EEG-81

EEG OPERATIONAL RADIATION SURVEILLANCE OF THE WIPP PROJECT DURING 2000

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New Mexico

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FOREWORD

The purpose of the New Mexico Environmental Evaluation Group (EEG) is to conduct an independent technical evaluation of the Waste Isolation Pilot Plant (WIPP) Project to ensure the protection of the public health and safety and the environment of New Mexico. The WIPP Project, located in southeastern New Mexico, became operational in March 1999 for the disposal of transuranic (TRU) radioactive wastes generated by the national defense programs. The EEG was established in 1978 with funds provided by the U. S. Department of Energy (DOE) to the State of New Mexico. Public Law 100-456, the National Defense Authorization Act, Fiscal Year 1989, Section 1433, assigned EEG to the New Mexico Institute of Mining and Technology and continued the original contract DE-AC04-79AL10752 through DOE contract DE-ACO4-89AL58309. The National Defense Authorization Act for Fiscal Year 1994, Public Law 103-160, and the National Defense Authorization Act for Fiscal Year 2000, Public Law 106-65, continued the authorization.

EEG performs independent technical analyses of the suitability of the proposed site; the design of the repository, its operation, and its long-term integrity; suitability and safety of the transportation systems; suitability of the Waste Acceptance Criteria and the compliance of the generator sites with them; and related subjects. These analyses include assessments of reports issued by the DOE and its contractors, other federal agencies and organizations, as they relate to the potential health, safety and environmental impacts associated with WIPP. Another important function of EEG is the independent on- and off-site environmental monitoring of radioactivity in air, water, and soil.

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ACRONYMS

ACTL	Action Level
Am	Americium
ANOVA	Analysis of variance
Bq	Becquerel
CEDE	Committed-effective-dose equivalent
CEMRC	Carlsbad Environmental Monitoring and Research Center
CFR	Code of Federal Regulations
Cs	Cesium
DOE	U. S. Department of Energy
EEG	Environmental Evaluation Group
EPA	U. S. Environmental Protection Agency
ICRP	International Commission on Radiological Protection
LVAS	Low volume air sampler
M	Mean
MDA	Minimum detectable activity
MOU	Memorandum of Understanding
mrem	Millirem
NCRP	National Council on Radiation Protection and Measurements
NESHAPS	National Emission Standards for Hazardous Air Pollutants
Pu	Plutonium
s	Sample standard deviation
Sr	Strontium
TLD	Thermoluminescent dosimeter
TRU	Transuranic
WIPP	Waste Isolation Pilot Plant
WTS	Westinghouse TRU Solutions

EXECUTIVE SUMMARY

The Environmental Evaluation Group (EEG) has measured the levels of ^{241}Am, ^{238}Pu, $^{239/240}$Pu, ^{137}Cs, and ^{90}Sr in samples of air and water collected at and in the vicinity of the U. S. Department of Energy's Waste Isolation Pilot Plant (WIPP) during 2000. WIPP received the first shipment of waste in March 1999 and became operational at that time. The EEG has compared these levels to those measured in the preoperational phase, prior to receipt of waste, as well as to the results of other monitoring organizations and to the U. S. Environmental Protection Agency (EPA) dose standards established for WIPP at 40 CFR 191, Subpart A, and, by an agreement between the DOE and EPA, at 40 CFR 61, Subpart H.

Based on these analyses and applying a *t* test for significant differences for normally-distributed data described in Chapter 4 of Taylor (1987), or analysis of variance (ANOVA) for non-normal data, the EEG concludes that

1. Four measurements of radionuclides in the environment around WIPP during 2000 were different from the preoperational baseline levels. The value for ^{241}Am in the Loving LVAS for the 3rd quarter was the only one of these four which exceeded the action level. This measurement was carefully investigated, but no clearly assignable cause was discovered. No measurements of ^{241}Am in effluent air from the WIPP underground exceeded the action level, and converting the LVAS measured concentration to dose yielded a committed dose of much less than 1% of the limit allowable under the standard.

2. Except as noted above, the measured levels are similar to those measured by other organizations, where direct comparisons can be made.

3. WIPP operations during 2000 did not result in measurable releases to the environment or radiation doses to the public.

1.0 INTRODUCTION

The Waste Isolation Pilot Plant (WIPP) is an underground repository near Carlsbad in southeast New Mexico, owned and operated by the U. S. Department of Energy (DOE) for the purpose of safely disposing of waste materials generated by the nation's nuclear weapons production programs. These waste materials are contaminated with varying levels of transuranic radionuclides, principally isotopes of plutonium and americium. Since 1978, the Environmental Evaluation Group (EEG) has been responsible for independent technical oversight of the DOE's activities at WIPP. Since 1985, this responsibility has included on-site and off-site monitoring of transuranic radionuclides and fission products in air, soil, and water. Prior to the opening of WIPP, the purpose of these monitoring efforts was to establish a baseline for comparison with future measurements. The EEG's program for conducting radiation surveillance of the WIPP project has been fully described in Kenney et al. (1990), Kenney and Ballard (1990), Kenney (1991), Kenney (1992), Kenney (1994), Kenney et al. (1998), and Kenney et al. (1999). The radionuclides measured by the EEG in this program account for more than 98% of the potential public radiation dose from WIPP operations (DOE 1996). A brief description of the EEG air and water sampling locations appears in Appendix E.

The first shipment of waste arrived at WIPP in late March 1999, and EEG published its final preoperational report in October 1999, covering results of the surveillance program for 1996 through 1998 (Kenney et al. 1999). The EEG published it's first operational monitoring report in September 2000. The present report is the EEG's second operational monitoring report and contains results obtained from sample collections and other activities during calendar year 2000. This report also compares these results to:

1. The preoperational baseline measured by EEG and reported in the above-referenced preoperational reports.

2. The results of other organizations engaged in environmental monitoring at and around the WIPP site, where direct comparisons can be made.

3. The U.S. Environmental Protection Agency's (EPA) standards governing the operation of WIPP; namely, 40 CFR 191 Subpart A and 40 CFR 61 Subpart H, adopted by agreement between DOE and EPA.

The procedures established for the preoperational phase and the overall goals of the program are unchanged, unless noted herein. The terminology applied to uncertainties in this report has been modified somewhat from previous reports to more closely comply with common practice.

2.0 PREOPERATIONAL BASELINE

A summary of the concentrations of ^{241}Am, ^{238}Pu, $^{239/240}Pu$, ^{137}Cs, and ^{90}Sr measured by EEG in air and water at and in the vicinity of the WIPP site for the period prior to storage of waste appears in Table 1. For ^{90}Sr, the data represent samples collected during 1999 and 2000; for all others they pertain to the six-year period prior to receipt of waste. The transuranic and ^{137}Cs data in Table 1 are the means and uncertainties of the results found in the appendices of Kenney et al. (1998) and Kenney et al. (1999). The ^{90}Sr data are the corresponding values from Gray et al. (2000) and this work. The uncertainties in Table 1 represent two standard deviations (2s), or the approximately 95% confidence interval of the results. This was incorrectly described in the first operational report (EEG-79) as the 95% confidence level of the means. Also, a number of errors were found in the preoperational baseline table (Table1) which appeared in EEG-79. These errors did not materially alter the conclusions in EEG-79 and have been corrected in this report. The units are nano-Becquerels (10^{-9} Becquerels)-per-cubic-meter (nBq/m^3) for air and milli-Becquerels (10^{-3} Becquerels)-per-liter (mBq/L) for water. The number of measurements in each data set are given in parentheses. For water samples, if the calculated results were less than 0.1 mBq/L, the results were rounded to zero. Of 822 measurements, 19 were found to be statistical outliers by the Grubbs test (Taylor 1987). These were disqualified only after investigation into possible causes.

Table 1. Mean EEG Preoperational Baseline

Radionuclide	Effluent Air M ± 2s (nBq/m^3)	Ambient Air M ± 2s (nBq/m^3)	Drinking Water M ± 2s (mBq/L)	Surface Water M ± 2s (mBq/L)	Ground Water M ± 2s (mBq/L)
^{241}Am	25 ± 177 (n = 18)	27 ± 109 (n = 79)	-0.1 ± 1.4 (n = 17)	-0.3 ± 2.0 (n = 30)	0.3 ± 2.4 (n = 32)
$^{239/240}Pu$	25 ± 200 (n = 20)	23 ± 56 (n = 88)	0 ± 0.8 (n = 17)	-0.2± 0.7 (n = 34)	0.1 ± 1.4 (n = 36)
^{238}Pu	13 ± 96 (n = 18)	6 ± 62 (n = 90)	0.1 ± 0.8 (n = 19)	0 ± 1.0 (n = 31)	0.1 ± 1.5 (n = 34)
^{137}Cs	880 ± 7800 (n = 23)	60 ± 2460 (n = 104)	20 ± 50 (n = 5)	22 ± 130 (n = 8)	-30 ± 110 (n = 10)
^{90}Sr	820 ± 5750 (n = 16)	1260 ± 2290 (n = 44)	8.6 ±29.4 (n = 8)	9.5 ± 40.1 (n = 11)	7.3 ± 27.5 (n = 13)

3.0 OPERATIONAL MONITORING RESULTS

3.1 Air Effluent and Environmental Monitoring

The results of air effluent and environmental monitoring during the operational phase are summarized in Table 2. The values in Table 2 are the means and two standard deviations (2s) of the results for the operational phase data in Appendices A and B of this report. The “expanded uncertainty” used in the Appendices is the combined standard uncertainty of the measurements multiplied by a coverage factor (k) to express an interval about the measured value within which the “true” value may be expected to lie at some specified level of confidence – in this case, 95%. The combined standard uncertainty expresses the standard deviation of the result and includes both random and systematic sources of uncertainty. Further discussion is found in the ISO Guide to the Expression of Uncertainty in Measurement (ISO 1992).

Table 2. Results of Specific Radionuclide Measurements in the Operational Phase

Radionuclide	Effluent Air M ± 2s Station A Station B (nBq/m^3)	Ambient Air M ± 2s (nBq/m^3)	Drinking Water M ± 2s (mBq/L)	Surface Water M ± 2s (mBq/L)	Ground Water M ± 2s (mBq/L)
^{241}Am	83 ± 143 -28 ± 81	6.2 ± 100	0.52 ± 1.21	0.52 ± 1.66	0.54 ± 0.89
$^{239/240}$Pu	36 ± 83 17 ± 32	4.5 ± 21.3	-0.45 ± 0.74	-0.24 ± 0.28	0.13 ± 1.22
^{238}Pu	4.6 ± 57 -0.7 ± 29	-7.4 ± 30.8	-0.29 ± 0.87	-0.30 ± 0.39	0 ± 1.07
^{137}Cs	3100 ± 3130 1110 ± 2090	1050 ± 2190	8.8 ± 88.0	22 ± 134	24 ± 110
^{90}Sr	2170 ± 7320 -530 ± 5540	1480 ± 2340	18.4 ± 29.4	19.6 ± 67.6	21.4 ± 109

The analysis results from the 2000 sampling year were evaluated against three criteria:

1. Grubbs' Outlier Test (Taylor 1987) to identify greater than expected within-group variances.

2. Action Level (ACTL) (Rodgers & Kenney 1997), defined in previous reports as the upper-95% confidence level of the baseline measurements, to identify measurements which appear to exceed the baseline.

3. The *t* test (Taylor 1987) to determine whether the means of the 2000 measurements differ significantly from the baseline means for normally-distributed data; for non-normal data, an analysis of variance (ANOVA) test was applied.

The outlier test is a preliminary test applied to the data before application of the ACTL, *t*, and ANOVA tests. Data failing the outlier test are rejected only if a clearly definable analytical or sampling problem can be identified. Subsequently, the ACTL, *t*, and ANOVA tests are applied to all remaining data.

Four TRU radionuclide measurements were found to be outliers but could not be rejected. Three of these did not exceed the action level and were deemed to be members of the baseline population. The fourth, ^{241}Am in the Loving low volume air sampler (LVAS) from the third quarter, exceeded the action level and was investigated, but no assignable cause was discovered. The calculated concentration (215 nBq/m^3) was then evaluated against the 25 mrem standard imposed by 40 CFR 191 Subpart A, using estimates from International Commission on Radiological Protection (ICRP) Report 23 (ICRP 1975) for "reference man" and dose factors in Federal Guidance Report 11 (Eckerman 1988). The derived committed-effective-dose equivalent (CEDE) was only 0.04% of the standard. Assuming the measurement was an estimate of a "true" ^{241}Am concentration, the consequences for public health are considered to be insignificant.

The ^{241}Am concentration in the 3rd quarter Loving ambient air sample appears to be a statistically real value. However, the contamination is almost certainly not from WIPP operations for several reasons:

1. No WIPP effluent air measurement exceeded an ACTL.

2. Plutonium contamination would also be expected if the observed ^{241}Am activity came from WIPP; none was found in the sample.

3. No WIPP waste shipments should have gone through Loving before May 2001, when the first Savannah River site shipment arrived.

The extremely low ^{241}Am activity found in the Loving air sample could have resulted from trapping a single sub-micron size particle, called a "hot" particle, on the filter. The absence of a concurrent elevated $^{239/240}$Pu activity suggests a source other than nuclear weapons production or fallout. It could be interesting to do a future scientific study aimed at identifying possible sources; however, there is no public health reason for such an investigation unless activity levels are observed that are at least 100 times higher.

Four ^{137}Cs measurements exceeded the ACTL: three LVAS measurements and one groundwater measurement. Again, no assignable cause was found for these four high measurements and the measurement with the greatest potential for health consequences (the Loving LVAS for the second quarter was 2925 nBq/m^3) was evaluated as above. The derived CEDE was much less than 0.0001% of the standard and is insignificant.

Appendix C contains the results of the matrix blanks analyzed with the samples from the year 2000 sample collection period. All sample measurements in this report were blank-corrected, meaning the average result of the blank analyses from Table C1 was subtracted from the corresponding sample result. As noted in the footnote to Appendix C, no ^{137}Cs blank measurements for water were available in 2000, so the mean and 2s deviations from 1999 were substituted.

3.2 TLD Data

In 2000 EEG deployed environmental thermoluminescent dosimeters (TLDs) at selected points along the WIPP exclusive use boundary for the purpose of providing a direct assessment of WIPP's compliance with the 40 CFR 191 Subpart A dose standard (Kenney et al. 1999). Average external dose measurements as determined by TLDs during 2000 are reported in Appendix D, including a "control" TLD which was kept in the EEG office in Carlsbad and was unaffected by WIPP operations. The average quarterly dose (excluding the control) during 2000 was 16.0 mrem/quarter ± 5.2 mrem/quarter and the calculated annual dose averaged 64.0 mrem/year ± 10.5 mrem/year. These doses are not different from the preoperational baseline doses in EEG-73. The dose uncertainties are an average of the uncertainties appearing in the table in Appendix D, and are intended to give a better picture of the overall measurement uncertainty of the TLD system. The calculated quarterly lower limit of detection (LLD), based on the standard deviation of the 1998 TLD data, taken as the preoperational baseline, was 11.2 mrem/quarter (Rodgers 1998). Based on measurements of control TLDs for the year 2000, the quarterly LLD was 9.4 mrem/quarter. A quarterly dose from WIPP operations that exceeded about 10 mrem would be detected. However, chronic exposures near 6.25 mrem/quarter (25 mrem/year) would be below the sensitivity of the TLD measurement system.

4.0 DISCUSSION OF RESULTS

4.1 Comparison to the EEG Preoperational Baseline

Tables 1 and 2 are summarized and compared graphically in Figures 1 through 8 on the following pages. The bars in Figures 1 through 8 represent the upper and lower 95% limits and the horizontal dash inside each bar is the mean value. In Figure 8, ^{90}Sr concentrations in air should be read from the left-hand Y scale, and those in water should be read from the right-hand Y scale.

Using the *t* test in Chapter 4 of Taylor (1987), four of the measurements in Table 2 were found to differ from the preoperational baseline. Three of the four (^{239}Pu in ambient air and drinking water and ^{238}Pu in ambient air) exhibited lower means than the baseline, which indicates they are not a concern for public health. The fourth (^{137}Cs in ambient air) exhibited a slightly elevated mean with respect to the baseline. However, as indicated in Table 3, below, the higher amount, if real, does not present a health concern. Inspection of Figure A2 (effluent air) shows that the maximum measured value for ^{137}Cs occurred during the second quarter of 2000 and correlates with the highest ^{137}Cs LVAS measurement (Loving, 2nd quarter was 2925 nBq/m^{3}). This occurred at a time when no ^{137}Cs appeared to be present in the WIPP inventory (WWIS 2001). Therefore, a higher level of ^{137}Cs in ambient air, if real, could not have resulted from WIPP operations.

4.2 Comparison to the Operational Results from Other Organizations

Radiological surveillance monitoring of WIPP is also being conducted by the Westinghouse TRU Solutions (WTS) and the Carlsbad Environmental Monitoring and Research Center (CEMRC). Where direct comparisons are possible, it is useful to compare monitoring data among the three organizations. Operational data from the WTS monitoring program for 2000 were unavailable at the time of the preparation of this report. Measurements obtained during 2000 by CEMRC of ^{241}Am, ^{238}Pu, and ^{239}Pu in WIPP effluent air, and ^{239}Pu at three ambient air sampling locations (Near Field, On Site, and Cactus Flats) were obtained from the CEMRC Web site on June 11, 2001. Application of the *t* test as in the previous section showed no significant differences between the EEG and CEMRC effluent air measurements.

A statistically significant difference was noted between the mean EEG measurement of ^{239}Pu in ambient air (4.46 ± 21.27(2s) nBq/m^3) and the CEMRC mean measurement (19.27 ± 25.58(2s) nBq/m^3). However, an ANOVA test comparing the CEMRC measurement with the EEG baseline value (23 ± 56(2s) nBq/m^3) for ^{239}Pu in ambient air indicated no statistically significant difference.

At present, no other direct comparisons can be made.

4.3 Comparison to the EPA Standard

The dose standards applied by the U. S. Environmental Protection Agency to WIPP operations are found both in 40 CFR 191 Subpart A and, following a memorandum of understanding (MOU) between DOE and EPA (EPA&DOE 1995), in 40 CFR Part 61, the National Emission Standards for Hazardous Air Pollutants, or NESHAPS. Respectively, these are annual committed-effective-dose-equivalents to the highest-risk individual of 25 mrem and 10 mrem. The NESHAPS standard applies to effluent airborne releases only. Comparisons to EPA standards in this and future operational reports will be relative to NESHAPS for airborne facility effluent measurements, and relative to 40 CFR 191 Subpart A for all other measurements having implications for WIPP's compliance with the pertinent regulations..

Comparisons of concentration measurements to a dose standard require appropriate conversions. In the preoperational reports, EEG applied the methods found in NCRP 123 (NCRP 1996) to measurements of facility effluent air, sampled at Station A (Kenney et al. 1999). EEG's analytical methodology provided sufficient sensitivity to detect releases which could potentially result in doses to the highest-risk individual of a few percent of the standard. EPA, in its guidance for the application of 40 CFR 191, Subpart A (EPA 1997), recommends the use of CAP88PC (Parks 1992) for estimating doses both to populations and to the individual at highest risk, based on effluent measurements made at a point of release. The EEG will follow the EPA's recommendation for this and future reports.

For measurements made at a receptor location, such as for ambient air samples versus a point-of-release location, a simpler dose-conversion factor can be used in some cases. For measurements of ambient air (LVAS) samples, the EEG uses the dose-conversion factors in Federal Guidance Report No. 11 (Eckerman 1988) and assumes intakes of 8400 m^3/year of air, based on the ICRP No. 23 "reference man" (ICRP 1975).

Using the upper 95% limit values for the means (Mean + 2s) from the tables in Appendices A and B as input values, the dose estimates obtained from these conversions were then expressed as a percentage of the appropriate standard and the results appear in Table 3, with the total of the individual isotopic dose contributions in the last row.

Table 3. Comparison of Measurements to the Standards

Applicable Standard ÿ	NESHAPS (10 mrem)		40 CFR 191 (25 mrem)
Radionuclide	Effluent Air Station A	Effluent Air Station B	Ambient Air
^{241}Am	<0.01%	<0.01%	0.04%
$^{239/240}$Pu	<0.01%	<0.01%	-0.01%
^{238}Pu	<0.01%	<0.01%	<0.01%
^{137}Cs	<0.01%	<0.01%	<0.01%
^{90}Sr (Baseline)	<0.01%		<0.01%
Total	<0.01%	<0.01%	-0.05%

6.0 CONCLUSIONS

The results of EEG's radiation surveillance of the WIPP project during 2000 show that operations at the site during 2000 did not result in detectable releases of radionuclides to the environment. Where direct comparisons can be made, the EEG results are similar to the results of other organizations engaged in radiation surveillance at WIPP. The sensitivity of EEG's methods is such that releases from the air exhaust shaft, resulting in a dose to the highest-risk individual of less than 0.01% of the standard, would have been detected.

Finally, an evaluation of the results of environmental sampling at various locations around the site relative to the applicable EPA radiation dose standards shows that the estimated dose to an individual residing year-round at a sampled location during 2000 is not different from the baseline dose before WIPP became operational. From this, the EEG concludes that WIPP operations during 2000 did not result in measurable doses to the public.

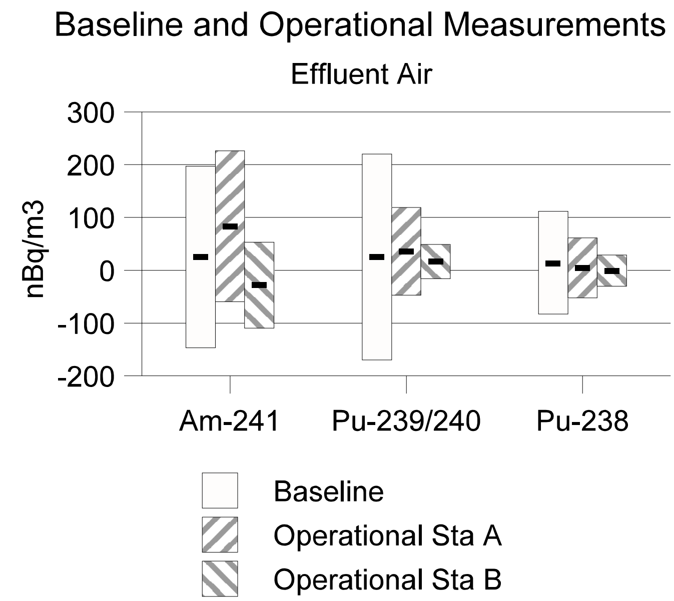

Figure 1. Baseline and 2000 Effluent Air Measurements of ^{241}Am, $^{239/240}$Pu, and ^{238}Pu

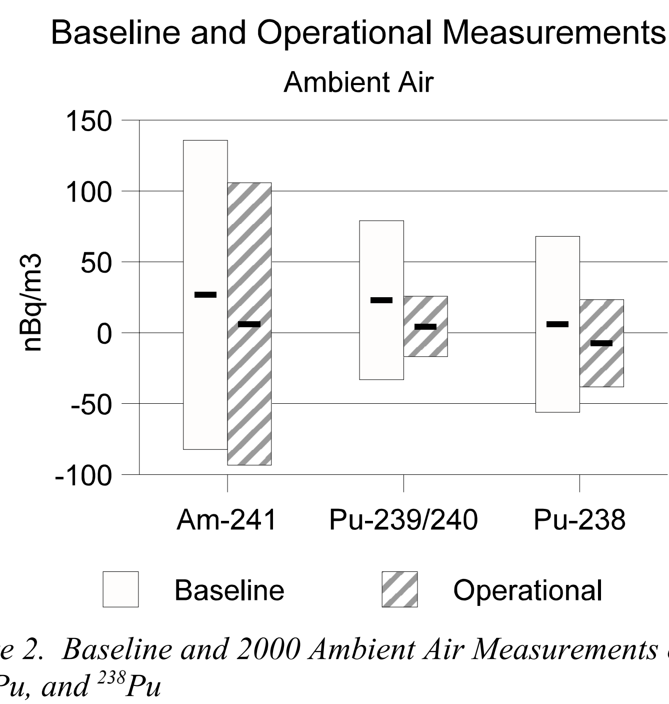

Figure 2. Baseline and 2000 Ambient Air Measurements of ^{241}Am, $^{239/240}$Pu, and ^{238}Pu

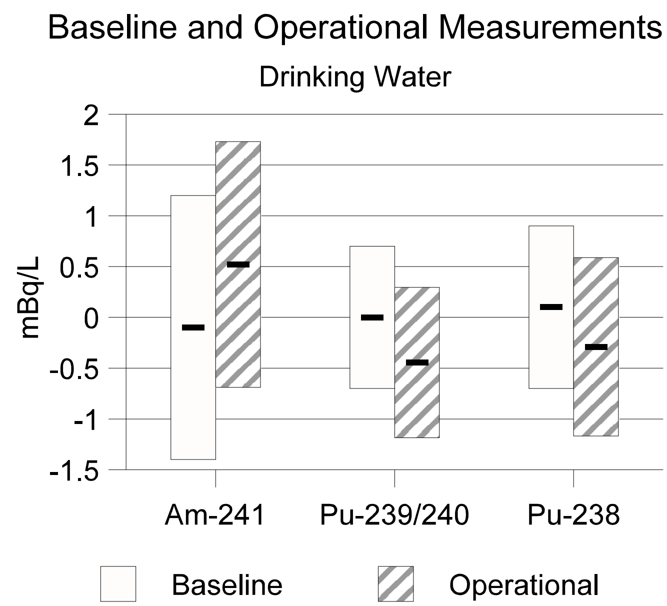

Figure 3. Baseline and 2000 Measurements of ^{241}Am, $^{239/240}$Pu, and ^{238}Pu in Drinking Water

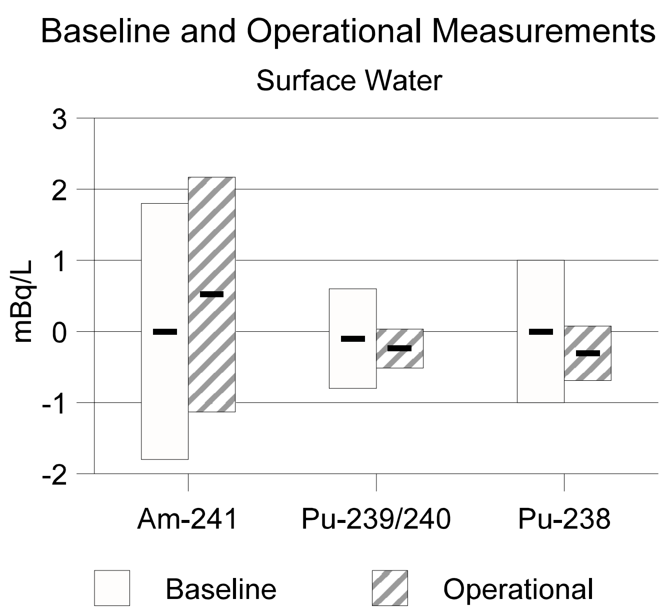

Figure 4. Baseline and 2000 Measurements of ^{241}Am, $^{239/240}$Pu, and ^{238}Pu in Surface Water

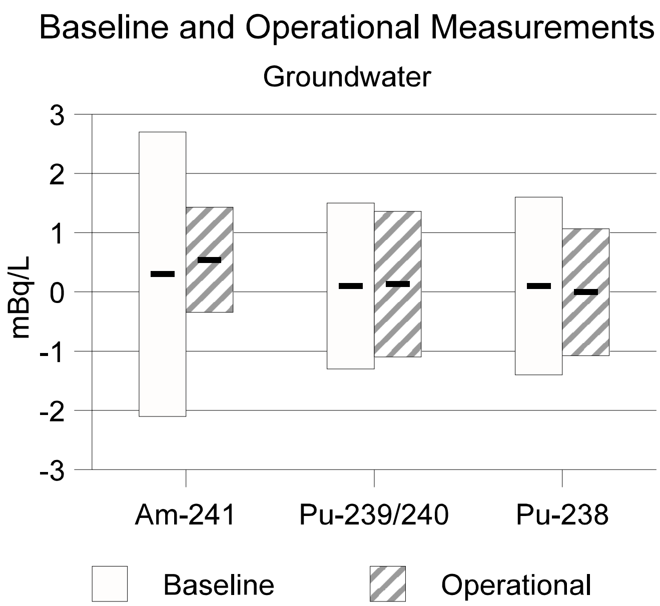

Figure 5. Baseline and 2000 Measurements of ^{241}Am, $^{239/240}$Pu, and ^{238}Pu in Groundwater

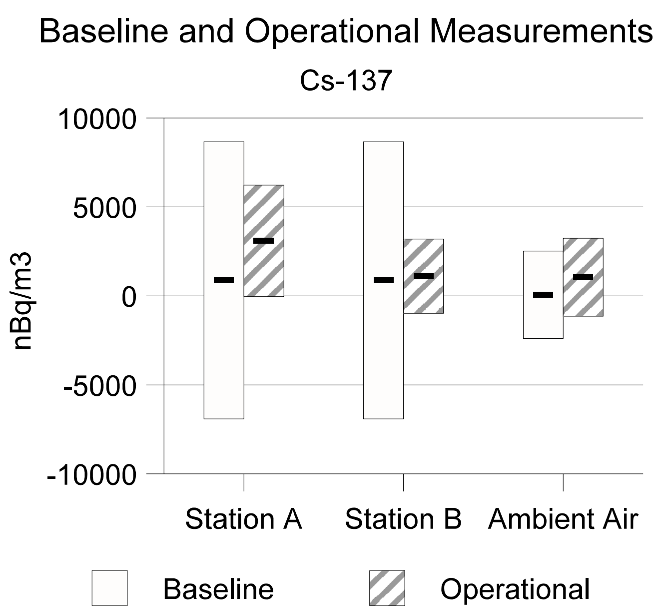

Figure 6. Baseline and 2000 Measurements of ^{137}Cs in Effluent Air and Ambient Air (Baseline is ***combined*** *effluent for Stations A and B)*

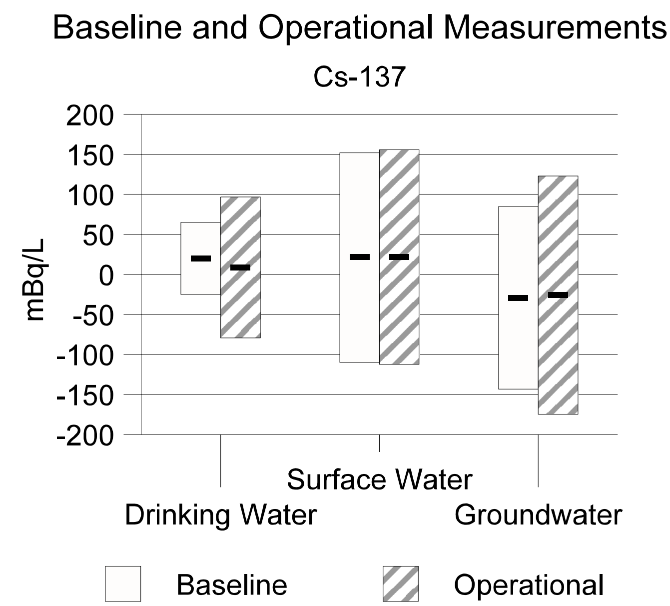

Figure 7. Baseline and 2000 Measurements of ^{137}Cs in Drinking Water, Surface Water and Groundwater

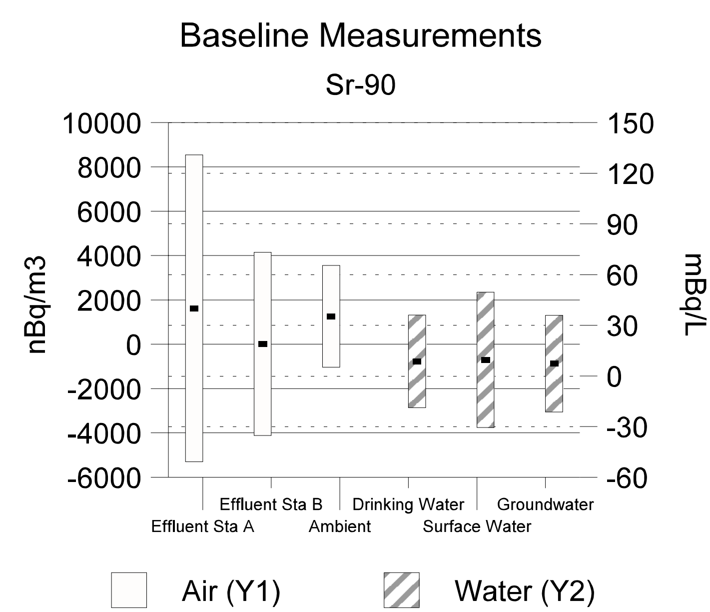

Figure 8. 1999-2000 Measurements of ^{90}Sr in Air and Water

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APPENDICES

(Note: “Expanded Uncertainty” in the following tables is defined in Chapter 6 of the ISO Guide to the Expression of Uncertainty in Measurement [ISO 1992])

APPENDIX A. AIR SAMPLE DATA

Table A1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station A Samples During 2000

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{241}Am CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	$^{239/240}$Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{238}Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2000	6168.00	NA	NA	NA	NA	NA	NA
2ND 2000	6267.00	56.91	201.64	0.51	38.78	34.61	102.85
3RD 2000	7170.00	164.39	186.13	81.60	105.88	1.05	143.31
4TH 2000	7302.00	28.71	170.61	25.62	47.18	-21.90	90.64
		Mean	2s	Mean	2s	Mean	2s
		83.34	143.19	35.91	83.03	4.59	56.84

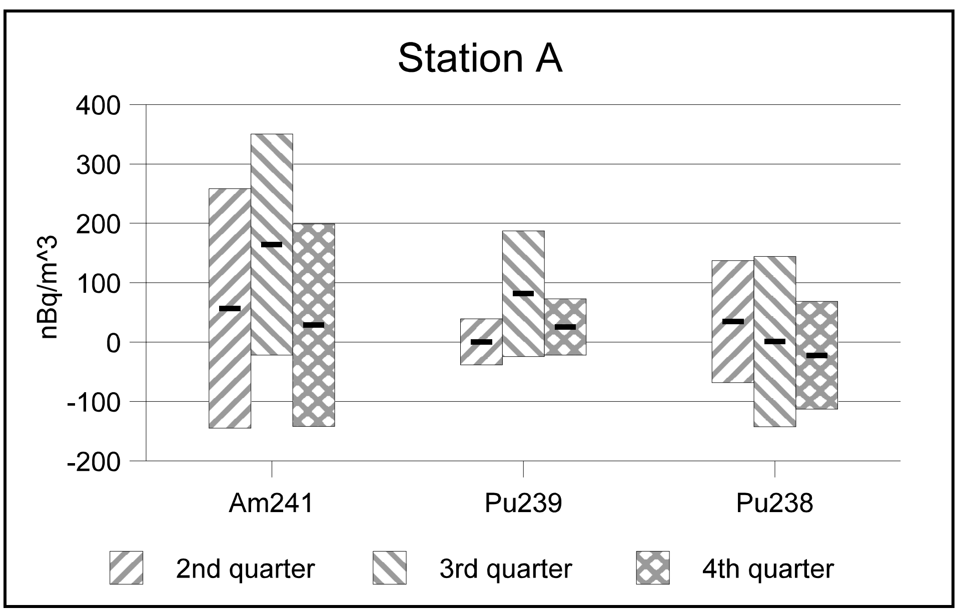

Figure A1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station A Samples During 2000

Table A2. ^{137}Cs and ^{90}Sr Measurements in Station A Samples During 2000

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{137}Cs CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{90}Sr CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2000	6168	3082	6174	-1004	3945
2ND 2000	6267	5203	6182	7234	5325
3RD 2000	7170	2651	5311	61	4122
4TH 2000	7302	1453	4645	2374	4683
		Mean	2s	Mean	2s
		3097	3128	2166	7322

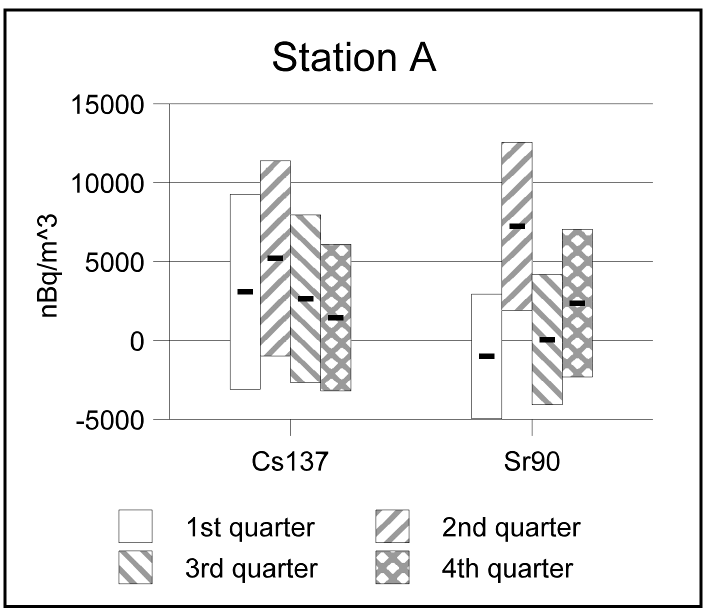

Figure A2. ^{137}Cs and ^{90}Sr Measurements in Station A Samples During 2000

Table A3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station B Samples During 2000

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{241}Am CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	$^{239/240}$Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{238}Pu CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2000	6745	NA	NA	10.39	83.62	-13.06	89.90
2ND 2000	6572	-64.26	217.63	37.75	57.80	11.85	94.24
3RD 2000	7027	-35.91	176.67	18.94	43.21	12.22	88.25
4TH 2000	7341	16.03	168.19	-0.73	34.29	-13.89	82.29
		Mean	2s	Mean	2s	Mean	2s
		-28.05	81.44	16.59	32.48	-0.72	29.47

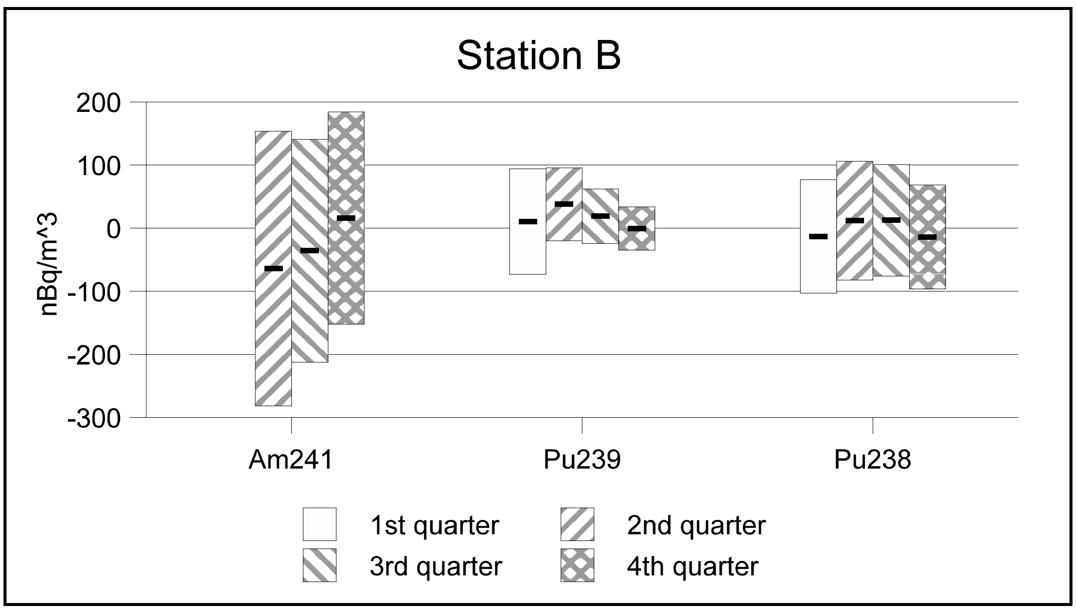

Figure A3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Station B Samples During 2000

Table A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2000

SAMPLE DATE	SAMPLE VOLUME (m^3)	^{137}Cs CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)	^{90}Sr CALCULATED CONC. (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
1ST 2000	6745	1262	4002	-1579	3869
2ND 2000	6572	899	3951	3581	4520
3RD 2000	7027	2406	3959	-1732	3881
4TH 2000	7341	-125	3554	-2407	4501
		Mean	2s	Mean	2s
		1111	2089	-534	5535

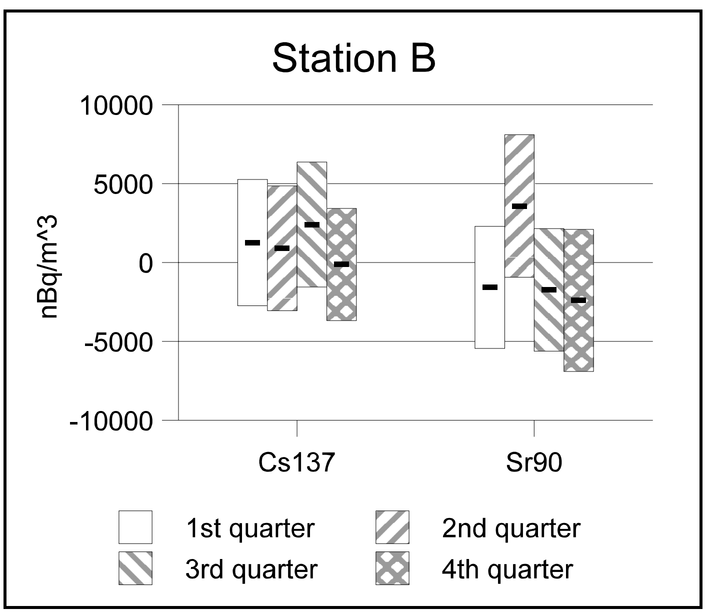

Figure A4. ^{137}Cs and ^{90}Sr Measurements in Station B Samples During 2000

Table A5. [241]Am Measurements in LVAS Samples During 2000

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2000	28939	NA	NA
CARLSBAD	1ST 2000	30295	NA	NA
LOVING	1ST 2000	33043	NA	NA
WIPP 1	1ST 2000	30277	-15.59	21.14
WIPP 2	1ST 2000	29006	-13.66	21.71
WIPP 3	1ST 2000	27132	-24.63	27.10
ARTESIA	2ND 2000	26958	-3.08	24.05
CARLSBAD	2ND 2000	29373	45.45	32.04
LOVING	2ND 2000	28341	2.68	24.15
WIPP 1	2ND 2000	25484	-1.42	25.08
WIPP 2	2ND 2000	26479	-4.99	23.97
WIPP 3	2ND 2000	27708	-10.12	22.59
ARTESIA	3RD 2000	23710	-7.39	26.74
CARLSBAD	3RD 2000	21896	-19.00	28.63
LOVING	3RD 2000	24583	214.98	51.46
WIPP 1	3RD 2000	25620	-5.63	24.77
WIPP 2	3RD 2000	23925	12.20	28.58
WIPP 3	3RD 2000	24715	-8.34	25.54
ARTESIA	4TH 2000	29431	-11.79	22.46
CARLSBAD	4TH 2000	31884	-2.92	20.15
LOVING	4TH 2000	27374	-4.42	23.17
WIPP 1	4TH 2000	30670	-9.24	20.40
WIPP 2	4TH 2000	26457	3.40	24.68
WIPP 3	4TH 2000	29411	-5.41	21.50
			Mean	2s
			6.24	99.60

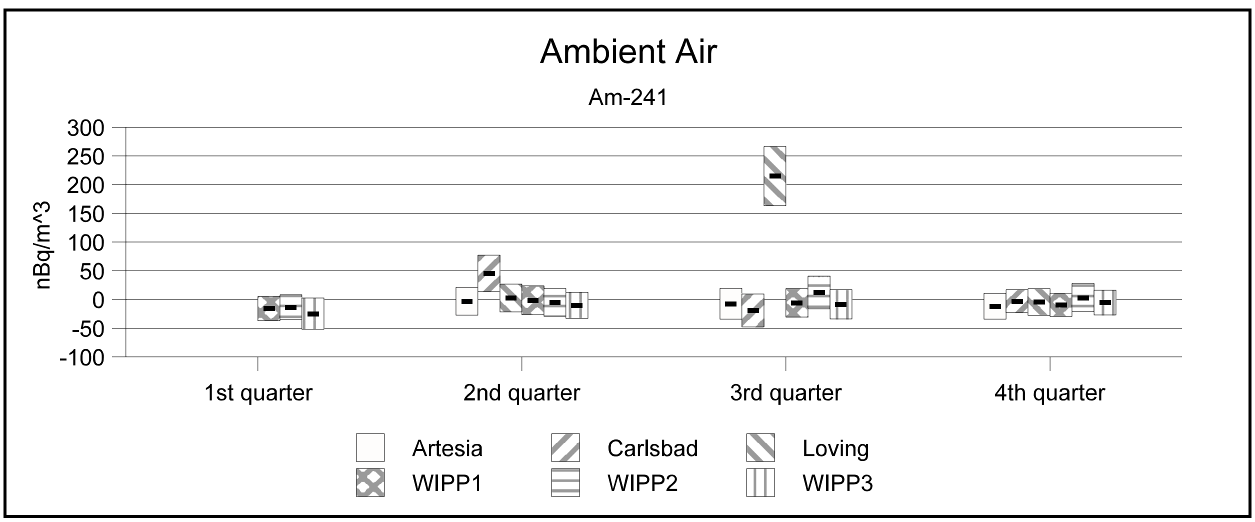

Figure A5. [241]Am Measurements in LVAS Samples During 2000

Table A6. $^{239/240}$Pu Measurements in LVAS Samples During 2000

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2000	28939	18.61	26.20
CARLSBAD	1ST 2000	30295	15.04	26.95
LOVING	1ST 2000	33043	11.97	22.17
WIPP 1	1ST 2000	30277	9.30	22.85
WIPP 2	1ST 2000	29006	-1.70	22.38
WIPP 3	1ST 2000	27132	11.19	26.39
ARTESIA	2ND 2000	26958	14.82	26.56
CARLSBAD	2ND 2000	29373	28.82	26.69
LOVING	2ND 2000	28341	1.33	27.25
WIPP 1	2ND 2000	25484	15.01	28.05
WIPP 2	2ND 2000	26479	19.70	30.63
WIPP 3	2ND 2000	27708	0.78	24.28
ARTESIA	3RD 2000	23710	-1.83	27.63
CARLSBAD	3RD 2000	21896	0.58	30.86
LOVING	3RD 2000	24583	-1.24	27.06
WIPP 1	3RD 2000	25620	2.05	26.15
WIPP 2	3RD 2000	23925	1.32	28.04
WIPP 3	3RD 2000	24715	-9.24	25.62
ARTESIA	4TH 2000	29431	-8.95	21.30
CARLSBAD	4TH 2000	31884	-3.49	23.20
LOVING	4TH 2000	27374	0.83	25.09
WIPP 1	4TH 2000	30670	-9.47	22.77
WIPP 2	4TH 2000	26457	4.90	32.47
WIPP 3	4TH 2000	29411	-13.37	20.01
			Mean	2s
			4.46	21.27

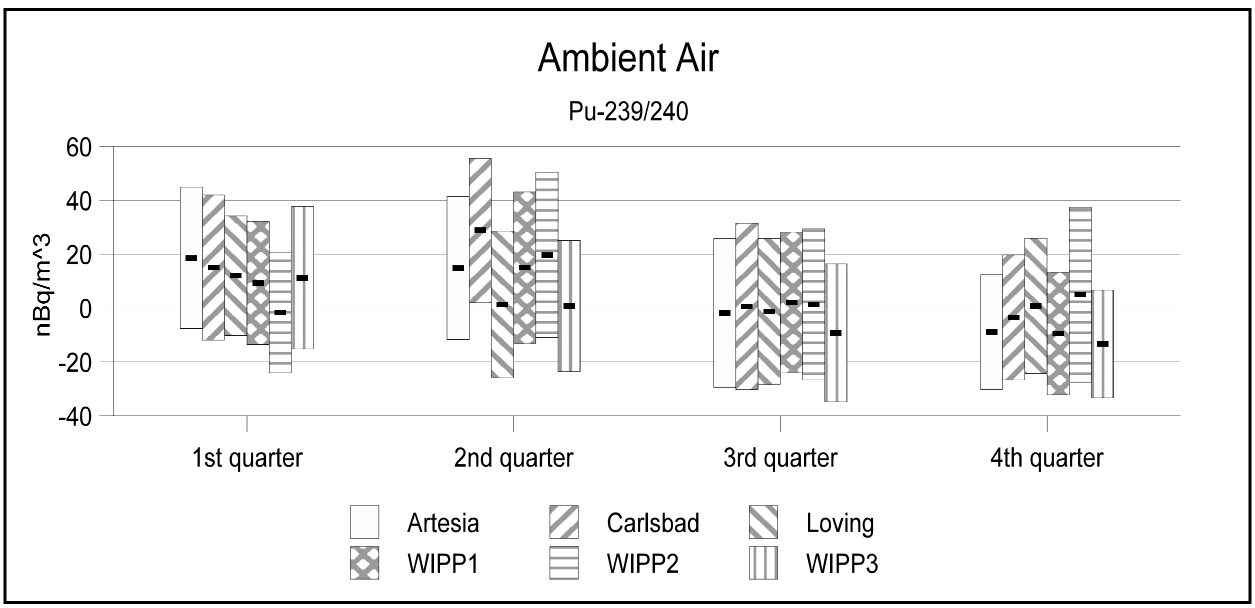

Figure A6. $^{239/240}$Pu Measurements in LVAS Samples During 2000

Table A7. ^{238}Pu Measurements in LVAS Samples During 2000

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2000	28939	-15.96	47.82
CARLSBAD	1ST 2000	30295	-13.22	45.07
LOVING	1ST 2000	33043	-7.22	41.40
WIPP 1	1ST 2000	30277	-8.21	45.56
WIPP 2	1ST 2000	29006	-19.15	47.02
WIPP 3	1ST 2000	27132	-17.12	50.86
ARTESIA	2ND 2000	26958	-14.94	50.37
CARLSBAD	2ND 2000	29373	46.82	50.49
LOVING	2ND 2000	28341	23.83	53.42
WIPP 1	2ND 2000	25484	-10.58	53.84
WIPP 2	2ND 2000	26479	-15.62	53.74
WIPP 3	2ND 2000	27708	-7.13	50.14
ARTESIA	3RD 2000	23710	-15.46	57.57
CARLSBAD	3RD 2000	21896	-13.36	63.87
LOVING	3RD 2000	24583	-10.11	56.34
WIPP 1	3RD 2000	25620	-10.64	53.54
WIPP 2	3RD 2000	23925	-16.95	57.88
WIPP 3	3RD 2000	24715	1.15	56.74
ARTESIA	4TH 2000	29431	-12.12	46.46
CARLSBAD	4TH 2000	31884	-14.64	46.23
LOVING	4TH 2000	27374	-15.69	50.38
WIPP 1	4TH 2000	30670	15.50	50.19
WIPP 2	4TH 2000	26457	-7.81	59.01
WIPP 3	4TH 2000	29411	-18.18	45.78
			Mean	2s
			-7.37	30.81

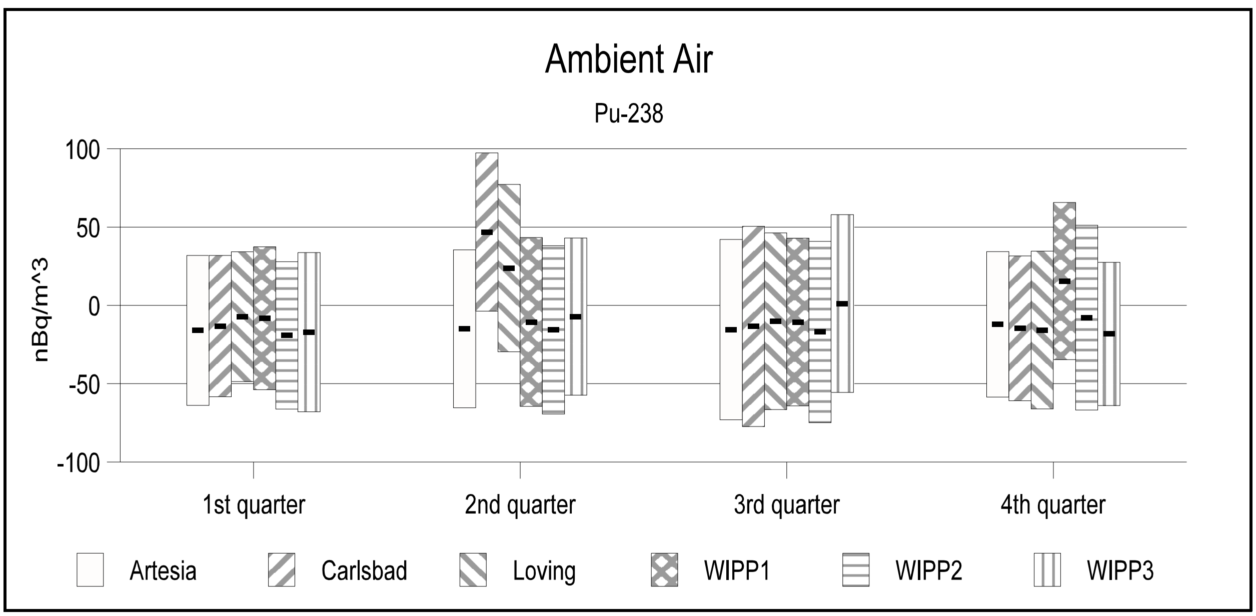

Figure A7. ^{238}Pu Measurements in LVAS Samples During 2000

Table A8. 137Cs Measurements in LVAS Samples During 2000

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME. (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2000	28939	881	2060
CARLSBAD	1ST 2000	30295	-1977	2126
LOVING	1ST 2000	33043	451	1798
WIPP 1	1ST 2000	30277	288	2028
WIPP 2	1ST 2000	29006	171	2131
WIPP 3	1ST 2000	27132	-358	2248
ARTESIA	2ND 2000	26958	198	2893
CARLSBAD	2ND 2000	29373	1832	2785
LOVING	2ND 2000	28341	2925	3034
WIPP 1	2ND 2000	25484	2186	3218
WIPP 2	2ND 2000	26479	1446	3029
WIPP 3	2ND 2000	27708	1205	2880
ARTESIA	3RD 2000	23710	1329	3357
CARLSBAD	3RD 2000	21896	1439	3635
LOVING	3RD 2000	24583	2542	3376
WIPP 1	3RD 2000	25620	664	3068
WIPP 2	3RD 2000	23925	995	3302
WIPP 3	3RD 2000	24715	1351	3229
ARTESIA	4TH 2000	29431	2718	2908
CARLSBAD	4TH 2000	31884	NA	NA
LOVING	4TH 2000	27374	654	2871
WIPP 1	4TH 2000	30670	174	2543
WIPP 2	4TH 2000	26457	1081	3001
WIPP 3	4TH 2000	29411	1962	2802
			Mean	2s
			1050	2193

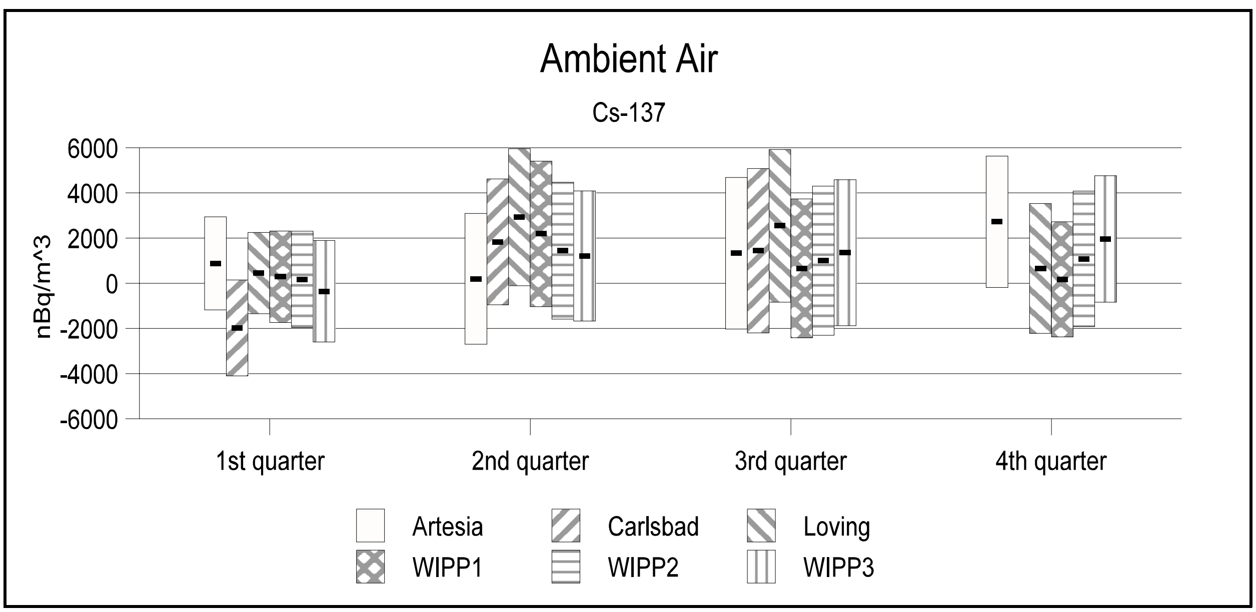

Figure A8. 137Cs Measurements in LVAS Samples During 2000

Table A9. ^{90}Sr Measurements in LVAS Samples During 2000

LVAS SAMPLE LOCATION	QUARTER SAMPLE COLLECTED	SAMPLE VOLUME (m^3)	CALCULATED CONCENTRATION (nBq/m^3)	EXPANDED UNCERT. (k=2) (nBq/m^3)
ARTESIA	1ST 2000	28939	1177	1314
CARLSBAD	1ST 2000	30295	1986	1228
LOVING	1ST 2000	33043	2008	1118
WIPP 1	1ST 2000	30277	2423	1351
WIPP 2	1ST 2000	29006	1026	1329
WIPP 3	1ST 2000	27132	1963	1448
ARTESIA	2ND 2000	26958	77	1345
CARLSBAD	2ND 2000	29373	1129	1235
LOVING	2ND 2000	28341	595	1276
WIPP 1	2ND 2000	25484	NA	NA
WIPP 2	2ND 2000	26479	NA	NA
WIPP 3	2ND 2000	27708	NA	NA
ARTESIA	3RD 2000	23710	276	1996
CARLSBAD	3RD 2000	21896	3487	1766
LOVING	3RD 2000	24583	3269	1615
WIPP 1	3RD 2000	25620	205	1319
WIPP 2	3RD 2000	23925	315	1525
WIPP 3	3RD 2000	24715	257	1481
ARTESIA	4TH 2000	29431	1201	1252
CARLSBAD	4TH 2000	31884	1002	1148
LOVING	4TH 2000	27374	4360	1586
WIPP 1	4TH 2000	30670	1205	1162
WIPP 2	4TH 2000	26457	2164	1397
WIPP 3	4TH 2000	29411	937	1214
			Mean	2s
			1479	2342

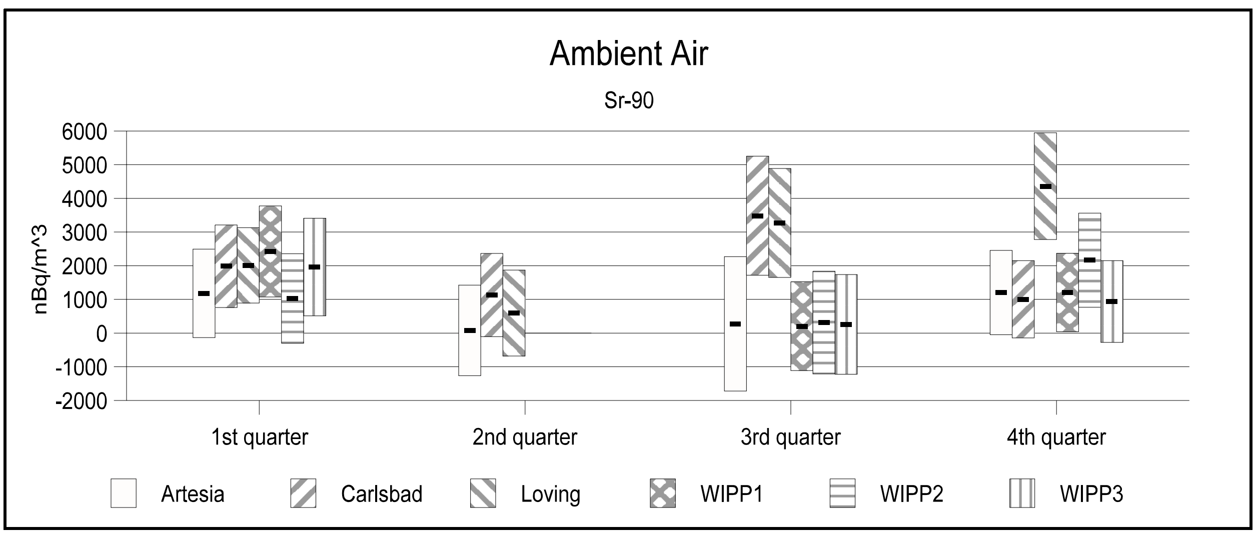

Figure A9. ^{90}Sr Measurements in LVAS Samples During 2000

APPENDIX B. WATER SAMPLE DATA

Table B1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Groundwater During 2000

WATER WELL IDENTIFICATION	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}$Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
WQSP-1	1.22	0.99	-0.26	0.60	-0.25	0.58
WQSP-2	0.87	1.18	-0.06	0.65	0.02	0.67
WQSP-3	0.60	3.78	1.15	1.49	-0.52	1.23
WQSP-4	0.33	0.64	0.87	1.05	1.10	1.16
WQSP-5	NA	NA	-0.22	0.60	0.15	0.64
WQSP-6	0.17	0.74	-0.17	0.72	-0.32	0.76
WQSP-6A	0.06	0.58	-0.39	0.65	-0.21	0.57
	Mean	2s	Mean	2s	Mean	2s
	0.54	0.89	0.13	1.22	0.00	1.07

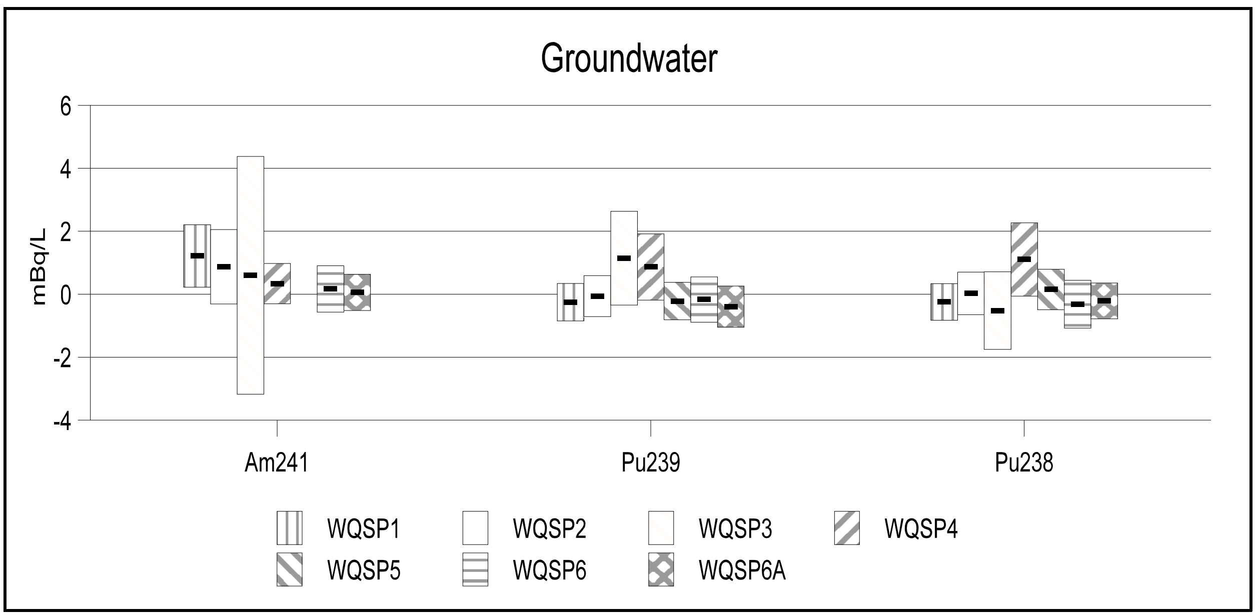

Figure B1. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Groundwater During 2000

Table B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2000

WATER WELL IDENTIFICATION	^{137}Cs CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{90}Sr CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
WQSP-1	-36.9	81.1	-4.6	20.5
WQSP-2	-13.5	85.8	22.3	47.3
WQSP-3	-141.0	98.9	142.4	101.9
WQSP-4	-60.0	73.7	1.7	76.4
WQSP-5	-55.0	66.2	-3.3	46.7
WQSP-6	94.3	54.9	-4.6	41.1
WQSP-6A	30.8	52.1	-4.4	34.2
	Mean	2s	Mean	2s
	-25.9	148.8	21.4	108.5

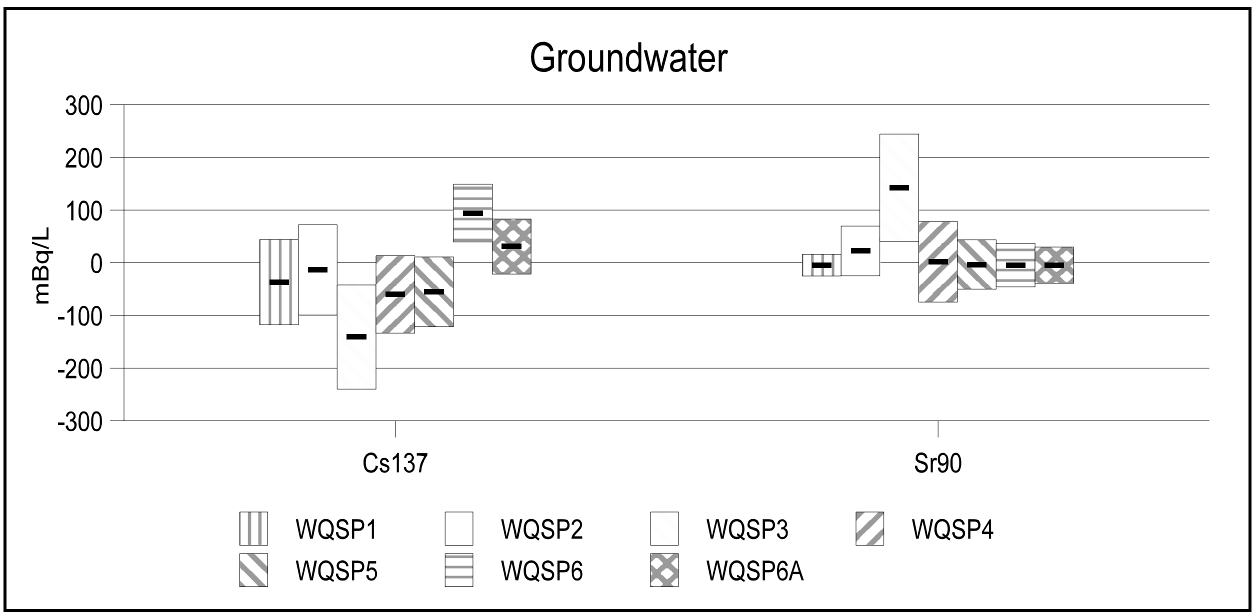

Figure B2. ^{137}Cs and ^{90}Sr Measurements in Groundwater During 2000

Table B3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Surface Water During 2000

SAMPLE SITE	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}$Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
PECOS @ CBD	0.91	1.78	-0.12	0.68	-0.15	0.55
PECOS @ PIERCE	1.08	1.50	-0.39	0.57	-0.52	0.66
WIPP STORMWATER	-0.43	0.84	-0.21	0.62	-0.25	0.62
	Mean	2s	Mean	2s	Mean	2s
	0.52	1.66	-0.24	0.28	-0.30	0.39

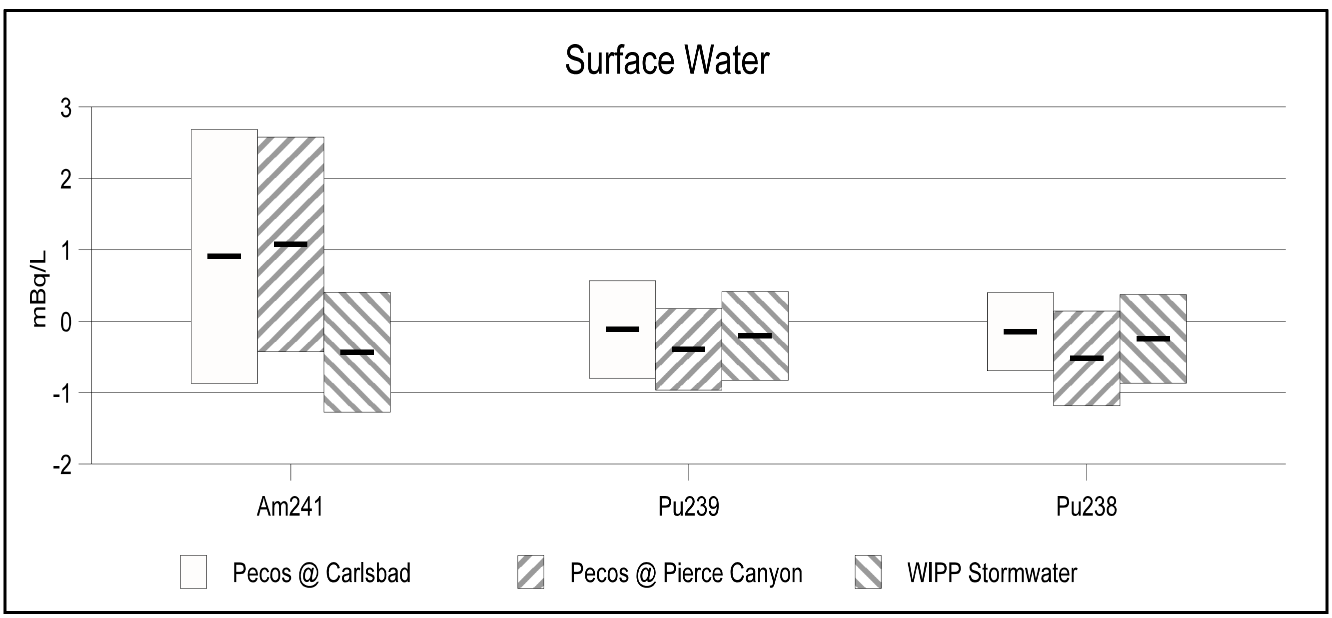

Figure B3. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Surface Water During 2000

Table B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2000

SAMPLE DATE	SAMPLE SITE	^{137}Cs CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{90}Sr CALCULATED CONCENTRATIO N (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
06/02/00	Pecos @ Carlsbad	19.4	48.9	20.7	37.0
08/02/00	Pecos @ Pierce	-56.4	48.4	52.8	38.2
07/06/00	WIPP Stormwater	15.9	41.0	-14.8	50.4
07/06/00	Laguna Grande	107.6	204.6	NA	NA
		Mean	2s	Mean	2s
		21.6	134.3	19.6	67.6

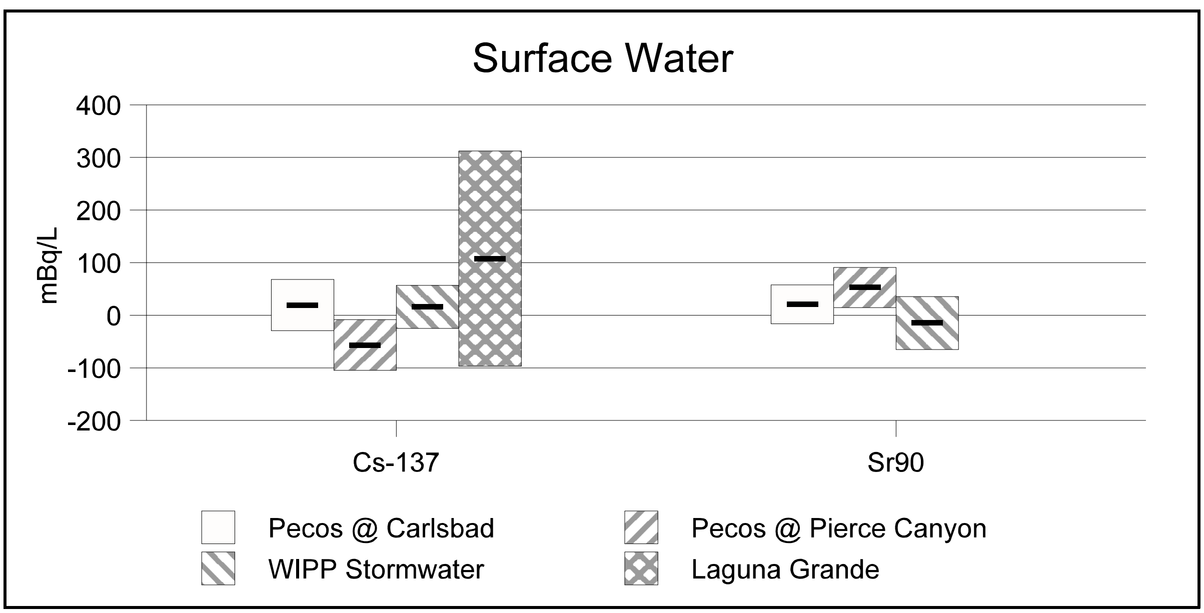

Figure B4. ^{137}Cs and ^{90}Sr Measurements in Surface Water During 2000

Table B5. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Drinking Water During 2000

SAMPLE DATE	PUBLIC WATER SUPPLY SYSTEM	^{241}Am CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	$^{239/240}$Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)	^{238}Pu CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
08/02/00	Carlsbad	-0.35	0.94	-0.27	0.63	-0.25	0.70
09/07/00	Loving	0.94	1.32	-0.58	0.62	-0.15	0.57
06/15/00	Otis	0.92	0.97	-0.04	0.63	0.14	0.64
07/27/00	WIPP	0.57	1.09	-0.89	0.60	-0.90	0.63
		Mean	2s	Mean	2s	Mean	2s
		0.52	1.21	-0.45	0.74	-0.29	0.87

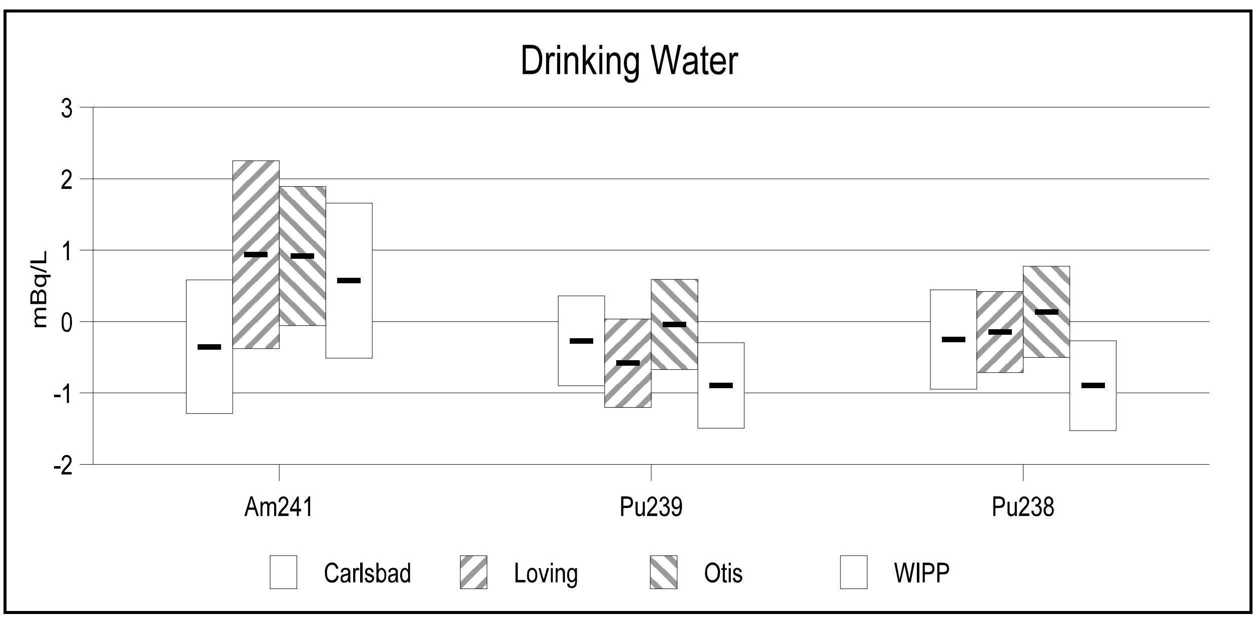

Figure B5. ^{241}Am, $^{239/240}$Pu, and ^{238}Pu Measurements in Drinking Water During 2000

Table B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2000

SAMPLE DATE	PUBLIC WATER SUPPLY SYSTEM	CS-137 CALCULATED CONCENTRATION (mBq/l)	EXPANDED UNCERT. (k=2) mBq/l)	SR-90 CALCULATED CONCENTRATIO N (mBq/l)	EXPANDED UNCERT. (k=2) (mBq/l)
08/02/00	Carlsbad	-26.5	45.7	0.7	32.0
06/15/00	Loving	51.1	46.8	16.6	35.5
07/27/00	Otis	-31.8	45.4	19.6	34.7
07/27/00	WIPP	42.3	43.7	36.5	35.7
		Mean	2s	Mean	2s
		8.8	88.0	18.4	29.4

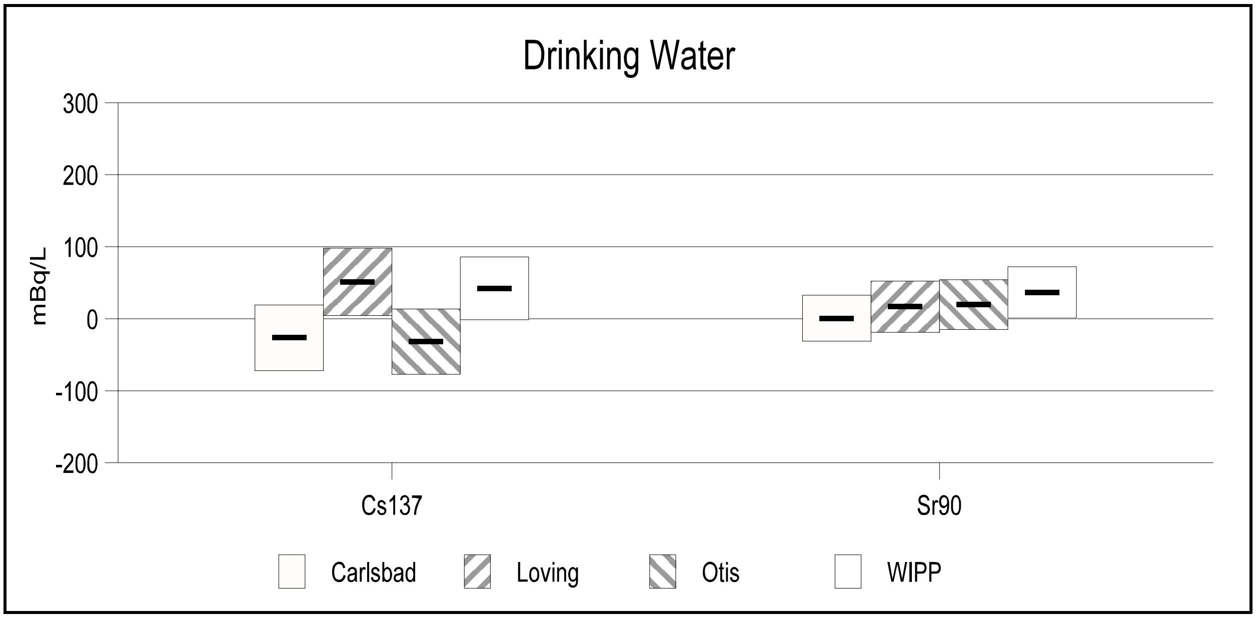

Figure B6. ^{137}Cs and ^{90}Sr Measurements in Drinking Water During 2000

APPENDIX C. MATRIX BLANK DATA

Table C1. Matrix Blank Results For the 2000 Sampling Period

Matrix Blank ID	^{241}Am	$^{239/240}$Pu	^{238}Pu	^{137}Cs	^{90}Sr
FAS (Effluent)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
FMB-000605	NA	2.25e-04	5.07e-04	1.81e-02	7.41e-03
FMB-000907	-7.43e-04	4.73e-05	1.89e-04	-1.18e-02	4.39e-03
FMB-001205	7.50e-04	0.00e+00	-2.86e-04	3.93e-03	9.05e-03
FMB-010129	1.77e-04	6.34e-05	-5.76e-05	8.13e-03	2.86e-02
Mean	6.13e-05	8.39e-05	8.81e-05	4.59e-03	1.24e-02
2s	1.51e-03	1.96e-04	6.80e-04	2.49e-02	2.20e-02
LVAS (Ambient)	Bq/composite	Bq/composite	Bq/composite	Bq/composite	Bq/composite
LMB-000426	6.52e-04	6.02e-05	5.78e-05	NA	2.25e-03
LMB-000911	9.67e-04	3.30e-04	-2.20e-04	3.54e-02	-3.42e-02
LMB-001218	7.79e-05	1.00e-03	1.55e-03	2.28e-02	NA
LMB-010226	1.30e-04	2.11e-04	2.57e-04	2.76e-02	-1.02e-02
LMB-010409	1.85e-04	3.42e-04	1.93e-04	1.70e-02	1.88e-04
LMB-010529	2.96e-04	4.17e-04	1.37e-03	-2.76e-02	-1.92e-02
LMB-010613	1.08e-04	NA	NA	-2.28e-02	1.10e-02
Mean	3.45e-04	3.93e-04	5.35e-04	8.73e-03	-8.36e-03
2s	6.75e-04	6.45e-04	1.48e-03	5.40e-02	3.29e-02
Water	Bq/L	Bq/L	Bq/L	Bq/L	Bq/L
WMB-000410	NA	5.69e-04	3.80e-04	NA	-9.55e-03
WMB-001002	3.94e-04	NA	NA	NA	NA
WMB-000615	5.95e-05	7.40e-04	3.26e-04	NA	-4.91e-04
WMB-000313	1.58e-04	2.09e-04	1.83e-04	NA	1.17e-02
WMB-000822	NA	5.96e-05	-2.98e-04	NA	1.66e-02
WMB-001010	-3.56e-04	NA	NA	NA	NA
Mean	6.39e-05	3.94e-04	1.48e-04	-5.90e-02*	4.56e-03
2s	6.26e-04	6.29e-04	6.17e-04	1.34e-01*	2.37e-02

** mean and 2s from 1999 Report*

APPENDIX D. TLD DATA

Table D1. Average Dose by TLD in 2000

TLD Badge Number	Average Quarterly Dose (mrem/qtr)	2-F Uncertainty (mrem/qtr)	Annual Dose (mrem/yr)	2-F Uncertainty (mrem/yr)
1	16.6	4.3	66.4	8.6
2	17.0	5.1	68.0	10.2
3	15.9	5.6	63.6	11.2
4	16.5	7.0	65.9	14.1
5	16.0	4.9	64.0	9.8
6	15.7	4.8	62.8	9.5
7	16.5	5.8	66.1	11.7
8	15.3	3.3	61.2	6.6
9	16.1	5.7	64.5	11.4
11	15.1	7.4	60.3	14.8
12	15.8	2.8	63.2	5.7
13	15.1	5.8	60.4	11.5
CONTROL	15.9	5.6	63.6	11.2

APPENDIX E. SAMPLE COLLECTION LOCATIONS

APPENDIX E
SAMPLE COLLECTION LOCATIONS

Detailed descriptions of the sampling locations are found in the preoperational reports, but are summarized in this Appendix.

Fixed Air Samplers (Effluent)

Two fixed air samplers are currently operating in the WIPP air effluent stream and one is about to come on-line. The two currently operating are Station A, located at the top of the air exhaust shaft and sampling the unfiltered exhaust, and Station B, located downstream of the HEPA filtration building, through which underground exhaust air can be diverted, if necessary. The third location is called Station D and is located underground, near the base of the exhaust shaft.

Low-Volume Air Samplers (Ambient)

Three low-volume air samplers are located on or close to the site, as listed below:

1. Approximately 225 meters northwest of the exhaust shaft (S1).
2. Approximately 500 meters northeast of the exhaust shaft (S2).
3. Approximately 1000 meters northwest of the exhaust shaft (S3).

Three additional low-volume air samplers are located in Artesia, Carlsbad, and Loving - the three population centers closest to the WIPP site and located on the main WIPP transportation routes.

Groundwater

Seven wells collect groundwater samples from the water-bearing zones of the Dewey Lake Redbed Formation, the Culebra dolomite member of the Rustler Formation, and the Capitan Reef Formation. Their approximate locations appear in Figure E1.

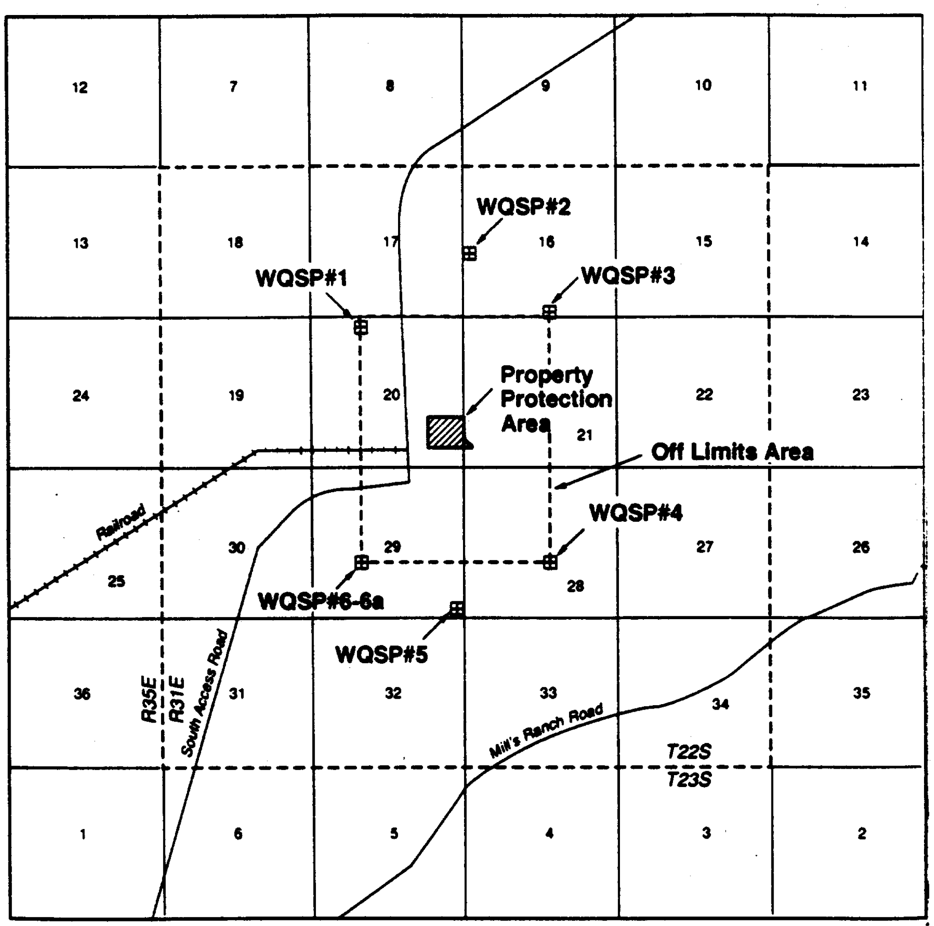

Figure E1. Groundwater Sampling Locations

Surface Water and Drinking Water

Surface water samples are collected at eight locations, shown in Figure E2. Other than Laguna Grande, no surface lake or impoundment (tank) was sampled during 2000. Drinking water samples are collected from the public water supply systems at the WIPP site and the communities of Carlsbad, Loving, and Otis. Otis does not appear in the figure. Otis is a small community on the south edge of Carlsbad.

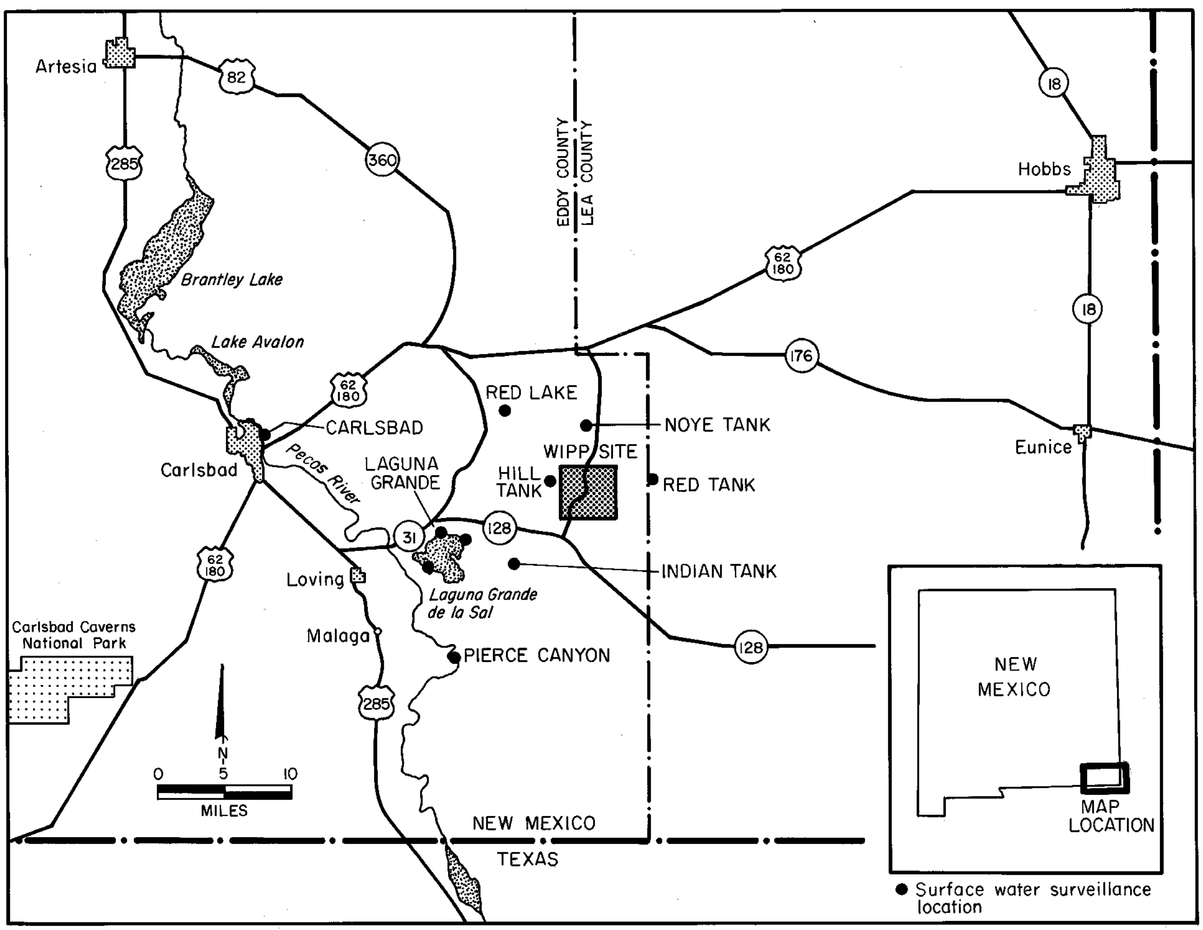

Figure E2. Surface Water Sampling Locations

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LIST OF EEG REPORTS

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