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Annual Progress Report: FY-1988

*Site Characterization Program at the
Radioactive Waste Management
Complex of the Idaho National
Engineering Laboratory*



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Idaho National Engineering Laboratory

U.S. Department of Energy • Idaho Operations Office



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ANNUAL PROGRESS REPORT: FY-1988
SITE CHARACTERIZATION PROGRAM AT THE
RADIOACTIVE WASTE MANAGEMENT COMPLEX
OF THE IDAHO NATIONAL ENGINEERING LABORATORY

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ABSTRACT

The Radioactive Waste Management Complex (RWMC) Site Characterization Program is a continuation of the Subsurface Investigation Program (SIP). The scope of the SIP has broadened in response to the results of past work that identified hazardous as well as radionuclide contaminants in the subsurface environment and in response to the need to meet regulatory requirements.

Two deep boreholes were cored at the RWMC during FY-1988. Selected sediment samples were submitted for Appendix IX of 40 CFR Part 264 and radionuclide analyses. Detailed geologic logging of archived core was initiated. Stratigraphic studies of the unsaturated zone were conducted. Studies to determine hydrologic properties of sediments and basalts were conducted. Geochemical studies and analyses were initiated to evaluate contaminant and radionuclide speciation and migration in the Subsurface Disposal Area (SDA) geochemical environment.

Analyses of interbed sediments in boreholes D15 and 8801D did not confirm the presence of radionuclide contamination in the 240-ft interbed. Analyses of subsurface air and groundwater samples identified five volatile organic compounds of concern: carbon tetrachloride, trichloroethylene, 1,1,1-trichloroethane, chloroform, and tetrachloroethylene.

Data from vadose zone instrumentation suggested the occurrence of downward movement of soil water for large portions of the year. Preliminary solute transport modeling under unsaturated flow conditions is in general agreement with observed radionuclide migration and subsurface water contents. These modeling results suggest that fractures may play an important role in unsaturated flow and solute transport.

EXECUTIVE SUMMARY

The Radioactive Waste Management Complex (RWMC) Site Characterization Program is a continuation of the Subsurface Investigation Program (SIP). The scope of the SIP has broadened in response to the results of past work that identified hazardous as well as radionuclide contaminants in the subsurface environment and in response to the need to meet regulatory requirements.

Two deep boreholes were cored at the RWMC during the FY-1988 field season. Borehole 8801D was cored to a total depth of 245 ft below land surface and designated for vapor monitoring instrumentation in FY-1989. Borehole 8802D was cored to a depth of 129 ft below land surface and temporarily capped, for completion in FY-1989. Two sediment samples from borehole 8801D were submitted for Appendix IX of 40 CFR Part 264 analysis; the results will be available in FY-1989. Sediment from the 240-ft interbed in borehole 8801D was submitted for radionuclide analysis. The results of that analysis indicated that no radionuclides were present at detectable levels.

Efforts to characterize the subsurface geology at the RWMC continued in FY-1988. A study to describe the sedimentology and depositional history of the three major interbeds underlying the RWMC was initiated. Preliminary results indicate that the primary source of the sediment in the 30-ft interbed was the accumulation of windblown sediments. The sediment in the 110-ft and 240-ft interbeds was primarily deposited by fluvial systems entering the Snake River Plain from adjacent basins.

Four drill holes were logged in detail for geological characteristics, and this work will continue in FY-1989. These data will be used to provide a more complete geological description of the subsurface and to help characterize the transport processes of the basalts.

An investigation of the stratigraphy of the unsaturated zone at the RWMC was undertaken. The stratigraphic relations between major basalt and sediment layers were investigated. Borehole data collected from 1971 to

1988 were used in the investigation. Results of this investigation will be published by the U.S. Geological Survey in 1989.

Hydrologic characterization focused on determination of hydraulic properties of portions of the subsurface environment at the RWMC. Hydraulic conductivities of the cover material were measured; measurements ranged over five orders of magnitude, suggesting a heterogeneous material. Reanalyses of archived cores for hydraulic conductivity indicated that the hydraulic conductivity remained relatively constant over several years of storage. These results suggest that stored cores can be used for hydrologic property measurements. Four basalt core samples, representative of vesicular, very vesicular, and massive basalts, were tested for selected hydraulic parameters. Effective porosities for all four samples were in the 12 to 24% range, and hydraulic conductivities ranged between 1.29 E-07 cm/s and 1.04 E-05 cm/s . A study was initiated to determine the fluid flow and transport properties of vesicular basalt from the Subsurface Disposal Area (SDA) under unsaturated flow conditions.

During FY-1988, the net downward flux study continued to collect data on a monthly basis from vadose zone instrumentation in 34 boreholes around the SDA. Standard operating procedures were compiled for use in data collection and published as an informal report. An initial analysis of instrument data was completed in FY-1988; preliminary results indicate that downward migration of water occurs seasonally.

The weighing lysimeter study recorded weights during the third and fourth quarters of FY-1988. Soil moisture profiles in the weighing lysimeters were compared to moisture profiles of a control pit. These moisture profiles matched during the period from July to September. Erratic weights were recorded during high wind conditions, and also during the first and second quarters of FY-1988 because of snow bridging.

A simulated waste trench was installed near the SDA and instrumented with suction lysimeters. Neutron access tubes were installed. Tracers were applied at three depths in the trench and also in sealed, clean drums buried

in the simulated waste trench. Soil temperature, soil moisture, and soil water potential were collected on a regular basis.

Geochemical activities conducted in FY-1988 included the solution chemistry, chemical mass transfer, and radionuclide/sediment leachability studies. Inorganic analyses of soil waters collected from suction lysimeters generally indicated sodium-potassium bicarbonate waters typical of waters that evolve in many arid soils. Soil water samples from the 30-ft interbed showed a higher dissolved solids concentration, in the brackish or saline range. The geochemical computer modeling codes PHREEQE and EQ3NR/EQ6 were obtained, and work was begun to modify the codes for use in SDA studies. A literature study on the effect that selected organic constituents could have on radionuclide mobility did not indicate significant complexation of radionuclides by volatile organic chemicals such as carbon tetrachloride or trichloroethylene.

Radionuclide analyses of sediment and soil waters were conducted in FY-1988. One surficial sediment sample from W13 tested positive for $^{239+240}\text{Pu}$, ^{238}Pu , ^{241}Am , and strontium-90. Selected samples from deep borehole D15 were analyzed during FY-1988. The results from D15 did not indicate the presence of radionuclides in the 110-ft or the 240-ft sedimentary interbeds. Samples from the 240-ft interbed in deep borehole 8801D were submitted and analyzed during FY-1988. No radionuclides were detected in those samples. Data received in FY-1988 for radiochemistry of soil waters collected at a depth of 7 ft 8 in. showed positive results for strontium-90.

Activities to characterize the hazardous contaminants present in the subsurface of the RWMC during FY-1988 included a comprehensive examination of disposal records, a survey of soil gas at the RWMC, collection of sediment samples for Appendix IX analysis, collection of water samples for purgeable organic compounds at or around the SDA, and gas sampling of boreholes at the SDA.

Current data indicate the presence of volatile organic compounds (VOCs) at the SDA from surface soil to the water table. The VOCs of primary concern

are carbon tetrachloride, trichloroethylene, 1,1,1-trichloroethane, chloroform, and tetrachloroethylene.

Available disposal records indicate that approximately 88,400 gal of organic sludge waste from the Rocky Flats Plant (RFP) were buried at the SDA from 1966 to 1970. Disposal records also indicate that the locations of organic sludge disposal in the SDA are probably Pits 4, 5, 6, 9, and 10. This information strongly correlates with the results of the soil gas survey, with the exception of two anomalies: the 1,1,1-trichloroethane found in the southeast corner of the SDA and several organics found at or near Pad A.

Two sediment samples from borehole 8801D were submitted for analysis of hazardous constituents as listed in Appendix IX. Final results will be published when they become available.

Eight aquifer wells and one perched water well at and near the SDA were sampled and analyzed for purgeable organics. VOCs were detected in waters from all nine wells. Carbon tetrachloride and trichloroethylene were the most widely found VOCs in the groundwater.

Air grab samples from boreholes 8801D and 8802D were collected throughout the deep drilling season during FY-1988 for health and safety purposes. Mercury and all five of the organics of primary concern were detected.

Computer model development in FY-1988 focused on computer code development and model calibration. A new computer code, FLASH, was developed to simulate moisture movement through the vadose zone. The FLASH computer code was calibrated using temperature data collected from the test trench, and produced excellent results. A computer code called PORFLO, which is used to simulate the organic vapor plume, was calibrated using available soil-gas survey data from the RWMC. The model provided relatively good results in the region where concentrations were the highest. However, available data for the calibration was limited, and PORFLO will need to be recalibrated when more field data become available. The MAGNUM-3D and FECTRA-3D computer codes were

modified to simulate organic vapor flow and transport. These codes will be used to calculate the three-dimensional soil-gas flow patterns induced by soil-gas pumping. Model application to radionuclide transport focused on evaluating the potential impact of unsaturated flow through fractures on the rate and extent of radionuclide transport as a dissolved phase. Simulations suggest that fracture flow may have played an important role in the migration of dissolved radionuclides.

A panel of reviewers, both Idaho National Engineering Laboratory (INEL) and non-INEL personnel, conducted a formal peer review of the Subsurface Investigations Program. Their recommendations were considered in planning the RWMC Site Characterization Program.

EPA regulations require extensive documentation of activities related to characterization of the VOCs released at the RWMC. Because of the requirements of the Consent Order and Compliance Agreement between EPA Region X and the INEL, a RCRA Facility Investigation (RFI) work plan (draft) was submitted in September 1988. The RFI work plan addresses the VOCs that have been detected in groundwater and soil gas samples from the SDA. Under the current definitions of hazardous materials in RCRA, radionuclides are not specifically addressed in the RFI work plan.

ACKNOWLEDGMENTS

The scope of the Site Characterization Program is too large to have any one person be an expert on all facets. For this reason, the reader's attention is directed to those who contributed to the different sections of this report. Steve Minkin contributed the Deep Drilling Section. The Geologic Characterization was covered by Steve Anderson, Linda Davis, and Joel Hubbell; and Debbie McElroy provided the information for Hydraulic Characterization of the RWMC Subsurface. Geochemical Activities and Characterization of Radionuclide Contaminants were covered by Shirley Rawson. Characterization of Hazardous Containments was a compilation of efforts by Mike Vigil, Debbie McElroy, and Steve Minkin. Computer Model Development was covered by Bob Baca, the Outside Peer Review by Debbie McElroy, and the development of documentation by Chris Bonzon. The report was compiled and edited by Debbie McElroy, with the help of Donovan Bramwell.

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FACTORS FOR CONVERTING ENGLISH UNITS TO METRIC (SI) UNITS

The following factors can be used to convert English units published herein to the International System of units (SI).

<u>Multiply</u>	<u>By</u>	<u>To Obtain</u>
inches (in.)	2.54	centimeters (cm)
inches (in.)	25.4	millimeters (mm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
acres	0.4047	hectares (ha)
gallons (gal)	3.785	liters (L)
gallons (gal)	3785.434	cubic centimeters (cc)
pounds (lb)	0.4536	kilograms (kg)
micromhos (μmho)	1.00	microsiemens (μS)
pounds per square inch (psi)	6.80	Kilopascals (kPa)
pounds per square inch (psi)	0.068	bars
$^{\circ}\text{F} - 32$	0.556	$^{\circ}\text{C}$
feet per second (ft/s)	31545.741	Darcies
parts per million (ppm)	1.0	milligrams per liter (mg/L)

ACRONYMS

ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BLS	Below Land Surface
BWP	Buried Waste Program
CDP	Common-Depth-Point
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COCA	Consent Order and Compliance Agreement
DOE	Department of Energy
DOT	Department of Transportation
EPA	Environmental Protection Agency
FY	Fiscal Year
INEL	Idaho National Engineering Laboratory
K	Hydraulic Conductivity
OWSER	Office of Solid Waste and Emergency Response
QA	Quality Assurance
QC	Quality Control
RCRA	Resource Conservation Recovery Act
RFI	RCRA Facility Investigation
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
RWMIS	Radioactive Waste Management Information System
SDA	Subsurface Disposal Area
SIP	Site Characterization Program
TCA	Trichloroethane

TD	Total Depth
TRU	Transuranic
TSA	Transuranic Storage Area
TWA	Time Weighted Average
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
VVE	Vapor Vacuum Extractions

1. INTRODUCTION

The Radioactive Waste Management Complex (RWMC) Site Characterization Program is a continuation of the Subsurface Investigation Program (SIP). The scope of the SIP has broadened in response to the results of past work that identified hazardous as well as radionuclide contaminants in the subsurface environment and in response to the need to meet regulatory requirements.

The RWMC, shown in Figure 1, was established near the southwestern corner of the Idaho National Engineering Laboratory (INEL) in 1952 and has served as a controlled disposal site for low-level and transuranic (TRU) waste. Radioactive waste is buried in the 88-acre Subsurface Disposal Area (SDA) and temporarily stored above ground in the 56-acre Transuranic Storage Area (TSA). Hazardous materials including TRU-contaminated organic wastes, oils, acids, and caustic materials were also disposed of at the RWMC.

Subsurface geology at the RWMC is characterized by sequences of basalt flows interbedded with relatively thin intervals of sedimentary beds. The major sedimentary units appear at depths of approximately 30-ft, 110-ft and 240-ft. The surface of the Snake River Plain Aquifer lies at approximately 580-ft. Previously, the program focused on the zone above the water table, that is, the vadose zone. However, the detection of contaminants in the groundwater has broadened the scope of the program to include the aquifer.

This report summarizes the progress made in FY-1988 under the RWMC Site Characterization Program. Section 4 covers the program's various activities and studies, including deep drilling, geologic and hydrologic characterization of the subsurface, solution chemistry, characterization of radionuclide and hazardous contaminants, and computer model development. Results from analyses performed in FY-1988 for both radionuclide and hazardous constituents are discussed. Section 5 presents the results of the outside Peer Review of the Subsurface Investigations Program. A large volume of documentation was developed to meet regulatory requirements, and this work is discussed in Section 6.

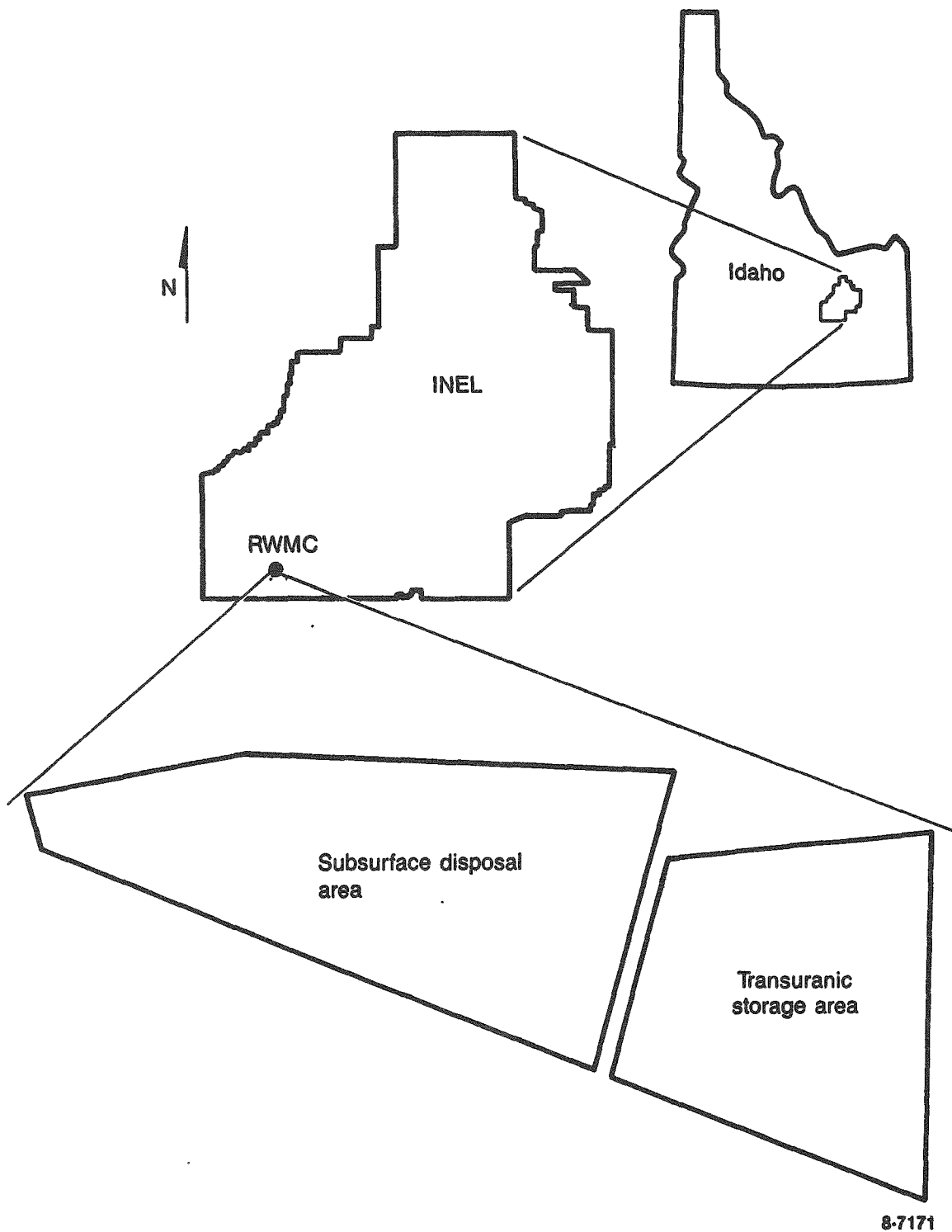


Figure 1. Location of the Radioactive Waste Management Complex.

The work discussed herein was performed by representatives of EG&G Idaho, Inc. and the U. S. Geological Survey (USGS) INEL Project Office. All work was performed under the direction of the U. S. Department of Energy (DOE), Idaho Operations Office.

2. RATIONALE AND STATEMENT OF OBJECTIVES

The overall goals of the RWMC Site Characterization Program are to develop an understanding of the hydrogeologic and contaminant transport system of the subsurface at the RWMC and to determine the extent of contaminant migration. Accomplishment of these goals will help decision makers to identify interim measures that will mitigate further release and spread of contaminants and to make informed decisions regarding the long-term management of wastes at the RWMC.

Current objectives of this program include the following:

- Characterize the three-dimensional hydrogeologic conditions at the RWMC
- Evaluate the present extent of contaminant migration in the subsurface at the RWMC
- Characterize the chemical and physical properties of the contaminants
- Identify and characterize the principal mechanisms, pathways, and rates of liquid and gaseous contaminant migration
- Assess long term patterns and effects of contaminant migration
- Meet associated regulatory requirements.

Table 1 presents a schedule of the various studies and activities that contribute to the accomplishment of the RWMC Site Characterization Program objectives.

TABLE 1. RWMC SITE CHARACTERIZATION PROGRAM SCHEDULE

<u>Task Description</u>	<u>FY-85</u>	<u>FY-86</u>	<u>FY-87</u>	<u>FY-88</u>	<u>FY-89</u>	<u>FY-90</u>	<u>FY-91</u>
<u>ACTIVITIES & STUDIES</u>							
Acid pit sampling					██████████		
Subpit sampling					██████████		
Analysis of non-aqueous liquid phase organics				██████████	██████████		
Waste and disposal pit/trench configuration identification					████████████████████		
Geophysical Investigations					████████████████████		
Deep drilling		████████████████████	████████████████████	████████████████████	████████████████████		
Shallow drilling	████████████████████				██████████		
Groundwater monitoring of SDA wells	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████
Monitoring of RWMC drinking water	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████
Hydrogeologic characterization of SDA	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████
Hydrogeologic properties of basalts				████████████████████	████████████████████		
Hydrogeologic properties of sediments				██████████	████████████████████		
Characterization of geologic material				████████████████████	████████████████████		
Hydrogeology of waste pits				████████████████████	████████████████████		
Net downward flux & interface phenomena	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████
Test trench	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████
Weighing lysimeter		████████████████████	████████████████████	████████████████████	████████████████████		
Investigation analysis					████████████████████		
Organic transport model validation				████████████████████	████████████████████		
Radionuclide transport model development		████████████████████	████████████████████	████████████████████	████████████████████	████████████████████	████████████████████

TABLE 1. (Continued)

<u>Task Description</u>	<u>FY-85</u>	<u>FY-86</u>	<u>FY-87</u>	<u>FY-88</u>	<u>FY-89</u>	<u>FY-90</u>	<u>FY-91</u>
<u>ACTIVITIES & STUDIES</u>							
Radionuclide transport model calibration					████████████████████		
Solution chemistry	██						
Radionuclide concentrations		██					
Horizontal and vertical distribution of radionuclides				██			
Radionuclide geochemistry				██			
Chemical form of radionuclides				████████████████████			
Chemical mass transfer				████████████████████			
Waste leachability				██			
Sorption coefficients & kinetics					████████████████████		
Source characterization, hazardous					████████████████████		
RFI workplan				████████████████████			
RFI Report					████████████████████		
Program review/support	██						
RI/FS Informal Document							████████████████████

3. HISTORY OF RWMC SITE CHARACTERIZATION PROGRAM

Studies of possible subsurface migration of contaminants at the RWMC began in 1960. These earlier studies were specific to radionuclide contamination and are reported in documents by Schmalz, B. L. (1972); Barraclough J. T. et al. (1976); Burgus, W. H. et al. (1976); Humphrey, T. G. et al. (1978); and Humphrey, T. G. (1980). The results obtained from these previous efforts provided useful data regarding potential migration of radionuclides. However, the techniques employed in several cases were susceptible to possible cross-contamination during sample collection or handling processes. Also, the data were insufficient for modeling radionuclide transport through the subsurface environment. Therefore, DOE requested EG&G Idaho, Inc. and the USGS INEL Project Office to prepare a comprehensive plan. Specifically, the purpose of the plan is to investigate and determine the extent of subsurface radionuclide migration and to develop and field-calibrate a computer model to help project the long-term migration of radionuclides.

The planning effort for this program was initiated in FY-1982 and completed early in FY-1984. The plan, detailed in the 1983 DOE report (DOE/ID-10116), integrated hydrogeologic and geochemical data requirements specific to radionuclide migration and described the studies necessary to collect the data. This plan formed the basis for the RWMC Subsurface Investigations Program (SIP). The long-term studies incorporated into the SIP were to be completed by the end of FY-1993 so that decisions could be made regarding possible retrieval of transuranic (TRU) waste at the RWMC.

However, events in 1987 precipitated a revision in the scheduled completion date and a change in the scope of the program. Sediment samples confirmed radionuclide migration to the 110-ft interbed underlying the RWMC. Sediment samples from the 240-ft interbed indicated the possible presence of radionuclides. In June, July, August, and October of 1987, sampling of aquifer wells at or near the RWMC detected the presence of volatile organic compounds (VOCs) in the groundwater. During drilling activities in the fall of 1987, VOC vapors were encountered in two boreholes. Concentrations of

carbon tetrachloride, 1,1,1-trichloroethane, and chloroform from boreholes were higher than the threshold limit values established for worker safety. In November 1987, a soil-gas survey at the RWMC confirmed the presence of VOCs in the surficial sediments, and the results suggested that VOCs in the groundwater were related to sources at the RWMC.

At that time, INEL was under a RCRA-3008(h) Consent Order and Compliance Agreement (COCA). Effective in 1986, the COCA established the compliance schedule for the investigation and remediation of hazardous waste land disposal units, solid waste disposal units, and release sites. The COCA specifically identified the RWMC as a solid waste management unit and established reporting requirements for notification of releases from the RWMC. In accordance with the reporting requirements, the 1987 release of VOCs from the Subsurface Disposal Area (SDA) at the RWMC was reported to the EPA Region X in January 1988.

Under COCA requirements, a Corrective Action Plan for the SDA was developed and submitted to EPA Region X in March 1988. The Corrective Action Plan identified actions to be taken at the SDA in response to the releases. A RCRA Facility Investigation (RFI) workplan for the SDA was subsequently developed and submitted to EPA Region X and the State of Idaho. The RFI workplan is more comprehensive than the Corrective Action Plan and includes background information on the SDA and the contaminants detected in the environment. The workplan also identifies additional data requirements, provides a preinvestigation evaluation of corrective measures technologies, and provides plans necessary to conduct a RCRA Facility Investigation.

The original 1983 study plan (for the SIP) was primarily concerned with radionuclide migration in the subsurface and did not encompass the current needs outlined in the RFI workplan. The SIP has been incorporated into the RWMC Site Characterization Program, and the original scope of the program has been expanded to include subsurface transport of hazardous waste, subsurface transport of mixed radioactive waste, and the regulatory requirements associated with a RCRA facility.

4. ACTIVITIES AND STUDIES

4.1 Deep Drilling

The objectives of the deep drilling Program are to provide samples from the sedimentary interbeds and the basalt, and to install moisture/vapor monitoring instrumentation in the open boreholes. The sediment samples are analyzed primarily for the presence of radionuclide and hazardous contaminants. In addition, sediment and basalt samples provide data for subsurface hydrogeologic studies. Rigorous quality assurance program procedures have been developed for deep drilling to prevent cross contamination of borehole samples from drilling and sampling equipment or from surface soil or subsurface material displaced within the borehole. Where possible, the deep boreholes are drilled or cored to a total depth (TD) of approximately 5 ft below the 240-ft interbed.

4.1.1 Drilling and Sampling

Two deep boreholes, 8801D and 8802D, shown in Figure 2, were drilled at the RWMC during the FY-1988 field season. Borehole 8801D was cored to a total depth of 245 ft below land surface. Instrumentation with vapor monitoring ports is planned for FY-1989. Borehole 8802D was cored to a depth of 129 ft and temporarily capped for completion in FY-1989. Geological logs of the retrieved core were maintained. A drilling report describing the drilling and sampling activities is scheduled for FY-1989.

Borehole 8801D was cored continuously from the top of the basalt at 20 ft below land surface (BLS) to a depth of 245 ft BLS. The 30-ft interbed was not present. High concentrations of hydrocarbon vapors were detected at approximately 95 ft and again at 130 ft. Air grab samples were taken; the analyses are briefly discussed in Section 4.6.4. The 110-ft interbed was intercepted at 103 ft. The interbed was 11 in. thick; 7 in. of this interval were recovered. This sedimentary material was sent to a contract laboratory for Appendix IX of 40 CFR Part 264 analyses.

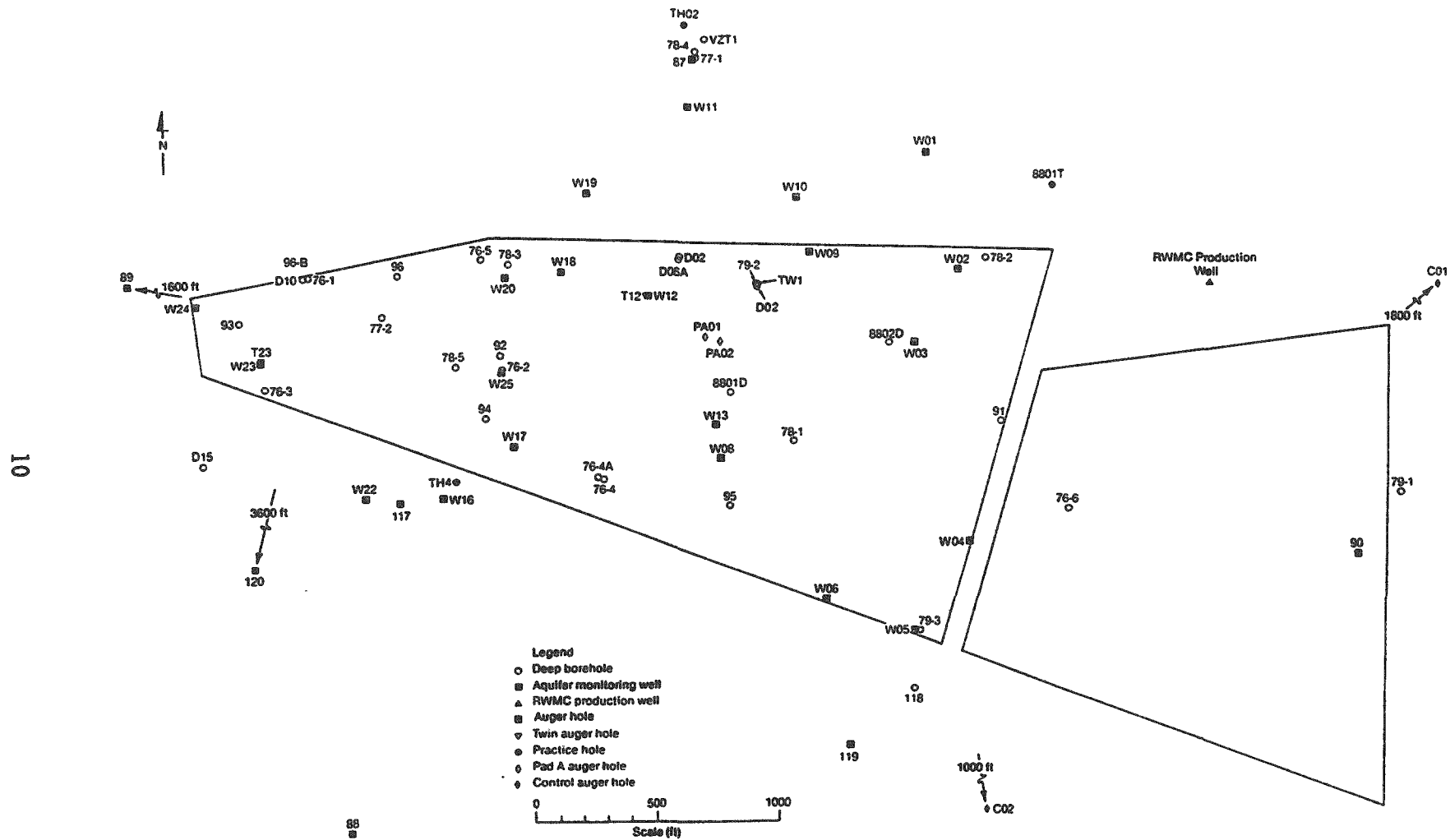


Figure 2. Locations of holes and wells at the RWMC.

After a 6-in. steel casing was set through the 110-ft interbed, coring continued downward through the basalt to the 240-ft interbed. The interbed was intercepted at 229 ft. Core from the 240-ft interbed was recovered from 229 ft to 236 ft and from 240 ft to 241 ft. No core was recovered below 241 ft. Two sediment samples from the 240-ft interbed were submitted for radionuclide analysis, and two were homogenized, split, and submitted for Appendix IX analyses.

Wet clay encountered below the 236-ft depth presented coring problems. The clay clogged up the air flow ports in the drill steel and blocked air circulation around the drill bit. An attempt was made to open the 240-ft interbed by reaming the borehole to a larger diameter. This practice could have permitted further coring. Immediately after it was reamed, sediment in the 240-ft interbed caved in, leaving the final depth at 233 ft BLS. Drilling on the borehole ceased at this point, and plans were made to install downhole vapor monitoring instruments.

Borehole 8802D was cored continuously from the top of the basalt at 6 ft BLS to a depth of 129 ft BLS. High concentrations of organic vapors were detected in the borehole at a depth of 99 ft (after the interbed was breached), and again at a depth of 129 ft. Air grab samples were collected. The analyses are briefly discussed in Section 4.6.4.

The 30-ft interbed was encountered at 26 ft. The interbed was 4 to 6 in. thick; full recovery was obtained. Coring resumed in the underlying basalt, and the 110-ft interbed was intercepted at 97 ft. The interbed was 4.6 ft thick. Borehole cuttings suggest that the sediment was noncemented and unconsolidated; no core was recovered in this interval.

Coring continued after a 6-in. casing was set to a depth of 5 ft below the 110-ft interbed. At a depth of 129 ft BLS, work on borehole 8802D was temporarily suspended because of health and safety concerns.

4.1.2 Geophysical Logs

Geophysical logs were run in 8801D and 8802D through the 110-ft interbed before the casing was set. In borehole 8801D, the entire hole was logged after total depth of 233 ft was reached. Three types of geophysical logs were taken: gamma-ray, gamma-gamma, and neutron. A borehole caliper log and a downhole television log were also run. The geophysical log responses for 8801D and 8802D will be reported and discussed in the forthcoming drilling report to be published in FY-1989.

4.1.3 Health Physics Smears

Health physics surveys were conducted to screen for radionuclide cross-contamination between the surface and the borehole. Smears were taken of the drilling rig and drilling equipment at the start of each day. Smears of the sampling equipment were taken before and after each sampling event. The smears were counted using an alpha spectrometer and beta/gamma counter.

Smear surveys associated with the FY-1988 deep drilling will be reported in greater detail in the forthcoming drilling report. These smears will be used to provide quality assurances for contamination control efforts in the field.

4.1.4 Field Quality Assurance/Quality Control for Hazardous Waste Analysis

Field quality control measures were also undertaken to provide quality assurance for samples submitted for Appendix IX analyses. These measures included decontamination rinses of all sampling equipment with hexane, methanol, and deionized water before each sampling event. Other measures included trip blanks, equipment blanks, field spikes, and a field split.

4.2 Geologic Characterizations of the RWMC

During FY-1988, several studies were undertaken that will provide a greater understanding of the strata underlying the RWMC. The approximately

217 ft of core from borehole 8801D, and 125 ft of core from borehole 8802D obtained during FY-1988 will provide a more complete geologic profile throughout the SDA. Basalt core studies are underway that will describe basalt flow sequences. The individual flow sequences contain discrete fracture zones, cinder zones, and flow rubble zones that may have a direct bearing on fluid and vapor migration.

The USGS has produced a series of subsurface maps that depict the subsurface framework of the RWMC and its surrounding areas. The first three major interbeds (at approximately 30 ft, 110 ft, and 240 ft) have been mapped along with the major basalt sequences. These maps illustrate the basalt and sediment distributions in the subsurface.

A graduate student at Idaho State University has begun a master's thesis on the sedimentology and depositional history of the sediments from the first three major interbeds underlying the RWMC. An explanation of the depositional paleoenvironment of a sediment unit will be useful in efforts to project the subsurface extent/trend of that unit.

A geophysical study was undertaken to evaluate existing subsurface investigation technologies and identify the best candidate technology for determining waste location, depth, and form at the SDA. Reflection seismic work was conducted south of the RWMC to identify and trace major geologic units in the shallow subsurface.

4.2.1 Core Logging

An inventory of the existing basalt and interbed sediment drill cores was compiled. Drill holes 94, 78-1, 76-2 and 79-2 were logged in detail for lithology, structure, fracture-filling, vesiculation, alteration, limited petrographic characteristics, and estimated porosity. These data will be used to provide a more complete geological description of the subsurface, and to help characterize the transport pathways within the basalts. Logging of available core, including cores from the FY-1988 deep drilling program, will continue in FY-1989.

4.2.2 Stratigraphy of the Vadose Zone

During FY-1988, the U.S. Geological Survey, in cooperation with the U.S. Department of Energy, began an investigation of the stratigraphy of the unsaturated (or vadose) zone at the RWMC. The investigation was undertaken to determine stratigraphic relations in the subsurface that might ultimately affect the migration of buried waste from pits and trenches at the SDA to the Snake River Plain aquifer. The primary purpose of this study is to describe the stratigraphic relations between major basalt and sediment layers in the vadose zone and uppermost part of the aquifer using borehole data collected from June 1971 to September 1988.

Preliminary results of the investigation indicate that the upper 700 ft of basalt and sediment is made up of 10 basalt-flow groups and seven major sedimentary interbeds. The flow groups are composed of at least 22 separate lava flows and flow-units that range in age from about 600,000 to 100,000 years old. Individual flow groups are made up of from one to five petrographically similar flows that erupted from common source areas during periods of less than 200 years. The sedimentary interbeds, which consist of fluvial, lacustrine, and aeolian deposits of clay, silt, sand, and gravel, accumulated during periods of volcanic inactivity ranging from thousands to hundreds of thousands of years. The flows and sediment are generally unsaturated to a depth of about 600 ft. The flows and sediment below a depth of 600 ft are saturated and form the uppermost part of the Snake River Plain aquifer.

The areal extent of flow groups and interbeds was determined from borehole cuttings, cores, geophysical logs, K-Ar ages, and geomagnetic properties. Stratigraphic control was provided by four sequential flows near the base of the vadose zone with reversed geomagnetic polarity and high emission of natural gamma radiation. Natural gamma logs were useful for correlation of flow groups and interbeds because the logs are sensitive to changes in the composition of basalt and sediment. In general, sediment emits more natural gamma radiation than basalt. Furthermore, emissions of natural

gamma radiation are relatively uniform in related, petrographically similar flows of individual flow groups, but increase or decrease between petrographically dissimilar flows of different age and source. The relations between natural gamma emissions and the composition of basalt and sediment in core holes were used to correlate flow groups and interbeds from selected core holes to numerous other boreholes from which cores were not taken.

Results of this investigation will be published by the U. S. Geological Survey in 1989. The report, Stratigraphy of the Unsaturated Zone at the Radioactive Waste Management Complex, Idaho National Engineering Laboratory, Idaho, will include geologic cross sections, maps, and tables showing the stratigraphic relations in the upper 700 ft of the subsurface at the RWMC.

4.2.3 Sedimentology and Depositional Environment

Detailed observation and sampling of core material from 13 boreholes drilled by EG&G Idaho, Inc. were the primary sources of information for the study of the subsurface sedimentary interbeds at the RWMC. Logs from these boreholes, in addition to logs from holes drilled by the USGS, were used primarily for correlation purposes. A detailed sieve analysis was performed on 170 selected samples from the core material and from an outcrop of the 30-ft interbed in the active burial pit at the RWMC.

The 30-ft interbed consists primarily of unconsolidated to partially consolidated red, tan, grey and black sandy silt and silty fine sand. The extremely high percentage of silts and fine sands, the homogenous bedding, and the vertical continuity of the deposits indicate that the primary source of the sediment is the accumulation of loess (windblown material). However, the presence of angular basalt and rounded quartz granules interbedded within fine sands and silts in cores from two separate holes suggests fluvial reworking. The sediment in the 30-ft interbed forms discontinuous basin fillings within topographic lows in the underlying basalt and exhibits a maximum thickness of approximately 12 ft.

The 110-ft interbed consists primarily of unconsolidated red, reddish brown, and grey sandy silts, to pebble gravels with angular to rounded textures. The lithology of the sediments and the observed sedimentary structures (such as cross-stratification and horizontal laminations) indicate that the sediment in this interbed was transported and deposited primarily by fluvial systems. The 110-ft interbed is thicker and more laterally continuous than the 30-ft interbed. The 110-ft interbed reaches a maximum thickness of approximately 26 ft and also forms discontinuous basin fillings within topographic lows on the underlying basalt.

Sediments in the 240-ft interbed consist primarily of unconsolidated red, tan, and brown silts to coarse sands. The sedimentary structures indicate that the sediment in this interbed was transported and deposited by fluvial systems entering the Snake River Plain from adjacent basins. Planar cross-stratification and lenticular and mixed mud/sand bedding indicate shallow water channel bar deposits with fluctuating current flow. The fluvial system responsible for the deposition of the 240-ft interbed appears to have had a lower deposition rate than that of the 110-ft interbed. However, the 240-ft sequence represents a much longer period of deposition than the 110-ft interbed, as evidenced by the time span between volcanic events. The 240-ft interbed reaches a maximum thickness within the RWMC of approximately 26 ft and is more laterally continuous than the 110-ft or-30 ft interbeds. The basalt on which the 240-ft interbed was deposited does not appear to have as much topographic variation as the basalt below the 110-ft interbed.

A complete discussion of the RWMC sedimentology will be presented in a Master's Thesis to be completed in FY-1989.

4.2.4 Geophysics

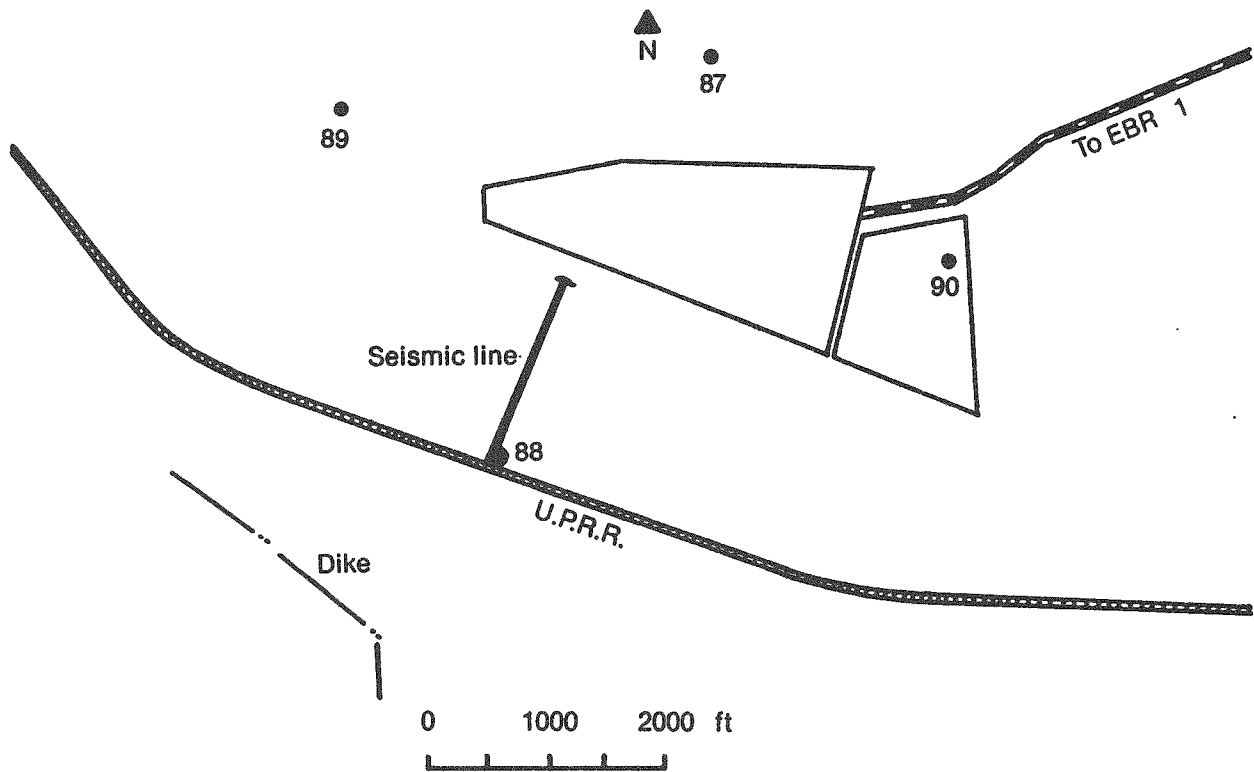
The goals of the current geophysics study are to evaluate existing geophysical subsurface investigation technologies, identify the best candidate technology (system) for determining the waste location, depth, and form at the SDA, and identify effective geophysical techniques for mapping subsurface geology at the RWMC.

Insufficient information concerning waste form, classification, packaging, and location makes site characterization difficult. Although the buried waste units are marked with monuments, their exact boundaries are uncertain. The accuracy and completeness of records concerning the waste buried between 1954 and 1970 are questionable. Therefore, it would be advantageous to define the exact waste perimeter, waste form, packaging classification, and depth of cover, if possible. INEL is investigating geophysical techniques as a means of obtaining this information.

Although previous attempts to employ geophysical methods at the INEL have yielded inconclusive results, geophysics have been successfully applied in many hazardous waste site investigations; and improvements in geophysical technology have occurred since last employed at the INEL. As part of the FY-1988 geophysics activity, an investigation of current geophysical methods was conducted.

No single method can provide all the desired information about the buried waste; therefore, an integrated multimethod approach was taken. Ground-penetrating radar, electromagnetic or resistivity techniques, and magnetics were determined to be the nonintrusive methods with the best chance of meeting the objectives, whereas borehole profiling was determined to be the best intrusive method (Brown, R. M., 1988). Media characteristics and moisture content will influence the effectiveness of the various geophysical methods.

The University of Kansas Geological Survey conducted a seismic survey to identify subsurface structures. The seismic data were collected along one 1640-ft line extending from about 164 ft south of the SDA perimeter fence to approximately 164 ft south of Well 88 (Figure 3). This effort produced 1640 ft of seismic-reflection data, with Well 88 as a control point to establish where the 110-ft interbed occurred on the seismic profile. The data were acquired and processed using the common-depth-point (CDP) method and were collected to optimize resolution within the target window (surface to 150 ft).



9-3069

Adapted from (Miller et al., 1988)

Figure 3. Location of the seismic survey.

The seismic survey effort was conducted with limited success. Interpretation of the data indicated the presence of a 10-to 13-ft thick sedimentary layer at the 98-ft depth within the basalt. This indication correlates well with the location of the 110-ft interbed as depicted in the log of Well 88. Extreme lateral variations in velocity were evident on the seismic data, making absolute depth calculations impossible. Results of the seismic reflection study are discussed in a subcontractor report (Miller, R. D. et al., 1988).

4.3 Hydraulic Characterization of RWMC Subsurface

Samples from the cover material overlying buried waste at the SDA were analyzed for hydraulic characteristics, and a report documenting the results of that study was submitted. Archived sediment samples were reanalyzed to determine the effects of long term storage on hydraulic properties. Selected samples of unfractured basalt were analyzed for hydraulic characteristics. A study was initiated that will investigate water movement through unfractured, vesicular basalt. The Net Downward Flux study continued, with data collected from the installed instruments on a regular basis, and selected data were analyzed. Data were also collected from the weighing lysimeter. A new test trench was installed at the RWMC. Results from these studies will provide information on moisture movement through the vadose zone.

4.3.1 Hydraulic Characteristics of Basalts and Sediments

A report was submitted in September 1988 entitled Hydraulic Characteristics of Soil Cover, Subsurface Disposal Area, Idaho National Engineering Laboratory (Borghese, J.V., 1988). This report presents laboratory determinations of saturated hydraulic conductivity (K), grain size distribution, dry bulk density, and porosity for four intervals within 14 samples collected from cover materials overlying buried waste in the southern portion of the SDA. The data indicates the cover is heterogeneous with K values ranging from 7.7 E-07 to 8.4 E-02 cm/s.

Five sediment samples from surficial sediments and from the 240-ft interbed were reanalyzed to determine if long term storage (years) of the samples would affect the hydraulic conductivity (K) of the materials (silt and sand). This analysis indicates that material properties may be relatively constant (within the limits of measurement error) for these samples. The K values for the samples analyzed ranged from 1.0 E-02 to 3.8 E-03 cm/s. Plans for FY-1989 are to determine hydraulic properties of surficial and interbed sediments from archived and newly collected core.

Basalt core samples were inventoried, and four representative samples were chosen and sent to a laboratory for determination of effective and total porosity, gas and liquid permeability, and capillary pressure by mercury injection. Three of the four basalt cores tested were representative of vesicular to very vesicular basalt; the fourth core was typical of massive basalt. Interestingly, the massive basalt exhibited the highest values for air and liquid permeabilities. Hydraulic conductivity (the permeability of a medium to water) for the basalts ranged from 1.04 E-05 cm/s to 1.29 E-07 cm/s . In addition, all of the four core samples exhibited relatively high effective porosities ranging from 12 to 24%.

A research proposal was submitted by a graduate student from the University of Arizona to study the fluid flow and transport properties of vesicular basalt from the SDA. The goal for this project is to provide information relating to water movement and transport through unsaturated, unfractured, vesicular basalt. The following are objectives of this study:

1. to obtain insight into the relationship between moisture infiltration into basalt and the vertical transmission of water through the vesicular matrix
2. to determine velocities of vertical moisture movement and solute transport for a range of suctions
3. to determine the effect of scale on unsaturated hydraulic conductivity and from this relationship develop techniques for assessing properties at other depths.

This research is being funded in FY-1989.

4.3.2 Net Downward Flux

The objectives of the Net Downward Flux study are to determine the volume and rate of moisture inflow through the SDA surface, identify pathways

of moisture migration, characterize the effect of lithologic interfaces on moisture movement, and provide data describing moisture entry into the ground and moisture movement through the unsaturated zone for verification of a simulation model. This study requires instrumentation throughout the SDA to characterize the availability, variability, and movement of moisture. In situ field equipment is used to measure and monitor soil water content at the RWMC.

During FY-1988, data were collected monthly from a combination of psychrometers, heat dissipation sensors, tensiometers, gypsum blocks, and neutron-access tubes installed in 34 boreholes around the SDA. Water samples were collected from suction lysimeters in three sampling events and submitted to laboratories for analysis for major ionic chemistry or radionuclides. Field readings from these instruments were entered into the RWMC Data Management System. Quality assurance tasks were completed for data through December 1987; these tasks entailed checking each field entry against the data base entries for correct dates and measurements.

Standard operating procedures were compiled for use in data collection and published as an informal report entitled RWMC Subsurface Investigations Program Guidelines for Data Collection (Hubbell, J. M. et al., 1988). These guidelines detail the specific procedures used to collect data from psychrometers, neutron access tubes, gypsum blocks, heat dissipation sensors, tensiometers, and lysimeters. The guidelines describe all aspects of data collection from collection and compilation, to entry of data into the RWMC Data Management System. Safety requirements are also described in the report.

A calibration schedule was instituted and maintained for all the gauges and meters. In addition, soil-moisture instruments (heat dissipation sensors and gypsum blocks) were calibrated in preparation for installation in new boreholes. These calibrated instruments have not yet been installed because of changes in the planned instrumentation.

An initial analysis of instrument data was completed in FY-1988 in conjunction with the writing of the FY-1987 annual report (Laney, P. T. et al., 1988). Results indicated the following:

- Psychrometer data exhibited a large variability that limited their usefulness in the analysis process (the variability may be a result of limited calibration). A statistical evaluation before any further evaluation of the data was recommended.
- Areas with wetter conditions were generally found near drainage and flood-control ditches, small depressions, or areas included in past flood events. In addition, boreholes within the SDA were generally wetter than boreholes outside the perimeter of the SDA.
- Matric potentials in the surficial sediments increased with depth below land surface, generally indicating increasing moisture with depth.
- Hydraulic gradients in several boreholes indicated downward moisture movement for large portions of the year.
- Neutron data indicated a zone (from the surface to 6 to 7 ft below land surface) strongly affected by seasonal cycles of precipitation and evapotranspiration. Movement below this active zone was predominantly downward, by the force of gravity.

Plans for FY-1989 include continued collection of data from instrumentation, statistical evaluation of the data, and calculation of ranges of soil-water flux rates through the subsurface at the SDA. The analyses of the data will be presented in an interpretive report, planned for FY-1989. A separate data report will present the raw data and associated Quality Assurance (QA) documentation.

4.3.3 Weighing Lysimeter

The objectives of the weighing lysimeter activity are to provide additional data that will describe soil moisture content, moisture changes with time, and rates of soil moisture infiltration typical of cover materials

at the RWMC. These data will be used to assist in the calibration of a numerical model of soil moisture movement at the RWMC.

Weighing lysimeters are used to determine rates of soil moisture evaporation and plant transpiration in the upper few meters of surficial sediment. The weighing lysimeter activity in FY-1988 consisted of weight data collection and neutron logging through access holes installed in the weighing lysimeters and the control pit. For details of the installation, refer to the FY-1985, -1986, and -1987 progress reports (Hubbell, J. M. et al., 1985; Hubbell, J. M. et al., 1987; Laney, P. T. et al., 1988).

During the first and second quarters of FY-1988 snow bridging between the lysimeter and the surrounding soil caused erratic weights to be recorded. Data were recorded during the third and fourth quarters of FY-1988. Moisture profiles of soil in the weighing lysimeters were compared to moisture profiles of the control pit to verify that the lysimeter was operating correctly. In May, the lysimeter and control pit moisture profiles were matched using suction candles in the lysimeters. This match could not be maintained on a continuous basis during high moisture conditions, but the match was maintained from July to September when infiltration was restricted by evapotranspiration to the upper 1 ft of soil. Erratic weights were recorded during high wind conditions as well.

The collection of data from the weighing lysimeters will continue in FY-1989. Work will continue on methods to automate the moisture profile matching of the lysimeter soil to ambient soil moisture and on improvements that will enable the lysimeter to work during thaw conditions. Statistical analyses will be performed to minimize the effects of wind loading.

4.3.4 Test Trench

The objective of the test trench study is to obtain detailed information on soil moisture movement in the unsaturated zone at the RWMC. Two test trenches and an instrumented simulated waste trench have been installed north of the SDA to determine, under actual and simulated

conditions, the typical moisture contents, unsaturated hydraulic conductivity, matric potential, soil-moisture flux, and soil-moisture velocity. The trenches will also be used to experimentally evaluate the behavior of soil moisture under simulated environmental extremes. Data from the test trenches are collected from instrumentation located in disturbed and undisturbed soils, adjacent to simulated waste containers, and along the surficial sediment/basalt interface.

These trenches were instrumented with neutron access holes, tensiometers, and psychrometers to measure temperatures, moisture contents, and tensions in the soil. Psychrometers are retrievable so that calibrations can be verified over time. Soil cores taken during instrumentation and installation of the neutron access holes are analyzed to determine their hydraulic properties and sediment characteristics.

A micrometeorological station is installed at this site to determine the effects of atmospheric and surface conditions on subsurface soil moisture and temperature variations. This station is also used to support the Net Downward Flux and Weighing Lysimeter studies.

The Test Trench activity is necessary in order to determine the net amount of precipitation available for downward migration through the subsurface and to develop an understanding of the movement of water from the soil surface through the waste pits and into the first sediment/basalt interface.

In the first quarter of FY-1988 a simulated waste trench was installed just north of the east test trench. A 10- x 31-ft trench was excavated to a depth of 12 ft in the surficial sediment. The trench was then backfilled with 2 ft of sediment. Four suction lysimeters were installed at specific depths from the sediment/basalt interface to the first backfill layer, and a 2,6-difluorobenzoic acid tracer solution was applied to the trench bottom. Fifteen 55 gal Department of Transportation (DOT) hazardous waste drums were filled with clean simulated waste treated with a potassium bromide tracer, sealed, and placed in the trench. The trench was backfilled to a depth of

5 ft and a 2-trifluoromethylbenzoic acid tracer applied. The trench was then backfilled to a 1 ft depth and a pentafluorobenzoic acid tracer was applied. The trench was then backfilled to land surface. Suction lysimeters were installed between the tracer layers. Five neutron access holes were installed adjacent to the trench in undisturbed soil and in the simulated waste trench disturbed soils.

Soil moisture data were collected from all neutron access holes on a bimonthly basis. No water samples were collected from the suction lysimeters because soil conditions were too dry for the lysimeters to function. Soil-water potential and soil temperature data were collected every twelve hours; micrometeorological data were collected hourly and summarized every 24 hours. Verified data were forwarded to the EG&G modeling group.

During FY-1988, seventeen surficial soil samples from selected depths at the test trench area were analyzed for particle size distribution. Preliminary examination of the data indicate that sediment at the test trench area is fine-grained, with between 5 to 26% of individual samples having particles in the sand size range (0.062 mm to 2.00 mm), 43 to 66% in the silt size range (0.004 mm to 0.062 mm), and 22 to 45% in the clay size range (<0.004 mm).

Selected samples were examined under a binocular microscope to determine bulk mineralogical components. These samples indicate that the major constituent is quartz; plagioclase feldspar, calcite, and basalt fragments are also present. X-Ray diffraction analyses performed in FY-1987 on samples from the same area and range of depths indicate that montmorillonite, kaolinite, and some illite are additional minor mineralogical constituents of these soils.

Analyses of soil samples from the test trench area will be presented in an upcoming data report to be published by the U.S. Geological Survey during FY-1989. Additional samples from the test trench area will be analyzed for particle size distribution and bulk sediment characteristics during FY-1989.

Quantitative analyses will be performed on selected test trench samples to determine approximate percentages of the different mineralogical components.

A U.S. Geological Survey report on the 1985 to 1986 test trench data was completed and sent out for colleague review and data verification. This report will be published in the second quarter of FY-1989. Data accuracy analyses were completed on the 1987 data and compiled for the 1987 data report. This report and a 1988 data report will be completed in FY-1989.

4.4 Geochemical Activities

Inorganic chemical analyses of soil waters collected from porous cup lysimeters installed in boreholes in the SDA are performed to provide information on the geochemical interactions that may affect radionuclide migration from the SDA.

A total of 68 soil water samples were obtained during June (25), August (23), and September (21), 1988. Complete water chemistry results were received for 58 of the samples and cation concentrations were available for all 68 samples. Tabulated data and an in-depth evaluation of the results will be presented in future data reports.

4.4.1 Sample Collection and Chemical Analysis

Samples were collected on three separate occasions. Sample collection techniques remained similar to those described in previous annual reports (Laney P. T. et al., 1988). The use of reservoir vacuum tanks on certain lysimeters was still required, indicating that air leaks were permanent in certain instruments. Field measurements of solution temperature and pH were made routinely, and it is planned to measure dissolved oxygen in FY-1989.

Since FY-1986, potassium bromide were used as a tracer during lysimeter installation. Bromide concentrations have been used in the past as an indicator that the lysimeter was sampling natural formation waters. Bromide concentrations in all but two of the shallow lysimeters (installed in

surficial sediments) and one of the deep lysimeters (installed in sedimentary interbeds) are usually below 5 mg/L, and were assumed to represent concentrations from the soil waters.

The majority of soil waters sampled from lysimeters during FY-1988 were sodium-potassium bicarbonate waters typical of waters that evolve in many arid soils. Total dissolved solids in the shallow lysimeters range from 2200 to 6500 mg/L. Water from a lysimeter within the 30-ft sedimentary interbed shows higher dissolved solids concentrations (approximately 12,000 mg/L). These waters fall into the classification of brackish or saline water. Detailed analysis of the chemistry is ongoing in FY-1989 to determine the inorganic speciation of these waters and the implications for radionuclide transport.

4.4.2 Other Geochemical Activities

Special studies on chemical mass transfer and radionuclide solubility/sediment leachability were performed during FY-1988. The major objective of the chemical mass transfer study was to obtain selected geochemical codes with which to calculate inorganic speciation for the soil waters. The geochemical codes PHREEQE and EQ3NR/EQ6 were obtained, and work was begun to modify the codes for use in SDA studies. Speciation calculations for soil water compositions are planned for FY-1989.

The objective of the radionuclide solubility/sediment leachability study was to conduct a literature study on the possible effects of hazardous organic constituents found at the RWMC on radionuclide mobility. Preliminary work did not indicate significant complexation of radionuclides by volatile organic chemicals such as carbon tetrachloride or trichloroethylene; work on this study continues during FY-1989.

4.4.3 Ongoing Activities

Three sampling events for inorganic chemical analyses of soil waters are planned as part of the routine monitoring of the SDA during FY-1989. Another sampling event is scheduled in FY-1989 to collect soil waters for analysis of

hazardous constituents.

Inorganic speciation calculations will be conducted on the soil waters during FY-1989, and the data will be used to evaluate the contribution of the soil water to the inorganic complexation of radionuclides. The possibility of radionuclide sorption on natural colloids formed from soil waters will be investigated.

4.5 Characterization of Radionuclide Contaminants

Radiochemical analyses of surficial sediments, sedimentary interbeds, and soil waters are conducted to determine the areal extent of radionuclide migration from the pits and trenches at the SDA. The data are used to interpret the geochemical and hydrological controls on radionuclide mobility following nuclide release from the pits and trenches, and to constrain conceptual flow and transport models of contaminant migration from the SDA.

In previous years, sediment and soil water samples were analyzed for a suite of 29 radionuclides (see Laney, P. T. et al., 1988) by alpha spectrometry, beta low-level counting, and gamma spectroscopy. Similar radiochemical analyses were performed for sediment samples during FY-1988.

Samples were collected and handled according to procedures designed to prevent cross-contamination of samples. One way to further reduce the possibility of sample cross-contamination is to take a core from within a sediment sample and submit the subcore for analysis. However, not all sediment samples contain sufficient undisturbed material to produce a subcore.

The results of complete radiochemical analyses were received for two samples of sediments from the 240-ft interbed in borehole 8801D, drilled in FY-1988. The results of gamma spectroscopy were received for 34 sediment samples from cores obtained in FY-1987 and for two soil QA samples. Data from alpha and beta analysis were received for 8 of the 34 samples. Other alpha and beta analytical results are forthcoming. Results of radiochemical analyses begun in FY-1987 and completed in FY-1988 were received for two

sediment samples and one soil water sample.

As in previous years (Laney P. T. et al., 1988), analytical results for radionuclides include a value for the analytical uncertainty, reported as a one sigma value. Concentrations measured in excess of three sigma (99% confidence level) are deemed "positive."

Results summarized here are limited to those results received in FY-1988 and not previously reported (i.e., in Laney P. T. et al., 1988).

4.5.1 Sediment Radiochemistry

Of the sediment samples discussed in the previous paragraphs, not all were subcored during preparation for radionuclide analysis. Results of analyses of interbed samples not subcored are currently undergoing a quality assurance process, necessary before their release. Of the subcored interbed samples included in this reporting period, none produced positive results.

Analyses of one surficial sediment sample yielded positive results for $^{239+240}\text{Pu}$, ^{238}Pu , ^{241}Am , and strontium-90. Sample number, depth, location, and concentrations for the detectable radionuclides are given in Table 2.

TABLE 2. SEDIMENT SAMPLES TESTING POSITIVE FOR RADIONUCLIDES (FY-1988)

<u>Sample No.</u>	<u>Sample Location</u>	<u>Sample Depth (ft-in.)</u>	<u>Nuclide</u>	<u>Activity (5Ci/g)</u>
C-262	W13	9-4	Pu-239, 240	$2.84 \pm 0.11 \text{ E-07}$
			Pu-238	$7.7 \pm 1.4 \text{ E-09}$
			Am-241	$5.46 \pm 0.18 \text{ E-07}$
			Sr-90	$4.9 \pm 0.3 \text{ E-07}$

Radiochemical analyses performed in previous years indicated that plutonium had migrated from the pits and trenches into the subsurface beneath the SDA (Laney P.T. et al., 1988). In FY-1987, deep borehole D15 was drilled outside the SDA to provide control samples. The data received to date from radiochemical analysis of samples from D15 do not show the presence of any

radionuclides in the 110-ft or the 240-ft sedimentary interbeds. Radiochemical analysis of two sediment samples obtained from the 240-ft interbed in borehole 8801D, located inside the SDA, did not detect the presence of radionuclides. Geochemical and hydrological controls on the radionuclide migration to the 110-ft interbed are under investigation during FY-1989.

4.5.2 Soil Water Radiochemistry

The results of the radiochemical analysis of a soil-water sample submitted in FY-1987 were received during FY-1988. The sample was collected from lysimeter L09, in borehole W23, at a depth of 7 ft 8 in. The results were positive for strontium-90, at an activity level of $1.19 \pm 0.12 \text{ E-08 } \mu\text{Ci/ml}$. In FY-1987, waters from lysimeter L08, in borehole W23 at a depth of 11 ft 1 in., tested positive for plutonium-238 and/or americium-241 (Laney P. T. et al., 1988). Tables of the analytical data and interpretations will be presented in a data report in FY-1989.

4.5.3 Ongoing Activities

Alpha and beta radiochemical analyses of 17 sediment samples will be completed in FY-1989. Sediment samples from 8802D will be obtained and analyzed for radiochemistry in FY-1989. Sediment from fractures within basalt for radiochemical analyses will be sampled. Monitoring of the radiochemistry in soil waters will continue during FY-1989. The lysimeters in the SDA are scheduled for radiochemical analysis in November 1988 and sampling again in August 1989.

4.6 Characterization of Hazardous Contaminants

Current data indicate that volatile organic compounds (VOCs) have been detected at the SDA from the surface soil to the water table. Measurements and results from groundwater monitoring, well gas monitoring, and the 1987 soil gas survey, indicate that the VOCs of primary concern are the following:

- Carbon tetrachloride

- Trichloroethylene
- 1,1,1-trichloroethane
- Chloroform
- Tetrachloroethylene

Other VOCs were found at lower concentrations and are as follows:

- 1,1,2-trichlorotrifluoroethane
- 1,1-dichloroethane
- 1,1-dichloroethylene
- Dichlorodifluoromethane
- Toluene

All of the above except for toluene are chlorinated hydrocarbons, and thus are relatively resistant to microbial degradation. These chlorohydrocarbons are also relatively chemically stable, and do not rapidly degrade through oxidation or hydrolysis.

4.6.1 Examination of Disposal Records

Available INEL waste shipment records do not contain a complete listing of potentially hazardous materials stored in the SDA or of transuranic wastes stored in the TSA. A 1987 investigation was conducted to estimate the quantity of organic wastes received from the Rocky Flats Plant (RFP) and stored at the RWMC. This effort was discussed in the FY-1987 Annual Report (Laney, P. T. et al., 1988). Information gathered from the 1987 investigation has been added to the database known as the Radioactive Waste Management Information System (RWMIS). The RWMIS compiles information derived from past and current investigations. Past investigations included examination of disposal and shipping records; identification of off-site waste generators' operations, processes, types of waste generated, material uses, waste management practices; and any significant changes occurring since storage of wastes began.

Although the dates of waste shipment to the SDA may be correlated with the dates specific pits were open, the quantity of organic waste placed in each individual pit can only be estimated. Available disposal records indicate that approximately 88,400 gal of organic sludge waste from the RFP were buried at the SDA from 1966 to 1970. These wastes are believed to be the major source of the contaminants of concern. The RFP organic wastes consist of approximately 24,000 gal of carbon tetrachloride, approximately 39,000 gal of machine oil, and approximately 25,000 gal of miscellaneous VOCs (1,1,1-trichloroethane, chloroform, trichloroethylene, and tetrachloroethylene).

One can tentatively identify the locations of organic sludge disposal in the SDA by using the specific year and annual quantity information obtained from the RFP and correlating that information with the pits in the SDA that were open during the same time period. This methodology has identified Pits 4, 5, 6, 9 and 10 as potentially having received the organic wastes.

The locations of organic sludge disposal identified by existing records strongly correlates with the results of the soil gas survey conducted in the fall of 1987 (see Laney, P. T. et al., 1988). However, three anomalies were noted: 1,1,1-trichloroethane (TCA) was found in the southeast corner of the SDA, and several VOCs were found at or near Pad A and in Pits 1 and 2. Disposal records did not indicate that these locations received organic waste from the RFP.

The results of the soil-gas survey indicated that much of the TCA soil-gas plume is substantially different from the other constituent plumes identified. The TCA plume is associated with trenches that are not known to contain RFP organic waste sludge. These trenches are associated with INEL generated waste. On-site generation of organic material is currently under investigation.

The data from on-site generators is being obtained through interviews conducted by a representative of the EG&G Buried Waste Program. An initial debriefing session has already been held with personnel who had prior

experience at the SDA. Future debriefings will be held with personnel familiar with past INEL operations, processes, material usage, waste management practices, etc. Additional information from early retrieval projects will also be obtained.

4.6.2 Results of Soil Analysis

Two sediment samples from borehole 8801D were submitted to the Roy F. Weston, Inc. laboratory in Stockton, California for analysis for hazardous constituents as listed in Appendix IX of 40 CFR Part 264. In the analysis of these samples, EPA Contract Laboratory Program (CLP) analytical methodologies were used in conjunction with the required quality control (QC) procedures. Analysis for non-CLP substances used applicable analytical methodologies and QC procedures detailed in Test Methods for Evaluating Solid Waste -- Physical/Chemical Methods, Third Edition (EPA, 1986). Of the two samples submitted for chemical analysis, one was collected from the 110-ft interbed and one was collected from the 240-ft interbed. As a field QC measure, the sample from the 240-ft interbed was homogenized, split, and submitted with a field replicate. Other field QC measures included the submittal of trip blanks with each sample shipment, and the submittal of field equipment blanks. In addition, two "blind" spiked samples prepared by EG&G were submitted for VOC and metal analyses.

Results of the sediment analysis are currently in the quality control review process, and final results are not yet available.

4.6.3 Results of Water Analysis

A study of purgeable organic compounds in the Snake River Plain aquifer was conducted from June through November 1987 (Mann L. J. et al., 1987). The study covered the entire 890 mi² INEL. Nine of the wells sampled--87, 88, 89, 90, 92, 117, 119, 120, and the RWMC production well--are at or within one mile of the SDA perimeter (See Figure 2). All nine wells obtain water from the Snake River Plain aquifer except Well 92, which obtains water from a perched water body.

Water samples from the nine wells listed above were collected and analyzed for 36 purgeable organic compounds by the USGS National Water Quality Laboratory. VOCs were detected in all nine of the SDA and perimeter wells. Detected VOCs, in order of highest-to-lowest concentrations, were: carbon tetrachloride, trichloroethylene, chloroform, 1,1,1-trichloroethane, and toluene. Carbon tetrachloride and trichloroethylene were the most widely distributed VOCs in the groundwater at and near the SDA. Samples from Well 88 (southwest of the SDA) show the most persistent detection of VOCs over time. The highest VOC concentration and widest range of VOC distribution was detected in Well 92, the perched water well. Toluene may be present as a result of the type of pump used to obtain the samples; toluene data need further evaluation.

Sampling of the SDA wells regionally downgradient did not detect the major organic constituents associated with the SDA; toluene was detected, but may possibly be attributed to the pump used for sampling.

The USGS collects groundwater samples from the groundwater monitoring wells on the INEL on a routine basis. Under the FY-1989 monitoring schedule, wells at or near the SDA (except Well 92) will be sampled on a quarterly basis and the samples analyzed for purgeable organic compounds and selected radionuclides. An additional sampling of the RWMC production well will be conducted on a monthly basis for analysis of purgeable organic compounds. Well 92, the perched water well, will be sampled on a semi-annual basis for analysis of purgeable organic compounds and radiological constituents.

4.6.4 Results of Gas Analyses

A soil-gas survey was conducted in October 1987 to determine the identity, location, and relative concentration of selected chlorinated and aromatic VOCs in the vadose zone at the RWMC. Analyses of the survey results show that carbon tetrachloride, 1,1,1-trichloroethane, trichloroethylene, and tetrachloroethylene are migrating from a number of pits. Measurable concentrations of VOCs occur in soil gasses at distances 2000 to 3400 ft

outside the SDA perimeter. Analysis of gasses collected at depth under the SDA indicate maximum gas concentrations around 100 ft BLS, and measurable concentrations down to 576 ft. Results are discussed in the FY-1987 Annual Progress Report (Laney, P. T. et al., 1988).

Air grab samples from deep boreholes 8801D and 8802D were collected throughout the FY-1988 deep drilling season for health and safety purposes. These samples were collected in response to HNU organic vapor monitor measurements above background levels. HNU monitoring detected above background organic vapor concentrations near the upper interface of the 110-ft interbed and again at approximately 30 ft below the top of the 110-ft interbed in these boreholes. In addition to the four organic compounds detected in the soil-gas survey, the analyses of the air grab samples also detected chloroform. Carbon tetrachloride, chloroform, and trichloroethylene were detected close to or above the Time Weighted Average (TWA) recommended by the American Conference of Governmental Industrial Hygienists for safe worker exposure.

During the fall of 1988, additional air grab samples were collected from boreholes 8801D and 8802D and analyzed for the presence of chemical parameters not previously targeted for analysis. In addition to compounds already detected, this more extensive analysis detected mercury, at a value slightly above the TWA in borehole 8801D.

4.7 Computer Model Development

The purpose of the research being conducted for the computer model development task is to assemble and develop a suite of computer models for predicting the long-term fate of the contaminants in the RWMC vadose zone. The computer models are currently being used to formulate an understanding of the processes and mechanisms that have produced the contaminant movement to date. They are also being used to evaluate potential future contaminant migration and possible remedial actions that would eliminate or minimize contaminant migration to the groundwater.

In FY-1988, work on the Computer Model Development task was performed in five specific areas: (1) computer code development, (2) model calibration using field data, (3) model application to evaluation of remedial actions, (4) model application to radionuclide transport processes, and (5) documentation and peer review of the model development work.

4.7.1 Computer Code Development

In the previous fiscal year, various computer codes were acquired, installed on the INEL Cray X/MP 24 computer, and modified for applications to the RWMC. During this reporting period, code development effort focused on the following areas: (1) development of the FLASH computer code, a two-dimensional unsaturated flow code for fractured-porous media, (2) modification of the MAGNUM-3D and FECTRA-3D codes to simulate organic vapor flow and transport, and (3) development of graphics software for production of color slides and video film sequences.

A new computer code, referred to as FLASH, was developed to simulate moisture movement through the vadose zone. The new code is intended to replace the TRACR3D code, which currently has limited applicability to fractured-porous media. The FLASH computer code is unique in that it can model unsaturated flow in porous media with discrete fractures. The FLASH code has the added capability of modeling heat transport and nonisothermal liquid and vapor flow. The FLASH computer code has been computationally tested against other computer codes such as: TRACR3D (Travis, B. J., 1984), UNSAT2 (Davis, L. A. et al., 1983), FEMWATER (Yeh, G. T. et al., 1980), SATURN (Huyakorn, P. A. et al., 1984), and SUTRA (Voss, C. I., 1984). In general, the code testing showed that the FLASH computer code was computationally faster, more versatile, and easier to use than the existing codes. Graphical comparisons of the FLASH results against results of the other codes tested showed good qualitative agreement.

Efforts were initiated to establish the capability for a full three-dimensional simulation of the organic vapor plume. For this purpose, the MAGNUM-3D and FECTRA-3D computer codes were acquired and installed on the

Cray X/MP 24 computer. The MAGNUM-3D code (Estey, S. A. et al., 1985) is a general finite element code that is capable of modeling three-dimensional fluid flow in a layered, anisotropic hydrogeologic system. The MAGNUM-3D code was modified to simulate the organic vapor plume evolution from 1966 to the present. In the future, the code will be used to calculate the three-dimensional subsurface-gas flow patterns induced by subsurface-gas extraction via pumping. The FECTRA-3D code is a general contaminant transport code and is a counterpart to the MAGNUM-3D computer code. The FECTRA-3D code will be used to predict the response of the vapor plume to the vapor vacuum extraction process.

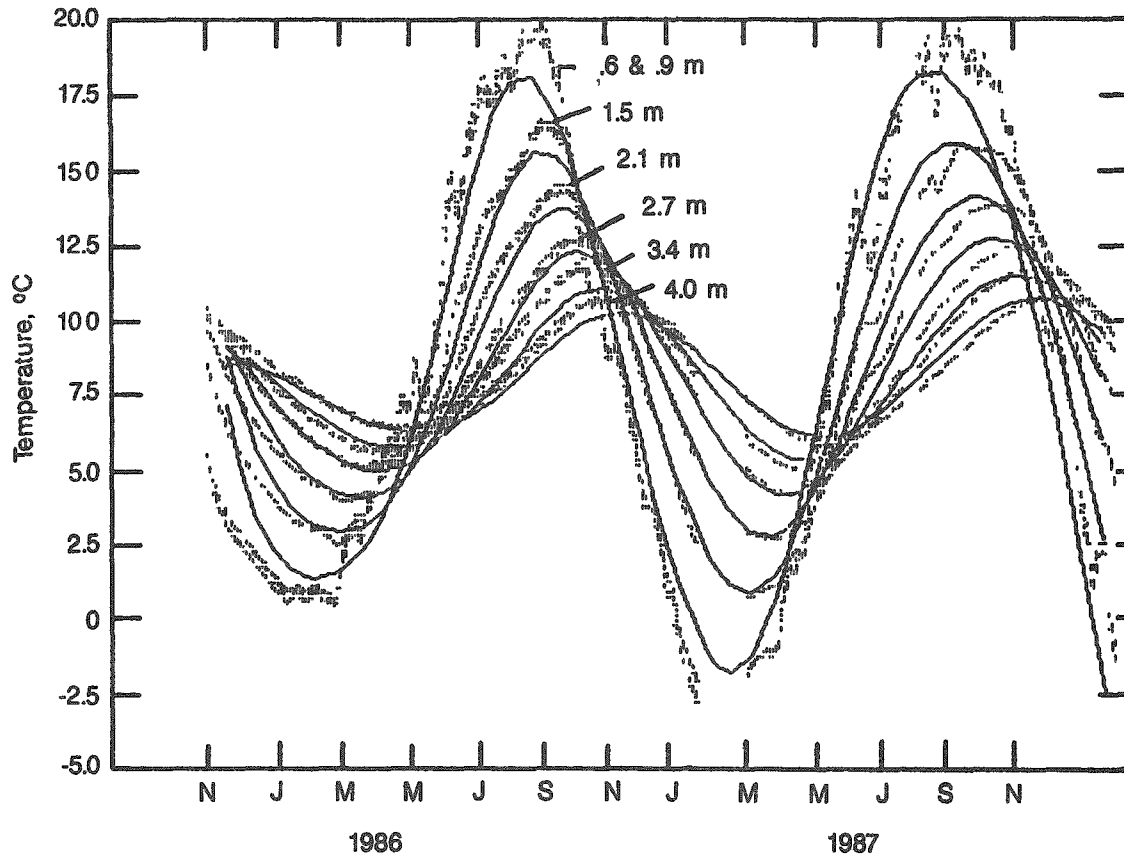
A computer program called VIDEO was developed and interfaced with existing computer codes. The VIDEO program reads the simulation output and produces color slides or a video film sequence. The VIDEO program was used to produce a color video of the organic vapor plume simulation. The new video segments illustrate the following: (1) the evolution of the plume from 1966 to the present, (2) plume clean-up using a single extraction well, and (3) plume cleanup for a single well and an impermeable cover. A legend was added to the video for ease in delineating concentration levels. Narration was also added to the video.

4.7.2 Model Calibration using Field Data

Two computer codes, FLASH and PORFLO, were calibrated using available field data from the RWMC. The FLASH computer code was calibrated using temperature data collected at the USGS test trench. The PORFLO code was calibrated using data from the 1987 soil-gas survey. The model calibration was performed by manually adjusting uncertain model parameters to achieve a best fit with observed data.

The FLASH computer code was set and run to simulate the annual temperature cycle in the upper 20 m of the geologic section. The purpose of the calibration process was two-fold: (1) to estimate the thermal diffusivity (i.e., thermal conductivity divided by the heat capacity) of the surficial sediments and (2) to evaluate how well the model would simulate the observed

soil-temperature patterns at the RWMC. The model calibration produced excellent results, shown in Figure 4. A thermal diffusivity of $0.034 \text{ cm}^2/\text{s}$ was obtained for the surficial sediments.



8-7473

Figure 4. Soil temperatures measured at the west test trench compared to soil temperatures predicted by the FLASH computer code (solid lines represent predicted temperatures).

The modified PORFLO code, which is used to simulate the organic vapor plume, was calibrated using soil gas survey data for the RWMC. The model was calibrated using the carbon tetrachloride concentrations measured in the surficial sediments, well 77-1, and the groundwater samples. The purpose of this calibration effort was to estimate the tortuosities of the strata and to simulate the plume evolution from 1966 to the present. Principal results of the calibration show that the model provides relatively good results in the

region where concentrations are greatest. Available data for calibration, however, are quite limited at this time. In particular, no subsurface data were available to define the vertical concentration profile in the center of the plume. Current plans are to recalibrate the plume in FY-1989 when more field data will be available.

4.7.3 Evaluating Remedial Actions using Computer Modeling

The modified PORFLO code was applied to simulate the organic plume response to alternative remedial actions. In particular, the alternatives for site remediation consisted of different Vapor Vacuum Extraction (VVE) configurations. The basic concept of VVE is to induce soil-gas flow towards a well or set of wells. This is accomplished by applying a vacuum at the extraction well. Atmospheric air enters the soil and displaces the vapor phase of the VOCs. The effectiveness of VVE operation depends greatly on the magnitudes and ratios of the permeability of the strata. Available data from the INEL indicate that permeabilities may range from a fraction of a Darcy to about 200 Darcies and that the ratio of horizontal to vertical permeability may be as high as 75. The clean-up sequence for a particular scenario is illustrated in Figure 5.

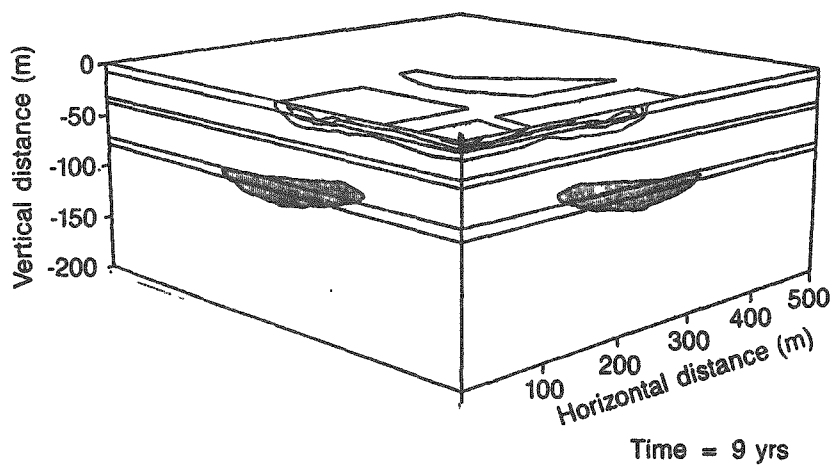
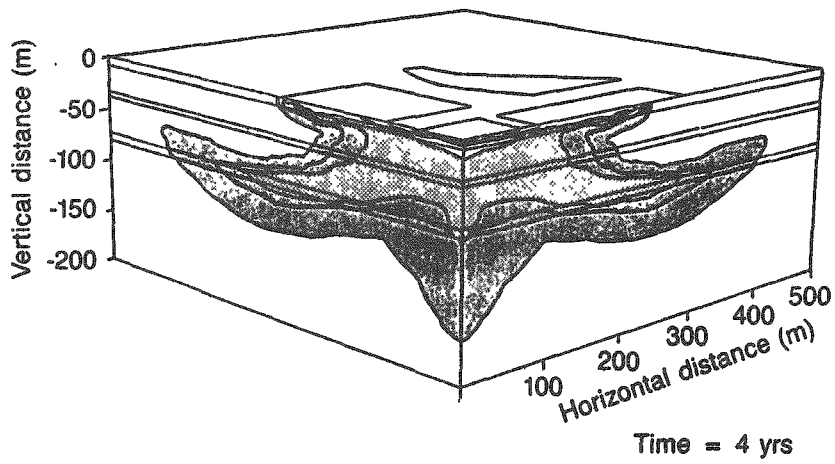
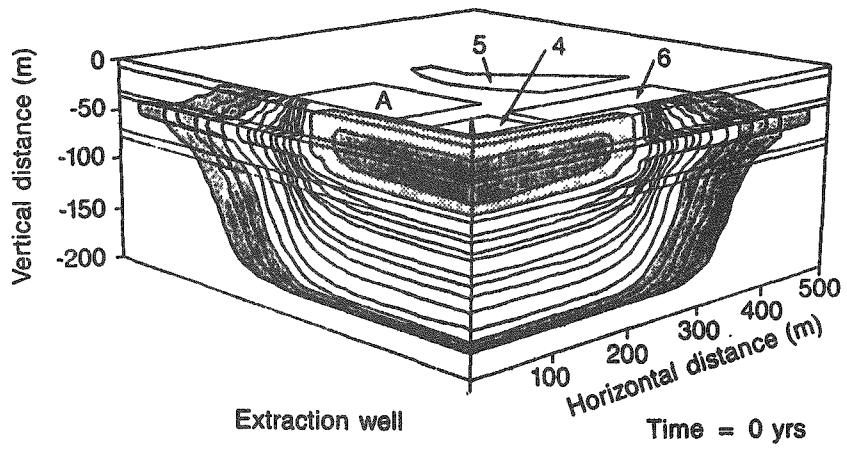


Figure 5. Vapor vacuum extraction of carbon tetrachloride, as simulated by the modified PORFLO computer code.

9-8546

4.7.4 Predicting Radionuclide Transport using Computer Modeling

The problem of modeling the release and migration of radionuclides at the RWMC is a complex and challenging task. The difficulty of this task arises from such factors as: (1) lack of data on leachate characteristics and mass release rates, (2) current uncertainty concerning the modes and mechanisms of transport, and (3) lack of definite mathematical theory for unsaturated flow in fractured rocks. In order to formulate a set of hypotheses for testing, preliminary modeling of unsaturated flow and solute transport was performed.

During this fiscal year, model applications focused on evaluating the potential impact of unsaturated flow through fractures on the rate and extent of radionuclide transport in the aqueous phase. Capillary perching is predicted to occur in the sedimentary material above the basalt layers. Assuming a steady-state flow field, the simulation predicts that a tracer migrating through the subsurface will begin reaching the 110-ft interbed in five years. These modeling results appear to be in reasonable qualitative agreement with field data of observed radionuclide migration and water contents. This suggests that fracture flow may have played an important role in the migration of dissolved radionuclides. These results are discussed in Walton, J. C. et al., 1989.

4.7.5 Documentation and Peer Review of Model Work

The results of the organic vapor modeling were documented in a series of external technical presentations and reports. Dissemination of the work throughout the scientific community provides one of the most effective forms of peer review. In all, three presentations were made at professional meetings, and conferences, and one journal article was produced (Baca, R. G. et al., 1988a, 1988b, 1988c; Walton, J. C. et al., 1988). In FY-1989 the results from the radionuclide modeling will be presented.

4.7.6 Research and Data Needs

The models for organic vapor release and transport indicate good quantitative agreement with measurements of plume migration. The models will be further refined and calibrated as more information becomes available from sampling, testing, and demonstration projects.

Three dimensional models will improve the model representation of the complex geology and the nonuniform and distributed nature of the source pits. Additional consideration of multiphase flow will allow evaluation of such phenomena such as vapor-liquid partitioning of the organic solvents and the potential migration of Texaco Regal Oil.

Radionuclide modeling needs to consider combined fracture and matrix flow and transport through the system. A source term model must be developed along with better understanding of the importance of organic complexing agents in the waste. The geochemical characteristics of the vadose zone will also be integrated in the transport model.

Estimated rates of organic vapor cleanup by Vapor Vacuum Extraction are most sensitive to the estimated air permeability of the subsurface strata. Since the ultimate goal of the program is the clean-up of the site, priority should be given to obtaining more representative estimates of basalt permeability. Understanding of vapor migration will be greatly improved when more complete data become available concerning the actual (i.e., measured) vertical distribution of the solvent plume.

Migration of radionuclides is related to water flow, the chemical/physical form of the radionuclides, and physical and chemical retardation processes. The nature of water flow in the basalts is fundamental to the question of radionuclide migration. Better understanding is required of the relative roles of basalt matrix, vesicles, and fractures to unsaturated flow. Current plans are to perform laboratory experiments using large blocks of fractured basalt. In these experiments, the seepage rate and moisture profiles would be measured and correlated.

5. OUTSIDE PEER REVIEW OF SUBSURFACE INVESTIGATIONS PROGRAM

The study plan (DOE/ID-10116) that outlined the Subsurface Investigations Program (SIP) provided for a formal peer review of the SIP to be conducted by a panel of reviewers that included non-INEL personnel. The reviewers would identify potential problems and issues and document their recommendations.

The SIP was subjected to such a peer review in March 1988, and results of the review are documented in an April 1988 report (Breckenridge, R. P. et al., 1988). The panel was composed of reviewers from the INEL, EG&G Idaho, Inc.; Savannah River Laboratory, E.I. du Pont de Nemours & Co., Inc; United States Geological Survey; Desert Research Institute, and HydroGeologic Inc.

The review panel found the SIP staff well-qualified, flexible, and responsive to DOE needs. They were favorably impressed with the program's rapid response, in terms of field measurements and the modeling effort, to the detection of volatile organic compounds found in the RWMC subsurface.

General recommendations included the following:

- Revise the original study plan (DOE/ID10116) to incorporate the changing regulatory climate (documents, quality assurance, etc.), and broaden the scope of the investigation to include other possible contaminants
- Develop a conceptual model of subsurface flow and contaminant transport
- Collect additional data and synthesize present data characterizing those geologic and hydrologic properties of the basalts that are critical to the transport process.
- Put a top priority on synthesis and analysis of collected data, reporting results via special reports or publications.

- Increase the technology transfer between the U.S.G.S., universities, and EG&G.
- Revise schedules to be more realistic, and reevaluate and reprioritize studies.
- Reserve a portion of the budget (10%) to research and application of innovative approaches to field studies.

6. DEVELOPMENT OF DOCUMENTATION

Documentation requirements for the Buried Waste Program (BWP) are generated by DOE and DOE-ID Orders and EPA regulations. The following define baseline documents for the BWP:

- BWP Program Management Plan
- RCRA Facility Investigation Work Plan
- Data Management Plan
- Quality Program Plan
- Data Collection Quality Assurance Plan
- Health and Safety Plan
- INEL Community Relations Plan.

BWP uses EG&G Idaho documentation systems to identify types of documents needed. Each task is evaluated as to documentation needs. Document requirements are divided into six categories: reports, quality documents, safety documents, technical requirements and criterion documents, operating documents, and training and certification records.

Approval and issuance requirements for documents are given in the Configuration Management Section of the Program Management Plan.

6.1 RFI Work Plan

A Consent Order and Compliance Agreement (COCA) between EPA Region X and the INEL designates the SDA as a solid waste management unit; thus, the SDA must be evaluated in accordance with the COCA requirements. In accordance with the requirements of the COCA, EPA Region X and the State of Idaho were

notified in January 1988 of a release of volatile chlorinated organic compounds from the SDA. A Corrective Action Plan for the SDA (Bonzon, C. J. 1988) was submitted to EPA Region X in March 1988. On June 1, 1988, sections of a revised Corrective Action Plan (which subsequently became the RCRA Facility Investigation Work Plan for the RWMC) were submitted.

After meetings and discussions with EPA Region X and the State of Idaho, a draft RCRA Facility Investigation Work Plan (RFI) was submitted on September 1, 1988 (Chantrill, B. 1988a). The RFI work plan addresses the volatile organic chemicals that have been detected in groundwater and soil gas samples from the SDA. Under the current definitions of hazardous materials in RCRA, radionuclides are not specifically addressed in this work plan. They will be addressed in a Remedial Investigation/Feasibility Study work plan to be written in 1989. A final RFI report developed from information gained through site characterization studies will be completed in September 1990.

6.2 Quality Documents

There are two baseline documents for the BWP: the Data Collection Quality Assurance Plan (Chantrill, B. 1988b) and the Quality Program Plan (EGG-QPP-149).

The Data Collection Quality Assurance Plan follows EPA Office of Solid Waste and Emergency Response (OWSER) Directives 9902.3 and 9335.3 and SW-846. This plan presents the functional activities, organization, and quality assurance/quality control activities of tasks that generate environmental data for the RFI report and the Corrective Measure Study. This plan pertains to all environmental data collection, evaluation, and review activities.

The Quality Program Plan follows requirements from DOE-ID Order 5700.6B and the EG&G Idaho Quality Manual, which was developed using American National Standards Institute/ American Society of Mechanical Engineers (ANSI/ASME) NQA-I requirements. This plan deals with 20 quality elements listed in NQA-I, including: design control; control of purchased items and services; inspection, test, and operating status; control of nonconforming items;

readiness reviews; and computer software configuration management.

The quality assurance role in site characterization is to ensure that all information, data, and decisions resulting from the SDA RFI report are technically sound and properly documented. Data quality levels depend on the intended uses of the data. The data use requiring the highest level of confidence and therefore the lowest level of uncertainty is health and safety. Groundwater samples taken from the production well at the RWMC will be of the highest quality level (Category IV as defined by EPA) to ensure protection of the health and safety of the public. Data for use in site characterization functions will be assigned the next highest quality levels (Categories III and II) and have less rigorous QA/QC objectives. The quality of the data generated in these categories will depend on the analyses requested and the data quality objectives of a particular task.

7. CONCLUSIONS

The Subsurface Investigations Program was integrated into the RWMC Site Characterization Program to serve the changing needs of subsurface studies at the RWMC. Data needs under RCRA were outlined in the RFI Workplan and used to help plan future work characterizing the nature and extent of VOC contamination. The transport of radionuclides remains a primary part of the site characterization program, although not specifically covered in the RFI.

Suspected radionuclide contamination of the 240-ft interbed was not confirmed by analysis of samples from borehole 8801D.

Compilation of hazardous waste analytical results from the soil-gas survey, groundwater samples, and air grab samples taken for health and safety concerns have detected five VOCs of primary concern in air and groundwater mediums. These VOCs are carbon tetrachloride, trichloroethylene, 1,1,1-trichloroethane, chloroform, and tetrachloroethylene. Organic waste shipped from the Rocky Flats Plant appears to be the primary source of VOC contamination. However, waste generated at the INEL may serve as the source of some of the contamination.

Recommendations for program changes were outlined in the Peer Review Report and were addressed in many of the studies conducted in FY-1988. The analyses of soil samples were broadened to detect hazardous constituents as well as radionuclides. Detailed logging of archived core was initiated, deep holes were cored rather than drilled, and stratigraphic studies of the unsaturated zone were conducted in order to characterize the geologic subsurface environment.

Geochemical analyses indicate the majority of soil waters were sodium-potassium bicarbonate waters typical of waters that evolve in many arid soils. This information is necessary in evaluating contaminant and radionuclide speciation and possible subsurface migration at the SDA.

Data from vadose zone instrumentation suggested the occurrence of downward movement of soil water for large portions of the year. This is significant when considered in the context of a semi-arid site. The intensity and duration of the yearly infiltration events may be important factors in unsaturated flow and contaminant transport processes at the RWMC.

Preliminary solute transport modeling under unsaturated flow conditions is in general agreement with observed radionuclide migration and subsurface water contents. These modeling results suggest that fractures may play an important role in unsaturated flow and solute transport.

Computer modeling tasks, net downward flux studies, geochemical studies, and contaminant characterization studies need hydrogeological and chemical data as input. Data on hydraulic properties from sediment and basalt cores and hazardous waste analysis of sediments are limited at this time. Plans for FY-1989 are to collect these critical data.

8. PRESENTATIONS AND PUBLICATIONS

The following presentations and publications were completed for the RWMC site characterization program during FY-1988:

Papers

Baca, R. G., J. C. Walton, A. S. Rood, and M. D. Otis, "Organic Contaminant Release From a Mixed Waste Disposal Site: A Computer Simulation Study of Transport Through the Vadose Zone and Site Remediation," Proceedings of the Tenth Annual DOE Low-Level Waste Management Conference, Denver, Colorado, August 30 to September 1, 1988.

Journal Articles

Walton, J. C., A. S. Rood, R. G. Baca, and M. D. Otis, "Model for Estimation of Chlorinated Solvent Release from Waste Disposal Sites," Journal of Hazardous Materials, (in press), 1988.

Reports

Baca, R. G. and J. C. Walton, Preliminary Conceptual Models of Contaminant Migration at the RWMC, EGG-WM-8023, 1988.

Chantrill, B., RWMC Facility Investigation Work Plan, EGG-WM-8219, September 1988.

Laney, P. T. et al., Annual Progress Report: FY-1987--Subsurface Investigation Program at the Radioactive Waste Management Complex of the Idaho National Engineering Laboratory, DOE/ID-10183, April 1988.

Oral Presentations

Baca, R. G., J. C. Walton, and A. S. Rood, "Modeling of Organic Constituents at the Idaho National Engineering Laboratory Radioactive Waste Management Complex," presented at the American Chemical Society Northwest Regional Meeting, Spokane, Washington, 1988.

Baca, R. G., J. C. Walton, and A. S. Rood, "Computer Simulation Study of Containment Migration through the Subsurface Environment," presented at the 2nd Annual INEL Computing Symposium, Idaho Falls, Idaho, 1988.

Brown, R., "Study of Subsurface Mapping Techniques for Use at the INEL Radioactive Waste Management Complex", In Situ Characterization and Monitoring Technologies, Proceeding of the Department of Energy In Situ Characterization and Monitoring Technologies Workshop, DOE/HWP-62, October 1988.

Hubbell, J. M. "Unsaturated Zone Monitoring Techniques", In Situ Characterization and Monitoring Technologies, Proceedings of the Department of Energy in Situ Characterization and Monitoring Technologies Workshop, DOE/HWP-62, October 1988.

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