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ACTIVE SITES ENVIRONMENTAL MONITORING PROGRAM FY 1993 ANNUAL REPORT

C. M. Morrissey
T. L. Ashwood
D. S. Hicks
J. D. Marsh

Environmental Sciences Division

Publication No. 4286

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Environmental Sciences Division

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C. M. Morrissey, T. L. Ashwood, D. S. Hicks, and J. D. Marsh

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ABBREVIATIONS AND ACRONYMS

ACD	Analytical Chemistry Division
ASEMP	Active Sites Environmental Monitoring Program
BNI	Bechtel National, Inc.
DO	dissolved oxygen
DOE	U.S. Department of Energy
EASC	Emergency Avoidance Solidification Campaign
ER	Environmental Restoration
ESD	Environmental Sciences Division
FRP	fiberglass-reinforced plastic
FY	fiscal year
HDTF	Hillcut Disposal Test Facility
IT	intratrench
IWMF	Interim Waste Management Facility
LWOG	Liquid Waste Operations Group
LLW	low-level waste
LWSP	Liquid-Waste Solidification Project
NPDES	National Pollutant Discharge Elimination System
ORNL	Oak Ridge National Laboratory
PWT	perched water table
PWTP	Process Waste Treatment Plant
QA	quality assurance
RCRA	Resource Conservation and Recovery Act
RSWOG	radioactive solid waste operations group
SWSA	Solid Waste Storage Area
TMOI	Tumulus I
TMOII	Tumulus II
TOC	total organic carbon
TRU	transuranic
UND	underpad
WOC	White Oak Creek
WMRAD	Waste Management and Remedial Action Division

EXECUTIVE SUMMARY

This report summarizes the activities of the Active Sites Environmental Monitoring Program (ASEMP) from October 1992 through September 1993. The Radioactive Solid Waste Operations Group (RSWOG) of the Waste Management and Remedial Action Division (WMRAD) and the Environmental Sciences Division (ESD) at Oak Ridge National Laboratory (ORNL) established ASEMP in 1989. The purpose of the program is to provide early detection and performance monitoring at active low-level waste (LLW) disposal sites in Solid Waste Storage Area (SWSA) 6 and transuranic (TRU) waste storage sites in SWSA 5 as required by Chapters II and III of U.S. Department of Energy (DOE) Order 5820.2A.

Control of the Tumulus I and II pads and associated monitoring facilities was transferred to the ORNL Environmental Restoration (ER) Program in April 1993. Therefore, ASEMP ceased routine monitoring of tumulus during fiscal year (FY) 1993. Both tumulus pads were covered by temporary covers for the entire period encompassed by this report. These covers prevent water contact with the waste-containing tumulus vaults and with the tumulus pad surfaces. Thus, no monitoring of pad runoff was necessary. However, water continued to drain from both tumulus pads' underpad drainage systems.

A tritium plume in the shallow groundwater in the tumulus area still exists. The tumulus area monitoring wells were sampled twice before they were turned over to ER. Results showed a continued spreading of the plume with increasing concentrations in wells both upgradient and downgradient of the tumulus pads. Significantly elevated tritium activity is also observed in the underpad drainage from both pads, particularly Tumulus II.

ASEMP continues to monitor the Interim Waste Management Facility (IWMF). Loading operations on the second IWMF pad began this year. Monitoring results from the IWMF disposal pads indicate that no LLW is leaching from the storage vaults. Storm water falling on the IWMF pads is sampled by electronically controlled sampling devices. Only 1 of the 47 samples collected had radiological activity that exceeded an action level. This sample only slightly exceeded the action level for gross beta activity. The presence of ^{40}K, probably leached from the concrete, is sufficient to account for the observed gross beta activity. Subsequent samples fell below the action level. Therefore, no further action, other than internal reporting, was required.

In response to pH levels above the National Pollutant Discharge Elimination System (NPDES) permit limit in the IWMF pad runoff water, a CO_2 bubbling system was installed as a "best management practice" to control the pH. This system is electronically controlled in response to flow from the pads at elevated pH. It has proven to be a low-cost, effective means of pH control and has eliminated the necessity and expense of transporting pad runoff to the Process Waste Treatment Plant (PWTP).

Samples were collected from intratrench (IT) wells around LLW silos, from backfill wells next to the asbestos silos, and from backfill wells next to the fissile wells. Samples were also collected from backfill wells in the high-range well area. Dissolved radionuclide concentrations were below action levels for all samples except water from two IT wells. The ^{60}Co concentration in one of these wells appeared to exceed the action level during the second quarterly sampling; however, there was a fairly large associated analytical error. Samples from one of the IT wells have consistently shown elevated gross beta activity, primarily resulting from ^{90}Sr. This activity is probably a result of ^{90}Sr leaching from waste in one or more of the silos in the trench. The silos were grouted in mid-1992 as part of a measure to reduce the potential for release of radionuclides from the LLW silos. Gross beta levels in at least one of the IT wells have declined since grouting. This suggests that the grouting effort was effective in reducing the amount of contaminant release.

Hillcut Disposal Test Facility (HDTF) pad runoff water samples were collected during each transfer to the holding tanks. Runoff from the pad occurs in significant volumes only during winter and spring. Gross radionuclide activities were below action levels, with the exception of one occurrence of gross beta activity. In addition, the ^{60}Co and ^{137}Cs activities in this sample were slightly elevated. However, subsequent samples showed activities below the action level. A total of about 10,000 L of pad runoff was collected in FY 1993.

This report presents the complete record of the analytical results from liquid that has accumulated in the Emergency Avoidance Solidification Campaign/Liquid-Waste Solidification Project (EASC/LWSP) storage casks. Only 29 of the 119 casks have ever contained sufficient water to sample, and the data are extremely variable and difficult to interpret. However, it is apparent that many of the samples have significant gross radionuclide activity and high concentrations of ions that are associated with the solidified waste. The reason for the presence of such

contamination may be that residual contamination remained on the outside of the waste-form containers after solidification.

Soil sampling in and around the EASC/LWSP casks storage site shows that loading and storage operations have not resulted in contaminant releases to the surrounding drainage areas.

Strontium-90 activity was detected on one occasion in water collected from a building sump in SWSA 5 North (N). Subsequent samples from this sump contained no ^{90}Sr activity. Gross beta activity is consistently present in samples of water from this sump and can usually be accounted for by the presence of ^{40}K.

Groundwater monitoring at SWSA 5 N has revealed a wide fluctuation in reported transuranic activity in the well that has consistently shown contamination from ^{244}Cm and ^{241}Am. The measured ^{244}Cm concentrations appear to be highly dependent upon some aspect of the local conditions at the time of sample collection. Water table elevation may be the most important variable. At higher water table elevations, more waste in the burial trenches is directly exposed to groundwater. If buried waste in contact with the water table is indeed the source of ^{244}Cm, then any remedial action must address either removal of the waste or isolation of the waste from the water table. Simply capping the trenches to eliminate infiltration will not prevent ground water from contacting the buried waste.

A groundwater characterization was conducted at Well 516 in SWSA 5 N. Results led to the hypothesis that the radionuclides are complexed by low molecular weight organics and are being transported in solution. This has important implications for the hydrogeochemical modeling of contaminant transport from SWSA 5 North as well as for any type of remediation technique to be applied to this site.

1. INTRODUCTION

Chapter III of U.S. Department of Energy (DOE) Order 5820.2A (DOE 1988) specifies requirements for the management of facilities that were used for the disposal of radioactive solid low-level waste (LLW) on or after the date of the order (September 26, 1988). Activities in Solid Waste Storage Area (SWSA) 6 at Oak Ridge National Laboratory (ORNL) (Fig. A.1) are governed by Chapter III. Chapter II of 5820.2A covers the transuranic (TRU) waste storage areas in SWSA 5 North (Fig. A.2) at ORNL. Both chapters require environmental monitoring to provide early warning of leaks before such leaks pose a threat to human health or the environment. Chapter III also requires the monitoring of LLW disposal facilities so that their performance can be evaluated. In order to comply with this Order, the Environmental Sciences Division (ESD) at ORNL implements the Active Sites Environmental Monitoring Program (ASEMP) for the Radioactive Solid Waste Operations (RSWO) Department within the Waste Management and Remedial Action Division (WMRAD) at ORNL. The scope of ASEMP includes all ORNL waste disposal sites that were active on or after the date of the Order and that are under the operational control of the RSWO Department of WMRAD.

This report continues a series of annual and semiannual reports that present the results of ASEMP monitoring activities (Wickliff et al. 1991a,1991b; Ashwood et al. 1991a,1991b; Morrissey et al. 1994; Yager et al. 1989). The report details monitoring data for fiscal year (FY) 1993 and is divided into three major areas: SWSA 6 [including tumulus pads, Interim Waste Management Facility (IWMF), and other sites], the low-level Liquid-Waste Solidification Project (LWSP), and TRU-waste storage facilities in SWSA 5 N. The detailed monitoring methodology is described in the second revision of the ASEMP program plan (Morrissey et al. 1994). This report also presents a summary of the methodology used to gather data for each major area along with the results obtained during FY 1993. Figures and tables are presented at the end of the report in Appendix A and Appendix B, respectively.

2. SWSA 6 LOW-LEVEL WASTE FACILITIES

SWSA 6 is currently the only operating LLW disposal facility at ORNL. Wastes that are certified free of liquid and hazardous wastes are further segregated into low- and high-activity wastes prior to disposal. Low-activity wastes are placed in concrete silos installed in trenches or in concrete vaults on concrete pads aboveground (called tumulus

facilities) (Fig. A.1). High-activity wastes are placed either in silos or in steel-lined, concrete-capped auger holes (called high-range wells), depending on the waste form and activity (Fig. A.1). Asbestos waste that cannot be certified free of radioactive contamination is placed in concrete silos below ground. Fissile material is stored in steel-lined wells. During the mid-1980s, high-activity wastes were stored in concrete vaults (similar to tumulus vaults) placed on a concrete pad cut into the side of a hill as a demonstration of this method of disposal. This Hillcut Disposal Test Facility (HDTF) is not an active site, but it is included in ASEMP.

Monitoring activities associated with SWSA 6 facilities are divided into four major areas: tumulus, IWMF, subsurface facilities, and HDTF. The original tumulus facilities in SWSA 6, the Tumulus I and Tumulus II pads, were loaded to capacity with waste in FY 1992. During FY 1993, the only monitoring activities related to Tumulus I and II were periodic monitoring of the underpad drains and two quarterly samplings of the tumulus area groundwater monitoring wells. IWMF monitoring thus far includes pad water runoff and the underpad drainage system. FY 1993 monitoring at the subsurface facilities included sampling of the perched water table that develops when shallow stormflow intercepts the silo trenches or the backfill surrounding the high-range wells, asbestos silos, and fissile wells. At HDTF, water that accumulates on the pad or in the underpad area is collected and sampled.

2.1 TUMULUS I and II

The monitoring of water at Tumulus I and Tumulus II was designed to provide three levels of detection for contaminant release. First, any release from the vaults to the pad surface would be detected in the pad water samples. Second, any contaminants that might seep through the pads would be detected in the underpad water. Third, any contaminant release that passed through the pads and the underpads to the shallow groundwater would be detected in the tumulus area monitoring wells.

The Tumulus I and Tumulus II pads were both covered by Rubb[1] buildings in January 1992. As a result, no water accumulated on the surface of either pad during FY 1993. Periodic inspections were made of the surface of the pads to

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[1] Rubb buildings are plastic, tent-like structures that completely cover the pads above and on all sides.

verify that no water was present.

However, water continued to drain from the underpads of both tumulus pads. This water flows through the monitoring shed and is released to West Tributary. The underpad drainage systems of the two pads are of different designs. Flow through the underpad of Tumulus II is expected, but a plastic liner that should prevent the accumulation of shallow groundwater was installed beneath the Tumulus I underpad. This liner was designed to capture any water that might leak through the pad. Apparently, the liner is not intact; shallow groundwater infiltrates the underpad collection system and drains to the monitoring shed. However, much less water drains from the underpad of Tumulus I than from the underpad of Tumulus II.

The 11 groundwater monitoring wells in the tumulus area were sampled on 2 occasions in FY 1993. Quarterly sampling of these wells was halted because several were plugged and abandoned in preparation for the construction of the permanent tumulus cap.

The Environmental Restoration (ER) program assumed operational control of the tumulus facilities in April 1993. As a result, monitoring the tumulus facilities was no longer a formal part of ASEMP after the transfer to ER.

2.1.1 Underpad Drainage

2.1.1.1 Methodology

Water that drains from the tumulus underpads flows to separate sumps in the tumulus monitoring shed. Grab samples were collected from the drain pipes that empty into the sumps. These samples are analyzed periodically for gross radionuclide and ^{3}H activity and cation and anion concentrations. One sample was also collected of the perched water table that accumulates in, and flows from, the Tumulus I construction base drain.

2.1.1.2 Results

Three samples were collected from each underpad drain and one sample was collected from the Tumulus I construction base drain. Water from all three of these areas shows significant ^{3}H activity (Table B.1). The source of the ^{3}H is suspected to be the shallow groundwater in the tumulus area. Tritium was first detected in one of the tumulus monitoring wells in 1988 and has since spread to most of the tumulus area wells (see section 2.1.2). As discussed earlier, the design of the Tumulus II underpad and the malfunctioning of

the Tumulus I underpad liner allow shallow groundwater to collect in both underpads. However, it is not clear why the tritium concentration present in the Tumulus II underpad water is so much higher than that from Tumulus I.

No significant gross alpha, gross beta, or gamma activity was detected in water from any of the three areas.

Table B.2 presents the results of the cation and anion analyses of the underpad water from the two pads. These data show that the underpad drainage is chemically similar to the shallow groundwater in the tumulus area.

2.1.2 Groundwater Monitoring

2.1.2.1 Methodology

Eleven wells designed to monitor the shallow groundwater in the tumulus area encircle the tumulus pads (Fig. A.3). These wells were drilled to the level of auger refusal (typically 20 to 30 ft.) and are screened to include as much of the zone of permanent groundwater above bedrock as possible (Wickliff et al. 1991b: Appendix C). The wells are equipped with dedicated sampling pumps and were sampled in accordance with ASEMP procedures. Samples were analyzed for gross alpha, gross beta, gamma, and ^{3}H activity.

2.1.2.2 Results

Analytical results from the two rounds of sampling are presented in Tables B.3 and B.4. All radionuclide activities in the tumulus area groundwater are below action levels. Tritium is the only radionuclide detected in any of the monitoring wells. This ^{3}H plume was first detected in well 1036 in 1988 (Table B.4). Tritium activity above background levels has since been observed, at least once, in all the tumulus area monitoring wells. Table B.4 presents a complete history of tritium activity in all of the tumulus area monitoring wells. These data indicate that the plume is spreading to the south and west and that there is possibly a new ^{3}H source north or east of the tumulus pads (see Fig. A.3 for well locations).

2.2 INTERIM WASTE MANAGEMENT FACILITY

IWMF became operational in December 1991 and is patterned after the earlier tumulus-type facilities. Concrete pads support concrete vaults containing LLW in a grout mixture. At some time in the future, the pads will be covered with an engineered cap that will minimize

infiltration of rain water. Eventually, the IWMF will consist of 12 concrete pads loaded with 330 vaults each.

Because the IWMF facility is above ground, the primary vector for contaminant transport is rain water falling on the vaults and pads. During loading operations the pads are uncovered and open to direct precipitation. The resulting runoff from the pads is directed through a monitoring shed where samples are collected. The runoff then flows through a National Pollutant Discharge Elimination System (NPDES) sampling point and discharges to a nearby surface stream.

The conceptual model for the IWMF differs from that of the earlier tumulus facilities only in that there is a French drain between the IWMF pads and the hill to the north. This drain is designed to prevent groundwater from entering the gravel base beneath the pads. Any water that does enter the gravel base will also drain to the monitoring station.

Values of pH exceeding the NPDES permit limit of 9.0 have been reported for IWMF as they were for the original tumulus pads (Ashwood et al. 1991a,1991b; Wickliff et al. 1991a,1991b; Morrissey et al., 1994). Because of concerns over the release of water from the concrete pads with a pH above the NPDES permit limit, an automated CO_2 bubbling system was installed and operated at IWMF in FY 1993. This system functions to maintain IWMF effluent pH below the NPDES permit limit. It is operated as a "best management practice" and is designed to bubble CO_2 into the pad water runoff when there is flow from the pad and the pH approaches the NPDES limit of 9.0.

2.2.1 Pad and Underpad Runoff

2.2.1.1 Methodology

The monitoring area at IWMF consists of three sumps for the collection of water from the active pad (i.e., the pad on which waste vaults are actively being loaded), the inactive (i.e., fully loaded) pad(s), and the underpads. The design of the IWMF pad drainage system allows runoff from the active pad to flow through PVC piping and into a sump, designated the stormwater sump, at the monitoring station. Runoff from the inactive pad(s) drains to a separate sump, called the infiltration sump, at the monitoring station. The volume of each sump is ~7500 L (2000 gal). Any water that accumulates in the underpad gravel base drain is routed to the monitoring station and is collected in a ~3800-L (1000-gal) sump at the monitoring station.

Samples of pad runoff are collected using electronically controlled automatic samplers. Each sample is analyzed for gross alpha, gross beta, and gamma activity. Samples are also occasionally analyzed for ^{3}H activity and cation and anion concentrations.

Pad runoff water pH is continuously monitored using pH probes in both the stormwater and infiltration sumps. These data are recorded electronically. A signal is sent to open a solenoid valve in the CO_2 lines if the pH rises above a preset level. This allows flow of CO_2 into the runoff water thus lowering the pH. This system has worked well and continues to maintain effluent pH levels below the NPDES limit. However, several adjustments were necessary to the system during the course of the year because of insufficient gas flow rates, faulty pH probes, and other minor problems.

To date, very little water has drained from the underpad even during periods of very heavy rainfall. This indicates that the upgradient French drain is functioning to route shallow groundwater around the facility. The valve controlling flow from the underpad discharge line into the underpad sump is kept closed during normal operations. When a visit is made to the site to collect pad runoff samples, this valve is opened to check for underpad drainage. If water does drain from this line, it will be collected, and samples will be taken and analyzed for gross radionuclide activity.

2.2.1.2 Results

Data for IWMF pad runoff water are presented in Table B.5. Forty-seven samples were collected from IWMF during FY 1993. All but one of these samples were from IWMF pad 1 or from the combined flows of pad 1 and pad 2. Separating the flow from the two pads into separate sumps caused unexpected problems with the pH control system. Therefore, flow from the two pads will be combined until these problems can be resolved.

A low level of gross beta activity is consistently present in the pad runoff water. Such activity has previously been observed for IWMF and for tumulus and is believed to be a result of leaching of ^{40}K from the concrete (Ashwood et al. 1991a,1991b; Wickliff et al. 1991a,1991b; Morrissey et al. 1994). Only three samples (IWMF-074, IWMF-088, and IWMF-118) were reported to have gross beta activity above the 5.0-Bq/L first action level. Analysis of the archived samples IWMF-074A and IWMF-088A showed gross beta activity below the action level. Apparently, the original analyses were in error for these two samples. Analysis of

archived sample IWMF-118A confirmed a gross beta activity above the action level. However, the gamma scan of this sample shows that ^{40}K is probably responsible for the majority of the beta activity. Subsequent samples of pad runoff showed that gross beta activities returned to levels below the action level. Therefore, no further action was taken.

Five runoff samples were analyzed for ^{3}H activity (Table B.5). These ^{3}H values are somewhat variable, but very low, and presumably reflect fluctuations in atmospheric levels.

Seven samples, five samples that were either from pad 1 or the combined flows from both pads and two samples from pad 2, were analyzed for cations and anions (Table B.6). The purpose of these analyses was to track changes in pad runoff water chemistry that may be indicative of accelerated concrete degradation. The general trend of increasing concentrations of calcium, potassium, magnesium, sodium, strontium, silicon, vanadium, nitrate, and sulfate probably reflects the increase in concrete mass with the addition of vaults to the pads. Long-term monitoring of the pad runoff water chemistry will be required to detect changes that may be indicative of accelerated concrete degradation.

Figures A.4a and A.4b show the effectiveness of the CO_2 pH control system. The high pH of the influent water from the pads is rapidly lowered by the CO_2 system.

2.3 LLW SILOS, HIGH-RANGE WELLS, ASBESTOS SILOS, AND FISSILE WELLS

LLW silos in SWSA 6 are generally installed in groups of four within a trench. The conditions of the disturbed soil (backfill) in trenches can cause an intermittent perched water table as a result of subsurface stormflow. Davis et al. (1989) demonstrated that some of the LLW silos within trenches leak. Therefore, in order to provide early contaminant detection, 2-in. drive-point monitoring wells with 5-ft screened sections were installed in May 1990 in trenches that were previously without monitoring wells. These intratrench (IT) wells provided a way to monitor groups of silos for containment failure, leaching of wastes, and contaminant transport. Drive-point wells were also installed in May 1990 in the backfilled soil next to high-range wells, asbestos silos, and fissile wells.

In May 1993, as a result of an effort to lower sampling cost and reduce the counting errors associated with

analyzing small samples, the monitoring frequency of IT and backfill wells was reduced to annual monitoring during the wet season (January to April). In October 1993, RSWO and ER decided to release all IT and backfill wells for either plugging or transfer to the ER Program. Much of the LLW silo area and the fissile well area has been transferred to ER. The transfer of the remaining areas containing LLW silos, asbestos silos, and high-range wells is planned for December 1993.

2.3.1 Methodology

The IT wells and backfill monitoring wells are equipped with a weighted sample bottle that collects a sample of any perched water. During the first and second quarters of FY 1993, samples were collected from those wells that contained sufficient water (usually 100 to 250 mL). Composite samples (around 1000 mL) were collected from those wells that have had ^{60}Co and/or ^{137}Cs activities above the action levels during the last 2 years. These "elevated" activities typically had high counting errors resulting from the small sample volumes. Samples were prepared for analyses by filtering the sample through a 0.45 μm filter and acidifying the sample to pH<2 with HNO_3. Filters were counted for gamma-emitting isotopes in ESD. Water samples were analyzed for gross alpha and gross beta activities and for gamma-emitting isotopes by ORNL's Analytical Chemistry Division.

2.3.2 Results

The FY 1993 quarterly sampling of IT wells around LLW silos and of wells next to high-range wells (AUG xx), asbestos silos (C520 and C595), and fissile wells (FIS xx) was completed in November 1992 and in February 1993. Data are presented in Tables B.7 and B.8. Samples were collected from 26 IT wells around LLW silos, from 2 backfill wells next to the asbestos silos, and from 2 backfill wells next to the fissile wells. Samples were also collected from five backfill wells in the high-range well area.

For continuity, the results from the last FY 1992 quarterly sampling are given in Tables B.7 and B.8 along with the results from the first and second FY 1993 quarterly sampling. Dissolved gross alpha, gross beta, ^{60}Co, and ^{137}Cs concentrations were below the action levels for all the samples with the exceptions of water from IT Well 19 and IT Well 23 (Table B.7). The ^{60}Co concentration in IT Well 23 exceeded the 1.5-Bq/L action level during the second quarterly sampling; however, there was a fairly large associated analytical error (± 2.4). Samples from IT

Well 19 have consistently contained elevated gross beta activities, primarily resulting from elevated ^{90}Sr activity. This activity is probably a result of ^{90}Sr leaching from waste in one or more of the silos in the trench (Ashwood et al. 1991a,1991b; 1992a; Wickliff et al. 1991b). The silos within this trench were installed using precast concrete drainage pipes obtained from the Clinch River Breeder Reactor Project, and the wastes within the silos were not originally grouted. However, in July 1992 the silos were grouted as part of a measure to reduce potential for release of radionuclides from the LLW silos. Gross beta levels in IT Well 19 since July 1992 suggest the grouting effort was effective in reducing the amount of contaminant release (Fig A.5). Sediment collected on 5 filters from the first quarter and 12 filters from the second quarter had low but detectable ^{137}Cs activities. Levels of ^{60}Co were below detection.

2.4 HILLCUT DISPOSAL TEST FACILITY

The HDTF is a demonstration project that was started in 1981 but was discontinued the following year before any wastes were emplaced (see Fig. A.1 for location). In 1985, the project was reactivated as part of the Low-Level Waste Disposal Development and Demonstration project. The HDTF provided a method for disposing of high-activity LLW because no suitable greater-confinement burial method was available at the time. The HDTF demonstration also provided a means by which to evaluate the use of hillslope cuts as possible sites for future engineered disposal facilities. The objective of the demonstration was to assess the degree of hydrologic isolation afforded by this type of design.

The HDTF is similar to the tumulus-type facilities and consists of a concrete pad (4.6 m × 4.6 m) constructed in a cut from the side slope of a hill (Fig. A.6). The pad was installed above the expected high water table in the area. Twenty-seven concrete boxes (1.1 m × 1.1 m × 1.4 m) of high-activity LLW were placed on the pad and covered with soil. The lids of the boxes were sealed with a bitumen mastic, and the boxes were banded. A runoff collection system was installed to drain both the pad and the gravel area surrounding the pad. Runoff from the pad and the gravel drain are collected separately in two above-grade 500-gal tanks. Two monitoring wells were installed, one on the pad and one in the gravel drain (Fig. A.6).

Water can reach the buried waste vaults through infiltrating precipitation or shallow stormflow. If the water table rises following heavy rains, the gravel base

below the pad should intercept water from the shallow aquifer, serving as a wick to drain the water away from the pad.

The contents of three of the vaults placed on the HDTF pad cannot be identified; therefore, these vaults cannot be certified to be free of Resource Conservation and Recovery Act (RCRA) material. The water that drains from the pad and underpad is, therefore, collected for treatment at the Process Waste Treatment Plant (PWTP).

2.4.1 Methodology

Measurements of the volume of water in the tank that collects pad runoff are made and recorded weekly. When water in this tank reaches ~70% of tank volume, a sample is collected and the contents of the tank are transferred to a holding tank. Since very little water drains from the underpad, this water is collected in a holding tank without routinely measuring the volume of runoff. A sample of this underpad water is also collected when the tank is ~70% full.

These samples are analyzed for gross alpha, gross beta, and gamma activity. When the analytical results are received, the SWSA 6 foreman is notified. The foreman sees that the water is taken to the appropriate waste treatment plant. If radioactivity levels are above the action levels, the ASEMP program manager will be notified.

Wells that reach the buried pad and the gravel base are monitored weekly for water levels. Samples are obtained whenever the water levels indicate that water is over the top of the curb around the pad. These samples are analyzed for gross alpha, gross beta, and gamma activity.

2.4.2 Results

Runoff from the pad is designed to collect in an above-grade tank (Tank 1) at the HDTF. Volume measurements of pad runoff were made weekly during FY 1993. The pad runoff collecting in Tank 1 was transferred to a holding tank whenever Tank 1 was near full. Pad runoff samples were collected during each transfer in December 1992, February, March, and April 1993. Runoff from the pad since April has been minimal. Gross alpha, gross beta, and gamma-emitting isotope activities were below the action levels, with the exception of the gross beta activity in the February 1993 sample (Table B.9). In addition, the ^{60}Co and ^{137}Cs activities in this sample were slightly elevated. This was the first occurrence of a gross beta value greater than

5 Bq/L and of ^{60}Co and ^{137}Cs at these levels; however, subsequent samples collected in March and April had activities below the action level and were more typical for the pad runoff. A total of about 10,000 L of pad runoff were collected in FY 1993.

Tank 2 at HDTF was designed to collect groundwater runoff from the gravel drain around the pad; however, in January 1991 a leak was detected in Tank 2. In February 1991, the 8-in. inflow pipe to Tank 2 was capped, and a 2-in. flexible hose was tapped into the cap to divert groundwater runoff to a holding tank downslope from HDTF. It is believed that the inflow pipe to Tank 2 was valved off during this time. On April 7, 1993, during a close inspection of the tanks, the inflow pipe to Tank 2 was found to be still valved off. The leak in Tank 2 was also identified as being at the bottom, where fittings connect a pipe to a drain spigot and stand pipe. The valve was opened, and a sample was collected from the inflow pipe and submitted for analyses; the valve was then closed again. The gross beta, ^{60}Co, and ^{137}Cs concentrations were all below action levels; however, there was elevated gross alpha activity (Table B.9). The archived sample that was collected on the same day was resubmitted for gross alpha analysis and had only 0.14 ± 0.12 Bq/L. Because the samples are not filtered, differences in sediment content in the original sample and the archived sample may be the reason for the gross alpha differences, or there may have been an error in one of the activities reported by ACD. There has not been sufficient runoff from the gravel drain since April for sample collection. In June, the valve on the inflow pipe was opened to divert any groundwater runoff to a holding tank just downslope from HDTF.

Two wells at HDTF were monitored weekly during the year. The well in the gravel layer around the pad remained dry. Weekly water levels in the well on the pad remained fairly constant. Water levels indicate that a small amount of standing water (depth < 0.5 in.) remained on the pad except during May 1993.

2.5 CONCLUSIONS

Tritium activity continues to be present in the tumulus area groundwater and is detected in water flowing from both the Tumulus I and Tumulus II underpads. The source(s) of this ^{3}H remain uncertain. Originally, the effluent from the French drain in the 49-trench area was suspected to be the source. However, in 1990 the effluent pipe from this French drain was relocated, and no reduction in ^{3}H activity in

tumulus area groundwater has occurred. In fact, tritium activity in Well 1036, which is the well nearest the French drain outfall, continues to increase.

Data from the IWMF pad runoff indicate that no leakage of waste has occurred from the vaults. Only low-level gross beta activity is consistently observed in the runoff water. This activity is postulated to be a result of ^{40}K leaching from the concrete.

The French drain at IWMF is performing its intended purpose of suppressing the water table beneath the pads. The absence of water in the underpad drainage system is an indication of the French drain's effectiveness.

The CO_2 bubbling system that was installed in the IWMF pad water runoff sump is functioning well and automatically maintains effluent water below the NPDES permit pH limit of nine.

Grouting of those LLW silos that were not grouted initially appears to have been effective in reducing leakage. Water that was collected in IT Well 19 showed significantly reduced gross beta activity after grouting was completed.

Water continues to drain from HDTF during the wet season. The first sample of HDTF pad water runoff to contain any significant activity was collected in FY 1993. However, subsequent samples exhibited no activity above any action levels.

3. LOW-LEVEL-LIQUID-WASTE SOLIDIFICATION PROJECT

The low-level Liquid Waste Solidification Project (LWSP), initially referred to as the Emergency Avoidance Solidification Campaign (EASC), was undertaken to solidify the supernatant from the Melton Valley storage tanks. The supernatant was mixed with cement and other solidifying agents and allowed to cure in steel cylindrical containers with a diameter and height of 1.8 meters that weigh approximately 12 metric tons.

For radiation shielding purposes, each steel container was loaded inside a storage cask prior to waste solidification. The waste forms were then transported to the LWSP cask storage site where they were placed inside concrete storage casks.

The EASC/LWSP cask storage site, Area 7856, is located south of Building 7860, the New Hydrofracture Facility (Fig. A.7). The site is an engineered, compacted, crushed-stone storage pad surrounded on all sides by fences and drainage ditches. The 119 casks are arranged on the pad as shown in Figure A.8. Four of the casks contain surrogate waste forms which are similar to the actual waste forms but do not contain radioactive constituents.

Each storage cask contains an integral fiberglass-reinforced plastic (FRP) liner with lid. The FRP lid is not sealed to the FRP liner at this time. Sampling lines were cast in place through the wall of the storage cask into the annular space between the waste form and the FRP-lined concrete storage cask. One tube extends to the bottom of the annular space and is used to collect any liquid that may be found inside the cask. The other tube extends to within a few inches of the top of the annular space and is can be used to collect gas samples (Figure A.9).

3.1 CASK-LIQUID SAMPLING

3.1.1 Methodology

Liquid samples are collected quarterly from the LWSP casks, if liquid has collected in the sampling ports, and are analyzed for gross alpha, gross beta, and gamma radiation. In addition, analyses are performed for sodium, nitrate, chloride, and other metals and nonmetals if enough sample is available. Sampling the casks for liquids is conducted by the Liquid Waste Operations Group (LWOG) of WMRAD.

3.1.2 Results

The complete historical record of the analytical results from the liquid that has accumulated in the LWSP storage casks is presented in Table B.10. Only 29 of the 119 casks have ever contained sufficient water to sample.

The data are extremely variable and difficult to interpret. Much of the problem with the analytical data is because only small volumes of sample are often available and the resulting analyses have high detection limits and large uncertainties. However, it is apparent that many of the samples have contained significant gross radionuclide activity and high concentrations of ions, such as chloride, that are associated with the solidified waste. The reason for the presence of such contamination may be that residual contamination remained on the outside of the waste form

after solidification. The water that accumulates in these casks probably evaporates to some extent thus concentrating any ions present. Also, the gross beta activity in the accumulated water could be partly the result of ^{40}K leaching from the concrete. During FY 1994, these casks will be on an annual sampling schedule. Hopefully, this will allow the accumulation of a greater volume of water and thus a more complete and reliable analysis of each sample obtained.

3.2 SOIL SAMPLING

3.2.1 Methodology

Soil samples are collected twice per year from five sampling locations at the EASC/LWSP cask storage area (Fig. A.8). Sample Site 3 was chosen to detect transport from offsite into the cask area, Sample Sites 1 and 5 for transport to offsite areas, and Sample Sites 2 and 4 were chosen to detect a combination of onsite and offsite transport (Yager 1991). The samples are analyzed for gross alpha, gross beta, and gamma radiation.

3.2.2 Results

Table B.11 presents the results of the FY 1993 soil sampling at the LWSP site. These data are very similar to previous soil data from the site and indicate that no changes in soil radionuclide activity have occurred as a result of LWSP operations and storage.

3.3 CONCLUSIONS

Although only ~25% of the EASC/LWSP casks have ever contained sufficient water to sample, gross beta activity is quite often detected. Gross alpha activity is detected less frequently. Some of the gross beta activity could be the result of ^{40}K leaching from the concrete casks. However, the frequent detection of high concentrations of elements associated with the solidified waste, such as Cl^-, NO_3^-, Ca^{+2}, and Na^+, along with the radiological activity, make it appear that some external contamination of the waste form is likely.

Soil sampling in and around the EASC/LWSP storage area indicates that loading and storage operations have not resulted in the release of contamination from the site.

4. TRANSURANIC WASTE FACILITIES IN SWSA 5 NORTH

Transuranic wastes have been stored in SWSA 5 N since 1970 (Shoun 1987). Active TRU waste management facilities in SWSA 5 N include aboveground buildings, buildings that are below ground on three sides, and auger holes similar to the high-range wells in SWSA 6 (Fig. A.2).

Before DOE Order 5820.2A went into effect, TRU wastes were also emplaced in unlined trenches in SWSA 5 N. Within the trenches, TRU wastes are contained in concrete casks and wooden and metal boxes (Stewart et al. 1989). There is evidence that the shallow aquifer extends above the bottom of at least some of the trenches during high water table conditions (Wickliff et al. 1991b). Furthermore, TRU contamination leached from wastes in the trenches has been measured in a downgradient well (Ashwood et al. 1990; Wickliff et al. 1991a,1991b; Ashwood et al. 1991a,1991b) and in seeps along the bank of White Oak Creek (Ashwood et al. 1991a,1991b). Thus, transport from the trenches is known to occur through the shallow aquifer and along discrete pathways.

Groundwater well 516, immediately downgradient from a group of TRU waste trenches (Fig. A.2), contains gross alpha activity varying from 30 to 210 Bq/L (Morrissey et al. 1994). The dominant radionuclide is ^{244}Cm, but traces of ^{241}Am have been reported from separate samples. The TRU waste trenches also contain some RCRA-regulated wastes: primarily elemental lead (Stewart et al. 1989). Samples from Well 516 have not contained detectable concentrations of volatile organics (Wickliff et al. 1991). Metal concentrations in this well have been below regulatory concern (Ashwood et al. 1991b).

Well 516 and the TRU waste trenches are upgradient from White Oak Creek (WOC), which drains most of ORNL and eventually enters the Clinch River. The radionuclides, ^{244}Cm and ^{241}Am were measured in two seeps (Fig. A.2: WOC 213 and WOC 255) in the bank of WOC (Ashwood et al. 1991b). These seeps are along geologic strike with the trenches.

During FY 1993, a special study was conducted in Well 516 to determine the chemical state of the ^{244}Cm and ^{241}Am routinely measured in the well. Results of this study are presented in Section 5.

4.1 METHODOLOGY

Fifteen groundwater wells surrounding the TRU-waste storage facilities were sampled quarterly (Ashwood et al. 1992a,1992b) through mid-FY 1993. After mid-FY 1993, sample frequency was reduced to semiannual. To avoid duplication of effort, the ASEMP samples for the second half of FY 1993 were collected by the Bechtel National, Inc., (BNI) team that was collecting samples for a remedial investigation of Waste Area Grouping 5.

Well samples are collected after the wells have been purged. All samples are filtered through 0.45-μm filters and then acidified to a pH <2 with nitric acid. Before October 1990, however, samples were acidified but not filtered. Analytes include gross alpha, gross beta, ^{60}Co, ^{137}Cs, ^{241}Am, and ^{244}Cm. Beginning in FY 1992, tritium analysis was limited to one quarterly sample because tritium is not a contaminant of concern for this site and because the tritium data have not provided substantial insight into the transport of transuranic contaminants.

Eight seep and stream locations are also sampled on the same frequency as the wells (Ashwood et al. 1992a,1992b), if water is present at the time of sample collection. Sample sites 5NNT 01 and 5NST 02 are located within small tributaries of WOC. Seeps identified as "WOC XXX" (Fig. A.2) are located in the bank of WOC; however, only four of those seeps (WOC 160, WOC 175, WOC 213, and WOC 255) are sampled at regular intervals. The remaining two seeps are located between SWSA 5 N and WOC. Seep samples are analyzed for the same set of parameters as are well samples, except that no seep samples were analyzed for ^{3}H during FY 1992 or FY 1993.

Action levels[1] have been established for gross beta (2 Bq/L), ^{60}Co (1.5 Bq/L), and ^{137}Cs (1 Bq/L) (Ashwood and Ashwood 1991). No action level was established for gross alpha because gross alpha is not a reliable indicator of transuranic contamination at trace levels below 1 Bq/L. Instead, concentrations of ^{241}Am or ^{244}Cm that exceed the associated counting error by a factor of 2 are flagged as potentially contaminated samples. This approach roughly corresponds to a 5% probability that a sample would be reported as contaminated when it is not.

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[1] The only action required when these levels are exceeded is internal reporting of the results, usually accomplished in monthly reports.

4.2 RESULTS

4.2.1 Storage Facility 7855

Sumps that drain Buildings 7855, 7826, and 7834 are sampled when sufficient amounts of water accumulate in them. Samples are analyzed for gross alpha, gross beta, and gamma activity. Samples that show activity may also be analyzed for metals, anions, and total organic carbon (TOC). If the gross alpha or gross beta activities exceed the action levels (10 and 20 Bq/L, respectively) Solid Waste Operations notifies ASEMP personnel.

During FY 1993, a gross beta activity > 20 Bq/L was detected on three occasions in samples from the 7855 sump (Table B.12). ASEMP personnel collected an additional sample each time from the sump to better characterize the water and the source of elevated activity. The sample was divided into aliquots and appropriately preserved. The aliquots were submitted for various analyses (typically ^{90}Sr, metals, anions, and TOC analyses). Two of the samples were counted in ESD for gamma-emitting isotopes (^{137}Cs and ^{40}K).

Radionuclide results indicate that on one occasion most of the elevated gross beta activity was a result of ^{90}Sr activity and on two other occasions the gross beta activity was a result of elevated concentrations of ^{40}K (Table B.12). The samples had unusually high amounts of potassium (Table B.13), including ^{40}K. Some ^{137}Cs activity was also detected in these two samples. Radionuclide analyses for the sample collected on December 29, 1992, were inadvertently omitted.

The pH of the first sample had been measured and was about 9. All but the sample collected on December 29, 1992, had high TOC levels and some elevated metal concentrations (Tables B.12 and B.13). The source of the ^{90}Sr in the one sample is unknown; however, the elevated potassium and sodium concentrations are probably a result of alkalies leaching from the concrete. The source of the elevated metals may be fly ash that is a part of the concrete vaults or pads. The chemistry of the sample collected on December 29, 1992, is distinctively different from the other three and may have had some shallow groundwater contribution (suggested by the higher calcium concentration).

4.2.2 Groundwater Wells

Well 516 continues to contain measurable quantities of ^{241}Am and ^{244}Cm in every sample (Table B.14). Although ^{244}Cm concentrations appeared to decline between March 1991 and March 1993, recent samples have increased slightly. More

importantly, concentrations measured in the special study (Sect. 5) are at levels similar to the highest readings from early samples.

Wells 514, 521, 708, 715, and 716 appeared to contain traces of ^{244}Cm in November 1992 (Table B.14). However, subsequent samples from those wells have not contained measurable ^{244}Cm. Well 523 appeared to contain traces of ^{241}Am and ^{244}Cm in March 1993. The May 1993 sample collected by BNI was not analyzed for these isotopes.

Well 516 continues to contain elevated gross beta concentrations on a sporadic basis (Table B.14). The elevated gross beta concentration reported by BNI for the May 1993 sample from Well 519 (Table B.14) has a high associated counting error that renders this value not significantly different from zero.

4.2.3 Seeps and Surface Water Samples

North Tributary samples continue to contain sporadic traces of ^{241}Am and ^{244}Cm (Table B.15). South Tributary frequently contains substantial gross alpha contamination (Table B.15); however, the gross alpha concentrations are not associated with measurable concentrations of ^{241}Am or ^{244}Cm. On the other hand, the June 1993 sample from South Tributary contained measurable traces of both isotopes but only a trace of gross alpha activity. Gross beta concentrations in South Tributary exceeded action levels twice in FY 1993 (Table B.15).

Of the bank seeps, only WOC 255 consistently contains measurable quantities of ^{244}Cm (Table B.15). Reported concentrations of ^{241}Am in this seep were consistent throughout FY 1993, but only the latest sample was significantly greater than zero.

Seep 5NW01 contained measurable amounts of ^{244}Cm throughout FY 1992 and FY 1993 (Table B.15), although flow in this seep was sufficient for sample collection on only three occasions during the 2-year period. The anomalous appearance of ^{241}Am in the April 1992 sample from seep 5NW02 was not repeated in any subsequent samples.

4.4 CONCLUSIONS

The presence of ^{90}Sr in water collected from the sump that drains Building 7855 has not been explained. Such activity was detected on only one occasion. Gross beta activity is consistently present in samples of water from

this sump and can usually be accounted for by the presence of ^{40}K.

The reported results from Well 516 vary widely; for example, ^{244}Cm varied from 220 Bq/L in March 1991 to 0.36 Bq/L in September 1992 (Table B.14). Although ^{244}Cm concentrations appear to be decreasing from 1991 levels, the most recent ASEMP results indicate a slight increase. More importantly, ^{244}Cm concentrations during the special investigation (Sect. 5) are of the same order of magnitude as earlier high levels. Thus, the measured ^{244}Cm concentrations appear to be highly dependent upon some aspect of the local conditions at the time of sample collection. As we suggested in an earlier report (Wickliff et al. 1991), water table elevation may be the most important variable. At higher water table elevations, more waste in the burial trenches is directly exposed to groundwater. If buried waste in contact with the water table is indeed the source of ^{244}Cm, then any remedial action must address either removal of the waste or isolation of the waste from the water table. Simply capping the trenches to eliminate infiltration will not prevent ground water from contacting the buried waste.

Sporadic reporting of traces of ^{241}Am and ^{244}Cm in wells other than Well 516 should not be interpreted as spreading of the contaminant plume. Reported values are so close to the detection limits and so random in time and location that the most likely explanation is analytical anomalies rather than true measurement of these isotopes.

Detection of traces of ^{244}Cm in Seep 5NW01 in three successive sampling periods over a 15-month period suggests that this seep is probably on the edge of the plume that moves through well 516. Seep 5NW01 is along strike and in a direct line with the burial trenches, well 516, and seep WOC 255 (Fig. B.15).

Bank Seep WOC 255 continues to discharge ^{244}Cm and probably ^{241}Am into WOC. The flow volume is small, and the concentrations are quite low.

Elevated concentrations of gross alpha in South Tributary are apparently not due to transuranic isotopes. ASEMP data indicate that virtually all alpha activity from SWSA 5 N is due to ^{244}Cm. Thus, the absence of this isotope in South Tributary suggests that the alpha activity in this stream is not from SWSA 5 N. Traces of ^{241}Am and ^{244}Cm were detected in South Tributary for the first time during March 1993. Further monitoring is needed before we can determine whether these results are analytical anomalies or real

indications of contamination.

5. SPECIAL STUDY OF PARTICLE DISTRIBUTION AND GEOCHEMISTRY OF ^{244}Cm AND ^{241}Am IN WELL 516

The objective of this study was to determine the mode and rate of physico-chemical transport of ^{244}Cm and ^{241}Am from the waste trenches in SWSA 5 N to Well 516. Quarterly monitoring for 2.5 years at this well revealed ^{244}Cm and ^{241}Am levels ranging from 192 to 5946 pCi/L and 1.54 to 189 pCi/L respectively (Ashwood et al 1991b; Wickliff et al 1991b). These levels are much higher than those for other wells in the immediate vicinity and give a unique opportunity to study the geochemistry and transport of the two actinide elements. Determining the physicochemical form of the actinide elements in groundwater is a necessary first step in assessing their transport from SWSA 5 N and will provide critical data for formulating successful remediation strategies. Three different tasks were completed to accomplish this objective.

Task 1 was designed to determine the chemistry of the groundwater environment in order to understand its effect on the physicochemical properties of the actinide elements. The speciation of any radionuclide is a function of its surrounding environment. The pH, redox conditions, degree of mineral saturation, dissolved organic carbon, and similar parameters play a role in determining the radionuclide's oxidation state, solubility, complexation, and adsorption properties, which then determine the fate of the radionuclide.

Task 2 was designed to separate any colloids that were present into particle-size fractions to determine the distribution of the alpha activity by particle size. Radionuclides associated with colloidal particles will be transported differently than those dissolved in solution. Transport of contaminants adsorbed onto colloids will occur at different rates and will follow different spatial flow paths than would the same radionuclides transported in the dissolved state. Colloids will be restricted to fractures and larger interconnected pore spaces, whereas dissolved ions can permeate the aquifer matrix. Stable colloids have the potential for migrating rapidly through zones of preferred flow and may be more readily mobilized by changes in hydrologic conditions.

Task 3 attempted to estimate, on the basis of radioactive decay schemes, the migration rate of ^{244}Cm and

^{241}Am from SWSA 5 N. Curium-244 has a convenient half-life (18.11 years) with respect to the age of the waste trenches. The buildup of the daughter product, ^{240}Pu, is dependent on this half-life. Therefore, the ^{240}Pu:^{244}Cm ratio acts as a clock, and the ingrowth time will be a measure of the migration time of the ^{244}Cm. This technique did not work as well for the ^{241}Am:^{237}Np pair because of the long half-life for ^{241}Am (432 years) in comparison with the age of the waste trenches and because of solubility considerations discussed later. The decay schemes for ^{241}Am and ^{244}Cm are shown below.

$$(^{241}Am)\ \frac{\alpha}{432 year} \rightarrow (^{237}Np)\ \frac{\alpha}{2.14\times10^{6} year} \rightarrow (^{233}Pa)\ \frac{\beta}{27\,day} \rightarrow (^{233}U)\ \frac{\alpha}{1.6\times10^{5} year} \rightarrow 4n+1/series$$

$$(^{244}Cm)\ \frac{\alpha}{18.11 year} \rightarrow (^{240}Pu)\ \frac{\alpha}{6560 year} \rightarrow (^{236}U)\ \frac{\alpha}{23\times10^{6} year} \rightarrow (^{232}Th)\ \frac{\alpha}{1.4\times10^{10} year} \rightarrow 4n/series$$

5.1 METHODOLOGY

Well 516 was sampled on three occasions beginning in December 1992 and ending in February 1993. The three sampling times were necessary to collect the different size fractions because of the slow hollow-fiber filtration process. A peristaltic pump was used to collect the groundwater from the 26.7-ft-deep well. The depth to water was ~9 ft with ~18 ft of water in the well. Hydrolab measurements of pH, Eh (Redox or Oxidation Reduction Potential), temperature, dissolved oxygen (DO), and conductivity were measured by using a flow-through cell. The use of a flow-through cell minimizes the effect of oxygen on the redox sensitive measurements and avoids the introduction of artifacts that could unintentionally produce colloids, such as colloidal ferric hydroxide. In addition to these, alkalinity by titration to pH 4.5 and turbidity were also measured in the field. The pumping rate varied from 60 to 100 mL/min to keep the drawdown of water in the well to a minimum. Minimizing drawdown is important in colloidal sampling because a faster flow rate would stir up particles from the sides of the well and could mobilize colloids that might not naturally be present.

The most direct means of identifying the importance of colloidal transport of radionuclides is physically separating the colloidal particles by size filtration. Such

separation was accomplished at Well 516 by filtering the groundwater through filters of 0.45-μm (in-line), 0.1-μm, 100,000-dalton (unit of molecular weight), and 3,000-dalton, hollow-fiber filters. The filters allow tangential flow of the groundwater past a bundle of hollow fibers of a certain pore size. Only particles smaller than the pore size may then pass into the hollow fiber and be effectively removed from the bulk of the solution. Because the filters remove all particles below a certain size from the groundwater, the alpha activity for particulate that is greater than the filter size is calculated by subtracting the alpha activity of that fraction from the alpha activity of an unfiltered portion of the groundwater. On each of these fractions, metals, radionuclides, dissolved organic carbon, and anions were analyzed to determine the contribution of each particle size to the concentrations of these analytes. A sampling scheme showing the analyses performed on each size fraction is shown in Figure A.10.

5.2 RESULTS

Tables B.16, B.17, and B.18 show the data for the sampling at Well 516. Except for the radionuclides present, this well had little contaminants in it. The groundwater in the well was mildly oxidizing with a pH of 6.5 to 6.8 and had an ionic strength of 0.01. The dominant cations were Na, Ca, Mg, Ba, and Sr. No iron or aluminum was present that might form natural colloids. The turbidity was also very low, 0.05 NTU. The absence of colloid-forming elements was the first indication that a process other than colloidal transport might be involved. The dominant anions were sulfate and bicarbonate with chloride, fluoride, and nitrate in lesser amounts. The groundwater was supersaturated with respect to barite ($BaSO_4$), which would remove by coprecipitation any naturally occurring radium and radon daughter products. A gamma scan of the groundwater verified the absence of radium and radon daughters by the absence of the ^{214}Pb and ^{214}Bi gamma lines at 352 KeV and 609 KeV, respectively.

The results of the colloidal sampling were somewhat surprising. Whereas colloids are a major means of contaminant transport at most waste sites around the country, no alpha activity occurred in the particulate fractions greater than 100,000 daltons, and only 5% of the ^{244}Cm was found in the fraction ranging between 3000 and 100,000 daltons. Thus, 95% of the ^{244}Cm and 100% of the ^{241}Am were in the fraction measuring <3000 daltons, which is considered to be the dissolved state (Fig. A.11). In addition, 95% of the dissolved organic carbon was also in

the smallest (<3000 dalton) fraction. We hypothesized that low molecular weight organics are complexing the radionuclides and keeping them in solution. This hypothesis has important implications for the hydrogeochemical modeling of contaminant transport from SWSA 5 N as well as for any type of remediation technique to be applied to this site. Organically complexed radionuclides will not easily be removed by ion exchange or filtration techniques and may be more mobile than if adsorbed to colloidal particles. A pretreatment of strong oxidant and/or ultraviolet radiation may be a necessary first step to break up the organics before they can be removed by cation exchange.

To determine the migration rate based on the ^{240}Pu:^{244}Cm ratio, four assumptions were necessary. First, we assumed that any plutonium buried at SWSA 5 N was in an insoluble form and was not being leached at any appreciable rate. This was the most important assumption; the second and third assumptions depended on it. The first assumption was reasonable because most waste trenches have a reducing environment in which plutonium is insoluble. The assumption was supported by the presence of low levels of ^{238}Pu (<0.4 pCi/L) in the groundwater. The assumption could not, however, be made for ^{237}Np, the daughter of ^{241}Am, because ^{237}Np is not necessarily insoluble under reducing conditions. Second, because the alpha energies of ^{239}Pu and ^{240}Pu cannot be separated by alpha spectroscopy, we reported their activities together and made the assumption that all the $^{239/240}Pu$ activity was due only to ^{240}Pu, the daughter of ^{244}Cm. In other words, we assumed that ^{239}Pu was not present. Third, we assumed that all the ^{240}Pu observed was produced by the decay of ^{244}Cm while in transit from the waste trenches to Well 516. Fourth, we assumed that the ^{240}Pu migrated concurrently with the ^{244}Cm. Having accepted these assumptions, the ^{240}Pu:^{244}Cm ratios at Well 516 for the three sampling periods were as follows:

Sample Date	^{244}Cm (pCi/L)	^{240}Pu (pCi/L)	^{240}Pu:^{244}Cm ratio	Migration time (years)
17 Dec 92	219.5	0.21	9.567×10^{-4}	7.777
26 Jan 93	266.9	0.20	7.493×10^{-4}	6.276
23 Feb 93	289.1	0.30	1.038×10^{-3}	8.342

The three migration times calculated for the measured ratios are remarkably similar and have an average of 7.5 ± 1.1 years. Because the distance from the nearest trenches to Well 516 is ~15 meters, the migration rate is ~2 m/year.

This is a fairly moderate migration rate and is consistent with the saprolitic geology at the site.

5.3 CONCLUSIONS

A groundwater characterization was conducted at Well 516 at SWSA 5 N. No contaminants other than ^{244}Cm and ^{241}Am were found. The groundwater was filtered for several colloidal size fractions, but most of the alpha activity was found in the dissolved state (<3000-dalton fraction). Most of the dissolved organic carbon was also in the dissolved state. This observation led to the hypothesis that the radionuclides are complexed by low molecular weight (<3000 daltons) organics and are transported in solution. Complexation of the radionuclides has important implications for the hydrogeochemical modeling of contaminant transport from SWSA 5 N as well as for any type of remediation technique to be applied to this site. Based on the ^{240}Pu:^{244}Cm ratio, a migration rate for ^{244}Cm was calculated to be ~2 m/year. At such a rate during the 20 years that the waste trenches have been in place, the contaminants would have moved ~40 m, much more than the 15 meters needed to reach Well 516.

6. ACKNOWLEDGMENTS

The authors wish to thank Jerry Cunningham of the Waste Management and Remedial Action Division for guidance and support. Della Marshall and Tony Thomas of the Environmental Sciences Division provided valuable assistance in sampling and analysis. Jeff Riggs and Roy Freeman of the Instrumentation and Controls Division have consistently supplied excellent guidance and craftsmanship in the design, operation, and maintenance of the electronic monitoring and sampling equipment.

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APPENDIX A: FIGURES

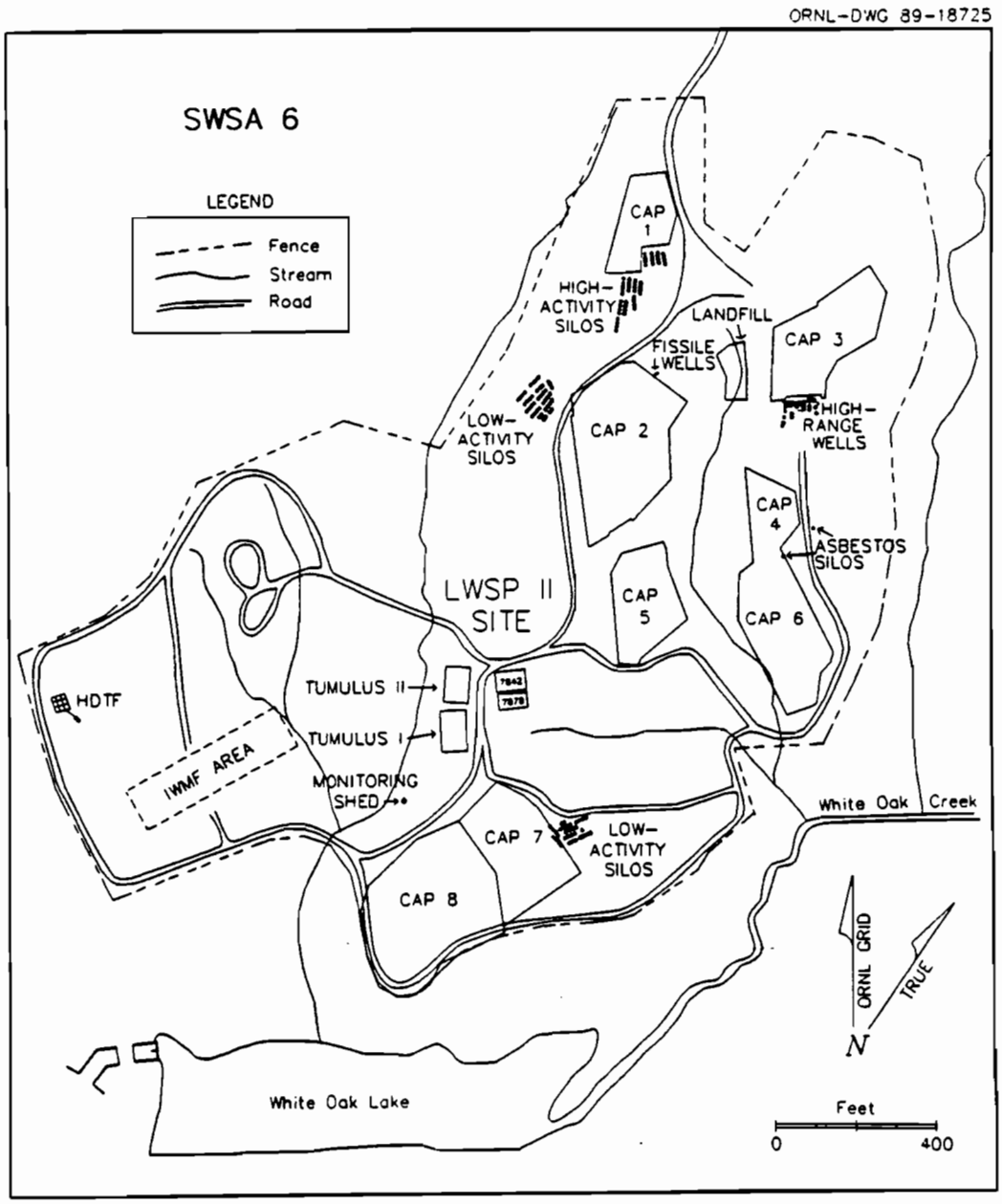


Fig. A.1. Active low-level-waste disposal sites and other major facilities in Solid Waste Storage Area 6.

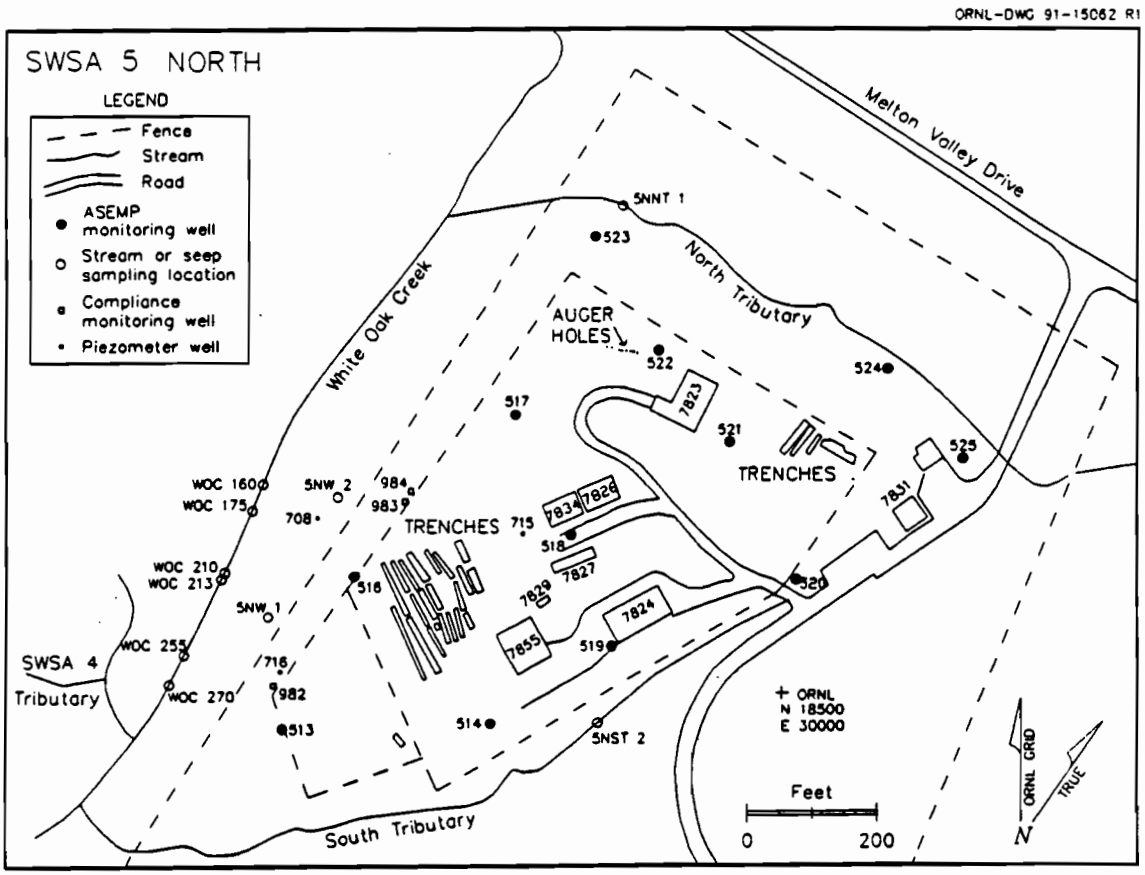


Fig. A.2. Transuranic waste storage sites, sampling locations, and other major facilities in Solid Waste Storage Area 5 North.

ORNL-DWG 91-14589

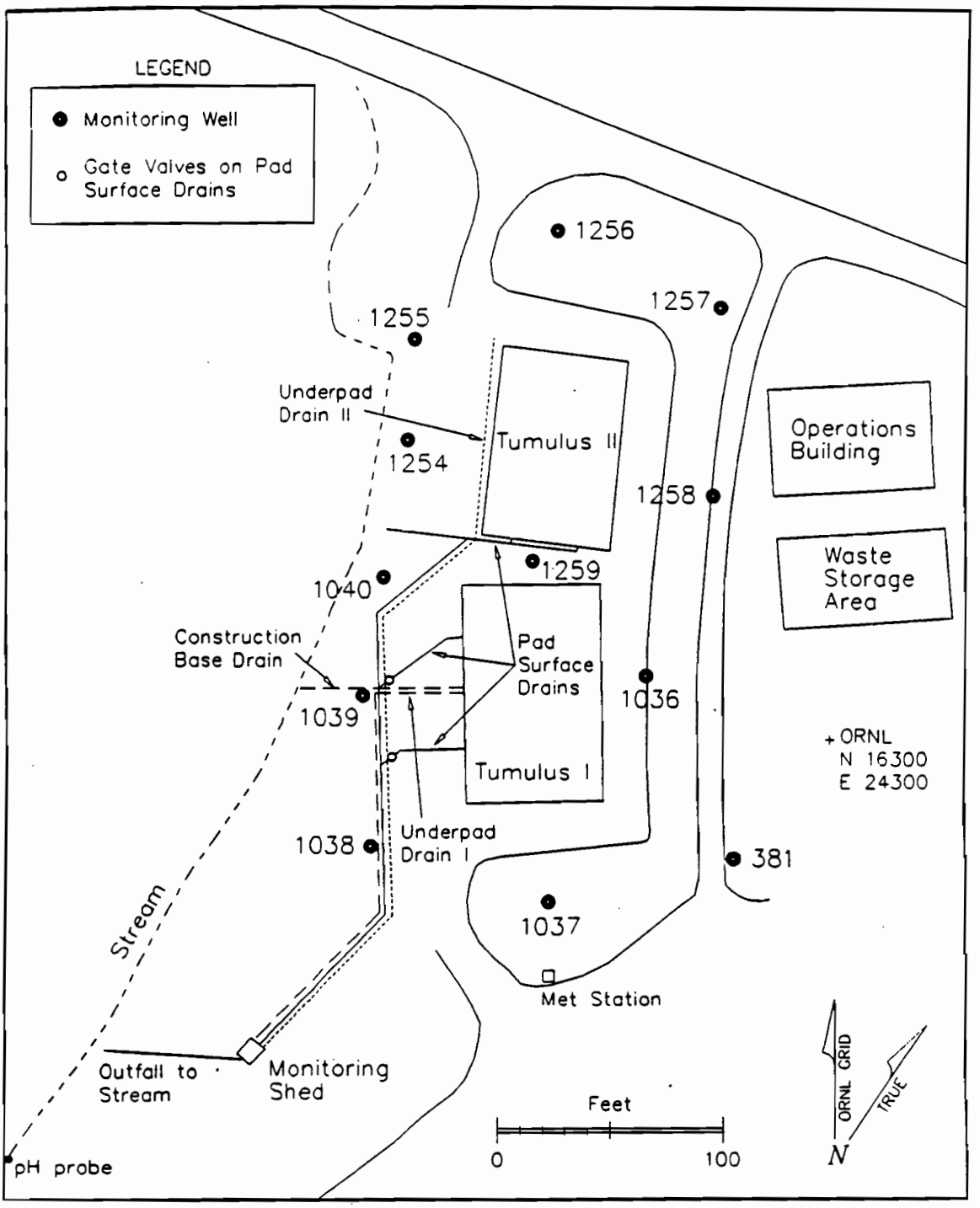
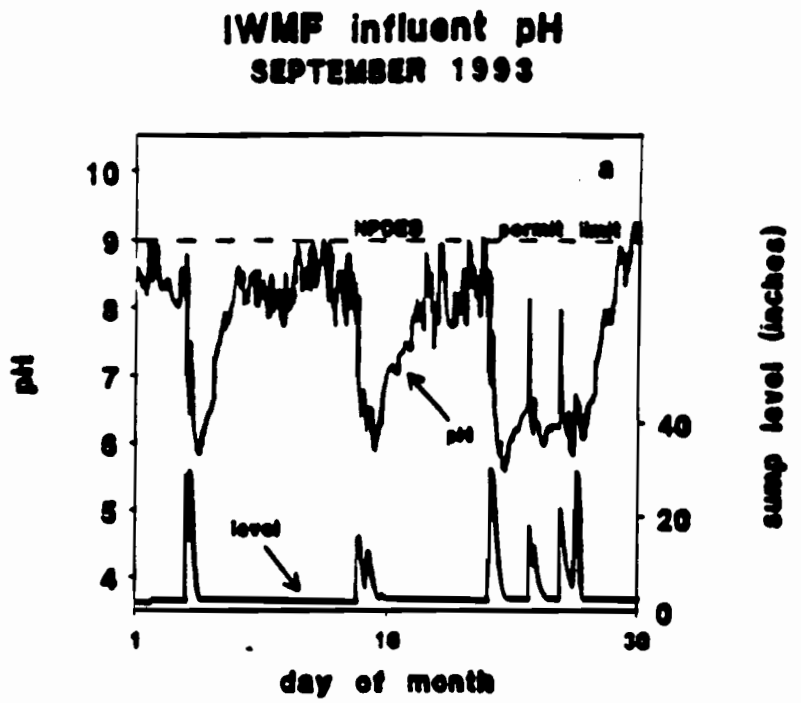


Fig. A.3. Tumulus area in Solid Waste Storage Area 6.



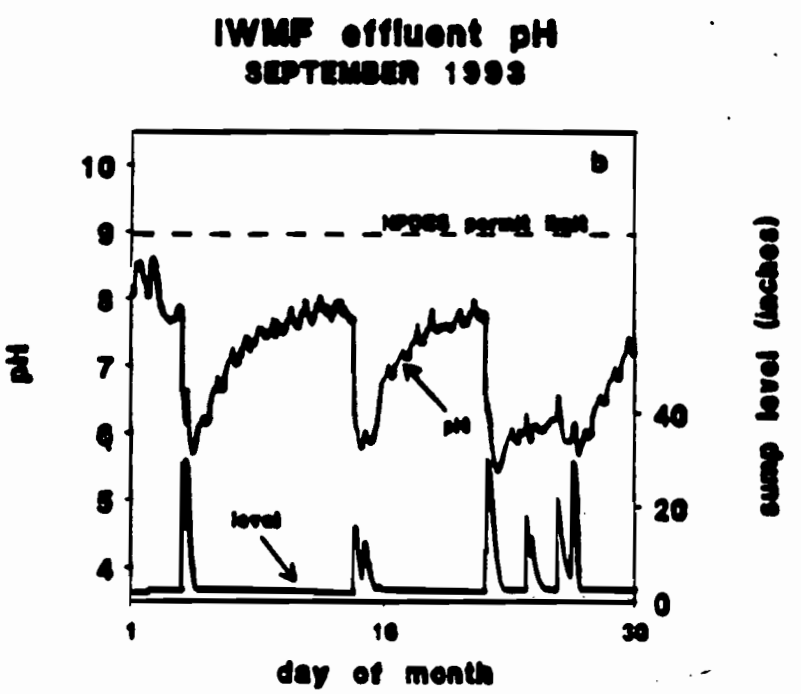


Fig. A.4. Effect of CO_2 bubbler system on Interim Waste Management System pad runoff water pH. (a) pH of water in storm water sump; (b) pH of effluent from monitoring shed.

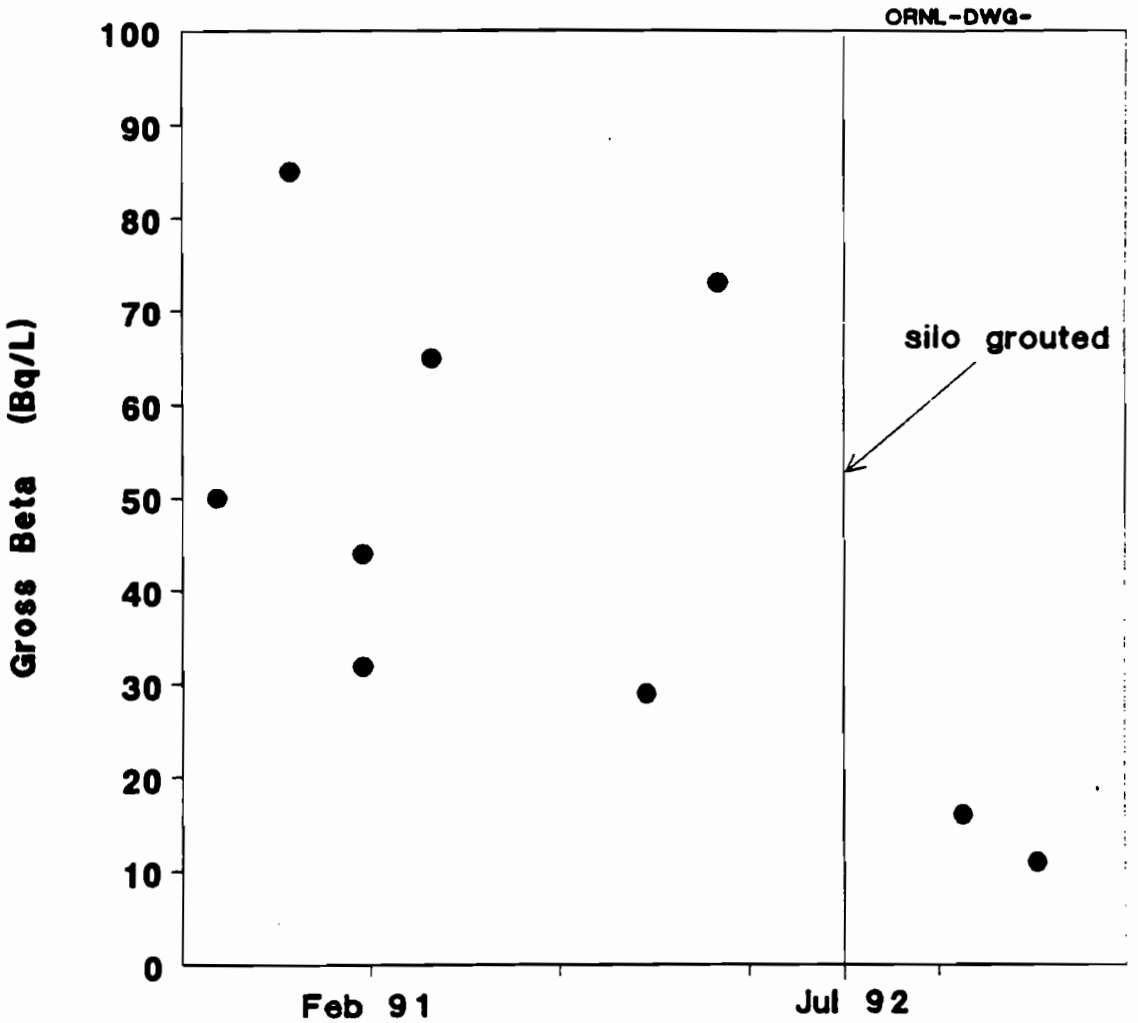


Fig. A.5. Effect of silo grouting on gross beta activity in intratrench well 19.

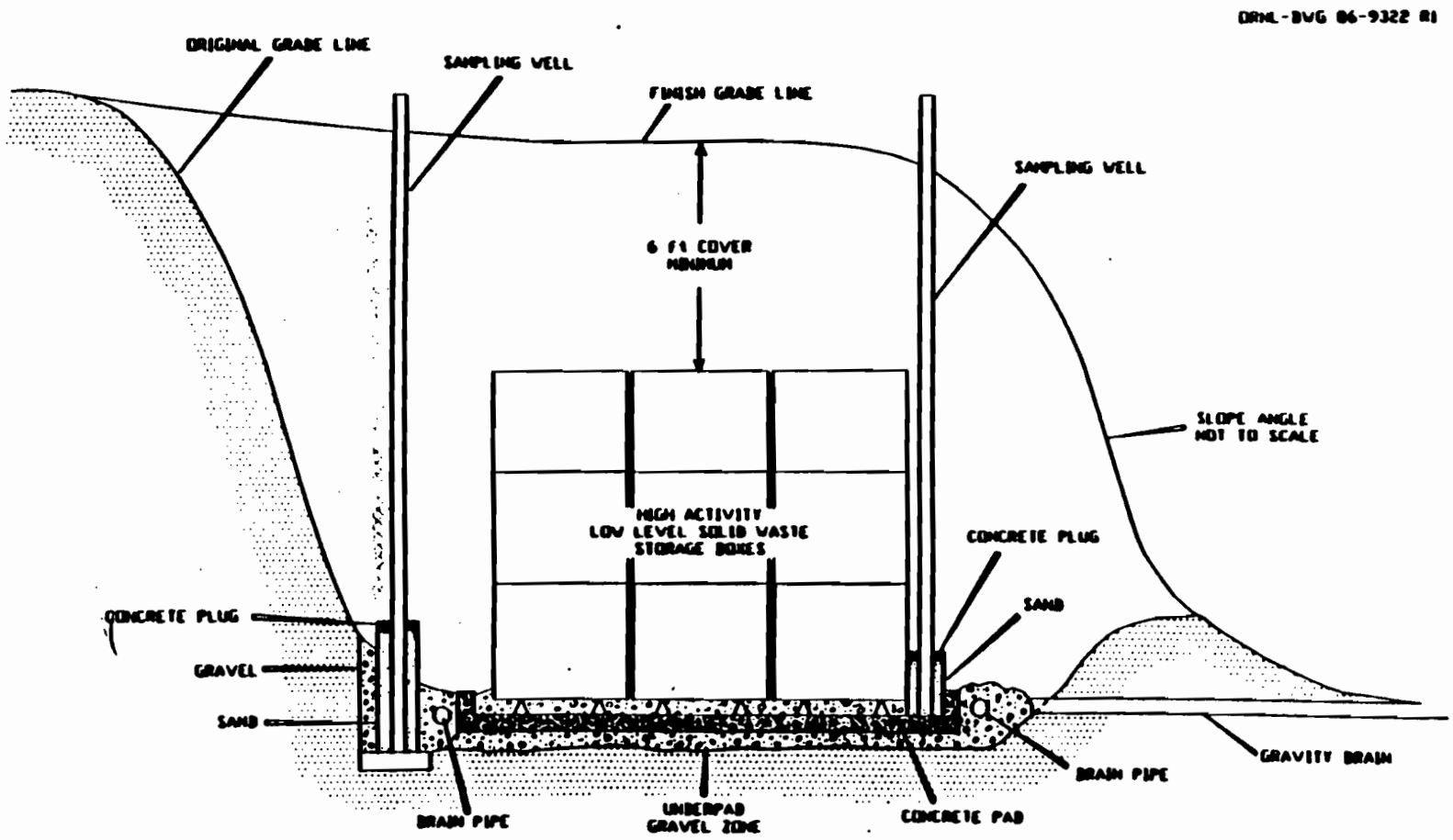


Fig. A.6. Schematic of Hillcut Disposal Test Facility.

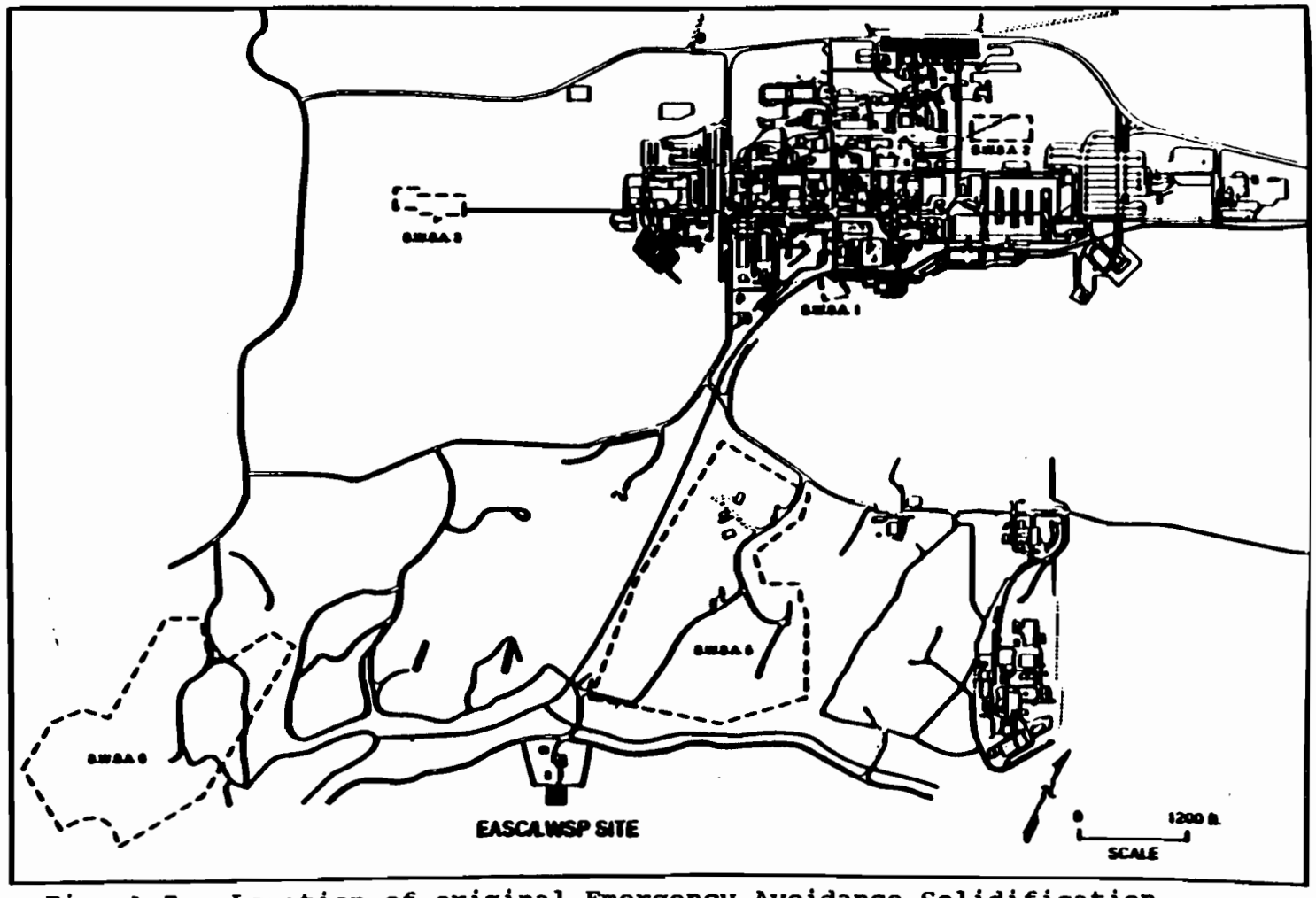


Fig. A.7. Location of original Emergency Avoidance Solidification Campaign/Liquid Waste Solidification Project cask storage area 7856

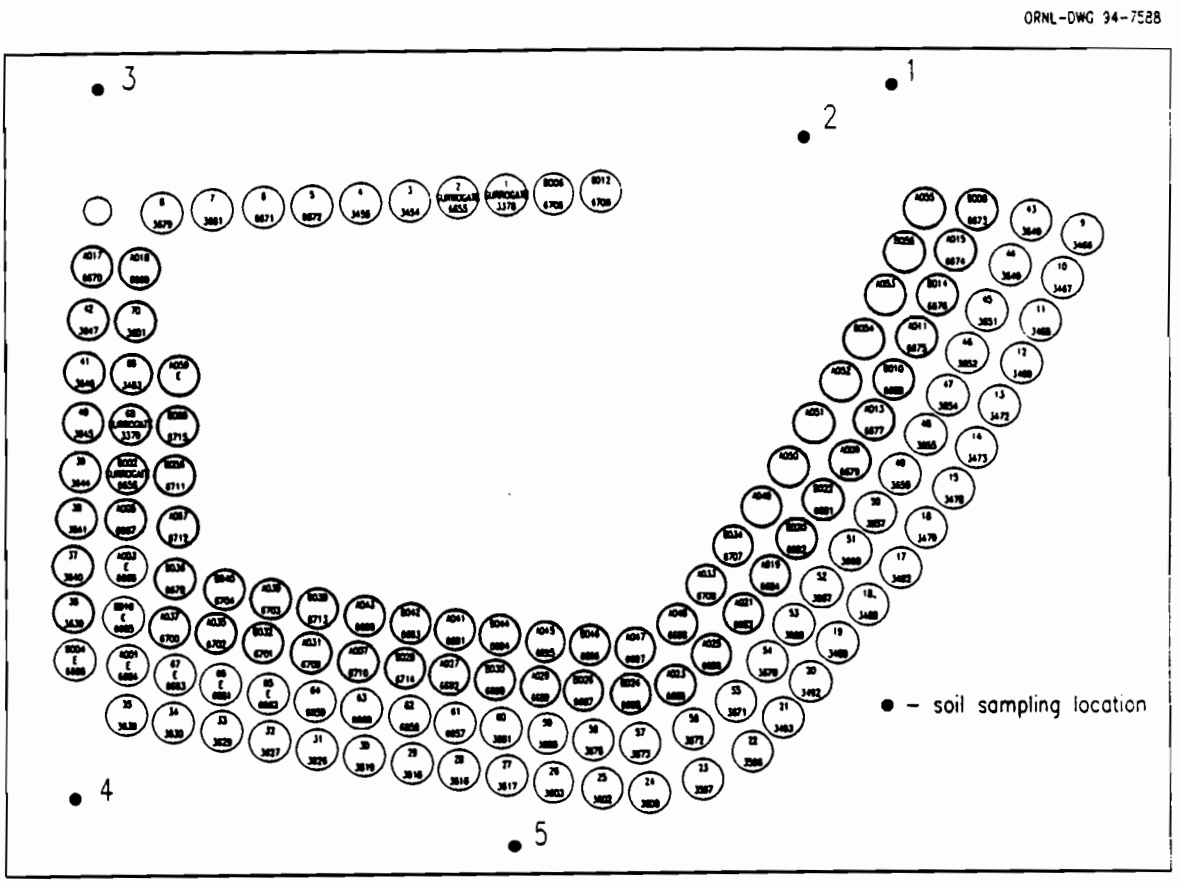


Fig. A.8. Arrangement of casks and location of soil sampling sites at the original Emergency Avoidance Solidification Campaign/Liquid Waste Solidification Project cask storage area 7856.

ORNL-DWG 93M-15138

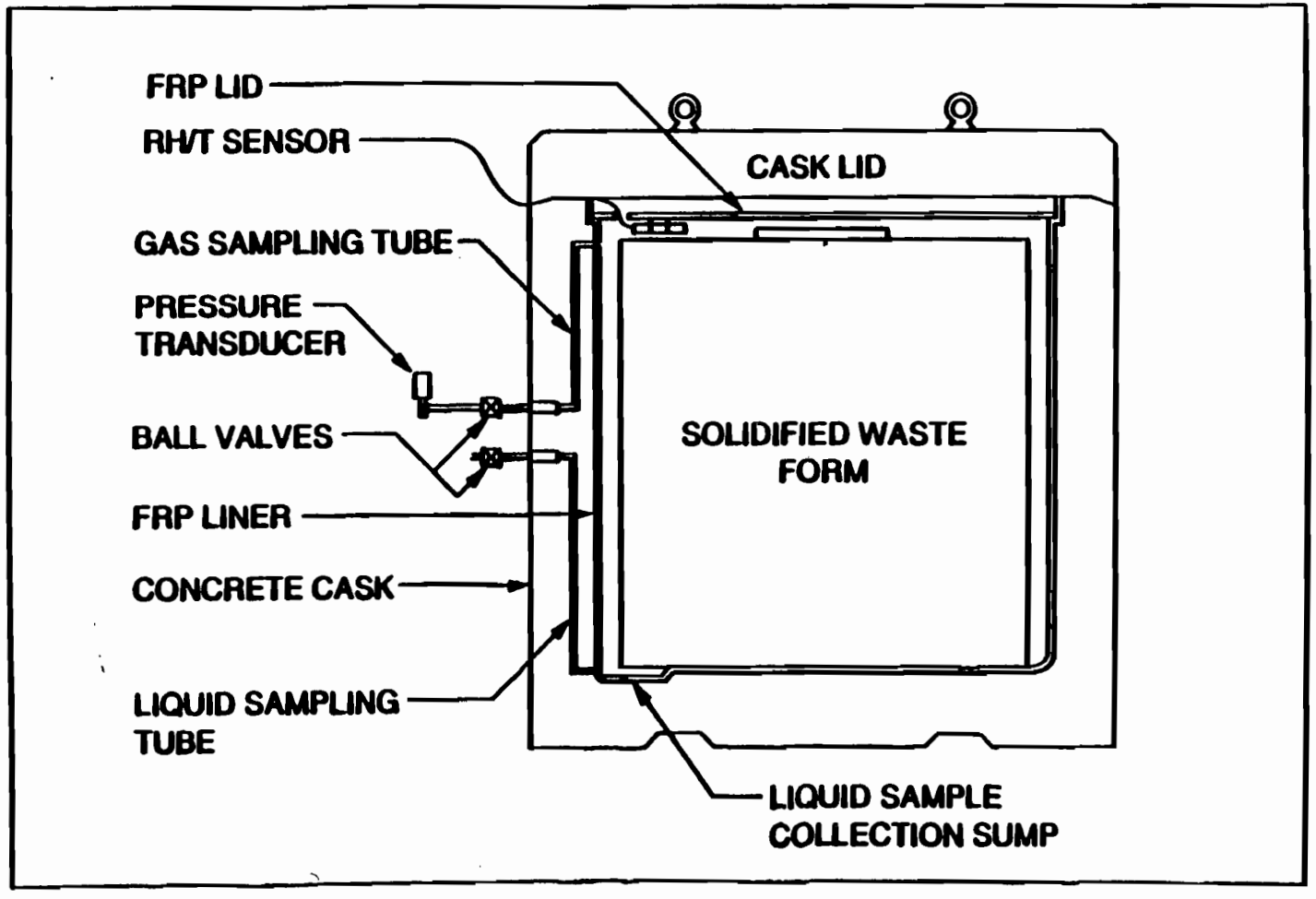


Fig. A.9. Emergency Avoidance Solidification Campaign/Liquid Waste Solidification Project waste storage casks.

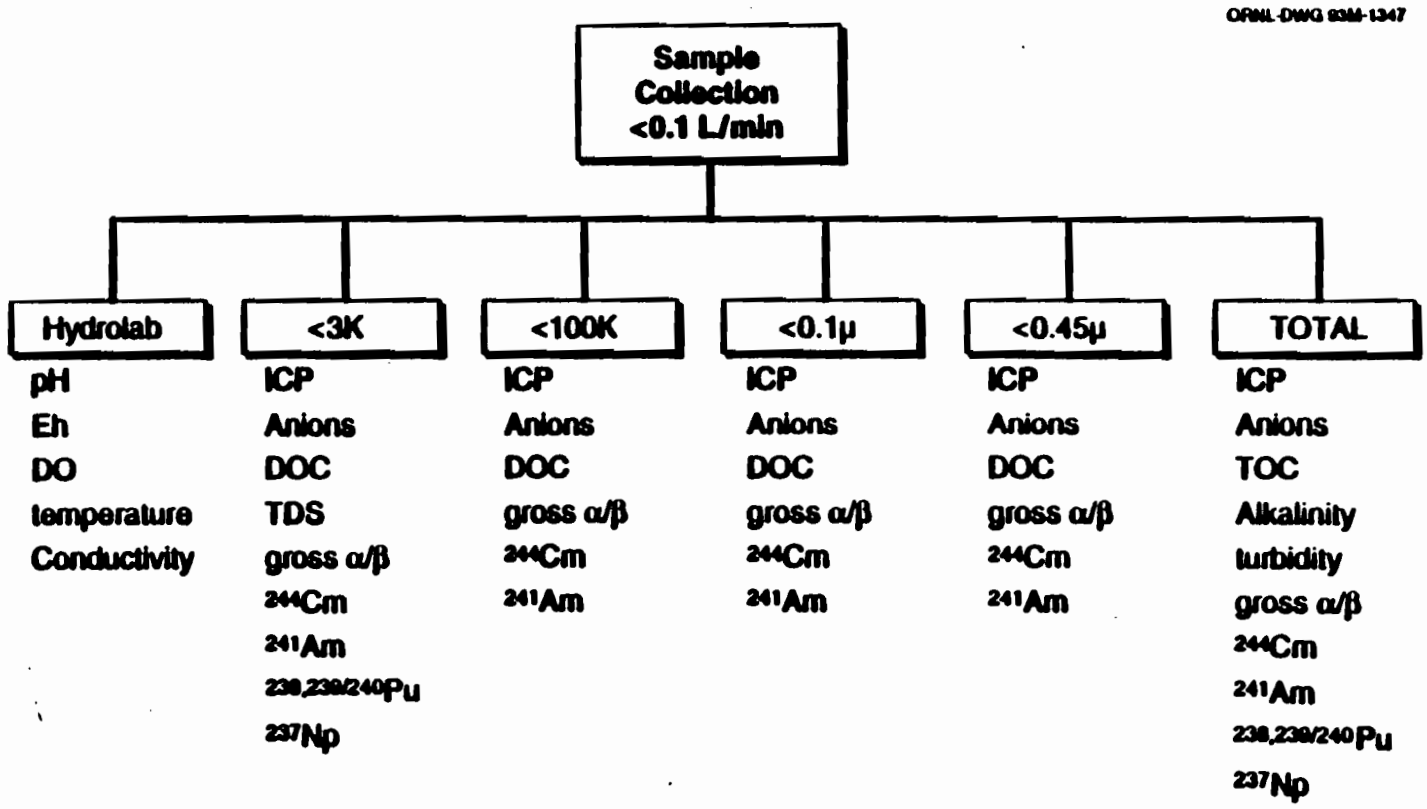


Fig. A.10. Colloidal sampling scheme for well 516 in Solid Waste Storage Area 6.

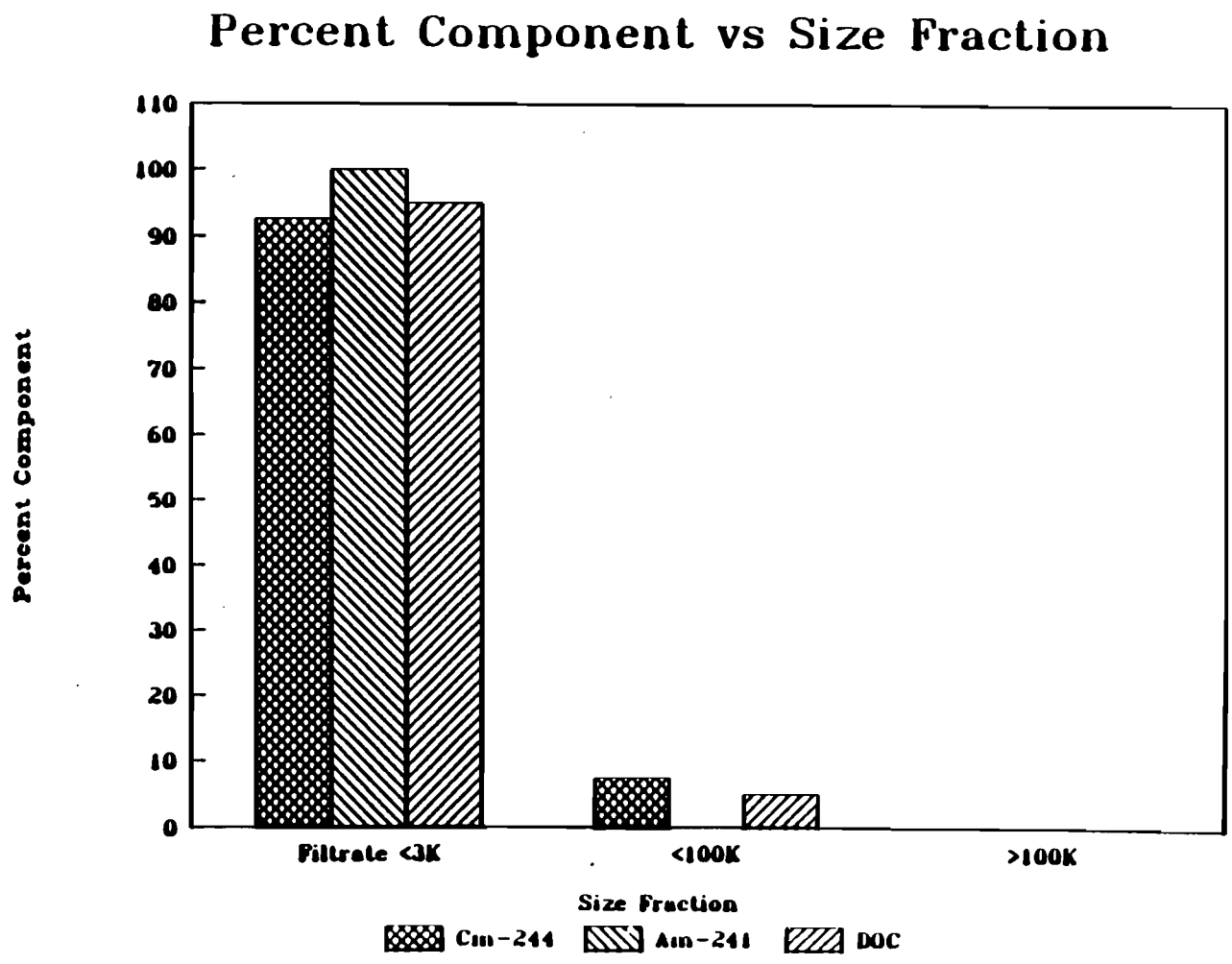


Fig. A.11. Percent component vs. size fraction for well 516 in Solid Waste Storage Area 5 North.

APPENDIX B: TABLES

Table B.1. Radionuclide data from the tumulus underpad drains[a]

Sample #[b]	Date	Gross Alpha	Gross Beta[c]	^{40}K	^{60}Co	^{137}Cs	^{3}H
TUMI–UND	10/28/92	0.064 ± 0.032	0.14 ± 0.06		−0.05 ± 0.15	−0.05 ± 0.12	330 ± 30
TUMI–UND	03/04/93	0.017 ± 0.025	0.40 ± 0.08		0.02 ± 0.06	0.10 ± 0.03	590 ± 25
TUMI–UND	07/15/93						470 ± 20
TUMII–UND	10/28/92	0.096 ± 0.037	0.06 ± 0.05		0.03 ± 0.08	0.04 ± 0.06	210000 ± 5000
TUMII–UND	03/04/93	0.079 ± 0.036	0.01 ± 0.05		0.06 ± 0.10	0.01 ± 0.20	350000 ± 5000
TUMII–UND	07/15/93						100000 ± 5000
TUMI–PWT	11/02/92	0.027 ± 0.025	0.16 ± 0.06		0.046 ± 0.048	−0.01 ± 0.06	1100 ± 50

[a] Radionuclide data are in Becquerel per liter, mean ± 1 standard error (counting error only); blank spaces indicate data not reported by Analytical Chemistry Division.
[b] TUMI = Tumulus I pad; TUMII = Tumulus II pad; UND = underpad; PWT = perched water table.
[c] Gross beta analysis does not include tritium.

Table B.2. Tumulus underpad water cation and anion data[a]

Sample #[b]	Date	Al	B	Ba	Ca	Cr	Fe	K	Li	Mg	Mn
TUMI–UND	10/18/92		0.17	0.061	11			15	0.001	42	
TUMII–UND	10/18/92	0.05		0.074	86			4.1	0.004	26	0.002

Sample #[b]	Date	Na	P	Si	Sn	Sr	V	Zn	Cl	NO_3	SO_4
TUMI–UND	10/18/92	7.7		2.9		0.7			17		265
TUMII–UND	10/18/92	4.6		1.8		0.5		0.01	2.1	3.9	149

[a] All data are in milligrams per liter; blank spaces indicate data not reported by Analytical Chemistry Division.
[b] TUMI=Tumulus I; TUMII=Tumulus II; UND = underpad.

Table B.3. Tumulus monitoring wells radionuclide data[a]

Well #	Date	Gross Alpha	Gross Beta[b]	^{60}Co	^{137}Cs
1036	10/06/92	0.10 ± 0.06	0.18 ± 0.10	0.11 ± 0.12	0.01 ± 0.10
1037	10/06/92	0.051 ± 0.037	0.21 ± 0.10	−0.02 ± 0.09	0.01 ± 0.09
1038	10/06/92	0.08 ± 0.06	0.14 ± 0.09	0.04 ± 0.11	0.04 ± 0.09
1039	10/06/92	0.13 ± 0.07	0.22 ± 0.11	0.07 ± 0.13	−0.07 ± 0.14
1040	10/06/92	0.09 ± 0.06	0.04 ± 0.08	−0.02 ± 0.11	0.01 ± 0.08
1254	10/06/92	0.11 ± 0.06	0.07 ± 0.09	0.03 ± 0.08	0.05 ± 0.06
1255	10/06/92	0.08 ± 0.05	0.16 ± 0.10	0.15 ± 0.12	0.03 ± 0.10
1256	10/06/92	0.005 ± 0.035	0.04 ± 0.08	−0.02 ± 0.09	0.01 ± 0.07
1257	10/06/92	0.10 ± 0.06	0.05 ± 0.10	0.03 ± 0.08	0.05 ± 0.06
1258	10/06/92	0.038 ± 0.045	0.12 ± 0.09	0.03 ± 0.09	0.06 ± 0.06
1259	10/06/92	0.057 ± 0.041	0.07 ± 0.10	0.02 ± 0.14	0.06 ± 0.15
1036	12/09/92	0.037 ± 0.026	0.18 ± 0.06	0.01 ± 0.07	0.02 ± 0.05
1037	12/09/92	0.18 ± 0.05	0.40 ± 0.08	−0.11 ± 0.13	−0.01 ± 0.09
1038	12/09/92	0.12 ± 0.04	0.71 ± 0.10	0.14 ± 0.10	0.09 ± 0.09
1039	12/09/92	0.16 ± 0.05	0.38 ± 0.07	0.05 ± 0.06	0.01 ± 0.06
1040	12/09/92	0.016 ± 0.024	0.28 ± 0.07	0.15 ± 0.08	0.01 ± 0.11
1254	12/09/92	0.12 ± 0.04	0.26 ± 0.08	0.04 ± 0.08	0.01 ± 0.08
1255	12/09/92	−0.011 ± 0.014	0.03 ± 0.06	−0.04 ± 0.11	0.04 ± 0.09
1256	12/09/92	−0.018 ± 0.004	0.08 ± 0.06	−0.01 ± 0.11	−0.06 ± 0.11
1257	12/09/92	0.024 ± 0.024	0.26 ± 0.06	0.03 ± 0.08	−0.03 ± 0.08
1258	12/09/92	0.058 ± 0.030	0.10 ± 0.06	0.03 ± 0.08	0.05 ± 0.07
1259	12/09/92	0.073 ± 0.034	0.40 ± 0.07	−0.04 ± 0.07	−0.02 ± 0.06

[a] Data in Becquerel per liter ± 1 standard error (counting error only).
[b] Gross beta activity does not include tritium.

Table B.4. History of tritium activity in the tumulus groundwater monitoring wells[a]

Date	Tumulus I wells					
	1035[b]	*1036*	*1037*	*1038*	*1039*	*1040*
Jun-87	100 ± 20	31 ± 15	63 ± 20	46 ± 17	81 ± 16	51 ± 17
Aug-87	100 ± 20	18 ± 12	36 ± 20	72 ± 25	59 ± 14	47 ± 12
Dec-87	82 ± 18	45 ± 16	67 ± 16	61 ± 16	90 ± 16	65 ± 16
Mar-88	95 ± 18	54 ± 16	44 ± 15	64 ± 18	73 ± 16	72 ± 18
Jun-66	120 ± 30	57 ± 16	46 ± 14	54 ± 16	65 ± 16	72 ± 18
Sep-88	110 ± 16	370 ± 30	27 ± 10	75 ± 14	55 ± 24	46 ± 12
Jan-89	55 ± 10	1800 ± 50	40 ± 10	30 ± 10	81 ± 24	40 ± 13
Mar-89	81 ± 12	3600 ± 50	25 ± 12	36 ± 10	220 ± 20	60 ± 14
Jun-89	90 ± 13	5800 ± 50	48 ± 13	62 ± 11	420 ± 25	71 ± 13
Sep-89	120 ± 18	6250 ± 50	73 ± 18	70 ± 15	370 ± 20	70 ± 15
Dec-89		5700 ± 100	56 ± 22	54 ± 22	390 ± 25	79 ± 24
May-90		8400 ± 100	60 ± 16	74 ± 16	650 ± 25	74 ± 17
Jun-90		8000 ± 100	67 ± 18	67 ± 18	600 ± 25	68 ± 18
Mar-91		10000 ± 500	64 ± 11	99 ± 20	290 ± 25	83 ± 19
Jul-91		11000 ± 500	410 ± 20	170 ± 20	400 ± 20	75 15
Sep-91		11000 ± 500	470 ± 20	170 ± 20	510 ± 20	70 ± 15
Jan-92		14000 ± 500	5600 ± 50	260 ± 20	320 ± 20	0 ± 16
Apr-92		14000 ± 500	2700 ± 50	580 ± 20	460 ± 20	66 ± 14
Jul-92		14000 ± 500	2300 ± 50	1300 ± 50	1200 ± 50	84 ± 21
Oct-92		16000 ± 500	19000 ± 500	1500 ± 150	1900 ± 150	6600 ± 50
Dec-92		15000 ± 500	2200 ± 50	1800 ± 50	2100 ± 50	120 ± 15
Dec-92[c]		17000 ± 500	2400 ± 50	1700 ± 50	2000 ± 50	130 ± 15

Table B.4 (continued)

	Tumulus II wells					
Date	*1254*	*1255*	*1256*	*1257*	*1258*	*1259*
Jun-90	26 ± 16	150 ± 20	120 ± 20	190 ± 20	270 ± 20	71 ± 18
Mar-91	22 ± 14	93 ± 12	120 ± 15	150 ± 15	200 ± 15	570 ± 25
Jul-91	25 ± 15	140 ± 20	410 ± 20	160 ± 20	170 ± 20	100 ± 15
Sep-91	40 ± 13	110 ± 15	150 ± 15	160 ± 15	130 ± 15	18 ± 25
Jan-92	-83 ± 15	51 ± 17	140 ± 20	130 ± 20	320 ± 20	71 ± 17
Apr-92	-19 ± 6	100 ± 15	180 ± 15	160 ± 15	510 ± 20	250 ± 15
Jul-92	9 ± 14	110 ± 15	230 ± 15	170 ± 15	690 ± 25	340 ± 20
Oct-92	15000 ± 500	1200 ± 50	280 ± 15	580 ± 20	1100 ± 50	1000 ± 50
Dec-92	20 ± 13	140 ± 15	280 ± 15	200 ± 15	820 ± 25	1400 ± 50
Dec-92[c]	52 ± 13	290 ± 15	280 ± 15	230 ± 15	1300 ± 50	640 ± 25

[a] Data are in Becquerel per liter ± 1 standard error (counting error only).
[b] Well 1035 was plugged and abandoned during construction of Tumulus II.
[c] Archive sample analyzed Feb-93.

Table B.5. Radionuclide and total organic carbon data from the Interim Waste Managment Facility pad runoff[a]

Sample #[b]	Date	Gross Alpha	Gross Beta[c]	^{40}K	^{60}Co	^{137}Cs	^{3}H	TOC[d]
IWMF Pad 1:								
IWMF-044	10/05/92	−0.012 ± 0.026	1.6 ± 0.2		−0.02 ± 0.10	0.04 ± 0.08	75 ± 12	2.7
IWMF-045	10/05/92	0.026 ± 0.034	0.18 ± 0.10		0.11 ± 0.08	0.10 ± 0.06		
IWMF-046	10/09/92	0.043 ± 0.032	4.2 ± 0.2		−0.02 ± 0.08	0.005 ± 0.050	360 ± 20	6.2
IWMF-047	10/09/92	0.028 ± 0.020	−0.01 ± 0.05		0.05 ± 0.10	0.03 ± 0.08		
IWMF-048	10/19/92	0.063 ± 0.032	4.2 ± 0.2		0.02 ± 0.08	0.06 ± 0.07	370 ± 20	7.2
IWMF-049	10/19/92	0.017 ± 0.021	0.01 ± 0.05		−0.07 ± 0.12	0.05 ± 0.11		
IWMF-050	10/28/92	−0.003 ± 0.013	2.2 ± 0.2		0.14 ± 0.08	0.11 ± 0.08		5.1
IWMF-051	10/28/92	0.058 ± 0.030	0.05 ± 0.06		−0.18 ± 0.22	0.12 ± 0.14		
IWMF-052	11/05/92	0.078 ± 0.036	2.4 ± 0.2		−0.08 ± 0.12	−0.03 ± 0.09		4.9
IWMF-053	11/05/92	0.23 ± 0.21	0.42 ± 0.08		0.01 ± 0.10	−0.04 ± 0.08		
IWMF-054	11/13/92	0.11 ± 0.04	2.0 ± 0.2		0.06 ± 0.10	0.08 ± 0.10		1.9
IWMF-055	11/13/92	0.081 ± 0.034	0.29 ± 0.07		0.04 ± 0.06	−0.02 ± 0.06		
IWMF-056	11/24/92	0.075 ± 0.031	0.95 ± 0.10		0.06 ± 0.09	0.18 ± 0.06		
IWMF-058	12/05/92	0.16 ± 0.05	2.2 ± 0.2		−0.01 ± 0.10	−0.02 ± 0.10		
IWMF-060	12/10/92	0.17 ± 0.05	2.6 ± 0.2		−0.09 ± 0.10	0.02 ± 0.08	120 ± 15	
IWMF-062	12/18/92	0.011 ± 0.019	2.7 ± 0.2		0.01 ± 0.08	0.02 ± 0.06		4.3
IWMF-063	12/18/92	0.020 ± 0.025	0.13 ± 0.06		−0.04 ± 0.12	−0.04 ± 0.12		
IWMF-064	12/21/92	0.014 ± 0.010	0.73 ± 0.06		0.03 ± 0.06	0.007 ± 0.045		3.1
IWMF-065	12/21/92	0.004 ± 0.006	0.026 ± 0.023		0.02 ± 0.14	0.04 ± 0.12		
IWMF-066	12/22/92	−0.001 ± 0.006	0.71 ± 0.05		0.03 ± 0.09	0.05 ± 0.07		3.0
IWMF-067	12/22/92	0.004 ± 0.007	0.10 ± 0.03		−0.03 ± 0.11	0.03 ± 0.08		
IWMF-068	12/23/92	0.006 ± 0.010	1.2 ± 0.0		0.18 ± 0.06	0.11 ± 0.07		3.1
IWMF-069	12/23/92	0.018 ± 0.010	0.055 ± 0.024		0.07 ± 0.09	0.16 ± 0.06		
IWMF-070	12/28/92	0.076 ± 0.035	2.6 ± 0.2		0.02 ± 0.10	−0.01 ± 0.08		1.6
IWMF-071	12/28/92	0.039 ± 0.028	1.8 ± 0.2		−0.02 ± 0.08	0.019 ± 0.044		
IWMF-072	01/05/93	0.025 ± 0.025	2.0 ± 0.2		0.23 ± 0.09	0.05 ± 0.09		1.6
IWMF-073	01/05/93	−0.009 ± 0.013	0.21 ± 0.07		−0.07 ± 0.12	0.12 ± 0.10		

Table B.5 (continued)

Sample #[b]	Date	Gross Alpha	Gross Beta[c]	^{40}K	^{60}Co	^{137}Cs	^{3}H	TOC[d]
IWMF-074	01/08/93	0.021 ± 0.026	97 ± 1		0.02 ± 0.10	0.12 ± 0.10		2.9
IWMF-074A[e]	01/08/93	0.060 ± 0.035	2.5 ± 0.2		0.02 ± 0.10	0.07 ± 0.08		
IWMF-075	01/08/93	−0.015 ± 0.011	2.0 ± 0.2		0.10 ± 0.07	0.05 ± 0.08		
IWMF-076	01/11/93	0.005 ± 0.014	3.0 ± 0.2		0.13 ± 0.15	0.08 ± 0.13		2.3
IWMF-077	01/11/93	0.53 ± 0.08	1.3 ± 0.1		0.17 ± 0.10	−0.01 ± 0.10		
IWMF-078	01/12/93	0.24 ± 0.06	2.6 ± 0.2		0.01 ± 0.07	0.01 ± 0.07		2.4
IWMF-079	01/12/93	0.16 ± 0.05	1.0 ± 0.1		0.17 ± 0.09	0.01 ± 0.11		
IWMF-080	01/19/93	0.024 ± 0.024	3.0 ± 0.2		0.08 ± 0.10	0.04 ± 0.09		2.5
IWMF-081	01/19/93	−0.002 ± 0.013	0.59 ± 0.09		0.11 ± 0.06	0.02 ± 0.06		
IWMF-082	01/21/93	0.028 ± 0.033	4.5 ± 0.2		−0.10 ± 0.13	−0.06 ± 0.12		11.4
IWMF-083	01/21/93	0.019 ± 0.024	0.12 ± 0.06		0.13 ± 0.08	0.06 ± 0.07		
IWMF-084	01/22/93	0.036 ± 0.026	3.4 ± 0.2		0.03 ± 0.06	0.01 ± 0.08		2.9
IWMF-085	01/22/93	0.065 ± 0.030	0.36 ± 0.08		0.09 ± 0.05	−0.01 ± 0.06		
IWMF-086	01/25/93	0.074 ± 0.038	3.0 ± 0.2		0.13 ± 0.11	0.01 ± 0.11		3.0
IWMF-087	01/25/93	0.026 ± 0.024	0.10 ± 0.07		0.10 ± 0.07	0.02 ± 0.08		
IWMF-088	02/02/93	0.085 ± 0.036	18 ± 0		−0.07 ± 0.10	0.01 ± 0.08		1.7
IWMF-088A[e]	02/02/93	−0.033 ± 0.006	1.6 ± 0.1		0.07 ± 0.08	0.54 ± 0.11		
IWMF-089	02/02/93	0.022 ± 0.026	1.0 ± 0.1		0.09 ± 0.10	0.12 ± 0.08		
IWMF-090	02/12/93	0.009 ± 0.028	3.2 ± 0.2		0.11 ± 0.06	0.02 ± 0.08		7.0
IWMF-091	02/12/93	0.038 ± 0.027	0.04 ± 0.05		0.12 ± 0.09	−0.03 ± 0.09		
IWMF-092	02/19/93	0.003 ± 0.022	2.3 ± 0.2		−0.03 ± 0.07	0.01 ± 0.06		4.0
IWMF-093	02/19/93	−0.002 ± 0.012	0.043 ± 0.046		0.03 ± 0.20	0.03 ± 0.10		
IWMF-094	03/08/93	0.024 ± 0.030	2.2 ± 0.2		0.13 ± 0.09	0.27 ± 0.06	62 ± 28	
IWMF-095	03/08/93	0.021 ± 0.022	0.03 ± 0.06		−0.13 ± 0.12	0.04 ± 0.09		
IWMF-096	03/17/93	0.053 ± 0.032	1.5 ± 0.1		0.04 ± 0.06	0.096 ± 0.042		3.0
IWMF-097	03/17/93	0.10 ± 0.04	0.10 ± 0.06		0.02 ± 0.12	0.10 ± 0.10		
IWMF-098	03/24/93	0.038 ± 0.028	1.7 ± 0.2		−0.10 ± 0.16	0.13 ± 0.12		7.2
IWMF-099	03/24/93	0.009 ± 0.017	0.14 ± 0.06		−0.07 ± 0.10	−0.06 ± 0.08		

Table B.5 (continued)

Sample #[b]	Date	Gross Alpha	Gross Beta[c]	^{40}K	^{60}Co	^{137}Cs	^{3}H	TOC[d]
IWMF-100	03/29/93	0.055 ± 0.033	1.9 ± 0.2		0.11 ± 0.11	0.09 ± 0.10		3.6
IWMF-101	03/29/93	0.045 ± 0.026	0.94 ± 0.09		0.04 ± 0.07	0.02 ± 0.07		
IWMF-102	04/06/93	−0.020 ± 0.015	2.2 ± 0.2		−0.11 ± 0.12	0.11 ± 0.08		3.3
IWMF-103	04/06/93	0.010 ± 0.017	0.05 ± 0.05		0.02 ± 0.08	0.06 ± 0.06		
IWMF-104	04/14/93	0.018 ± 0.019	1.4 ± 0.1		0.01 ± 0.12	0.10 ± 0.12		2.3
IWMF-105	04/14/93	0.010 ± 0.017	0.03 ± 0.05		0.11 ± 0.10	0.06 ± 0.12		
IWMF-106	04/19/93	0.037 ± 0.027	2.8 ± 0.2		−0.07 ± 0.17	0.03 ± 0.13		4
IWMF-107	04/19/93	0.10 ± 0.04	3.0 ± 0.2		−0.01 ± 0.10	0.03 ± 0.06		
IWMF-108	04/22/93	0.031 ± 0.028	1.3 ± 0.1		−0.13 ± 0.13	0.18 ± 0.08		3.6
IWMF-109	04/22/93	0.058 ± 0.030	0.05 ± 0.06		0.08 ± 0.10	0.51 ± 0.09		
IWMF-110	05/11/93	0.045 ± 0.032	1.5 ± 0.1		−0.12 ± 0.16	−0.09 ± 0.16		5.2
IWMF-111	05/11/93	0.027 ± 0.025	0.13 ± 0.06		0.07 ± 0.08	0.05 ± 0.06		
IWMF-112	05/20/93	0.025 ± 0.032	2.8 ± 0.2		−0.02 ± 0.07	0.04 ± 0.05		4.1
IWMF-113	05/20/93	0.10 ± 0.04	0.09 ± 0.06		0.05 ± 0.11	0.07 ± 0.10		
IWMF-114	05/28/93	0.046 ± 0.032	2.5 ± 0.2		0.02 ± 0.15	0.04 ± 0.07		5.07
IWMF-115	05/28/93	−0.032 ± 0.014	0.020 ± 0.097		0.14 ± 0.09	−0.02 ± 0.10		
IWMF-116	06/02/93	0.031 ± 0.027	1.9 ± 0.1		0.09 ± 0.09	0.07 ± 0.08		4.19
IWMF-117	08/02/93	−0.028 ± 0.013	−0.026 ± 0.005		0.07 ± 0.06	−0.01 ± 0.06		
IWMF-118	07/01/93	0.16 ± 0.07	6.6 ± 0.2		0.01 ± 0.07	−0.01 ± 0.07		
IWMF-118A[e]	07/01/93	0.024 ± 0.044	8.0 ± 0.2	5.8 ± 1.4	0.05 ± 0.09	−0.02 ± 0.09		
IWMF-120	07/16/93	0.073 ± 0.042	3.4 ± 0.2	2.8 ± 1.0	−0.01 ± 0.12	0.17 ± 0.07	30 ± 14	
IWMF-121	07/16/93	0.044 ± 0.030	0.09 ± 0.05		−0.02 ± 0.12	0.05 ± 0.10		
IWMF-122	07/29/93	0.019 ± 0.028	3.2 ± 0.2	2.9 ± 1.1	−0.02 ± 0.10	0.01 ± 0.07		3.44
IWMF-123	07/29/93	0.012 ± 0.024	0.05 ± 0.06		0.10 ± 0.08	−0.01 ± 0.10		
IWMF-124	08/13/93	0.048 ± 0.038	2.2 ± 0.2		−0.11 ± 0.16	0.41 ± 0.10		2.9
IWMF-125	08/13/93	0.005 ± 0.025	0.21 ± 0.06		0.16 ± 0.08	0.23 ± 0.10		
IWMF-126	08/18/93	0.008 ± 0.024	1.5 ± 0.1	2.0 ± 1.2	−0.02 ± 0.12	0.07 ± 0.10		4.5
IWMF-127	08/18/93	−0.012 ± 0.035	0.07 ± 0.06	1.1 ± 1.1	0.19 ± 0.08	0.02 ± 0.12		

Table B.5 (continued)

Sample #[b]	Date	Gross Alpha	Gross Beta[c]	^{40}K	^{60}Co	^{137}Cs	^{3}H	TOC[d]
IWMF-128	09/14/93	0.093 ±	2.1 ±		−0.02 ±	−0.08 ±		2.6
IWMF-129	09/14/93	0.11 ±	0.12 ±		0.09 ±	−0.13 ±		
IWMF-130	09/16/93	0.066 ±	1.9 ±		0.27 ±	0.32 ±		5.14
IWMF-131	09/16/93	0.002 ±	0.19 ±		0.10 ±	0.01 ±		
IWMF-132	09/24/93	0.13 ± 0.05	1.2 ± 0.1		0.03 ± 0.09	−0.06 ± 0.10		3.1
IWMF-133	09/24/93	0.056 ± 0.032	0.12 ± 0.05		0.09 ± 0.09	0.03 ± 0.09		
IWMF-134	09/27/93	0.055 ±	2.1 ±		0.02 ±	−0.01 ±		3.5
IWMF-135	09/27/93	0.012 ±	0.13 ±		0.09 ±	0.10 ±		
IWMF Pad 2:								
IWMF2-002	07/01/93	0.003 ± 0.024	3.4 ± 0.2		0.05 ± 0.10	0.04 ± 0.09		

[a] Radionuclide data are in Becquerel per liter, mean ± 1 standard error (counting error only); total organic carbon data in milligram per liter; blank spaces indicated data not reported by Analytical Chemistry Division; boldface indicates data that exceeds an action level.
[b] IWMF = Interim Waste Management Facility; odd sample numbers are blanks.
[c] Gross beta analysis does not include tritium.
[d] TOC = total organic carbon.
[e] Archived sample submitted for analysis after original sampling date.

Table B.6. Interim Waste Management Facility pad water cation and anion data[a]

Sample #[b]	Date	Al	B	Ba	Ca	Cr	Fe	K	Li	Mg	Mn
IWMF-042	10/22/92	0.10		0.003	4.1	0.006	0.16	70	0.029	0.20	0.007
IWMF-058	12/05/92	0.14		0.004	7.5	0.012	0.54	96	0.031	0.37	0.014
IWMF-060	12/10/92	0.08		0.005	12	0.013	0.18	110	0.040	0.47	0.014
IWMF-118	07/01/93			0.012	22	0.005	0.11	250	0.066	0.82	0.013
IWMF-120	07/16/93			0.002	4.9	0.016		110	0.047	0.29	0.003
IWMF pad 2[c]	10/18/92	0.06		0.002	8.9			11	0.003	0.28	0.001
IWMFII-002	07/01/93			0.003	4.2	0.017	0.16	180	0.066	0.37	0.023

Sample #[b]	Date	Na	P	Si	Sn	Sr	V	Zn	Cl	NO_3	SO_4
IWMF-042	10/22/92	9.4		4.7	0.063		0.006	0.02	5.7	1.1	14.3
IWMF-058	12/05/92	11		5.1		0.017	0.017	0.12	3.7	1.4	17.2
IWMF-060	12/10/92	14		5.3		0.027	0.017	0.13	3.5	2.6	18.7
IWMF-118	07/01/93	29		11		0.043	0.021	0.06	4.9	3.5	20
IWMF-120	07/16/93	12		10		0.010	0.037	0.05	3.9	3.7	20
IWMF pad 2[c]	10/18/92	1.3		4.7				0.02		1.4	3.0
IWMFII-002	07/01/93	19	0.44	14		0.012	0.044	0.06	9.8	4.4	45

[a] All data are in milligrams per liter.
[b] IWMF = Interim Waste Management Facility.
[c] Sample collected from IWMF pad 2 prior to loading of waste.

Table B.7. Radionuclide data from low-level-waste silos intratrench well samples in Solid Waste Storage Area 6[a]

Well No.	Date	Gross Alpha	Gross Beta	^{137}Cs	^{60}Co
4	02/05/93	0.01 ± 0.19	0.24 ± 0.62	1.3 ± 4.9	0.9 ± 5.5
6	08/31/92	0.15 ± 0.13	1.5 ± 0.4	−0.3 ± 2.4	−0.9 ± 3.0
6	11/20/92	0.10 ± 0.08	0.93 ± 0.21	0.9 ± 1.9	−0.4 ± 2.1
6	02/05/93	0.13 ± 0.14	0.28 ± 0.25	−0.8 ± 2.6	0.7 ± 1.8
10	08/28/92	0.12 ± 0.14	1.1 ± 0.4	−1.7 ± 3.8	0.8 ± 2.6
10	02/05/93	0.032 ± 0.047	0.35 ± 0.14	−0.5 ± 2.5	−0.8 ± 2.6
11	08/28/92	0.057 ± 0.066	0.38 ± 0.17	−0.7 ± 2.8	0.3 ± 2.6
11	11/18/92	0.34 ± 0.20	1.4 ± 0.4	0.24 ± 0.45	0.07 ± 0.56
11	02/05/93	0.079 ± 0.073	0.14 ± 0.11	−0.1 ± 2.2	−0.8 ± 2.8
13	08/28/92	0.56 ± 0.36	4.3 ± 0.8	−1.3 ± 5.5	1.0 ± 4.2
15	08/28/92	0.063 ± 0.072	0.47 ± 0.17	−0.2 ± 2.7	0.4 ± 2.2
15	11/18/92	0.056 ± 0.065	0.71 ± 0.19	0.03 ± 0.14	0.07 ± 0.17
15	02/05/93	−0.010 ± 0.028	0.25 ± 0.14	0.14 ± 0.38	0.04 ± 0.32
16	02/05/93	0.23 ± 0.27	0.56 ± 0.60	−0.9 ± 6.8	−1.7 ± 7.5
17[a]	08/92–02/93	0.029 ± 0.057	0.50 ± 0.17	0.10 ± 0.26	0.05 ± 0.28
19	11/18/92	−0.01 ± 0.11	16 ± 1	4.7 ± 4.7	6.7 ± 5.9
19	02/05/93	0.11 ± 0.22	11 ± 1	−0.9 ± 4.4	−0.5 ± 4.9
20	08/28/92	0.30 ± 0.36	4.5 ± 1.1	0.3 ± 7.8	−1.3 ± 8.5
20	02/05/93	0.067 ± 0.078	0.48 ± 0.16	0.6 ± 2.2	0.7 ± 2.4
21	08/28/92	0.56 ± 0.51	3.6 ± 1.4	−1 ± 11	1 ± 10
22	08/28/92	0.053 ± 0.054	0.36 ± 0.15	0.1 ± 2.8	−0.4 ± 2.8
22	11/18/92	0.053 ± 0.075	0.36 ± 0.19	0.08 ± 0.38	0.33 ± 0.29
22	02/05/93	0.024 ± 0.047	2.7 ± 0.3	0.3 ± 2.1	0.7 ± 2.2
23	02/05/93	−0.066 ± 0.026	0.52 ± 0.41	−0.4 ± 3.2	1.9 ± 2.4
25	08/28/92	0.041 ± 0.057	0.20 ± 0.15	−0.8 ± 3.1	−0.1 ± 2.5
25	11/18/92	0.054 ± 0.064	0.41 ± 0.16	−0.03 ± 0.26	0.01 ± 0.29
25	02/05/93	−0.026 ± 0.012	0.45 ± 0.32	0.01 ± 0.48	0.1 ± 0.4
27	08/31/92	0.067 ± 0.068	2.1 ± 0.3	−0.7 ± 3.1	−0.2 ± 2.6
27	11/20/92	0.10 ± 0.09	0.43 ± 0.23	0.01 ± 0.33	0.27 ± 0.35
27	02/11/93	0.24 ± 0.23	0.40 ± 0.34	−0.2 ± 3.0	1.2 ± 3.1
30	02/11/93	0.003 ± 0.065	0.17 ± 0.16	−0.10 ± 0.43	−0.11 ± 0.54

Table B.7 (continued)

Well No.	Date	Gross Alpha	Gross Beta	^{137}Cs	^{60}Co
31[b]	08/31, 09/23/92	0.080 ± 0.073	0.24 ± 0.16	0.18 ± 0.10	−0.01 ± 0.15
31[b]	11/92−02/93	0.003 ± 0.053	0.30 ± 0.20	0.20 ± 0.36	0.33 ± 0.21
32[b]	8/31−11/20/92	0.034 ± 0.050	1.1 ± 0.2	0.01 ± 0.10	−0.01 ± 0.12
35[b]	08/31, 09/23/92	0.036 ± 0.059	0.64 ± 0.17	0.11 ± 0.23	0.17 ± 0.18
35[b]	11/92−02/93	0.12 ± 0.12	0.37 ± 0.20	−0.07 ± 0.18	0.03 ± 0.18
36[b]	08/31, 09/23/92	0.026 ± 0.058	0.46 ± 0.16	0.06 ± 0.16	−0.01 ± 0.20
36[b]	11/92−02/93	0.12 ± 0.13	0.37 ± 0.22	0.03 ± 0.13	0.01 ± 0.15
38	09/02/92	−0.049 ± 0.013	1.5 ± 0.3	0.21 ± 0.35	0.01 ± 0.4
38	11/20/92	0.059 ± 0.060	1.9 ± 0.3	−0.08 ± 0.30	−0.07 ± 0.32
38	02/17/93	0.22 ± 0.20	1.9 ± 0.5	0.07 ± 0.39	0.01 ± 0.48
40	09/02/92	−0.016 ± 0.041	0.42 ± 0.19	−0.9 ± 3.1	−0.7 ± 2.5
40	11/20/92	0.069 ± 0.071	0.26 ± 0.14	0.06 ± 0.19	−0.10 ± 0.24
40	02/17/93	0.003 ± 0.060	0.13 ± 0.17	0.05 ± 0.19	0.04 ± 0.20
41	09/02/92	0.05 ± 0.28	1.7 ± 1.5	−1 ± 11	−2 ± 10
41	11/20/92	0.16 ± 0.18	0.38 ± 0.35	0.4 ± 5.5	−1.1 ± 6.2
41	02/17/93	−0.002 ± 0.010	0.62 ± 0.24	0.15 ± 0.23	0.20 ± 0.30
42	09/02/92	−0.006 ± 0.036	0.19 ± 0.16	0.03 ± 0.23	0.13 ± 0.22
42	11/20/92	−0.11 ± 0.04	2.4 ± 1.1	−0.4 ± 2.2	0.1 ± 2.6
42	02/17/93	0.076 ± 0.078	0.30 ± 0.15	0.14 ± 0.20	0.03 ± 0.21
43	09/02/92	0.081 ± 0.091	0.06 ± 0.16	0.84 ± 0.79	0.48 ± 0.65
43	11/20/92	0.09 ± 0.10	0.45 ± 0.23	0.47 ± 0.13	0.02 ± 0.23
43	02/17/93	0.054 ± 0.064	0.29 ± 0.13	0.11 ± 0.19	0.10 ± 0.21
44	09/02/92	−0.026 ± 0.010	0.40 ± 0.19	0.15 ± 0.54	0.16 ± 0.49
44	11/20/92	−0.023 ± 0.009	0.24 ± 0.18	0.01 ± 0.24	−0.05 ± 0.29
44	02/17/93	0.055 ± 0.066	0.13 ± 0.12	−0.06 ± 0.15	0.07 ± 0.14
45	09/02/92	0.29 ± 0.38	2.0 ± 0.9	1.1 ± 5.3	−0.2 ± 5.4
45	02/17/93	0.012 ± 0.042	0.34 ± 0.14	0.12 ± 0.12	0.18 ± 0.17
46	09/02/92	−0.044 ± 0.074	0.21 ± 0.30	0.8 ± 2.4	0.4 ± 2.2
46	11/20/92	0.017 ± 0.088	1.8 ± 0.5	0.04 ± 0.18	0.05 ± 0.27
46	02/17/93	0.094 ± 0.097	0.20 ± 0.16	0.08 ± 0.19	0.03 ± 0.15

[a] All data are in Becquerel per liter ± 1 standard error (counting error only).
[b] Composite sample.

Table B.8. Radionuclide data from backfill wells next to high-range wells, asbestos silos, and fissile wells in Solid Waste Storage Area 6[a]

Well No.	Date	Gross Alpha	Gross Beta	^{137}Cs	^{60}Co
AUG 48A[b]	11/92–02/93	0.13 ± 0.11	1.1 ± 0.2	0.91 ± 0.16	−0.11 ± 0.25
AUG 48B	02/23/93	0.25 ± 0.73	2.9 ± 1.8	0.9 ± 3.0	−1.1 ± 4.3
AUG 49	11/24/92	0.08 ± 0.16	0.52 ± 0.41	0.2 ± 2.1	−0.1 ± 2.8
AUG 49	02/23/93	0.01 ± 0.12	0.33 ± 0.22	−0.09 ± 0.36	−0.04 ± 0.45
AUG 50A[b]	09/92–02/93	0.15 ± 0.21	1.1 ± 0.4	0.35 ± 0.13	0.04 ± 0.21
AUG 50B	02/23/93	0.026 ± 0.067	0.14 ± 0.12	0.01 ± 0.12	0.03 ± 0.13
AUG W540	11/24/92	0.09 ± 0.19	0.40 ± 0.46	0.1 ± 2.6	0.1 ± 2.3
AUG W540	02/23/93	0.62 ± 0.87	2.6 ± 0.9	−1.1 ± 4.6	−1.6 ± 6.2
AUG W572	11/24/92	0.05 ± 0.13	1.2 ± 0.5	0.04 ± 0.39	0.37 ± 0.40
AUG W572	02/23/93	0.24 ± 0.20	1.5 ± 0.4	0.1 ± 2.8	0.6 ± 3.0
C520	09/03/92	−0.02 ± 0.10	0.28 ± 0.36	−0.2 ± 3.4	0.6 ± 2.4
C520	11/24/92	0.01 ± 0.07	0.32 ± 0.24	0.12 ± 0.27	−0.02 ± 0.29
C520	02/23/93	0.046 ± 0.065	0.39 ± 0.15	0.24 ± 0.19	−0.08 ± 0.45
C595	09/03/92	0.04 ± 0.11	0.15 ± 0.29	−0.3 ± 2.9	0.4 ± 2.5
C595	11/24/92	0.01 ± 0.06	0.55 ± 0.23	0.03 ± 0.20	0.16 ± 0.20
C595	02/23/93	0.018 ± 0.054	0.28 ± 0.14	0.12 ± 0.15	0.12 ± 0.23
FIS 102[b]	08/31, 09/23/92	0.008 ± 0.047	0.36 ± 0.16	0.03 ± 0.15	0.12 ± 0.15
FIS 102	11/24/92	0.031 ± 0.062	0.28 ± 0.19	−0.04 ± 0.13	0.01 ± 0.12
FIS 102	02/23/93	0.061 ± 0.063	0.28 ± 0.12	0.03 ± 0.23	0.06 ± 0.24
FIS ?	09/03/92	0.22 ± 0.18	0.57 ± 0.38	0.20 ± 0.18	0.06 ± 0.19
FIS ?	11/24/92	0.002 ± 0.046	0.15 ± 0.16	0.06 ± 0.23	0.01 ± 0.21
FIS ?	02/23/93	0.010 ± 0.082	0.09 ± 0.11	0.06 ± 0.16	0.06 ± 0.15

[a] All data are in Becquerel per liter ± 1 standard error (counting error only).
[b] Composite Sample

Table B.9. Hillcut Disposal Test Facility pad runoff water data[a]

Tank No.	Sample ID	Date	Gross Alpha	Gross Beta[b]	^{60}Co	^{137}Cs
1	1-120892-1	12/08/92	0.09 ± 0.11	1.5 ± 0.04	0.12 ± 0.15	−0.01 ± 0.18
1	1-122992-1	12/29/92	0.10 ± 0.08	1.4 ± 0.2	−0.06 ± 0.13	0.091 ± 0.09
1	1-020293-1	02/02/93	0.049 ± 0.070	**5.2 ± 0.4**	1.1 ± 0.2	1.5 ± 0.2
1	1-033193-1	03/31/93	0.075 ± 0.076	0.98 ± 0.20	−0.09 ± 0.24	0.10 ± 0.16
1	1-042793-1	04/27/93	0.10 ± 0.09	0.83 ± 0.20	0.21 ± 0.19	−0.02 ± 0.21
2	2-040793-1	04/07/93	3.6 ± 0.7	3.1 ± 0.5	0.09 ± 0.16	0.26 ± 0.12
2	2-040793-2	04/07/93	0.14 ± 0.12			

[a] All data are in Becquerel per liter ± 1 standard error (counting error only). Blank spaces indicate analyses not performed. Boldface indicates value exceeding action level.
[b] Gross beta analysis does not include tritium.

Table B.10. Liquid Waste Solidification Project cask liquid sampling data.

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3627 (#32)							
Sept. 1990	50	1170		240	36										440 ± 460	1360 ± 10900
Sept. 1991	100	214	120												20 ± 20	50 ± 40
Oct. 1992	40														10 ± 20	350 ± 70
July 1993	110	209	≤1				0.40	5.2	0.21	100		2.2	0.34	1.2	≤10	≤20
Sept. 1993	230	62						4.3	0.051	47		0.9	0.078	0.27	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1990													
Sept. 1991													
Oct. 1992													
July 1993	3.9	250	21	0.082	180	0.05	0.26					0.03	0.30
Sept. 1993			8.4		71				22	0.51			0.21

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3629 (#33)							
Sept. 1990	250	517		326					0.28				0.41		310 ± 420	270 ± 10900
Sept. 1991	300	634	128												20 ± 20	80 ± 40
Oct. 1992	100	473	≤0.1				0.111		0.056	146		0.737	0.269	0.67	250 ± 60	3130 ± 190
July 1993	200	355	≤1				0.31	6.1	0.1	110		0.88	0.30	1.6	≤10	25 ± 8
Sept. 1993	250	114						3.5	0.052	73		0.36	0.08	0.08	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1990													
Sept. 1991													
Oct. 1992	1.02	370	17.1	0.027	188	0.156						0.042	0.085
July 1993	0.92	210	13		160	0.05	0.35					0.03	0.27
Sept. 1993	0.55		7.5		83				53	0.30			

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3630 (#34)							
Oct. 1992	40														20 ± 20	480 ± 80
July 1993	70	2370	≤10												≤10	129 ± 14
Sept. 1993	130	680													≤10	75

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3638 (#35)							
Sept. 1991	25														10 ± 20	50 ± 40
Oct. 1992	45	1160	≤0.1												150 ± 50	650 ± 90
July 1993	75	7165	≤10												≤10	≤20
Sept. 1993	225	1987						11	0.30	1000		0.44	0.081	0.47	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1991													
Oct. 1992													
July 1993													
Sept. 1993	0.72		110		62				29	2.3			0.34

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3640 (#37)							
Sept. 1991	25														10 ± 20	120 ± 50
July 1993	80	27.2	≤1												≤10	78 ± 11
Sept. 1993	120	20	9.2					4.1	0.037	51		0.36	0.049	0.63	≤10	63

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1991													
July 1993													
Sept. 1993	0.78		13						11	0.12		0.03	0.44

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3641 (#38)							
Oct. 1992	50	31.3	≤0.1												≤10	750 ± 100
July 1993	90	18.4	23												≤10	79 ± 12
Sept. 1993	200	14	9.6					4.3	0.110	88		0.54	0.085	0.76		

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Oct. 1992													
July 1993													
Sept. 1993	1.00		21						12	0.17		0.024	0.46

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3645 (#40)							
July 1993	75	47.4	≤1												≤10	35 ± 9
Sept. 1993	130	19						8.3	0.051	120		0.76	0.08	0.31	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
July 1993													
Sept. 1993	1.00		59		57				23	0.40			0.43

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3648 (#43)							
Sept. 1991	30														10 ± 20	40 ± 40
Oct. 1992	100	55.4	≤0.1				0.156		0.102	468		4.04	1.17	1.2	160 ± 50	270 ± 60
July 1993	25	67	≤10												≤10	≤20
Sept. 1993	250	61	44					8.7	0.08	200		2.3	0.67	0.16	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1991													
Oct. 1992	2.1	76.6	58.2	0.037	265	0.127						0.054	0.232
July 1993													
Sept. 1993	0.83		26		200				48	0.99		0.04	

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3652 (#46)							
June 1989	75	210	12												2400 ± 2400	−9400 ± 11200
Sept. 1989	80	110	≤50												≤1	≤1
Sept. 1990	70	92		326											40 ± 320	1360 ± 10900
Sept. 1991	80	77	6												130 ± 50	340 ± 70
Oct. 1992	120	106	≤0.1				0.13		0.20	469		1.57	0.09	0.22	30 ± 20	370 ± 60
July 1993	130	199	135			0.01		6.1	0.24	1100		2.1	0.16	1.1	≤10	≤10
Sept. 1993	250	121	≤1									1.2	0.06		≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
June 1989													
Sept. 1989													
Sept. 1990													
Sept. 1991													
Oct. 1992	2.62	21.2	37.1	0.014	319	0.09						0.12	0.15
July 1993	3.0	130	38	0.051	250	0.09					0.11	0.16	0.03
Sept. 1993	2.10		26	0.018	190				32	3.00		0.12	0.15

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3655 (#48)							
Sept. 1989	20														≤1000	≤1000
Sept. 1990	30	190		713											3 ± 300	600 ± 10700
Sept. 1991	60	255	111												130 ± 50	260 ± 60
July 1993	30	586	≤10												≤10	≤20
Sept. 1993	150	414	64.3					7.3	0.52	4000		3.00	0.21	0.25		

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Tl	V	Zn
Sept. 1989													
Sept. 1990													
Sept. 1991													
July 1993													
Sept. 1993	4.80		70		370				49	8.7		0.30	0.31

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3656 (#49)							
Sept. 1991	30														10 ± 20	70 ± 40
July 1993	100	439	≤10					4.2	0.37	1100		2.4	0.21	1.7	≤10	≤20
Sept. 1993	350	247						3.6	0.11	150		1.6	0.11	0.25	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Tl	V	Zn
Sept. 1991													
July 1993	0.85	110	36	0.005	230	0.08						0.17	0.34
Sept. 1993			16		200				47	1.9		0.15	0.07

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3657 (#50)							
Sept. 1989	20														≤1	≤1
Oct. 1992	90	126	≤0.1				0.165		0.029	238		2.41	0.141	0.222	80 ± 40	220 ± 60
July 1993	125	19	≤10				0.21	3.2	0.04	69		1.2	0.27	1.5	≤10	≤20
Sept. 1993	250	26						2.9	0.021	46		1.1	0.11	0.08	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1989													
Oct. 1992	3.66	51.6	43	0.07	253	0.71						0.089	0.29
July 1993	1.5	38	13		110							0.02	0.18
Sept. 1993			11		160				32	0.23			

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3660 (#51)							
Sept. 1989	20														≤1	≤1
Sept. 1991	25														140 ± 50	290 ± 70
July 1993	55	74	≤1												≤10	≤20
Sept. 1993	50	12													≤10	≤20

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3668 (#53)							
Oct. 1992	15														≤10	390 ± 80
July 1993	80	127	≤1												≤10	≤20
Sept. 1993	100	33						2.6	0.015	89		1.2		0.18	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Tl	V	Zn
Oct. 1992													
July 1993													
Sept. 1993			7.4		96				37	0.37		0.042	0.30

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3670 (#54)							
June 1989	25	36	5.4												1100 ± 1900	−7300 ± 11400
Sept. 1989	20														≤1	≤1
Sept. 1990	100	80	8.2	53	30				0.13				0.11			
Sept. 1991	80	9.36	0.71												120 ± 50	260 ± 60
Oct. 1992	200	122	≤0.1				0.07		0.05	270		2.73	0.18	0.21	120 ± 40	280 ± 60
July 1993	300	70.5	≤0.1				0.17	3.6	0.06	45	0.02	2.80	0.18	0.87	≤10	≤20
Sept. 1993	250	36.2	≤1					2.7		22		1.40	0.05	0.08	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Tl	V	Zn
June 1989													
Sept. 1989													
Sept. 1990													
Sept. 1991													
Oct. 1992	1.12	85.8	33.1	0.012	224	0.11						0.56	0.08
July 1993	0.72	66	10		140	0.06	0.17					0.04	0.13
Sept. 1993			3.7		82				31	0.13			

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3671 (#55)							
Sept. 1991	20														110 ± 40	310 ± 70
Oct. 1992	70	87.9	≤0.1												20 ± 20	360 ± 80
July 1993	80	18.3	5.9												≤10	≤20
Sept. 1993	100	6						1.0		33		0.28		0.15	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
Sept. 1991													
Oct. 1992													
July 1993													
Sept. 1993			2.2		55				29	0.11			0.15

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3672 (#56)							
Sept. 1989	40														≤1000	≤1000
Sept. 1990	70	9.2													70 ± 340	4330 ± 10800
Sept. 1991	50	40.4	17.2												80 ± 40	240 ± 60
Oct. 1992	25														60 ± 30	310 ± 70
July 1993	75	29.9	≤1												≤10	54 ± 10
Sept. 1993	60	14	≤1												≤10	≤20

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3678 (#58)							
Sept. 1993	50	42													≤10	64

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-3680 (#59)							
July 1993	90	45.8	≤1												≤10	76 ± 11
Sept. 1993	65	30													≤10	84

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6657							
Sept. 1993	65	439													≤10	≤20

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6677							
July 1992	25														20 ± 30	280 ± 90
Oct. 1992	225	5.8	≤0.1				0.54			21	0.013	0.312	0.065	0.065	20 ± 10	270 ± 40
July 1993	200	7	≤10				0.14	0.52	0.03	15		0.26	0.05	0.50	≤10	39 ± 9
Sept. 1993	150	8	85					1.4	0.012	25		0.34	0.067	0.10	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Tl	V	Zn
July 1992													
Oct. 1992	0.571	5.31	1.72	0.035	268	0.052						0.023	0.343
July 1993	0.15	5.1	1.2		230		0.18					0.03	0.08
Sept. 1993			3.2		170				18			0.003	0.15

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6680							
July 1992	15														80 ± 50	40400 ± 1000
Oct. 1992	25														2520 ± 150	375000 ± 1560

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6682							
July 1992	200	≤25	≤25				2.93		0.174	124	0.082	0.785	0.185	1.13	10 ± 30	140 ± 70
Oct. 1992	125	14.3	19.4				0.978		0.068	71.6	0.03	0.415	0.077	0.767	≤10	160 ± 40

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
July 1992	3.75	82.8	17.4	0.328	20.2			0.345				0.034	1.07
Oct. 1992	2.75	47.7	8.69	0.098	24.9	0.062						0.025	0.315

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6683							
July 1992	200	≤25	≤25				1.45		0.166	137	0.062	0.328	0.36	0.256	≤10	90 ± 60
Oct. 1992	190	3.61	19.4				1.82		0.078	140	0.069	0.298	0.352	0.617	30 ± 20	260 ± 40
July 1993	25	9	≤10												≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
July 1992	0.946	8.95	7.12	0.327	14.5			0.316				0.028	3.77
Oct. 1992	6.42	6.31	5.59	0.295	20.5	0.062						0.018	4.67
July 1993													

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6684							
July 1992	1000	≤25	≤25			0.004	0.271		0.096	70.2	0.010	0.392	0.381	0.008	≤10	380 ± 100
Oct. 1992	190	10	160				0.336		0.049	87.3	0.009	0.488	0.267	0.529	≤10	250 ± 40

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
July 1992	0.618	12.7	2.74	0.026	6.02			0.218				0.010	0.481
Oct. 1992	0.762	16.0	4.37	0.083	18.3	0.025						0.008	0.872

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6685							
July 1992	25														≤10	100 ± 60

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6689							
July 1992	50	49	≤25												≤10	250 ± 90

Table B.10 (continued)

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6709							
July 1992	200	≤25	≤25				4.51		0.334	247	0.073	0.303	0.221	1.65	≤10	90 ± 60
Oct. 1992	220	22.0	2.8						0.171	303	0.037	0.467	0.298	14.0	30 ± 20	180 ± 40
July 1993	200	13	≤10				0.30	3.9	0.06	79		0.37	0.19	0.39	≤10	≤20
Sept. 1993	100	12						4.6	0.11	510		1.00	0.58	0.08	≤10	≤20

Date	Fe	K	Mg	Mn	Na	Ni	Pb	Sb	Si	Sr	Ti	V	Zn
July 1992	9.09	76.5	12.6	0.968	28.6			0.477				0.038	2.65
Oct. 1992	5.84	19.3	11.3	0.816	28.3	0.387						0.023	4.07
July 1993	0.74	76	10	0.025	77	0.14	0.22					0.04	0.07
Sept. 1993	0.86		18	0.45	84				10	0.90		0.023	0.99

Date	mL	Cl	NO_3	SO_4	F	Ag	Al	B	Ba	Ca	Cd	Co	Cr	Cu	gross alpha	gross beta
									LL-6710							
Sept. 1993	70	23													≤10	≤20

[a] Radionuclide data are in Becquerel per liter ± 1 standard error (counting error only); cation and anion data in milligram per liter.
[b] mL = milliliters of liquid collected by pumping from the cask liquid collection sump.
[c] Gross beta analysis does not include tritium.

Table B.11. Radionuclide concentrations in Liquid Waste Solidification Project storage area soil samples[a]

Sample site #	Date	Gross alpha	Gross beta	^{60}Co	^{137}Cs	^{40}K
1	04/21/93	640 ± 230	1600 ± 300	0.4 ± 2.2	1.4 ± 1.4	780 ± 40
2	04/21/93	560 ± 220	1400 ± 300	0.5 ± 2.3	3.1 ± 1.8	820 ± 40
3	04/21/93	480 ± 200	1800 ± 400	0.9 ± 2.5	5.2 ± 1.7	900 ± 40
4	04/21/93	580 ± 210	1900 ± 400	0.2 ± 2.0	0.2 ± 1.9	1000 ± 100
5	04/21/93	680 ± 220	1500 ± 300	1.1 ± 2.6	3.3 ± 1.3	890 ± 40
5	04/21/93	740 ± 240	1600 ± 300	0.4 ± 2.2	4.2 ± 1.7	950 ± 40
1	09/18/93	440 ± 200	1000 ± 300	1.2 ± 2.3	2.5 ± 3.0	620 ± 80
2	09/18/93	380 ± 180	1300 ± 300	−0.8 ± 2.0	1.7 ± 2.8	850 ± 90
3	09/18/93	330 ± 150	1200 ± 300	2.1 ± 2.1	3.9 ± 3.2	940 ± 90
4	09/18/93	410 ± 200	1800 ± 400	−1.4 ± 3.8	2.2 ± 2.6	930 ± 90
5	09/18/93	570 ± 220	1700 ± 400	0.7 ± 1.9	0.4 ± 1.1	870 ± 90
5	09/18/93	430 ± 200	1600 ± 400	1.5 ± 2.5	3.2 ± 2.0	720 ± 80

[a]All data are in Becquerel per kilogram, mean ± 1 standard error (counting error only).

Table B.12. Radionuclide, total organic carbon, and anion results for samples from Building 7855 sump in Solid Waste Storage Area 5 North[a]

Sample Date	WO[b] Gross Beta[c]	ACD[d] ^{90}Sr	ESD[e] ^{40}K	ESD[e] ^{137}Cs	TOC[f]	Cl^-	F^-	NO_3	PO_4	SO_4
10/08/92	90	0.05 ± 0.2	89 ± 6	0.97 ± 0.26	69.5					
12/29/92					2.9	1.5	0.4	<1	<3	19
06/23/93	46	45 ± 1			44	2.0	<0.1	18	11	590
09/08/93	80	0.8 ± 2.4	95 ± 3	0.67 ± 0.11	34.4	5.6	10	38	14	680

[a] Radionuclide data are in Becquerel per liter, mean ± 1 standard error (counting error only); total organic carbon and anion data are in milligram per liter; blank spaces indicate data not reported.
[b] Values reported by Waste Operations personnel.
[c] Gross beta analysis does not include tritium.
[d] Values determined by Analytical Chemistry Division.
[e] Values determined by Environmental Sciences Division.
[f] TOC = total organic carbon.

Table B.13. Cation results for samples from Building 7855 sump in Solid Waste Storage Area 5 North[a]

Sample Date	Al	As	Ca	Cr	Cu	Fe	K	Mg	Mn	Na	Ni	Si	V	Zn
10/08/92	<0.05	0.16	3.5	0.014	0.12	0.10	2800	1.2	0.003	500	0.023	12.0	0.130	0.033
12/29/92	0.79	<0.5	45.0	<0.004	<0.007	0.39	33	7.2	0.019	3	<0.01	1.9	0.004	0.025
06/23/93	0.08	0.21	4.6	0.006	0.08	0.07	1700	1.3	0.005	301	0.020	10.7	0.048	0.026
09/08/93	<0.05	0.37	1.8	0.012	0.08	0.05	2500	0.8	0.002	<0.05	<0.01	12.0	0.110	0.050

[a] Data are in milligram per liter.

Table B.14. Current and historical radionuclide data from Solid Waste Storage Area 5 North monitoring wells[a]

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				Well 513			
29 Nov 89	0.068 ± 0.034			0.19 ± 0.06	0.4 ± 1.7	0.7 ± 1.9	
27 Mar 90	0.05 ± 0.04			0.14 ± 0.05	<0.35	<0.35	60 ± 17.5
18 Jun 90	0.012 ± 0.02			0.09 ± 0.04	<0.55	<0.55	
13 Aug 90	−0.12 ± 0.03			0.1 ± 0.8			
06 Dec 90	0.02 ± 0.02			0.01 ± 0.06	−0.08 ± 0.115	−0.08 ± 0.095	25 ± 17.5
22 Mar 91	0.17 ± 0.05	0.003 ± 0.07	−0.004 ± 0.002	0.54 ± 0.095	<0.1	<0.1	45 ± 17
04 Sep 91	−0.029 ± 0.001	0.002 ± 0.01	−0.017 ± 0.009	0.13 ± 0.095	−0.3 ± 0.55	−0.4 ± 0.55	43 ± 20.5
16 Dec 91	0.068 ± 0.049	0.008 ± 0.008	0.07 ± 0.011	−0.01 ± 0.1	0.03 ± 0.195	−0.06 ± 0.24	47 ± 13
09 Mar 92	0.026 ± 0.023			0.2 ± 0.075	−1.5 ± 1.35	0.7 ± 1.05	
24 Jun 92	0.011 ± 0.04	−0.002 ± 0.014	0.01 ± 0.007	0.09 ± 0.06	0.05 ± 0.05	0.058 ± 0.048	
22 Sep 92	0.15 ± 0.045	0.001 ± 0.006	0.001 ± 0.006	0.08 ± 0.06	−0.06 ± 0.13	−0.02 ± 0.115	68 ± 13
25 Nov 92	0.044 ± 0.042	0.01 ± 0.008	0.037 ± 0.049	0.03 ± 0.075	0.04 ± 0.065	−0.01 ± 0.06	69 ± 12.5
09 Mar 93	−0.011 ± 0.014	0.006 ± 0.004	0.005 ± 0.014	0.05 ± 0.055	0.12 ± 0.08	−0.03 ± 0.08	97 ± 14
03 Jun 93[d]	0.596			1.33			144 ± 15
				Well 514			
29 Nov 89	0.053 ± 0.031			0.26 ± 0.065	−4 ± 3.75	−1.4 ± 2.3	
22 Mar 90	0.01 ± 0.02			0.12 ± 0.04	<0.35	<0.35	66 ± 17.5
14 Jun 90	0.005 ± 0.02			0.20 ± 0.05	<0.55	<0.55	
29 Aug 90	0.02 ± 0.22			0.4 ± 0.85			
15 Nov 90	0.035 ± 0.036			0.04 ± 0.105	0.06 ± 0.155	0.12 ± 0.125	33 ± 17
15 Mar 91	0.032 ± 0.023	0.004 ± 0.002	−0.005 ± 0.002	0.27 ± 0.07	<0.1	0.07 ± 0.03	49 ± 17
23 Aug 91	−0.011 ± 0.024	−0.06 ± 0.065	−0.18 ± 0.045	−0.041 ± 0.078	0.6 ± 0.75	0.3 ± 0.8	63 ± 20.5
06 Dec 91	0.12 ± 0.06	0.001 ± 0.06	0.000 ± 0.003	0.28 ± 0.125	−0.5 ± 0.9	−0.5 ± 0.9	
27 Feb 92	0.029 ± 0.030			0.00 ± 0.065	−0.2 ± 0.9	0.1 ± 0.8	31 ± 12.5
28 May 92	0.022 ± 0.038	0.007 ± 0.005	−0.002 ± 0.002	−0.08 ± 0.085	0.27 ± 0.135	0.06 ± 0.165	
16 Sep 92	0.002 ± 0.017	0.002 ± 0.006	−0.005 ± 0.006	0.11 ± 0.06	0.12 ± 0.08	0.02 ± 0.085	64 ± 13
17 Nov 92	0.046 ± 0.028	0.011 ± 0.009	0.023 ± 0.011	0.46 ± 0.075	−0.01 ± 0.09	0.08 ± 0.065	78 ± 12.5
09 Mar 93	0.061 ± 0.036	0.011 ± 0.010	−0.005 ± 0.002	0.15 ± 0.055	0.17 ± 0.06	0.12 ± 0.075	110 ± 15
13 Apr 93[d]	0.010 ± 0.010		−0.001 ± 0.000	0.06 ± 0.015		<0.74	44 ± 11

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
			Well 516				
29 Nov 89	170 ± 10		140 ± 5	13 ± 1.5	0.15 ± 0.085	0.01 ± 0.095	
28 Mar 90	79 ± 3	5.53 ± 0.21	71.1 ± 2.7		0.8 1.2	1.1 1.05	40 ± 17
26 Jun 90	9.3 ± 0.23		±	2.68 ± 0.14	<0.55	<0.55	
26 Jul 90	120 ± 5	0.66 ± 0.025	43 ± 0.5				
16 Aug 90	110 ± 5			7.3 ± 0.35			
13 Nov 90	38 ± 1	1.7 ± 0.25	41 1	2.2 ± 0.25	−0.02 ± 0.295	0.14 ± 0.22	51 ± 12
22 Mar 91	210 ± 5	7 ± 0.5	220 ± 0.002	15 ± 0.5	0.07 ± 0.05	0.08 ± 0.05	35 ± 16.5
04 Sep 91	46 ± 1	0.99 ± 0.115	54 ± 0.009	3.8 ± 0.2	0.6 ± 0.7	0.7 ± 0.6	−49 ± 19
18 Dec 91	24 ± 0.5	0.62 ± 0.03	24 ± 0.011	1.6 ± 0.15	−0.01 ± 0.38	−0.01 ± 0.3	36 ± 13
30 Jun 92	14 ± 0.5	0.18 ± 0.02	15 ± 0.5	0.99 ± 0.145	0.1 ± 0.105	0.07 ± 0.1	
28 Sep 92	6.4 ± 0.3	0.019 ± 0.007	0.36 ± 0.015	0.71 ± 0.1	0.04 ± 0.09	0.02 ± 0.07	49 ± 12
09 Nov 92	5.0 ± 0.25	0.057 ± 0.010	7.1 ± 0.1	1.3 ± 0.1	−0.04 ± 0.08	0.03 ± 0.06	62 ± 12.5
25 Mar 93	7.0 ± 0.35	0.39 ± 0.025	6.2 ± 0.1	0.58 ± 0.085	0.24 ± 0.11	0.07 ± 0.12	
30 Apr 93[d]	15.9 ± 3.5	0.407 ± 0.081	9.26 ± 1.15	14.8 ± 2.26		<0.63	
30 Apr 93[e]	13.2 ± 0.40	0.14 ± 0.048	12.3 ± 2.13	1.25 ± 0.13		<0.56	56 ± 12
			Well 517				
29 Nov 89	−0.21 ± 0.04			−3 ± 0.7	−1.1 ± 2.9	0.9 ± 2.1	
06 Mar 90[c]	−0.001 ± 0.006			0.22 ± 0.05	<2.5	<2.5	54 ± 17.5
14 Jun 90[c]	−0.002 ± 0.01			0.09 ± 0.03	<0.55	<0.55	
29 Aug 90	0.09 ± 0.23			0.1 ± 0.9			
15 Nov 90	0.023 ± 0.041			0.28 ± 0.11	−0.11 ± 0.165	0.05 ± 0.15	37 ± 17
20 Mar 91	0.00 ± 0.029	−0.008 ± 0.01	−0.007 ± 0.008	0.31 ± 0.075	<0.1	<0.1	19 ± 16.5
30 Aug 91	0.004 ± 0.029	−0.02 ± 0.05	−0.045 ± 0.045	0.51 ± 0.11	−1 ± 2.05	0.2 ± 1.35	9 ± 20
10 Dec 91	0.05 ± 0.05	0.001 ± 0.008	−0.003 ± 0.006	0.07 ± 0.115	1.2 ± 0.6	0.1 ± 0.75	
27 Feb 92	−0.019 ± 0.02			0.24 ± 0.085	0.37 ± 0.125	0.16 ± 0.485	35 ± 13
08 Jun 92	0.019 ± 0.047	0.008 ± 0.0065	−0.008 ± 0.002	0.18 ± 0.105	−0.02 ± 0.175	−0.02 ± 0.155	
17 Sep 92	0.003 ± 0.021	0.015 ± 0.008	0.009 ± 0.006	0.06 ± 0.06	0.06 ± 0.09	0.06 ± 0.1	44 ± 12
19 Nov 92	0.12 ± 0.05	0.003 ± 0.009	−0.006 ± 0.008	0.33 ± 0.075	0.07 ± 0.085	−0.02 ± 0.085	61 ± 12
11 Mar 93	−0.031 ± 0.024	0.001 ± 0.006	0.002 ± 0.005	0.07 ± 0.06	−0.19 ± 0.18	0.16 ± 0.09	83 ± 13.5
09 Jun 93[d]	0.60			1.33			62 ± 12

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				Well 518			
29 Nov 89	0.028 ± 0.024			0.13 ± 0.055	1.4 ± 0.85	−1.2 ± 2.1	
23 Mar 90	0.004 ± 0.01			0.09 ± 0.04	<0.35	<0.35	64 ± 17.5
14 Jun 90	0.013 ± 0.01			0.08 ± 0.04	<0.55	<0.55	
29 Aug 90	0.03 ± 0.02			0.11 ± 0.05			
09 Dec 90	0.14 ± 0.05			0.32 ± 0.08	0.08 ± 0.14	0.05 ± 0.155	22 ± 18
15 Mar 91	0.04 ± 0.034	−0.002 ± 0.006	−0.009 ± 0.003	0.34 ± 0.08	<0.1	<0.1	31 ± 16.5
29 Aug 91	0.026 ± 0.028	0.09 ± 0.07	−0.12 ± 0.05	0.25 ± 0.08	0.3 ± 0.55	0.23 ± 0.42	68 ± 20.5
10 Dec 91	0.12 ± 0.065	0.03 ± 0.010	0.002 ± 0.007	0.37 ± 0.115	1.5 ± 0.7	0.2 ± 0.8	
27 Feb 92	0.024 ± 0.028			0.30 ± 0.15	−0.6 ± 0.95	0.1 ± 0.85	40 ± 13
01 Jun 92	0.06 ± 0.05	−0.004 ± 0.006	0.000 ± 0.003	−0.11 ± 0.065	−0.21 ± 0.29	0.03 ± 0.195	
15 Sep 92	0.037 ± 0.027	0.003 ± 0.006	−0.010 ± 0.003	0.19 ± 0.065	0.03 ± 0.06	0.012 ± 0.047	66 ± 13
17 Nov 92	0.08 ± 0.037	0.019 ± 0.008	0.003 ± 0.006	0.47 ± 0.08	−0.18 ± 0.14	0.06 ± 0.07	56 ± 12.5
11 Mar 93	0.053 ± 0.037	0.021 ± 0.014	−0.018 ± 0.006	0.12 ± 0.06	0.05 ± 0.12	−0.01 ± 0.10	81 ± 14
24 May 93[d]	0.55			1.33			63 ± 13
				Well 519			
29 Nov 89	−0.21 ± 0.04			0.078 ± 0.0475	−0.4 ± 2.35	−0.9 ± 2.1	
23 Mar 90	−0.001 ± 0.006			0.08 ± 0.04	<0.35	<0.35	56 ± 17.5
13 Jun 90	−0.002 ± 0.01			0.17 ± 0.04	<0.55	<0.55	
29 Aug 90	0.09 ± 0.23			0.06 ± 0.05			
15 Nov 90	0.023 ± 0.041			0.30 ± 0.11	0.05 ± 0.14	0.18 ± 0.135	27 ± 17
14 Mar 91	0 ± 0.029			0.15 ± 0.065	<0.1	<0.1	23 ± 16.5
29 Aug 91	0.004 ± 0.029	0.03 ± 0.095	−0.2 ± 0.085	−0.06 ± 0.07	−1.3 ± 2.4	1.2 ± 2.1	22 ± 20
06 Dec 91	0.05 ± 0.05	−0.007 ± 0.007	−0.013 ± 0.003	0.23 ± 0.11	−0.7 ± 0.85	0.5 ± 0.75	
27 Feb 92	−0.019 ± 0.02			0.24 ± 0.08	−0.1 ± 0.9	−0.1 ± 0.9	18 ± 12.5
28 May 92	0.019 ± 0.047	0.013 ± 0.006	0.009 ± 0.005	0.07 ± 0.095	0.15 ± 0.15	0.09 ± 0.125	
16 Sep 92	0.018 ± 0.024	−0.004 ± 0.006	−0.004 ± 0.003	0.05 ± 0.055	0.04 ± 0.1	0.01 ± 0.11	42 ± 13
17 Nov 92	0.15 ± 0.005	0.005 ± 0.006	0.002 ± 0.007	0.58 ± 0.085	0.02 ± 0.11	0.08 ± 0.105	55 ± 12
09 Mar 93	0.003 ± 0.021	0.015 ± 0.008	−0.006 ± 0.002	0.07 ± 0.055	−0.08 ± 0.12	−0.03 ± 0.11	110 ± 15
11 May 93[d]	0.54			6.09 ± 4.0			329 ± 8
11 May 93[f]				1.34 ± 0.97			

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				Well 520			
29 Nov 89	0.02 ± 0.025			0.05 ± 0.07	0.08 ± 0.175	0.01 ± 0.165	
22 Mar 90	0.01 ± 0.02			0.08 ± 0.04	<0.35	<0.35	76 ± 17.5
13 Jun 90	0.007 ± 0.02			0.10 ± 0.04	<0.55	<0.55	
30 Aug 90	0.32 ± 0.32			0.80 ± 0.85			
12 Nov 90	0.05 ± 0.055			0.08 ± 0.10	0.12 ± 0.09	0.02 ± 0.09	36 ± 12
20 Mar 91	0.021 ± 0.027	−0.004 ± 0.005	−0.007 ± 0.002	0.19 ± 0.065	<0.1	<0.1	26 ± 16.5
28 Aug 91	0.09 ± 0.042	0.08 ± 0.06	−0.12 ± 0.035	0.21 ± 0.08	−2.4 ± 2.8	0.2 ± 0.6	9 ± 20
13 Dec 91	−0.005 ± 0.027	0.002 ± 0.008	−0.012 ± 0.006	0.20 ± 0.10	−1.4 ± 0.8	−0.6 ± 0.85	
05 Mar 92	0.014 ± 0.025			0.10 ± 0.07	1.1 ± 0.8	−0.4 ± 1.05	23 ± 12.5
10 Jun 92	0.12 ± 0.04	0.015 ± 0.019	0.11 ± 0.02	0.14 ± 0.06	0.01 ± 0.1	0.02 ± 0.09	
28 Sep 92	0.052 ± 0.031	−0.005 ± 0.005	−0.001 ± 0.005	0.14 ± 0.065	0.01 ± 0.07	0.01 ± 0.055	44 ± 12.5
17 Nov 92	0.068 ± 0.035	−0.007 ± 0.004	0.000 ± 0.004	0.29 ± 0.07	0.03 ± 0.08	0.05 ± 0.07	53 ± 12
18 Mar 93	0.06 ± 0.036	0.002 ± 0.016	−0.008 ± 0.012	0.17 ± 0.065	−0.04 ± 0.12	0.04 ± 0.10	100 ± 15
10 Jun 93[d]	0.64 ± 0.54			1.33			197 ± 16
10 Jun 93[e]	0.55			1.33			138 ± 14
				Well 521			
29 Nov 89	0.014 ± 0.012			0.64 ± 0.05	0.08 ± 0.125	0.2 ± 0.07	
23 Mar 90	0.004 ± 0.017			0.21 ± 0.05	<0.35	<0.35	28 ± 17
18 Jun 90	0.01 ± 0.01			0.13 ± 0.04	<0.55	<0.55	
30 Aug 90	−0.15 ± 0.035			1.2 ± 0.9			
05 Dec 90	0.00 ± 0.05			0.12 ± 0.075	0.04 ± 0.12	−0.04 ± 0.12	−45 ± 16.5
20 Mar 91	−0.10 ± 0.13			0.9 ± 0.6	<0.1	<0.1	7 ± 16
30 Aug 91	0.84 ± 0.405	0.08 ± 0.075	0.30 ± 0.09	1.1 ± 0.75	−1.6 ± 2.95	−1.4 ± 2.65	13 ± 20
12 Dec 91	0.16 ± 0.13	0.062 ± 0.014	0.002 ± 0.01	0.28 ± 0.23	0.3 ± 0.8	−0.1 ± 0.85	
05 Mar 92	0.10 ± 0.10			−0.09 ± 0.145	0.05 ± 0.475	−0.13 ± 0.485	3 ± 12
28 May 92	−0.06 ± 0.012	0.006 ± 0.006	0.015 ± 0.005	1.4 ± 0.035	−0.05 ± 0.1	−0.07 ± 0.1	
18 Sep 92	0.1 ± 0.07	0.004 ± 0.006	0.002 ± 0.006	0.15 ± 0.105	−0.05 ± 0.11	0.03 ± 0.085	30 ± 12
19 Nov 92	0.04 ± 0.037	0.027 ± 0.014	0.038 ± 0.014	0.20 ± 0.07	−0.01 ± 0.085	−0.01 ± 0.075	31 ± 12
18 Mar 93	−0.02 ± 0.06	0.006 ± 0.016	−0.006 ± 0.008	0.13 ± 0.065	0.08 ± 0.10	0.01 ± 0.09	110 ± 15
10 May 93[d]	0.32 ± 0.21			0.63 ± 0.36			60 ± 5

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				Well 522			
29 Nov 89	0.01 ± 0.010			0.39 ± 0.045	−0.03 ± 0.095	0.04 ± 0.095	
08 Mar 90	−0.01 ± 0.02			0.23 ± 0.05	<2.5	<2.5	32 ± 17
18 Jun 90	0.007 ± 0.03			0.28 ± 0.06	<0.55	<0.55	
31 Aug 90	0.02 ± 0.23			−1.4 ± 0.5			
20 Mar 91	0.044 ± 0.031	0.006 ± 0.005	0.007 ± 0.004	0.08 ± 0.07	<0.3	<0.1	−9 ± 15.5
02 Aug 91	0.035 ± 0.03	0.014 ± 0.031	0.048 ± 0.029	0.18 ± 0.075	−0.4 ± 1.8	1.8 ± 0.8	−28 ± 14.5
12 Dec 91	0.024 ± 0.044	0.013 ± 0.013	−0.006 ± 0.010	0.18 ± 0.1	−0.5 ± 0.85	−0.5 ± 0.8	
05 Mar 92	−0.018 ± 0.018			0.17 ± 0.085	−1 ± 1.35	−0.3 ± 1.2	−18 ± 11.5
08 Jun 92	0.017 ± 0.042	−0.01 ± 0.006	−0.007 ± 0.005	0.14 ± 0.105	0.08 ± 0.04	0.08 ± 0.05	
17 Sep 92	0.015 ± 0.022	0.005 ± 0.004	−0.015 ± 0.004	0.18 ± 0.06	0.05 ± 0.08	0.01 ± 0.08	8 ± 12
19 Nov 92	−0.016 ± 0.024	0.004 ± 0.010	0.002 ± 0.008	0.36 ± 0.075	−0.07 ± 0.07	0.01 ± 0.05	27 ± 12
11 Mar 93	0.003 ± 0.022	0.002 ± 0.010	0.004 ± 0.004	0.20 ± 0.065	0.09 ± 0.05	−0.01 ± 0.09	35 ± 12.5
11 May 93[d]	0.54 ± 0.49			1.33			153 ± 6
				Well 523			
29 Nov 89	0.083 ± 0.038			1.9 ± 0.15	0.4 ± 0.08	1.1 ± 0.1	
15 Mar 90	0.01 ± 0.02			0.28 ± 0.05	<0.35	<0.35	80 ± 18
19 Jun 90	0.008 ± 0.02			0.16 ± 0.04	<0.55	<0.55	
31 Aug 90	−0.14 ± 0.035			0.6 ± 0.85			
15 Nov 90	0.15 ± 0.085			0.22 ± 0.18	0.1 ± 0.095	−0.04 ± 0.09	55 ± 17.5
25 Mar 91	0.032 ± 0.028	0.003 ± 0.002	0.006 ± 0.004	0.26 ± 0.075	<0.1	<0.1	66 ± 17.5
05 Sep 91	−0.006 ± 0.017	−0.079 ± 0.042	−0.004 ± 0.046	−0.01 ± 0.08	0.3 ± 1.5	0.9 ± 1	15 ± 20
19 Dec 91	0.026 ± 0.034	−0.013 ± 0.006	−0.003 ± 0.0055	0.06 ± 0.15	−0.04 ± 0.38	−0.57 ± 0.3	52 ± 13
18 Mar 92	−0.016 ± 0.016			−0.03 ± 0.06	0.8 ± 0.8	−0.2 ± 1.1	45 ± 13
02 Jul 92	0.05 ± 0.003	−0.004 ± 0.006	−0.007 ± 0.005	0.26 ± 0.12	0.03 ± 0.09	0.1 ± 0.065	
28 Sep 92	0.05 ± 0.032	0.005 ± 0.005	−0.001 ± 0.004	0.1 ± 0.07	0.07 ± 0.08	0.01 ± 0.085	55 ± 12.5
30 Nov 92	−0.005 ± 0.025	0.003 ± 0.007	−0.003 ± 0.003	0.21 ± 0.095	0.26 ± 0.18	−0.11 ± 0.195	64 ± 12
25 Mar 93	0.059 ± 0.035	0.016 ± 0.007	0.018 ± 0.007	0.12 ± 0.055	0.12 ± 0.04	0.03 ± 0.065	72 ± 14
11 May 93[d]	0.54			1.33			78 ± 12

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
			Well 524				
29 Nov 89	0.014 ± 0.012			0.87 ± 0.055	0.1 ± 0.145	0.09 ± 0.145	
15 Mar 90	0.01 ± 0.01			0.54 ± 0.07	<0.35	<0.35	300 ± 20
19 Jun 90	0.001 ± 0.01			0.22 ± 0.05	<0.55	<0.55	
31 Aug 90	0.02 ± 0.25			0.2 ± 1			
15 Nov 90	−0.01 ± 0.028			0.35 ± 0.115	−0.02 ± 0.12	0.04 ± 0.12	370 ± 22.5
26 Mar 91	0.021 ± 0.027			3 ± 0.15	<0.1	<0.1	160 ± 20
05 Sep 91	0.018 ± 0.024	−0.014 ± 0.015	0.01 ± 0.012	0.14 ± 0.075	1.6 ± 0.75	−2 ± 2.45	240 ± 25
19 Dec 91	0.053 ± 0.044	0.048 ± 0.0115	0.011 ± 0.005	0.37 ± 0.115	0.42 ± 0.12	−0.34 ± 0.485	220 ± 15
18 Mar 92	−0.008 ± 0.017			2.2 ± 0.15	−1 ± 1.4	−1.2 ± 1.3	100 ± 15
02 Jul 92	−0.008 ± 0.003	0.017 ± 0.0065	0.004 ± 0.004	0.78 ± 0.16	0.08 ± 0.125	0.07 ± 0.105	
28 Sep 92	0.14 ± 0.045	−0.002 ± 0.005	0.001 ± 0.004	0.06 ± 0.06	0.09 ± 0.075	0.01 ± 0.11	320 ± 20
30 Nov 92	0.17 ± 0.07	0.007 ± 0.006	−0.002 ± 0.004	0.31 ± 0.10	0.06 ± 0.09	−0.01 ± 0.08	230 ± 15
25 Mar 93	0.080 ± 0.041	0.004 ± 0.003	0.000 ± 0.000	0.93 ± 0.10	0.02 ± 0.15	0.10 ± 0.08	180 ± 15
28 Apr 93[d]	0.10 ± 0.04	0.00 ± 0.00	−0.004 ± 0.001	1.78 ± 0.28		<0.59	233 ± 23
			Well 525				
29 Nov 89	0.018 ± 0.012			0.32 ± 0.04	0.05 ± 0.135	0.08 ± 0.11	
22 Mar 90	0.002 ± 0.014			0.19 ± 0.05	<0.35	<0.35	20 ± 17
13 Jun 90	0.015 ± 0.02			0.11 ± 0.04	<0.55	<0.55	
29 Aug 90	−0.21 ± 0.04			−0.9 ± 0.9			
13 Nov 90	0.05 ± 0.065			0.17 ± 0.13	−0.06 ± 0.12	0.11 ± 0.105	2 ± 10
14 Mar 91	0.015 ± 0.022			0.18 ± 0.085	<0.1	0.067 ± 0.033	9 ± 16
05 Sep 91	0.02 ± 0.029	−0.01 ± 0.02	0.014 ± 0.021	0.15 ± 0.08	0.4 ± 1.35	0.2 ± 0.95	−30 ± 19
13 Dec 91	0.10 ± 0.055	0.017 ± 0.010	−0.013 ± 0.004	0.17 ± 0.095	0.8 ± 0.8	0.1 ± 0.75	
05 Mar 92	−0.008 ± 0.022			0.15 ± 0.09	0.2 ± 1.1	0.9 ± 1	−2 ± 12
15 Jun 92	0.023 ± 0.038	0.004 ± 0.006	0.000 ± 0.003	0.07 ± 0.105	0.1 ± 0.075	0.04 ± 0.085	
17 Sep 92	0.044 ± 0.026	0.003 ± 0.006	−0.011 ± 0.002	0.15 ± 0.065	0.02 ± 0.06	0.02 ± 0.049	28 ± 14.5
19 Nov 92	0.074 ± 0.034	−0.003 ± 0.006	0.000 ± 0.002	0.31 ± 0.075	−0.07 ± 0.175	0.02 ± 0.115	20 ± 11.5
18 Mar 93	0.003 ± 0.021	0.005 ± 0.011	−0.008 ± 0.004	0.20 ± 0.065	−0.04 ± 0.075	0.06 ± 0.08	40 ± 12.5
14 Jun 93[d]	0.64 ± 0.54			1.33			66 ± 12

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
			Well 708				
06 Dec 90	0.01 ± 0.02			0.1 ± 0.06	0.07 ± 0.105	0.15 ± 0.06	220 ± 20
22 Mar 91	0.022 ± 0.021	−0.002 ± 0.003	−0.002 ± 0.003	0.26 ± 0.07	<0.1	<0.1	120 ± 20
04 Sep 91	−0.043 ± 0.026	0.005 ± 0.003	0.00 ± 0.05	0.11 ± 0.09	0.7 ± 1.05	0.89 ± 0.415	−6 ± 19.5
16 Dec 91	0.005 ± 0.036	0.01 ± 0.006	**0.15** ± 0.015	0.26 ± 0.115	0.09 ± 0.38	0.15 ± 0.35	56 ± 13.5
11 Mar 92	−0.014 0.004			0.01 0.07	0.1 0.8	0.2 0.105	
24 Jun 92	0.044 ± 0.026	0.012 ± 0.009	**0.075** ± 0.013	0.15 ± 0.06	−0.01 ± 0.105	0.03 ± 0.08	
22 Sep 92	0.081 ± 0.038	0.004 ± 0.004	−0.006 ± 0.004	0.17 ± 0.08	0.1 ± 0.065	0.081 ± 0.038	85 ± 13.5
19 Nov 92	0.22 ± 0.08	0.005 ± 0.005	**0.026** ± 0.006	0.42 ± 0.115	0.14 ± 0.10	0.02 ± 0.095	85 ± 12.5
18 Mar 93	0.022 ± 0.028	0.007 ± 0.004	0.000 ± 0.000	0.17 ± 0.065	−0.02 ± 0.075	−0.07 ± 0.065	93 ± 14
04 Jun 93[d]	0.53			1.96 ± 1.03			30
			Well 715				
15 Nov 90	0.026 ± 0.034			0.6 ± 0.12	−0.09 ± 0.17	−0.03 ± 0.14	10 ± 16.5
15 Mar 91	0.076 ± 0.039	0.008 ± 0.009	−0.004 ± 0.006	0.34 ± 0.075	<0.1	<0.1	42 ± 16.5
29 Aug 91	0.029 ± 0.034	0.002 ± 0.002	0.004 ± 0.003	0.19 ± 0.075	−2 ± 2.4	−0.8 ± 2.45	21 ± 20
10 Dec 91	0.024 ± 0.031	0.003 ± 0.011	0.003 ± 0.011	0.37 ± 0.11	0.4 ± 0.8	0.2 ± 0.8	
27 Feb 92	0.00 ± 0.02			0.17 ± 0.075	−0.7 ± 1.2	0.6 ± 1	26 ± 12.5
01 Jun 92	0.038 ± 0.027	0.006 ± 0.0145	0.005 ± 0.005	0.16 ± 0.065	0.17 ± 0.105	−0.17 ± 0.145	
15 Sep 92	0.1 ± 0.04	−0.008 ± 0.006	−0.008 ± 0.005	0.32 ± 0.075	0.01 ± 0.07	0.05 ± 0.06	80 ± 13.5
17 Nov 92	0.098 ± 0.038	0.013 ± 0.008	**0.018** ± 0.009	0.34 ± 0.07	−0.05 ± 0.11	−0.01 ± 0.105	67 ± 12.5
11 Mar 93	0.042 ± 0.035	−0.039 ± 0.014	−0.007 ± 0.003	1.3 ± 0.1	0.17 ± 0.12	0.12 ± 0.14	67 ± 13.5
23 May 93[d]	0.54			1.33			86 ± 14

Table B.14 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
			Well 716				
06 Dec 90	0.04 ± 0.03			0.27 ± 0.08	0.11 ± 0.095	0.09 ± 0.1	−30 ± 17
22 Mar 91	0.026 ± 0.03			0.059 ± 0.01	<0.1	<0.1	−20 ± 15.5
04 Sep 91	0.15 ± 0.06	**0.067** ± 0.015	**0.039** ± 0.012	0.83 ± 0.115	0.8 ± 0.65	0.2 ± 1.35	−70 ± 37
16 Dec 91	0.52 ± 0.36	0.01 ± 0.007	**0.022** ± 0.005	1.1 ± 0.3	0.5 ± 0.7	−0.2 ± 0.8	
09 Mar 92	0.085 ± 0.048			0.66 ± 0.11	1.6 ± 0.9	0.1 ± 1.1	
24 Jun 92	0.09 ± 0.065	0.007 ± 0.0065	0.002 ± 0.004	0.28 ± 0.115	0.23 ± 0.05	0.04 ± 0.12	
22 Sep 92	0.03 ± 0.028	0.007 0.008	0.003 ± 0.006	0.08 ± 0.055	0.51 ± 0.08	0.8 ± 0.075	−5 ± 10.5
25 Nov 92	0.09 ± 0.05	0.007 0.007	**0.014** ± 0.007	0.60 ± 0.075	0.01 ± 0.11	−0.09 ± 0.05	35 ± 12.5
09 Mar 93	0.003 ± 0.021	0.004 0.003	−0.003 ± 0.004	0.21 ± 0.06	0.01 ± 0.065	0.048 ± 0.049	92 ± 14
15 Apr 93[d]	0.14 ± 0.04	0.00 0.00	0.001 ± 0.005	0.20 ± 0.03		<0.74	15 ± 9

[a] Concentrations reported in Becquerel per liter, mean ± 1 standard error (counting error only). Boldface indicates value exceeds 1 Becquerel per liter (gross alpha) or is significantly greater than zero (t−test, alpha = 0.05) based on counting error (^{241}Am and ^{244}Cm). Blank spaces indicate analysis not performed.
[b] Gross beta analysis does not include tritium.
[c] This value was actually reported as ^{243}Am.
[d] Data provided by Bechtel National, Inc. as part of the Remedial Investigation of Waste Area Grouping 5. Counting error not reported by Bechtel for all analyses. Only data from filtered samples are reported.
[e] Duplicate sample.
[f] Second value reported for same sample.

Table B.15. White Oak Creek seep and tributary monitoring results from Solid Waste Storage Area 5 North[a]

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				North Tributary			
07 Mar 90[c]	−0.004 ± 0.026			0.14 ± 0.05	<2.5	<2.5	52 ± 17.5
26 Jun 90[c]	0.02 ± 0.03			0.23 ± 0.05	<2.5	<2.5	
12 Nov 90	0.05 ± 0.12			0.07 ± 0.13	−0.01 ± 0.21	0.01 ± 0.21	
16 Apr 91	0.014 ± 0.021			0.26 ± 0.07	<0.1	<0.1	
12 Dec 91	0.14 ± 0.045	0.001 ± 0.007	**0.028** ± 0.01	0.28 ± 0.09	−0.02 ± 0.06	−0.01 ± 0.06	
29 Apr 92	0.19 ± 0.05	0.013 ± 0.012	**0.13** ± 0.02	1.8 ± 0.15	0.01 ± 0.09	0.03 ± 0.075	
28 Jul 92	0.02 ± 0.035	**0.01** ± 0.004	0.005 ± 0.004	0.63 ± 0.12	−0.08 ± 0.2	0.03 ± 0.175	
12 Oct 92	0.38 ± 0.27	0.007 ± 0.008	−0.001 ± 0.004	−0.93 ± 0.49	0.05 ± 0.075	0.01 ± 0.075	
02 Dec 92	0.034 ± 0.035	0.009 ± 0.005	**0.009** ± 0.004	0.61 ± 0.12	0.12 ± 0.09	0.03 ± 0.11	
30 Mar 93	−0.031 ± 0.005	**0.016** ± 0.006	0.002 ± 0.003	0.37 ± 0.07	0.09 ± 0.075	0.03 ± 0.085	
15 Jun 93	0.016 ± 0.024	**0.025** ± 0.009	0.005 ± 0.006	1.2 ± 0.1	0.10 ± 0.10	0.01 ± 0.115	
				South Tributary			
07 Mar 90[c]	3.93 ± 0.5			3.45 ± 0.29	<2.5	<2.5	970 ± 30
12 Nov 90	2.6 ± 0.6	0.038 ± 0.04	−0.028 ± 0.015	2.1 ± 0.5	−0.02 ± 0.27	0.08 ± 0.22	760 ± 50
16 Apr 91	0.54 ± 0.08			0.076 ± 0.095	<0.1	<0.1	
12 Dec 91	13 ± 0.5	−0.001 ± 0.006	−0.01 ± 0.006	**16** ± 0.5	−0.03 ± 0.16	0.02 ± 0.145	
29 Apr 92	6.8 ± 0.3	−0.08 ± 0.345	0.14 ± 0.16	**8.8** ± 0.25	−0.01 ± 0.125	0.11 ± 0.08	
28 Jul 92	1 ± 0.1	0.047 ± 0.038	−0.011 ± 0.018	1.5 ± 0.15	−0.01 ± 0.12	0.05 ± 0.095	
12 Oct 92	0.64 ± 0.33	−0.002 ± 0.007	−0.005 ± 0.002	1.5 ± 0.65	0.01 ± 0.055	0.01 ± 0.055	
02 Dec 92	8.4 ± 0.35	−0.001 ± 0.003	0.000 ± 0.001	**8.5** ± 0.25	0.08 ± 0.10	0.04 ± 0.11	
30 Mar 93	12 ± 0.5	0.004 ± 0.003	0.001 ± 0.002	**8.4** ± 0.25	0.01 ± 0.09	0.11 ± 0.075	
15 Jun 93	0.47 ± 0.08	**0.019** ± 0.009	**0.024** ± 0.010	0.90 ± 0.095	0.01 ± 0.075	−0.03 ± 0.065	

Table B.15 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs
			Seep WOC 160			
19 Dec 90	0.12 ± 0.08			0.47 ± 0.14	<0.5	<0.5
15 Jan 91	0.03 ± 0.07			0.12 ± 0.2	0.40 ± 0.27	0.8 ± 2.5
16 Apr 91					<0.1	<0.1
09 Sep 91	0.34 ± 0.095	0.056 ± 0.036	−0.009 ± 0.021	1.5 ± 0.2	0.30 ± 0.85	0.10 ± 0.60
09 Sep 91	0.45 ± 0.11	−0.011 ± 0.023	−0.025 ± 0.011	1.5 ± 0.2	1.3 ± 0.7	−0.10 ± 1.35
12 Dec 91	0.13 ± 0.04	0.021 ± 0.015	−0.003 ± 0.004	0.28 ± 0.075	0.21 ± 0.135	0.04 ± 0.155
29 Apr 92	0.051 ± 0.042	0.012 ± 0.026	0.003 ± 0.007	0.35 ± 0.105	0.2 ± 0.55	0.50 ± 0.50
28 Jul 92	−0.002 ± 0.024	0.007 ± 0.006	0.000 ± 0.002	0.6 ± 0.125	0.08 ± 0.085	−0.06 ± 0.10
12 Oct 92	1.4 ± 0.55	−0.002 ± 0.005	0.014 ± 0.006	1.3 ± 0.9	−0.08 ± 0.15	0.01 ± 0.145
02 Dec 92	0.12 ± 0.045	0.009 ± 0.005	0.000 ± 0.001	0.32 ± 0.08	0.10 ± 0.155	−0.10 ± 0.165
30 Mar 93	−0.018 ± 0.014	0.006 ± 0.004	−0.005 ± 0.001	0.11 ± 0.055	0.03 ± 0.105	−0.05 ± 0.10
			Seep WOC 175			
19 Dec 90	0.09 ± 0.07			0.8 ± 0.18	<0.5	<0.5
15 Jan 91	−0.01 ± 0.05			0.25 ± 0.19	0.19 ± 0.59	0.12 ± 0.62
16 Apr 91					<0.3	<0.1
12 Dec 91	0.15 ± 0.045	−0.002 ± 0.012	−0.002 ± 0.004	0.29 ± 0.08	0.03 ± 0.135	0.15 ± 0.09
29 Apr 92	0.073 ± 0.048	0.002 ± 0.01	0.009 ± 0.006	0.34 ± 0.105	−0.04 ± 0.13	−0.01 ± 0.115
02 Dec 92	−0.014 ± 0.004	0.006 ± 0.004	−0.001 ± 0.002	0.13 ± 0.09	0.05 ± 0.05	0.023 ± 0.048
30 Mar 93	0.05 ± 0.034	0.006 ± 0.004	−0.013 ± 0.002	0.17 ± 0.065	−0.16 ± 0.215	0.13 ± 0.085
			Seep WOC 213[d]			
19 Dec 90	0.26 ± 0.16			0.5 ± 0.23	<0.5	<0.5
15 Jan 91	13 ± 1	0.72 ± 0.22	13 ± 1	1.6 ± 0.2	−0.1 ± 1.3	0.3 ± 1.1
16 Apr 91					<0.3	0.7 ± 0.37

Table B.15 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
			WOC 255				
19 Dec 90	0.27 ± 0.11			0.31 ± 0.13	<0.5	<0.5	
15 Jan 91	0.99 ± 0.31	0.04 ± 0.06	**0.79** ± 0.18	0.06 ± 0.17	0.01 ± 0.15	0.03 ± 0.13	33 ± 17.5
16 Apr 91					<0.1	<0.1	
09 Sep 91	0.31 ± 0.09	0.011 ± 0.031	−0.004 ± 0.032	0.49 ± 0.145	0.10 ± 1	0.80 ± 0.75	
09 Sep 91	0.32 ± 0.095	−0.001 ± 0.023	**0.084** ± 0.032	0.22 ± 0.135	−0.20 ± 1.15	−0.10 ± 1.05	
12 Dec 91	0.32 ± 0.065	0.009 ± 0.005	**0.18** ± 0.02	0.25 ± 0.07	−0.04 ± 0.1	0.01 ± 0.1	
29 Apr 92	0.35 ± 0.09	−0.03 ± 0.05	**0.32** ± 0.055	0.26 ± 0.11	−0.02 ± 0.185	0.12 ± 0.16	
28 Jul 92	0.17 ± 0.07	0.01 ± 0.014	**0.22** ± 0.03	0.21 ± 0.095	0.09 ± 0.23	0.10 ± 0.175	
12 Oct 92	0.26 ± 0.24	0.011 ± 0.008	**0.28** ± 0.025	−0.65 ± 0.49	0.05 ± 0.065	−0.06 ± 0.065	
30 Mar 93	0.15 ± 0.05	0.014 ± 0.02	**0.14** ± 0.02	0.25 ± 0.07	0.02 ± 0.105	0.02 ± 0.085	
14 Jun 93	0.084 ± 0.039	**0.018** ± 0.008	**0.12** ± 0.02	0.12 ± 0.06	0.21 ± 0.08	0.17 ± 0.085	
			5NW 01				
07 Mar 90[c]	0.11 ± 0.12			0.58 ± 0.14	<2.5	<2.5	610 ± 25
19 Dec 90	0.17 ± 0.09			0.27 ± 0.12	<0.5	<0.5	
15 Jan 91	0.27 ± 0.09			0.31 ± 0.23	−0.03 ± 0.31	−0.01 ± 0.3	39 ± 17.5
16 Apr 91					<0.1	<0.1	
12 Dec 91	0.067 ± 0.034	−0.002 ± 0.006	**0.018** ± 0.008	0.16 ± 0.07	0.11 ± 0.215	0.08 ± 0.215	
02 Dec 92	0.059 ± 0.042	0.000 ± 0.003	**0.019** ± 0.005	0.38 ± 0.11	0.01 ± 0.105	0.08 ± 0.09	
30 Mar 93	0.089 ± 0.037	0.011 ± 0.006	**0.032** ± 0.013	0.17 ± 0.065	0.02 ± 0.10	−0.05 ± 0.10	

Table B.15 (continued)

Sample date	Gross alpha	^{241}Am	^{244}Cm	Gross beta[b]	^{60}Co	^{137}Cs	Tritium
				5NW 02			
07 Mar 90[c]	0.04 ± 0.11			0.11 ± 0.1	<2.5	<2.5	350 ± 20
19 Dec 90	0.12 ± 0.08			0.4 ± 0.14	<0.5	0.126 ± 0.119	
15 Jan 91	−0.02 ± 0.01			0.02 ± 0.16	0.23 ± 0.27	0.11 ± 0.45	220 ± 20
16 Apr 91					<0.1	<0.1	
12 Dec 91	0.12 ± 0.04	0.008 ± 0.065	−0.006 ± 0.005	0.12 ± 0.065	0.06 ± 0.13	−0.04 ± 0.13	
29 Apr 92	0.044 ± 0.042	**0.046** ± 0.016	−0.011 ± 0.01	0.11 ± 0.1	0.02 ± 0.085	0.29 ± 0.055	
28 Jul 92	0.05 ± 0.029	0.008 ± 0.008	−0.007 ± 0.003	0.14 ± 0.06	0.02 ± 0.225	−0.08 ± 0.25	
12 Oct 92	−0.09 ± 0.12	0.002 ± 0.006	−0.001 ± 0.005	−0.58 ± 0.42	0.08 ± 0.085	−0.03 ± 0.115	
02 Dec 92	−0.021 ± 0.004	0.000 ± 0.003	0.001 ± 0.003	0.32 ± 0.095	0.10 ± 0.05	0.03 ± 0.05	
30 Mar 93	0.035 ± 0.026	0.001 ± 0.002	−0.003 ± 0.002	0.04 ± 0.05	0.09 ± 0.05	0.03 ± 0.055	

[a] All data are in Becquerel per liter, mean ± 1 standard error (counting error only). Blanks indicate analysis not performed. Boldface indicates value for transuranic is statistically >0 based on counting error. Sporadic reporting reflects insufficient flow to sample seep.
[b] Gross beta analysis does not include tritium.
[c] Gross alpha/beta analyses for these samples were performed in the Health and Safety Research Division following sample preparation in the Environmental Sciences Division (ESD). Values for these analyses are typically lower than values from analyses performed in Analytical Chemistry Division. Gamma scans were performed in the ESD counting room.
[d] Seep WOC 213 was not sampled after April 1991 because of insufficient flow.

Table B.16. Radiological data for well 516 in Solid Waste Storage Area 5 North[a]

Date	Size Fraction[b]	Gross Alpha	Gross Beta	^{244}Cm	^{241}Am	^{238}Pu	$^{238/240}Pu$	^{237}Np
17 Dec 92	total	280 ± 28	15.0 ± 2.5	219.5 ± 29.0	1.5 ± 0.29	0.28 ± 0.15	0.21 ± 0.10	1.67 ± 1.18
	0.45μ	290 ± 29	16.0 ± 2.6	227.0 ± 27.5	2.0 ± 0.35	0.38 ± 0.16	0.17 ± 0.10	1.97 ± 1.14
26 Jan 93	total	322.5 ± 20.4	16.5 ± 7.0	266.9 ± 31.9	2.2 ± 0.37	0.25 ± 0.14	0.20 ± 0.12	2.37 ± 0.89
	<100K	349.4 ± 21.5	17.1 ± 7.1	251.8 ± 33.6	3.8 ± 0.60	0.44 ± 0.17	0.15 ± 0.10	0.62 ± 0.38
	<3K	294.4 ± 20.0	16.5 ± 7.1	194.5 ± 26.0	4.0 ± 0.62	0.58 ± 0.21	0.17 ± 0.16	1.29 ± 1.01
23 Feb 93	total	401.7 ± 22.9	18.4 ± 6.6	289.1 ± 37.7	2.8 ± 0.62	0.64 ± 0.24	0.30 ± 0.15	−0.05 ± 0.28
	<3K	342.7 ± 21.2	18.6 ± 6.6	267.8 ± 39.7	2.9 ± 0.78	0.74 ± 0.28	0.18 ± 0.15	0.18 ± 0.08
	<1K	386.9 ± 22.5	18.2 ± 6.6	312.8 ± 47.7	3.0 ± 0.75	0.42 ± 0.22	0.13 ± 0.12	−0.07 ± 0.49

[a] All radionuclide data in picocurie per liter.
[b] Total = unfiltered sample; <0.45 μm = portion of sample passing a 0.45−μm filter; <100K = portion of sample passing a 100K ultrafilter; <3K = portion of sample passing a 3K ultrafilter; <0.1 μm = portion of sample passing a 0.1−μm ultra filter.

Table B.17. Major cation and anion data for well 516 in Solid Waste Storage Area 5 North[a]

Date	Size Fraction[b]	Ba	Ca	Mg	Na	Sr	Cl	F	NO_3 as N	SO_4
17 Dec 92	total	0.396	133	15.4	13.0	0.194	3.38	0.18	0.726	23.2
	0.45μ	0.406	135	15.0	13.2	0.192	3.97	0.121	1.19	23.2
26 Jan 93	total	0.382	136	15.5	12.7	0.187	5.95	<2.5	0.904	22.6
	<100K	0.388	134	15.4	12.9	0.187				
	<3K	0.378	133	15.2	12.6	0.183	14.3	0.055	1.25	26.2
23 Feb 93	total	0.375	129	14.7	12.2	0.182	4.75	1.290	3.80	23.1
	<3K	0.359	124	14.4	11.6	0.177	2.89	0.511	3.86	22.6
	<1K	0.371	128	14.6	12.0	0.182	2.85	0.475	3.74	32.3

[a] All data are in milligram per liter. All major cations, anions, and trace metals were sought. This table contains only ions present above detection limits.
[b] Total = unfiltered sample; <0.45 μm = portion of sample passing a 0.45−μm filter; <100K = portion of sample passing a 100K ultrafilter; <3K = portion of sample passing a 3K ultrafilter; <0.1 μm = portion of sample passing a 0.1−μm ultra filter.

Table B.18. Other chemical data for well 516 in Solid Waste Storage Area 5 North[a]

Date	Size Fraction[b]	Total Alkalinity	Organic Carbon	pH	Eh	Dissolved Oxygen	Specific Conductance	Temperature	TDS	Turbidity
17 Dec 92	total	380	4.50	6.8	0.314	4.53	0.772	15.23	420	
	0.45μ	380	4.54							
26 Jan 93	total	421		6.47	0.169	2.38	0.762	13.50	309	0.05
	<100K									
	<3K									
23 Feb 93	total	380	1.75	6.8	0.170	4.97	0.739	7.58	460	0.09
	<3K									
	<1K		1.12							

[a] Total alkalinity and organic carbon in milligram per liter; pH in standard pH units; Eh in volts; dissolved oxygen in parts per million; specific conductance in micromhos per centimeter; temperature in degrees Celsius; TDS = total dissolved solids in milligram per liter; turbidity in nephlometric turbidity units.
[b] Total = unfiltered sample; <0.45 μm = portion of sample passing a 0.45−μm filter; <100K = portion of sample passing a 100K ultrafilter; <3K = portion of sample passing a 3K ultrafilter; <0.1 μm = portion of sample passing a 0.1−μm ultra filter.

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