Table 4-69. Detections of Pu-238, Pu-239/240, and the Pu-238:Pu-239/240 activity ratios for deep lysimeter or perched water well samples.

Lysimeter or Well	Pu-238 (pCi/L)	Pu-239/240	Pu-238: Pu-239/240 Activity Ratio	Probable Waste-Generating Process Source	Sample Type	Sample Depth (ft)	Date
O6D-DL26	Analyzed for but not detected (ND)	2.7 pCi/L[a]	Not applicable (NA)	Weapons	Soil moisture	220	June 2000
USGS-92	0.39[b]	ND	NA	Reactors[b]	Perched water	214	November 1994
USGS-92	ND	0.32 pCi/g	NA	Weapons[a]	Filtered sediment	214	February 1998
USGS-92	4.8	ND	**NA**	Reactors[b]	Perched water	214	December 2000

a. Positive Pu-239/240 detections, without detections of Pu-238, are indicative of weapons manufacturing waste or fallout. The Pu-239/240 activity in weapons manufacturing waste is approximately 40 times higher than the Pu-238 activity. Therefore, the Pu-238:Pu-239/240 ratio for weapons manufacturing waste is 0.02 to 0.03, whereas the Pu-238:Pu-239/240 ratio for fallout is approximately 0.03 to 0.06.

b. Positive Pu-238 detections without detections of Pu-239/240 are indicative of high burnup reactor fuel and fuel processing waste. The Pu-238 activity in high burnup reactor fuel and fuel processing waste is approximately 11 times higher than the Pu-239/240 activity. Therefore, the Pu-238:Pu-239/240 ratio for fuel is approximately 11. In many cases presented in the table above, the concentration of expected Pu-239/240 would be too low to detect.

4.6.13.5.4 Summary of Plutonium in Deep Lysimeter and Perched Water ***Samples—*** Plutonium occurs sporadically in samples collected from the deep lysimeters and perched water wells. When detected, the Pu-238 or Pu-239/240 in Well USGS-92 occurred in either the sediment or the water sample, but never occurred in both media from the same sampling event. The detections in perched Well USGS-92 are most likely because of sample contamination or random error equivalent to that seen in true background locations. The positive detection in the liquid sample was not confirmed by reanalysis and it is unlikely that Pu-238 would be detected in the liquid but not the solid form. The plutonium detections and ratios associated with the deep lysimeter and perched water sample analyses are indicative of both weapons manufacturing waste and reactor operations.

4.6.13.6 Aquifer

4.6.13.6.1 Plutonium-238 in Aquifer ***Samples—*** Of the total 264 RWMC aquifer well samples analyzed by INEEL for Pu-238 between 1992 and April 2001, 10 were positive detections (see Table 4-70). The occurrences of the detections from both the INEEL and USGS wells monitored between 1992 and 2001 are shown in Figure 4-32.

Only the October 2000 Pu-238 results for aquifer Wells M7S and M11S had supporting reanalysis confirmation of the original sample. Subsequent samples collected from the seven wells (through April 2001) have not contained detectable Pu-238 with the exception of a Pu-238 detection in aquifer Well M6S from the January 2001 sample collection period,

In addition to the detections shown in Table 4-70, eight results were identified from the September 2000 INEEL sampling campaign that had been reported as positive detections, but were reevaluated and classified as false positive because Pu-238 also was detected in the corresponding field blank at a concentration equivalent to the sample results. The September 2000 data were revalidated and

the revised limitations and validations report was issued to DOE-ID on January 31, 2002 (see footnote a, p. 4-52).

Table 4-70. Detected concentrations of Pu-238 from aquifer monitoring around the Radioactive Waste Management Complex.

Aquifer Well	Concentration ± 1σ (pCi/L)	Confirmation Flag[a]	Date
M1S	0.019 ± 0.006	B	October 2000
M3S	0.37 ± 0.07	**B**	September 2000
M4D	0.028 ± 0.008	B	October 2000
M6S	0.044 ± 0.010	B	April 1999
	0.17 ± 0.03	B	January 2001
M7S	0.071 ± 0.013	D	October 2000
	0.047 ± 0.010	D	October 2000
M10S	0.018 ± 0.006	A	October 2000
M11S	0.026 ± 0.007	D	October 2000
	0.030 ± 0.007	D	October 2000

a. Confirmation flag:
A = No second sample collected, no reanalysis performed.
B = Reanalysis performed, no confirmation.
D = Detection confirmed by reanalysis.
Note: Highlighted values indicate that the sample was reanalyzed and the reanalysis confirmed the presence of **Pu-238.**

Seven of the 10 Pu-238 detections in Table 4-70 occurred in October 2000. The large number of positive Pu-238 detections from the October 2000 sampling event is unusual. These positive, low-level Pu-238 detections were highly scrutinized by INEEL and the **USGS** scientists and no analytical anomalies were found that would discredit the results. However, there are several reasons why the October 2000 results from the INEEL are still questionable. These are listed below:

- Samples from Wells M1S and M3S are routinely cosampled by the INEEL, the **USGS,** and state oversight program. The radioanalytical results are used for comparative purposes to help confirm the presence or absence of measured radionuclides. The samples collected by the state oversight program in October 2000 show one detection from Well M1S and one nondetection from Well M3S (see Table 4-71). None of the **USGS** samples between 1993 and April 2001 showed positive detections for Pu-238, including the sample from October 2000 (see Table 4-72). The comparative results provide conflicting evidence about the presence of Pu-238 in samples collected from Wells M1S and M3S.

- Other actinides (e.g., Pu-239/240 and Am-241) were not detected with the Pu-238, which is unusual for contamination emanating from waste generated by weapons manufacturing.

- Because of the inconsistent results, the potential for cross-contamination at the analytical laboratory was examined. No issues were identified; however, additional quality control samples were specified for subsequent sampling efforts to increase confidence in the analytical results for low-level detections at concentrations very close to the method detection limit.

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	A11A31	OW-2
1992	1																							
	2																							
	3																							
	4																							
1993	1																							
	2																							
	3																							
	4																							
1994	1																							
	2																							
	3																							
	4																							
1995	1																							
	2																							
	3																							
	4																							
1996	1																							
	2																							
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	4																							
1997	1																							
	2																							
	3																							
	4																							
1998	1																							
	2																							
	3																							
	4																							
1999	1																							
	2												0.044											
	3																							
	4																							
2000	1																							
	2																							
	3										0.37													
	4									0.019		0.028		0.071	0.018	0.030								
2001	1												0.17											
	2																							
	3																							
	4																							

Key	
	Analysis was performed for Pu-238, but none was detected.
	Pu-238 was detected (pCi/L).
	If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.

Figure 4-32. Occurrence of plutonium-238 in aquifer samples collected by the Idaho National Engineering and Environmental Laboratory and U.S. Geological Survey from 1992 through 2001.

Table 4-71. Plutonium-238 detections in cosampled Wells M1S and M3S during September and October 2000.

	September 2000		October 2000	
Sampler	M1S	M3S	M1S	M3S
Idaho National Engineering and Environmental Laboratory	Analyzed for but not detected (ND)	Detected	Detected	ND
U.S. Geological Survey	Not sampled (NS)	NS	ND	NS
State oversight	ND	ND	Detect	ND

Table 4-72. Plutonium-238 detections from U.S. Geological Survey aquifer monitoring around the Radioactive Waste Management Complex.

Aquifer Well	Concentration ± 1σ (pCi/L)	Date
USGS-87	0.040 ± 0.009[a]	April 1973
	0.029 ± 0.008[a]	May 1973
	0.080 ± 0.006[a]	November 1973
USGS-88	0.028 ± 0.007'	April 1973
	0.27 ± 0.03'	May 1973
	0.040 ± 0.010.	December 1973
	0.033 ± 0.009[a]	April 1974
	0.81 ± 0.08	April 1983
USGS-89	0.040 ± 0.010.	September 1973
	0.021 ± 0.006[a]	November 1973
	0.040 ± 0.010"	April 1974
	0.040 ± 0.010[a]	May 1974
USGS-90	0.96 ± 0.09[a]	February 1972
	9.00 ± 0.03'	September 1972
	0.13 ± 0.02[a]	July 1973
	0.035 ± 0.009[a]	February 1974

a. The 1972 to 1974 data must be used with discretion. They are questionable because of cross-contamination concerns (see Section 4.5.5).
Note: Values in red bold indicate that the concentration exceeded the 1E-05 aquifer risk-based concentration for Pu-238 of 3.6 pCi/L.

- A statistical analysis of the data indicated that the cluster of detections was statistically anomalous, and that the detected Pu-238 was most likely from a source other than the aquifer (Leecaster 2002).

Numerous improvements were made to the sampling and analytical protocols to increase confidence in the analytical results for low-level detections at concentrations very close to the method detection limit (see Section 4.5.1). The INEEL sampling, analytical, and data reporting protocols now require an equipment rinsate, a certified sealed quality control blank that is not opened until it arrives at the analytical laboratory, and statistical hypothesis testing of all plutonium and americium data. Also,

because of the cluster of Pu-238 detections, the laboratory created a cleanroom for processing and preparing very low-level samples.

Only the October 2000 Pu-238 results for aquifer Wells M7S and M11S had supporting reanalysis confirmation of the original sample. Subsequent samples collected from the seven wells in Table 4-72 (through April 2001) have not contained detectable Pu-238 from the January 2001 sample collection period, with the exception of a Pu-238 detection in aquifer Well M6S (see Figure 4-32).

In addition to the aquifer monitoring routinely conducted by the INEEL, the **USGS** manages, controls, and routinely samples eight other aquifer wells in the vicinity of the RWMC. These eight wells have been monitored by the **USGS** for Pu-238 since 1972. A total of 489 **USGS** aquifer well samples in the vicinity of the RWMC were analyzed for Pu-238 between 1972 and October 2000. There were 16 detections (3.3%), with 15 of them occurring between 1972 and 1974, shortly after the wells were drilled and installed (see Table 4-72). The 1972 to 1974 detections are known to be suspect and questionable because of cross-contamination problems (Barraclough et al. 1976). Samples collected by the **USGS** between 1975 and 2000 have shown only one detectable Pu-238 concentration. The detection occurred in a sample collected from Well **USGS-88** in April 1983. The relatively high concentration was not confirmed by reanalysis and no detections have occurred in the 51 subsequent sampling events from April 1983 through October 2000. The concentrations of detectable Pu-238 are below the MCL for total alpha-emitting radionuclides (i.e., 15 pCi/L). The 1972 through 1991 **USGS** Pu-238 occurrences are shown in Figure 4-33.

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120
1972	1				0.96				
	2								
	3				9.00				
	4								
1973	1								
	2	0.040	0.27						
	3			0.040	0.13				
	4	0.080	0.040	0.021					
1974	1				0.035				
	2		0.033	0.040					
	3								
	4								
1975	1								
	2								
	3								
	4								
1976	1								
	2								
	3								
	4								
1977	1								
	2								
	3								
	4								
1978	1								
	2								
	3								
	4								
1979	1								
	2								
	3								
	4								
1980	1								
	2								
	3								
	4								
1981	1								
	2								
	3								
	4								
1982	1								
	2								
	3								
	4								
1983	1								
	2		0.81						
	3								
	4								
1984	1								
	2								
	3								
	4								
1985	1								
	2								
	3								
	4								
1986	1								
	2								
	3								
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1987	1								
	2								
	3								
	4								
1988	1								
	2								
	3								
	4								
1989	1								
	2								
	3								
	4								
1990	1								
	2								
	3								
	4								
1991	1								
	2								
	3								
	4								

Key		
		Analysis was conducted for Pu-238, but none was detected.
		Pu-238 was detected (pCi/L).
		If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.

Figure. 633. Occurrences of plutonium-238 in aquifer samples collected by the U.S. Geological Survey from 1972 through 1991.

4.6.13.6.2 ***Plutonium-239/240 in Aquifer*** Samples — A total of **264** RWMC aquifer well samples were analyzed by the INEEL for **Pu-239/240** between **1992** and April **2001,** with three positive detections *(see* Table **4-73).**

Table **4-73.** Plutonium-239/240 detections in wells monitored by the Idaho National Engineering and Environmental Laboratory.

Aquifer Well	Concentration ± 1a (pCi/L)	Confirmation Flag[a]	Date
M3S	**0.09 ± 0.02**	B	September 2000
M4D	1.3 ± 0.3	A	May **1993**
	4.3 ± 0.5	A	November **1993**

a. Confirmation flag:
A = No second sample collected, no reanalysis performed.
B = Reanalysis performed, no confirmation.
Note: Values in **red bold** indicate that the concentration exceeds the 1E-05 aquifer risk-based concentration of 3.5 pCi/L for Pu-239/240.

The sample from Well **M3S** (with the positive result) was reanalyzed and the reanalysis failed to confirm that the contaminant was present. The samples from Well **M4D** (with positive detections) were not reanalyzed. Subsequent samples collected from the two wells (through April **2001)** have not contained detectable **Pu-239/240.** The occurrence of the detections relative to other samples collected by the INEEL between **1992** and **2001** is shown in Figure **4-34.**

Samples from the INEEL aquifer Wells **M1S, M3S,** and **M7S** are routinely split with the USGS and the radioanalytical results are used for comparative purposes to help confirm detections and nondetections. None of the samples split with the USGS between **1993** and April **2001** showed positive detections for **Pu-239/240.**

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120	M1S	M3S	M4D	M6S	M7S	M10S	M11S	M12S	M13S	M14S	M15S	M16S	M17S	A11A31	OW-2
1992	1																							
	2																							
	3																							
	4																							
1993	1																							
	2											4.3												
	3																							
	4											1.3												
1994	1																							
	2																							
	3																							
	4																							
1995	1																							
	2																							
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	4																							
1996	1																							
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1997	1																							
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1998	1																							
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	4																							
1999	1																							
	2																							
	3																							
	4																							
2000	1																							
	2																							
	3											0.09												
	4																							
2001	1																							
	2																							
	3																							
	4																							

Key	
	Analysis was conducted for Pu-239/240, but none was detected.
	Pu-239/240 was detected (pCi/L).
If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.	

Figure 4-34. Occurrence of detectable Pu-239/240 in aquifer samples collected by the Idaho National Engineering and Environmental Laboratory and U.S. Geological Survey from 1992 through 2001.

Besides the 15 RWMC monitoring wells routinely sampled by the INEEL, the USGS manages, controls, and routinely samples eight other wells in the vicinity of the RWMC. These eight wells have been monitored by the USGS for Pu-239/240 since 1972. Out of 485 analyses, six detections of Pu-239/240 were identified (see Table 4-74).

Table 4-74. Plutonium-239/240 detections in U.S. Geological Survey monitoring wells.

Aquifer Well	Concentration ± 1σ (pCi/L)	Date
USGS-87	0.030 ± 0.004"	November 1973
	0.030 ± 0.008"	April 1974
USGS-88	0.040 ± 0.009"	April 1974
	0.040 ± 0.010	October 1976
USGS-89	0.29 ± 0.02[a]	May 1973
	0.036 ± 0.008[a]	May 1974

a. The 1972 to 1974 data must be used with discretion. They are questionable because of cross-contamination concerns (see Section 4.5.5).

Five of the six detections occurred between 1972 and 1974, shortly after the wells were drilled and installed. The 1972 to 1974 detections are known to be suspect because of cross-contamination problems (Barraclough et al. 1976). Only one subsequent sample collected from the USGS wells (from 1975 through 2000) has contained detectable Pu-239/240. The occurrences of all the positive Pu-239/240 detections in the USGS wells between 1972 and 1991 are shown in Figure 4-35.

The concentrations of detectable Pu-239/240 are below the aquifer 1E-05 RBC of 3.5 pCi/L.

Low-level TIMS analyses of aquifer samples do not confirm the presence of Pu-239 in the aquifer (see Section 4.6.14)

4.6.13.6.3 Plutonium Ratios in Aquifer Samples — The activity ratios for the aquifer samples with detectable plutonium are shown in Table 4-75. Plutonium-238 has been detected in aquifer samples using radiochemical analysis, without detecting Pu-239 (e.g., several wells in the October 2000 sampling and Well USGS-88 in April 1983). Such occurrences are suggestive of reactor-related waste because reactor waste contains more Pu-238 activity than Pu-239/240 activity.

Some of the 1970s plutonium data from the aquifer samples are questionable because of cross-contamination concerns. Excluding the 1970s data 15 plutonium detections remain (i.e., 11 Pu-238 and four Pu-239/240) out of 29 analyses (see Table 4-75). Of those 15 detections, eight are associated with the September and October 2000 sampling events. The September and October plutonium data are highly questionable because (a) such a cluster of detections is highly irregular, (b) no plutonium detections have been identified in subsequent sampling events, (c) the field blank for the September 2000 samples contained a positive detection of Pu-238, (d) the results were not corroborated by samples collected in the same time frame by the oversight committee or USGS, and (e) the two sample sets did not contain a sealed quality control blank sample to assess potential laboratory-introduced contamination (see Section 4.6.1.3).

Year	Quarter	USGS-87	USGS-88	USGS-89	USGS-90	RWMC Prod	USGS-117	USGS-119	USGS-120
1972	1								
	2								
	3								
	4								
1973	1								
	2			0.29					
	3								
	4	0.030							
1974	1								
	2	0.030	0.040	0.036					
	3								
	4								
1975	1								
	2								
	3								
	4								
1976	1								
	2								
	3								
	4		0.040						
1977	1								
	2								
	3								
	4								
1978	1								
	2								
	3								
	4								
1979	1								
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1989	1								
	2								
	3								
	4								
1990	1								
	2								
	3								
	4								
1991	1								
	2								
	3								
	4								

Key	
	Analysis was performed for Pu-239/240, but none was detected.
	Pu-239/240 was detected (pCi/L).
	If more than one detection occurred in a well in a single quarter, only the highest concentration is listed.

Figure 4-35. Occurrence of Pu-239/240 in wells monitored by the U.S. Geological Survey from 1972 through 1991.

Table 4-75. Plutonium detections and Pu-238:Pu-239/240 activity ratios for aquifer samples.

Aquifer Well	Pu-238 pCi/L	Pu-239/240 pCi/L	Pu-238: Pu-239/240 Activity Ratio	Probable Waste-Generating Process[a,b]	Sample Depth Screened Interval (ft)	Date
M1S	0.019	Analyzed for but not detected (ND)	Not applicable (NA)	Reactors[b]	608 to 638	Oct 2000
M3S	0.37	0.09	4.1	Indeterminate	603 to 633	Sept 2000
M4D	0.0276	ND	NA	Reactors[b]	798 to 828	Oct 2000
M4D	ND	1.3	NA	Weapons[a]	798 to 828	May 1993
M4D	ND	4.3	NA	Weapons[a]	798 to 828	Nov 1993
M6S	0.044	ND	NA	Reactors[b]	642 to 668	April 1999
M6S	0.17	ND	NA	Reactors[b]	642 to 668	Jan 2001
M7S	0.071	ND	NA	Reactors[b]	598 to 628	Oct 2000
M7S	0.047	ND	NA	Reactors[b]	598 to 628	Oct 2000
MlOS	0.018	ND	NA	Reactors[b]	617 to 647	Oct 2000
M11S	0.026	ND	NA	Reactors[b]	559 to 569, 604 to 624	Oct 2000
M11S	0.030	ND	NA	Reactors[b]	559 to 569, 604 to 624	Oct 2000
USGS-87	0.040[c]	ND	NA	Reactors[b]	585 to 673	April 1973
USGS-87	0.029[c]	ND	NA	Reactors[b]	585 to 673	May 1973
USGS-87	0.080[c]	ND	NA	Reactors[b]	585 to 673	Nov 1973
USGS-88	0.028[c]	ND	NA	Reactors[b]	584 to 635	April 1973
USGS-88	0.27[c]	ND	NA	Reactors[b]	584 to 635	May 1973
USGS-88	0.040[c]	ND	NA	Reactors[b]	584 to 635	Dec 1973
USGS-88	0.033[c]	ND	NA	Reactors[b]	584 to 635	April 1974
USGS-88	ND	0.04	NA	Weapons[a]	584 to 635	Oct 1976
USGS-88	0.8I	ND	NA	Reactors[b]	584 to 635	April 1983
USGS-89	0.040'	ND	NA	Reactors[b]	576 to 646	Sept 1973
USGS-89	0.021[c]	ND	NA	Reactors[b]	576 to 646	Nov 1973
USGS-89	0.040[c]	ND	NA	Reactors[b]	576 to 646	April 1974
USGS-89	0.040[c]	ND	NA	Reactors[b]	576 to 646	May 1974
USGS-90	0.96[c]	ND	NA	Reactors[b]	577 to 626	Feb 1972
USGS-90	9.00[c]	ND	NA	Reactors[b]	577 to 626	Sept 1972

Table 4-75. (continued).

Aquifer Well	Pu-238 pCi/L	Pu-239/240 pCi/L	Pu-238: Pu-239/240 Activity Ratio	Probable Waste-Generating Process[a,b]	Sample Depth Screened Interval (ft)	Date
USGS-90	0.13[c]	ND	NA	Reactors[b]	577 to 626	July 1973
USGS-90	0.035[c]	ND	NA	Reactors[b]	577 to 626	Feb 1974

a. Positive Pu-239/240 detections, without detections of Pu-238 are indicative of weapons (manufacturing waste or fallout). The Pu-239/240 activity in weapons manufacturing waste is approximately 40 times higher than the Pu-238 activity. Therefore, the Pu-238:Pu-239/240 ratio for weapons manufacturing waste is 0.02 to 0.03.

b. Positive Pu-238 detections without detections of Pu-239/240 are indicative of high burnup reactor fuel and fuel processing waste. The Pu-238 activity in high burnup reactor fuel and fuel processing waste is approximately 11 times higher than the Pu-239/240 activity. Therefore, the Pu-238:Pu-239/240 ratio for fuel is approximately 11. In many cases presented in this table, the concentration of expected Pu-239/240 would be too low to detect.

c. The 1972 to 1974 data must be used with discretion. They are questionable because of cross-contamination concerns (see Section 4.5.5).

4.6.13.6.4 Summary of Plutonium *in* Aquifer Samples — Plutonium is detected sporadically in RWMC aquifer samples and has been confirmed via reanalysis in some cases. With 10 detections out of 264 analyses, the detection rate is around 4%. Of the 10 detections, only the October 2000 results from M7S and M11S were confirmed with reanalysis. Both wells with confirmed detections are upgradient of the SDA, with Well M11S a couple of miles away. The recurring detections coupled with occasional confirmation of positive detections suggest that Pu-238 is present in the aquifer, though not as a widespread or continuous plume but rather as randomly occurring particles. Plutonium-238 was detected in all the wells near the SDA except for Well M17S, which is located inside the SDA fence line.

Plutonium-239/240 detections in the aquifer wells are rare, with a detection rate around 1%. Two detections were identified in aquifer Well M4D (821-ft deep) in 1993 but no other detections in the 11 sampling events since the November 1993. A Pu-239/240 detection recently occurred in aquifer Well M3S, which previously had no detectable concentrations.

4.6.14 Plutonium Special Study

Because of the sporadic nature of plutonium detections over the years, it was hypothesized that plutonium may exist in the aquifer beneath the SDA at concentrations just below the detection sensitivity of routine radioanalytical methodology (approximately 0.02 to 0.03 pCi/L). Therefore, some RWMC aquifer samples were analyzed using more sensitive analytical methodology. The Isotope Dilution-Thermal Ionization Mass Spectrometry (ID-TIMS) method with its ultra-low detection capability was intended to: (a) determine if ultra low (background) levels of plutonium are present in the aquifer, (b) and if so, identify the sources of plutonium (e.g., fallout, nuclear weapons manufacturing waste, reactor waste) using Pu-239/240 ratios and, (c) determine if sample results that were previously identified as statistically positive (greater than 2σ but $> 3\sigma$) actually contained low levels of plutonium. The TIMS analysis can achieve detection limits on water samples approximately 10 to 100 times lower than standard radioanalytical methods. The TIMS is capable of attaining detection levels around 0.002 to 0.0002 pCi/L.

Nine shallow lysimeter water samples (i.e., PA01-L15, PA02-L16, PA03-L33, W23-LO8, D06-L01, D06-L02, 98-4L38, 98-5L39, and W25-L28) were collected from the shallow surficial sediments in 1999 and sent for TIMS analysis. The water samples were filtered and both the filtrate and filtered material were analyzed for Pu-239. None of the samples yielded evidence of the presence of Pu-239 above 0.002 pCi/L, with the exception of a statistical anomaly on the PA03 lysimeter well-filter

result (Roback et al. 2000). The statistical irregularity does not prove the presence of Pu-239 on the Well PA03 lysimeter well filter; it only suggests the possibility that Pu-239 may be present.

Four intermediate-depth lysimeter samples were collected from the B and C basalt flows and B-C interbed (D06-DL01, D06-DL02, TW1-DL04, and D15-DL06) in 1999 and sent for TIMS analyses. The water samples were filtered and both the filtrate and filtered material were analyzed for Pu-239. The results from filter sample lysimeter well TW 1-DL04 has statistically higher Pu-239 concentrations than the other lysimeter well samples, which suggests the possibility that Pu-239 may be present in the sample (Roback et al. 2000).

Two water samples collected from perched Wells USGS-92 and 8802D in 1999 (deep vadose zone) were sent for TIMS analysis. The water samples were filtered and both the filtrate and filtered material were analyzed for Pu-239. The Pu-239 result from the 8802D filtered fraction was statistically higher than the other samples, which suggests the possibility that Pu-239 may be present in the sample (Roback et al. 2000).

Nine aquifer samples collected in 1999 from RWMC aquifer Wells M1S, M3S, M7S, MlOS, M14S, USGS-87, USGS-117, USGS-119, and USGS-120 and sent for TIMS analysis. The water samples were filtered and both the filtrate and filtered material were analyzed for Pu-239. None of the aquifer samples contained Pu-239 above 0.0002 pCi/L (Roback et al. 2000).

The INEEL plans to continue the TIMS analysis for plutonium (including Pu-238) for selected RWMC aquifer samples. Because the TIMS is capable of identifying plutonium from fallout, it can be used to identify background levels of plutonium in the SRPA below the INEEL.

4.6.15 Summary of Plutonium

Plutonium-238 and Pu-239/240 occur sporadically in the vadose zone and aquifer wells, and there are no obvious trends. Plutonium-238 detection rates for the various media, summarized in Table 4-76, range from 0% in the deep core samples to 7.5% in the intermediate-depth lysimeter samples. There is no apparent correlation between detection rates and media or depth. Figure 4-36 shows the distribution of Pu-238 detections in the various sampling media.

Plutonium-239/240 detection rates range from 0.5% in the aquifer to 13.6% in the intermediate-depth core samples (see Table 4-77). The Pu-239/240 detection rate is highest in the intermediate-depth core samples, however, the result is somewhat misleading because there were so many duplicate analyses of core samples from the 100 to 110-ft depth interval, many of which showed up as detections. Figure 4-37 shows the distribution of Pu-239/240 detections in the various sampling media.

Some of the boreholes associated with the vadose zone core samples were instrumented with lysimeters (i.e., TW1) or bailers (i.e., 8802D, USGS-92) and sampled after the core analysis program was completed. Results from the two programs combined are inconclusive. At TW1, Pu-238 was detected at the 100-ft depth in the core sample, but not detected in the soil moisture sample; Pu-239/240 was detected in both the core and the moisture samples. At the USGS-92 perched water well, no plutonium isotopes were detected in the core samples, but Pu-238 was detected in the filtered perched water and Pu-239/240 was detected in the filtered sediment sample from the bailed perched water.

Results from aquifer monitoring are also inconclusive. There were several plutonium detections in USGS wells from 1972 through 1974, suggesting that Pu-238 and Pu-239/240 may have been widespread at low levels in the aquifer at that time, but those data are highly suspect because of potential cross-contamination concerns. Subsequent sampling results from the USGS from the same wells show no detected concentrations of Pu-239/240 since 1976, and only one sample with detected Pu-238 since 1974. The Pu-238 detection occurred in 1983. There have been no additional plutonium detections in the USGS wells in the 30 sampling events since these low-level detections of the 1970s and 1983. Low-level detections of Pu-238 occurred in INEEL aquifer samples in 2000 and 2001, but there were no Pu-238 detections in the most recent sampling event in any of the INEEL wells.

The last 30 years of monitoring data from the vadose zone and aquifer suggest that plutonium exists not as a widespread or continuous plume in the subsurface of the RWMC, but rather as randomly occurring particles (see Figures 4-36 and 4-37).

Table 4-76. Detection rates for Pu-238 in the sampled media.

Media	Detection Rate (%)	Concentration Range	Number of Detections Higher than the Risk-Based Concentration[a]	Wells Higher than the Risk-Based Concentration
Vadose zone 0 to 35 ft:				
Cores	6.1	0.0149 to 0.26 pCi/g	0	None
Soil moisture	6.7	0.9 to 24 pCi/L	4	PA01, PA02, PA03, 98-5
Vadose zone 35 to 140 ft:				
Cores	7.8	0.0031 to 0.17 pCi/g	0	None
Soil moisture	7.5	3.1 to 11.6 pCi/L	1	D06
Vadose zone greater than 140 ft:				
Cores	3.2	0.0015 to 0.033 pCi/g	0	None
Soil moisture	5.4	0.39 to 4.8 pCi/L	1	USGS-92
Aquifer-Idaho National Engineering and Environmental Laboratory	3.8	0.019 to 0.37 pCi/L	0	
Aquifer-U.S. Geological Survey	3.3	0.03 to 9.00 pCi/L	1	USGS-90

a. For cores, the concentrations are compared to the risk-based concentrations (RBCs) of **29.2** pCi/g. The soil moisture and aquifer results are compared to a 1E-05 aquifer RBC of 3.6 pCi/L. The RBCs do not apply to soil moisture data but are used here as a basis of comparison.