.82 to 3.90)
^{155}Eu	Whole Body	3.8 (2.8 to 4.8)	3.55 (2.99 to 4.10)
^{59}Fe	Whole Body	3.8 (2.8 to 4.8)	5.88 (5.18 to 6.59)
^{131}I	Whole Body	5.2 (4.0 to 6.4)	4.20 (3.60 to 4.8)
^{133}I	Whole Body	3.3 (2.3 to 4.2)	4.11 (3.51 to 4.7)
^{192}Ir	Whole Body	4.1 (3.1 to 5.1)	4.20 (3.60 to 4.8)
^{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)	11.95 (10.98 to 12.92)

Table 7-3: "Lie Down and Be Counted"
Results through December 31, 2015
(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 2015) N = 1071
		% of Results ≥ [b]L_C	% of Results ≥ [b]L_C
^{103}Ru	Whole Body	2.2 (1.4 to 3.0)	1.77 (1.38 to 2.17)
^{106}Ru	Whole Body	4.4 (3.3 to 5.4)	4.58 (3.95 to 5.20)
^{125}Sb	Whole Body	5.2 (4.0 to 6.4)	4.3 (3.69 to 4.90)
^{232}Th via ^{228}Ac	Whole Body	34.7 (32.2 to 37.2)	25.21 (23.91 to 26.51)
^{88}Y	Whole Body	7.7 (6.3 to 9.0)	6.44 (5.71 to 7.18)
^{95}Zr	Whole Body	6.6 (5.3 to 7.9)	3.83 (3.25 to 4.4)

[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 *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 underground 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. The current in-vivo gamma analyses could not compete with radiochemical 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 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 WBC counter taking advantage of the under-ground infrastructure facility at WIPP. The advantage is that the background can be reduced by a factor of three and thus sensitivity can be enhanced at the WIPP 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 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 WIPP location. 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

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 and are delivered for analysis to the CEMRC in weekly batches.

The 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, the 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). The 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 5th, 2014, and the second was an underground radiological release on February 14th, 2014. The last regular samples from the WIPP underground were collected on February 3rd, 2014. Following these two events, the WIPP started collecting surface samples on February 26th, 2014 to ensure that VOCs on the surface were well within regulatory limits and to ensure that there is no discharge of VOCs from the underground.

VOC Project Expansion

The original VOC laboratory was set up in room 149 in the science laboratory wing at the CEMRC and only included the equipment necessary for Confirmatory VOCs analysis. In late 2003, the Department of Energy (DOE) requested that the 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, the 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. Although the CEMRC did purchase a backup Preconcentrator to minimize system downtime, 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 allowed 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.

At this time, a backup Agilent 6890/5973 GC/MS system was transferred to the CEMRC by the Central Characterization Project (CCP) for use in headspace gas analysis and a backup autosampler for HSG analysis was also purchased by the 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.

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 the CEMRC. However, it is important to note that some of the equipment obtained for the headspace gas analysis project is currently being used for analysis of closed room samples for VOCs and percent levels of hydrogen and methane.

In 2015, CEMRC purchase a new Agilent 7820/5977 GC/MS along with an Entech 7200/7016D preconcentrator/autosampler system for analysis of low-levels of VOCs.
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 continued until the underground fire and radiological events in 2014. In 2007, 2008, 2009, 2010, 2011, 2012, 2013, and 2014 CEMRC analyzed a total of 749, 608, 571, 711, 615, 559, 709, and 342 samples

for VOCs and 182, 254, 339, 441, 398, 376, 360, and 46 samples, respectively, for hydrogen and methane. In 2015, CEMRC analyzed a total of 253 samples for VOCs collected from WIPP above ground locations. As was mentioned previously, no underground sampling was performed in 2015 due to the ongoing recovery and cleanup activities associated with the underground fire and radiological events of 2014.

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 preconcentration 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 Preconcentrator 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 preconcentration.

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 underground events essentially made it impossible to collect samples in the WIPP underground due to the presence of radioactive contamination in a majority of the waste disposal areas in the underground. 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. SIM increases sensitivity for target analytes through the selective detection of ions most indicative of the compounds of interest. The CEMRC has developed a low-level VOC analysis method using the SIM mode where the low calibration level is 50 pptv (0.05 ppbv) with MDLs less than 10 pptv. 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 are 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 8-1 through 8-4 show an example of laboratory precision through LCS % recovery and RPD for the target analytes Carbon tetrachloride and Trichloroethylene using the low-level method in SIM mode.

Results and Discussion

The OC lab analyzed a total of 253 surface samples in 2015 using GC/MS SIM/scan methods. All of the samples were analyzed and reported in a timely manner under an extensive quality assurance (QA) / quality control (QC) program. All of these samples achieved 100% completeness.

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 requirements for analysis of low-levels of VOCs made it necessary to clean and certify each and every canister and Passive Air Sampling Kit (PASK) to ensure that the VOC levels were well below the MRL. In 2015, CEMRC cleaned 373 canisters and 266 PASKs, and all these were individually certified using low-level GC/MS SIM/scan method.

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.

No Hydrogen/Methane samples were analyzed in 2015.

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	Required Repository Surface Monitoring MRL for SIM mode (ppbv)	Required Repository Surface Monitoring MRL for SCAN mode (ppbv)	Required Disposal Room MRL (ppbv)
1,1-Dichloroethylene	0.1	0.2	500
Carbon tetrachloride	0.1	0.2	500
Methylene chloride	0.1	0.2	500
Chloroform	0.1	0.2	500
1,1,2,2-Tetrachloroethane	0.1	0.2	500
1,1,1-Trichloroethane	0.1	0.2	500
Chlorobenzene	0.1	0.2	500
1,2-Dichloroethane	0.1	0.2	500
Toluene	0.1	0.2	500
Trichloroethylene	0.1	0.2	500

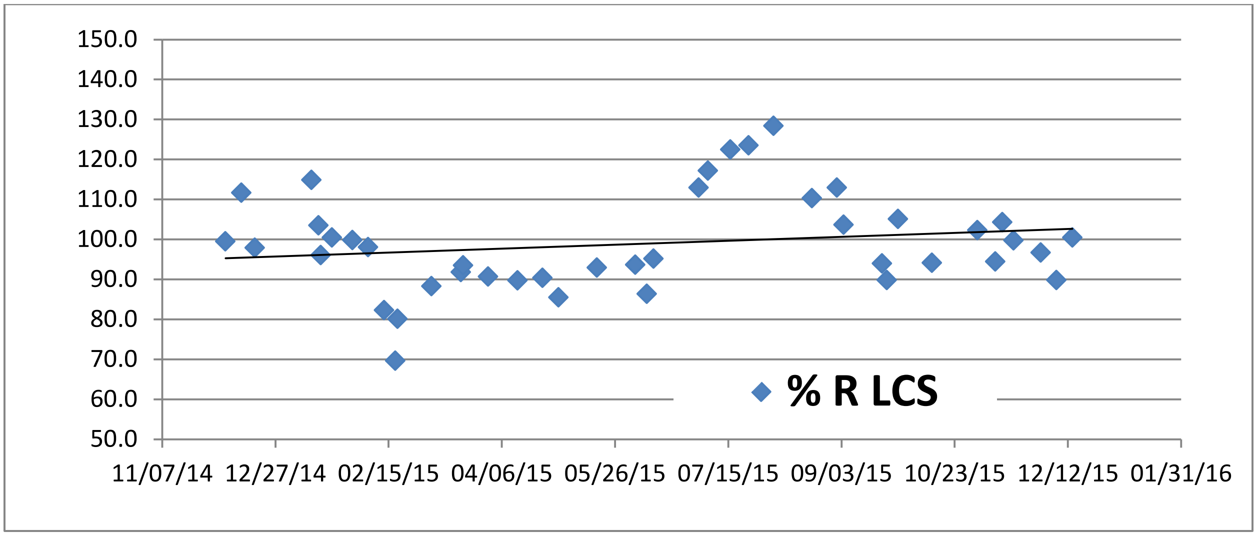


Figure 8-1: Percent Recovery of Carbon Tetrachloride in LCS (Recovery range: 60-140%) using low-level GC/MS SIM mode

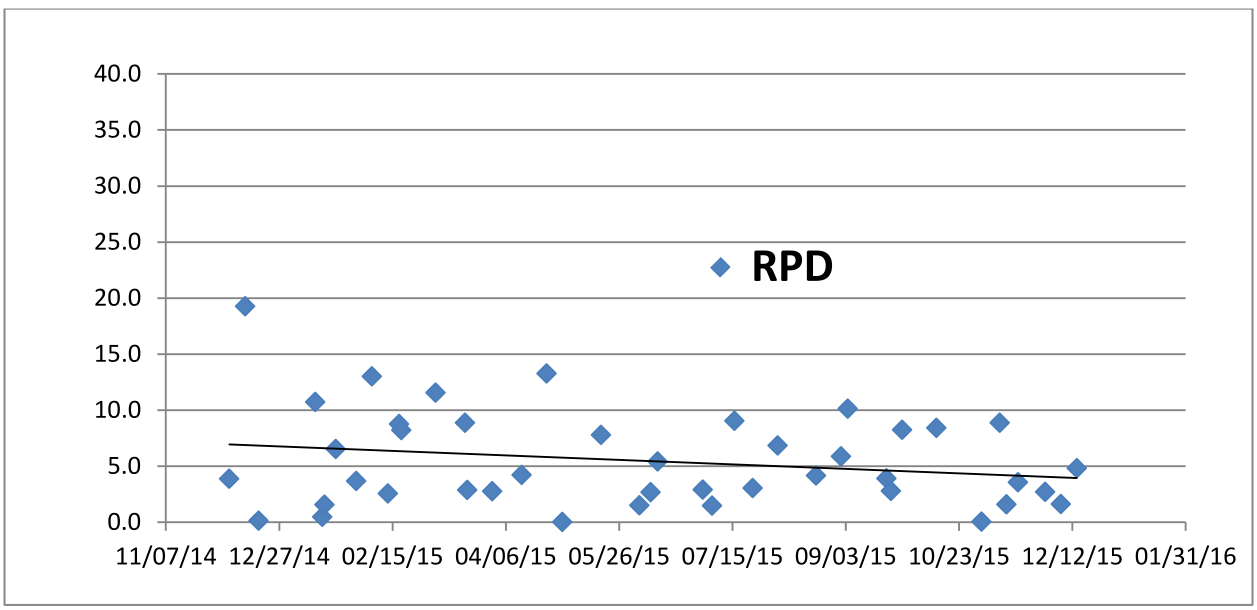


Figure 8-2: Relative Percent Deviation (RPD) between LCS and LCS-Duplicate for Carbon Tetrachloride (RPD range: 25%) using low-level GC/MS SIM mode

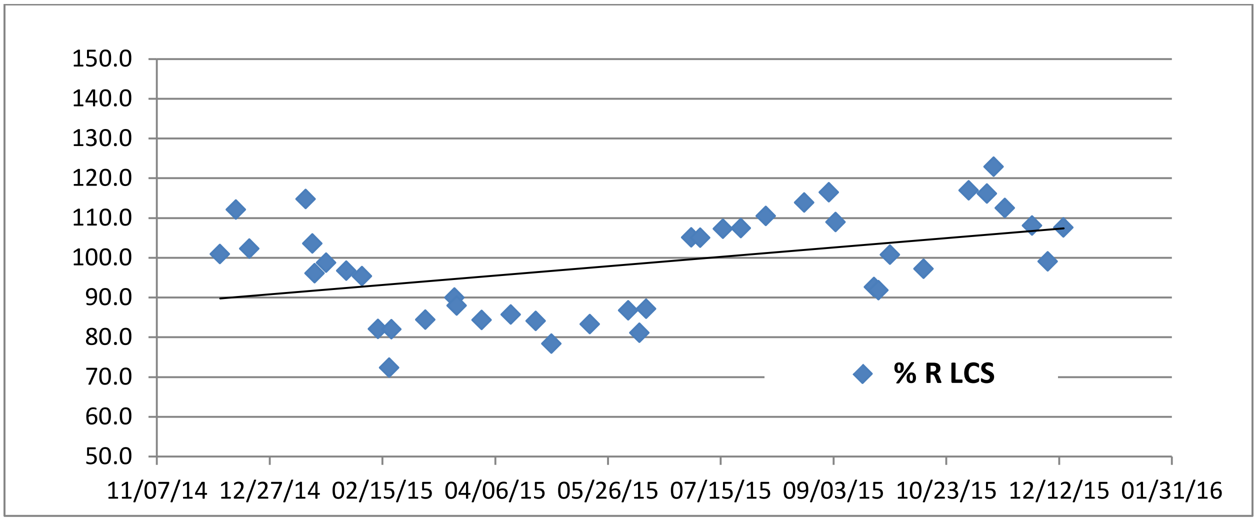


Figure 8-3: Percent Recovery of Trichloroethylene in LCS (Recovery range: 60-140%) using low-level GC/MS SIM mode

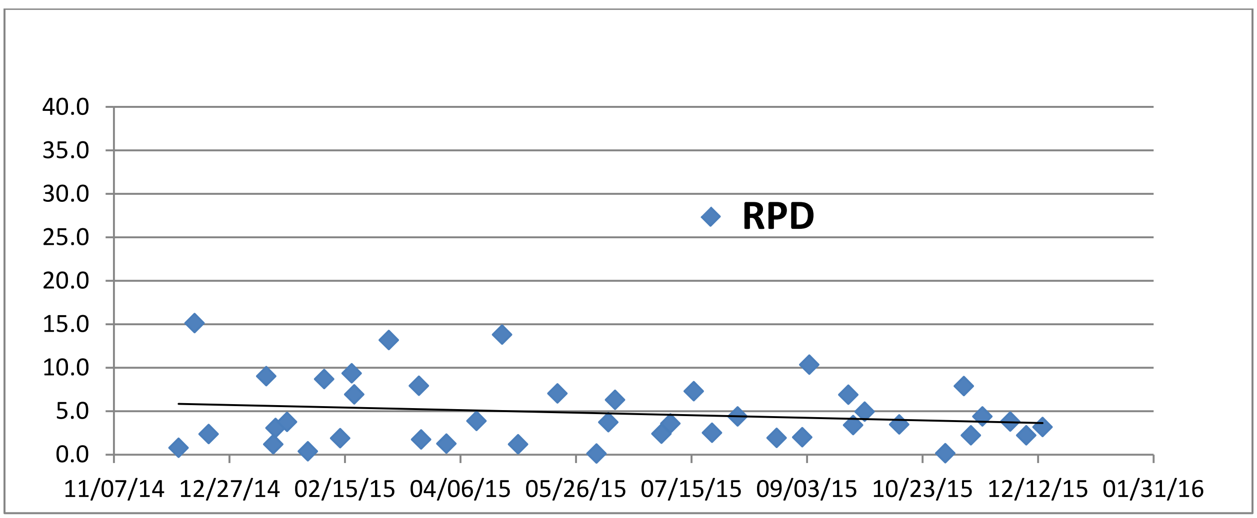


Figure 8-4: Relative Percent Deviation (RPD) between LCS and LCS-Duplicate for Trichloroethylene (RPD range: 25%) using low-level GC/MS SIM mode.

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 α/β proportional counter used for the FAS program, efficiency control charting was performed using ^{239}Pu and ^{90}Sr check sources along with ensuring that α/β 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 2015, CEMRC radio-analytical program analyzed MAPEP- air filter, water, soil, gross alpha/beta on air filters & water and unknown sample matrix 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, ^{244}Cm 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. All analysis results for MAPEP and NIST were deemed 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.

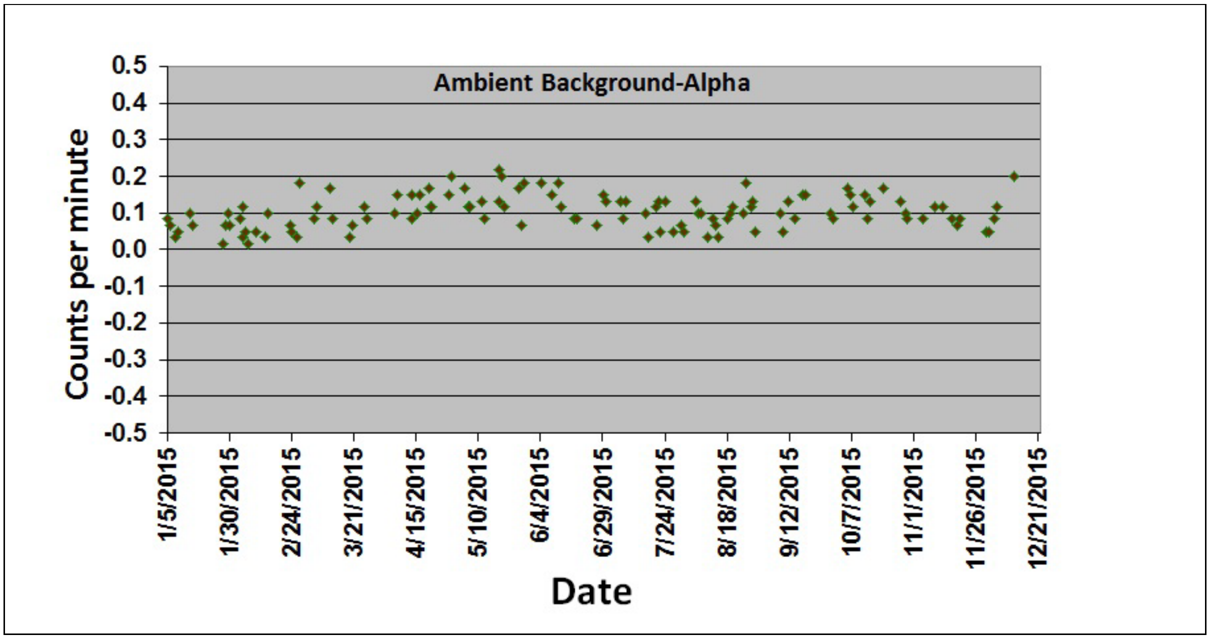


Figure 9-1: Sixty Minutes Alpha Ambient Background Count for the PIC-MPC 9604 Gross Alpha and Beta

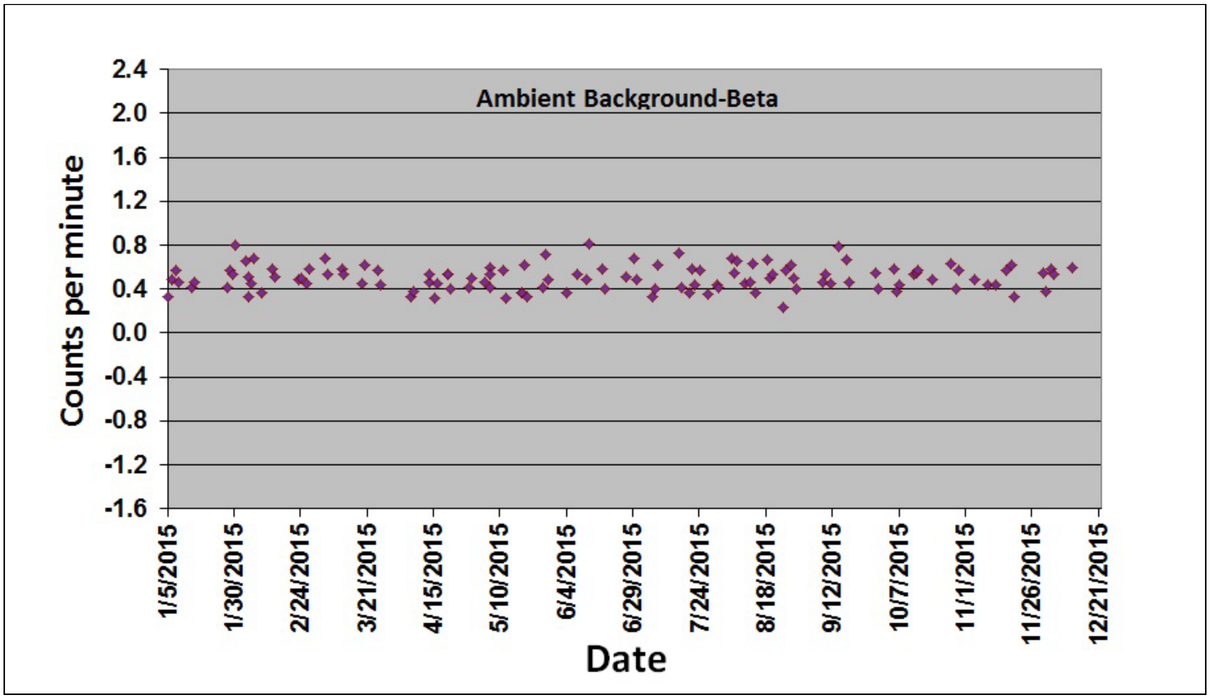


Figure 9-2: Sixty Minutes Beta Ambient Background Count for PICMPC 9604 Gross Alpha and Beta Counter

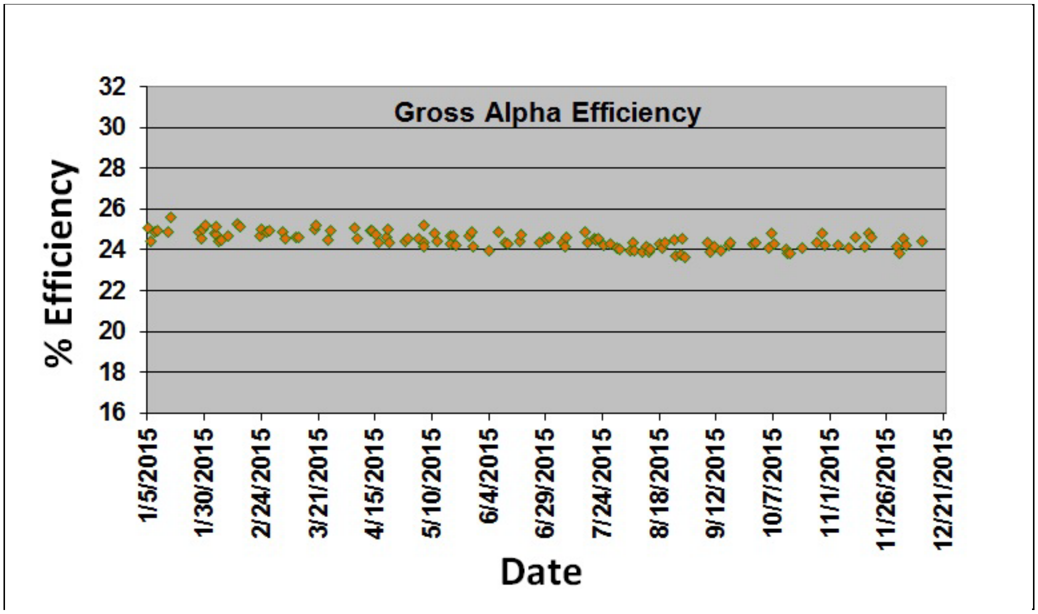


Figure 9-3: Control Chart of Daily Alpha Efficiency of the PICMPC 9604 Gross Alpha and Beta Counter

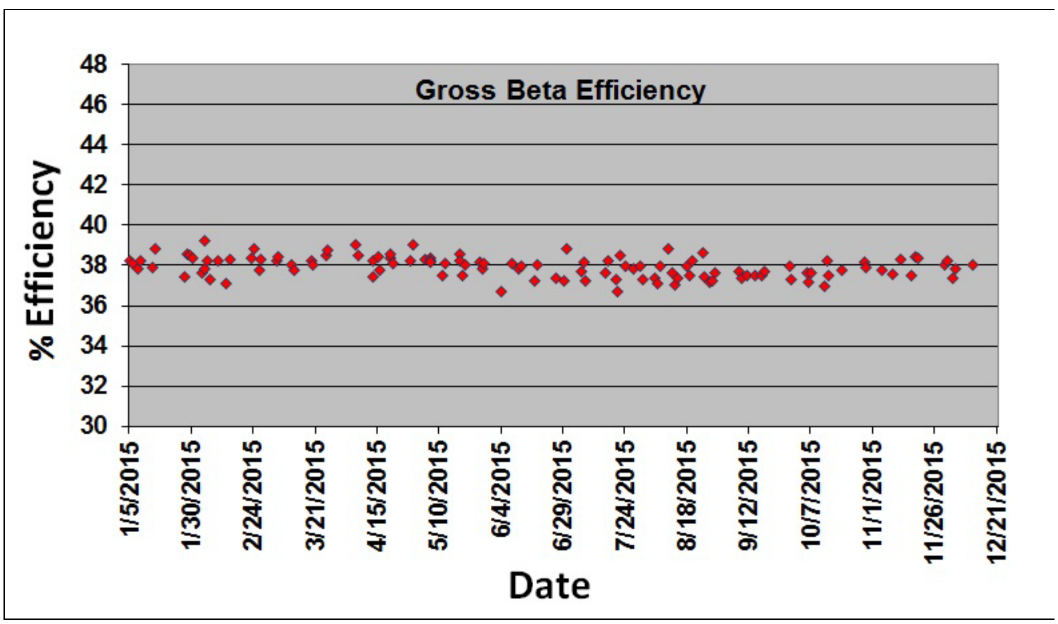


Figure 9-4: Control Chart of Daily Beta Efficiency of the PIC-MPC 9604 Gross Alpha and Beta Counter

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'15-AF
Matrix Description	^{60}Co, ^{90}Sr, ^{137}Cs, ^{230}Th, ^{234}U, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, and ^{241}Am on Glass-Fiber Filters[1]
Test Activity Range	0.02 Bq•sample^{-1} to 250 Bq•sample^{-1}
Reference Time	12:00 EST, April 1, 2015

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)	(±% Bias)
^{60}Co	389.8	0.62	376.1	3.1	-3.5
^{137}Cs	825.5	0.79	806.0	4.0	-2.4
^{234}U	3.57	1.00	4.12	15.1	15.4
^{235}U	0.171	0.65	0.176	30	3.2
^{238}U	3.71	0.63	3.45	15.3	-6.9
^{238}Pu	2.78	0.71	2.65	13.1	-4.7
^{239}Pu	2.35	0.71	2.19	13.2	-6.5
^{241}Am	2.64	0.33	2.57	12.8	-2.7

Methods

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

Evaluation (per ANSI N42.22)

Nuclide	ANSI N42.22 Traceable[8]	Traceability Limit (%)
^{60}Co	Yes	4.6
^{137}Cs	Yes	6.0
^{234}U	Yes	26
^{235}U	Yes	47
^{238}U	Yes	21
^{238}Pu	Yes	18.7
^{239}Pu	Yes	18.6
^{241}Am	Yes	18.7

Samples Distributed 02 November 2015
Reporting Data Received 29 January 2016

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

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

Test Identification	NRIP'15-AW
Matrix Description	^{60}Co, ^{90}Sr, ^{137}Cs, ^{230}Th, ^{234}U, ^{235}U, ^{238}U, ^{237}Np, ^{238}Pu, ^{239}Pu, and ^{241}Am in acidified water[1]
Test Activity Range	0.01 Bq•sample^{-1} to 50 Bq•sample^{-1}
Reference Time	12:00 EST, April 1, 2015

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	389.8	0.62	374.3	6.7	-4.0
^{137}Cs	825.5	0.79	830.2	5.9	0.6
^{234}U	3.57	1.00	4.10	15.8	14.8
^{235}U	0.171	0.65	0.177	52	3.5
^{238}U	3.71	0.63	3.52	16.3	-5.1
^{238}Pu	2.78	0.71	2.70	15.6	-2.7
^{239}Pu	2.35	0.71	2.29	16.1	-2.4
^{241}Am	2.64	0.33	2.59	15.3	-2.1

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	9.7
^{137}Cs	Yes	9.0
^{234}U	Yes	27
^{235}U	Yes	80

Nuclide	ANSI N42.22 Traceable[8]	Traceability Limit (%)
^{238}U	Yes	23
^{238}Pu	Yes	23
^{239}Pu	Yes	24
^{241}Am	Yes	22

Samples Distributed 02 November 2015
Reporting Data Received 29 January 2016

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'15-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, 2015

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	0.75	2.52	0.65	671	-13.0
^{60}Co	363.9	0.59	349.4	3.1	-4.0
^{137}Cs	682.1	0.77	657.5	4.0	-3.6
^{234}U	4.53	1.00	4.80	14.5	5.9
^{235}U	0.216	0.65	0.246	23.5	13.5
^{238}U	4.70	0.63	4.81	14.5	2.3
^{238}Pu	1.345	0.71	1.343	17.6	-0.2
^{240}Pu	1.768	0.79	1.689	17.3	-4.5
^{241}Am	4.12	0.82	3.90	14.0	-5.2

Methods

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

Evaluation (per ANSI N42.22)

Nuclide	ANSI N42.22 Traceable[8]	Traceability Limit (%)
^{57}Co	Yes	876
^{60}Co	Yes	4.5
^{137}Cs	Yes	6.0
^{234}U	Yes	23
^{235}U	Yes	40

Nuclide	ANSI N42.22 Traceable[8]	Traceability Limit (%)
^{238}U	Yes	22
^{238}Pu	Yes	26
^{240}Pu	Yes	25
^{241}Am	Yes	20

Samples Distributed 02 November 2015
Reporting Data Received 29 January 2016

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-15-GrF33
(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	0.751	0.90	A		-16.6	0.27 - 1.53	0.018	A
Gross beta	1.64	1.56	A		5.1	0.78 - 2.34	0.15	A

Radiological Reference Date: August 1, 2015

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

Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results

MAPEP Mixed Analyte Performance Evaluation Program

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

Laboratory Results For MAPEP-15-MaS33
(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	0.31				Sensitivity Evaluation		
Arsenic	NR	6.2				Sensitivity Evaluation		
Barium	NR	561				393 - 729		
Beryllium	NR	60.3				42.2 - 78.4		
Cadmium	NR	11.1				7.8 - 14.4		
Chromium	NR	59.1				41.4 - 76.8		
Cobalt	NR	257				180 - 334		
Copper	NR	88				62 - 114		
Lead	NR	90.9				63.6 - 118.2		
Mercury	NR	0.933				0.653 - 1.213		
Nickel	NR	163				114 - 212		
Selenium	NR	14.14				9.90 - 18.38		
Silver	NR	48.7				34.1 - 63.3		
Technetium-99	NR	1.01E-3				0.00071 - 0.00131		
Thallium	NR	108				76 - 140		
Uranium-235	NR	0.0480				0.0336 - 0.0624		
Uranium-238	NR	17.69				12.38 - 23.00		
Uranium-Total	NR	17.69				12.38 - 23.00		
Vanadium	NR	195				137 - 254		
Zinc	NR	406				284 - 528		

Radiological — Units: (Bq/kg)

Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	5.09E+01	49.5	A		2.8	34.7 - 64.4	3.30	A
Cesium-134	1.02E+03	1010	A		1.0	707 - 1313	2.17	A
Cesium-137	8.73E+02	809	A		7.9	566 - 1052	2.89	A
Cobalt-57	1.28E+03	1180	A		8.5	826 - 1534	3.89	A
Cobalt-60	1.40E+00	1.30	A	(17)		Sensitivity Evaluation	4.74E-01	
Iron-55	NR	555				389 - 722		
Manganese-54	1.41E+03	1340	A		5.2	938 - 1742	3.79	A
Nickel-63	NR	682				477 - 887		
Plutonium-238	1.06E+02	97.5	A		8.7	68.3 - 126.8	1.28	A
Plutonium-239/240	8.36E+01	80.4	A		4.0	56.3 - 104.5	9.38	A
Potassium-40	6.04E+02	599	A		0.8	419 - 779	4.10	A
Strontium-90	NR	425				298 - 553		
Technetium-99	NR	631				442 - 820		

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Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

Radiological								Units: (Bq/kg)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-234/233	6.06E+01	56	A		8.2	39 - 73	4.16	A
Uranium-238	2.30E+02	220	A		4.5	154 - 286	1.50	A
Zinc-65	7.37E+02	662	A		11.3	463 - 861	2.26	A

Radiological Reference Date: August 1, 2015

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

Notes:

(17) = NOT DETECTED - reported a statistically zero result

Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

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

Laboratory Results For MAPEP-15-GrW33
(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	0.1467	0.429	A		-65.8	0.129 - 0.729	0.0388	W
Gross beta	3.69	3.52	A		4.8	1.76 - 5.28	0.32	A

Radiological Reference Date: August 1, 2015

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 2015 Inter-comparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

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

Laboratory Results For MAPEP-15-MaW33
(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	13.6				9.5 - 17.7		
Arsenic	NR	4.07				2.85 - 5.29		
Barium	NR	8.02				5.61 - 10.43		
Beryllium	NR	2.27				1.59 - 2.95		
Cadmium	NR	0.739				0.517 - 0.961		
Chromium	NR	3.83				2.68 - 4.98		
Cobalt	NR	14.8				10.4 - 19.2		
Copper	NR	4.40				3.08 - 5.72		
Lead	NR	3.98				2.79 - 5.17		
Mercury	NR	0.127				0.089 - 0.165		
Nickel	NR	16.8				11.8 - 21.8		
Selenium	NR	0.537				0.376 - 0.698		
Technetium-99	NR	1.15e-5				8.10E-6 - 1.50E-5		
Thallium	NR	2.32				1.62 - 3.02		
Uranium-235	NR	6.59e-4				4.61E-4 - 8.57E-4		
Uranium-238	NR	0.095				0.067 - 0.124		
Uranium-Total	NR	0.095				0.067 - 0.124		
Vanadium	NR	10.3				7.2 - 13.4		
Zinc	NR	15.8				11.1 - 20.5		

Radiological								Units: (Bq/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	9.69E-01	1.055	A		-8.2	0.739 - 1.372	6.32E-02	A
Cesium-134	2.13E+01	23.1	A		-7.8	16.2 - 30.0	6.88E-01	A
Cesium-137	2.87E-02		A			False Positive Test	4.55E-01	
Cobalt-57	2.07E+01	20.8	A		-0.5	14.6 - 27.0	8.49E-01	A
Cobalt-60	1.58E+01	17.1	A		-7.6	12.0 - 22.2	6.86E-01	A
Hydrogen-3	NR	216				151 - 281		
Iron-55	NR	13.1				9.2 - 17.0		
Manganese-54	1.52E+01	15.6	A		-2.6	10.9 - 20.3	7.48E-01	A
Nickel-63	NR	8.55				5.99 - 11.12		
Plutonium-238	6.59E-01	0.681	A		-3.2	0.477 - 0.885	5.13E-02	A
Plutonium-239/240	8.42E-01	0.900	A		-6.4	0.630 - 1.170	5.53E-02	A
Potassium-40	2.06E+02	214	A		-3.7	150 - 278	1.04	A
Strontium-90	NR	4.80				3.36 - 6.24		
Technetium-99	NR	7.19				5.03 - 9.35		

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Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

Radiological								Units: (Bq/L)
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Uranium-234/233	1.08E+00	1.14	A		-5.3	0.80 - 1.48	8.21E-02	A
Uranium-238	1.10E+00	1.18	A		-6.8	0.83 - 1.53	8.03E-02	A
Zinc-65	1.56E+01	13.9	A		12.2	9.7 - 18.1	1.40	A

Radiological Reference Date: August 1, 2015

Result 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

Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

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

Laboratory Results For MAPEP-15-RdF33
(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	0.086				0.060 - 0.112		
Uranium-238	NR	11.9				8.3 - 15.5		
Uranium-Total	NR	12.0				8.4 - 15.6		

Radiological							Units: (Bq/sample)	
Analyte	Result	Ref Value	Flag	Notes	Bias (%)	Acceptance Range	Unc Value	Unc Flag
Americium-241	1.33E-01	0.147	A		-9.5	0.103 - 0.191	8.55E-03	A
Cesium-134	2.37E+00	2.45	A		-3.3	1.72 - 3.19	5.91E-02	A
Cesium-137	1.96E+00	1.96	A		0.0	1.37 - 2.55	6.25E-02	A
Cobalt-57	2.78E+00	2.74	A		1.5	1.92 - 3.56	9.74E-02	A
Cobalt-60	1.69E+00	1.71	A		-1.2	1.20 - 2.22	4.74E-02	A
Manganese-54	2.10E+00	2.11	A		-0.5	1.48 - 2.74	6.55E-02	A
Plutonium-238	1.03E-01	0.104	A		-1.0	0.073 - 0.135	6.84E-03	A
Plutonium-239/240	2.31E-03	0.0025	A			Sensitivity Evaluation	4.14E-04	
Strontium-90	NR	2.18				1.53 - 2.83		
Uranium-234/233	1.36E-01	0.143	A		-4.9	0.100 - 0.186	1.01E-02	A
Uranium-238	1.36E-01	0.148	A		-8.1	0.104 - 0.192	1.01E-02	A
Zinc-65	1.38E+00	1.32	A		4.5	0.92 - 1.72	1.04E-01	A

Radiological Reference Date: August 1, 2015

Result 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%

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Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

MAPEP Mixed Analyte Performance Evaluation Program

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

Laboratory Results For MAPEP-15-XrM33
(CMRC01) Carlsbad Environmental Monitoring and Research Center
1400 University Dr.
Carlsbad, NM 88220

Radiological

Sample ID	Nuclide	Known Activity	Expt'l Activity	Bias (%)
MAPEP-15-XrM33	Am-241	0.077 +/- 0.003 Bq/sample	6.99E-02 +/- 5.11E-03	-9.2
MAPEP-15-XrM33	Cs-134	1.37 +/- 0.04 Bq/sample	1.40E+00 +/- 4.30E-02	2.2
MAPEP-15-XrM33	Cs-137	2.01 +/- 0.05 Bq/sample	2.05E+00 +/- 5.87E-02	2.0
MAPEP-15-XrM33	Co-57	2.43 +/- 0.07 Bq/sample	2.47E+00 +/- 7.68E-02	1.6
MAPEP-15-XrM33	Co-60	1.56 +/- 0.06 Bq/sample	1.54E+00 +/- 3.96E-02	-1.3
MAPEP-15-XrM33	Cm-244	0.105 +/- 0.003 Bq/sample	9.92E-02 +/- 6.85E-03	-5.5
MAPEP-15-XrM33	Ir-192	4.76 +/- 0.15 Bq/sample		
MAPEP-15-XrM33	Mn-54	1.64 +/- 0.05 Bq/sample	1.66E+00 +/- 5.48E-02	1.2
MAPEP-15-XrM33	Pu-238	0.098 +/- 0.003 Bq/sample	9.22E-02 +/- 6.61E-03	-5.9
MAPEP-15-XrM33	Pu-239	0.077 +/- 0.003 Bq/sample	7.61E-02 +/- 5.60E-03	-1.2
MAPEP-15-XrM33	K-40		5.77E-02 +/- 2.49E-01	
MAPEP-15-XrM33	Sr-90	1.19 +/- 0.04 Bq/sample		
MAPEP-15-XrM33	Tc-99	1.11 +/- 0.03 Bq/sample		
MAPEP-15-XrM33	Th-228	0.0155 +/- 0.0014 Bq/sample		
MAPEP-15-XrM33	Th-230	0.0272 +/- 0.0018 Bq/sample		
MAPEP-15-XrM33	Th-232	0.0161 +/- 0.0018 Bq/sample		
MAPEP-15-XrM33	U-234	0.038 +/- 0.002 Bq/sample	3.56E-02 +/- 3.28E-03	-6.3
MAPEP-15-XrM33	U-235		2.77E-03 +/- 7.69E-04	
MAPEP-15-XrM33	U-238	0.117 +/- 0.004 Bq/sample	1.16E-01 +/- 8.55E-03	-0.9
MAPEP-15-XrM33	Zn-65	1.15 +/- 0.04 Bq/sample	1.25E+00 +/- 1.03E-01	8.7

Radiological Reference Date: August 1, 2015

Issued 12/2/2015 Printed 11/20/2016

Figure 9-6: Radiochemistry MAPEP 2015 Inter-comparison Results (continued)

Appendices

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 1×10^9 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 2.0×10^3 (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 2.0×10^{-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 (1×10^{-3} Ci)	kBq	kilobecquerel (1×10^{3} Bq)
µCi	microcurie (1×10^{-6} Ci)	MBq	megabecquerel (1×10^{6} Bq)
nCi	nanocurie (1×10^{-9} Ci)	mBq	millibecquerel (1×10^{-3} Bq)
pCi	picocurie (1×10^{-12} Ci)	GBq	gigabecquerel (1×10^{9} Bq)
fCi	femtocurie (1×10^{-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.

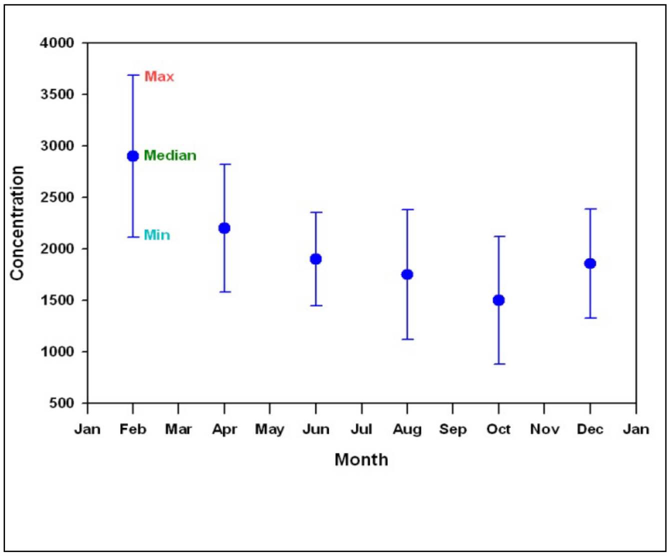

Figure A-1: Graphical representation of maximum, median and minimum values

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 radioactive 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.

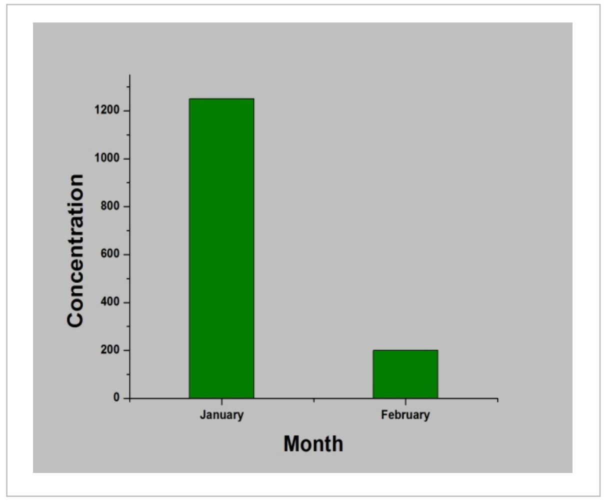

Figure A-2: Data plotted using a linear scale

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).

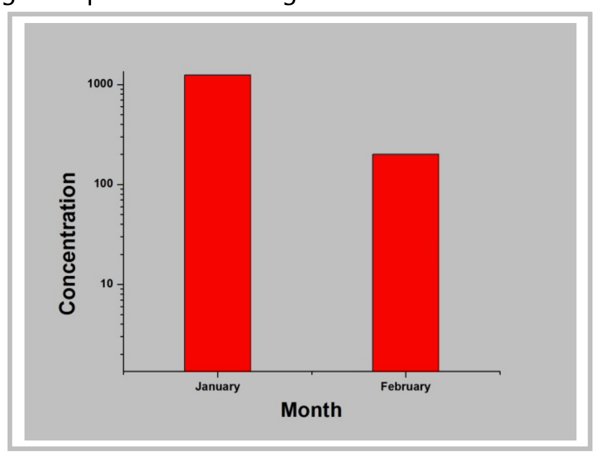

Figure A-3: Data plotted using a logarithmic scale

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.

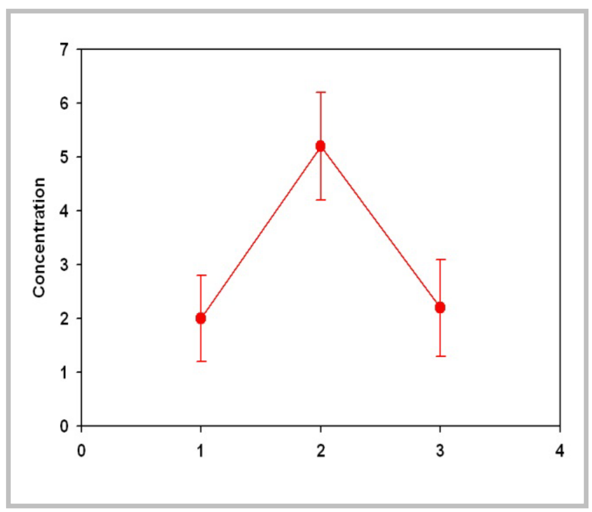

Figure A-4: Data with error bars plotted using a linear scale

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 ± 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).

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