10.0 Onsite ^{238}Pu AND $^{239+240}$Pu IN WATER

For data analysis purposes the sampling locations for plutonium-238 and plutonium-239+240 in water are divided into seven types. These types of water sampling locations are:

- Potable water or supply wells are the wells that supply water for human consumption. These wells may also be used to supply water for industrial and construction purposes. In 1996, ten supply wells were sampled quarterly.

- Industrial wells or non-potable water wells are wells that supply water only for industrial and construction purposes. One industrial well was sampled quarterly, and a second industrial well was sampled the first quarter and then was shut down.

- Potable water end points or water supply distribution points are locations where water is drawn for human consumption. These are typically faucets in buildings such as offices and cafeterias. There were seven end point locations that were sampled quarterly.

- Natural springs are places where ground water comes to the surface. They are used by the fauna of the NTS and sometimes are dry when visited for sampling. Seven natural springs were sampled annually in July.

- Sewage lagoons are the end points for the several sanitary sewage systems operated on the NTS. Water is lost from these lagoons primarily by evaporation. Nine lagoons were sampled quarterly.

- Open reservoirs are man-made water storage ponds. Most are adjacent to wells, but this type also includes the reservoirs that supply the concrete batch plants (Mud Plants) and the Area 23 recreational swimming pool, which is now empty. In 1996, there were nine open reservoirs with water that were sampled once a year, in July.

- Containment ponds are used to contain the effluents from the tunnels. The water in these typically has elevated levels of tritium. Loss of water is primarily by evaporation. These locations are sampled quarterly. Only the E Tunnel effluent and containment ponds contained water in 1996. The effluent is grouped with the ponds.

The names of the sampling locations in each of these type classifications is given in the attachments to this chapter. (Figures, tables, and attachments are located at the end of the chapters.) For a few of the potable water sampling locations, samples may be collected from adjacent locations when the primary location is unavailable. For example, when it was time to sample Building 101 in Area 1 for the third quarter sample the building was locked. The sampler took the sample from an adjacent building, the Area 1 Ice House. A similar situation occurred in Area 12 where Building 12-23, the Medical Aid Station, and the Area 12 Ice House are adjacent buildings. It is known that adjacent buildings are on the same water supply system and are connected to the system in close proximity.

Sampling locations, sample collection dates, measured concentrations, analytic standard deviations, and analytic minimum detectable concentrations (MDCs) for ^{238}Pu appear in Attachment 10.1, and for $^{239+240}$Pu these data appear in Attachment 10.2. Refer to Figure 9.1, in the previous chapter, for a map of the Nevada Test Site (NTS) water sampling locations. Descriptive statistics for sampling locations with quarterly sampling appear in Table 10.1 for ^{238}Pu and Table 10.2 for $^{239+240}$Pu. The annual averages for locations sampled once a year are identical to the single sample results in the attachments.

PLUTONIUM-238

^{238}Pu concentrations in water were measured quarterly at 29 locations and annually at an additional 16 locations. An examination of the data, displayed in Attachment 10.1, reveals that all concentrations are below the corresponding MDC except for the seven containment pond results and the first quarter data from the Area 23 Sewage Lagoon. The median MDC is 1.92×10^{-10} µCi/mL. Plutonium in the E Tunnel effluent is known to result from the several nuclear experiments that were preformed within that tunnel. Water that seeps into the tunnel picks up contamination within the tunnel then exits the tunnel as the effluent and is collected in the containment ponds. The concentrations measured from the containment ponds in 1996 are consistent with historical levels at those locations. The reason for the one high value in the Area 23 Sewage Lagoon has been investigated and will be discussed below.

Excluding the eight values that are above detection limits, 71 percent of the values are less than zero, and all but one value are within one standard deviation of zero. This situation indicates that the measurements represent only randomness in the analytical procedures, and no plutonium was actually found in the samples. Thus no further statistical analyses were performed.

PLUTONIUM-239+240

$^{239+240}$Pu concentrations in water were measured using the same samples used for ^{238}Pu; thus, the same sampling pattern applies. The results were also similar. Results for the seven containment pond samples and the Area 23 sewage lagoon, for the first quarter, were above MDC. In addition, the annual sample from Reitman Seep was above MDC. The median MDC is 2.02×10^{-11} µCi/mL. $^{239+240}$Pu levels in the containment ponds are known to be elevated for the same reason ^{238}Pu levels are elevated. The Area 23 sewage lagoon sample will be discussed in the next section. Reitman Seep has historically shown elevated levels. Water samples from this seep are typically turbid; thus, the analytical results represent concentrations in sediments. Sixty-eight percent of the reported values were less than zero, and, excluding the nine values above MDC, 80 percent of the results are within one standard deviation of zero. As for ^{238}Pu, no further statistical analyses of the $^{239+240}$Pu results were performed.

AREA 23 SEWAGE LAGOON

The first quarter sample from the Area 23 sewage lagoon contained detectable levels of both ^{238}Pu and $^{239+240}$Pu. This sampling location did not contain detectable levels of these isotopes in water in the other three quarters of the year and historically plutonium concentrations have been below detection limits at this location. This incident was investigated and attributed to the accumulation of old fallout (from atmospheric test in the 1950s and 1960s) in sewer line sediments. These lines were flushed with water shortly before the first quarter sample was collected. Sediment samples collected after this finding was noted to also contained detectable levels of these isotopes. The radiochemistry laboratory that uses this sewer system was eliminated as a source, since the ratio of $^{239+240}$Pu to ^{238}Pu in the sediments was 50, while the ratio in the laboratory standard is 3,000. The ratio in environmental air and soil samples ranges from 50 to 100, when quantitative levels are present.

HISTORICAL TRENDS

Annual averages for the plutonium isotopes in water have been reported since 1989. Detailed reporting of historical data from all water sampling locations would result in an unwieldy document. Instead, two representative locations were chosen from each of the following types of water sampling locations: supply wells, potable water, open reservoirs, natural springs, and sewage lagoons. In addition, the E Tunnel effluent was added to the list in order to show the trend at a location with an inventory of plutonium. The chosen locations were further restricted to be locations with data available for all years, since plutonium concentrations were first included in annual reports and to be geographically disperse within the NTS. The chosen locations are identified in Tables 10.3 and 10.4, which contain the historical annual averages.

Most of the annual averages in these tables are below detection limits, but there are a few notable exceptions. Over the years the median detection limit for both plutonium isotopes has been approximately 20×10^{-12} µCi/mL. In the introduction to this volume, it was noted that prior to 1996 the sensitivity of water analyses were reported as detection limits, and in 1996, this was changed to reporting minimum detectable concentrations. Thus it is appropriate to use detection limits when discussing historical plutonium concentrations in water. The mathematical definition of these sensitivity measures is given in the Executive Summary.

The E Tunnel effluents have had high plutonium levels of both isotopes for all the tabled years. These levels are from known sources, as discussed above. Note that, for both isotopes, the concentrations show a declining trend over time and the 1989 concentrations are over seven times the 1996 concentrations.

^{238}Pu was slightly above detection limits at Cane Spring in 1989 and 1990, and Tippipah Spring was slightly above the detection limit in 1991. $^{239+240}$Pu was above detection limits at Tippipah Spring in 1991. The annual reports for these years do not comment on these observations. There were severe drought conditions at the NTS during these years, resulting in a lack of growth of annual plants and a loss of the integrity of the soil surface. This results in dusty conditions which increase the sediment collected by ponds. The natural springs also tend to dry up during drought years, making collection of sediment free samples difficult. Sediments in water samples on the NTS are a known reason for measurable levels of plutonium.

The Area 23 sewage lagoon contained above MDCs of both plutonium isotopes in 1996, and slightly above detection limit levels of $^{239+240}$Pu in 1989. The 1996 observations are discussed in the previous section. The 1989 annual report did not comment on the finding for that year.

CONCLUSIONS

With a few exceptions, all of the 1996 plutonium in water results were below MDCs. The exceptions are the E Tunnel effluents for all quarters of the year and the first quarter sample from the Area 23 Sewage Lagoon. The Tunnel effluents are from a known and well documented source and are in radiologically controlled locations. The sewage lagoon finding was investigated and found to, most likely, be due to sewer system maintenance, which flushed plutonium containing sediments into the lagoon shortly before the sample was collected.

Table 10.1 Descriptive Statistics for ^{238}Pu in Water by Sampling Location ($\mu Ci/mL \times 10^{-12}$) - 1996

Station Name	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
WELLS						
Well 5B	4	-0.82	-0.87	1.36	-2.12	0.60
Well 5C	4	-2.81	-2.28	3.04	-6.98	0.32
Well No. 4A	4	-0.79	-0.75	1.33	-2.18	0.53
Well No. 4	4	-4.31	-3.10	3.21	-8.95	-2.09
Well C-1	4	1.50	3.00	5.54	-6.43	6.43
Well UE-16D	4	-2.57	-1.86	2.92	-6.69	0.16
Well HTH No. 8	4	-3.02	-2.35	1.65	-5.47	-1.90
Army Well No. 1	4	-2.71	-2.13	1.23	-4.54	-2.02
Well J-12	4	-3.52	-2.16	2.87	-7.82	-1.92
Well J-13	4	-2.85	-2.32	2.98	-6.95	0.20
Well UE-5C	4	-1.94	-1.01	4.84	-8.53	2.79
POTABLE WATER						
Building 101	4	-2.65	-0.80	4.78	-9.62	0.61
Area 2, Restroom	4	-1.43	-0.96	2.31	-4.30	0.51
Area 6, Cafeteria	4	-1.51	-2.34	3.12	-4.31	2.95
Building 6-900	4	-1.99	-2.11	2.05	-4.38	0.63
Building 12-23	3	-1.25	0.35	4.98	-6.83	2.74
Mercury Cafeteria	4	-3.80	-1.70	5.61	-12.10	0.29
Building 4221	4	-0.32	-0.72	2.21	-2.28	2.44
CONTAINMENT PONDS						
E Tunnel Effluent	4	355.75	344.50	112.61	233.00	501.00
E Tunnel Pond No. 1	2	326.00	326.00	175.36	202.00	450.00
SEWAGE LAGOONS						
RWMS Sewage Pond	4	-4.31	-2.25	4.19	-10.60	-2.16
Yucca Sewage Pond	4	-2.01	-2.05	1.80	-4.08	0.15
DAF Sewage Pond	4	-0.75	-0.61	1.40	-2.42	0.65
LANL Sewage Pond	4	-2.38	-2.46	4.32	-7.50	2.92
Area 12, Sewage Pond	4	-2.19	-1.95	2.23	-5.12	0.25
Area 22, Sewage Pond	4	-2.32	-0.69	4.17	-8.40	0.52
Area 23, Sewage Pond	4	13.94	-2.17	32.78	-3.02	63.10
Reactor Control Sewage	2	-2.37	-2.37	0.95	-3.04	-1.70
Central Supply Sewage	4	-2.75	-4.08	5.10	-7.03	4.18

Table 10.2 Descriptive Statistics for $^{239+240}Pu$ in Water by Sampling Location (µCi/mL × 10^{-12}) - 1996

Station Name	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
WELLS						
Well 5B	4	-1.77	-2.26	1.29	-2.70	0.14
Well 5C	4	-2.44	-1.61	3.13	-6.71	0.16
Well No. 4A	4	1.73	-0.05	3.75	-0.34	7.34
Well No. 4	4	-2.89	-2.70	1.99	-5.49	-0.66
Well C-1	4	-2.70	-2.50	0.94	-3.94	-1.67
Well UE-16d	4	-3.41	-2.60	2.02	-6.42	-2.02
Well HTH No. 8	4	-3.53	-2.96	3.29	-8.04	-0.16
Army Well No. 1	4	-2.55	-2.68	3.48	-6.67	1.83
Well J-12	4	-2.62	-1.56	3.52	-7.51	0.14
Well J-13	4	-1.13	-0.09	3.87	-6.67	2.32
Well UE-5c	4	-2.68	-2.52	4.38	-8.19	2.52
POTABLE WATER						
Building 101	4	-2.78	-2.22	4.78	-9.14	2.45
Area 2, Restroom	4	-3.53	-3.09	1.92	-6.22	-1.70
Area 6, Cafeteria	4	-2.39	-2.61	1.54	-3.98	-0.38
Building 6-900	4	-1.72	-1.48	1.99	-4.04	0.15
Building 12-23	3	-3.84	-3.07	2.36	-6.48	-1.96
Mercury Cafeteria	4	-4.08	-2.25	5.04	-11.50	-0.32
Building 4221	4	0.98	1.04	1.24	-0.30	2.16
CONTAINMENT PONDS						
E Tunnel Effluent	4	2840.00	2835.00	710.35	2060.00	3630.00
E Tunnel Pond No. 1	2	2530.00	2530.00	1301.08	1610.00	3450.00
SEWAGE LAGOONS						
RWMS Sewage Pond	4	-2.76	-1.51	3.91	-8.25	0.25
Yucca Sewage Pond	4	4.33	5.36	5.82	-3.51	10.10
DAF Sewage Pond	4	-2.21	-2.67	1.26	-3.12	-0.40
LANL Sewage Pond	4	-0.66	-1.18	5.90	-7.20	6.91
Area 12, Sewage Pond	4	-2.61	-1.59	3.52	-7.52	0.27
Area 22, Sewage Pond	4	-4.12	-2.98	2.65	-8.07	-2.43
Area 23, Sewage Pond	4	819.90	0.06	1640.06	-0.51	3280.00
Reactor Control Sewage	2	0.62	0.62	4.96	-2.88	4.13
Central Supply Sewage	4	-1.84	-3.63	5.02	-5.72	3.83

Table 10.3 Historical ^{238}Pu in Water Annual Averages at Selected Locations ($\mu Ci/mL \times 10^{-12}$) - 1996

Location	1989	1990	1991	1992	1993	1994	1995	1996
Area 18, Well HTH No. 8	7.3	31.0	2.2	-12.0	4.8	-2.1	-1.7	-3.0
Area 25, Well J-13	-26.0	12.0	0.7	-5.0	-6.9	-0.7	-0.4	-2.9
Area 2, Restroom	12.0	21.0	-5.5	-13.0	0.8	1.3	4.6	-1.4
Area 23, Mercury Cafeteria	-8.9	12.0	18.6	5.0	0.0	1.3	1.5	-3.8
Area 5, Well 5B Reservoir	5.4	11.3	6.3	7.0	2.2	2.4	-2.0	-2.4
Area 18, Camp 17 Reservoir	6.3	-36.4	9.0	5.7	0.7	-0.6	2.4	-2.0
Area 5, Cane Spring	32.7	25.5	10.7	10.6	2.3	2.3	-1.5	-2.6
Area 16, Tippipah Spring	11.9	7.0	23.9	-18.5	0.8	8.0	1.8	-2.5
Area 12, Sewage Lagoon	2.7	26.7	-4.8	-9.2	1.8	-1.7	-1.3	-2.2
Area 23, Sewage Lagoon	26.0	-14.5	1.3	-11.4	0.0	-1.3	1.3	13.9
Area 12, E Tunnel Eff.	2625.0	1616.7	732.5	660.0	450.0	687.3	323.0	355.8

Table 10.4 Historical $^{239+240}Pu$ in Water Annual Averages at Selected Locations ($\mu Ci/mL \times 10^{-12}$) - 1996

Location	1989	1990	1991	1992	1993	1994	1995	1996
Area 18, Well HTH No. 8	1.6	-3.0	0.6	7.2	-8.2	2.5	-1.1	-3.5
Area 25, Well J-13	-0.3	7.8	2.6	13.2	-6.9	2.1	-1.6	-1.1
Area 2, Restroom	-2.4	2.7	0.5	0.1	2.3	2.2	0.0	-3.5
Area 23, Mercury Cafeteria	3.2	0.5	2.9	0.1	2.1	0.6	-0.1	-4.1
Area 5, Well 5B Reservoir	1.8	-5.4	1.0	11.3	7.4	1.7	-2.0	0.0
Area 18, Camp 17 Reservoir	8.0	3.4	8.0	4.0	5.7	5.0	2.4	-0.3
Area 5, Cane Spring	-5.5	0.0	12.4	-3.1	8.9	3.2	0.7	0.0
Area 16, Tippipah Spring	0.3	7.8	66.0	-1.0	9.2	6.6	24.1	-2.7
Area 12, Sewage Lagoon	11.8	0.5	12.9	-2.0	4.3	2.2	-0.9	-2.6
Area 23, Sewage Lagoon	6.9	3.5	16.1	1.8	7.1	9.0	5.0	819.9
Area 12, E Tunnel Eff.	21250.0	9223.0	9500.0	6275.0	4333.0	5343.0	5208.0	2840.0