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DOE/RL-94-53
Rev. 0

Limited Field Investigation Report for the 100-HR-2 Operable Unit

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EXECUTIVE SUMMARY

This report summarizes the data collection and analysis activities conducted during the 100-HR-2 Operable Unit investigative phase and the associated qualitative risk assessment. The 100-HR-2 Operable Unit contains solid waste burial grounds, an ash pit, burn pits, electrical facilities, septic systems, and support facilities. All known and suspected areas of contamination were classified as solid waste burial grounds or low-priority waste sites based on the collective knowledge of the operable unit managers (representatives from the U.S. Department of Energy, the U.S. Environmental Protection Agency, and Washington State Department of Ecology during the preparation of the 100-HR-2 Operable Unit Work Plan (DOE-RL 1993f). Solid waste burial grounds were judged to pose sufficient risk(s), through one or more pathways, to require evaluation for an interim remedial measure as per the *Hanford Past-Practice Strategy* (DOE-RL 1991) and negotiations with the Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology. An interim remedial measure is intended to achieve remedies that are likely to lead to a final record of decision. Low-priority sites are those judged not to pose significant risk to require the streamlined evaluation. There were six low-priority waste sites and seven solid waste burial grounds identified.

The investigative phase was conducted in accordance with the *RCRA Facility Investigation/ Corrective Measures Study Work Plan for the 100-HR-2 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1993f). The qualitative risk assessment was performed in accordance with the *Hanford Site Baseline Risk Assessment Methodology* (DOE-RL 1993b), and the recommendations incorporate the strategies of the *Hanford Past-Practice Strategy*. The purpose of this report is to: 1) provide a summary of site investigative activities; 2) refine the conceptual exposure model (as needed); 3) identify chemical- and location-specific corrective action requirements; and 4) provide a human health and ecological QRA associated with solid waste burial grounds.

Intrusive investigations were not conducted in the 100-HR-2 Operable Unit. The investigative activities consisted of nonintrusive investigations, review of analogous site information, evaluation of historical data, and examination of process knowledge information.

Results from these investigations show that radionuclide contamination is of primary concern in the 100-HR-2 Operable Unit. The highest radionuclide concentrations were associated with the 116-H-4 pluto crib, which is buried in the 118-H-5 burial ground. Analogous site data from the 116-F-4 pluto crib collected under the 100 Areas excavation treatability study (DOE-RL 1994a) were evaluated in the qualitative risk assessment. Using the analogous site data, the 118-H-5 burial ground has a medium priority for remediation based on human-health risk under the occasional use scenario and an environmental hazard quotient rating of > 1. The major risk driver for human health is cesium-137. The ecological risk driver is strontium-90. All solid waste burial grounds in 100-HR-2 are to remain interim remedial measure candidates as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the Department of Energy, U.S. Environmental Protection Agency, and Washington State Department of Ecology (Table ES-1).

Table ES-1. IRM Candidate Summary.

Waste Sites	QRA Remediation Priority		Conceptual Model	Exceeds CAR	Probable Current Impact on Groundwater	Potential for Natural Attenuation by 2018	Solid Waste Burial Ground	IRM Candidate[a]
	Human Health	Ecological						
	Occasional-use scenario	EHQ >1						
118-H-1	Low	No	Complete	Unknown[b]	Unknown	Yes	Yes	Yes
118-H-2	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-3	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-4	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-5	Medium	Yes	Complete	No	Unknown	No	Yes	Yes
Buried Thimble Site	Low	No	Complete	Unknown[b]	Unknown	No	Yes	Yes
105-H Horizontal Control Rod Storage Cave	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes

[a]All burial grounds are IRM candidates as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology.
[b]Only radiological data were available.

ACRONYMS

ARAR	applicable or relevant and appropriate requirements
CAR	corrective action requirements
CERCLA	*Comprehensive Environmental Response Compensation and Liability Act of 1980*
CLP	Contract Laboratory Program
CMS	corrective measures study
COPC	contaminants of potential concern
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EHQ	environmental hazard quotient
EII	Environmental Investigations Instruction
EMI	electromagnetic induction
EPA	U.S. Environmental Protection Agency
ERA	expedited response actions
FS	feasibility study
GC	gas chromatographs
GM	Geiger-Mueller
GPR	ground-penetrating radar
HEAST	Health Effects Assessment Summary Tables
HPPS	*Hanford Past-Practice Strategy*
HSBRAM	*Hanford Site Baseline Risk Assessment Methodology*
HQ	hazard quotient
ICR	incremental cancer risk
IRIS	Integrated Risk Information System
IRM	interim remedial measure
LFG	landfill gas (analyzer)
LFI	limited field investigation
MCL	maximum contaminant level
MCLG	maximum contaminant level goals
MSCM	Mobile Surface Contamination Monitor
MTCA	*Model Toxics Control Act*
NOAEL	no observable adverse effect level
NRC	Nuclear Regulatory Commission
PCB	polychlorinated biphenyls
PPE	personal protective equipment
QRA	qualitative risk assessment
RCRA	*Resource Conservation and Recovery Act of 1976*
RFI	RCRA facility investigation
RI	remedial investigation
ROD	record of decision
SCA	Surface Contamination Areas
SVOC	semivolatile organic compound
TBC	to be considered
TCL	target compound list
Tri-Party Agreement	*Hanford Federal Facility Agreement and Consent Order*
TRU	transuranic

UTL	upper threshold limits
VOC	volatile organic compounds
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company

METRIC CONVERSION CHART

Measurements used in this report are actuals. The following conversion chart is provided to the reader as a tool to aid in conversion.

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	0.836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
short ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius

If You Know	*Multiply*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	short ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 5/9ths, then add 32	Fahrenheit

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1.0 INTRODUCTION

This limited field investigation (LFI) report summarizes results of the investigative activities completed for the 100-HR-2 Operable Unit. The 100-HR-2 Operable Unit is a source operable unit within the 100 Areas and includes solid waste burial grounds, burn pits, ash pits, septic systems, and demolished support facilities. All solid waste burial grounds were thought to pose a risk(s) through one or more pathways sufficient to recommend streamlined action via an interim remedial measure (IRM) as designated in the 100-HR-2 Work Plan (DOE-RL 1993f). IRMs are intended to achieve remedies that are likely to lead to a final record of decision (ROD). The final decision to conduct an IRM will rely on many factors including applicable or relevant and appropriate requirements (ARAR), future land use, point of compliance, time of compliance, a bias-for-action, and the threat to human health and the environment. The objectives of the LFI are described fully in the *RCRA Facility Investigation/Corrective Measures Study Work Plan for the 100-HR-2 Operable Unit, Hanford Site, Richland, Washington* (DOE-RL 1993f).

To limit the size of this report, the reader is referred to other documents for specific details. This LFI report is based on agreements discussed in these Hanford Site-specific documents:

- *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1989)
- *Hanford Past Practice Strategy* (HPPS) (DOE-RL 1991)
- *Hanford Site Baseline Risk Assessment Methodology* (HSBRAM) (DOE-RL 1993b)
- 100-HR-2 Operable Unit Work Plan (DOE-RL 1993f).

The methods and requirement for completing IRM process, qualitative risk assessment (QRA), and LFI reports are specific to the Hanford Site and may differ from activities with similar names performed elsewhere. The methods and requirements used at the Hanford Site were agreed to by the U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology).

1.1 PURPOSE AND APPROACH

The investigative phase at 100-HR-2 burial grounds did not involve a typical LFI, as per the HPPS, however, this LFI report was prepared to:

- Report results of the investigative phase (historical and analogous site information, nonintrusive investigations)
- Identify the contaminant- and location-specific corrective action requirements (CAR)
- Refine the conceptual model as needed
- Provide a qualitative assessment of the risks associated with the sites.

This LFI report includes the QRA for solid waste burial grounds in the 100-HR-2 Operable Unit. The purpose of the QRA is to focus on a predefined set of human and environmental exposure scenarios to provide sufficient information to assist the parties to Tri-Party Agreement in making defensible decisions on the necessity of an IRM. It is not intended to replace or be a substitute for a baseline risk assessment. Per agreements stated in the HSBRAM (DOE-RL 1993b), the QRA for a source operable unit considers only two human health scenarios (frequent and occasional use) with three exposure pathways (soil ingestion, fugitive dust inhalation, and external radiation exposure), and a limited ecological evaluation. The QRA does not include evaluation of pathways for ingestion of groundwater or agricultural crops.

The QRA is conducted using the HSBRAM (DOE-RL 1993b) as guidance and consists of:

- An evaluation of the data sources and/or process information
- Identification of maximum constituent concentrations, where data are available
- A human health risk evaluation
- An ecological risk evaluation
- Key factors that contribute to uncertainty throughout the risk assessment process.

1.2 HANFORD PAST-PRACTICE STRATEGY AND 100-HR-2 INVESTIGATIVE APPROACH

1.2.1 Description

The signatories to the Tri-Party Agreement (Ecology et al. 1989) recognized the need for a new strategy of *Resource Conservation and Recovery Act of 1976* (RCRA)/*Comprehensive Environmental Response Compensation and Liability Act of 1980* (CERCLA) integration to provide greater uniformity in the applicability of requirements to the Hanford Site. Additionally, the signatories agreed that proceeding with the traditional CERCLA approach would likely require too much time and too large a portion of a limited budget be spent before actual cleanup would occur. Another motivation for a new strategy was the need to coordinate past-practice investigations with RCRA closure activities since some operable units contain RCRA treatment, storage, and/or disposal facilities.

In response to the above concerns, the three parties have decided to manage and implement all past-practice investigations under one characterization and remediation strategy, regardless of the regulatory agency lead (as defined in the Tri-Party Agreement). The HPPS (DOE-RL 1991) was developed to expedite cleanup by initiating and completing waste site cleanup through interim actions. The strategy focuses on reaching early decisions to initiate and complete cleanup projects, maximizing the use of existing data, coupled with focused short-time-frame investigations, where necessary. As more data become available on contamination problems and associated risk, the details for longer-term investigations and studies are better defined. The effective use of existing data plus better management of uncertainty should reduce the number of sampling episodes and expedite treatability studies, feasibility studies (FS), and cleanup actions, including expedited response actions (ERA) and IRMs.

The HPPS includes three paths for interim decisionmaking and a final remedy-selection process for the operable unit that incorporates the three paths and integrates sites not addressed in

those paths. An important element of this strategy is the application of the observational approach, in which characterization data are collected concurrently with cleanup.

As shown in Figure 1-1, the three paths for interim decisionmaking are as follows:

- ERA path - used when an existing or near-term unacceptable health or environmental risk from a site is determined or suspected, and a rapid response is necessary to mitigate the problem.

- IRM path without an LFI - used when existing data are sufficient to formulate a conceptual model and perform a QRA. If a determination is made that an IRM is justified, the process will proceed to select an IRM remedy. If necessary, a focused FS will be conducted to select a remedy.

- LFI path - used to identify and gather the minimum additional data needed to formulate a conceptual model and perform a QRA. This information is then used to aid in decisions regarding performing ERAs or IRMs.

Although interim actions (ERA and IRM) may be used to mitigate specific contamination problems, the process of final remedy selection must be completed for the operable unit and 100 Areas National Priority List CERCLA site to reach closure. The information obtained from the LFIs and interim actions may be sufficient to perform the baseline risk assessment, and to select the remedy for the operable unit. If the data are not sufficient, additional investigations and studies may be performed to support the operable unit remedy selection. These investigations would be performed within the framework and process defined for remedial investigation (RI)/FS programs.

1.2.2 Application

Implementation of the HPPS to the 100-HR-2 Operable Unit began with the development of the 100-HR-2 Operable Unit Work Plan (DOE-RL 1993f). Following agreement on the HPPS, the three parties rescoped the initial 100 Areas work plans with a bias toward IRM action. The collective knowledge and judgment of the EPA, DOE, and Ecology and the information contained in the existing work plans were used to prioritize waste sites in the 100-HR-2 Operable Unit and the paths to be followed to implement the HPPS. The decisions made during joint meetings among the three parties are documented by meeting minutes that are part of the administrative record.

The solid waste burial grounds were identified during the 100-HR-2 scoping meetings as the highest priority sites in 100-HR-2 Operable Unit:

Solid Waste Burial Grounds	Low Priority Sites
118-H-1 Burial Ground	126-H-1 Ash Pit
118-H-2 Burial Ground	151-H Primary Electrical Facility
118-H-3 Burial Ground	128-H-1 Burn Pit
118-H-4 Burial Ground	128-H-2 Burn Pit
118-H-5 Burial Ground	128-H-3 Burn Pit
Buried Thimble Site	1607-H-1 Septic System and Drain Field
105-H Horizontal Control Rod Storage Cave	1607-H-3 Septic System and Drain Field Storage Facilities

During the scoping process, it was determined that existing data for the solid waste burial grounds were sufficient to formulate a conceptual model and perform a QRA. Thus, LFIs were not proposed for the solid waste burial grounds within the 100-HR-2 Operable Unit. Instead, information gained from analogous sites and historical sampling was used to perform a QRA for the solid waste burial grounds in the 100-HR-2 Operable Unit, where applicable.

1.3 SITE BACKGROUND

Between 1943 and 1963, nine water-cooled, graphite-moderated, plutonium-production reactors were built along the Columbia River upstream from the now-abandoned town of Hanford. These nine reactors (B, C, D, DR, F, H, KE, KW, and N) have been retired from service and are under evaluation for decommissioning.

The 100-H Area is located in Benton County along the south bank of the Columbia River in the north-central part of the Hanford Site, approximately 27 mi north-northwest of the city of Richland, Washington (Figure 1-2). The 100-H Area contains the H Reactor, which operated from 1949 to 1965. The operations resulted in the release of chemical and radioactive waste into the soil, air, and water. For cleanup purposes, the 100-H Area has been divided into three operable units: 100-HR-1 (concerned with reactor liquid effluent sites); 100-HR-2 (concerned with solid and buried waste sites); and 100-HR-3 (concerned with the groundwater beneath and between the 100 H and 100 D/DR Areas, including all saturated soils, groundwater, surface water, and aquatic biota). The 100 D/DR Area is located approximately 2 mi southwest of the 100-H Area.

1.3.1 100-HR-2 Operable Unit

The 100-HR-2 Operable Unit is located adjacent to the 100-HR-1 Operable Unit in the west and south portions of the 100-H Area. It covers approximately 100 acres. Figure 1-3 shows the approximate boundaries of the 100-HR-2 Operable Unit as defined by the waste units it includes, and its location with respect to the 100-HR-1 Operable Unit. The 100-HR-2 Operable Unit lies within north/south state plane coordinates N153500 and N151600 and east/west state plane coordinates E576900 and E578300.

H Reactor was retired in 1965. Once retired, the DOE instituted a program of decontamination and decommissioning of buildings and facilities to minimize the potential spread of radioactive isotopes from the reactor and associated facilities. The process is ongoing, and in the 100-H Area, most of the aboveground facilities have undergone decommissioning and no longer exist. Facilities presently aboveground in the 100-HR-2 Operable Unit are the 1713 warehouse and the 1720-HA munitions arsenal.

Radioactive and nonradioactive waste was produced during operation of the H Reactor and its support facilities. This waste contributed to the present-day contamination in the 100-HR-2 Operable Unit. Waste present can be categorized as radioactive solid waste, nonradioactive solid waste, and sanitary liquid waste. All of the 100-HR-2 Operable Unit waste facilities can be grouped into the following general categories: 1) solid waste burial grounds; 2) ash disposal basins; 3) burning pits; 4) sewage transfer, treatment, and disposal facilities; and 5) demolished support facilities.

The primary focus in the 100-HR-2 Operable Unit is the solid waste burial grounds. The majority of waste generated from routine reactor operations was placed in primary burial grounds associated with their respective reactors. Other burial grounds resulted from reactor upgrade projects, major maintenance projects, or served special programs such as thimble removal, retention basin repair and effluent line modifications, or the tritium separations program.

1.3.2 Conceptual Site Model

The conceptual site model for the 100-HR-2 Operable Unit was developed during the preparation of the work plan. The conceptual model addressed the following:

- Structure and process of the waste sites
- Source of contaminants
- Type of contaminants
- Nature and potential routes or migration
- Known and potential human and environmental receptors.

The conceptual model has been updated with data acquired throughout the investigative phase at the 100-HR-2 Operable Unit and is discussed in Section 5.0.

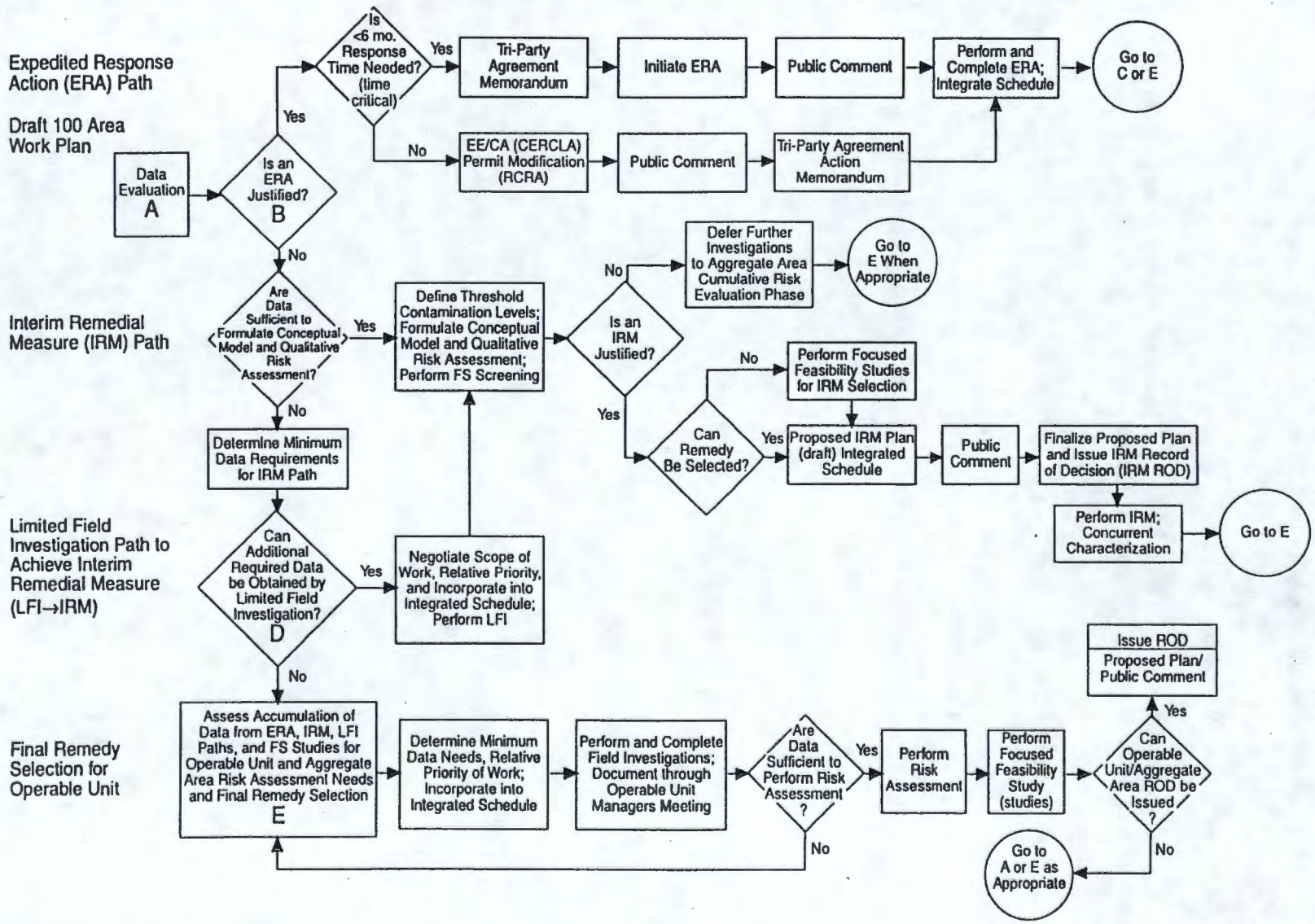


Figure 1-1. Hanford Past-Practice Strategy.

Figure 1-2. The Hanford Site with 100-H Area Inset.

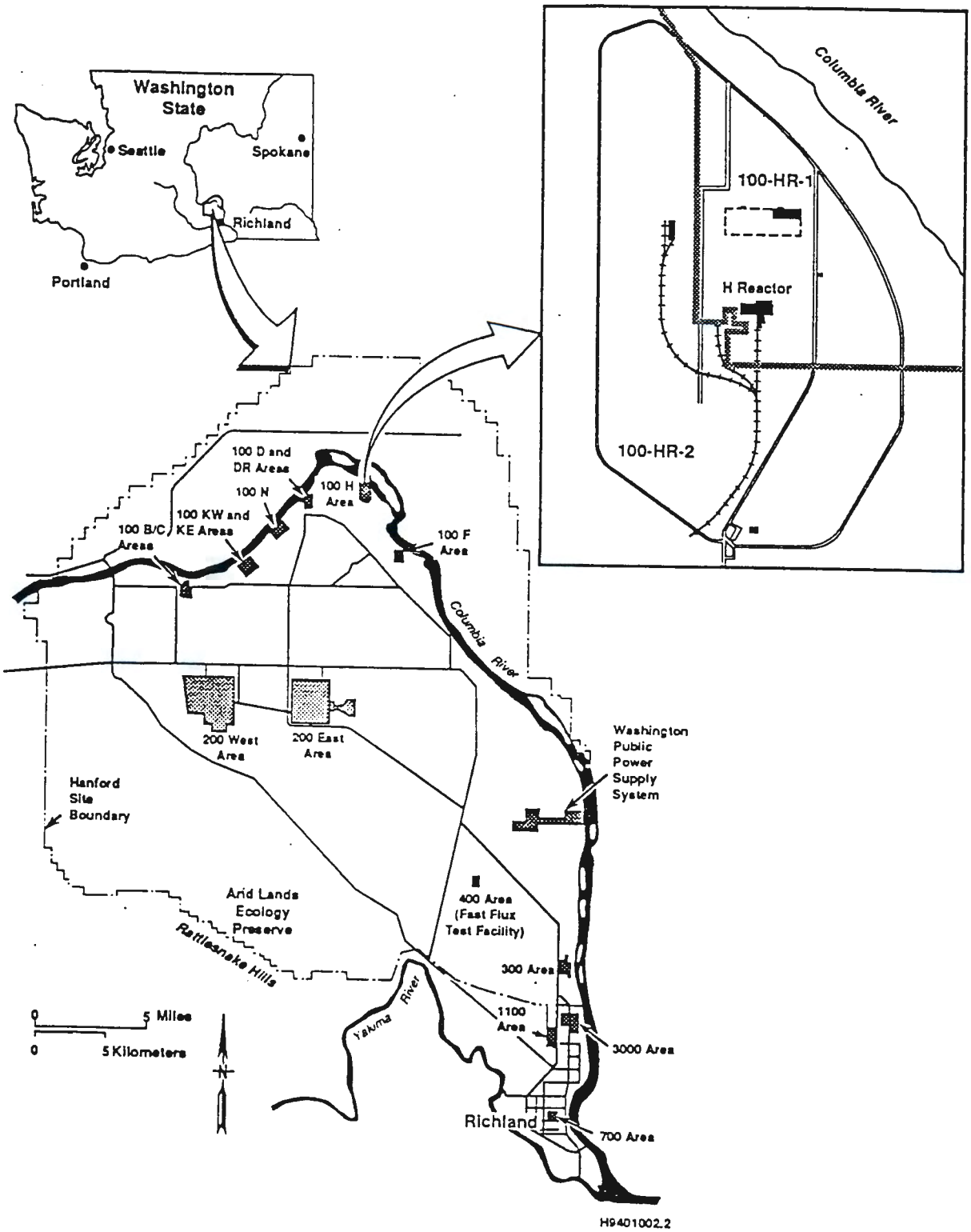
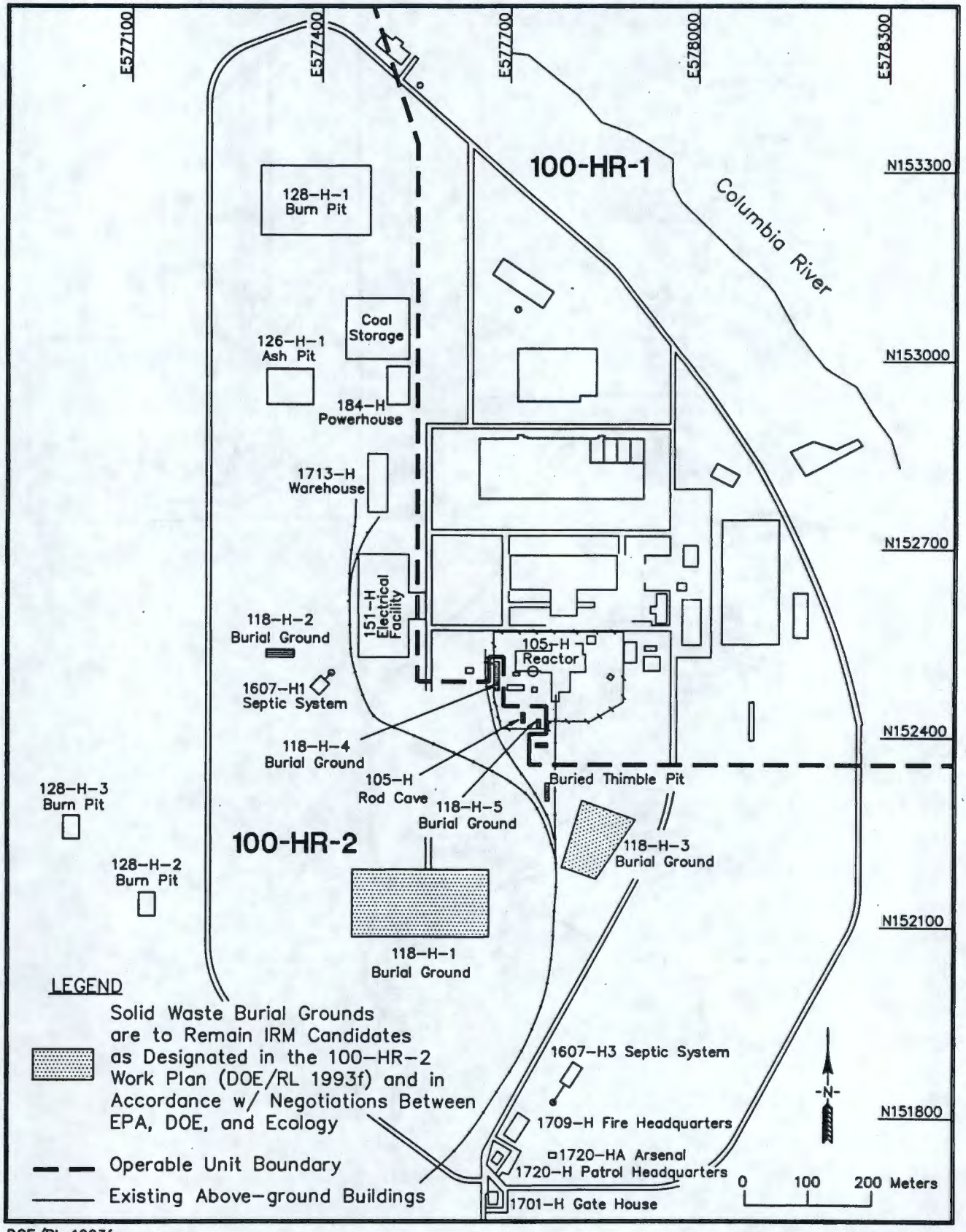


Figure 1-3. The 100-HR-2 Operable Unit.



DOE/RL 1993f

ITH:JJA:PE2CA-A1

2.0 INVESTIGATIVE PHASE

No intrusive field sampling was done at any of the 100-HR-2 waste sites. Therefore, the data were compiled from a number of different sources spanning different time frames and originally gathered or derived with different purposes in mind. The investigative activities consisted of nonintrusive investigations, review of analogous site information, evaluation of historical data, and examination of process knowledge. Historical radionuclide concentrations were corrected for rad decay through 1994. The maximum decay-corrected concentrations were used in the QRA. Investigation of all of the sites identified in the 100-HR-2 Operable Unit work plan (DOE-RL 1993f) was completed and the investigative approach taken at each waste site is summarized in Table 2-1. When historical, LFI, and/or analogous site data existed, a QRA was completed for each waste site considered an IRM candidate.

2.1 HISTORICAL INFORMATION

Historical information includes operations records and reports, engineering drawings, photographs, interviews with former or retired operations personnel, and data from sampling and analysis of facilities and the local environment.

The primary historical reference for radiological characterization of the 100-HR-2 burial grounds is a study of the 100 Areas performed during 1975 and 1976 by Dorian and Richards (1978). Historical samples were collected as part of the 116-H-2 overflow trench investigation in the vicinity of the buried thimble waste site. The samples were analyzed for radionuclides and the inventories of the radionuclides for the facilities and sites were calculated. It should be noted, however, that only concentrations and inventories of selected radionuclides were reported in the study. Although standard laboratory procedures were used in sample analysis, the Dorian and Richards (1978) data were not validated.

2.2 PROCESS KNOWLEDGE

An integral part of the RCRA facility investigation/corrective measures study (RFI/CMS) process for the 100-HR-2 Operable Unit has been the acquisition, evaluation, and utilization of records pertaining to the construction, operation, and decontamination/decommissioning of the H Reactor and related 100 H facilities. This information is categorized as "process knowledge information." Process knowledge information has been included in Section 3.0, when available.

Estimates of Solid Waste Buried in 100 Area Burial Grounds (Miller and Wahlen 1987) provides a source of radionuclide inventories for the solid waste burial grounds in the 100 Areas. Miller and Wahlen (1987) used process knowledge information to calculate radionuclide inventories for the solid waste burial grounds in the 100 Areas. They calculated the inventories using estimated quantities of waste generated, as functions of the total years each reactor operated, taking into consideration special production programs, major maintenance, repair, and reactor upgrade programs that involved burial of discarded reactor components. The inventories corresponded to each reactor area as a whole, assuming all waste was buried in an area's main operation's burial ground. In the 100-H Area, this is the 118-H-1 burial ground.

2.3 NONINTRUSIVE FIELD INVESTIGATIONS

Nonintrusive investigation in the 100-HR-2 Operable Unit included a soil gas survey of the 128-H-1 burn pit, ground-penetrating radar (GPR) and electromagnetic induction (EMI) surveys on the 118-H-1, 118-H-2, and 118-H-3 burial grounds and on the buried thimble site as well as a portion of the 128-H-1 burn pit, field screening of discolored soil near the 1607-H-1 septic system, and polychlorinated biphenyls (PCB) sampling at the 151-H primary electric facility. Surface radiation surveys covering the 100-HR-2 Operable Unit were completed in May 1994.

2.3.1 Soil-Gas Survey

A soil-gas survey was conducted in the eastern portion of the 128-H-1 burn pit. It was conducted to determine if significant quantities of volatile organic compounds (VOC) or landfill gases could be detected in the vadose zone associated with the burn pit. Eighteen soil-gas probes were installed in the study area at depths of 4 to 6 ft. The probes were installed in accordance with Environmental Investigations Instruction (EII) 5.9, "Soil-Gas Sampling" (WHC 1988b). Soil-gas vapors were field evaluated using two total organic-vapor monitoring instruments, and an infrared landfill gas analyzer. Soil-gas samples were also collected and analyzed using two portable gas chromatographs (GC). Appendix A contains the results of the soil-gas survey.

2.3.2 Ground-Penetrating Radar and Electromagnetic Induction Surveys

GPR and EMI surveys were completed on the 118-H-1, 118-H-2, and 118-H-3 solid waste burial grounds and the buried thimble site, and a portion of the 128-H-1 burn pit. The primary objectives of the geophysical investigations were to locate individual trenches, locate concentrations of debris within the trenches, determine the thickness of the overlying fill, and locate any additional debris not called out in the historical documents that may be buried within the burial ground. The surveys were conducted in accordance with EII 11.2, "Geographical Survey Work", Appendix A and B (WHC 1988b). The results are summarized in Chapter 3.0. The complete surveys of 118-H-1, 118-H-2, and 118-H-3 are reported in Bergstrom 1994a, 1994b, and 1994c. The reports for the 128-H-1 burn pit and the Buried Thimble Site have been completed and are being cleared for public release.

2.3.3 Field Screening of Discolored Soil

A soil sample containing suspected contamination was taken near the 1607-H-1 septic system in 1993. Samples were collected from the tile field and from the powerhouse's ash pit for comparison. Samples were analyzed using the X-Met 880 portable x-ray fractionation analyzer (trademark of Outokumpu Electronics, Inc.) to detect heavy metals. Appendix A contains the results.

2.3.4 Surface Soil Sampling at Electrical Facilities

Surface soil samples were collected at the 151-H primary electrical facility as part of the 100-HR-1 Operable Unit LFI (DOE-RL 1993c). These were collected in accordance with EII 5.2, "Soil and Sediment Sampling" (WHC 1988b). Sampling sites were selected based on signs of spills

identified during visual inspections or at abandoned electrical facility sites. A total of eight surface soil samples were analyzed for PCB contamination using EPA Method 8080 (EPA 1986).

All samples were screened for evidence of radionuclides. These were screened by the field geologist using a Geiger-Mueller (GM) instrument, and all sample screening data were recorded in the field logs per EII 9.1, "Geologic Logging" (WHC 1988b). The GM instrument generally detects gamma radiation only and will not detect alpha or low energy beta emissions. The detected counts per minute should be interpreted as relative values rather than absolute values.

All samples were screened for evidence of radionuclides. The amount of PPE that was needed changed if radionuclides were detected above the action level. The action level for radionuclide screening was set at twice the background level. The background levels were determined at the start of each shift, from ambient air, at a background site located near the Columbia River, generally north at the sampling location (DOE-RL 1993c). Results of the electrical facilities sampling can be found in Appendix A.

2.3.5 Surface Radiation

A surface radiation survey was conducted over the 100-HR-2 Operable Unit. The objective of this survey was to develop a map of surface radiation levels throughout the operable unit and identify areas of surface and, potentially, subsurface radioactive contamination. This will be used to identify any waste disposal areas not previously identified in the 100-HR-2 Operable Unit Work Plan (DOE-RL 1993f). The survey was conducted in accordance with the procedures contained in the *Health Physics Procedures Manual* (WHC 1990) and measures gross gamma radiation levels of the surface soil.

The surveys were conducted using the Mobile Surface Contamination Monitor II (MSCM-II). If the MSCM-II indicated radioactive contamination, follow up surveys of areas were conducted utilizing hand-held count rate meters outfitted with 2 in. by 2 in. NaI detectors and GM probes. Approximately 258 acres of the 100-HR-2 Operable Unit were surveyed with the MSCM-II. The survey results indicated a 19-acre area of underground radioactive material south of the 116-H-1 trench, a small number of random surface contamination locations, and 165 discrete areas of surface contamination. The areas of surface contamination were small locations ≤ 2 ft^2 and were decontaminated to less than detectable levels using hand trowels to remove the contaminated soil. Results of the survey can be found in Appendix B.

The analysis of the radiation survey results (Appendix B) shows that the 19 acres of underground radioactive material are contaminated with radionuclides characteristic of single pass reactor effluent, and the adjacent 116-H-1 liquid waste disposal trench has been suggested as a possible source. In situ measurements indicate that "most of the area has levels of contamination barely above the natural background." (Appendix B, page B-31). This area will be considered a part of 116-H-1, and remediated (to the extent necessary) as part of that trench. In the interim, the area is planned to be posted as an "Underground Radioactive Materials" area.

South of this 19-acre area were two hot spots with gamma energy spectra signatures different than the contamination in the 19 acres. The spectra from these spots indicated that most of the contamination was from cesium-137. These sites are reported to have been decontaminated (Appendix B, Page B-5), along with the rest of the 165 spots of speck contamination found during the survey.

The results suggest animal waste (urine and feces) as a possible cause of the 165 discrete areas of surface contamination. This is a plausible explanation; O'Farrell et al. (1975) reported distribution of contaminated rabbit feces and urine from animals digging into a crib and using the exposed salt as a mineral lick. Similarly, Johnson et al. (1994) reported on historical records of radioactive contamination in biota from intrusion into waste sites in the 200 Areas, and steps taken to minimize such pathways. However, it is not possible to determine positively if these 100-HR-2 surface contamination areas are from animals or when they occurred. The lack of significant amounts of radionuclides in 100 Area wildlife (see for example, Woodruff et al. 1993) lessens the possibility that such contaminated animal waste dispersal is occurring today. Animals that intruded into the waste site in the past and then dispersed would probably have distributed contaminants evenly around the waste site, while the radiation survey found contamination only on the south side.

Instead, consideration of the pattern of contaminant located near the 118-H-1 burial ground suggests an additional hypothesis. These areas of surface contamination might have been caused by an isolated wind gust spreading particles of contaminated waste from the 100-HR-1 burial ground during previous burial ground operations. Such dispersal could have resulted in the pattern of surface radiation shown on the map (Appendix B). The lack of surface contamination areas on top of the waste site supports this concept, because clean backfill would have been used to cover the site, and thus not been subject to wind-blown contamination.

A supplemental surface radiation survey is planned for the area beyond the southwest boundary of 100-HR-2.

The surface radiation survey is included in Appendix B.

2.4 ANALOGOUS SITES

Site investigations in the 100-FR-1, 100-DR-1, and 100-BC-2 Operable Units were applied analogously to sites in the 100-HR-2 Operable Unit. Each of the reactors and their support facilities in the 100 B/C, 100 H, and 100 D/DR and 100 F Areas are similar in construction and use. An analogous site is a site associated with one of the other 100 Areas reactor sites that has a similar process history, waste stream, and potentially the same contaminants to a site in the 100-HR-2 Operable Unit. However, an analogous site does not necessarily have the same geology, suite of contaminants, or extent of contamination. Table 2-2 presents the 100 Areas analogous sites that are applicable to the 100-HR-2 Operable Unit. Data collected from the 116-F-4 pluto crib during the 100 Area excavation treatability test were applied analogously to the 118-H-5 burial ground, which contains the soil from the 116-H-4 pluto crib. Specifics on the investigation of the 116-F-4 pluto crib can be found in the *100 Area Excavation Treatability Test Report* (DOE-RL 1994a). The QRA and LFI conclusions for the 118-B-1 burial ground were applied analogously to the 118-H-1 burial ground. Specifics on the historical sampling information are provided by Dorian and Richards (1978) and the 100-BC-2 Operable Unit LFI report (DOE-RL 1994b).

2.5 GENERAL HANFORD SITE BACKGROUND SUMMARY

Results of the characterization of the natural chemical composition of Hanford Site soils are presented in *Hanford Site Background: Part 1, Soil Background for Nonradioactive Analytes*

(DOE-RL 1993a). The characterization included an analysis of physical properties and factors that might affect the natural soil chemical composition, as determined by regulatory protocols. Hanford Site soils have not been characterized to establish the natural concentrations of radionuclides. Because sitewide background levels for organic and radionuclide constituents have not been established, all detected concentrations of these constituents were considered in the QRA as potential contaminants of concern.

Table 2-3 presents the 95% percentile of the lognormal distribution and the lognormal distribution 95% upper threshold limits (UTL) for inorganic analyses of Hanford Site soils (DOE 1993a). LFI analytical data for inorganic constituents are considered contaminants of potential concern if they exceed the 95% UTL values.

2.6 GROUNDWATER INVESTIGATION

Constituents in sediments or soils associated with the solid waste burial grounds in the 100-HR-2 Operable Unit may migrate through the vadose zone into groundwater. As opposed to liquid waste disposal units, waste in the burial grounds was not exposed to significant amounts of water and, therefore, groundwater and surface water in the vicinity of the 100-HR-2 Operable Unit burial grounds are not expected to be a transport mechanism of major concern. When assessing the potential groundwater impacts from the waste sites in 100-HR-2, the groundwater information from the 100-HR-3 LFI was used. The 100-HR-3 Operable Unit underlies 100 D/DR Area, 100 H Area, and the 600 Area between them. It includes all contamination found in the aquifer soils and water within its boundary. The groundwater wells in the 100-H Area are shown in Figure 2-1. The water table elevations for the 100-H Area are shown in Figure 2-2.

The LFI report for the 100-HR-3 Operable Unit (DOE-RL 1993d) provides information on groundwater investigations in the 100-H Area. The LFI for the 100-HR-3 Operable Unit was conducted to determine the nature and extent of hazardous/radioactive materials present in the groundwater. This was done by collecting data from existing wells and 22 new wells drilled for the RI/FS. Specifics on the investigations are found in the LFI report for the 100-HR-3 Operable Unit (DOE-RL 1993d).

Current groundwater conditions are perhaps the most direct empirical evidence regarding groundwater impacts from a waste site. If groundwater contamination concentrations downgradient of a waste site are elevated above upgradient concentrations, it is possible that the waste site is impacting groundwater. Unfortunately, due to proximity to other waste sites and uncertainties associated with groundwater flow directions, it is often not possible to definitively identify which waste site is impacting groundwater.

2.7 AGGREGATE AREA STUDIES

The 100 Areas aggregate studies and Hanford Site studies provide integrated analyses of selected issues on a larger scale than the operable unit. The 100-HR-3 Operable Unit Work Plan (DOE-RL 1992d) addresses activities common to the 100 Areas such as a river impact study, shoreline studies, ecological studies, and cultural resources studies. These studies provide data to be used in the selection of final remedies.

2.7.1 100 Area Topography

The 100 Areas operable units, which cover a total area of 4,530 acres, are topographically and environmentally similar. Each is situated along the Columbia River, with the reactor located on a high gravel terrace left by the recession of glacial floodwaters at the end of the Pleistocene. Shoreline areas grade from steep banks with narrow cobble beaches to broad, stepped, well-defined floodplain terraces with gently sloping beaches. The floodplain terraces consist of sand deposited during the Holocene and occur on at least two levels: one dating to the early or middle Holocene and another representing the later Holocene. Inland areas are broad flats broken only by stabilized dunes. Information on the geology specific to the 100-H Area can be found in *Geologic Setting of 100-HR-3 Operable Unit, Hanford Site, South-Central Washington* (Lindsey and Jaeger 1993).

2.7.2 Ecological Investigation

Ecological surveys of the H Reactor area were completed (DOE-RL 1993a, Appendix D-2). Ecological surveys and sampling related to CERCLA activities have been conducted in the 100 Areas and in and along the Columbia River adjacent to the 100 Areas. The field investigations concentrated on bird surveys, mammal and insect surveys, vegetation surveys, and sampling of various biota for radionuclides and inorganic waste constituents. Biota and soil samples were collected from species and media with either a history of documented contaminant uptake or an important position in the foodweb. In and near the 100-H Area, sampling included reed canary grass (*Phalaris arundinacea*), tree leaves, asparagus (*Asparagus officinalis*), soil excavated from mammal burrows, ant mounds, raptor pellets, and coyote scat. These samples were analyzed for EPA target analyte list analytes and selected radionuclides. The results of these sample analyses have been compiled and are presented by Landeen et al. (1993). The ecological samples evaluated show no noticeable contamination within the H Reactor area. Other ecological sampling results generated by sitewide surveillance and facility monitoring programs are presented by Schmidt et al. (1993) and Weiss and Mitchell (1992).

Schmidt et al. (1993) report that only strontium-90 was above detection limits in 100-H Area vegetation samples, at 0.067 pCi/g, in 1992. The species of vegetation sampled were not given. Samples were collected on or near facilities that were used to dispose of radioactive waste. Landeen et al. (1993) show soil sampling results from eight animal and harvester ant burrows adjacent to 100-H Area waste sites. A maximum of 0.5 pCi/g cesium-137, and a maximum of 0.36 pCi/g strontium-90 were detected in these samples. Vegetation sampled by Landeen et al. (1993) was taken from the shoreline near the 100-H Area, rather than at specific waste sites. Weiss and Mitchell (1992) summarize historical vegetation sampling results, which show steadily declining levels of contamination in biota at the 100-H Area, to the current levels reported by Schmidt et al. (1993).

The shoreline adjacent to the 100-H Area is steeply sloped, with a narrow riparian zone dominated by reed canary grass and bluegrass and several white mulberry and golden currant trees. The shoreline flattens out in the south of 100-H Area in the vicinity of 100-H slough (Landeen et al. 1993). Stegen (1994) reports vegetation communities in the 100-H Area to be cheatgrass/ tumbleweed (*Bromus tectorum/Salsola kali*), gray rabbitbrush/Sandberg's bluegrass (*Chrysothamnus nauseosus/Poa sandbergii*), and disturbed/nonvegetated.

Animals of concern in and near the 100-HR-2 Operable Unit include the bald eagle, a state and federally listed threatened species, and the long-billed curlew, a state-listed monitor species. Bald eagles use night roosts less than 0.5 mi. from parts of the 100-HR-2 Operable Unit; some activities at

the unit from November to March could cause eagle disturbance. Curlews may nest in grassy areas of the operable unit from late March to early July, and some land-disturbing activities could damage nests or cause nest abandonment during that period. In either case, any proposed activities should be reviewed by an ecologist as early as possible during project planning to help minimize or avoid potential effects.

2.7.3 Cultural Resources Review

In compliance with Section 106 of the *National Historic Preservation Act*, and at the request of Westinghouse Hanford Company (WHC), the Hanford Cultural Resources Laboratory conducted an archaeological survey of the 100 Areas reactor compounds on the Hanford Site. This survey was conducted as part of a comprehensive cultural resources review of the 100 Areas operable units in support of CERCLA characterization activities. The work included a literature and records review and pedestrian survey of the project area following procedures established in the *Hanford Cultural Resources Management Plan* (Chatters 1989).

Archaeological surveys were completed in 1991 at the H Reactor area as directed in the 100-HR-3 Operable Unit work plan (DOE-RL 1992d, Appendix D-3). No new sites were recorded within the 100-H Area during these surveys (Chatters et. al. 1992). An ethnographic village site occupied by the Wanapum Tribe until 1943 was previously recorded by Rice (1968).

2.8 DATA EVALUATION

Analogous site data from the 116-F-4 pluto crib treatability test were evaluated for use in the QRA. This evaluation included: 1) data compilation and review, and 2) a review of laboratory and field (including trip and equipment) blanks. The sample inventory was conducted using multiple information sources including project sample lists and sample tracking sheets.

Data sources were EPA Contract Laboratory Program (CLP) analysis data disks, analytical reports (i.e., "Form 1" sheets), CLP data packages, and the *100 Area Excavation Treatment Test Report* (DOE-RL 1994a). Laboratory and field blanks were used to evaluate each data set for common laboratory contaminants or sources other than media contamination. This review was conducted using the EPA's "five or ten times rule" (EPA 1989a). The 10 times rule applies to common laboratory contaminants (e.g., methylene chloride, acetone, toluene, 2-butanone, and common phthalate esters). Detected concentrations of common laboratory contaminants had to be >10 times their corresponding blank value to be considered valid. Detected concentrations of other contaminants had to be greater than five times their corresponding blank value to be considered valid.

Data marked with "J" qualifiers were used as indications of contamination present, as were data that had no qualifiers attached. Data that were marked with "U" or "UJ" qualifiers were not further evaluated in the QRA because these qualifiers indicate no contamination is present above detection limits. Inorganic data marked with "B" qualifiers indicate the analyte was detected at a concentration between the instrument detection limit and the contract required detection limit. These were used as indications of contamination present. Organic and radionuclide data marked with a "B" qualifier indicate the constituent was found in the blank. These data were evaluated using the EPA 5 or 10 times rule to assess if they were usable.

2.9 DATA UNCERTAINTY

Data uncertainty and quality are linked. The uncertainty in the QRA risk characterization includes specific uncertainties related to the data evaluation process for detected contaminants. Uncertainty can also be related to the quality of data carried forward to the QRA. For example, the data used from the Dorian and Richards (1978) report were analyzed following routine laboratory protocols, but have not been validated; therefore, the quality of the data is medium. Data from the 118-B-1 Burial Ground and the 116-F-4 Treatability Test are considered to be of low quality because they are analogous.

The contaminants and concentrations identified are not necessarily representative of all the soil within the waste site. The maximum concentrations of contaminants of potential concern (COPC) used might be an under- or overestimate of the actual contaminants. The possibility also exists that contaminants other than those identified may be present.

Uncertainty associated with the historical or LFI data contributes to the overall uncertainties of human health risk estimates in this QRA. Contaminant identification uncertainty is considered to be higher for waste sites evaluated using only historical or analogous data. The primary objective of historical studies was to investigate radionuclides in exposure media added by Hanford Site operations. As a result, the historical data do not include analyses for chemical COPC and do not report soil concentrations of naturally occurring radionuclides (e.g., ^{40}K). The process for sample collection and analysis may be less clear for historical data. Evaluation of sites by analogy introduces uncertainties about the types and amount of contamination present.

2.10 OVERVIEW OF QRA APPROACH

2.10.1 Human Health Evaluation Methodology

The human health evaluation for this operable unit considers only two scenarios: frequent- and occasional-use, with three exposure pathways: soil ingestion, fugitive dust inhalation, and external radiation exposure. Because there were no organic COPC, the inhalation of VOCs exposure pathway is not evaluated. Once the COPCs have been identified, their concentrations are compared to: 1) analytical results from blanks (5 or 10 times rule, [EPA 1989a]), 2) established site background values (DOE-RL 1993a), and 3) a risk-based screening level (1E-07) for human health. While the 1E-07 level is conservative, it can help take the focus away from those contaminants above background but with low risk, so the more significant contaminants can be emphasized. More information on risk-based screening can be found in Section 2.1.4 of DOE-RL 1993b.

2.10.1.1 Exposure Assessment. The exposure assessment methodology is presented in HSBRAM (DOE-RL 1993b, Section 2.2 and Appendices A and C). The exposure assessment was conducted according to a conceptual site model that includes: 1) the determination of exposure scenarios; 2) exposure pathways; 3) exposure parameters; 4) exposure point concentrations; and 5) the quantification of exposures.

The conceptual model for the 100-HR-2 Operable Unit (Figure 2-3) shows the general exposure pathways for human receptors. Figure 2-4 displays the site model used in evaluation of the QRA for a source operable unit. The potential impact of the 100-HR-2 Source Operable Unit on the

groundwater in the 100-HR-3 Groundwater Operable Unit is discussed in Section 5.1.3. Groundwater exposure pathways are evaluated in the 100-HR-3 Operable Unit Work Plan (DOE-RL 1992d) and LFI (DOE-RL 1993d). Refer to applicable portions of Section 2.11 of this document that discuss interim remedial action goals and their relation to groundwater protection.

Under current site conditions, there are no residents at the 100-HR-2 Source Operable Unit, and institutional controls prevent inadvertent intrusion into waste sites. Thus, exposures and associated risks evaluated in the QRA are not actual risks but are estimates of potential risks assuming only two human health scenarios (frequent and occasional use) with three exposure pathways (soil ingestion, fugitive dust inhalation, and external radiation exposure). The QRA does not include evaluation of pathways for ingestion of groundwater or agricultural crops. The frequent-use scenario represents exposures of a hypothetical resident (i.e., long-term exposure) to each burial ground from the three selected exposure pathways. The occasional-use scenario approximates the exposures to hypothetical intruders (i.e., short-term exposure) from the three exposure pathways.

A future frequent-use scenario was also evaluated, using the maximum concentrations of radionuclides that were corrected for radioactive decay to the year 2018 per agreements stated in Attachment 1 to the Tri-Party Agreement Project Managers Meeting Minutes of March 19, 1992. The Tri-Party Agreement Project Managers agreed to present information that compares the estimated risk after implementation of remedial alternatives, including varying lengths of institutional control (e.g., 30 years after the 1988 initiation of the Tri-Party Agreement).

The pathways evaluated for each waste site and scenario are as follows:

- Soil ingestion
- Fugitive dust inhalation
- External radiation exposure.

Because the groundwater ingestion exposure pathway was not used, no modeling of contaminant transport through the vadose zone to the unconfined aquifer was considered.

Exposure parameters for the scenarios evaluated in this QRA are defined in the HSBRAM (DOE-RL 1993b, Appendix A). Recreational exposure parameters are used to evaluate the occasional-use scenario and residential exposure parameters are used to evaluate the frequent-use scenario.

For purposes of the QRA, the maximum soil concentration of a COPC measured within the specified depth interval is used as the exposure point concentration. Historical radionuclide soil concentration data were corrected to the year 1994 to allow for radionuclide decay.

The methods for quantifying receptor exposures in the various scenarios is in HSBRAM (DOE-RL 1993b). Standard EPA equations (EPA 1989a; DOE-RL 1993b) are used as the basis for all intake calculations. Exposures of humans to chemical COPC are expressed as dose rate (i.e., milligrams of contaminant per kilogram of receptor bodyweight per day). Exposures to radionuclide COPC are expressed as picocuries per gram environmental (e.g., soil) concentrations per time.

The Washington Administrative Code (WAC) requires the assumption that a reasonable estimate of the depth of soil that could be excavated and distributed at the ground surface as a result of site development activities (e.g., constructing a basement) is from ground surface to 4.6 m (15 ft)

below ground surface (WAC 173-340-740[6][c]). Therefore, the maximum concentration of a contaminant detected in the upper 15 ft of the soil is used to calculate contaminant intakes for the frequent- and occasional-use scenarios.

Assuming that soil excavation activities do not occur in the occasional-use scenario, the radiation shielding provided by clean-fill soil covering the waste sites can reduce external radiation exposure of human receptors. This shielding was not considered in this QRA because of the assumptions made in using analogous site comparisons. Insufficient sampling data are available for the top 6 ft of soil at these waste sites. Therefore, no risk reduction from the shielding effect of clean-fill soils could be estimated.

Air concentration data specific to individual waste sites were not available for use in this QRA. Therefore, COPC airborne concentrations are estimated from their respective maximum soil concentrations. Fugitive dust concentrations are estimated using a particulate emission fraction of 2×10^7 m^3/kg. This particulate emission fraction conservatively assumes that the fugitive dust concentrations at each waste site are constantly equivalent to the National Primary Ambient Air Quality Standard for particulate matter of 50 $\mu g/m^3$ (EPA 1993, Appendix A-V). The particulate emission factor calculation is provided in Appendix C of the 100-BC-1 QRA (Kytola 1993).

2.10.1.2 Toxicity Assessment. The general procedures for toxicity assessment are presented in the HSBRAM (DOE-RL 1993b). The toxicity assessment for the QRA identifies contaminant-specific toxicity factors and briefly discusses the key toxicities associated with the detected contaminants.

When historical data did not specify which uranium isotope was detected, ^{238}U was assumed for the calculations. It was assumed that the detected uranium originated from natural sources; uranium occurs naturally in the environment (Woodruff et. al. 1993). The natural sources are approximately 99% ^{238}U by mass (^{238}U is not the by-product of any process known to have been used at the Hanford Site).

2.10.1.3 Risk Characterization. The risk characterization for the QRA is conducted as presented in the HSBRAM (DOE-RL 1993b). The risk characterization methodology provides estimates of lifetime incremental cancer risk (ICR) for exposures to carcinogenic COPC and hazard quotients for exposures to systemic toxicant COPC. For this QRA, no nonradionuclide COPC were above the human health screening criteria, and thus none were carried through the calculations. Direct quantitative analytical data (historical) were available for only one waste site; for some others, only analogous data were used. There were no usable data for the rest of the site.

For waste sites without analytical data, potential COPC releases are identified from available historical information or from process knowledge of the waste site's historical activities. Human health risks assessed at analogous waste sites were used to establish a range of risks that may exist at the investigated waste site. The resulting risk characterization includes a discussion of both the potential site risk and the appropriateness of the selected analogous site.

The total lifetime ICR to human receptors at each site was determined by summing the individual COPC ICR contributions from the three selected pathways. Because the risk characterization equation for carcinogens used in this QRA is only valid up to estimated risks of approximately 1E-02 (EPA 1989a), lifetime ICR estimates that exceeded 1E-02 were reported as $>$1E-02.

For sites where analogous data (118-H-5) or historical data (buried thimble site) were used to calculate potential risk, the slope factors used in the equations are provided in Table 2-4. The remediation priority for each waste site is qualitatively described with respect to the following levels of the total lifetime ICR:

Remediation Priority	Total Lifetime ICR
high	> 1E-02
medium	< 1E-02 and > 1E-04
low	< 1E-04 and > 1E-06
very low	< 1E-06

2.10.1.4 Uncertainties. The human health risks calculated in this QRA are estimates that reflect several assumptions and related uncertainties. Table 2-5 summarizes the uncertainty. Uncertainties inherent in these estimated risks reflect a combination of uncertainties in the data used, exposure and toxicity assessments, and risk characterization calculations.

2.10.1.4.1 Exposure Assessment Uncertainties. The impact of the exposure assessment uncertainties can be grouped into the following qualitative categories (EPA 1989a):

- Low uncertainty might affect estimates by less than one order of magnitude.
- Moderate uncertainty might affect estimates by one to two orders of magnitude.
- High uncertainty might affect estimates by more than two orders of magnitude.

The major contributions to exposure assessment uncertainties result from assumptions concerning land-use scenarios, exposure parameters, exposure pathways, soil concentrations, and appropriateness of analogous sites. Institutional controls that currently prevent frequent-use and limit occasional-use scenario exposures are assumed to be removed, although the future uses of the site are uncertain at this time.

COPC in subsurface soil to a depth of 15 ft were assumed to be accessible to the hypothetical receptor by all exposure pathways. Inhalation and ingestion exposures are generally limited to COPC concentrations located near the surface. This assumption results in overestimations of receptor exposures, especially in the occasional-use scenario, and at sites known to be covered with clean soil.

The use of maximum soil concentrations of all COPC from the surface to a depth of 15 ft introduces high uncertainty into the exposure assessment. Spatial distributions of surface and subsurface COPC concentration are not considered. Because the maximum observed concentration is assumed to be everywhere in the surface and subsurface soil, the potential human exposure is overestimated, especially in the occasional-use scenario.

An assumption of "infinite source" geometry is used to evaluate individual external radiation exposures. This assumption is inherent in the EPA toxicity parameters used in this QRA (EPA 1993). Exposures calculated using this assumed geometry estimate that a hypothetical receptor

would be exposed to radiation from an infinitely wide and deep soil column uniformly distributed with the maximum concentrations of all radionuclide COPC. Because this assumption ignores differences in radiation intensity provided from any other distribution of COPC in soil, a high amount of uncertainty is introduced. At certain sites, this uncertainty causes exposures to be overestimated, and the associated risks to be dominated by the external exposure pathway.

While the actual amount of fill material over buried waste is not known, site investigations show covers of 1 to 18 ft. In addition, quarterly radiological surveys (e.g., McKinney 1993) are completed over waste sites to verify compliance with posting standards for WHC (1991); each waste site is surveyed at least once a year. Areas posted as "Underground Radioactive Material" must be below 1 mrem/h and have no surface contamination. Such areas are reposted as "Surface Contamination Areas" (SCA) if surveys have readings greater than twice background. Only one of the 100-HR-2 waste sites (part of the buried thimble site) is posted as an SCA. Risk managers can reduce the decisionmaking uncertainty by being aware of how posting guidelines indicate relative exposure potential.

Uncertainty in data used to evaluate external radiation exposures was considered high because the evaluation used toxicity slope factors that extrapolate external radiation risks from radionuclide concentrations in soil. Direct measurements of external radiation intensity were not available for this QRA. Because exposure via the external radiation pathway is shown to be a major contributor to risk at many waste sites, this high data uncertainty is expected to significantly impact this QRA.

Uncertainty in data used to evaluate the inhalation pathway exposures was also considered high because of both the data source and the extrapolation of airborne dust concentrations from soil concentrations. However, this high data uncertainty is not expected to significantly impact this QRA, because exposure via the inhalation pathway is not shown to be a major contributor to risk at most waste sites. In summary, over all the pathways, the results of the QRA have a "high" degree of uncertainty.

2.10.1.4.2 Toxicity Assessment Uncertainties. The effects of toxicity assessment uncertainties may reflect either under- or overestimations of site risks. Uncertainties associated with the various toxicity parameters result from using the following:

- Data from animal exposures to predict health effects in humans
- Dose-response information from a homogeneous animal or human population to predict potential health effects that may occur in the more heterogeneous general population
- Information on dose-response effects from high dose exposures to predict effects at low doses
- Short-term exposure data to estimate effects from chronic exposures, or vice versa.

The EPA addresses these uncertainties by assigning degrees of confidence to the published toxicology studies for the compounds in question. An assignment of low confidence indicates that a change in the toxicity parameter is expected when additional chronic data become available (EPA 1989a). Thus, an assignment of low confidence implies greater uncertainty in the toxicity

assessment for this QRA. A medium confidence implies moderate uncertainty, and high confidence implies low uncertainty.

2.10.1.4.3 Risk Characterization Uncertainties. The risk characterization process combines the results of the exposure assessment with the toxicity assessment into a measure of risks to human health at the evaluated waste site. Therefore, uncertainties inherent in the component assessments are propagated into the risk characterization.

The major contributions to exposure assessment uncertainties result from assumptions concerning land-use scenarios, exposure parameters, exposure pathways, soil concentrations, and appropriateness of analogous sites. The QRA does not include evaluation of pathways for ingestion of groundwater or agricultural crops based on methodology agreed to by the Tri-Party Agreement signatories concerning the scope of the QRA (DOE-RL 1993b), and because of the lack of information regarding appropriate input parameters. While these factors result in uncertainty during the decisionmaking process, all of the sites evaluated in the LFI are recommended to remain IRM candidates.

For the QRA, estimated risks are compared to 1E-06. The selection of this risk level is associated with some practical considerations in evaluating the QRAs especially because a key exposure pathway is the external exposure pathway. Given the conservatism built into this pathway, it may be desirable to measure actual dose rates to confirm that the estimated risk is representative of the assumed exposure scenarios. However, it is not possible (using survey data) to determine whether the external exposure risk is less than 1E-05 because this is the approximate risk associated with a fluctuation in natural background radiation levels. Survey data are of insufficient quality to calculate external exposure risks; they are used only to estimate whether the external exposure risk is greater than or less than 1E-05. The assumption that above background levels represent a 1E-05 risk is also highly uncertain because it is based on risk factors of unknown accuracy.

Use of conservative assumptions usually results in overestimation of human health risk and increased uncertainty. This approach serves a useful purpose in this QRA by providing strict criteria for identifying the contaminants and exposure pathways of concern at the 100-HR-2 Operable Unit. Although these conservative assumptions serve to simplify the risk characterization process, the resulting numerical values do not represent the most realistic estimates of risks and hazards to human health. The use of the numerical risk and hazard estimates should be limited to comparisons with QRAs for other operable units evaluated using the same methodology (DOE-RL 1993b). However, because of the nature of the assumptions used with QRAs and the uncertainties involved, even these comparisons must be made cautiously and qualitatively.

It should be noted that there are many uncertainties in both the exposure assumptions and the toxicity evaluations. The computed risk assessment values for each of the two scenarios, frequent use and occasional use, appear to be different. However, the uncertainties in computing these values may accumulate to the point that the apparent differences in values may not actually be real.

2.10.2 Ecological Evaluation Methodology

The qualitative ecological evaluation estimates the potential ecological risks from existing contaminant concentrations for a selected ecological receptor.

The approach assesses the dose to the Great Basin pocket mouse from each of the waste sites (DOE-RL 1993b). The mouse is used as the indicator receptor because its home range is comparable to the size of most waste sites and it will receive most of its dose from within a waste site. This allows a risk comparison between waste sites.

The 100-HR-2 Operable Unit is a terrestrial operable unit. The qualitative ecological evaluation approach relies mainly on assumptions regarding waste site stressors, appropriate ecological receptors and primary exposure pathways and uses existing or analogous data. The QRA is not an absolute measure of risk in that it does not utilize detailed conceptual models and pathway analyses. The operating assumption is that contaminants are present at the site and the QRA evaluates the estimated risk from these contaminants to an ecological receptor.

Issues relevant to evaluating the qualitative ecological risk for waste sites are the stressor characteristics, the ecosystems likely to be affected by these stressors, and the possible effects on the receptor (i.e., pocket mouse) from exposure to physical and chemical stressors. The stressors of concern are identified as those contaminants detected above background. All inorganic contaminants exceeding background are included in the QRA. Because there currently are no accepted background values for radioactive and organic contaminants, all analytes that were detected were included in the risk evaluation.

All contaminants evaluated have been detected in the soil within the operable unit, were identified through historical records, or have been identified in analogous sites. The operable unit does not contain surface water bodies and is not apparently subject to mass flows from surface water runoff. Contaminants found in the soil at waste sites include radioactive and nonradioactive elements and organic compounds. For nonradioactive elements and organic compounds, ecological effects were evaluated by considering uptake of contaminants from the soil by plants, and by accumulation of these constituents through the foodweb. In general, uptake of contaminants from soil by vegetation serves as the primary source of contaminant entry into the food chain. Intake of contaminants by the mouse was estimated using intake parameters obtained from published literature or derived from EPA formulas. Intake of contaminants in vegetation was estimated using an equation adapted from EPA's *Human Health Evaluation Manual* (EPA 1989a).

To evaluate the chemical toxicity to the pocket mouse, intake values for a given contaminant were compared to the no observed adverse effect level (NOAEL). As indicated by DOE (1992a), toxicity information for terrestrial organisms relied on animal studies that support the Integrated Risk Information System (IRIS) database (EPA 1991a) and the Health Effects Assessment Summary Tables (HEAST) (EPA 1990) databases. As a screening tool, toxicity data presented in the IRIS or in the HEAST database (when absent in IRIS) were used for mammals. Uncertainty factors were applied to the animal toxicity data to correct for differences between species, to modify lowest observed effect levels to NOAEL, and to adjust data obtained through short-term studies to that which would be expected in long-term studies.

Radionuclides can induce ecological effects as a result of their presence in the abiotic environment (external dose rate) and by their incorporation into the body (e.g., internal dose rate from consumption of contaminated food). The total daily radiation dose rate to an organism can be estimated as the sum of doses received from all radioactive elements ingested, residing in the body, and available in the organism's environment. The radiological dose rate an organism receives is usually expressed as radians per day (rad/day). For the purposes of this QRA, external doses of ionizing radiation (DOE-RL 1993b), inhalation of contaminants, and ingestion of contaminants via

preening or grooming fur are assumed to be minimal (DOE-RL 1994c). For radionuclides, the environmental hazard quotient (EHQ) is determined by comparing the dose to a mouse to an aquatic benchmark of 1 rad/day (DOE Order 5400.5).

The approach taken in this QRA is to evaluate risk for the small herbivore component (Great Basin pocket mouse) based on a two-step accumulation model (e.g., soil-to-plant and plant-to-mouse). Equations relating to dose rate calculations for primary and secondary organisms are reported by DOE-RL (1993b). The accumulation model is operated on a waste-site-by-waste-site basis. Because the home range of the mouse is approximately the size of a typical waste site, the mouse is assumed to be exposed to contaminants within the specific waste site during most or all of its lifetime. No attempt was made to discriminate between seasonal uses of the site by the mouse.

2.10.2.1 Uncertainties. There are a number of uncertainties in the evaluation of ecological risks associated with the approach used in this ecological evaluation. A major source of uncertainty that limits the conclusions drawn from the evaluation is the extrapolation from the individual to the population level of ecological organization. There is a minimal amount of information concerning dose/response relationships at the population level for the Great Basin pocket mouse.

The use of the maximum detected contaminant concentrations and the assumption that the contaminants are distributed uniformly throughout the soil add a level of conservatism to the ecological risk evaluation that may result in overestimation of the true risk. Conversely, because there is little site-specific data for many of the waste sites within the 100-HR-2 Operable Unit, there may be contaminants present at levels in excess of the concentrations evaluated in the ecological evaluation. This would result in an underestimation of the true risk.

Vegetation is the source of additional uncertainties. First, all of the burial grounds in the 100-HR-2 Operable Unit are presently covered with cobble or gravel, and are regularly treated with herbicides to eliminate vegetation. Therefore, the amount of contaminated vegetation available for consumption by the pocket mouse is limited. Second, modeling the transport from the soil to the pocket mouse requires several assumptions, including the soil-to-plant uptake factors. A review of available literature produces a range of values. As a conservative measure, the highest reported transfer factor for each contaminant was used. This may lead to an overestimation of the ecological risk.

Assumptions associated with the pocket mouse also introduce uncertainty to the evaluation. It is assumed that the pocket mouse only consumes vegetation on a single waste site and that all of the vegetation is contaminated. The possibilities that the mouse may feed in uncontaminated areas or on multiple waste sites are not considered. Additionally, seasonal use of the waste site and hibernation/estivation are not considered in the evaluations.

Uncertainty is also introduced through the calculation of the NOAELs used in determining the EHQs. The NOAEL values for the pocket mouse are derived empirically from toxicological data developed for different species. For radionuclides, the only available guidance is DOE Order 5400.5, which requires exposure to aquatic organisms to be less than 1 rad/day. This dose was used as a default value for the mouse in a terrestrial environment. However, there are not enough data to determine if the true risk is over or underestimated.

The ecological significance of the QRA is limited because it does not take into consideration actual sampling of biota in and around the waste sites and operable unit. Some of this sampling data

can be found in current and past Hanford Site documents, such as Woodruff et al. (1993), Schmidt et al. (1993), and Landeen et al. (1993). The concentrations of radionuclides in wildlife and plants, as reported in these documents, indicate only low and occasional levels of radionuclides; these levels are lower than those reported to cause effects (Driver 1994). In addition, the QRA models a dose to an individual animal, when the level of concern for ecological significance (except for endangered species) is at the community or population level (Warren-Hicks et al. 1989). Field data from the past decades (as cited above) do not indicate any effects to wildlife at these levels. For example, Schmidt et al. (1993) reported up to 0.112 pCi/g strontium-90 in vegetation at 100-H area waste-site vegetation; Landeen et al. (1993) reported a maximum of 88 pCi/g strontium-90 in tree leaves from all the 100 Areas, with the maximum near 100-K, and trees near 100-H Area showing a maximum of 2.6 pCi/g.

2.11 CORRECTIVE ACTION REQUIREMENTS

Remedial investigations and planning activities for the 100 Areas have been conducted in accordance with the *Hanford Site Past-Practice Strategy* (DOE-RL 1991) to streamline the remedial action process, with emphasis on early action at high-priority sites through expedited response actions and IRMs. Corrective action at the 100-HR-2 Operable Unit is generally required to comply with federal and state environmental laws and promulgated standards, requirements, criteria, and limitations that are legally ARAR under the circumstances presented by the release or threatened release of hazardous substances, pollutants, or contaminants.

The public has provided input to the DOE on the future use of the 100 Areas through various forums including the Hanford Future Site Uses Working Group. However, a final land use determination for the 100 Areas of the Hanford Site has not been established. Remedial action objectives and cleanup goals may be revisited if land use and groundwater use determinations are inconsistent with the goals presented in this plan. Ecology, EPA, and DOE have agreed to cleanup goals that, to the extent practical, would support a goal not to limit future uses of the 100 Areas land due to contaminants resulting from Hanford Site operations. This would be accomplished through remediation of the sites to address the potential direct effects of exposure, as well as potential releases to air and groundwater. Remediation would minimize ecological and cultural impacts. The development of mitigation plans to address site-specific ecological and cultural resources will occur during the remedial design phase that follows after the ROD is signed.

Interim remedial action goals represent contaminant concentrations in soils that are considered to be protective of human health and the environment. Cleanup goals are based on the three laws and the proposed standard, which are discussed as follows:

- Washington State *Model Toxics Control Act* (MTCA) guidelines for organic and inorganic chemical constituents in soil to support unrestricted (residential) use

- Protection of groundwater such that contaminants remaining in the soil after remediation do not result in an impact to groundwater that could exceed MCL under the *Safe Drinking Water Act*. This applies to waste sites where groundwater has not been impacted

- Protection of the Columbia River such that contaminants remaining in the soil after remediation do not result in an impact to groundwater and, therefore, the Columbia

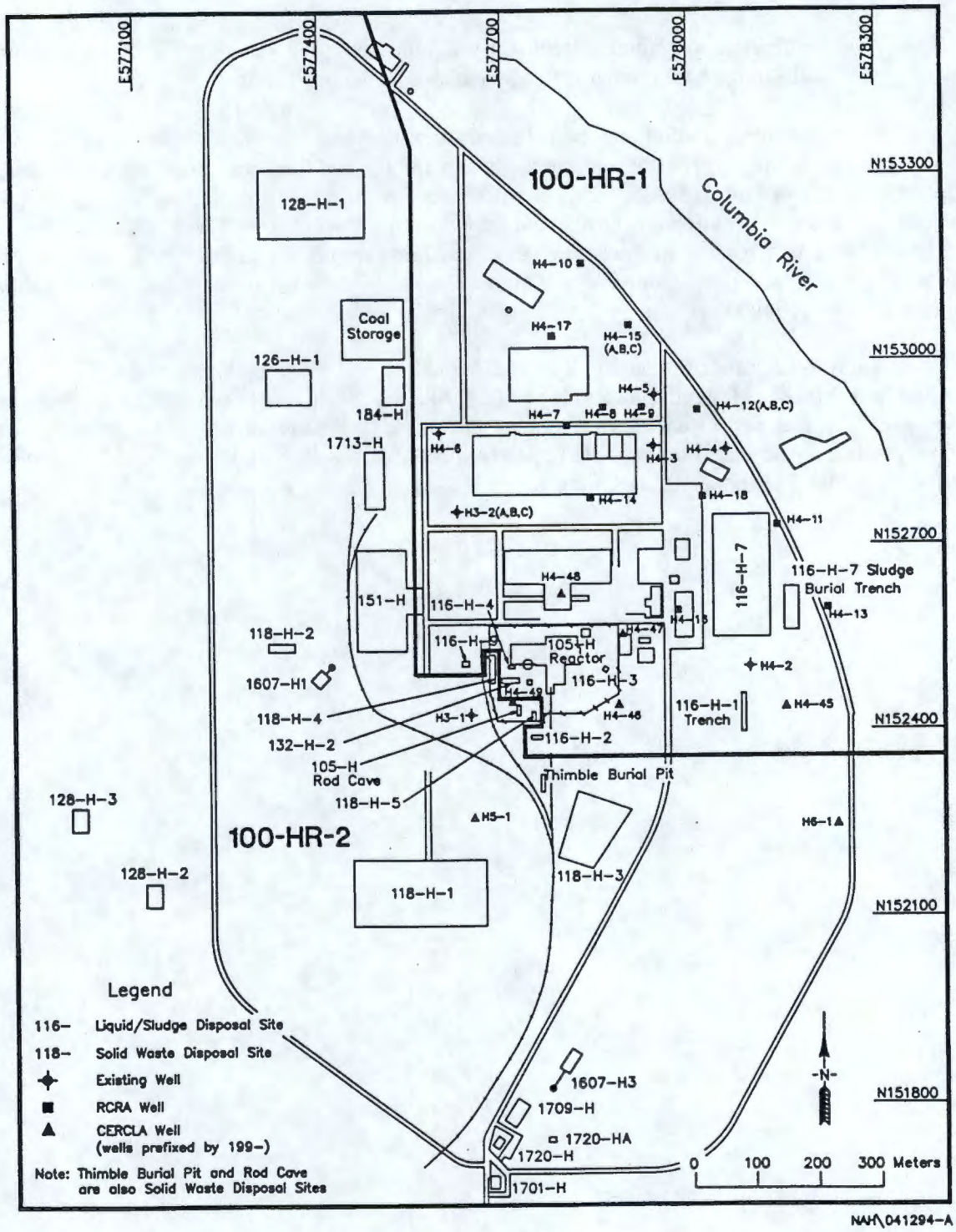
River, which could exceed the Ambient Water Quality Criteria under the *Clean Water Act* for consumption of fish. This applies to sites where groundwater has already been impacted

- Draft EPA and Nuclear Regulatory Commission proposed standard of 15 mrem/yr in soils above background for radionuclides for human health

The extent of remediation may be balanced against several factors, including reduction of risk by decay of radionuclides, protection of human health and the environment, costs, sizing of the Environmental Restoration Disposal Facility, worker safety, presence of ecological and cultural resources, the use of institutional controls, and long-term monitoring costs. Negotiated "action levels" may be considered for sites where cleanup standards are neither technically feasible nor economically practical. If contaminated soil above cleanup goals is left in place, additional public comment may be solicited.

Potential CARs are presented in Tables 2-6 and 2-7, and the to be considereds (TBC) are presented in Table 2-8. Potential location-specific CARs are identified for the 100 Areas because of the presence of threatened or endangered species and archaeological resources. In addition, potential location-specific CARs based on possible impacts to wetlands and floodplains are included. These are included in Tables 2-9 and 2-10; TBCs are in Table 2-11.

Figure 2-1. Groundwater Wells in the 100-H Area.



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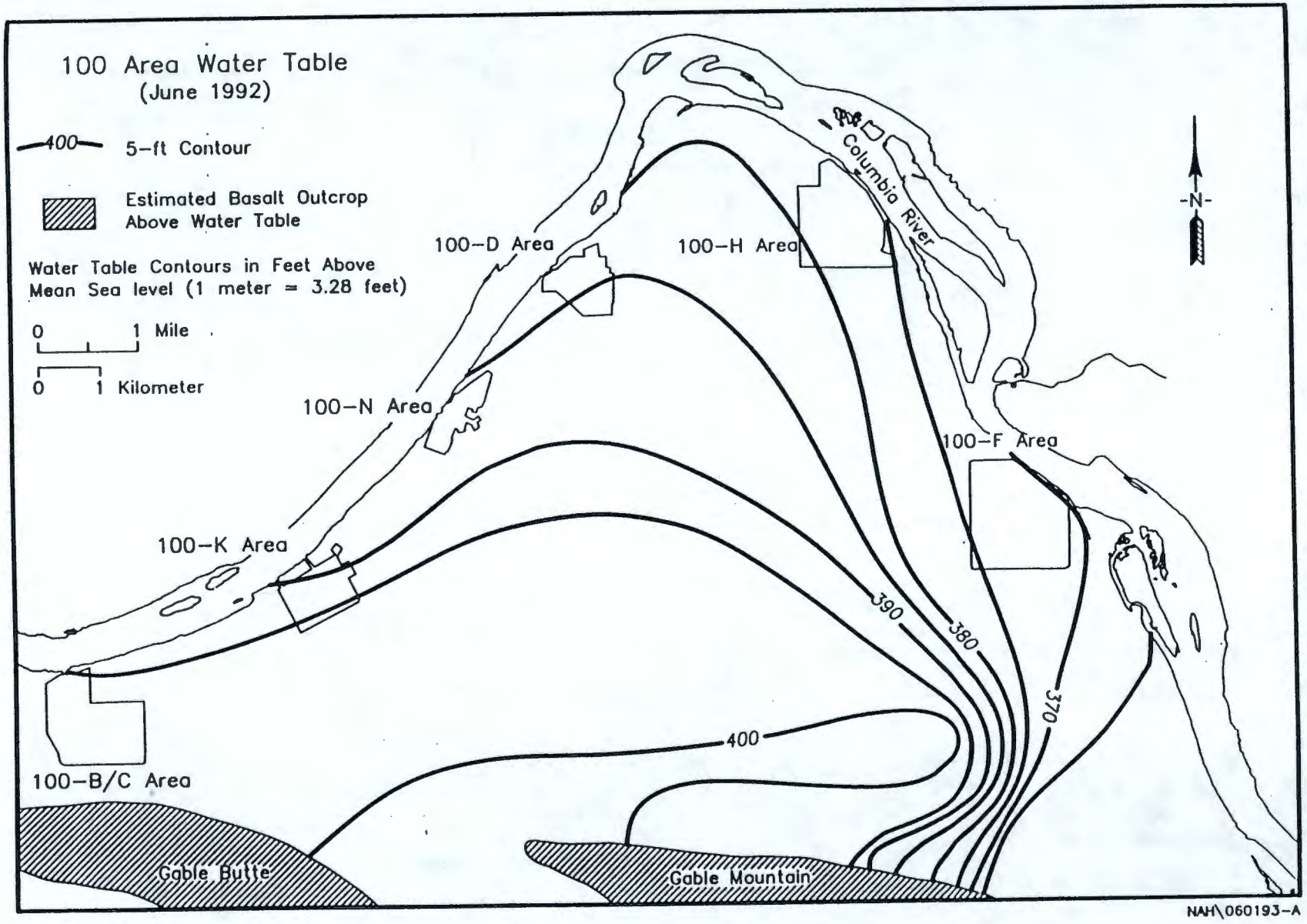

Figure 2-2. Water Table Elevations for June 1992.

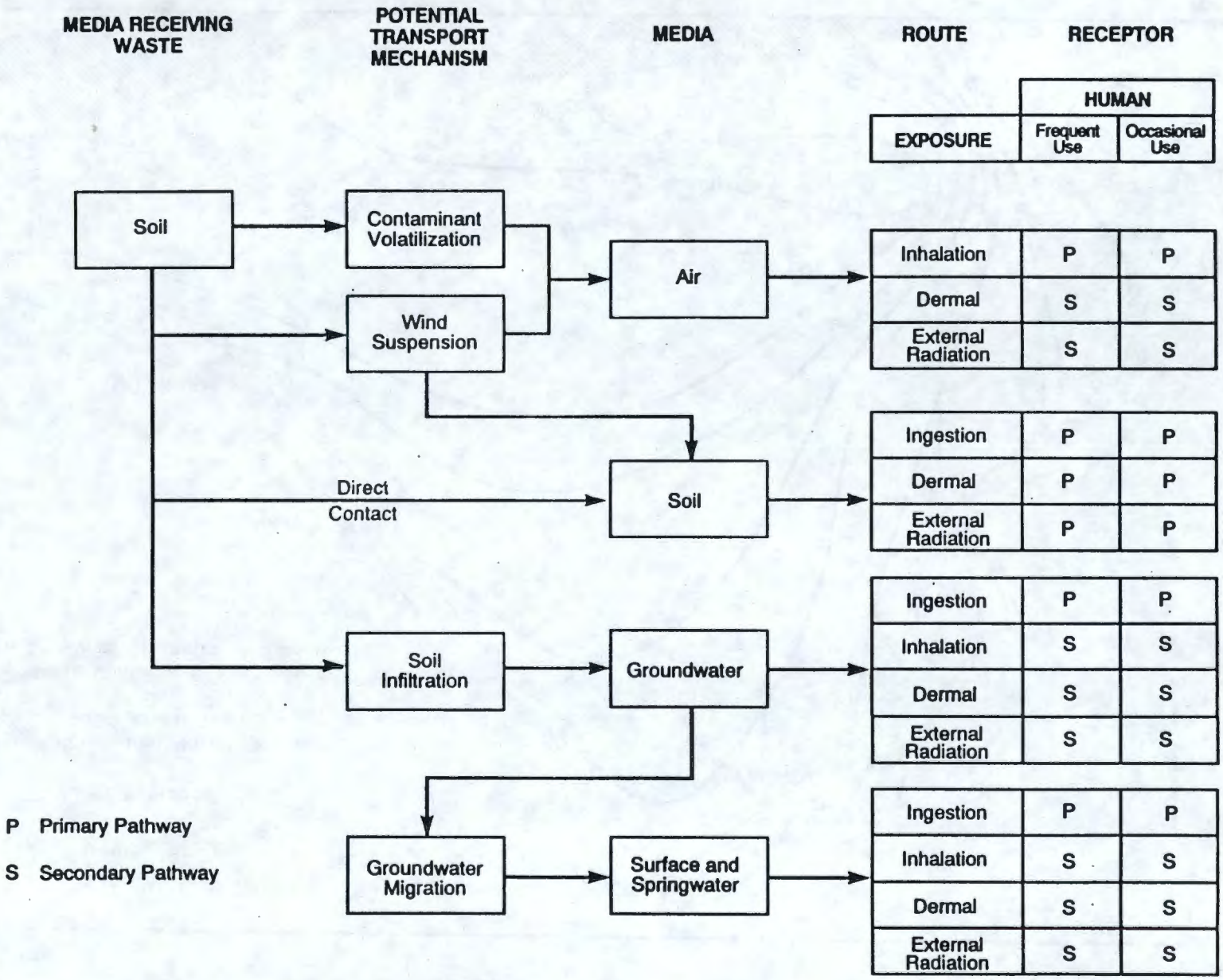

Figure 2-3. Hypothetical Exposure Pathway Used in the 100-HR-2 Operable Unit QRA.

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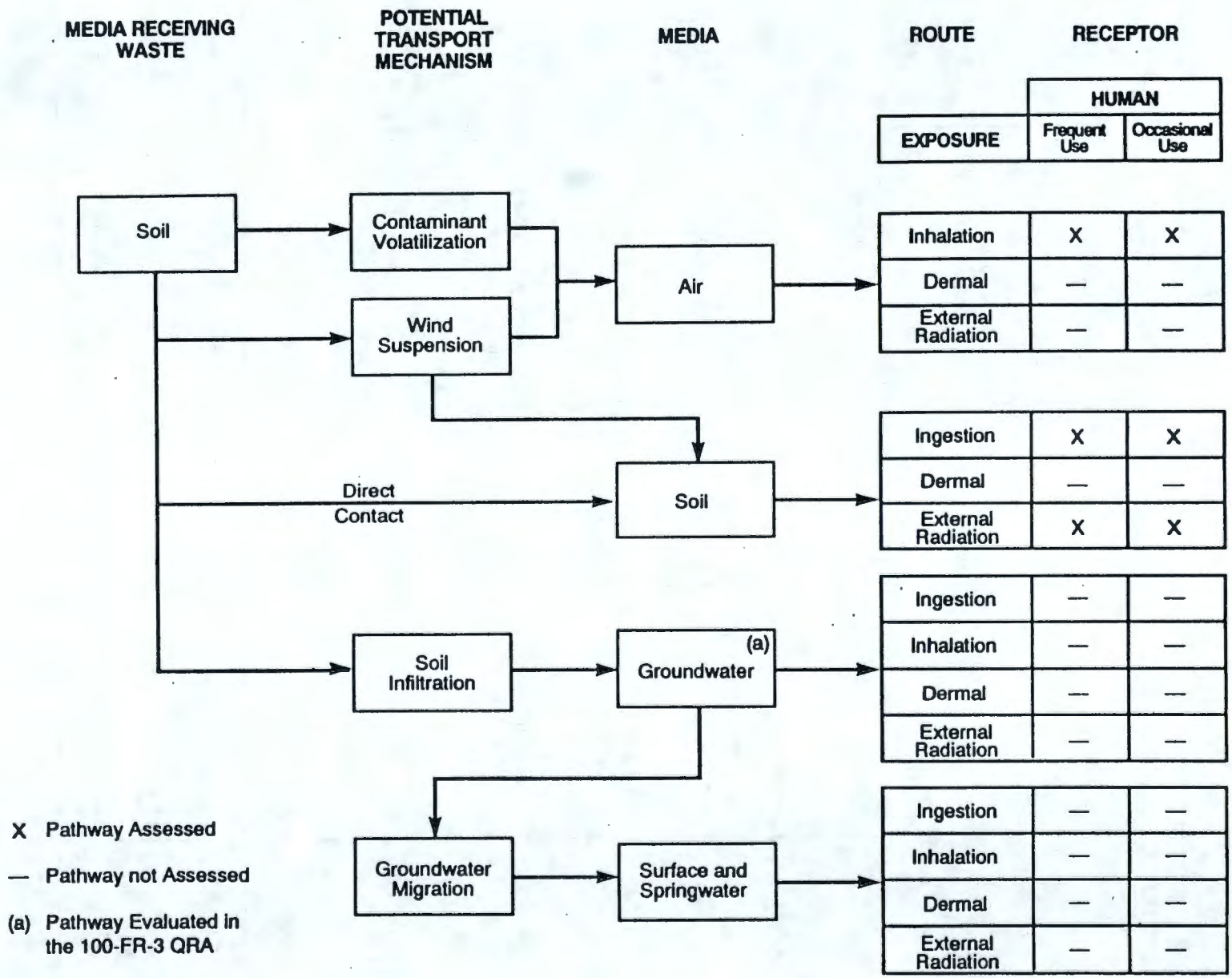

Figure 2-4. Conceptual Model for Existing Pathways for 100-HR-2 Operable Unit Soils.

Table 2-1. Investigative Approach for 100-HR-2 Waste Sites.

Site	Name/Size	Comments	Investigative Approach
Burial Grounds			
118-H-1	100-H burial ground #1, 100-H-1/700 by 350 by 20 ft deep	Site received waste consisting of activated components, dummy elements, process tubing and horizontal control rods; misc. surface-contaminated materials broken hand tools, rags, sweeping compound, light bulbs, sheets of plastic and paper from zones, etc. Misc. waste was sealed in boxes and placed in separate trenches from activated waste.	HAS, G
118-H-2	100-H burial ground #2, H-1 loop burial ground/ 140 by 50 by 15 ft deep	East vault received stainless-steel double-tube with associated hardware (cleaning solutions and misc. capsule components). West vault was used for disposal of contaminated pipe.	G,P
118-H-3	Construction burial ground/100 by 375 by 313 by 400 ft, 20 ft deep	Site received waste consisting of sections of contaminated 16-in. pipe used as chutes for removal of thimbles from 105 H, reactor hardware, and components from reactor modification programs.	G
118-H-4	Ball 3X burial ground/150 by 30 by 20 ft deep	Site received irradiated materials, such as vertical safety rod thimbles and guides, from 105-H during the Ball 3X Program.	P
118-H-5	105-H thimble pit/30 by 2 by 10 ft deep	Site received a thimble assembly from the B Experiment Hole from the 105-H X-Level. In 1960, 105-H pluto crib was excavated and placed in this burial ground.	P,A,TS
105-H Rod Cave	40 by 25 ft	Site suspected to contain contaminated horizontal control rods and possibly other misc. reactor facility components.	
Buried Thimble	40 ft long	Site suspected to contain a vertical safety rod thimble.	
Low Priority Sites			
128-H-1	100-H burning pit #1/ 100 by 100 by 10 ft deep	Site received nonradioactive, combustible materials such as paint waste, office waste, and chemical solvents.	SG
151-H	Electrical substation	Potential PCB contamination in soils where oil-filled equipment was located.	N

HAS Historical analogous sampling
P Process knowledge information
G Ground-penetrating radar/electromagnetic induction
A Analogous site sampling
N Nonintrusive sampling
SG Soil-gas survey
TS Treatability study

(DOE-RL 1993f)

Table 2-2. Analogous Sites Applicable to 100-HR-2 Waste Sites.

100-HR-2 Operable Unit Waste Site[a]	100-F Area	100-D Area	100-B Area	100-K Area
118-H-1	118-F-1	118-D-1 118-D-2 118-D-3	118-B-1 118-C-1	118-K-1
118-H-3	118-F-2	118-D-4	118-B-2 118-B-3	None
118-H-4	118-F-3	118-D-5	118-B-5	None
105-H Horizontal Control Rod Storage Cave	None	None	118-C-4	118-K-2W 118-K-2E
116-H-4 Pluto Crib[b]	116-F-4	116-D-2A	116-C-2A	None

[a]Burial grounds 118-H-2 and 118-H-5 and buried thimble site do not have analogous sites in the 100 Areas.
[b]Soil from the 116-H-4 pluto crib was buried in the 118-H-5 burial ground.

An analogous site is a site associated with one of the other 100 Areas reactor sites that has a similar process history, waste stream, and potentially the same contaminants to a site in the 100-HR-2 Operable Unit. However, an analogous site does not necessarily have the same geology, suite of contaminants, or extent of contamination.

Table 2-3. Summary Statistics and Upper Threshold Limits for Inorganic Analytes.

Analyte[a]	95% Distribution (mg/kg)[b]	95% Upper Threshold Limit (mg/kg)[c]
Aluminum	13,800	15,600
Antimony	[d]	15.7[e]
Arsenic	7.59	8.92
Barium	153	171
Beryllium	1.62	1.77
Cadmium	[d]	0.66[e]
Calcium	20,410	23,900
Chromium	23.4	27.9
Cobalt	17.9	19.6
Copper	25.3	28.2
Iron	36,000	39,160
Lead	12.46	14.75
Magnesium	7,970	8,760
Manganese	562	612
Mercury	0.614	1.25
Nickel	22.4	25.3
Potassium	2,660	3,120
Selenium	[d]	5[e]
Silver	1.4	2.7
Sodium	963	1,290
Thallium	[d]	3.7[e]
Vanadium	98.2	111
Zinc	73.3	79
Molybdenum	[d]	1.4[e]
Titanium	3,020	3,570
Zirconium	47.3	57.3
Ammonia	15.3	28.2
Alkalinity	13,400	23,300
Silicon	108	192
Fluoride	6.4	12
Chloride	303	763
Nitrite	[d]	21[e]
Nitrate	96.4	199
Orthophosphate	3.7	16
Sulfate	580	1,320

[a]Analytes for RCRA analyses per Method 6010 (EPA 1986) plus selected anions.
[b]95th percentile of the data for a lognormal distribution.
[c]95% confidence limit of the 95th percentile of the data distribution.
[d]Not reported.
[e]Limit of detection.

(DOE-RL 1993a)

Table 2-4. Summary of Carcinogenic Information for Radionuclide Analytes Detected at the 116-F-4 Pluto Crib. (Analogous Data for 118-H-5 Burial Ground)

Radionuclide Analyte	Weight of Evidence Classification	Type of Cancer	Oral SF (a) $(pCi)^{-1}$	Inhalation SF (a) $(pCi)^{-1}$	External SF (a) $pCi\text{-}yr/g^{-1}$	Half-life (years)
Cobalt-60	A[b]	-[c]	1.5E-11	1.5E-10	8.6E-06	5.3
Strontium-90 +D	A	-	3.6E-11	6.2E-11	(d)	28.6
Americium-241	A	-	2.4E-10	3.2E-08	4.9E-09	433
Cesium-137 +D	A	-	2.8E-11	1.9E-11	2E-06	30.2
Europium-152	A	-	2.1E-12	1.1E-10	3.6E-06	13.6
Europium-154	A	-	3.0E-12	1.4E-10	4.1E-06	8.8
Potassium-40	A	-	1.1E-11	7.6E-12	5.4E-07	1.26E+09
Plutonium-239/240	A	-	2.3E-10	3.8E-08	2.7E-11	24100
Plutonium-238	A	-	2.2E-10	3.9E-08	2.8E-11	87.8
Uranium-233/234	A	-	1.6E-11	2.7E-08	4.2E-11	2.4E+05
Uranium-235 + D	A	-	1.6E-11	2.5E-08	2.4E-07	7E+08
Uranium-238 + D	A	-	2.0E-11	2.4E-08	5.1E-08	4.5E+09
Technetium-99	A	-	1.3E-12	8.3E-12	6E-13	2.12E+05
Thorium-228 + D	A	-	5.5E-11	7.8E-08	5.6E-06	1.9
Thorium-232	A	-	1.2E-11	2.8E-08	2.6E-11	1.4E+10
Radium-226 +D	A	-	1.2E-10	3E-09	6E-06	1600
Radium-228 + D	A	-	1E-10	6.9E-10	2.9E-06	5.75

[a]Health Effects Summary Tables (EPA 1993). SF = Slope Factor.
[b]Group A Weight-of-Evidence; Human Carcinogen.
[c]Not determined. The carcinogenic potential of these contaminants is based on the fact that they emit ionizing radiation. EPA does not cite direct epidemiological evidence linking these radionuclides with a particular form of cancer (56 FR 33050). NOTE: Radionuclide slope factors account for the contribution of radioactive daughter products, as indicated in HEAST (EPA 1993).
[d]No external exposure hazard.

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Table 2-5. Uncertainties in the Qualitative Risk Assessment.
(refer to text for discussion of uncertainties)

Uncertainty	Human Health Evaluation	Ecological Evaluation
EXPOSURE ASSESSMENT		
Land Use	x[a]	x
Exposure parameters	x	
Exposure pathways	x	x
Soil concentrations	x	x
Analogous sites	x	x
TOTAL MAGNITUDE OF UNCERTAINTIES	High[b]	High
TOXICITY ASSESSMENT EXTRAPOLATIONS		
Animal to human	x	
Homogeneous to heterogeneous populations	x	x
High dose in studies to low doses in field	x	x
Short-term to long-term exposures	x	x
Individual to population		x
TOTAL MAGNITUDE OF UNCERTAINTIES	High	High
OTHER TOXICITY ASSESSMENTS		
Presence and amount of vegetation		x
Soil to plant uptake		x
Mouse behavioral assumptions		x
NOAEL values		x
TOTAL MAGNITUDE OF UNCERTAINTIES	High	High
RISK CHARACTERIZATION		
Exposures to multiple contaminants summed	x	x
All uncertainties summed	x	x
Selection of risk levels for screening/action		x
TOTAL MAGNITUDE OF UNCERTAINTIES	High	High

[a]"x" indicates a component of the uncertainty; the individual magnitudes not determined.
[b]Because many of the uncertainties are contaminant-specific, and because there are many subtleties to each uncertainty, only the total is presented for each category.

Table 2-6. Potential Federal Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Atomic Energy Act of 1954, as amended	42 USC 2011 et seq.	Authorizes DOE to set standards and restrictions governing facilities used for research, development, and utilization of atomic energy.	
Radiation Protection Standards	40 CFR 191	Establishes standards for management and disposal of high-level and transuranic (TRU) waste and solid fuel (SF).	
Standards for Management and Storage	40 CFR 191.03[a]	Requires that management and storage of SF, high-level, or TRU radioactive waste at all facilities for the disposal of such fuel or waste that are operated by DOE and that are not regulated by the Commission or Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 mrem to the whole body and 75 mrem to any critical organ.	Applicable to waste disposed of after November 18, 1985.
NRC Standards for Protection Against Radiation	10 CFR 20		
Radiation Dose Standards	10 CFR 20.101-20.105[b]	Sets specific radiation doses, levels, and concentrations for restricted and unrestricted areas.	May be relevant and appropriate, as radioactive materials in the 100 Areas can contribute radiation doses, levels, and concentrations that could exceed the limits; however, the Hanford Site is not a Nuclear Regulatory Commission (NRC)-licensed facility.
Safe Drinking Water Act	42 USC 300f et seq.	Creates a comprehensive national framework to ensure the quality and safety of drinking water.	
National Primary Drinking Water Regulations	40 CFR 141[b]	Establishes maximum contaminant level (MCL) and maximum contaminant level goals (MCLG) for organic, inorganic, and radioactive constituents. The MCL for combined radium-226 and -228 is 5 pCi/L. The MCL for gross alpha particle activity (including radium-226, but excluding radon and uranium) is 15 pCi/L. The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to total body or any internal organ in excess of 4 mrem/yr.	Applicable to public water systems. Potential chemicals and radionuclides of concern may migrate to the drinking water supply as a result of remedial activities. Although federal MCLGs are not enforceable standards, they are potential CAR under MTCA when more stringent than other standards. See state CAR.

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Table 2-6. Potential Federal Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Solid Waste Disposal Act, as amended by RCRA	42 USC 6901 et seq.	Establishes the basic framework for federal regulation of solid and hazardous waste.	
Groundwater Protection Standards	40 CFR 264.92 (WAC 173-303-645)[c]	A facility shall not contaminate the uppermost aquifer underlying the waste management area beyond the point of compliance, which is a vertical surface located at the hydraulically downgradient limit of the waste management area that extends down into the uppermost aquifer underlying the regulated area. The concentration of certain chemicals shall not exceed background levels, certain specified maximum concentrations, or alternate concentration limits, whichever is higher.	Groundwater concentration limits in this section do not exceed 40 CFR 141, except for chromium, which has a limit of 50 μg/L.
Uranium Mill Tailings Radiation Control Act of 1978	P.L. 95-605, as amended		
Standards for Uranium and Thorium Mill Tailings	40 CFR 192	Establishes standards for control, cleanup, and management of radioactive materials from inactive uranium processing sites.	
Land Cleanup	40 CFR 192-10 to 192.12[b]	Requires remedial actions to provide reasonable assurance that, as a result of residual radioactive materials from any designated processing site, the concentration of radium-226 in land, averaged over any area of 100 m^2, shall not exceed the background level by more than 5 pCi/g when averaged over the first 15 cm of soil below the surface, and by 15 pCi/g when averaged over 15-cm-thick layers of soil more than 15 cm below surface. In any habitable building, a reasonable effort shall be made during remediation to achieve an annual average (or equivalent) radon decay product concentration (including background) not to exceed 00.02 working levels (WL). In any case, the radon decay-produced concentration (including background) shall not exceed 0.03 WL and the level of gamma radiation shall not exceed the background level by more than 20 μR/hr.	May be relevant and appropriate, as any radium-226 encountered during remediation did not result from uranium processing.

Table 2-6. Potential Federal Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Uranium Mill Tailings Radiation Control Act of 1978 (Contd)			
Land Cleanup Standards (Contd)			
Implementation	40 CFR 192.20 to 192.23[b]	Requires that when radionuclides other than radium-226 and its decay products are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials, remedial action shall reduce other residual radioactivity to levels ALARA.	May be relevant and appropriate, as any radium-226 encountered during remediation did not result from uranium processing.

[a]Applicable.
[b]Relevant and appropriate.
[c]These are Washington State regulatory citations equivalent to 40 CFR 264 and 268 as stated in WAC 173-303.

ALARA = as low as reasonably achievable
CAR = corrective action requirements
CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
MCL = maximum contaminant level
MCLG = maximum contaminant level goals
MTCA = *Model Toxics Control Act*
NRC = Nuclear Regulatory Commission
RCRA = *Resource Conservation and Recovery Act of 1976*
SF = spent nuclear fuel
TRU = transuranic
USC = U.S. Code
WAC = *Washington Administrative Code*
WL = working level

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Table 2-7. Potential State Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Model Toxics Control Act	70.105D RCW	Requires remedial actions to attain a degree of cleanup protective of human health and the environment.	
Cleanup Regulations	WAC 173-340	Establishes cleanup levels and prescribes methods to calculate cleanup levels for soils, groundwater, surface water, and air.	
Groundwater Cleanup Standards	WAC 173-340-720[a]	Requires that where the groundwater is a potential source of drinking water, cleanup levels under Method B must be at least as stringent as concentration established under applicable state and federal laws, including the following: (A) MCLs established under the *Safe Drinking Water Act* and published in 40 CFR 141, as amended (B) MCLGs for noncarcinogens established under the *Safe Drinking Water Act* and published in 40 CFR 141, as amended (C) Secondary MCLs established under the *Safe Drinking Water Act* and published in 40 CFR 143, as amended (D) MCLs established by the state board of health and published in Chapter 248-54 WAC, as amended.	Federal MCLGs for drinking water (40 CFR 141) and federal secondary drinking water regulation standards (40 CFR 143) are potential CARs under MTCA when they are more stringent than other standards. Method B cleanup levels are levels applicable to remediation at the Hanford Site unless a demonstration can be made that Method C (alternate cleanup levels) is valid.
Soil Cleanup Standards	WAC 173-340-740[a]	MTCA Method B concentration limits in milligrams per kilogram for potential contaminants in soils, sediments, and sludges are: Aluminum 80,000 Arsenic 24 (0.6) Barium 5,600 Cadmium 40 Selenium 400 Silver 240 Acetone 8,000 Benzene 34.5	

Table 2-7. Potential State Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Model Toxics Control Act (Cont'd)	70.105D RCW		
Soil Cleanup Standards (Contd)	WAC 173-340-720[a]	Continued MTCA Method B concentration limits in milligrams per kilogram for potential contaminants in soils, sediments, and sludges are: 2-butanone 48,000 4-methyl-1-pentanone 4,000 Methylene chloride 133 Toluene 16,000 Anthracene 24,000 Benzo(a)anthracene 0.137 Benzo(b)fluoranthene 0.137 Benzo(a)pyrene (0.14) Bis(2-ethylhexyl)phthalate 1,600(71) Chrysene 0.137 Di-n-butylphthalate 8,000 Di-n-octyphthalate 1,600 Fluoranthene 3,200 Phenathrene Fluoride 4,800 Endrin 24 ( ) indicates carcinogen risk	

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Table 2-7. Potential State Chemical-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit. (3 Sheets)

Description	Citation	Requirements	Remarks
Washington Department of Health	RCW 43.70		
Radiation Protection -- Air Emissions	WAC 246-247	Establishes procedures for monitoring, control, and reporting of airborne radionuclide emissions.	
New and Modified Sources	WAC 246-247 -070[a]	Requires the use of best available radionuclide control technology.	
Radiation Protection Standards	WAC 246-221	Establishes standards for protection against radiation hazards.	
Radiation dose to individuals in restricted areas	WAC 246-221 -010[a]	Specifies dose limits to individuals in restricted areas for hands and wrists, ankles, and feet of 18.75 rem/quarter and for skin of 7.5 rem/ quarter.	

[a]Applicable.

CFR = *Code of Federal Regulations*
MCL = Maximum Contaminant Levels
MCLG = Maximum Contaminant Level Goals
MTCA = *Model Toxics Control Act*
RCW = *Revised Code of Washington*
WAC = *Washington Administrative Code*

Table 2-8. Potential Chemical-Specific To-Be-Considered Guidance for the 100-HR-2 Operable Unit. (2 Sheets)

Description	Citation	Requirements	Remarks
Model Toxics Control Act	70.105D RCW		
Cleanup Regulations	WAC 173-340	Ecology is adapting the calculations in MTCA to be applicable to radioactive contaminants. These cleanup standards may become available prior to or during remediation.	
Solid Waste Disposal Act, as amended by RCRA	42 USC 6901 et seq.		
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR 257.3-4	A facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary.	The courts or the state may establish alternate boundaries.
Corrective Action for Solid Waste Management Units	40 CFR 264 Subpart S, proposed	Establishes requirements for investigation and corrective action for release of hazardous waste from solid waste management units.	
U.S. Department of Energy Orders	DOE 5400.5		
Radiation Protection of the Public and the Environment	DOE 5400.5, Chapter II, Section 1a	Establishes radiation protection standards for the public and environment.	
Radiation Dose Limit (All Pathways)		Exposure of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent >100 mrem from all exposure pathways, except under specified circumstances.	Pertinent if remedial activities are "routine DOE activities."

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Table 2-8. Potential Chemical-Specific To-Be-Considered Guidance for the 100-HR-2 Operable Unit. (2 Sheets)

Description	Citation	Requirements	Remarks
U.S. Department of Energy Orders (Contd)			
Radiation Dose Limit (Drinking Water Pathway)	DOE 5400.5, Chapter II, Section 1d	Provides a level of protection for persons consuming water from a public drinking water supply operated by DOE so that persons consuming water from the supply shall not receive an effective dose equivalent to >4 mrem/yr. Combined radium-226 and radium-228 shall not exceed 5×10^{-9} μCi/mL, and gross alpha activity (including radium-226 but excluding radon and uranium) shall not exceed 1.5×10^{-8} μCi/mL.	Pertinent if radionuclides may be released during remediation.
Residual Radionuclides in Soil	DOE 5400.5 Chapter IV, Section 4a	Generic guidelines for radium-226 and radium-228 are: 1. 5 pCi/g averaged over the first 15 cm of soil below the surface. 2. 15 pCi/g averaged over 15-cm-thick layers of soil more than 15 cm below the surface. Guidelines for residual concentrations of other radionuclides must be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these deviations are given in *A Manual for Implementing Residual Radioactive Material Guidelines* (DOE/CH-8901). Procedures for determination of hot spots, hot-spot cleanup limits, and residual concentration guidelines for mixtures are in DOE/CH-8901. Residual radioactive materials above the guidelines must be controlled to the required levels in DOE Order 5400.5, Chapters II and IV.	Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged an area of 100 m^2.

CFR = *Code of Federal Regulations*
DOE = U.S. Department of Energy
MTCA = *Model Toxics Control Act*
RCW = *Revised Code of Washington*
USC = U.S. Code
WAC = *Washington Administrative Code*

Table 2-9. Potential Federal Location-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit.

Description	Citation	Requirements	Remarks
Archaeological and Historical Preservation Act of 1974	16 USC 469[a]	Requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts.	
Endangered Species Act of 1973	16 USC 1531 et seq.	Prohibits federal agencies from jeopardizing threatened or endangered species or adversely modifying habitats essential to their survival.	
Fish and Wildlife Services List of Endangered and Threatened Wildlife and Plants	50 CFR Parts 17, 222, 225, 226, 227, 402, 424[a]	Requires identification of activities that may affect listed species. Actions must not threaten the continued existence of a listed species or destroy critical habitat.	Requires consultation with the Fish and Wildlife Service to determine if threatened or endangered species could be impacted by activity.
Historic Sites, Buildings, and Antiquities Act	16 USC 461[a]	Establishes requirements for preservation of historic sites, buildings, or objects of national significance. Undesirable impacts to such resources must be mitigated.	
National Historic Preservation Act of 1966, as amended	16 USC 40 et seq[a]	Prohibits impacts on cultural resources. Where impacts are unavoidable, requires impact mitigation through design and data recovery.	Applicable to properties listed in the National Register of Historic Places, or eligible for such listing. B Reactor is listed on the Register.
Wild and Scenic Rivers Act	16 USC 1271[a]	Prohibits federal agencies from recommending authorization of any water resource project that would have a direct and adverse effect on the values for which a river was designated as a wild and scenic river or included as a study area.	The Hanford Reach of the Columbia River is under study for inclusion as a wild and scenic river.
American Indian Religious Freedom Act	42 USC 1996 and DOE 1987	Federal land managers are directed to act in such a way as to protect and preserve the access of Native American people to sacred lands and their rights to worship in their traditional manner.	An agency undertaking a land use project will be in compliance with the AIRFA if, in the decision making process, it obtains and considers the views of Indian leaders (Chatters 1989).

[a]Applicable.
CFR = *Code of Federal Regulations*
USC = U.S. Code

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Table 2-10. Potential State Location-Specific Corrective Action Requirements for the 100-HR-2 Operable Unit.

Description	Citation	Requirements	Remarks
Habitat Buffer Zone for Balk Eagle Rules	RCW 77.12.655		
Bale Eagle Protection Rules	WAC 232.12-292[a]	Prescribes action to protect bald eagle habitat, such as nesting or roost sites, through the development of a site management plan.	Applicable if the areas of remedial activities includes bald eagle habitat.
Regulating the Taking or Possessing of Game	RCW 77.12.040		
Endangered, Threatened, or Sensitive Wildlife Species Classification	WAC 232-12-297[a]	Prescribes action to protect wildlife classified as endangered, threatened, or sensitive, through development of a site management plan.	Applicable if wildlife classified as endangered, threatened, or sensitive are present in areas impacted by remedial activities.

[a]Applicable.

RCW = *Revised Code of Washington*
WAC = *Washington Administrative Code*

Table 2-11. Potential Location-Specific To-Be-Considered Guidance for the 100-HR-2 Operable Unit.

Description	Citation	Requirements	Remarks
Floodplains/Wetlands Environmental Review	10 CFR 1022	Requires federal agencies to avoid, to the extent possible, adverse effects associated with the development of a floodplain or the destruction or loss of wetlands.	Pertinent if remedial activities take place in a floodplain or wetlands.
Protection and Enhancement of the Cultural Environment	EO 11593	Provides direction to federal agencies to preserve, restore, and maintain cultural resources.	Pertains to sites, structures, and objects of historical, archaeological, or architectural significance.
Hanford Reach Study Act	PL 100-605	Provides for a comprehensive river conservation study. Prohibits the construction of any dam, channel, or navigation project by a federal agency for 8 yr after enactment. New federal and nonfederal projects and activities are required, to the extent practicable, to minimize direct and adverse effects on the values for which the river is under study and to utilize existing structures.	This law was enacted November 4, 1988.

EO = Executive Order
PL = Public Law

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3.0 SITE EVALUATION

This chapter presents results from the investigative phase at the 100-HR-2 operable unit. Although no intrusive investigations were conducted, the following information is presented, when available, in the discussion of the solid waste burial grounds and low priority sites:

- Site location, size, characteristics, history, and expected contaminants
- Results of historical sampling
- Information regarding radionuclide inventories derived from process knowledge
- Results of nonintrusive investigations
- Results of analogous site sampling
- Results obtained from the 100-HR-3 Operable Unit LFI that are applicable to potential groundwater impacts in the 100-HR-2 Operable Unit
- Human health and ecological risk evaluations.

3.1 118-H-1 SOLID WASTE BURIAL GROUND

3.1.1 Site Description

The 118-H-1 burial ground is an inactive, solid mixed waste, burial site. It was the first and is the largest burial ground in 100-H Area. The site is located approximately 1,300 ft southwest of the 105-H Reactor building. It measures 700 by 350 by 20 ft deep, and is oriented in an east-west direction. The boundaries are permanently marked with concrete posts and underground radioactive material warning signs. The Hanford Site coordinates of the corner posts, starting with the northwest and continuing clockwise, are: N94185 W40650, N94175 W39954, N93835 W39956 and N93835 W40680.

The burial ground was opened in 1949, enlarged in 1955, and remained active until 1965. It is recognized as having been the primary burial ground to receive all routine reactor operations waste. The waste included activated components such as process tubing, dummy fuel elements, vertical safety rods, horizontal control rods, gun barrels, pigtails, nozzles, thimbles, etc.; surface contaminated materials and equipment such as broken hand tools, rags, sweeping compound used in decontamination work, sheets of plastic and paper used to keep floors and equipment free of contamination, air filters, equipment from the cooling water system, and contaminated dirt removed from near effluent lines; nonradioactive solid waste such as paper, trash, plastic, metal parts, and sludges from the water treatment process; and contaminated decommissioning and demolition waste such as wood, concrete, metal piping, asbestos, and chemicals.

All trenches and pits were backfilled to original grade, which reportedly ranged from 2 to 6 ft of soil cover (Herman 1965). Approximately 4 ft of soil has since been added and stabilized with gravel to prevent wind erosion. The burial ground appears today as a cobble-covered field mounded

approximately 3 ft above grade at the center, tapering to 1 ft above grade at its borders. A frequently used road crosses the center of the burial ground from north to south.

3.1.2 Process Knowledge Information

Estimates of Solid Waste Buried in the 100 Area Burial Grounds (Miller and Wahlen 1987) provides a breakdown of materials included in the 118-H-1 burial ground, the tonnage of waste disposed of, and the radiological content of the components. The radionuclide inventory for the burial ground in Table 3-1 is presented in curies, and calculated to account for decay through June 1, 1987, 1994, and 2018. Results from Miller and Wahlen (1987) identify the primary radionuclides as cobalt-60 and nickel-63, other radionuclides present are europium-152, europium-154, cesium-137, strontium-90, tritium, carbon-14, nickel-59, barium-133, calcium-41, and silver-108m. Estimates of metallic and other waste are presented in Table 3-2.

3.1.3 Nonintrusive Investigation Data

GPR and EMI surveys were conducted as part of the characterization of the burial ground. General results from this survey indicate that the thickness of overlying fill within the burial ground ranges from 2 to 14 ft. Nineteen zones representing trenches or pits were interpreted as containing a relatively high volume of buried waste. The results also indicate that the burial ground may extend beyond the northeast corner of the posts delineating the burial ground. The specifics on the results of the GPR and EMI surveys are provided by Bergstrom (1994a).

3.1.4 Analogous Sites

Sites in the 100 Areas considered analogous to the 118-H-1 burial ground are the 118-F-1, 118-K-1, 118-D-1, 118-D-2, 118-D-3, 118-B-1, and 118-C-1 burial grounds. These sites were the primary solid waste burial grounds in the respective reactor areas. No soil sampling was conducted at 118-H-1. However, Dorian and Richards (1978) sampled the 118-B-1 burial ground in 1976. The 100-BC-2 LFI (DOE-RL 1994b) presents the sampling data and the associated human health and ecological evaluations. Sampling revealed the presence of cobalt-60, europium-152, europium-154, cesium-137, strontium-90, nickel-63, europium-155, and plutonium-239/240. Table 3-3 presents a summary of the data reported in historical sampling at the 118-B-1 burial ground.

3.1.5 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 Operable Unit groundwater from December 1992 through April 1993 sampling rounds. No monitoring well is located close enough to 118-H-1 to be considered an upgradient well. The closest upgradient well is in the 600 Area, over 6,560 ft from the 118-H-1 burial ground. Monitoring well 199-H5-1A is located downgradient to this site. The maximum detection of nitrate was 8.4 mg/L and the maximum concentration of chromium was 127 mg/L. No strontium-90 or technetium-99 was detected in well 199-H5-1A. Historical information does not indicate that nitrate or chromium were disposed of at this site. Upgradient values were not available; therefore, impact to groundwater from the 118-H-1 burial ground could not be determined.

3.1.6 118-H-1 LFI Summary

Process knowledge information and analogous site sampling indicate the following radionuclides may be associated with this burial ground: cobalt-60, europium-152, europium-154, cesium-137, strontium-90, nickel-63, nickel-59, europium-155, plutonium-239/240, tritium, carbon-14, barium-133, calcium-41, and silver-108m. Process knowledge does not indicate that organics, inorganics, pesticides, and PCBs are associated with this site. It cannot be determined at this time if the 118-H-1 burial ground is currently impacting groundwater.

3.1.7 Risk Evaluation

Human health risks estimated for the frequent- and occasional-use scenarios at 118-H-1 burial ground are taken from the QRA for the analogous burial ground 118-B-1 (see DOE-RL 1994b). Because this is an analogous comparison, only the results are included in this QRA.

The QRA results for analogous burial ground 118-B-1 are as follows:

- No COPC are found to have an ICR >1E-06 in the ingestion or inhalation exposure pathways for the frequent-use scenario. The ICR for cesium-137, europium-152, and europium-154 represent a low priority for remediation (ICR between 1E-06 and 1E-04); the ICR for cobalt-60 represents a medium priority for remediation (ICR between 1E-02 and 1E-04) from the external exposure pathway in the frequent-use scenario. In the occasional-use scenario, the ICR for cobalt-60 represents a low priority for remediation (ICR between 1E-06 and 1E-04) from the external exposure pathway. External radiation exposure is the primary pathway contributing to ICR. Cobalt-60 is considered to be the greatest contributor to ICR in both the frequent- and occasional-use scenarios.

- The total ICR anticipated, if the onset of the frequent-use scenario exposures is delayed until the year 2018, represents a low priority for remediation (ICR of 4E-05) for the frequent-use scenario and very low priority for remediation (IRC of 3E-07) for the occasional-use scenario. The primary pathway contributing to ICR in the year 2018 would remain the external radiation pathway.

- The total dose to the Great Basin pocket mouse from radionuclides does not exceed the EHQ (1 rad/day).

While no concentration data are available through process knowledge for any of these solid waste burial grounds, Table 3-4 presents risk-based concentrations that would result in a medium priority for remediation (ICR of 1E-04) for radionuclides with an external exposure hazard. Ingestion and inhalation concentrations are not reported because of the nature of solid waste. The large majority of the solid waste and radionuclide inventory is irradiated reactor parts and therefore will not migrate. Other buried material, such as rags, paper, demolition waste, and filters, may have surface contamination. However, the nature of the site hydrology (little, if any, natural recharge from precipitation) and low potential for intrusion by biota (because of lack of soil for plant growth and because of the depth of burial) diminish the potential for radionuclide ingestion or inhalation.

3.2 118-H-2 BURIAL GROUND

3.2.1 Site Description

The 118-H-2 burial ground is an inactive, solid, mixed waste burial site located roughly 1,500 ft west of the 105-H Reactor building. It measured approximately 140 by 50 by 15 ft deep when originally excavated. It is oriented in an east-west direction. The boundaries are permanently marked with concrete posts and underground radioactive material warning signs. The Hanford Site coordinates of the corner posts, starting with the northwest and continuing clockwise, are: N95318 W41130, N95314 W40983, N95268 W40985, and N95267 W41128.

The site operated from 1955 to 1965 to receive activated and contaminated hardware associated with an experimental reactor test facility, reportedly on behalf of the U.S. Navy. It consists of two in-line concrete vaults. In 1955, the east vault received an irradiated test loop, or "stainless steel double tube" from the reactor after several years of irradiation. Within this area there are also reported to be solutions that were used to clean the tubes and miscellaneous capsule components (Herman 1965). The west vault was constructed in 1958 and intended for a similar purpose, however, it was not utilized in that program. It was used during the deactivation of H Plant for disposal of a small amount of contaminated pipe.

Both vaults were filled with gravel and backfilled to grade (Herman 1965). An additional 2 ft of gravel was also added on top of the entire site. The site appears today as a cobble-covered field, mounded 2 to 3 ft above grade at the center.

3.2.2 Process Knowledge Information

Miller and Wahlen (1987) report that 0.3 ton of waste are buried in the 118-H-2 burial ground. The waste constituents are not known.

3.2.3 Nonintrusive Investigations

GPR and EMI surveys were conducted as part of the characterization of the 118-H-2 burial ground. General results from this survey indicate that the thickness of overlying fill within the burial ground is approximately 3 ft. The data also indicate that each vault is approximately 10 ft wide and 40 ft long. There were several isolated anomalies detected within the survey area, but no major concentrations of debris were identified except possibly near the eastern and western ends of the burial ground. The specifics on the results of the GPR and EMI surveys are provided by Bergstrom (1994b).

3.2.4 Analogous Sites

The 118-H-2 burial ground has no known analogous sites in the 100 Areas.

3.2.5 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. No monitoring well is located close enough to 118-H-2 to be considered an upgradient well. The closest well upgradient well is in the 600 Area, over 6,560 ft from the 118-H-2 burial ground. Monitoring wells 199-H3-2 and 199-H4-48, both over 656 ft away, are the closest downgradient wells to this site. In well 199-H3-2, the maximum detection of chromium was 50 mg/L, technetium-99 was 0.52 mg/L, and nitrate was 25 mg/L. Strontium-90 was not detected in this well. In well 199-H4-48, the maximum detection of nitrate was 1.5 mg/L and the maximum concentration of chromium was 39.4 mg/L. No strontium-90 or technetium-99 were detected in well 199-H4-48. The elevated levels of nitrate and chromium could be attributed to several waste sites (Table 3-5). Currently, it is not possible to assess the origin of the nitrate and chromium. Historical information does not indicate nitrate or chromium was disposed of at this site. Upgradient values were not available; therefore, the impact to groundwater from the 118-H-2 burial ground could not be determined.

3.2.6 LFI Summary

Historical sampling has not been conducted for the 118-H-2 burial ground, analogous site information is not available, and process knowledge does not supply sufficient information to determine a contaminant inventory. Historical information does not indicate that inorganics, pesticides, or PCBs are associated with this site. It cannot be determined at this time if the 118-H-2 burial ground is impacting groundwater.

3.2.7 Risk Evaluation

This burial ground received concrete, pipes, hardware, and other reactor components. The radionuclides and levels present are unknown. (GPR surveys indicate that there are about 3 ft of fill above material in the trench, and the material buried is not evenly distributed.) The burial grounds are surveyed periodically for radiation levels above background; those with surface readings are posted as surface contaminant areas. The 118-H-2 burial ground is posted only as an underground radioactive material area, and does not pose an external exposure concern.

Because of the lack of knowledge, no risk is computed for this site. An assumption, however, is that under the frequent-use scenario, if someone were to excavate the burial ground for building a home, he or she might receive a dose if the reactor pieces were exposed. However, there are no data to evaluate the risks associated with this dose. No further assumptions can be made for the occasional-use scenarios regarding risk based on process knowledge information.

The ecological risk at this site is not known; however, herbicides are applied routinely and limited habitat and food source would be available for wildlife. Nor further evaluation can be completed because of the lack of soil contaminant data.

No data are available to quantify human health or ecological risks; thus the results are highly uncertain, but the presence of several feet of fill serves to reduce the actual dose for nonintrusive scenarios (even allowing for some animal and vegetation intrusion).

3.3 118-H-3 BURIAL GROUND

3.3.1 Site Description

The 118-H-3 burial ground is an inactive, solid mixed waste burial site located approximately 800 ft southeast of the 105-H Reactor building. Its shape is an uneven polygon with side lengths of 100 ft by 375 ft by 313 ft by 400 ft. It is roughly 20 ft deep and oriented in a northeast-southwest direction. The boundaries are permanently marked with concrete posts and underground radioactive material warning signs. The Hanford Site coordinates of the corner posts, starting with the northwest and continuing clockwise, are: N94539 W39482, N94437 W39200, N94130 W39413 and N94196 W39585.

The burial ground was active from 1953 to 1957 to receive reactor components and hardware from modification programs, including lengths of contaminated 16-in. pipe used as chutes for the removal of vertical safety rod thimbles. Historical documents report two trenches at this site that were backfilled to grade with approximately 6 ft of soil (Herman 1965). An aerial photo, however, suggests there were at least three separately fenced trenches during operational years (#9621, date unknown). All the trenches are now included in the area within the permanent concrete markers.

3.3.2 Nonintrusive Investigation

GPR and EMI surveys were conducted as part of the characterization of the 118-H-3 burial ground. General results from this survey indicate that the thickness of overlying fill within the burial ground is approximately 1 to 10 ft. Debris was located at depths of 1 to approximately 18 ft. Boundaries of three pits/trenches were clearly delineated. A fourth trench-like anomaly was identified, but does not appear to contain much, if any, metallic debris. The specifics on the results of the GPR and EMI surveys are provided by Bergstrom (1994c).

3.3.3 Analogous Sites

Several sites in the 100 Areas are considered analogous to the 118-H-3 burial ground. These are the 118-B-2, 118-B-3, 118-D-4, and 118-F-2 burial grounds. Radionuclide, inorganic, organic, pesticide, and PCB sampling have not been conducted at any of these sites.

3.3.4 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. Monitoring well 199-H5-1A is upgradient to the 118-H-3 burial ground. Monitoring well 199-H4-46 is the downgradient well to 118-H-3. Groundwater samples from this well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient well. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to 199-H5-1A (upgradient to this site). The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Currently, it is not possible to assess the origin of the strontium-90 or the technetium-99. Therefore, it cannot be determined if the 118-H-3 burial ground is impacting groundwater.

3.3.5 LFI Summary

Historical sampling has not been conducted for the 118-H-3 burial ground, analogous site information is not available, and process knowledge does not supply sufficient information to provide an accurate contaminant inventory. Historical information does not indicate that organics, inorganics, pesticides, or PCBs are associated with this site. It cannot be determined at this time if the 118-H-3 burial ground is impacting groundwater.

3.3.6 Risk Evaluation

This burial ground received concrete, pipes, hardware and other reactor components. The radionuclides and levels present are unknown. GPR surveys indicate that there is about 1 to 10 ft of fill above material in the trench, and the material buried is not evenly distributed. The burial grounds are surveyed periodically for radiation levels above background; those with surface readings are posted as surface contamination areas. The 118-H-3 burial ground is posted only as an underground radioactive material area, and does not pose an external exposure hazard.

Because of the lack of knowledge, no risk is computed for this site. An assumption, however, is that under the frequent use scenario, if someone were to excavate the burial ground for building a home, he or she might receive a dose if the reactor pieces were exposed. However, there are no data to evaluate the risk associated with this dose. No further assumptions can be made based on process knowledge information for the occasional use scenario.

The ecological risk at this site is not known; however, herbicides are applied routinely and limited habitat and food source would be available for wildlife. Nor further evaluation can be completed because of the lack of soil contaminant data.

Human health and ecological risks are highly uncertain because no data are available, thus the results are highly uncertain. However, the presence of several feet of fill serves to reduce the actual dose or nonintrusive scenarios (even allowing for some animal and vegetation intrusion).

3.4 118-H-4 BURIAL GROUND

3.4.1 Site Description

The 118-H-4 burial ground is an inactive, solid mixed waste burial site. It is located about 100 ft west of the 105-H Reactor building, within and adjacent to the 105-H exclusion area fence. The site consists of one trench running north-south, which measured 150 by 30 by 10 ft deep before it was backfilled. Concrete monuments marks the north and south end of the site.

The burial site was dug in 1953 and was intended to be used as a "one-time" burial pit. It contains irradiated gear related to the Ball 3X Project such as vertical safety rod thimbles and guides removed from the 105-H Reactor building during the project. No 3X balls are buried at this site as its alias name (Ball 3X burial ground) implies. The name originated from the project upgrading the 3X safety system, not from its contents.

The trench has been covered to grade with 5 ft of soil and appears today as a gravel- and cobble-covered area with limited grass and sage growth on the surface. Railroad ties and rails have been placed on the surface running parallel to the north-south axis of the burial ground.

3.4.2 Process Knowledge Information

Miller and Wahlen (1987) included all vertical safety rod thimbles in the miscellaneous waste inventory for the 118-H-1 burial ground along with gun barrels, horizontal control rods, vertical safety rods, nozzle assemblies, and contaminated tools. The primary radionuclides associated with the miscellaneous waste are cobalt-60, nickel-63, and nickel-59. Miller and Wahlen (1987) estimated 5,490 lb of waste resulted from removal of the thimbles and the boron solution system. It is unknown how many thimbles were buried at this site.

Data for other irradiated materials that may have been buried at this site, such as the guides from the 105-H Reactor building, are not available.

3.4.3 Analogous Sites

The sites in the 100 Areas that are considered analogous to the 118-H-4 burial ground are the 118-F-3, 118-D-5, and 118-B-5 burial grounds. Radionuclide, inorganic, organic, pesticide, and PCB sampling has not been conducted at these sites.

3.4.4 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. No monitoring well is located close enough to the 118-H-4 burial ground to be considered an upgradient well. The closest upgradient well is in the 600 Area, over 6,560 ft from the 118-H-4 burial ground. Monitoring well 199-H4-49 is downgradient to this site. In well 199-H4-49, the maximum detections of chromium was 87.9 mg/L and nitrate was 4.5 mg/L. Strontium-90 and technetium-99 were not detected. The elevated levels of nitrate and chromium could be attributed to several waste sites (Table 3-5). Contaminants thought to be associated with the burial ground, such a cobalt-60, were not detected in the downgradient monitoring well. There are no values from upgradient wells; therefore, it cannot be determined if the 118-H-4 burial ground is impacting groundwater.

3.4.5 LFI Summary

Historical and nonintrusive sampling have not been conducted at the 118-H-4 burial ground and no analogous sites have been sampled. Process knowledge information reported in Miller and Wahlen (1987) indicated cobalt-60, nickel-63, and nickel-59 may be associated with this waste site. Historical information does not indicate that organics, inorganics, pesticides, or PCBs are associated with this site. There are no values from upgradient wells, therefore, it cannot be determined if the 118-H-4 burial ground is impacting groundwater.

3.4.6 Risk Evaluation

The 118-H-4 burial ground contains thimbles and guides replaced during the Ball 3X program. The only data available are process knowledge estimates of total curies. Consequently, no risk calculations have been done. A safe assumption, however, is that under the frequent-use scenario, if someone were to excavate the burial ground for building a home, he or she would receive an external dose from nickel-59 and cobalt-60 if the reactor pieces were exposed. No further assumptions based on process knowledge information can be made for the occasional use scenario. The burial grounds are surveyed periodically for radiation levels above background; those with surface readings are posted as surface contamination areas. The 118-H-3 burial ground is posted only as an underground radioactive material area, and does not pose an external exposure hazard.

The ecological risk at this site is not known; however, herbicides are applied routinely and limited habitat and food sources would be available for wildlife. No further evaluation can be completed because of the lack of soil contaminant data.

Human health and ecological risks are highly uncertain because no data are available.

3.5 118-H-5 BURIAL GROUND

3.5.1 Site Description

The 118-H-5 burial ground is an inactive, solid, mixed waste site located about 200 ft south of the 105-H Reactor Building within the 105-H Exclusion Area fence. The site consists of a single trench approximately 30 by 2 by 5 ft deep. It is oriented in a north-south direction with concrete monuments at both ends of the trench. The site appears today as a vegetation-free, gravel- and cobble-covered area.

The site was dug in 1953, as a one-time burial pit, for the burial of a thimble assembly used in the "B Hole of the 105-H X Level." In 1960, however, the 116-H-4 pluto crib was excavated to allow for the construction of the 117-H Reactor air filter facility and the crib and associated soil column were buried at this site (reportedly at the north end). The 116-H-4 pluto crib measured 4 ft by 2 ft deep and was covered with 10 ft of soil after operation. The crib received cooling water from a single process tube for short periods until the failed fuel element was discharged from the tube.

3.5.2 Process Knowledge Information

Miller and Wahlen (1987) included all vertical safety rod thimbles in the miscellaneous waste inventory for the 118-H-1 burial ground along with gun barrels, horizontal control rods, vertical safety rods, nozzle assemblies and contaminated tools. The primary radionuclides associated with the miscellaneous waste are cobalt-60, nickel-63, and nickel-59.

Process knowledge information is not available for the 116-H-4 Pluto Crib.

3.5.3 Analogous Sites

There are no sites in the 100 Areas that are considered analogous to the 118-H-5 burial ground. However, the 116-F-4, 116-DR-2A, and 116-B-3 are considered analogous to the 116-H-4 pluto crib (soil from the 116-H-4 pluto crib is buried in this burial ground). The 116-C-2A pluto crib is potentially analogous because it handled a similar waste stream; however, it was preceded by a sand filter.

Sampling has been conducted at an LFI borehole at the 116-F-4, 116-B-3, and 116-D-2A pluto cribs for the full suite of CERCLA target compound list (TCL) and target analyte list, specific anions, and radionuclides. Sampling was also conducted at a single borehole at 116-C-2A for radionuclides and inorganics.

Inorganic compounds were detected above the Hanford Site background 95% UTL in two of the three analogous sites (Appendix A, Table A-4). Barium was detected in 116-F-4. Cadmium and silver were detected in 116-B-3.

VOCs were detected in 116-F-4, 116-D-2A, and 116-B-3 (Appendix A, Table A-4). The 116-F-4 crib showed detectable levels of 2-butanone, acetone, methylene chloride, and toluene. The 116-B-3 crib showed elevated levels of 2-butanone, 4-methyl-2-pentanone, acetone, and benzene. The 116-D-2A crib showed elevated levels of methylene chloride and toluene.

Semivolatile organic compounds (SVOC) were detected in two of the analogous sites (Appendix A, Table A-4). The 116-F-4 crib showed elevated levels of bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and di-n-octylphthalate. The 116-B-3 crib showed elevated levels of anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene and phenanthrene.

The pesticide, endrin, was detected in the 116-D-2A crib (Appendix A, Table A-4).

Radionuclides were detected in all of the analogous sites (Appendix A, Table A-4). The 116-F-4 crib showed elevated activities of potassium-40, strontium-90, cesium-137, europium-152, thorium-232, uranium-238, plutonium-239/240, and americium-241. The 116-B-3 crib showed elevated activities of carbon-14, strontium-90 and cesium-137. The 116-D-2A crib showed elevated activities of potassium-40, strontium-90, cesium-137, europium-152, europium-154, radium-226 and plutonium-239/240.

The 100 Area Excavation Treatability Test Report (DOE-RL 1994a) was also conducted at the 116-F-4 pluto crib. This study provides more characterization detail than a single borehole. Multiple locations were sampled at 2-ft intervals (vertical) throughout the entire excavation of the 116-F-4 pluto crib. The data are presented in Appendix A, Tables A-5 through A-8. Maximum concentrations are presented in Tables 3-6a and 3-6b. The separations of maximum concentrations of constituents at different depths is not relevant for the 116-H-4 pluto crib because soils may have been mixed during its excavation and burial process.

Inorganics were not detected above the Hanford Site background 95% UTL (Table 3-6b).

The VOCs detected were acetone, methylene chloride, toluene, and 4-methyl-2-pentanone (Table 3-6b).

SVOCs, bis(2-ethylhexyl)phthalate, and di-n-butylphthalate were detected (Table 3-6b).

Fluoride was detected above the 95% UTL (Table 3-6b).

Radionuclides detected above 1 pCi/g were: cobalt-60, potassium-40, strontium-90, cesium-137, europium-152, thorium-232, uranium-238, americium-241, europium-154, radium-226, radium-228, thorium-228, technetium-99, uranium 233/234, plutonium 238, and plutonium-239/240 (Table 3-6a).

3.5.4 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. Monitoring wells 199-H4-49 and 199-H3-1 are upgradient of the 118-H-5 burial ground. Monitoring well 199-H4-46 is the downgradient well to this site. Groundwater samples from this well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient wells. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient wells. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites in the 100-HR-1 and 100-HR-2 Operable Units, including a number of liquid waste disposal sites (Table 3-5). Currently, it is not possible to assess the origin of the strontium-90 or the technetium-99. Therefore, it cannot be determined if the 118-H-5 burial ground is impacting groundwater.

3.5.5 LFI Summary

Historical and nonintrusive sampling have not been conducted at the 118-H-5 burial ground. Sampling conducted at sites considered analogous to the 116-H-4 pluto crib and process knowledge information for the 118-H-5 indicate the radionuclides that may be associated with this waste site are: cobalt-60, nickel-63, and nickel-59, potassium-40, strontium-90, cesium-137, europium-152, thorium-232, uranium-238, americium-241, europium-154, radium-226, radium-228, thorium-228, technetium-99, uranium 233/234, plutonium 238, and plutonium-239/240, carbon-14.

Sampling conducted at sites considered analogous to the 116-H-4 pluto crib indicates the organics that may be associated with this waste site are: acetone, methylene chloride, toluene, 4-methyl-2-pentanone, 2-butanone, and benzene, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, di-n-octylphthalate, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, and phenanthrene. The process knowledge did not suggest disposal of any organic compounds to the 116-H-4 pluto crib system.

Sampling conducted at sites considered analogous to the 116-H-4 pluto crib indicates endrin, a pesticide, may be associated with this site. Process knowledge did not suggest that any pesticides were disposed of at the 116-H-4 pluto crib system. Barium, cadmium, and silver were detected above the 95% UTL in sampling conducted at analogous sites and may be associated with this site. The anion, fluoride, was detected above the 95% UTL. It cannot be determined at this time if the 118-H-5 burial ground is currently impacting groundwater.

3.5.6 Risk Evaluation

The human health evaluation is based on treatability test data from the analogous

116-F-4 pluto crib, collected in 1993, using the maximum soil concentrations detected. These maximum concentrations have been assumed to be anywhere in the top 15 ft of the burial ground, because the 116-H-4 pluto crib was dug from its previous location and reburied in 118-H-5. This burial ground also received 90 lb of reactor pieces (an experimental thimble assembly), as well as the 116-H-4 pluto crib, which was excavated in 1960 and moved to 118-H-5.

In other cases when analogous sites have been compared, the analogous risk assessment has been used, rather than a recomputation of analogous data. However, in the case of the analogous 116-F-4 pluto crib and its treatability test, the QRA has been done on the clean soil returned to the crib, not on the contaminated soil removed. Sampling data from the removed contaminated soil are probably more appropriate to the conditions at 118-H-5 burial ground, which received the contaminated soil from the 116-H-4 pluto crib.

Data usability screening includes comparing contaminant concentrations to analytical results for blanks according to the 5 or 10 times rule (EPA 1989a) and comparison to Hanford Site background. All radionuclide results were significantly above 5 times the reported analytical results in the silica blanks, so all were retained through this point. Anions reported (Cl, F, PO_4, SO_4, NO_2, NO_3) were all, except F, below reported background (DOE-RL 1993d). No radionuclide or organic background levels have been established. Consequently, all radionuclides, organics, and fluoride were carried to the next stage of screening. Fluoride, however, has been screened out because the levels reported are far below MTCA Method B concentrations (12,000 ppm).

Sections 2.1.4 and C.2.1 of the HSBRAM (DOE-RL 1993b) describe the process for further identifying contaminants of concern for each high-priority waste site by also using a preliminary risk-based screening. This screening uses residential scenario exposure parameters at a lifetime ICR of 1E-07. Preliminary risk-based screening is used to identify potential risk-driving contaminants and to save time and resources in the risk assessment. Tables 3-6a and 3-6b show the contaminant screening for 118-H-5.

While some of the contaminants reported at some of these other cribs are higher than those for 116-F-4 (e.g., for carbon-14 and nickel-63), including these results would not alter the results of this QRA.

Risks estimated for 1994 under the frequent- and occasional-use scenarios at the 118-H-5 burial ground are summarized in Table 3-7. It should be kept in mind that there is a high degree of uncertainty with the classifications of risk because of the use of analogous data and the qualitative nature of the assessment.

All contaminants have an estimated qualitative ICR $>1.0E-7$ in the frequent-use scenario, with the maximum estimated qualitative risk at 3.9E-01 from cesium-137 as an external exposure. Most of the estimated risk is from external exposure. The total estimated lifetime ICR to humans is classified "high" in the frequent-use scenario.

For the occasional-use scenario, the highest estimated qualitative risk is also from cesium-137, at 2.5E-03, again from external exposure. The total estimated lifetime ICR to humans is classified "medium" in the occasional-use scenario.

Risks estimated for the year 2018 for the frequent- and occasional-use scenarios at the 118-H-5 burial ground are summarized in Table 3-8.

For the year 2018, all COPC, except technetium-99, have an estimated ICR >1.0E-7 in the frequent-use scenario, with the maximum estimated qualitative risk at 2.2E-01 from cesium-137 as an external exposure. Most of the estimated risk is from external exposure. The total estimated lifetime ICR to humans is classified "high" in the frequent-use scenario.

For the occasional-use scenario, the highest estimated qualitative risk is also from cesium-137, at 1.4E-03, again from external exposure. The total estimated lifetime ICR to humans is classified "medium" in the occasional-use scenario.

The total calculated dose rates to the Great Basin pocket mouse from radionuclides within the 118-H-5 burial ground are listed in Table 3-9a. The total calculated dose exceeds the EHQ of 1 rad/day and is due almost entirely to strontium-90. Calculated doses of organic constituents are provided in Table 3-9b. None of the detected concentrations of organic contaminants exceeded the EHQ of 1.0. For fluoride, there are no wildlife toxicity values, but Suter et al. (1993) suggest a terrestrial plan toxicology benchmark of 200 ppm.

Uncertainty is introduced to the analysis by the use of the analogous site data from the 116-F-4 pluto crib. Therefore, the calculated risks could be over- or underestimates of the true risk associated with this specific site.

3.6 BURIED THIMBLE SITE

3.6.1 Site Description

The buried thimble site is an inactive, mixed solid waste site. It is located approximately 70 yd south of the 105-H Reactor Building's southern exclusion area fence, due west of the 118-H-3 burial ground. It is between approximate Hanford Site coordinates N94500 W39700 and N94400 W39700. It lays in the southern wedge of an area bounded by the convergence of two railroad tracks. This area is known as the 116-H-2 crib (or 1608-H crib) overflow area. Only one concrete monument marks the site; therefore, the orientation of the burial trench is unknown.

The date the site was excavated is unknown. It is suspected to contain a thimble assembly and could be up to 40 ft long. The crib overflow area has been covered with approximately 6 ft of clean soil. Today the site appears as a flat, gravel- and cobble-covered area. A light-weight chain forms a 5- by 5-ft radioactive surface contamination barricade around the concrete monument.

3.6.2 Historical Sampling

Dorian and Richards (1978) sampled the area around the 116-H-2 overflow area. Two of the sample locations are in the vicinity of the buried thimble site (Figure 3-5). Sampling was completed in December 1976. Samples at the southern location were taken at 1, 5, and 10 ft. The sample to the west of the site was taken at 10 ft. The sampling revealed the presence of cobalt-60, tritium, europium-152, europium-154, cesium-137, cesium-134, strontium-90, europium-155, uranium, and plutonium-239/240. Table 3-10 presents a summary of the historical data.

3.6.3 Analogous Sites

The buried thimble site has no known analogous sites in the 100 Areas.

3.6.4 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. Monitoring well 199-H5-1 is upgradient of the buried thimble site. Monitoring well 199-H4-46 is the downgradient well to this site. Groundwater samples from this well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient well. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient well. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Currently, it is not possible to assess the origin of the strontium-90 or technetium-99. Therefore, it cannot be determined if burial ground is impacting groundwater.

3.6.5 LFI Summary

Historical sampling data and process knowledge indicate the radionuclides associated with the buried thimble site are: cobalt-60, tritium, europium-152, europium-154, cesium-137, cesium-134, strontium-90, europium-155, uranium, and plutonium-239/240, nickel-63, and nickel-59. There is no information regarding organics, inorganics, pesticides, or PCBs that may be associated with this site. It cannot be determined at this time if the buried thimble site is impacting groundwater.

3.6.6 Risk Evaluation

3.6.6.1 Human Health Evaluation. The buried thimble site is believed to contain one thimble, weighing 90 lb. The only data available are process knowledge estimates of total curies. In addition, this site received some overflow from the 116-H-2 trench. The QRA for this site is based on the sampling completed by Dorian and Richards (1978). The HSBRAM (DOE-RL 1993b) describes the process for identifying contaminants of concern for each high-priority waste site by using a preliminary risk-based screening. This screening uses residential scenario exposure parameters at a lifetime ICR of 1E-07. Preliminary risk-based screening is used to identify potential risk-driving contaminants and to save time and resources in the risk assessment. Table 3-11 shows the contaminant screening against human-health-risk-based concentrations for the buried thimble site.

No risk calculations have been done for the process knowledge on the thimbles. A safe assumption, however, is that under the frequent-use scenario, if someone were to excavate the burial ground for building a home, he or she might receive a dose if the thimbles were exposed.

Risks estimated for 1994 for the frequent- and occasional-use scenarios at the buried thimble site are summarized in Table 3-12. All COPC except europium-155 have an estimated ICR $>$ 1.0E-7 in the frequent-use scenario, with the maximum estimated qualitative risk at 9.3E-04 from europium-152 as an external exposure. The total estimated lifetime ICR to humans is classified medium in the frequent-use scenario.

For the occasional-use scenario, the highest estimated qualitative risk is also from europium-152 at 6.0E-06, again from external exposure. The total estimated lifetime ICR to humans is classified as low in the occasional-use scenario.

Risks estimated for the year 2018 for the frequent- and occasional-use scenarios at the buried thimble site are summarized in Table 3-13. No significant reduction of risk will occur by the year 2018.

Uncertainties attributed to the methodology and quality of data used in this QRA are discussed in Sections 2.10.1.3 and 2.10.2.1, respectively. Because analytical site data are used to estimate risk for this site, the uncertainty is high.

3.6.6.2 Ecological Evaluation. The calculated doses to the Great Basin pocket mouse from radiological contaminants in the soil within the buried thimble site are provided in Table 3-14. The total dose from all radionuclides is less than the EHQ of 1 rad/day. The major contributor to the calculated dose is strontium-90.

Uncertainty is introduced into the risk calculations by the assumption that the contaminant levels in the overflow area are similar to those in the 116-H-2 trench. Therefore, the calculated dose rates may be over or underestimations of the actual ecological risk at this site.

3.7 105-H HORIZONTAL CONTROL ROD STORAGE CAVE

3.7.1 Site Description

The 105-H horizontal control rod storage cave is an inactive, mixed, solid waste site. It is located inside the 105-H exclusion area fence, about 150 ft south southwest of the 105-H Reactor building with approximate Hanford Site coordinates N95000 W39700. The cave is roughly 40 by 7 ft and rises 4.5 ft above grade with a north-to-south orientation.

The dates of operation are unknown; however, it appears in aerial photographs as early as September 1950. Rod caves were used for temporary storage of irradiated vertical safety and horizontal control rods and tools used in their removal and/or installation. Such rods and hardware were usually contaminated and a potential for contamination exists within this rod cave. No information could be located to identify the cave's contents, if any. The site is suspected to contain contaminated horizontal control rods and possibly other miscellaneous reactor facility components.

DeFord (1994) reports "The cave appears to have been constructed of materials at hand and is of primitive construction when compared with the concrete rod caves at other Hanford reactor sites. Lead bricks are visible at its south end which appear to have been stacked to form the end wall. Its roof is covered with gravel and is not visible. A counter-balance type steel door is installed in its north end which swings upward to provide access. The door is closed and the interior is not visible." A light-weight chain forms a 90- by 90-ft radioactive surface contamination barricade around the rod cave and a portion of the 118-H-5 burial ground.

3.7.2 Analogous Sites

The sites in the 100 Areas considered analogous to the 105-H horizontal control rod storage cave are the 118-C-4, 118-KW-2, and 118-KE-2 horizontal control rod storage caves. No sampling has been conducted at these sites.

3.7.3 Potential Groundwater Impacts

Figures 3-1 through 3-4 present the strontium-90, technetium-99, chromium, and nitrate maximum concentrations in the 100-HR-3 groundwater from December 1992 through April 1993 sampling rounds. Monitoring wells 199-H4-49 and 199-H3-1 are upgradient of the 105-H rod cave. Monitoring well 199-H4-46 is the downgradient well to this site. Groundwater samples from this well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient wells. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient wells. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites in the 100-HR-1 and 100-HR-2 Operable Units, including a number of liquid waste disposal sites (Table 3-5). Currently, it is not possible to assess the origin of the strontium-90 or the technetium-99. Therefore, it cannot be determined if the 105-H horizontal control rod storage cave is impacting groundwater.

3.7.4 LFI Summary

Historic and nonintrusive sampling has not been conducted at this site, analogous sites have not been sampled, and process knowledge information is not available for this site. It cannot be determined at this time if the 118-H-5 burial ground is impacting groundwater.

3.7.5 Risk Evaluation

No LFI or historical sampling data are available from this site; therefore, the risk cannot be evaluated using the HSBRAM (DOE-RL 1993b) methodology. No data from analogous sites are available.

Human health and ecological risks are highly uncertain.

No LFI or historical sampling data are available from this site; therefore, no ecological risk characterization can be done.

3.8 LOW PRIORITY SITES

Low priority sites are not generally sampled as part of the LFI. However, the 151-H was sampled during the 100-HR- LFI due to possible PCB contamination. Additionally, a soil gas survey was performed at the 128-H-1 burn pit per Ecology request to confirm the presence/absence of VOCs. The results of these investigations indicate that these sites should remain low priority.

3.8.1 128-H-1 Burning Pit

The 128-H-1 burning pit is an inactive, nonradioactive, hazardous solid waste site that operated from 1949 to 1965. The site is located northwest of the 100-H Area, about 50 ft east of the perimeter road at Hanford Site coordinates N97750 W41200. It was used for the disposal of nonradioactive, combustible materials such as paint waste, office waste, chemical solvents, and for ash from the 148-H power house (WHC 1991).

The burning pit is about 300 by 300 by 10 ft deep, and is partially divided by a north-south earthen berm. Two 10-in. steel lines enter the pit from the south wall and terminate in an earthen mound. These may have carried ash in slurry form from the power house to the pit. The entire pit floor is covered with evenly distributed ash and cinder similar to that found in the 126-H-1 ash pit.

Evidence of burning exists along the western edge of the pit, and a wooden stake near the northwest corner is marked "burn pit." Light vegetation growing on its floor includes field grasses and weeds. No fencing or warning signs exist.

A soil-gas survey was performed in the eastern portion of the 128-H-1 burn pit. The survey location is shown in Figure 3-5. This portion of the burn pit was suspected to have been used to burn chemicals. Initial field screening was performed on November 29 and 30, 1993. Eighteen soil-gas probes were installed in the study areas at depths of 4 to 6 ft. Probe location coordinates correspond to the coordinate grid used for the GPR survey, conducted by the WHC Surface Geophysics Team on November 5, 1993. Soil-gas vapors were field screened using two total-organic-vapor monitoring instruments, and an infrared landfill gas (LFG) analyzer.

On December 6 and 7, 1993, soil-gas samples were collected and analyzed using two portable GCs. The samples were analyzed for VOCs and LFGs.

Levels of VOCs or LFGs were not detected above the minimum detection limit during the initial screening or from the GCs. Appendix A, Table A-3, presents the data.

3.8.2 151-H Primary Substation

This facility was located approximately 800 ft due west of the 105-H Reactor Building. It supplied all normal electrical power to the 100-H Area from 1948 until about 1965. It contained two power transformers rated at 31,250 kVA and associated transformers, capacitors, switchgear, etc. The 151-H primary substation was demolished. The building debris was placed in the basement cavity and covered with earth. The electrical switchgear was reused in 151-B (Wahlen 1991).

Seven surface soil samples were taken on December 9, 1991 around the 151-H electrical facilities as part of the 100-HR-1 LFI. The soil samples were taken from areas where PCB contamination was suspected, and analyzed for PCBs. These samples indicate that PCB levels are below *Toxic Substance Control Act* cleanup levels (DOE-RL 1993c). The data are provided in Appendix A, Table A-2. Sample locations are shown in Figure 3-5.

Historical and process knowledge information is not available for this site.

Figure 3-1. Strontium-90 Concentrations in the 100-H Area Groundwater. (DOE-RL 1993d)

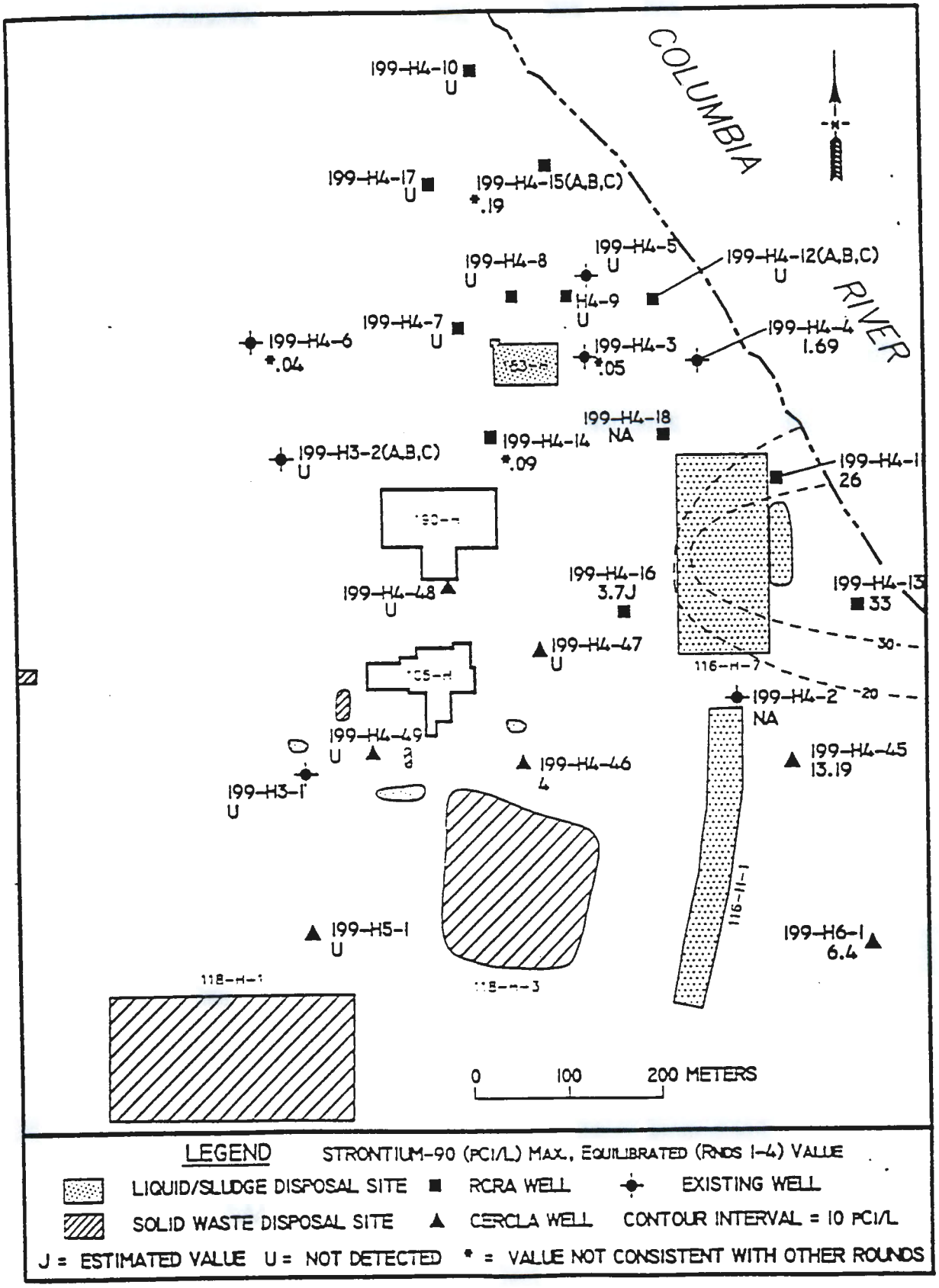


Figure 3-2. Technetium-99 Concentrations in the 100-H Area Groundwater. (DOE-RL 1993d)

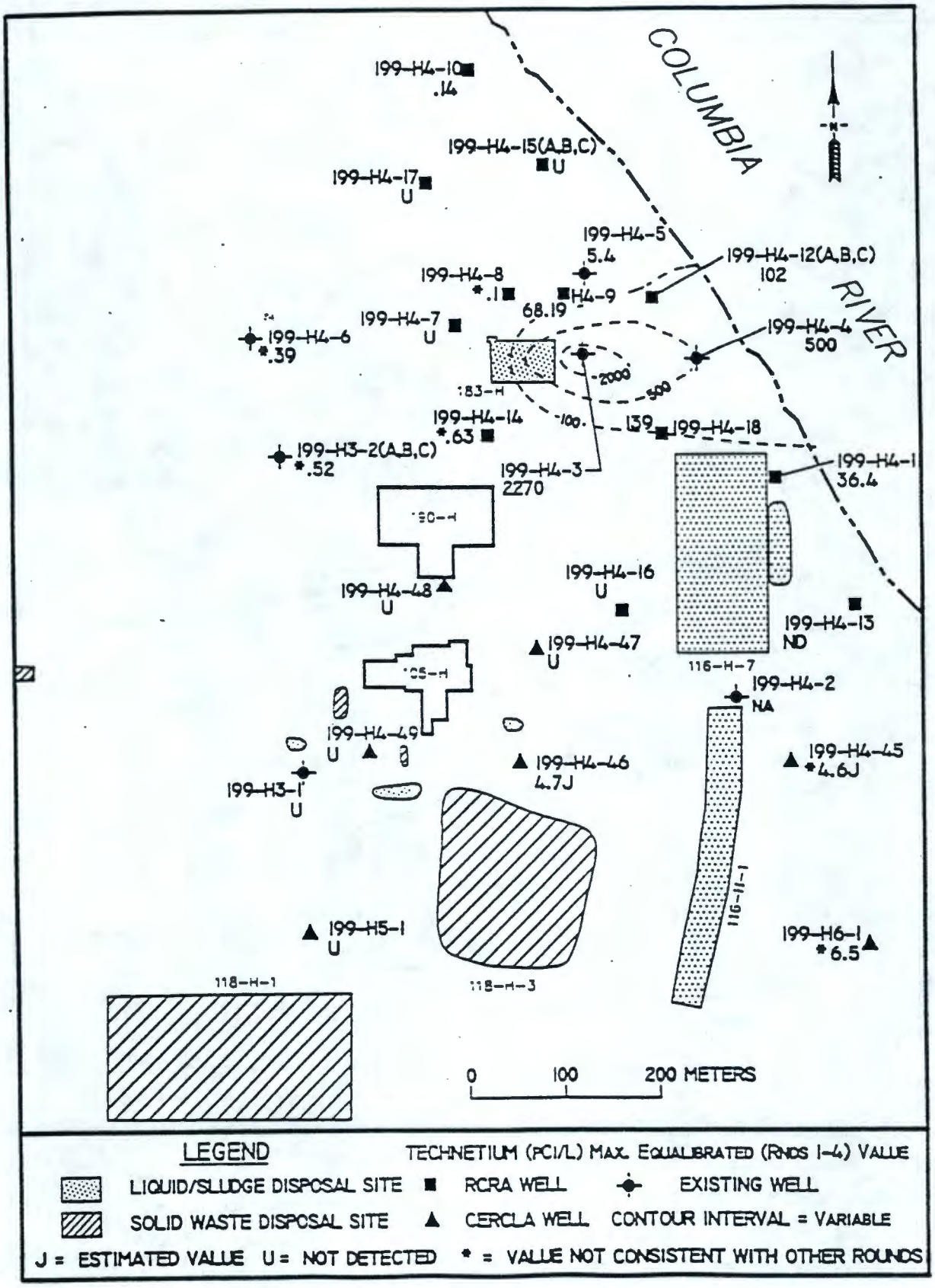


Figure 3-3. Chromium Concentrations in the 100-H Area Groundwater. (DOE-RL 1993d)

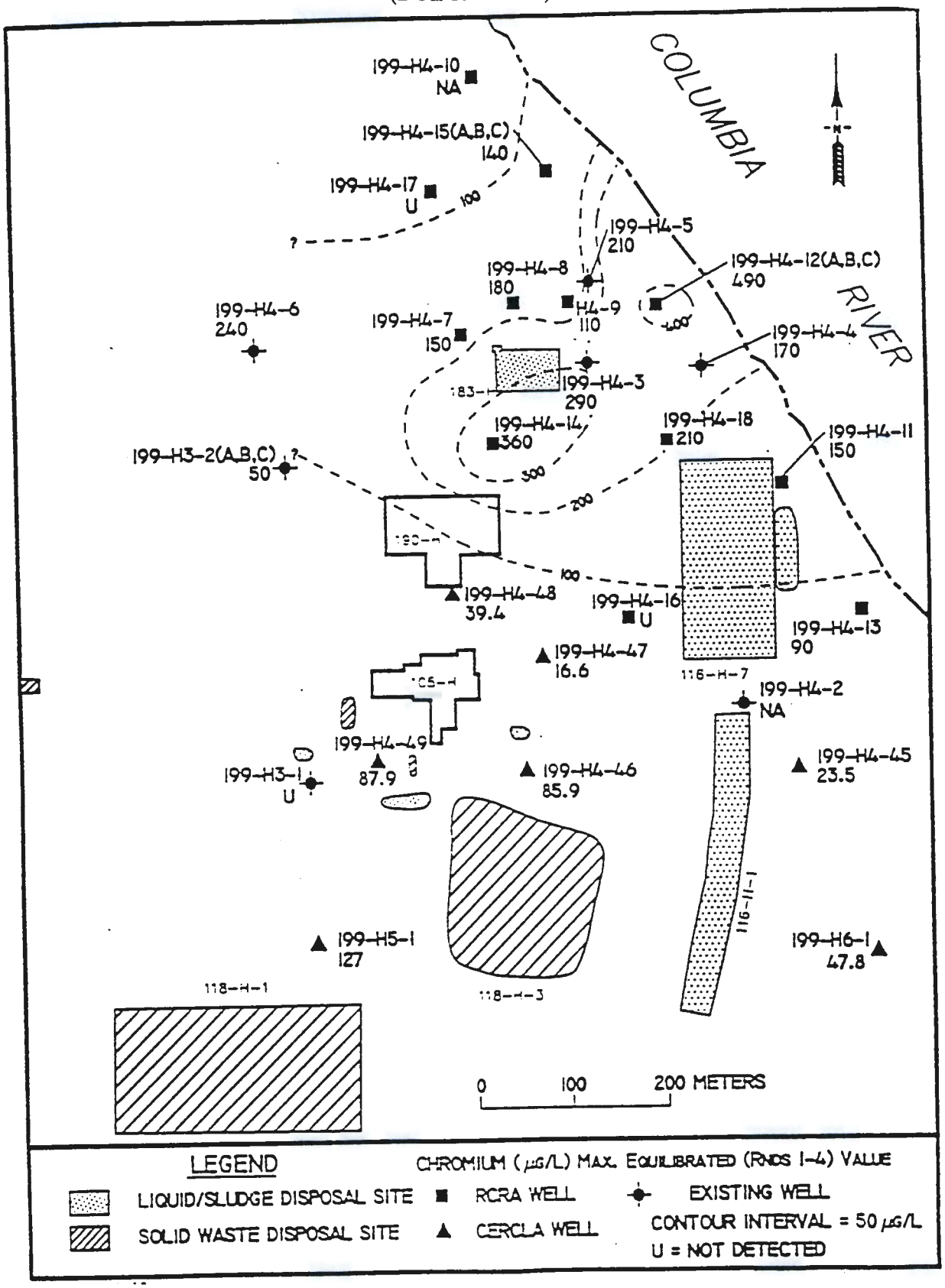


Figure 3-4. Nitrate Concentrations in the 100-H Area Groundwater. (DOE-RL 1993d)

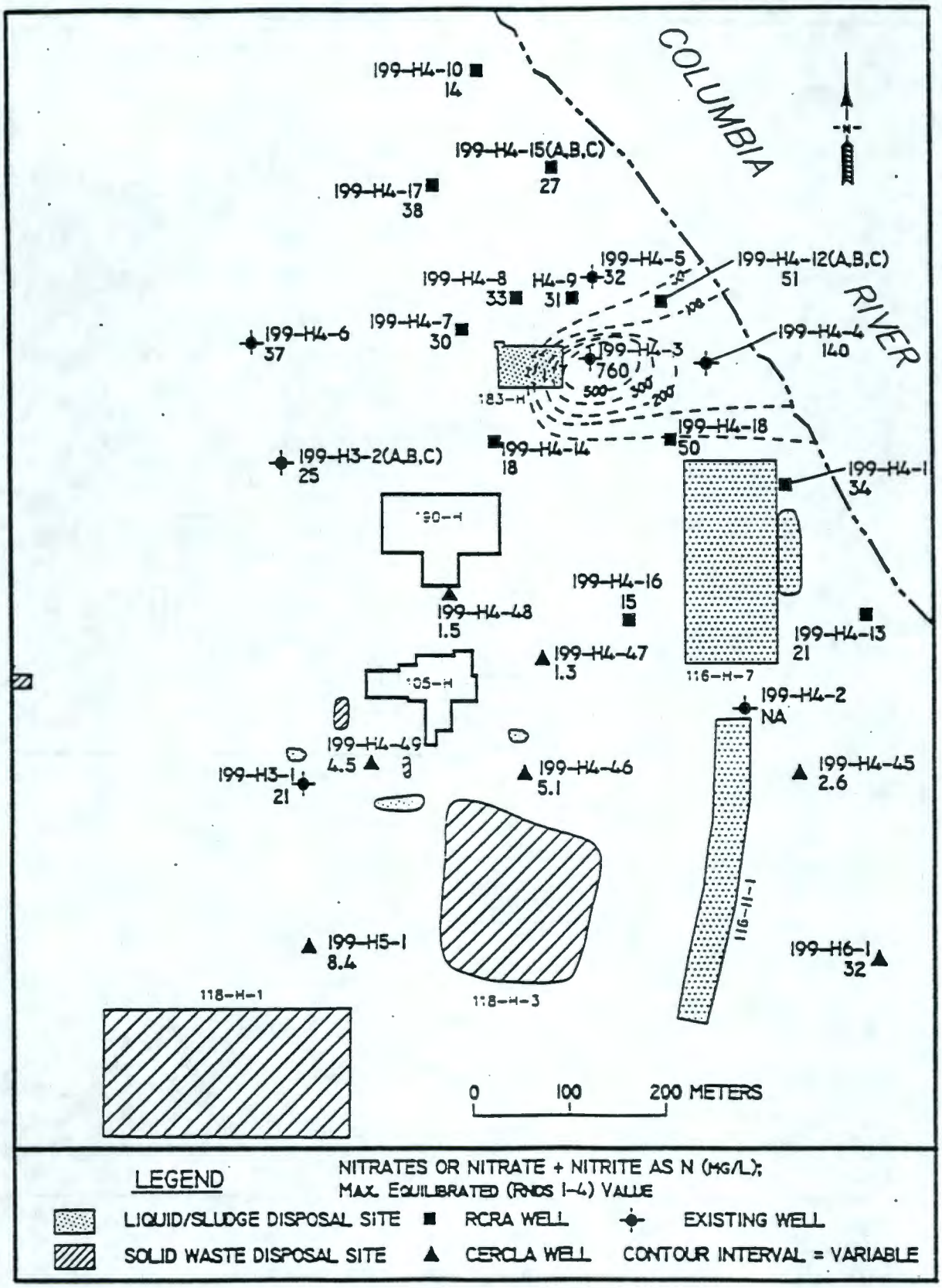
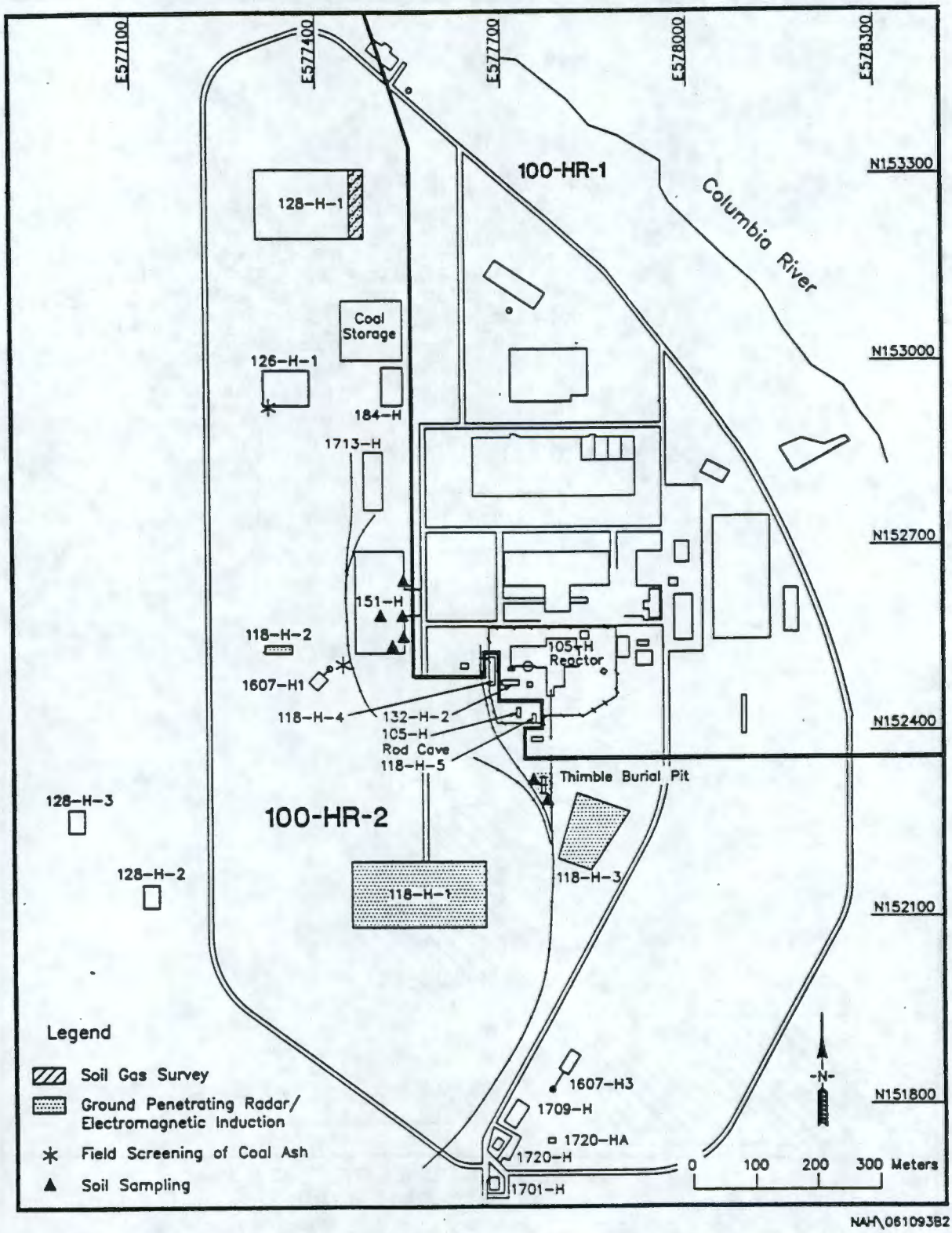


Figure 3-5. Sampling Locations in the 100-HR-2 Operable Unit.



See Appendix A for location references. (Bergstrom 1994a, 1994b, 1994c; Dorian and Richards 1978)

Table 3-1. 118-H-1 Burial Ground Process Knowledge Information.

Radionuclide summary (Curies)		Curies decayed to:		
Radionuclide	1/2 Life (years)	1987	1994	2018
Tritium	1.23E+01	1.40E+00	9.43E-01	2.43E-01
Carbon-14	5.73E+03	1.90E-01	1.90E-01	1.90E-01
Cobalt-60	5.30E+00	2.09E+02	8.33E+01	3.55E+00
Nickel-63	1.00E+02	2.76E+02	2.63E+02	2.23E+02
Nickel-59	7.50E+04	2.10E+00	2.10E+00	2.10E+00
Strontium-90	2.86E+01	1.30E-01	1.10E-01	6.13E-02
Silver-108m	1.27E+02	6.60E+00	6.35E+00	5.57E+00
Barium-133	1.05E+01	3.51E-01	2.21E-01	4.53E-02
Cesium-137	3.02E+01	1.31E-01	1.12E-01	6.43E-02
Europium-152	1.36E+01	1.90E+00	1.33E+00	3.91E-01
Europium-154	8.80E+00	1.20E+00	6.91E-01	1.04E-01
Calcium-41	1.00E+05	7.00E-03	7.00E-03	7.00E-03

(Miller and Wahlen 1987)

Table 3-2. 118-H-1 Burial Ground (1949 to 1965) Descriptive Waste Summary.

Site	Waste	General composition	Quantity
118-H-1 1949-1965	Reactor processing tubing	Aluminum	38.6 tons
	Spacers	Aluminum (6063 T6 alloy)	42.5 tons total 37.5 tons irradiated
	Lead brick, sheeting, casks, wool	Lead	23.7 tons
	Lead-Cadmium Element (dummies)	Lead Cadmium	148.3 tons 6.2 tons
	Gun Barrels	Schedule (SCH) 40 carbon steel	1 ton
	Horizontal control rods	Aluminum (63-ST-S) poison is sintered boron-carbide and aluminum	1.2 tons
	Vertical Safety Rod	Chrome plated carbon steel tube with a 5% boron 95% graphite core	2.2 tons
	Thimble	Aluminum	2.75 tons
	Nozzle Assemblies	Aluminum Carbon Steel Stainless Steel	15 tons
	Thermocouple Wires	Nickel Chromium	54 lb
	Splines	Boron-carbide sintered with aluminum	7.8 tons
	Soft Waste	Paper, masking tape, plastic, wiping rags	182.5 tons
	Graphite dust	Graphite	207 lb
	Silica Gel	Silica gel	0.9 tons

(Miller and Wahlen 1987)

Table 3-3. Maximum Concentrations in Analogous Sampling at 118-B-1.

Radionuclides	1/2 Life (yrs)	Maximum concentration, pCi/g							
		Sampled April 1976							
		15 ft	20 ft	22 ft	22.5 ft	25 ft	30.5 ft	32 ft	(a)
Tritium	12.3	(b)	(b)	(b)	(c)	(b)	(b)	(b)	(b)
Cobalt-60	5.3	3.40E+01	7.00E-02	1.70E+05	9.90E+01	5.20E+03	3.50E+02	3.80E+02	8.20E+03
Nickel-63	100.0	(b)	(b)	3.20E+01	(b)	7.80E+01	(b)	(b)	(b)
Strontium-90	28.6	1.00E-01	1.90E-01	6.00E-01	5.70E-01	1.40E+02	2.30E-02	6.20E+00	?
Cesium-134	2.1	(c)	6.40E+01	(c)	(c)	(c)	2.80E-01	(c)	1.30E+01
Cesium-137	30.2	5.40E-01	6.60E+01	2.70E+03	1.40E+00	4.90E+01	1.30E+00	5.30E+00	1.20E+02
Europium-152	13.6	4.60E-01	8.30E+01	4.50E+03	1.30E+00	2.80E+01	7.90E-01	5.40E+00	3.10E+03
Europium-154	8.8	6.60E-01	4.50E+02	2.70E+03	9.30E-01	2.50E+03	1.80E+00	7.80E+00	3.80E+02
Europium-155	5.0	6.50E-02	4.80E+01	6.00E+02	(c)	7.50E+00	5.60E-01	3.00E+00	1.80E+01
Uranium		(b)	(b)	(b)	(b)	1.60E-01	(b)	(b)	(b)
Plutonium-238	87.8	(c)	(c)	(c)	(c)	(c)	(c)	(c)	(c)
Plutonium-239-240	24100	(c)	2.80E-01	(c)	(c)	5.90E-01	4.20E-01	1.00E+00	(c)

118-B-1 Sampling Data applied analogously, Dorian and Richards 1978.

(a) Sample at 33 ft was perforated aluminum fuel element spacer (dummy) found 20 ft east of one of the trenches.
(b) not analyzed.
(c) below analytical detection limits.

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Table 3-4. Risk-Based Concentrations for Radioactive Contaminants in Solid Waste at 100-HR-2 Waste Sites (as described in Process Knowledge Information).

Radionuclide	Frequent-use scenario external exposure ICR = 1E-04 (pCi/g)	Occasional-use scenario external exposure ICR = 1E-04 (pCi/g)
Cobalt-60	4.8E-01	7.6E+01
Barium-133	5.0E+00	7.8E+02
Cesium-137	2.1E+00	3.3E+02
Europium-152	1.2E+00	1.8E+02
Europium-154	1.0E+00	1.6E+02
Plutonium 239/240	1.5E+05	2.4E+07

The risk-based concentration reported (ICR of 1E-04) for radionuclides with an external exposure hazard, is defined as having a "medium" priority for remediation in this QRA. No actual concentration data are known for these contaminants through process knowledge.

Table 3-5. 100-HR-2 Operable Unit Waste Sites Up- and Downgradient Well Designations.

Solid waste burial grounds	Upgradient well	Downgradient well	Other possible source sites
118-H-1	600 Area well	H5-1	128-H-2, 128-H-3
118-H-2	600 Area well	H3-2	151-H,1607-H-1
118-H-3	H5-1	H4-46	116-H-2, 116-H-9, 118-H-4, 105-H Horizontal Control Rod Storage Cave, 118-H-5, 132-H-2, Buried Thimble Pit
118-H-4	600 Area well	H4-49	132-H-2, 116-H-9
118-H-5	H3-1, H4-49	H4-46	105-H Horizontal Control Rod Storage Cave, 116-H-2, 132-H-2, 118-H-4, 116-H-9, 118-H-3, Buried Thimble Pit
Buried Thimble Site	H5-1	H4-46	105-H Horizontal Control Rod Storage Cave, 116-H-2, 132-H-2, 118-H-4, 116-H-9, 118-H-3, 118-H-5
105-H Horizontal Control Rod Storage Cave	H3-1	H4-46	118-H-5, 116-H-2, 132-H-2, 118-H-4, 116-H-9, 118-H-3, Buried Thimble Pit

(DOE-RL 1993d)

Table 3-6a. Radionuclides Detected in the Treatability Test at the 116-F-4 Pluto Crib (used as analogous data for the 116-H-4 crib, displaced to the 118-H-5 burial ground).

Detected radionuclide analyte	Maximum concentration interval (pCi/g) 1993[a]	Maximum concentration decayed to 1994 (pCi/g)	Maximum concentration interval (pCi/g) 2018[a]	Human health risk-based screening concentration (pCi/g)
Cobalt-60	54	47.3	2.01	0.00048 (Retain)
Strontium-90	6400	6247	3491.7	2.1 (Retain)
Americium-241	96	95.8	92.22	0.29 (Retain)
Cesium-137	8300	8111	4673.4	0.0021 (Retain)
Europium-152	120	114	33.56	0.0012 (Retain)
Europium-154	13	12	1.81	0.001 (Retain)
Potassium-40	17	17	17	0.00077 (Retain)
Plutonium-239/240	530	530	530	0.24 (Retain)
Plutonium-238	6.1	6.1	5.0	0.23 (Retain)
Uranium-233/234	4	4	4	0.34 (Retain)
Uranium-235	0.34	0.34	0.34	0.018 (Retain)
Uranium-238	3.9	3.9	3.9	0.082 (Retain)
Technetium-99	2.7	2.7	2.7	0.59 (Retain)
Thorium-228	2	1.4	0.0002	0.00074 (Retain for 1994)
Thorium-232	2.3	2.3	2.3	0.32 (Retain)
Radium-226	2.75	2.75	2.72	0.00069 (Retain)
Radium-228	2.3	2.04	0.11	0.0014 (Retain)

[a](DOE-RL 1994a).

Table 3-6b. Organics and Inorganics Detected in the Treatability Test at the 116-F-4 Pluto Crib. (2 Sheets)

Volatile organic and semi-volatile organic compounds (ppm)	Maximum values detected	95% Upper threshold limit	MTCA Method B (mg/kg)	Health-based risk screening (ppm)
4-Methyl-2-Penanone	0.019	N/A	4,000	47 (Remove, below benchmark concentration)
Acetone	0.140	N/A	U	360 "
Methylene Chloride	0.006 BJ	N/A	133	1.9 "
Toluene	0.001 J	N/A	16,000	72 "
bis(2-Ethylhexyl)phthalate	0.032 J	N/A	1,600 (71)	4.6 "
Di-n-butylphthalate	0.290 BJ	N/A	8,000	800 "
Inorganics (mg/kg)				
Aluminum	7,610	15,600 (Remove, below background)	[d]	
Arsenic	3.4 (B)	8.92 "	24 (0.59)[c]	
Barium	125	171 "	5,600	
Beryllium	0.44 (B)	1.77 "	400 (0.23)[c]	
Cadmium	0.35 (B)	0.66[a] "	40	
Calcium	12,600	23,900 "	[d]	
Chromium	11.1	27.9 "	400[e]	
Cobalt	9.5 (B)	19.6 "	N/L	
Copper	17.3	28.2 "	3,200	
Iron	16,600	39,160 "	[d]	
Lead	12.3	14.75 "	U	
Magnesium	4,590	8,760 "	[d]	
Manganese	339	612 "	400	
Mercury	0.1	1.25 "	24	
Nickel	13.5	25.3 "	1,600	
Potassium	1,450	3,120 "	[d]	
Selenium	2.4	5[a] "	400	
Silver	1.1 (B)	2.7 "	400	
Sodium	581 (B)	1,290 "	[d]	
Vanadium	41.1	111 "	560	
Zinc	51.9	79 "	24,000	

Table 3-6b. Organics and Inorganics Detected in the Treatability Test at the 116-F-4 Pluto Crib. (2 Sheets)

Volatile organic and semi-volatile organic compounds (ppm)	Maximum values detected	95% Upper threshold limit	MTCA Method B (mg/kg)	Health-based risk screening (ppm)
Anions (mg/kg)				
Chloride	427	763 "	N/L	
Fluoride	53.7	12 "	4,800	480[b] "
Phosphate	7.7	16 "	N/L	
Sulfate	120	1,320 "	N/L	
Nitrite/Nitrate	10.8	199 "	8,000	

[a]Limit of detection.
[b]Equivalent to a hazard quotient of 0.1 (for ingestion only, no hazard quotient for dermal and inhalation exposures).
[c]Carcinogen risk-based concentration in parenthesis.
[d]Analytes are essentially nontoxic in soil (DOE-RL 1993b).
[e]Hexavalent chromium.

B = Analyte found in the associated blank as well as in sample.
(B) = Reported value is < Contract Required Detection Limit, but > Instrument Detection Limit.
J = Value is estimated.
N/L = Not listed in MTCA human health risk-based Method B formula values table for soil.
U = Unavailable.

(DOE-RL 1994a)

Table 3-7. 118-H-5 Burial Ground Human Health Risk Characterization--1994 (using analogous data from the 116-F-4 pluto crib).

Radionuclide COPC[a]	Frequent-use scenario				Occasional-use scenario			
	Ingestion ICR[b]	Inhalation ICR	External exposure ICR	Total ICR	Ingestion ICR	Inhalation ICR	External exposure ICR	Total ICR[c]
Cobalt-60	9E-07	8E-08	1E-02	1E-02	2E-08	1E-09	6E-05	6E-05
Strontium-90	3E-04	4E-06	[c]	3E-04	6E-06	8E-08	[c]	6E-06
Americium-241	3E-05	3E-05	1E-05	7E-05	6E-07	6E-07	7E-08	1E-06
Cesium-137	3E-04	2E-06	4E-01	>1E-02	6E-06	3E-08	2E-03	2E-03
Europium-152	3E-07	1E-07	1E-02	1E-02	6E-09	3E-09	6E-05	6E-05
Europium-154	5E-08	2E-08	1E-03	1E-03	9E-10	4E-10	7E-06	7E-06
Potassium-40	2E-07	1E-09	2E-04	2E-04	5E-09	3E-11	1E-06	1E-06
Plutonium-239/240	2E-04	2E-04	3E-07	4E-04	3E-06	4E-06	2E-09	7E-06
Plutonium-238	2E-06	3E-06	4E-09	4E-06	3E-08	5E-08	2E-11	8E-08
Uranium-233/234	8E-08	1E-06	3E-09	1E-06	2E-09	2E-08	2E-11	2E-08
Uranium-235[a]	7E-09	9E-08	2E-06	2E-06	1E-10	2E-09	1E-08	1E-08
Uranium-238	1E-07	1E-06	5E-06	6E-06	2E-09	2E-08	3E-08	5E-08
Technetium-99	5E-09	2E-10	4E-11	5E-09	9E-11	5E-12	2E-13	9E-11
Thorium-228	1E-07	1E-06	2E-04	2E-04	2E-09	2E-08	1E-06	1E-06
Thorium-232	4E-08	7E-07	1E-09	7E-07	7E-10	1E-08	9E-12	1E-08
Radium-226	4E-07	9E-08	4E-04	4E-04	8E-09	2E-09	2E-06	2E-06
Radium-228	3E-07	2E-08	1E-04	1E-04	5E-09	3E-10	9E-07	9E-07
Site Totals	8E-04	2E-04	>1E-02	1E-02	2E-05	5E-06	2E-03	2E-03

[a]Contaminant of potential concern.
[b]Lifetime incremental cancer risk.
[c]Not an external exposure hazard.

(DOE-RL 1994a)

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Table 3-8. 118-H-5 Burial Ground Human Health Risk Characterization--2018 (using analogous data from the 116-F-4 pluto crib).

Radionuclide COPC[a]	Frequent-use scenario				Occasional-use scenario			
	Ingestion ICR[b]	Inhalation ICR	External exposure ICR	Total ICR	Ingestion ICR	Inhalation ICR	External exposure ICR	Total ICR[c]
Cobalt-60	4E-08	3E-09	4E-04	4E-04	8E-10	6E-11	3E-06	3E-06
Strontium-90	2E-04	2E-06	[c]	2E-04	3E-06	5E-08	[c]	3E-06
Americium-241	3E-05	3E-05	1E-05	7E-05	6E-07	6E-07	7E-08	1E-06
Cesium-137	2E-04	2E-06	2E-01	2E-01	3E-06	2E-08	1E-03	1E-03
Europium-152	9E-08	4E-08	3E-03	3E-03	2E-09	8E-10	2E-05	2E-05
Europium-154	7E-09	3E-09	2E-04	2E-04	1E-10	5E-11	1E-06	1E-06
Potassium-40	2E-07	1E-09	2E-04	2E-04	5E-09	3E-11	1E-06	1E-06
Plutonium-239/240	2E-04	2E-04	3E-07	4E-04	3E-06	3E-06	2E-09	7E-06
Plutonium-238	1E-06	2E-06	3E-09	4E-06	3E-08	4E-08	2E-11	7E-08
Uranium-233/234	8E-08	1E-06	4E-09	1E-06	2E-09	2E-08	2E-11	2E-08
Uranium-235	7E-09	9E-08	2E-06	2E-06	1E-10	2E-09	1E-08	1E-08
Uranium-238	1E-07	1E-06	5E-06	6E-06	2E-09	2E-08	3E-08	5E-08
Technetium-99	5E-09	2E-10	4E-11	5E-09	9E-11	5E-12	2E-13	9E-11
Thorium-228	2E-11	2E-10	3E-08	3E-08	3E-13	4E-12	2E-10	2E-10
Thorium-232	4E-08	7E-07	1E-09	7E-07	7E-10	1E-08	9E-12	1E-08
Radium-226	4E-07	9E-08	4E-04	4E-04	8E-09	2E-09	2E-06	2E-06
Radium-228	1E-08	9E-10	8E-06	8E-06	3E-10	2E-11	5E-08	5E-08
Site Totals	6E-04	2E-04	>1E-02	>1E-02	1E-05	3E-06	1E-03	1E-03

[a]Contaminant of potential concern.
[b]Lifetime incremental cancer risk.
[c]Not an external exposure hazard.

(DOE-RL 1994a)

Table 3-9a. Radiological Dose Calculation for the Great Basin Pocket Mouse for 118-H-5 Burial Ground.[a]

Isotope	Soil activity (pCi/g)	Veg. activity (wet) (Ci/Kg)	Dose rate (Rad/day)	Fractional use	Dose rate (Rad/day)
Am-241	9.60E+01	3.07E-10	8.95E-06	1	9E-06
Co-60	5.40E+01	8.64E-09	1.22E-04	1	1E-04
Cs-137	8.11E+03	1.61E-06	6.60E-02	1	7E-02
Eu-152	1.14E+02	3.65E-11	2.34E-07	1	2E-07
Eu-154	1.20E+01	3.84E-12	5.06E-09	1	5E-09
Pu-238	6.10E+00	1.37E-10	3.99E-06	1	4E-06
Pu-239/240	5.30E+02	1.19E-08	3.25E-04	1	3E-04
Sr-90	6.25E+03	3.80E-05	4.21E+01	1	4E+01
Tc-99	2.70E+00	3.64E-07	5.14E-03	1	5E-03
Th-228	1.40E+00	4.48E-14	2.24E-10	1	2E-10
Th-232	2.30E+00	7.36E-14	3.13E-10	1	3E-10
U-233/234	4.00E+00	1.28E-09	6.08E-04	1	6E-04
U-235	3.40E-01	1.09E-10	4.85E-05	1	5E-05
U-238	3.90E+00	1.25E-09	5.20E-04	1	5E-04
Ra-226	2.75E+00	8.80E-11	1.02E-03	1	1E-03
Ra-228	2.04E+00	6.53E-11	6.39E-07	1	6E-07
				Total	4E+01

[a]Based on maximum values from the 116-F-4 Pluto Crib Excavation Treatability Test Report (DOE-RL 1994a), 0 to 15 ft depth, decayed to 1994.

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Table 3-9b. Estimated Risk to the Great Basin Pocket Mouse - 118-H-5 Burial Ground Organic Analytes Based on Data from 116-H-4 Pluto Crib Excavation Treatability Test.

Organic constituent	Maximum soil conc. (mg/Kg)	Veg. conc. wet weight (mg/Kg)	Dose (mg/Kg/day)	NOAEL (mg/Kg/day)	Ratio of risk (dose/NOAEL)
Toluene	0.001	3.46E-04	9.85E-05	56.1	1.76E-06
Methylenechloride	0.003	7.05E-03	2.01E-03	14.7	1.37E-04
Acetone	0.140	2.39E+00	6.81E-01	23.2	2.93E-02
Di-n-butylphthalate	0.066	1.20E-03	3.43E-04	47.3	7.26E-06
4-methyl-2-pentanone	0.019	4.83E-02	1.38E-02	12.6	1.09E-03
Bis(2-ethylhexyl)phthalate	0.032	5.92E-04	1.69E-04	1.57	1.07E-04

Table 3-10. Buried Thimble Historic Sampling Data.

Radionuclide summary (pCi/g)					
Radionuclide	1/2 Life (yrs)	Sampled 1976			
		Borehole A 1 ft	Borehole A 5 ft	Borehole A 10 ft	Borehole F 10 ft
Plutonium-238		[a]	[a]	[a]	[a]
Plutonium-239/240	2.40E+04	1.30E-01	[a]	[a]	[a]
Strontium-90	2.80E+01	7.30E+01	3.30E+01	1.90E-01	1.80E-01
Tritium	1.23E+01	1.90E+00	6.80E+00	[a]	[b]
Europium-152	1.36E+01	2.70E+01	3.80E-01	[a]	[a]
Cobalt-60	5.27E+00	6.40E+00	2.60E-01	[a]	[a]
Europium-154	8.80E+00	6.20E+00	2.20E-01	[a]	1.30E-01
Cesium-134	2.06E+00	8.20E-02	3.30E-02	[a]	[a]
Cesium-137	3.02E+01	2.80E-01	1.40E+01	[a]	6.50E-02
Europium-155	4.96E+00	2.50E+00	3.50E-01	[a]	8.30E-02

Data from 116-H-2 Overflow Trench Historic Sampling (boreholes A and F), Dorian Richards 1978.

[a]Not detected.
[b]Not analyzed.

Table 3-11. Buried Thimble Human Health Risk Screening.

Detected radionuclide analyte	Maximum concentration 0'-15' interval (pCi/g) 1976	Maximum concentration 0'-15' interval (pCi/g) 1994[a]	Maximum concentration 0'-15' interval (pCi/g) 2018[a]	Human health risk-based screening concentration (pCi/g)
Cobalt-60	6.4	0.6	0.0256	0.00048 (Retain)
Strontium-90	7.3	47.2	26.4	2.1 (Retain)
Cesium-137	14.0	9.26	5.33	0.0021 (Retain)
Europium-152	27.0	10.8	3.18	0.0012 (Retain)
Europium-154	6.2	1.5	0.227	0.001 (Retain)
Europium-155	2.5	0.202	0.00706	0.071 (Retain)
Cesium-134	0.082	0.000193	6.08E-08	0.0008 (Remove, below benchmark concentration)
Tritium	6.8	2.46	0.635	1400 (Remove, below benchmark concentration)
Plutonium-239/240	0.13	0.13	0.13	0.24 (Remove, below benchmark concentration)
Uranium[a]	0.45	0.45	0.45	0.082 (Retain)

[a]Data reported as "Uranium" was considered Uranium-238.

(Dorian and Richards 1978)

Table 3-12. Buried Thimble Site Health Risk Characterization - 1994.

Radionuclide COPC[a]	Frequent-use scenario				Occasional-use scenario			
	Ingestion ICR[b]	Inhalation ICR	External exposure ICR	Total ICR	Ingestion ICR	Inhalation ICR	External exposure ICR	Total ICR[c]
Cobalt-60	1E-08	1E-09	1E-04	1E-04	2E-10	2E-11	8E-07	8E-07
Strontium-90	2E-06	3E-08	[c]	2E-06	4E-08	6E-10	[c]	4E-08
Cesium-137	3E-07	2E-09	4E-04	4E-04	6E-09	4E-11	3E-06	3E-06
Europium-152	3E-08	1E-08	9E-04	9E-04	6E-10	2E-10	6E-06	6E-06
Europium-154	6E-09	2E-09	1E-04	1E-04	1E-10	4E-11	9E-07	9E-07
Europium-155	1E-10	4E-11	3E-07	3E-07	2E-12	8E-13	2E-09	2E-09
Uranium	1E-08	1E-07	6E-07	7E-07	2E-10	2E-09	3E-09	6E-09
Site Totals[d]	2E-06	1E-07	2E-03	2E-03	5E-08	3E-09	1E-05	1E-05

[a]Contaminant of potential concern.
[b]Lifetime incremental cancer risk.
[c]Not an external exposure hazard.

(Dorian and Richards 1978)

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Table 3-13. Buried Thimble Site Health Risk Characterization - 2018.

Radionuclide COPC[a]	Frequent-use scenario				Occasional-use scenario			
	Ingestion ICR[b]	Inhalation ICR	External exposure ICR	Total ICR	Ingestion ICR	Inhalation ICR	External exposure ICR	Total ICR[c]
Cobalt-60	5E-10	4E-11	5E-06	5E-06	1E-11	8E-13	3E-08	3E-08
Strontium-90	1E-06	2E-08	[c]	1E-06	2E-08	3E-10	[c]	2E-08
Cesium-137	2E-07	1E-09	3E-04	3E-04	4E-09	2E-11	2E-06	2E-06
Europium-152	9E-09	4E-09	3E-04	3E-04	2E-10	7E-11	2E-06	2E-06
Europium-154	9E-10	3E-10	2E-05	2E-05	2E-11	7E-12	1E-07	1E-07
Europium-155	4E-12	1E-12	1E-08	1E-08	8E-14	3E-14	6E-11	6E-11
Uranium	1E-08	1E-07	6E-07	7E-07	2E-10	2E-09	3E-09	6E-09
Site Totals	1E-06	1E-07	6E-04	6E-04	2E-08	2E-09	4E-06	4E-06

[a]Contaminant of potential concern.
[b]Lifetime incremental cancer risk.
[c]Not an external exposure hazard.

(Dorian and Richards 1978)

Table 3-14. Radiological Dose Calculation for the Great Basin Pocket Mouse - Buried Thimble Site. (Soil Depth 0 to 15 ft, Decayed to 1994).

Isotope	Soil activity (pCi/g)	Veg. activity (wet) (Ci/Kg)	Dose rate (Rad/day)	Fractional use	Dose rate (Rad/day)
Sr-90	4.72E+01	2.87E-07	3.18E-01	1	3E-01
Pu-239/240	1.30E-01	2.91E-12	7.97E-08	1	8E-08
H-3	2.46E+00	3.78E-09	4.61E-07	1	5E-07
Co-60	6.00E-01	9.60E-11	1.36E-06	1	1E-06
Eu-152	1.08E+01	3.46E-12	2.22E-08	1	2E-08
Eu-154	1.50E+00	4.80E-13	6.33E-10	1	6E-10
Eu-155	2.02E-01	6.46E-14	7.99E-11	1	8E-11
Cs-134	1.93E-04	1.54E-14	6.09E-10	1	6E-10
Cs-137	9.26E+00	1.84E-09	7.54E-05	1	8E-05
U-238	4.50E-01	1.44E-10	6.00E-05	1	6E-05
				Total	3E-01

(Dorian and Richards 1978)

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4.0 QUALITATIVE RISK ASSESSMENT SUMMARY AND CONCLUSIONS

4.1 HUMAN HEALTH EVALUATION

The 100-HR-2 Operable Unit human health evaluation provides estimates of risks that occur under frequent- or occasional-use scenarios based on the best available knowledge of current waste site conditions. Because neither of these exposure scenarios currently occur, and because of the conservative, analogous, and qualitative nature of the analysis, the results of this evaluation provide only an estimate of potential future health risks.

4.1.1 Results

Table 4-1 summarizes the results of the 100-HR-2 Operable Unit human health and ecological evaluation of the solid waste burial sites. The external radiation exposure pathway is shown to be the primary risk-contributing pathway at the evaluated waste sites. Consequently, radionuclide COPC that are the most significant external radiation exposure risks are cobalt-60, cesium-137, and europium-152. The actual depth of clean soil varied over all waste sites from 1 to 18 ft. For the purpose of this QRA, shielding was not assumed.

4.1.1.1 118-H-1 Burial Ground. The 118-H-1 burial ground is assigned to the medium human health risk category for the frequent-use scenario and low for the occasional-use scenario. The data uncertainty is high because an analogous site (118-B-1) was used to estimate risk. External radiation exposure is the major pathway contributing to ICR. The major risk-driving radionuclide is cobalt-60. The potential human health risks decrease by delaying the onset of human frequent-use scenario exposures to the year 2018. Approximately 6 to 10 ft of soil cover has been added to the site and shields the waste.

4.1.1.2 118-H-5 Burial Ground. The 118-H-5 burial ground waste site has a high human health risk potential for the frequent-use scenario and a medium human health risk potential for the occasional-use scenario. Analogous data, from a pluto crib at the 100-F Area, was used to estimate the qualitative risk category for this site. Analogous data are considered to have high uncertainty, which can be reduced if site-specific data become available for this waste site. The potential human health risks decrease by delaying the onset of human exposures to the year 2018, as shown in Section 3.0. However, there is no reduction in qualitative risk categories (high and medium) over the 24-yr period. The thickness of the overlying fill appears to range from 2 to 14 ft.

4.1.1.3 Buried Thimble Pit. The total estimated lifetime ICR to humans in 1994 is classified medium in the frequent-use scenario, mostly from external exposure. For the occasional-use scenario, the highest estimated qualitative risk is also mostly from external exposure. The total estimated lifetime ICR to humans is classified as low in the occasional-use scenario. Human risk estimated for 2018 is classified medium in the frequent-use scenario and low in the occasional-use scenario. The uncertainty in the risks is high. Part of this site is posted as a "Surface Contamination Area".

4.1.1.4 Other Burial Grounds. Human health risk estimations were not performed for the 118-H-2, 118-H-3, 118-H-4, or rod cave burial grounds because of the lack of soil contaminant concentration data. The risks for these sites is unknown. Varying amounts of fill, from 1 to 18 ft, appear to cover the debris in the 118-H-2, 118-H-3, and 118-H-4 burial grounds.

4.1.2 Summary of Key Uncertainties

The human health risks presented in the QRA are conditional estimates that reflect multiple assumptions and related uncertainties. The sources of uncertainty considered to have the greatest influence on the conclusions of the 100-HR-2 Operable Unit QRA are provided in the following paragraphs. The QRA does not include evaluation of pathways for ingestion of groundwater or agricultural crops based on methodology agreed to by the Tri-Party Agreement signatories concerning the scope of the QRA (DOE-RL 1993b) and because of lack of information regarding appropriate input parameters.

Perhaps the most significant uncertainty associated with the QRA is the use of analogous data and results from waste sites in other operable units. In addition, the analogous data used are mostly limited to radionuclides with few data available for organics or inorganics.

Exposure estimates to hypothetical human receptors include an extrapolation of external radiation exposures and air COPC particulate concentrations from soil COPC concentrations. The uncertainty associated with the external radiation exposure extrapolation is expected to greatly impact this QRA because this exposure pathway was found to be the primary risk contributor at the 100-HR-2 Operable Unit waste sites. Media-specific data (e.g., external radiation dosimeters) would significantly reduce this source of uncertainty in the 100-HR-2 Operable Unit QRA.

The use of maximum soil concentrations of all COPC from the surface to a depth of 15 ft as the exposure point concentration ignores the spatial distributions of surface and subsurface COPC concentrations that exist at all waste sites. Because the maximum concentrations are assumed to be ubiquitous and readily assessable to potential human receptors, this source of uncertainty probably results in overestimation of the exposure intakes and corresponding health risks from all COPC detected at each waste site.

An assumption of an "infinite source" geometry, such that homogenous distributions at the maximum soil concentration of each radionuclide COPC, is used to evaluate individual external radiation exposure risks. Uncertainty is introduced into the QRA because this assumption ignores the differences in radiation intensity provided for any other distribution of radionuclide COPC in soil, and results in overestimation of the external radiation exposure risks. Because the external radiation exposure pathway was found to be the primary risk-contributing pathway at all evaluated waste sites, this source of uncertainty is expected to significantly impact the 100-HR-2 Operable Unit QRA. As noted earlier, actual soil cover and postings as "Underground Radioactive Material" areas (for all but part of one site) indicate that the external exposure hazards are less than those indicated.

4.2 ECOLOGICAL EVALUATION

A qualitative ecological evaluation was completed for radiological constituents for the 100-HR-2 Operable Unit and is summarized in Table 4-1. The findings are as follows:

- Soil from inside the 118-H-1 burial ground does not exceed the 1-rad/day benchmark. Radiological data from this site were obtained from historical data (Dorian and Richards 1978) collected at the analogous 118-B-1 burial ground and was decayed to July 1993.

- Soil < 15 ft in depth inside the 118-H-5 burial ground exceeds the 1-rad/day benchmark with an EHQ > 1. This estimate is based on data collected at the 116-F-4 pluto crib and decayed to 1994. Strontium-90 is the major contributor to the total dose to the pocket mouse. Nonradiological contaminants at the analogous site were detected at concentrations well below the levels required to exceed the wildlife NOAEL.

- Soil < 15 ft in depth at the buried thimble site does not exceed the 1-rad/day benchmark. This estimate was based on historical data (Dorian and Richards 1978) collected at the adjacent 116-H-2 trench, which is known to have overflowed into the buried thimble site.

- Ecological risk estimations were not performed for the 118-H-2, 118-H-3, 118-H-4, or rod cave burial grounds because of the lack of soil contaminant concentration data.

All of the burial grounds within the 100-HR-2 Operable Unit contain reactor components and/or other solid materials that are assumed to be highly radioactive. However, in their present physical state, these materials are not expected to be bioavailable, and would not be taken up by plants or transported to the pocket mouse. Therefore, the risks to the Great Basin pocket mouse due to these solid materials are expected to be minimal.

The large majority of the solid waste and radionuclide inventory is irradiated reactor parts and not surface contamination and therefore will not migrate. Other buried material, such as rags, paper, demolition waste, and filters, may have surface contamination. However, the nature of the site hydrology (little, if any, natural recharge from precipitation) and low potential for biota intrusion (from lack of soil for growth and depth of burial) diminish the potential for radionuclide inhalation or ingestion.

4.2.1 Summary of Key Uncertainties

The uncertainty in contaminant concentrations for the ecological evaluation is related to the accuracy of the data. For the QRA, uncertainty exists in both the contaminants identified and the exposure concentrations. As for the human health evaluation, the maximum contaminant concentration is used. Uncertainty associated with site-specific information is described in Section 3.0 for the individual sites analyzed.

The QRA models the potential exposure of wildlife suspected to be present in or near the waste site. The issues of concern with regard to ecological risk assessment (particularly qualitative) are the uncertainties in using an assortment of environmental variables in risk modeling. This begins with the source term. If this number is not realistic, no amount of modeling will overcome this deficiency. For example, in the case of the 116-H-4 pluto crib, the maximum reported waste concentration is used as the source term no matter how deep this concentration was found.

Generally, site-specific organisms (e.g., pocket mouse), are identified as being associated with a site, but little if any data may exist concerning transfer of contaminants to site-specific organisms. Often, it is necessary to use biological trophic transfer information for related species.

A significant source of uncertainty in the exposure scenario is the assumptions of uniform waste sites and total contamination of mouse foodstuffs. No provision is made for dilution of

contaminated foodstuff by noncontaminated foodstuff. It was also assumed contaminants were not passed through the digestive system but completely retained (100% absorption efficiency).

To complete the QRA for the 100-HR-2 Operable Unit, it is necessary to use transfer coefficients from non-Hanford-specific plants for modeling the uptake of contaminants from soil-to-plants. The approach does not consider whether roots of a plant actually grow deep enough to contact a contaminant, and the model does not account for reduced concentrations from plant to seed (the bulk of the mouse's diet is seed, and it was assumed the seed concentration is the same as the plant). The pocket mouse food consumption rate is generalized and seasonal behavior (hibernation) that can reduce internal exposure and body burden is not considered.

Uncertainty associated with the receptor (e.g., pocket mouse) accessibility to the waste site is significant with this operable unit. The pocket mouse must have access to the contaminant to be exposed. All of the burial grounds in the 100-HR-2 Operable Unit are maintained free of vegetation, which minimizes the quantity of contaminated foodstuffs and leads to a reduced pocket mouse population and overall risk.

Table 4-1. Summary of Qualitative Risks for the 100-HR-2 Operable Unit.

Waste site	QRA remediation priority in the year 1994		QRA remediation priority in the year 2018		Ecological
	Frequent	Occasional	Frequent	Occasional	EHQ > 1?
118-H-1	medium	low	low	very low	no
118-H-2, 3, 4, Rod Cave	unknown	unknown	unknown	unknown	unknown
118-H-5	high	medium	high	medium	yes
Buried Thimble Site	medium	low	medium	low	no

5.0 SUMMARY

In contrast to a typical LFI report, which recommends those waste sites that should remain candidates for the IRM path and those waste sites that can be eliminated from IRM consideration, this LFI report was prepared for the following purposes:

- Report results of the investigative phase (historical and analogous site information, nonintrusive investigation)
- Identify the contaminant- and location-specific CARs
- Refine the conceptual model
- Provide a qualitative assessment of the risks associated with the sites.

5.1 INVESTIGATIVE PHASE SUMMARY

The steps of the investigative phase for this LFI report for the 100-HR-2 burial grounds involved the following:

- Perform a QRA for the burial grounds
- Assess the waste site conceptual model
- Evaluate site-specific contaminant impact on groundwater
- Identify sites where natural attenuation by the year 2018 may mitigate contamination
- Identify any CAR exceedance for vadose zone contaminants.

The results of these activities are summarized in Table 5-1.

5.1.1 Qualitative Risk Assessment

The QRA provides a risk evaluation for human health and for adverse ecological effects. Human health risks for burial grounds were developed in the QRA using two scenarios: frequent use and occasional use. Based on the ICR, the qualitative risk estimates for the occasional-use scenario presented in Table 5-1 are grouped into high (> 1E-02), medium (> 1E-04 to < 1E-02), low (> 1E-06 to < 1E-04), and very low (< 1E-06) risk categories.

Environmental hazard quotients are calculated as part of the qualitative ecological risk evaluation performed in Chapter 3.0. These are presented in Table 5-1.

5.1.2 Conceptual Model

The conceptual model for the waste sites includes sources of contamination, types of contaminants, nature and extent of contamination in each affected media, known and potential routes of migration, known or potential human and environmental receptors, and the general understanding of the site structure/process (waste generation and handling). This information, originally presented in the 100-HR-2 Work Plan (DOE-RL 1993f), has been revised and is discussed for each waste site in Chapter 3.0. Figure 2-4 presents the known and potential routes of migration and known or potential human and environmental receptors for the operable unit. Table 5-2 presents the revised conceptual model.

5.1.3 Current Impact on Groundwater

The probability of current impact of groundwater was evaluated for each site by comparing groundwater contamination concentrations for monitoring wells located upgradient and downgradient of each specific site, where wells are available. The concentrations of strontium-90, technetium-99, chromium, and nitrate are compared. Groundwater contamination concentrations in a downgradient well that were higher than in an upgradient well indicate current impact to groundwater. Presently, there are no waste or effluent charges in the operable unit. Infiltration may be a driving force for movement of contaminants from the vadose zone to the saturated zone, however, the average annual precipitation and evapotranspiration are about equal. Waste sites near the Columbia River may be affected by changes in groundwater elevations of the uppermost unconfined aquifer, which is known to fluctuate in response to changes in river stage. Contaminant transport modeling was not performed as part of the 100-HR-2 LFI or QRA. The data available are not sufficient to support such modeling.

5.1.4 Potential for Natural Attenuation

The potential for the contaminants at a site to be reduced by natural attenuation (e.g., radioactive decay by the year 2018) may be a consideration at sites where radionuclides with half-lives of 30 years or less are the primary contaminants and external exposure is the only pathway. Sites with excess risk (i.e., greater that 1E-06) attributed to radionuclides with half-lives of 30 years or less (e.g., cobalt-60, cesium-134, tritium, europium-152 and europium-154) have potential for natural reduction of risk through radioactive decay. Natural attenuation is not a consideration for sites contaminated by metals, by radionuclides with a half-life greater that 30 years, or when there are multiple radionuclide exposure pathways.

5.1.5 Corrective Action Requirements

The Washington State MTCA Method B concentrations are potential CARs for soil contamination, as discussed in Section 2.10 and in the *100 Area Feasibility Study, Phase 1 and 2* (DOE-RL 1992a). The MTCA Method B limits are used because they represent a conservative, standardized approach for source units. Table 5-3 lists the Hanford Site background 95% UTL values for metallic constituents in soils and the MTCA Method B guidelines for soil.

5.2 IRM CANDIDATE CONSIDERATIONS

The final selection of IRM sites and priority of action are decisions left to the Tri-Party Agreement signatories. Factors that the Tri-Party Agreement signatories may consider in the selection and prioritization of IRM sites include the following:

- Impact of IRM actions in relation to the environmental impact statement for decommissioning of the 100 Area surplus reactors (DOE 1989)
- Access control
- Relation to the IRM program plan recommendations
- Land use
- Point of compliance
- Time of compliance
- Feasibility
- Bias-for-action
- Threat to human health and the environment.

All burial grounds are IRM candidates as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and with negotiations with the Tri-Party Agreement signatories. Due to the heterogenous nature of the burial ground waste, there is tremendous uncertainty as to contaminant type, concentrations, and extent. Characterization efforts (short of total excavation) will not sufficiently reduce this uncertainty, and if further characterization does occur, it should occur concurrent with remediation. For those sites that are recommended for an IRM, the next step is to evaluate remedial alternatives in a focused feasibility study.

The low priority sites were judged not to pose significant risk to require a streamlined evaluation. Therefore, these sites are not considered for IRMs and will be addressed during the final remedy selection. Information obtained during the investigative phase does not change the priority rating of these sites.

5.2.1 118-H-1 Burial Ground

The 118-H-1 burial ground will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. There are no upgradient wells to this site; therefore, current groundwater impacts cannot be assessed. The human health risks assessed at the analogous site 118-B-1 are low under occasional use and the EHQ is <1. Natural attenuation from radioactive decay by year 2018 will reduce the risk posed by the principal contaminants and associated exposure pathway.

5.2.2 118-H-2 Burial Ground

The 118-H-2 burial ground will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. There are no upgradient wells to this site; therefore, current groundwater impacts cannot be assessed. No soil sampling data have been collected for the 118-H-2 burial ground and there are no analogous sites in the 100 Areas. Surface radiation surveys, however, indicate no current external radiation hazard exists. Without soil sampling, it is difficult to estimate the risk from this site for potential future land use. The conceptual model is incomplete because of the uncertainty regarding the contaminants, the concentrations of contaminants, and the extent of contamination at the 118-H-2 burial ground.

5.2.3 118-H-3 Burial Ground

The 118-H-3 burial ground will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. Data to assess groundwater impact are provided by groundwater analyses for December 1992 through April 1993 sampling rounds. Contaminant concentration data from the downgradient well, 199-H4-46, and the upgradient well, 199-H5-1, were compared, as shown in Figures 3-1 through 3-4. Groundwater samples from well 199-H4-46 have elevated concentrations of strontium-90 and technetium-99 relative to well 199-H5-1. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to well 199-H5-1. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Therefore, it cannot be determined if the 118-H-3 is currently impacting groundwater. No soil sampling data have been collected for the 118-H-3 or any of its analogous sites. Surface radiation surveys, however, indicate no current external radiation hazard exists. Without soil sampling, it is difficult to estimate the risk from this site for potential future land use. The conceptual model at the 118-H-3 burial ground is considered incomplete because of the lack of data regarding the contaminants, the concentrations of contaminants, and the extent of contamination.

5.2.4 118-H-4 Burial Ground

The 118-H-4 burial ground will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. There are no upgradient wells to this site; therefore, current groundwater impacts cannot be assessed. No soil sampling data have been collected for the 118-H-4 or any of its analogous sites. Surface radiation surveys, however, indicate no current external radiation hazard exists. Without soil sampling, it is difficult to estimate the risk from this site for potential future land use. Because of the uncertainty regarding the contaminants, the concentrations of contaminants, and extent of contamination that the 118-H-4 burial ground received, the conceptual model is incomplete.

5.2.5 118-H-5 Burial Ground

The 118-H-5 burial ground will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. Data to assess groundwater impact are provided by groundwater analyses for December 1992 through April 1993 sampling rounds. Contaminant concentration data from well 199-H4-46

(downgradient to this site) and 199-H4-49 (upgradient to this site) were compared, as shown in Figures 3-1 through 3-4. Groundwater samples from the 199-H4-46 monitoring well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient well. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient well. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Therefore, current groundwater impacts from 118-H-5 cannot be assessed. Based on the 116-F-4 analogous site data (DOE-RL 1994a), the human health risk is medium under occasional use and the EHQ is >1. Concentrations of metals and organics in the soil at 116-F-4, 116-DR-2A, and 116-B-3 are assumed to be similar to the contamination at the 116-H-4 site (buried in the 118-H-5 burial ground) and thus are not expected to exceed MTCA Method B guidelines. Natural attenuation (i.e., radioactive decay) by the year 2018 will not mitigate the risk posed by the principal contaminants and associated exposure pathway.

5.2.6 Buried Thimble Site

The Buried Thimble Site will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. Data to assess groundwater impact are provided by groundwater analyses for December 1992 through April 1993 sampling rounds from downgradient well 199-H4-46 and upgradient well 199-H5-1, as shown in Figures 3-1 through 3-4. Groundwater samples from the 199-H4-46 monitoring well have elevated concentrations of strontium-90 and technetium-99 relative to 199-H5-1. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient well. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Therefore, current groundwater impact at this site cannot be determined. The human health risks at the Buried Thimble Site are low, and the EHQ is <1. Natural attenuation (e.g., radioactive decay) by year 2018 will not mitigate the risk posed by the principal contaminants and associated exposure pathway.

5.2.7 105-H Horizontal Control Rod Storage Cave

The 105-H Horizontal Control Rod Storage Cave will remain an IRM candidate as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology. Data to assess groundwater impact are provided by groundwater analyses for December 1992 through April 1993 sampling rounds from downgradient well 199-H4-46 and upgradient wells 199-H4-49 and 199-H3-1, as shown in Figures 3-1 through 3-4. Groundwater samples from the 199-H4-46 monitoring well have elevated concentrations of strontium-90 and technetium-99 relative to the upgradient wells. The chromium and nitrate concentrations were not elevated in well 199-H4-46 relative to the same upgradient wells. The elevated levels of strontium-90 and technetium-99 could be attributed to several waste sites (Table 3-5). Therefore, current groundwater impacts cannot be assessed at this site. No soil sampling data have been collected for this site or any of its analogous sites. Without soil sampling, it is difficult to estimate the risk from this site for potential future land use. Because of the uncertainty regarding the contaminants, the concentrations of contaminants, and the extent of contamination that the 105-H Horizontal Control Rod Storage Cave received, the conceptual model is incomplete.

Table 5-1. IRM Candidate Summary.

Waste sites	QRA remediation priority		Conceptual model	Exceeds CAR	Probable current impact on groundwater	Potential for natural attenuation by 2018	Solid waste burial ground	IRM candidate[a]
	Human health	Ecological						
	Occasional-use scenario	EHQ > 1						
118-H-1	Low	No	Complete	Unknown[b]	Unknown	Yes	Yes	Yes
118-H-2	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-3	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-4	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes
118-H-5	Medium	Yes	Complete	No	Unknown	No	Yes	Yes
Buried Thimble Site	Low	No	Complete	Unknown[b]	Unknown	No	Yes	Yes
105-H Horizontal Control Rod Storage Cave	Unknown	Unknown	Incomplete	Unknown	Unknown	Unknown	Yes	Yes

[a]All burial grounds are IRM candidates as designated in the 100-HR-2 Work Plan (DOE-RL 1993f) and in accordance with negotiations among the DOE, EPA, and Ecology.
[b]Only radiological data were available.

Table 5-2. Conceptual Model of 100-HR-2 Solid Waste Burial Grounds. (2 Sheets)

Site	Structure/process	Contaminant source	Contaminants	Nature and extent of contamination[a]
118-H-1	Burial Ground 700 ft x 350 ft x 20 ft deep	The site received waste consisting of: activated components - dummy elements, process tubing and horizontal control rods; misc. surface contaminated materials - broken hand tools, rags, sweeping compound, light bulbs, sheets of plastic and paper from zones, etc. Misc. waste was sealed in boxes and placed in different trenches than the activated waste.	cobalt-60, europium-152, europium-154, cesium-137, strontium-90, nickel-63, nickel-59, europium-155, plutonium-239/240, tritium, carbon-14, barium-133, calcium-41, and silver-108m.	Soil contamination likely between 2 and 20 ft
118-H-2	Burial Ground 140 ft x 50 ft x 15 ft deep	The east vault received one stainless-steel double-tube with associated hardware (cleaning solutions and misc. capsule components). The west vault was used for disposal of contaminated pipe.	unknown	Soil contamination likely between 3 and 15 ft
118-H-3	Burial Ground uneven polygon with side lengths of approximately 100 ft, 375 ft, 313 ft and 400 ft, It is roughly 20 ft deep	Received sections of contaminated 16-in. pipe used as chutes for removal of thimbles from 105-H, reactor hardware, and components from reactor modification programs.	unknown	Soil contamination likely between 1 and 20 ft
118-H-4	Burial Ground 150 ft x 30 ft x 10 ft deep	Received materials, such as vertical safety rod thimbles and guides, from 105-H during the Ball 3X Program.	cobalt-60, nickel-63, and nickel-59	Soil contamination likely to 10 ft

Table 5-2. Conceptual Model of 100-HR-2 Solid Waste Burial Grounds. (2 Sheets)

Site	Structure/process	Contaminant source	Contaminants	Nature and extent of contamination[a]
118-H-5	Burial Ground 30 ft x 2 ft x 10 ft deep	Received a thimble assembly from the B Experimental Hole from the 105-H X-Level. In 1960, the 105-H Pluto Crib was excavated and placed in this burial ground.	cobalt-60, nickel-63, nickel-59, potassium-40, strontium-90, cesium-137, europium-152, thorium-232, uranium-238, americium-241, europium-154, radium-226, radium-228, thorium-228, technetium-99, uranium 233/234, plutonium 238, and plutonium-239/240, carbon-14, acetone, methylene chloride, toluene, 4-methyl-2-pentanone, 2-butanone, benzene, endrin, barium, cadmium, and silver Semi-volatile organics[b]	Soil contamination likely to 10 ft
105-H Rod Cave	Burial Ground It consists of a concrete lined structure, approximately 40 ft by 25 ft, mostly underground	Suspected to contain contaminated horizontal control rods and possibly other miscellaneous reactor facility components.	unknown	unknown
Buried Thimble Site	Burial Ground It is reportedly 40 ft long	Suspected to contain a vertical safety rod thimble.	cobalt-60, europium-152, europium-154, cesium-137, strontium-90, nickel-63, europium-155, uranium, and plutonium-239/240, nickel-63, and nickel-59	unknown

[a]Lateral extent of contamination is assumed to be equal to the facility dimensions.
[b]Bis(2-ethylhexyl)phthalate, di-n-butylphthalate, di-n-octylphthalate, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene and phenanthrene.

Table 5-3. MTCA Method B and Hanford Site 95% UTL Summary Statistics. (Revised per 1/95 and 8/31/94 MTCA Method B Updates.)

Analyte[a]	MTCA Method B (mg/kg)	95% UTL[b] (mg/kg)
Antimony	32	15.7[c]
Arsenic	60 (1.43)[d]	8.92
Barium	5,600	171
Beryllium	400 (0.23)[d]	1.77
Cadmium	80 (0.164)	0.66[c]
Chromium	400[e]	27.9
Cobalt	N/L	19.6
Copper	2,960	28.2
Lead	U	14.75
Manganese	11,200	612
Mercury	24	1.25
Nickel	1,600	3,120
Selenium	400	5[c]
Silver	400	2.7
Thallium	5.6-7.2[f]	3.7[c]
Vanadium	560	111
Zinc	24,000	79
Molybdenum	400	1.4[c]
Titanium	N/L	3,570
Zirconium	N/L	57.3
Ammonia	N/L	28.2
Alkalinity	N/L	23,300
Silicon	N/L	192
Fluoride	4,800	12
Chloride	N/L	763
Nitrite	8,000	21[c]
Nitrate	128,000	199
Orthophosphate	N/L	16
Sulfate	N/L	1,320

(DOE-RL 1993a)

N/L = Not listed in MTCA human health risk-based Method B formula values table for soil
U = Unavailable
[a]Analytes essentially nontoxic in soil are not listed. These include aluminum, magnesium, iron, calcium, potassium, sodium (DOE-RL 1993b)
[b]95th confidence limit of the 95th percentile of the data distribution.
[c]Limit of detection.
[d]Carcinogen risk-based concentration in parenthesis.
[e]Hexavalent chromium.
[f]Range of risk-based concentrations for thallium compounds.

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APPENDIX A

NONINTRUSIVE INVESTIGATION RESULTS FOR THE 151-H, 128-H-1, AND 1607-H1 WASTE SITES

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DON'T SAY IT --- Write It!

Date: March 3, 1994

TO: N.A. Holman
J.M. Ayres
A.J. Stegun

cc: R.C. Roos

FROM: R.G. McCain
H6-04, 6-0777

SUBJECT: XRF Evaluation of Soil Samples, 100H Area

On may 24, 1993, I accompanied J.M. Ayres and N.A. Holman in a visit to the 1607-H1 site, located in the 100-HR-2 operable unit. A fine-grained grayish soil at this location was suspected of contamination. A sample was obtained of the surface soil at this location. A second sample was obtained from the 184-H Powerhouse ash pit. Both samples were analyzed using the X-Met 880 portable XRF analyzer to detect heavy metals. XRF spectra are attached.

Examination of the spectra do not indicate any anomalous concentrations of heavy metals relative to a composite Hanford background spectra. Both samples appear to be physically similar, and similar XRF spectr are obtained. The likely source of the grayish soil at 1607-H1 is the coal ash from the power plant.

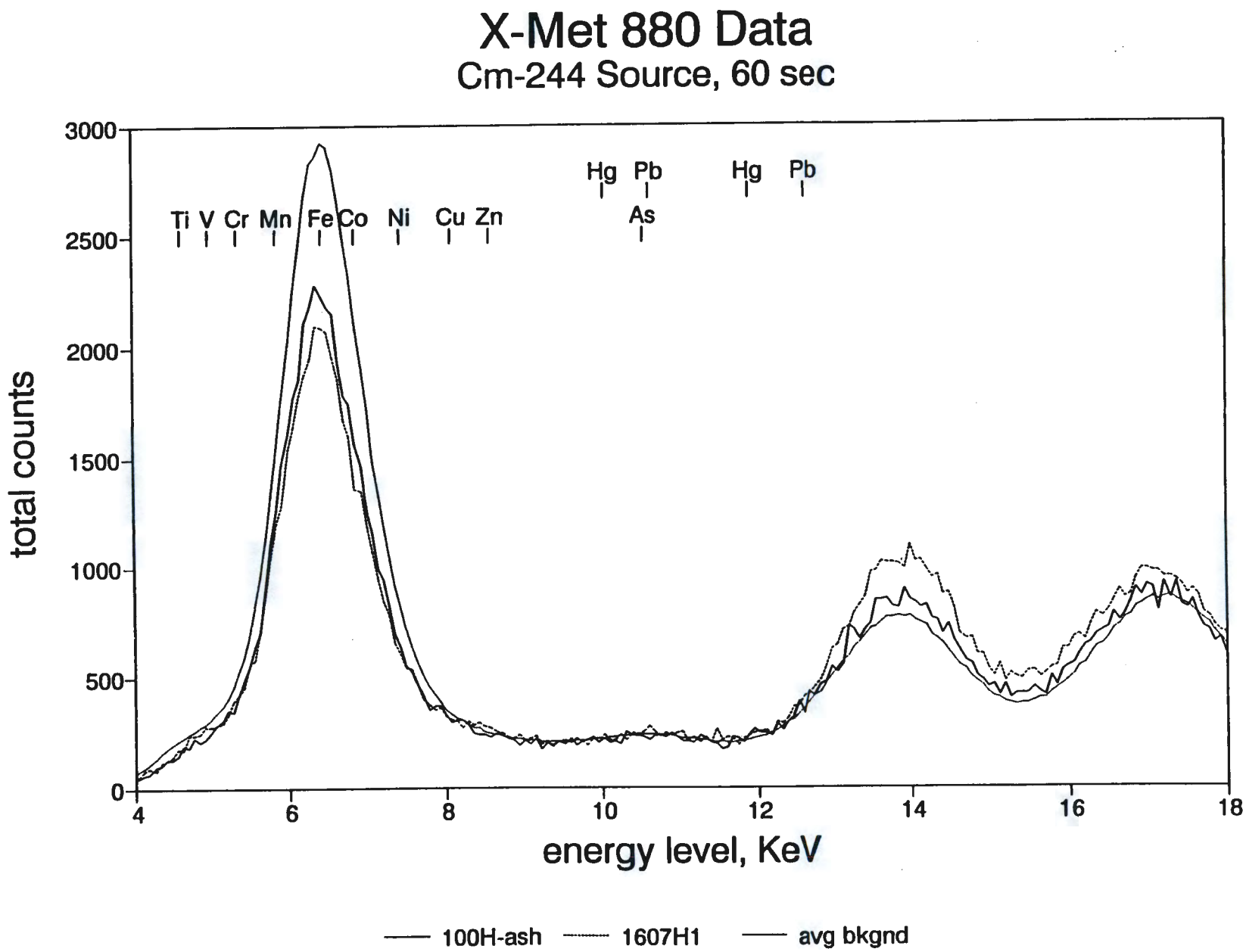


Figure A-1. X-Met 880 Data.

Table A-1. 151-H Primary Electrical Substation Sampling Data.

Constituent	Maximum Concentration Ug/kg Sampled December 1991 0-1 ft.	Qualifier
AROCLOR		
-1016	2.00E+01	U
-1221	3.90E+01	U
-1232	2.00E+01	U
-1242	2.00E+01	U
-1248	2.00E+01	U
-1254	3.50E+02	
-1260	1.20E+03	JN

U = Undetected

J = Concentration estmated

N = Presumtive evidence of presence of material

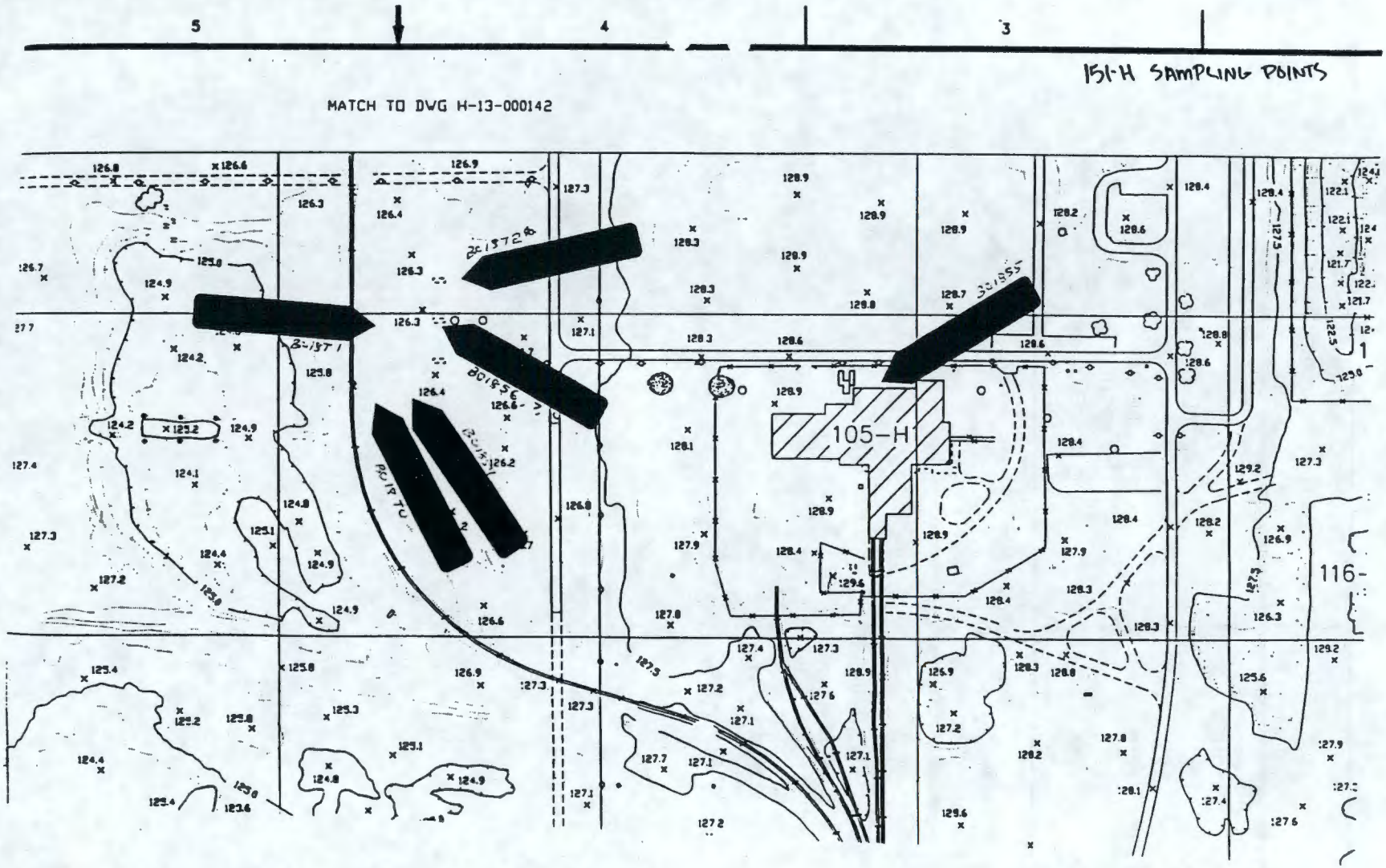


Figure A-2. Sampling Locations.

Westinghouse Hanford Company | **Internal Memo**

From: Site Remediation Management Section 81353-94-002
Phone: 372-3314 H6-04
Date: January 14, 1994
Subject: SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT

To: N. A. Homan H6-02

cc: I. D. Jacques H6-04
R. P. Henckel H6-02
R. C. Roos H6-04
R. G. McCain H6-04
RBK File/LB

The Site Remediation Management Section, Soil Gas Survey Team, has completed the requested soil-gas investigation at the 128-H-1 Burn Pit. The results of that investigation are detailed in the attached report.

If you have any questions or require any further information, please feel free to contact me at 372-3314 or I. D. Jacques at 376-3306.

Richard Kerkow

R. B. Kerkow, Engineer
Site Remediation
Management Section

kla

Attachment

Soil-Gas Survey at the 128-H-1 Burn Pit (Sheet 1).

SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT
January 14, 1994

INTRODUCTION

This document reports the results of a soil-gas survey conducted by the Site Remediation Management, Soil-gas Investigation Team, in a burn pit located in the eastern portion of 128-H-1, which is in the 100-HR-2 Operable Unit. The soil-gas survey was conducted in support of the investigative strategy established for low priority waste sites as discussed in the 100-HR-2 work plan (DOE, 1993), and in the scoping meeting minutes for development of the work plan.

The soil-gas survey was requested to determine if significant quantities of volatile organic compounds (VOCs) or landfill gases (LFGs) could be detected in the vadose zone associated with the burn pit. The investigation consisted of installing 18 soil-gas probes into the region of the vadose zone 4 to 6 feet below the surface. Soil-gas vapors were field screened using two total-organic-vapor monitoring instruments, and an infrared landfill gas analyzer. Soil-gas samples were also collected and analyzed using two portable gas chromatographs (GCs). No VOC contaminants were detected by the total-vapor instruments or by the portable GCs, and the landfill gas analyzer LFG readings were at or near ambient levels.

SITE DESCRIPTION

The investigation was performed in the eastern portion of 128-H-1 (Figure 1). The site is an area approximately 50 feet wide and 450 feet long which has been excavated to a depth of about 10 feet below grade. The location is known to have been used as a burn pit and is suspected of containing residue from painting materials and paint solvents. The surface of the burn pit is comprised of a thin layer of fly-ash (less than 1-inch thick). Under the fly ash layer is river rock cobble (approximately 2-inch to 6-inch diameter river rock). The river rock cobble is characteristic of the vadose zone in the 100 Areas and has been described geologically as - the gravel with intercalated sand and silt layer of the Hanford Formation (DOE, 1993). Depth to ground water in this vicinity is estimated to be 25 to 30 feet based on existing ground water wells located in the 100 H Area.

PROBE INSTALLATION

Eighteen soil-gas probes were installed in the study area at depths of 4 to 6 feet (Figure 2). The probes were installed in accordance with Environmental Investigations Instruction (EII) 5.9, "Soil-Gas Sampling", (WHC 1988). Each probe consists of a dedicated, perforated stainless-steel point connected to an 8-foot section of ¼-inch outside diameter (OD) Teflon (a trade-mark of E. I. du Pont de Nemours & Company) tubing. The exposed end of the tubing was capped with a plastic cap prior to installation, and the soil around the tubing was firmly packed to minimize the annular space after installation. The location and depth of each probe was documented, at the time of installation, in field logbook EFL-1117, (WHC 1993b). Probe location coordinates correspond to the coordinate grid used for the Ground Penetrating Radar (GPR) Survey, conducted by the Surface Geophysics Team of WHC Geophysics on November 5, 1993, (WHC 1993c).

FIELD SCREENING INSTRUMENTS AND METHODOLOGY

Initial field screening was performed on November 29 and 30, 1993. Each probe was screened for total-VOC levels using three field screening instruments: a total-vapor photo-ionization detector (PID), a total-vapor flame ionization detector (FID), and an infrared landfill gas analyzer (IRGA). The total-vapor PID instrument is a MicroTip HL-2000 (a trademark of Photovac International, Inc.) Photoionization Detector equipped with a 10.6-eV lamp. The total-vapor FID is an OVA 128 Organic Vapor Analyzer (a trademark of Foxboro Company) Flame Ionization Detector. The IRGA is a Geo Group, Model GA-90, Infrared Gas Analyzer (a trademark of the Geotechnical Instrument Company).

The field screening instruments were calibrated, before use (daily), as follows:

- The PID was zeroed using a laboratory grade zero air standard. The instrument span was set using a standard calibration mixture of 101 ppm isobutylene (C_4H_8) in air, and the instrument response was verified using a standard calibration mixture of 9.51 ppm isobutylene in air.

- The FID was zeroed using a laboratory grade zero air standard, and the preset factory calibration was checked using standard calibration mixtures of 9 ppm and 95 ppm methane (CH_4) in air.

- The IRGA was set to the preset factory calibration settings and the instrument response was checked using a standard calibration mixture of 4.24% methane (CH_4), 5.40% carbon dioxide (CO_2), and 9.55% oxygen (O_2) in nitrogen.

Instrument readings were obtained by connecting each instrument directly to the soil-gas probe, teflon tube, using a 1-inch section of Tygon (a trademark of the Norton Company) tubing. The following methodology was used for collecting field-screening measurements:

- First, the IRGA instrument was connected to the probe and allowed to pump for 60 seconds. This time was sufficient to draw about 500 mL of soil-gas vapor thereby providing a purge volume of approximately 6 tube-volumes. The IRGA instrument reading was then recorded.

- Second, the PID instrument was attached to the probe and allowed to pump for 15 seconds. The PID instrument response was then recorded.

- Finally, the FID instrument was attached to the probe. The FID instrument response was noted for 5 seconds and then recorded. One probe (probe #6 - N380 E140) did not allow sufficient flow of oxygen to support the FID flame. In this case, the instrument was disconnected from the probe before the flame was extinguished, and the response was recorded as "No flow".

Soil-Gas Survey at the 128-H-1 Burn Pit (Sheet 3).

GAS CHROMATOGRAPHY INSTRUMENTS AND METHODOLOGY

On December 7 and 8, 1993, soil-gas samples were collected and analyzed using two portable Gas Chromatographs (GCs). Vapor samples of approximately 500 mL volume were collected in 1-L tedlar bags. The samples were collected via the outlet port of an Organic Vapor Monitor (OVM) (a trademark of Thermo Environmental). The battery powered pump on this device provides a flow rate of approximately 500 mL per minute. Each soil-gas probe was purged for a minimum of 60 seconds before the bag sample was drawn.

The samples were transported to the 300 area for GC analysis. One GC used is a Photovac 10S Plus (a trademark of Photovac International, Inc.) portable gas chromatograph (10S Plus). The 10S Plus is a self-contained, battery-powered portable gas chromatograph that incorporates a 10-meter, non-polar, wide-bore, capillary column and a photoionization detector (PID) which utilizes a 10.6 eV lamp. The PID is a broad-spectrum detector that is particularly sensitive to aromatic compounds, and is also able to detect many ketones and chlorinated compounds. Each sample aliquot was drawn directly from the sample bag for 10-seconds, transferring a volume of 500 uL via the sample loop to the GC column. The 10S Plus was operated at an isothermal column temperature of 40 °C and using ultra high-purity air carrier gas at a flow rate of 8 mL/min.

The 10S Plus makes qualitative identification of compounds by comparing observed retention times with an established method library of VOC compounds. Quantification is based on peak area, as adjusted by appropriate response factors for each compound of interest. Three-point calibration curves have been developed for a wide variety of VOC contaminants commonly detected at hazardous waste sites. At the beginning of each sampling day, the 10S Plus was calibrated using a gas calibration standard containing 1 ppm each of benzene, toluene, ethyl benzene and o-xylene. The acceptable calibration tolerance is ± 10% (ASTM 1993).

The other GC used is a Sentex Scentograph (a trademark of Sentex Systems Incorporated) portable gas chromatograph. The Scentograph is a self-contained, battery-powered portable gas chromatograph that incorporates a 30-meter, non-polar, wide-bore, capillary column and an argon ionization detector (AID). The AID is a broad-spectrum detector with an effective ionization potential of 11.7 eV. Each sample aliquot is drawn into the Scentograph from the sample bag by an on-board pump. The sample is routed via a tenax trap preconcentrator then desorbed at high temperature into the GC column for separation. The Scentograph was operated using an isothermal column temperature of 60 °C and using high-purity argon carrier gas at a flow rate of 9.4 mL/min.

The Sentograph makes qualitative identification of compounds by comparing observed retention times with an established method library of VOC compounds. Quantification of compounds is based on comparison of an observed peak area and a peak of known concentration in the method library. A calibration standard containing carbon tetrachloride (CCl_4), chloroform (TCM), trichloroethylene (TCE), 1,1,1-trichloroethane (111-TCA), 1,1,2-trichloroethane (112-TCA), and tetrachloroethylene (PCE) was prepared each sampling day by adding headspace vapor above laboratory-grade pure chemical standards to a tedlar bag containing 1.5 L high-purity air. The calibration standard was analyzed to establish the method library.

RESULTS AND DISCUSSION

Probe Installation

Eighteen probes were installed in the investigation. All probes were driven beyond the minimum depth of 4-feet, and eight of the eighteen probes were driven beyond a depth of 5-feet. The deepest probe is probe #9 at 5.5 feet. One probe, probe #6, appears to be completely plugged, as it would not allow enough flow to permit sampling by the FID or IRGA. Several attempts to unplug probe #6 were unsuccessful indicating that the probe tip may have been damaged during installation causing the inlet to become irreversibly plugged. Replacement of probe #6 was contemplated, but was not considered cost effective or necessary based on data from surrounding probes. Another probe, probe #17, was found to be partially plugged, with silt, when it was first sampled. This probe was successfully unplugged and most of the silt was removed with suction. The remaining sixteen probes provided normal flow, when sampled, and appear to be functioning normally.

Field Screening Results

No significant levels of VOCs or LFGs were detected during the initial field screening phase of the investigation. Field Screening results are summarized on Table 1-1. The total-vapor PID readings of up to 0.3 ppm are not considered significant because they are not supported by any of the FID or GC data. Additionally, the PID readings were discounted because the PID detector is known to be affected by high moisture conditions (weather conditions at the time of field screening consisted of low clouds, fog and light drizzle with humidity at or near 100%). FID readings were reported as "negative-response" (N-R) because the instrument gauge moved from an arbitrary ambient setting of 3.0 ppm to a reading of approximately 1.5 ppm when connected to the probe tubing (a net change of negative 1.5 ppm). IRGA readings indicated no LFG levels of concern. No methane gas was detected at any of the probes and the oxygen level readings were at or near ambient conditions. Carbon dioxide readings showed slightly elevated levels at probes 5, 7, 8, 9 and 10, with probe 9 showing the highest level at 1.3% (v/v). Carbon dioxide gas, in the vadose zone, is generally produced as a by product of microbial decomposition of organic materials. The carbon dioxide readings observed in this investigation may indicate some microbial activity in this region of the burn pit, but are not considered significant enough to warrant further study.

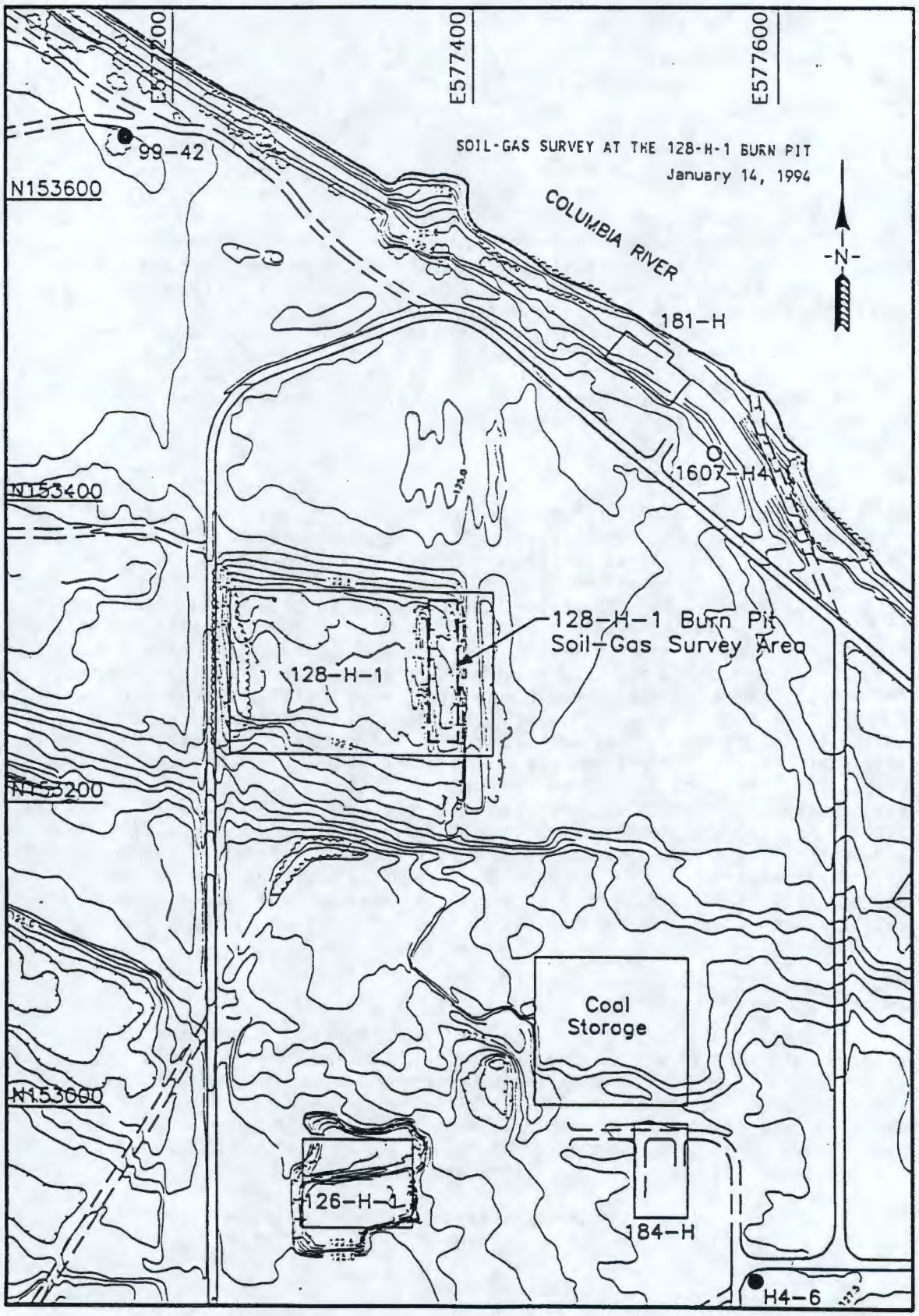
Gas Chromatography Results

No VOC contaminants were detected by gas chromatograph, in excess of the minimum detection levels established for the GCs used in this survey. Minimum GC detection levels for a number of VOCs commonly associated with hazardous waste sites are identified on Table 1-2, *Soil-Gas Analytes for the 128-H-1 Burn Pit Investigation*. Minimum detection levels were established for each contaminant by ensuring that reported values are greater than at least twice the baseline noise level on the instrument (ASTM 1993).

Quality control samples for the GC analysis included: equipment blanks, ambient air samples, field duplicate samples, and calibration standards.

Soil-Gas Survey at the 128-H-1 Burn Pit (Sheet 5).

Figure A-3 Location of the 128-H-1 Burn Pit



GEN\010394-B

Figure A-3. Location of the 128-H-1 Burn Pit.

REFERENCES

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Figure A-4. Soil-Gas Probe Locations in the 128-H-1 Burn Pit.

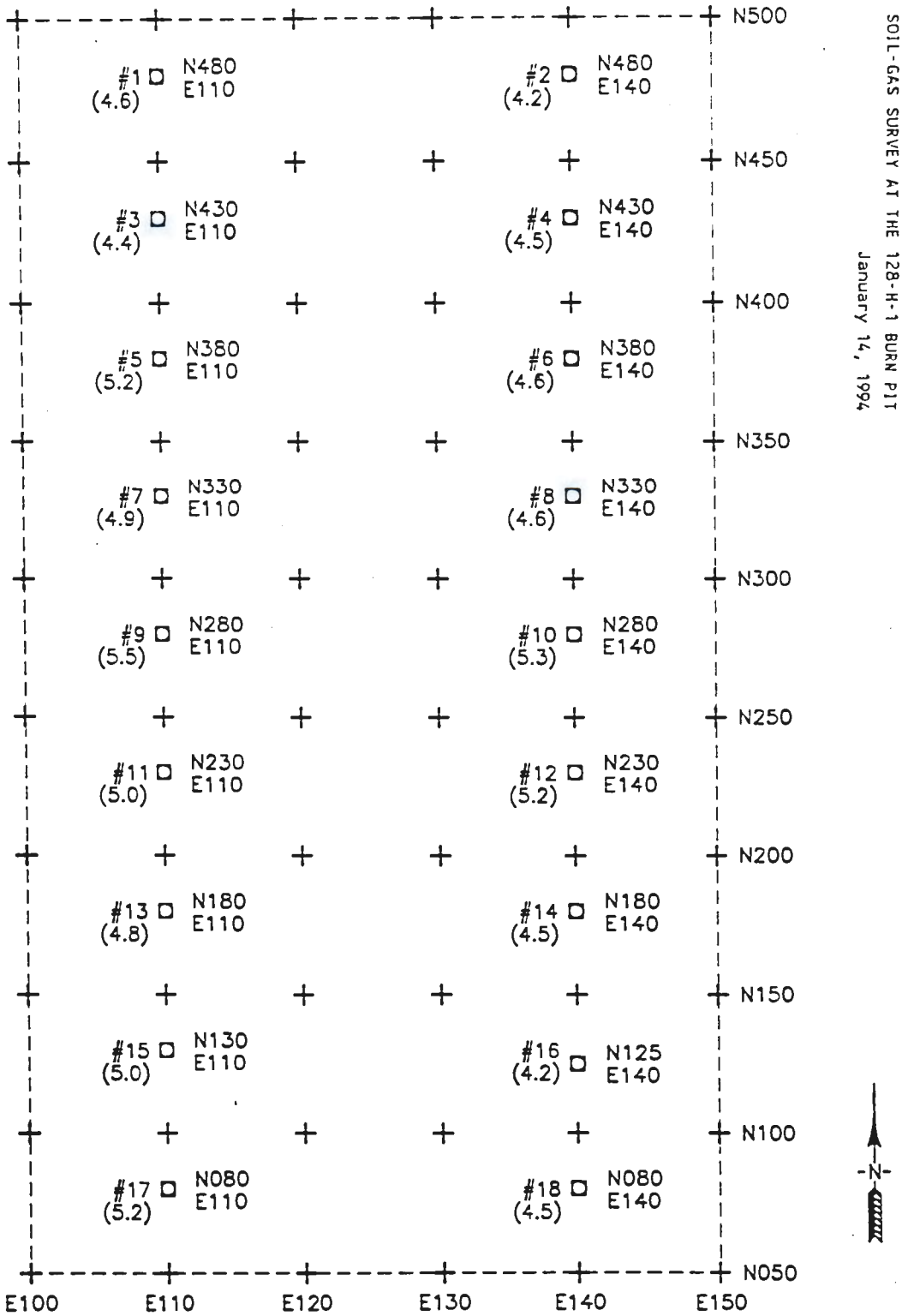

Table A-2. Field Screening Results for the 1280-H-1 Burn Pit Investigation.

SOIL-GAS SURVEY AT THE 128-H-1 BURN PIT
January 14, 1994

Probe #	GPR Coordinates		Depth (feet)	Micro-Tip PID (ppm)	OVA-128 FID (ppm)	GEO TECH - IRGA CH4 (%)	CO2 (%)	O2 (%)
1	N 480	E 110	4.6	0.1	N-R	0.0	0.2	21.5
2	N 480	E 140	4.2	0.0	N-R	0.0	0.2	21.5
3	N 430	E 110	4.4	0.0	N-R	0.0	0.1	21.6
4	N 430	E 140	4.5	0.0	N-R	0.0	0.1	21.6
5	N 380	E 110	5.2	0.1	N-R	0.0	0.3	21.6
6	N 380	E 140	4.6	0.0	No flow	NA	NA	NA
7	N 330	E 110	4.9	0.3	N-R	0.0	0.5	21.3
8	N 330	E 140	4.6	0.0	N-R	0.0	0.4	21.3
9	N 280	E 110	5.5	0.0	N-R	0.0	1.3	20.9
10	N 280	E 140	5.3	0.3	N-R	0.0	0.4	21.3
11	N 230	E 110	5.0	0.2	N-R	0.0	0.2	21.3
12	N 230	E 140	5.2	0.3	N-R	0.0	0.2	21.3
13	N 180	E 110	4.8	0.1	N-R	0.0	0.2	21.3
14	N 180	E 140	4.5	0.2	N-R	0.0	0.0	21.4
15	N 130	E 110	5.0	0.1	N-R	0.0	0.1	21.3
16	N 125	E 140	4.2	0.0	N-R	0.0	0.1	21.4
17	N 080	E 110	5.2	0.0	N-R	0.0	0.1	21.4
18	N 080	E 140	4.5	0.0	N-R	0.0	0.1	21.4

NOTES: N-R = Negative response on FID (indicator needle moved from 3 ppm to 1.5ppm when attached to soil-gas tubing)

NA = Not available (the pump motor on the Geo Tech - IRGA switched OFF automatically due to lack of flow)

Table A-3. Soil-Gas Analytes for the 128-H-1 Burn Pit Investigation.

Analyte	CAS Number	Chemical Formula	Molecular Weight	I.P. (eV)	Minimum Detection
Acetone	67-64-1	CH_3COCH_3	58.08[1]	9.69[2]	50 ppb [P]
Benzene	71-43-2	C_6H_6	78.11[2]	9.24[3]	50 ppb [P]
Carbon tetrachloride	56-23-5	CCl_4	153.82[2]	11.47[2]	150 ppb [S]
Chloroform	67-66-3	$CHCl_3$	119.38[2]	11.42[2]	200 ppb [S]
1,2-dichloroethane	107-06-2	$ClCH_2CH_2Cl$	98.96[2]	11.05[2]	200 ppb [P]
cis-1,2-dichloroethylene	540-59-0	$ClCH=CHCl$	96.94[2]	9.65[3]	50 ppb [P]
dichloromethane (methylene chloride)	75-09-2	CH_2Cl_2	84.93[2]	11.35[2]	50 ppb [P]
Ethylbenzene	100-41-4	$C_6H_5CH_2CH_3$	106.2[2]	8.76[2]	50 ppb [P]
Methyl Ethyl Ketone	78-93-3	$CH_3COCH_2CH_3$	72.1[1]	9.54[2]	50 ppb [P]
Methyl Isobutyl Ketone	108-10-1	$CH_3COCH_2CH(CH_3)_2$	100.2[1]	9.30[2]	50 ppb [P]
1,1,2,2-Tetrachloroethane	79-34-5	$CHCl_2CHCl_2$	167.9[2]	11.10[3]	250 ppb [S]
Tetrachloroethylene	127-18-4	$Cl_2C=CCl_2$	165.83[2]	9.32[3]	50 ppb [S]
Toluene	108-88-3	$C_6H_5CH_3$	92.11[2]	8.82[2]	50 ppb [P]
1,1,1-Trichloroethane	71-55-6	CH_3CCl_3	133.40[2]	11.00[3]	100 ppb [S]
1,1,2-Trichloroethane	79-00-5	$CHCl_2CH_2Cl$	133.40[2]	11.00[3]	50 ppb [S]
Trichloroethylene	79-01-6	$ClCH=CCl_2$	131.39[2]	9.45[3]	50 ppb [S]
m-xylene	1330-20-7	$C_6H_4(CH_3)_2$	106.2[2]	8.56[2]	50 ppb [P]
o-xylene	1330-20-7	$C_6H_4(CH_3)_2$	106.2[2]	8.56[2]	50 ppb [P]

ppb [P] = Photovac 10s Plus, portable GC with PID (10.6 eV lamp) and 10 meter capillary column
ppb [S] = Sentex Sentograph, portable GC with AID and 30 meter capillary column

1. Montgomery, J.H., and L.M. Welkom, 1989, Groundwater Chemicals Desk Reference. Lewis Publishers, Inc., Chelsea, Michigan.

2. Verschueren, K., 1983, Handbook of Environmental Data on Organic Chemicals. Second Edition, Van Nostrand Reinhold, New York.

3. NIOSH, 1990, Pocket Guide to Chemical Hazards. National Institute for Occupational Safety and Health, U.S. Department of Health and Human Services, Washington, D.C.

Table A-4. 128-H-1 Burn Pit Soil Gas Sampling Data.

Analyte	Minimum Detection Limit (ppb)**
	Sampled December 1993
Acetone	50 (a)
Benzene	50 (a)
Carbon tetrachloride	150 (b)
Chloroform	200 (b)
1,2-dichloroethane	200 (a)
cis-1,2-dichloroethylene	50 (a)
dichlormethane	50 (a)
Ethylbenzene	50 (a)
Methyl Ethyl Ketone	50 (a)
Methyl Isobutyl Ketone	50 (a)
1,1,2,2-Tetrachloroethane	250 (b)
Tetrachloroethylene	50 (b)
Toluene	50 (a)
1,1,1 - Trichlorethane	100 (b)
1,1,2-Trichloroethane	50 (b)
Trichloroethylene	50 (b)
m-xylene	50 (a)
o-xylene	50 (a)

**No analyte measured above minimum detection limits

(a) = Photovac 10s Plus (a trademark of Photovac International Inc), portable GC with PID (10.6 eV lamp) and 10 meter capillary column

(b) = Sentex Sentograph (a trademark of Sentex System Inc), portable GC with AID and 30 meter capillary column

Table A-5. 116-H-4 Pluto Crib Analogous Site Borehole Sampling. (2 Sheets)

Maximum concentration	116-C-2A	116-F-4	116-B-3	116-D-2A	95% UTL (c)
INORGANICS (a)	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Barium	BB	208	BB	BB	171
Cadmium	2.2	U	1.8	U	0.66 (d)
Chromium	235	BB	44.5	BB	27.9
Silver	-	BB	3	BB	2.7
Zinc	188[JE]	BB	BB	BB	79
VOLATILE ORGANICS	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
2-Butanone	NA	22	5[J]	U	NR
4-Methyl-2-pentanone	NR	U	3[J]	U	NR
Acetone	NA	14	40	U	NR
Benzene	NA	U	1[J]	U	NR
Methylene Chloride	NA	5[J]	U	3[J]	NR
Toluene	NA	13	U	2[J]	NR
SEMI-VOLATILE	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Anthracene	NA	U	27[J]	U	NR
Benzo(a)anthracene	NA	U	160[J]	U	NR
Benzo(a)pyrene	NA	U	97[J]	U	NR
Benzo(b)fluoranthene	NA	U	100[J]	U	NR
Benzo(k)fluoranthene	NA	U	130[J]	U	NR
bis(2-Ethylhexyl)phthalate	NA	800	U	U	NR
Chrysene	NA	U	190[J]	U	NR
Di-n-butylphthalate	NA	280[J]	U	U	NR
Di-n-octylphthalate	NA	170[J]	U	U	NR
Fluoranthene	NA	U	310[J]	U	NR
Phenanthrene	NA	U	120[J]	U	NR
PESTICIDES/PCB	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Endrin	NA	U	U	16[J]	NR
RADIONUCLIDES (b)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Carbon-14	63[(R)(J)]	U	3.58[J]	<1	NR
Potassium-40	23[(R)]	12	U	13.4[J]	NR
Cobalt-60	210[(R)]	<1	U	<1	NR
Nickel-63	5500[(R)(J)]	NA	NA	NA	NR
Strontium-90	92[(R)(J)]	1,500	39.2[J]	26	NR
Cesium-137	U	1,800	78.58	105[J]	NR
Europium-152	690[(R)]	16	U	6.87[J]	NR
Europium-154	73[(R)]	U	U	5.01[J]	NR
Europium-155	4.9[(R)]	NA	U	U	NR
Radium-226	<1	<1	U	13[J]	NR

Table A-5. 116-H-4 Pluto Crib Analogous Site Borehole Sampling. (2 Sheets)

Maximum concentration	116-C-2A	116-F-4	116-B-3	116-D-2A	95% UTL (c)
RADIONUCLIDES (b)	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
Thorium-232	<1	1.4[J]	U	NA	NR
Uranium-238	<1	1.0	U	<1	NR
Plutonium-239/240	<1	130[J]	NR	1.0[R]	NR
Americium-241	<1	12	<1	<1	NR

a = Inorganic values were screened against Hanford Site background 95% UTL (Table 2-2), Region X excluded elements.
b = Only radionuclides greater than 1 pCi/g were reported.
c = 95% confidence limit of the 95th percentile of the data distribution.
d = Value reported is limit of detection.
E = Estimated value.
J = Value is estimated, concentration less than contract required detection limit.
(J) = Estimated value, qualified by validators for administrative reasons due to incomplete paperwork transfer, revalidation of data underway.
R = Value marked as rejected in validation report.
(R) = Rejected by validators for administrative reasons due to incomplete paperwork transfer, used per WHC instructions, revalidation of data underway.
NR = Not reported.
U = Not detected.
BB = Concentration less than 95% UTL.
NA = Not analyzed.
Analogous site data taken from associate LFI reports (DOE-RL 1993f, 1993e, 1994).
UTL = Upper threshold limit.
LFI = Limited Field Investigation.

Table A-6. 116-F-4 Soil Sampling - Radionuclide Analysis Results (pCi/g) (3 Sheets).

Radionuclides			Th-232			U-235			U-238			U-233/234			Ra-226			Ra-228			Th-228			Pu-238		
Performance Limit						15			60																	
Lift #	Coordinate	Sample #	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q
1	N2/W2	B09790	0.86	0.16		0.035	0.071	U	1.1	0.39		0.7	0.31		0.74	0.074		0.86	0.18		0.88	0.041		-0.00	0.034	U
	W1/S2	B09791	0.92	0.85		0.078	0.053	U	0.83	0.21		0.85	0.21				U	0.92	0.85				U	0.65	0.13	
	S2/E2	B09793	0.81	0.12		0.056	0.056	U	0.46	0.19		0.41	0.19		0.56	0.06		0.81	0.12		0.75	0.046		-0.01	0.026	U
	S1/S2	B09792	0.69	0.11		0	0.074	U	0.55	0.26		0.49	0.26		0.47	0.06		0.69	0.11		0.69	0.035		0.017	0.023	U
2	N1	B09781	0.58	0.17		0.071	0.072	U	0.41	0.24		0.47	0.25		0.46	0.13		0.58	0.17		0.61	0.078		-0.01	0.078	U
	N3	B09782	0.68	0.18		0.059	0.059	U	0.31	0.2		0.53	0.25		0.46	0.072		0.68	0.18		0.59	0.044		0	0.046	U
	S1	B09783	0.9	0.29		0.071	0.072	U	0.47	0.25		0.67	0.31		0.4	0.18		0.9	0.29		0.73	0.2		0.02	0.035	U
3	N1	B09795	0.67	0.24		0.009	0.028	U	0.22	0.063	J	0.25	0.071	J	0.41	0.098		0.67	0.24		0.55	0.059		0.003	0.018	U
	D1	B09796	0.63	0.22		0.012	0.016	U	0.17	0.046	J	0.21	0.053	J	0.64	0.15		0.63	0.22		0.71	0.13		-0.01	0.018	U
	W3	B09797	0.62	0.17		0.025	0.02	U	0.25	0.069	J	0.22	0.068	J	0.43	0.076		0.62	0.17		0.57	0.042		-0.02	0.018	U
	E2	B09798	0.59	0.18		0.056	0.056	U	0.48	0.15		0.37	0.14		0.42	0.093		0.59	0.18		0.59	0.048		-0.01	0.032	U
4	N1	B097B5			U	0.11	0.047	J	1.6	0.17		1.6	0.17				U	NA					U	2.7	0.48	
	N3	B097B2			U	0.042	0.028	J	0.51	0.097		0.5	0.097				U			U			U	0.095	0.033	
	S1	B097B3			U	0.34	0.079		3.9	0.34		4	0.35				U	NA					U	6.1	0.32	
	00	B097B4			U	0.14	0.056	J	2.4	0.26		2.4	0.26				U			U			U	3.7	0.63	
5	D4(W1/S1)	B097B9	0.66	0.33		0.032	0.038	U	0.59	0.12		0.56	0.12		0.57	0.46		0.66	0.33				U	0.098	0.041	
	D4(W1/S1)	B097C0	1	0.37		0.015	0.029	U	0.45	0.11		0.46	0.11				U	1	0.37				U	0.065	0.039	
	D4(W1/S1)	B097C1	NA					U	0.097	0.026		NA			2.75	1.27		NA			0.527	0.124		NA		
6	E2	B097C8	0.61	0.17		0.039	0.039	U	0.48	0.17		0.51	0.2		0.52	0.15		0.61	0.17		0.5	0.085		0.035	0.024	J
	S2	B097C9			U	0.04	0.034	J	0.82	0.13		0.7	0.12				U			U			U	0.12	0.038	
	S3	B097D0	0.65	0.17		0.057	0.076	U	0.54	0.2		0.68	0.23		0.46	0.1		0.65	0.17		0.63	0.068		0	0.018	U
7	N2	B09787	0.52	0.21		0.037	0.05	U	0.47	0.15		0.43	0.15		0.42	0.073		0.52	0.21		0.62	0.1		0.008	0.026	U
	S2	B09786	2.3	2.1		0.064	0.034	J	1.5	0.17		1.4	0.16		1.5	1.3		2.3	2.1		2	1.4		0.21	0.042	
	W2	B09788	0.58	0.26		0	0.038	U	0.38	0.16		0.53	0.2		0.4	0.11		0.58	0.26		0.69	0.092		0.006	0.025	U
8	00	B09F13	0.49	0.2		0.055	0.055	U	0.41	0.14		0.32	0.14		0.41	0.084		0.49	0.2		0.62	0.056		0.01	0.028	U
	S3	B09F14	0.77	0.2		0	0.038	U	0.51	0.19		0.43	0.18		0.39	0.11		0.77	0.2		0.55	0.064		0.004	0.028	U
	S2	B09F17	0.84	0.2		0.004	0.022	U	0.5	0.082	B	0.58	0.095		0.62	0.17		0.84	0.2		0.73	0.18		0.008	0.033	U
9	N3	B09F22	0.71	0.23		0.042	0.034	J	0.44	0.087		0.45	0.087		0.49	0.094		0.71	0.23		0.75	0.07		-0.00	0.013	U
	00	B09F21	0.58	0.23		0.066	0.035	J	0.56	0.099		0.65	0.11		0.42	0.093		0.58	0.23		0.59	0.055		0	0.007	U
	W2/S2	B09F20	0.62	0.22		0.01	0.034	UX	0.42	0.096		0.5	0.12	X	0.43	0.12		0.62	0.22		0.93	0.11		-0.01	0.006	U

NA: Not Available

Table A-6. 116-F-4 Soil Sampling - Radionuclide Analysis Results (pCi/g) (3 Sheets).

Radionuclides			Radionuclides				Am-241		Co-60			Cs-137			Eu-152			Eu-154			K-40			Pu-239/240			Sr-90			Tc-99		
Performance Limit			Performance Limit				20		1			3			3			3						75			13			1750		
Lift #	Coordinate	Sample #	Lift #	Coordinate	Sample #	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q
1	N2/W2	B09790	1	N2/W2	B09790	0.006	0.011	U	0.048	0.03	J	0.19	0.028				U			U	11	0.67		0.027	0.021	U	-0.04	0.7	U	0.21	0.11	U
	W1/S2	B09791		W1/S2	B09791	5.3	0.26		0.27	0.12		1200	4		12	3.1		1.1	0.52		11	2.1		59	5.8		650	38		1.6	0.26	B
	S2/E2	B09793		S2/E2	B09793	-0.04	0.089	U			U	0.15	0.036				U			U	17	0.82		0.022	0.013	J	-0.21	0.72	U	0.22	0.14	U
	S1/S2	B09792		S1/S2	B09792	0.005	0.011	U			U	1.1	0.05				U			U	12	0.62		0.058	0.023		0.6	0.89	U	0.17	0.18	U
2	N1	B09781	2	N1	B09781	0.026	0.021	J			U	21	0.28				U			U	14	0.96		0.19	0.07		0.93	0.79	J	1.6	0.17	
	N3	B09782		N3	B09782	-0.01	0.011	U			U	0.17	0.042				U			U	14	0.88		0.018	0.028	U	-0.16	0.83	U	0.17	0.088	U
	S1	B09783		S1	B09783	0.1	0.043		0.34	0.067		54	0.47		0.42	0.27				U	15	1		0.83	0.12		5.6	0.71		0.2	0.11	U
3	N1	B09795	3	N1	B09795	0.005	0.022	U			U	3.4	0.12				U			U	16	1.1		0.045	0.024	J	0.46	0.24	U	0.22	0.1	J
	D1	B09796		D1	B09796	0.007	0.026	U			U	21	0.29				U			U	14	0.99		0.09	0.028		1.7	0.36	J	0.086	0.068	U
	W3	B09797		W3	B09797	0.003	0.016	U			U	0.58	0.056				U			U	14	0.85		0.005	0.009	U	0	1.6	U	0.11	0.13	U
	E2	B09798		E2	B09798	0.006	0.034	U			U	2.6	0.092				U			U	17	0.92		0.038	0.028	J	0.8	2.2	J	0.027	0.088	U
4	N1	B097B5	4	N1	B097B5	24	1.7		17	1.6		3900	18		62	11		5.8	2.5				U	240	9.8	B	2400	180		0.72	0.44	U
	N3	B097B2		N3	B097B2	0.99	0.1				U	180	4		3.7	2.8				U	11	6.4		8.8	0.41	B	83	16		0.11	0.12	U
	S1	B097B3		S1	B097B3	96	12		54	3.1		6300	27		120	17		9.9	4.8		12	11		530	21	B	6400	140		2.7	0.82	
	00	B097B4		00	B097B4	38	2.3		31	2.4		5300	22		80	17		13	3.8		13	6.1		330	15	B	3700	88		1	0.55	
5	D4(W1/S1)	B097B9	5	D4(W1/S1)	B097B9	0.55	0.08				U	110	1.1		1.2	0.89				U	13	1.6		5.8	0.42		78	3.4		-0.02	0.11	U
	D4(W1/S1)	B097C0		D4(W1/S1)	B097C0	0.65	0.09				U	120	1.2		1.7	1				U	14	1.8		6	0.43		74	6.2		0.19	0.18	U
	D4(W1/S1)	B097C1		D4(W1/S1)	B097C1	0.73	0.11				U	171	17		1.81	0.3				U	16.2	1.6		4.6	0.3		80	1				U
6	E2	B097C8	6	E2	B097C8	0.16	0.055				U	31	0.31		0.48	0.17				U	16	0.96		1.6	0.16		22	3		-0.08	0.12	U
	S2	B097C9		S2	B097C9	1.2	0.15				U	180	4.3				U			U	12	5.9		12	0.58	B	170	22		0.43	0.34	U
	S3	B097D0		S3	B097D0	0.039	0.04	U			U	9.5	0.18				U			U	17	1		0.24	0.058		4.1	0.55		0.024	0.1	U
7	N2	B09787	7	N2	B09787	0.016	0.02	U			U	4.5	0.15				U			U	15	1.1		0.18	0.049		2.7	1.2		0.22	0.14	U
	S2	B09786		S2	B09786	2	0.14				U	310	4.8		4.3	2.7				U	9.1	6.3		20	0.81	B	290	6.1		0.2	0.12	U
	W2	B09788		W2	B09788	0.006	0.012	U			U	2.3	0.11				U			U	17	1.1		0.089	0.032		1.2	0.37	J	0.018	0.094	U
8	00	B09F13	8	00	B09F13	-0.01	0.019	U			U	2	0.092				U			U	15	0.96		0.097	0.042		0.54	1.1	U	0.11	0.11	U
	S3	B09F14		S3	B09F14	0.02	0.022	U			U	5.3	0.16				U			U	16	1.1		0.27	0.067		2.8	0.45		-0.01	0.16	U
	S2	B09F17		S2	B09F17	0.093	0.035				U	54	0.44		0.59	0.25				U	14	0.96		1.6	0.21		18	2.2		-0.05	0.2	U
9	N3	B09F22	9	N3	B09F22	-0.00	0.02	U			U	0.36	0.067				U			U	16	1.1		0.013	0.013	U	0.083	0.23	U	0.2	0.19	U
	00	B09F21		00	B09F21	0.027	0.026	U			U	1.8	0.096				U			U	14	1		0.074	0.037		0.7	0.58	U	0.18	0.16	U
	W2/S2	B09F20		W2/S2	B09F20	-0.00	0.021	U			U	0.34	0.079				U			U	15	1.2		0.009	0.017	U	0.077	0.82	U	0.043	0.14	U

NOTES:
Eu-155 not detected in any samples. Highest MDA = 10pCi/g. Performance limit = 100 pCi/g
Be-7 Detected in two samples. B097B5: 280 +/- 100 pCi/g B097B3: 160 +/- 95 pCi/g
Q = Qualifier
U = Undetected
J = Estimated value
B = Analyte also detected in laboratory blank samples

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Table A-6. 116-F-4 Soil Sampling - Radionuclide Analysis Results (pCi/g) (3 Sheets).

Radionuclides		Am-241			Cs-137			K-40			Pu-239/240			Sr-90			Tc-99			Th-232		
Performance Limit		20			3						75			13			1750					
Lift #	Sample #	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q
1	B09769	0.007	0.007	U			U	13	0.97		0.003	0.006	U	0.097	0.23	U	0.13	0.14	U	0.87	0.22	
	B09770	-0.004	0.008	U			U	13	0.99		0.003	0.012	U	-0.11	0.24	U	0.11	0.17	U	0.76	0.2	
	B09771			U			U	12.9	1.3				U			U			U	NA		
3	B097B0	0.034	0.031	U	0.33	0.1		12	0.92		0.005	0.015	U	0.089	0.21	U	1.5	0.17		0.72	0.19	
5	B097B8	0.014	0.014	U	0.14	0.0		14	0.81		0.016	0.032	U	0	1.6	U	0.11	0.13	U	0.77	0.19	
6	B097C7	-0.005	0.005	U			U	15	1		0	0.005	U	-0.05	1	U	-0.01	0.2	U	0.67	0.14	
7	B097D6	0.019	0.023	U	0.052	0.0		14	0.82		0.004	0.008	U	0.17	0.39	U	0.073	0.18	U	0.72	0.17	
8	B09F12	0.002	0.019	U	3.5	0.1		15	1		0.08	0.034		1.6	0.34	J	0.022	0.12	U	0.77	0.21	
9	B09F19	0.01	0.016	U	0.72	0.1		16	1.2		0.071	0.03		0.63	0.26	U	0.14	0.12	U	0.64	0.24	

Radionuclides		U-235			U-238			U-233/234			Ra-226			Ra-228			Th-228			Pu-238		
Performance Limit		15			50																	
Lift #	Sample #	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q	Result	Error	Q
1	B09769	0.063	0.051	U	0.53	0.2		0.44	0.15		0.63	0.093		0.87	0.22		0.85	0.067		0.003	0.012	U
	B09770	0	0.028	U	0.41	0.1		0.58	0.17		0.59	0.094		0.76	0.2		1	0.098		0	0.006	U
	B09771			U	0.14	0.0		NA			0.791	0.303		NA			0.543	0.054		NA		
3	B097B0	0.029	0.029	U	0.46	0.1		0.43	0.091		0.48	0.084		0.72	0.19		0.52	0.048		-0.01	0.024	U
5	B097B8	0.037	0.037	U	0.55	0.1		0.44	0.1		0.62	0.084		0.77	0.19		0.93	0.069		0.016	0.032	U
6	B097C7	0.017	0.017	U	0.42	0.1		0.34	0.062		0.37	0.076		0.67	0.14		0.56	0.05		0.003	0.01	U
7	B097D6	0.055	0.055	U	0.47	0.1		0.66	0.19		0.42	0.075		0.72	0.17		0.81	0.073		-0.01	0.017	U
8	B09F12	0.035	0.035	U	0.42	0.2		0.51	0.18		0.43	0.11		0.77	0.21		0.73	0.082		0.037	0.04	U
9	B09F19	0.075	0.038	J	0.48	0.1		0.72	0.11		0.49	0.1		0.64	0.24		0.62	0.059		0.012	0.024	U

NA: Not Available

No Co-60 was detected. Performance limit is 1 pCi/g. Highest detection limit was:

Eu-152	3
Eu-154	3
Eu-155	100

Table A-7. 116-F-4 Inorganic Analysis Results (mg/kg).

Metals			Al		Sb		As		Ba		Be		Cd		Ce		Cr		Co		Cu		Fe		Pb	
Lin #	Coordinates	Sample #	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Clean Spoil Pile Sampling																										
1		BO9769	7610		4	U	2.3	B	116		0.44	B	0.33	U	4800		10.8		9.5	B	17.3		16600		6.2	
		BO9770	7340		3.7	U	3.4	B	125		0.36	B	0.31	U	4590		10.5		8.6	B	15.6		15700		5.6	
		BO9771	5880		10.1	U	2.2		96.3		0.21	U	1.07	U	3960		8.4		9.1	B	13.4		15600		5.1	
3		BO97B0	5270		2.4	U	1.8	B	44.6		0.21	B	0.25	U	4290		8.1		8.3	B	15		12100		2.7	
5		BO97B8	6900		2.6	U	1.8	B	99.5		0.27	B	0.26	U	4540		9.8		8.1	B	14.7		15200		4.2	
6		BO97C7	4880		1.8	U	1.9	B	31.8	B	0.07	B	0.2	U	6790		9.7		5.5	B	9.9		10200		2.5	
7		BO79D6	6220		1.9	U	2.5		81.9		0.34	B	0.21	U	6240		11.1		7.2	B	11.9		13200		4.5	
8		BO9F12	4560		1.8	U	2	B	29.2	B	0.28	B	0.2	U	6350		7.2		4.9	B	10.8		9450		2.1	
9		BO9F19	4630		1.9	U	1.9	B	30.6	B	0.3	B	0.21	U	6670		7.8		5.1	B	11.2		10000		2.7	
Suspect Contaminated Soil Sampling																										
5	D4(W1/S1)	BO97B9	5340		2.7	U	1.8	B	28.3	B	0.24	B	0.35	B	5540		10.1		6.2	B	13.3		12000		3.1	
	D4(W1/S1)	BO97C0	5340		2.5	U	2.6		35.7	B	0.28	B	0.26	B	12600		9.7		5.9	B	12.5		11800		4	
	D4(W1/S1)	BO97C1	3190		9.6	U	1.6	B	22.3	B	0.21	U	1.04	U	5480		6.8		4.2	B	10		8840		2.8	
9	N3	BO9F22	4120		2.6	U	2.4		28.1	B	0.22	B	0.26	U	6870		8.1		4.4	B	12.1		8700		2.6	
	0	BO9F21	4050		2.6	U	1.9	B	34.3	B	0.2	B	0.26	U	6110		7.3		4.3	B	11.6		8550		2.6	
	W2/S2	BO9F20	4200		2.6	U	2.1		27.8	B	0.2	B	0.35	B	6210		7.6		4.4	B	14.1		9030		12.3	

Metals			Mg		Mn		Hg		Ni		K		Se		Ag		Na		Th		V		Zn		Cn	
Lin #	Coordinates	Sample #	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q	Result	Q
Clean Spoil Pile Sampling																										
1		BO9769	4590		339		0.06	U	11.2		1450		2.4		1.1	B	581	B	0.46	U	41.1		43.7		NA	
		BO9770	4200		298		0.05	U	9.7		1330		1.1		0.99	B	532	B	0.4	U	38.2		39.7		NA	
		BO9771	3720		288		0.05	U	13.5		1250		0.43	U	1.29	U	161	B	0.86	U	36.1		51.9		107	
3		BO97B0	3770		226		0.05	U	8.7		855	B	0.58	B	0.49	U	213	B	0.3	U	31.3		30.2		NA	
5		BO97B8	4330		291		0.05	U	10.2		1130		0.56	U	0.53	B	209	B	0.32	U	39.1		34		NA	
6		BO97C7	3640		210		0.05	U	8.5		709	B	0.55	U	0.73	U	186	B	0.31	U	26.9		26.9		NA	
7		BO79D6	4060		251		0.1		9.7		927	B	0.59	U	0.95	B	224	B	0.34	U	36.8		32.5		NA	
8		BO9F12	3500		203		0.05	U	8.1		670	B	0.56	U	0.74	U	170	B	0.32	U	23.8		23.4		NA	
9		BO9F19	3730		212		0.05	U	9.2		658	B	0.77	B	0.78	U	212	B	0.34	U	25.2		24.7		NA	
Suspect Contaminated Soil Sampling																										
5	D4(W1/S1)	BO97B9	3840		215	N	0.05	U	9.9		1170		0.79	B	0.7	B	446	B	0.33	U	32.8		30.9		NA	
	D4(W1/S1)	BO97C0	3900		242	N	0.05	U	9.2		1260		0.55	U	0.58	B	443	B	0.32	U	31.6		31.7		NA	
	D4(W1/S1)	BO97C1	2490	E	178	E	0.05	U	8.3	B	1070		0.42	UW	1.46	U	412	B	0.42	U	18.9		22.4		NA	
9	N3	BO9F22	3330		195		0.05	U	9		603	B	0.57	U	0.53	U	226	B	0.32	U	19.4		22.9		NA	
	0	BO9F21	3130		197		0.05	U	7.8	B	659	B	0.56	U	0.62	B	244	B	0.32	U	20.2		21.8		NA	
	W2/S2	BO9F20	3330		188		0.05	U	7.6	B	625	B	0.57	U	0.53	U	261	B	0.32	U	21.2		23.8		NA	

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Table A-8. 116-F-4 Anions Analysis Results (mg/kg).

Anions			Cl		F		PO4		SO4		NO2/NO3	
Lift #	Coordinates	Sample #	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier
Clean Spoil Pile Sampling												
1		BO9769	7.1		2.8		3.3		21		10.8	
		BO9770	6.6		2.7		3.3		21		10.3	
		B09771	12.3		3.1		7.7		21		1.3/29.8	U
3		BO97B0	103		1.5		2	U	32		7.76	
5		BO97B8	21.1		1.6		2.3		60		2.49	U
6		BO97C7	55.8		1.5		2	U	17		2.96	
7		B097D6	51.2		1		2	U	18		2.47	U
8		BO9F12	58.2		0.8		2	U	35		2.4	U
9		BO9F19	16.3		53.7		2	U	68		2.46	U
Suspect Contaminated Soil Sampling												
5	D4(W1/S1)	BO97B9	427		27.6		2	U	51		2.5	U
	D4(W1/S1)	BO97C0	344		25.9		2	U	51		2.5	U
	D4(W1/S1)	BO97C1	340		17.4		1.3	U	50.6		0.1	U
9	N3	BO9F22	14.3		43.5		2		78		NA	
	0	BO9F21	13.8		47		2	U	76		NA	
	W2/S2	BO9F20	13.6		71		2.6		120		NA	

Table A-9. 116-F-4 VOA/Semi-VOA Analysis Results (ug/mg).

VOAs/Semi VOAs			4-Methyl-2-Pentanone		Acetone		Methylene Chloride		Toluene		bis(2-Ethylhexyl)phthalate		Di-n-butylphthalate	
Lift #	Coordinates	Sample #	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier	Result	Qualifier
Clean Spoil Pile Sampling														
1		BO9769		U	12	B	4	BJ	1	J		U	290	BJ
		BO9770		U		U	3	BJ		U		U	270	BJ
		BO9771		U	3	JB	6	JB		U	32	J	46	J
Suspect Contaminated Soil Sampling														
5	D4(W1/S1)	BO97B9	19		140		3	BJ	1	J		U	66	BJ

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APPENDIX B

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS

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100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS 8-11-94

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100-HR-2 OPERABLE UNIT MOBILE SURFACE CONTAMINATION MONITOR II RADIOLOGICAL SURVEYS

Scope

This report summarizes and documents the results of the radiological surveys conducted from March 16 through May 12, 1994 over a partial area of the 100-HR-2 Operable Unit, 100-H Area, Hanford Site, Richland, Washington (Fig 1). In addition, this report explains the survey methodology of the Mobile Surface Contamination Monitor II (MSCM-II).

The radiological survey of the 100-HR-2 Operable Unit was conducted by the Site Investigative Surveys/Restoration and Remediation Health Physics Organization of the Westinghouse Hanford Company. The survey methodology was based on utilization of the Mobile Surface Contamination Monitor II for automated recording of the gross beta/gamma radiation levels at or near six (6) inches from the surface soil.

Purpose

The purpose was to perform an initial radiological survey of the area, providing data to assist in the development of a Remedial Action Work Plan.

Procedure

The radiological surveys were conducted following the procedures contained in the Environmental Restoration Health Physics Radiological Protection Procedures Manual, (RPP); in particular; Section 6.7.5, Operation of the Mobile Surface Contamination Monitor II.

Introduction

The surveys were conducted using the MSCM-II (Ref. Appendix 1). Follow up surveys of areas where the MSCM-II showed indications of radioactive contamination were conducted utilizing hand held count rate meters outfitted with 2" by 2" NaI detectors and GM probes.

Radiological information was obtained from large area plastic scintillation detectors interfaced with a National Nuclear Sys-10 controller recording background reference detector counts per second (CPS), counting detector CPS and calculated radioactive activity in pico-curies (pCi). This calculated activity is normalized for Cs-137 utilizing the detector efficiency determined during system calibration.

Approximately 258 acres (1.1E6 meters^2) of 100-HR-2 Operable Unit was surveyed with the MSCM-II.

Hand Held Instrumentation

Ludlum Model 2221 Count Rate Meter, Serial No. 5580
w/Ludlum 44-10 NaI Detector
Ludlum Model 2221 Count Rate Meter, Serial No. 5581
w/Ludlum 44-10 NaI Detector
Eberline Model; RO-3B CP Dose Rate Meter, Serial No. 6582
Eberline EGM Count Rate Meter, Serial No. 1161
w/Eberline HP-260 GM Probe No. 1627
Eberline EGM Count Rate Meter, Serial No. 1752
w/Eberline HP-260 GM Probe No. 1262
Eberline EGM Count Rate Meter, Serial No. 1211
w/Eberline HP-260 GM Probe No. 371
Eberline EGM Count Rate Meter, Serial No. 1844
w/Eberline HP-260 GM Probe No. 1139

These instruments are maintained and calibrated by Pacific Northwest Laboratory.

Instrumentation Response Verification

The MSCM-II and hand held radiation survey instruments were checked at the beginning of each day for the proper instrument response. This was accomplished by placing a radioactive check source next to the detector(s) and observing the instrument's response to the source. Local background gamma radiation readings were also recorded in the vicinity of all contaminated areas found.

Discussion

MSCM-II METHODOLOGY

Each days survey efforts entailed initializing the Global Positioning System (GPS) differential correction base station, initializing the on-board GPS receiver, powering up the radiation detection controller system and computer, source checking detection instrumentation to insure proper response, and performing the survey. The purpose of the initialization sequence is to allow the GPS receivers to locate and establish a radio reception lock on at least four individual NAVSTAR Global Positioning Satellites to insure valid positional information.

Every attempt was made to traverse the survey area on parallel passes insuring 100% coverage of the area, however, due to the roughness of the terrain this was not always possible. Speed of survey was approximately 2 miles/hr. The MSCM-II detectors were maintained as near as practical to six inches from the soil surface by operation of the tractors hydraulic front end loader assembly. In this manner detector geometry remained relatively constant throughout the entire survey.

The methodology for determining whether radiation eminating from the soil is caused by surface contamination or underground radioactive material, is as follows. A small amount soil from the area of concern is removed. This removed soil is surveyed, as is the site of soil removal. Suspected underground radioactive material can be identified as follows: the removed soil is found not to be contaminated, and the radiation levels from the removal site are increasing. It is typical to only remove soil to a depth of 2 inches (not to exceed 6 inches), and the site of removal is a small area (≤ 2 ft^2).

SURVEY RESULTS

A total of 267,037 data points were collected. Each of these data points represents the radiological information from the Sys-10 controller along with the physical coordinates of the readings. The MSCM-II records these data points in electronic files in the on-board computer system. This allows down loading of these files into a Geographic Information System (GIS) for generating maps of the surveyed area and creation of a data base relevant to the positions and radiological readings.

The principle findings for the 100-HR-2 Operable Unit MSCM-II Radiological Survey are as follows: 1). There were 165 discrete areas of surface contamination identified, and 2). There was an area of approximately 19 acres that is a suspect Underground Radioactive Material Area. See the text that follows for more infomation on these findings.

The 165 contaminated areas identified in the portion of the 100-HR-2 Operable Unit surveyed (see figure 2) are summarized in Table 1. These identified areas were small locations of ≤ 2 ft^2. Contamination in these locations may be due to radioactive animal waste and wind blown "specky" contamination. These areas were decontaminated by Environmental Restorations Operations personnel to < detectable levels.

Five samples were taken from the contaminated locations and were sent to 183-KE Health Physics Laboratory for Qualitative Gamma Spectroscopy Analysis, the results of which are submitted as Table 2.

One area of approximately 19 acres (76,590 meters^2) was discovered in a non radiologically controlled location with elevated radiation readings over the entire surface leading to the conclusion that it is a probable undocumented radioactive disposal site. This area is located south of the 116-H-1 trench and is slated to be posted as an Underground Radioactive Materials Area (URM). This area is shown in figures 2 and 3. Figure 4 is a Radiological Profile (which includes a surface model and a contour of radiation levels) of the area.

Indications of Underground Radioactive Materials were also noted at several other smaller areas. These smaller areas, as well as the large URM Area south of 116-H-1 were further characterized with Field Gamma Isotopic Spectroscopy. Results of these investigations are submitted as Appendix B.

Figures 5, 6, 7, and 8 show the locations of the 165 surface contaminatin areas. These readings were verified with hand held radiological detection instrumentation. Figure 9 is a composite survey track map of the entire area surveyed.

Table 1

CONTAMINATED LOCATIONS FOUND W/MSCM-II AT 100-HR-2

NUMBER	DATE	EASTING	NORTHING	CPM *
1	16-Mar-94	577195	152014	700
2	17-Mar-94	577138	152017	400
3	17-Mar-94	577124	152289	200
4	17-Mar-94	577149	152264	700
5	22-Mar-94	577768.2	151783.9	5000
6	22-Mar-94	577737.5	151807.8	1000
7	24-Mar-94	577241.9	152067.4	1000
8	25-Mar-94	577264	152152.2	4000
9	25-Mar-94	577262.2	152055.7	1000
10	05-Apr-94	577369.1	152551.2	10 K
11	06-Apr-94	577558.6	152432.4	400
12	08-Apr-94	577546.4	152408.9	450
13	11-Apr-94	577576	152379.2	750
14	11-Apr-94	577484.6	152216.2	2 K
15	12-Apr-94	577569.3	152316	>100 K
16	12-Apr-94	577571.9	152282	30 K
17	12-Apr-94	577280.6	152037.9	1700
18	07-Apr-94	577528.8	152804.1	600
19	13-Apr-94	577292.7	152442.2	1500
20	13-Apr-94	577315.8	152431.5	800
21	13-Apr-94	577329.1	152138.4	800
22	13-Apr-94	577328.7	152226.6	300
23	14-Apr-94	577333.2	151948.0	700
24	14-Apr-94	577337.3	151988.1	3500
25	14-Apr-94	577346.5	152150.3	700
26	14-Apr-94	577345.6	152188.9	2500

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
27	14-Apr-94	577350.5	152163.3	950
28	14-Apr-94	577347.1	152046.0	550
29	15-Apr-94	577368.0	151957.5	450
30	15-Apr-94	577378.5	152125.5	450
31	15-Apr-94	577378.4	152170.5	350
32	15-Apr-94	577372.6	151944.4	300
33	15-Apr-94	577375.9	151945.6	300
34	15-Apr-94	577380.1	151901.7	600
35	15-Apr-94	577393.4	152046.2	1000
36	15-Apr-94	577395.0	152148.9	1500
37	19-Apr-94	577400.2	152013.5	350
38	19-Apr-94	577402.6	152211.0	300
39	19-Apr-94	577407.8	152082.4	450
40	19-Apr-94	577398.8	151911.4	1500
41	19-Apr-94	577410.4	152052.6	1200
42	19-Apr-94	577408.5	151935.2	1600
43	19-Apr-94	577411.5	151954.7	550
44	20-Apr-94	577419.9	151966.5	550
45	20-Apr-94	577417.8	151855.9	400
46	20-Apr-94	577433.8	152039.5	500
47	20-Apr-94	577434.8	152058.6	1500
48	20-Apr-94	577441.0	151862.7	650
49	20-Apr-94	577460.4	151960.6	1200
50	20-Apr-94	577475.1	152055.1	450
51	20-Apr-94	577461.2	151888.7	2000
52	21-Apr-94	577475.9	151990.5	5000
53	21-Apr-94	577481.1	151976.0	600

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
54	21-Apr-94	577478.9	151949.1	2000
55	21-Apr-94	577489.4	152011.5	500
56	21-Apr-94	577475.2	151849.4	500
57	21-Apr-94	577491.8	151980.6	1800
58	21-Apr-94	577501.1	152054.1	2000
59	21-Apr-94	577498.3	151968.3	300
60	21-Apr-94	577500.1	151998.3	400
61	21-Apr-94	577508.9	152037.9	400
62	21-Apr-94	577503.8	151933.0	3000
63	21-Apr-94	577506.1	151955.8	800
64	21-Apr-94	577511.6	152042.6	300
65	21-Apr-94	577496.1	151813.2	3000
66	21-Apr-94	577513.6	151880.5	400
67	21-Apr-94	577514.8	151824.0	800
68	22-Apr-94	577526.4	151887.1	600
69	22-Apr-94	577535.3	152003.8	200
70	22-Apr-94	577523.8	151839.3	500
71	22-Apr-94	577523.8	151836.9	200
72	22-Apr-94	577540.7	151991.8	300
73	22-Apr-94	577545.6	151948.1	300
74	22-Apr-94	577558.8	152053.5	3000
75	22-Apr-94	577555.7	152015.5	2000
76	22-Apr-94	577559.4	152031.7	600
77	22-Apr-94	577567.2	152063.6	200
78	22-Apr-94	577551.6	151863.5	1000
79	22-Apr-94	577554.6	151862.1	400
80	22-Apr-94	577564.4	152003.4	250

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
81	22-Apr-94	577566.3	151951.7	2000
82	22-Apr-94	577570.2	151998.1	800
83	22-Apr-94	577577.2	151905.7	500
84	22-Apr-94	577581.3	152072.9	700
85	22-Apr-94	577582.4	151930.6	700
86	22-Apr-94	577574.3	151845.7	1500
87	22-Apr-94	577567.6	151764.8	1200
88	22-Apr-94	577567.0	151759.8	400
89	25-Apr-94	577596.4	151987.9	2000
90	25-Apr-94	577595.5	151979.5	400
91	25-Apr-94	577603.7	152005.2	1200
92	25-Apr-94	577598.7	151919.4	500
93	25-Apr-94	577605.6	151966.5	400
94	25-Apr-94	577605.6	151971.3	400
95	25-Apr-94	577607.0	152026.2	600
96	25-Apr-94	577606.9	152045.3	800
97	25-Apr-94	577611.8	152034.6	700
98	25-Apr-94	577611.7	152022.2	300
99	25-Apr-94	577609.5	151945.6	600
100	25-Apr-94	577591.6	151751.8	350
101	25-Apr-94	577607.5	151882.8	1000
102	25-Apr-94	577621.0	152034.9	250
103	25-Apr-94	577598.5	151762.4	400
104	25-Apr-94	577618.0	151908.9	250
105	25-Apr-94	577619.4	151926.7	350
106	25-Apr-94	577620.7	151952.4	2000
107	25-Apr-94	577623.2	152039.4	600

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
108	26-Apr-94	577624.3	151926.2	400
109	26-Apr-94	577624.6	151940.3	300
110	26-Apr-94	577628.0	152047.9	400
111	26-Apr-94	577632.7	152023.7	250
112	26-Apr-94	577632.7	152015.6	300
113	26-Apr-94	577625.6	151841.0	300
114	26-Apr-94	577640.7	152048.1	500
115	26-Apr-94	577636.8	151875.4	600
116	26-Apr-94	577638.0	151900.8	700
117	26-Apr-94	577641.8	152013.1	250
118	26-Apr-94	577642.3	152059.1	250
119	26-Apr-94	577646.4	152078.6	1200
120	26-Apr-94	577649.1	152065.1	1500
121	26-Apr-94	577649.4	152061.1	1100
122	26-Apr-94	577648.1	152057.5	200
123	26-Apr-94	577648.2	152026.9	850
124	26-Apr-94	577647.7	152006.1	1000
125	26-Apr-94	577647.2	151993.9	600
126	26-Apr-94	577645.8	151976.8	650
127	26-Apr-94	577646.2	151973.7	650
128	26-Apr-94	577649.9	152006.7	300
129	26-Apr-94	577650.9	152045.3	800
130	26-Apr-94	577650.7	152049.0	1000
131	26-Apr-94	577652.0	152059.9	600
132	26-Apr-94	577655.7	152065.6	10000
133	26-Apr-94	577663.0	151914.8	600
134	26-Apr-94	577664.1	151967.8	2000

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
135	26-Apr-94	577664.5	151987.5	600
136	26-Apr-94	577665.2	152034.2	3000
137	26-Apr-94	577665.8	152058.1	300
138	26-Apr-94	577671.0	152059.4	1000
139	26-Apr-94	577670.3	152010.3	600
140	26-Apr-94	577672.0	151959.2	600
141	26-Apr-94	577678.2	151996.3	400
142	26-Apr-94	577677.3	151955.9	250
143	26-Apr-94	577679.8	151968.8	400
144	26-Apr-94	577685.3	151988.3	600
145	26-Apr-94	577685.1	151982.7	400
146	27-Apr-94	577687.3	152012.4	2000
147	27-Apr-94	577701.2	152088.2	1500
148	27-Apr-94	577702.4	152017.4	300
149	27-Apr-94	577702.2	151894.9	60000
150	27-Apr-94	577736.6	152022.8	500
151	27-Apr-94	577748.4	151682.1	400
152	29-Apr-94	578163.2	151990.4	300
153	29-Apr-94	578157.5	151994.4	2000
154	26-Apr-94	577632.4	151796.2	200
155	26-Apr-94	577653.0	151909.5	200
156	26-Apr-94	577678.0	151980.0	200
157	06-May-94	577965.9	152376.5	350
158	10-May-94	577589.4	152011.1	700
159	10-May-94	577592.8	151915.6	550
160	10-May-94	577594.8	152016.2	500
161	10-May-94	577596.0	151814.1	800

Table 1 Continued

NUMBER	DATE	EASTING	NORTHING	CPM *
162	10-May-94	577604.1	151900.2	350
163	10-May-94	577605.0	151908.3	300
164	10-May-94	577615.4	152059.8	400
165	10-May-94	577608.3	151900.2	400

* Note: The CPM readings are the maximum obtained from an EGM with an HP-260 probe held 1/2 inch from the soil.

Table 2

Soil Sample Gamma Spectroscopy Analysis Results

Sample Number	Isotopes Present (*)
HR2(1), K94-1212	Cs-137, Co-60, Eu-152
HR2(2), K94-1211	Cs-137, Co-60, Eu-152, Eu-154
HR2(3), K94-1210	Cs-137, Co-60, Eu-152, Eu-154
HR2(4), K94-1213	Cs-137, Co-60, Eu-152, Eu-154
HR2(5), K94-1214	Cs-137, Co-60, Eu-152, Eu-154

* Note: The soil samples had a qualitative analysis only (see pg B6 for more information).

APPENDIX 1

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS

THE MOBILE SURFACE CONTAMINATION MONITOR

MSCM-II

The second generation Mobile Surface Contamination Monitor was developed by Westinghouse Hanford Company for the purpose of performing radiological surveys of vast outdoor areas in order to verify the presence or absence of surface contamination and/or uncharted radiological burial grounds. The MSCM-II will also be used for verifying that contamination is removed from sites undergoing remediation and for tracking and trending stabilized burial sites in order to ensure environmental compliance regulations are being met.

The MSCM II was first conceptualized by Westinghouse Hanford Co. Engineering Applications personnel who designed the prototype, MSCM I. This first MSCM has been successfully operated for the past six years, mainly for tracking and trending stabilized burial sites. While the first MSCM was a success, many design deficiencies and needed enhancements were identified and provided for in the second generation design.

The MSCM-II contains three major sub-systems: the Radiation Detection System and carrier vehicle, the Global Positioning System, and the Geographic Information System.

Radiation detection system/carrier

The MSCM II is a nine ton, four wheel drive tractor with a dual cab design equipped with a modified front end loader. This modified loader consists of a header to support three paired plastic scintillation radiation detectors and a caster wheel assembly to support the detector pairs at the proper height above the varying terrain of the Hanford Site.

The rear cab contains the radiation detection system controller, a GPS receiver, VHF radio receiver, radio modem, and a computer with monitor which is used to observe data collected and as a navigational display. The hardware is rack mounted in order to protect the equipment and allow room for the operator.

The front cab houses the driver, who in addition to driving is responsible for operating the front end header assembly with it's detector array that is typically maintained at six inches above the ground and is hydraulically lifted when obstacles are encountered.

Three pairs of plastic scintillator detectors are mounted on the header. The six detectors are each 34x11x1.5 inches in size and are lead shielded. The total weight of the header assembly is about two tons. Each detector header assembly contains two detectors, a reference detector and the main detector.

Beta or gamma radiation causes light pulses in the plastic scintillant material which are detected by photomultiplier (PM) tubes mounted within the detector itself. Pulses from the PM tubes are amplified and passed via coaxial cable to the radiation controller box located within the instrument cab for amplification, counting, and processing.

The main detector views the ground being monitored through a thin titanium window and is shielded on all other sides with lead. Detector efficiencies have been established at approximately 10% using a mixed source containing Cs-137, Co-60, and Sr/Y-90. Since the detectors will ride 6 inches off the ground, the effective viewing area under the assembly is approximately 24 " long (in the direction of travel). At a traveling speed of 3 ft/sec, (2 mph) this allows a count time of 0.67 seconds. Using a sigma factor of 3.5 and a confidence level of 95%, the system can detect a minimum of 50 nCi source (point or 100 sq. cm. planar).

The detectors are bit slice counted with a slice duration of forty-seven milliseconds. The reference detectors record a counts-per-second background which is used internally to calculate the detector pair alarm levels. The main detectors record counts into a rolling register which are normalized to counts-per-second every forty-seven milliseconds and compared to the calculated detector pair alarm level. Every second, the gross counts-per-second from each detector and the results of the alarm level comparison, are transmitted via RS-232 link to an on board 386 PC.

In survey mode, the operator may set the controller to alarm at any time the main detector registers a reading greater than established background, or at a pre-set detection level programmed in units of pCi. Each detector assembly is equipped with a solenoid triggered aerosol paint ejection system which will mark the ground where an elevated reading is detected. The operator will be alerted to this event by a visual and audible alarm integrated in the controller.

Global Positioning and Mapping System

The MSCM-II's positioning is achieved utilizing a real-time differentially corrected Global Positioning System (GPS). This system consists of a base unit, a Trimble 4000 SE[1] GPS receiver with reference locator and Radio Technical Commission for Maritime Services Version 1.04 (RCTM-104) options. It is known as the 400 RL unit. RCTM-104 refers to a standard for sending and receiving GPS correctional messages. These messages are used to correct a roving GPS receiver's position in the field in real time. Correction of position minimizes the effects of intentional scrambling of the GPS position information (known as Selective Availability or SA), atmospheric perturbation, and other systemic errors.

The base station is equipped with a radio modem and a VHF radio for transmission of RTCM-104 corrections from the base to the roving MSCM-II. The entire base is powered by two 100 amp/hr batteries and housed in NEMA cabinets to allow up to sixty hours of unattended operation.

The base is located at a known fixed location and the coordinates of it's location loaded into it using the keypad located on the GPS receivers front face.

Located within the instrument cab of the MSCM-II is a radio and modem for receiving the base's RTCM-104 corrections and a Trimble 4000 SE GPS receiver with differential locator (DL) options. This GPS receiver determines it's position by correcting it's own GPS position information with the information obtained from

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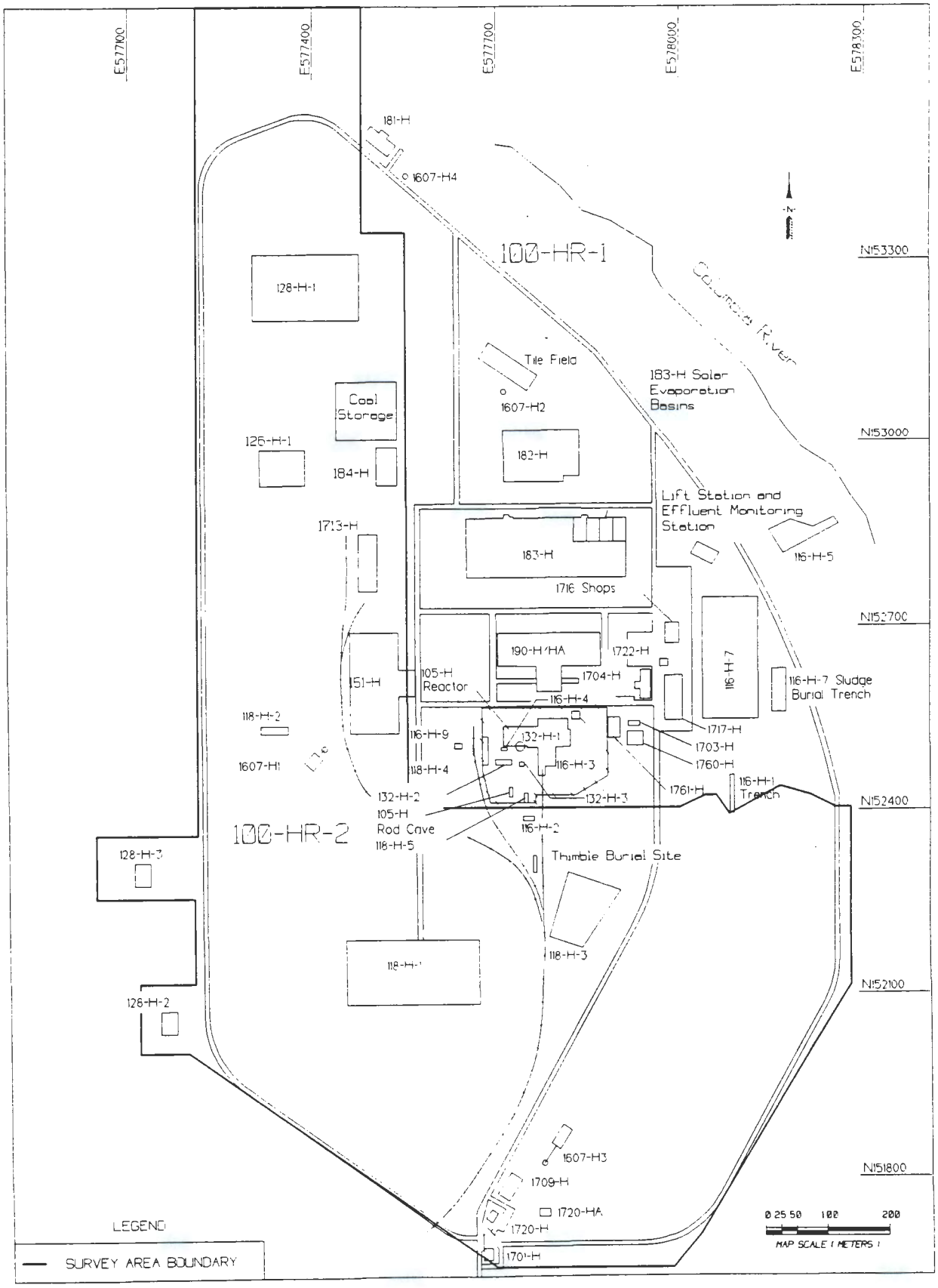
[1] Trimble is the registered company name and 4000 SE a registered trademark of Trimble Navigation, Sunnyvale, CA.

the base. This GPS receiver downloads positional information via serial link to the on-board 386 PC once each second.

Loaded on this PC is a modified version of GeoResearch's GeoLink XDS[2] software. This software allows a background map of the survey area to be shown on screen with the tractors path updated once each second. Counts that exceed an alarm level are highlighted with a different color and the software store all the positioning and radiation detector information into files on the PC's hard drive. This allows for an on screen representation of survey coverage and entry of other information as attributes, such as radiological boundaries, fences, well locations, etc. by the instrument operator. This data is downloaded from the on-board PC and loaded into a Hanford Radiological Geographical Informational System (GIS).

[2] GeoResearch is a registered servicemark and GeoLink and GeoEdit registered trademarks of GeoResearch, Inc., Billings, MT.

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEY

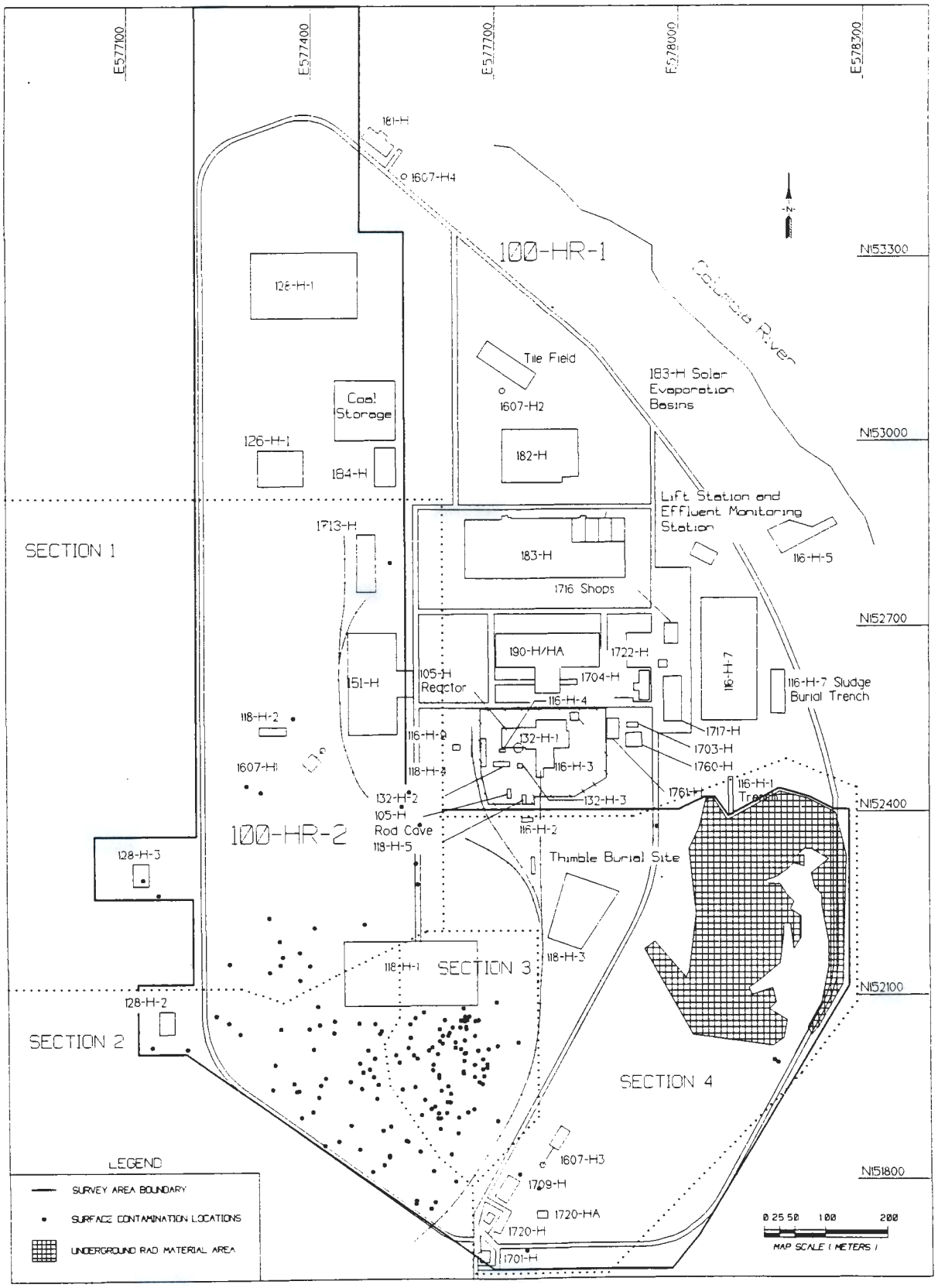


MSCM-II SURVEYS
DRP/Site Investigative Survey

FIGURE 1

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEY

LOCATIONS OF SURFACE CONTAMINATION/UNDERGROUND RAD. MATERIAL

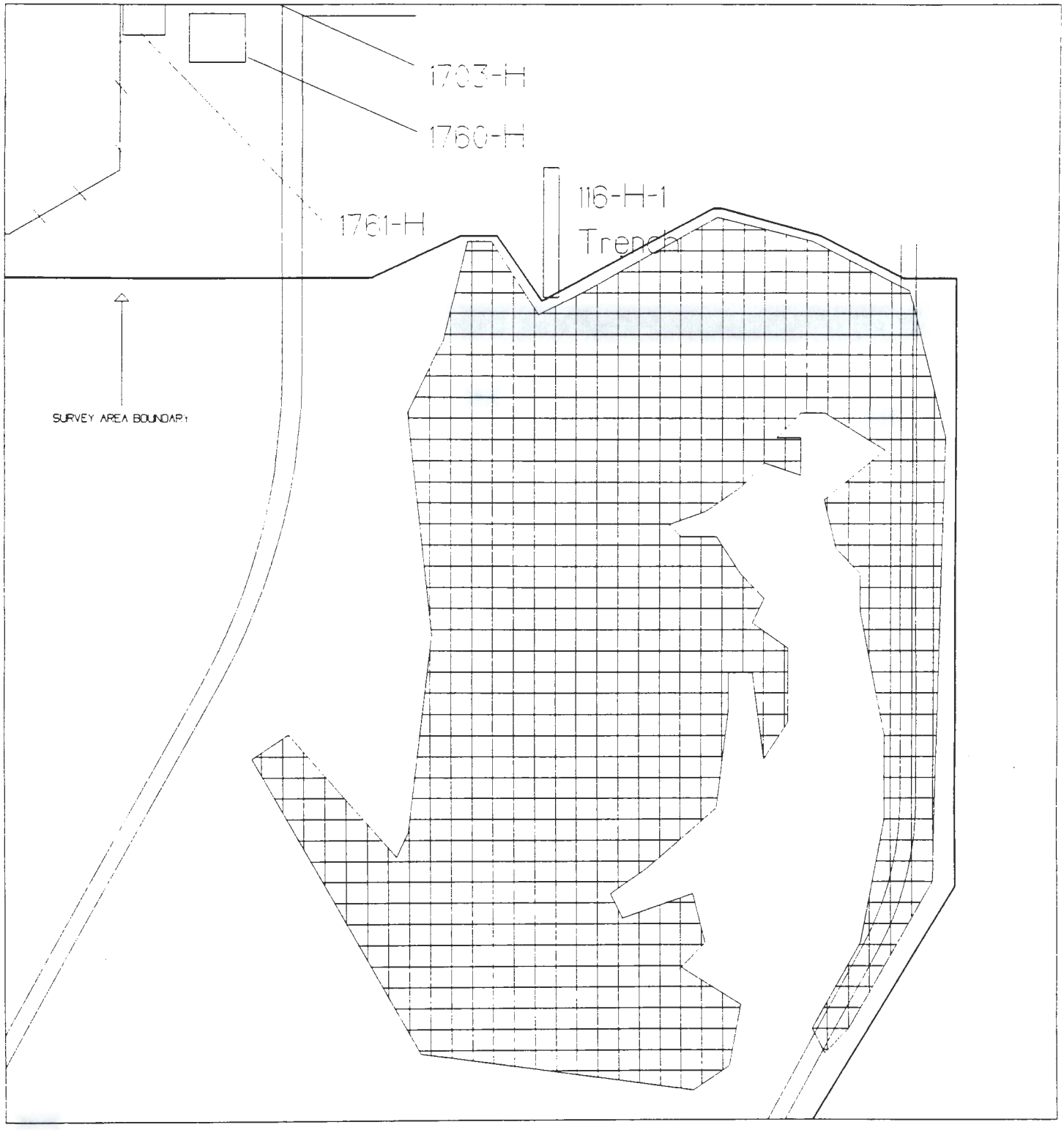


MSCM-II SURVEYS
ERAP/Site Investigation Survey

FIGURE 2

WHC-SD-EN-RPT-026

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS
AREA OF UNDERGROUND RADIOACTIVE MATERIAL



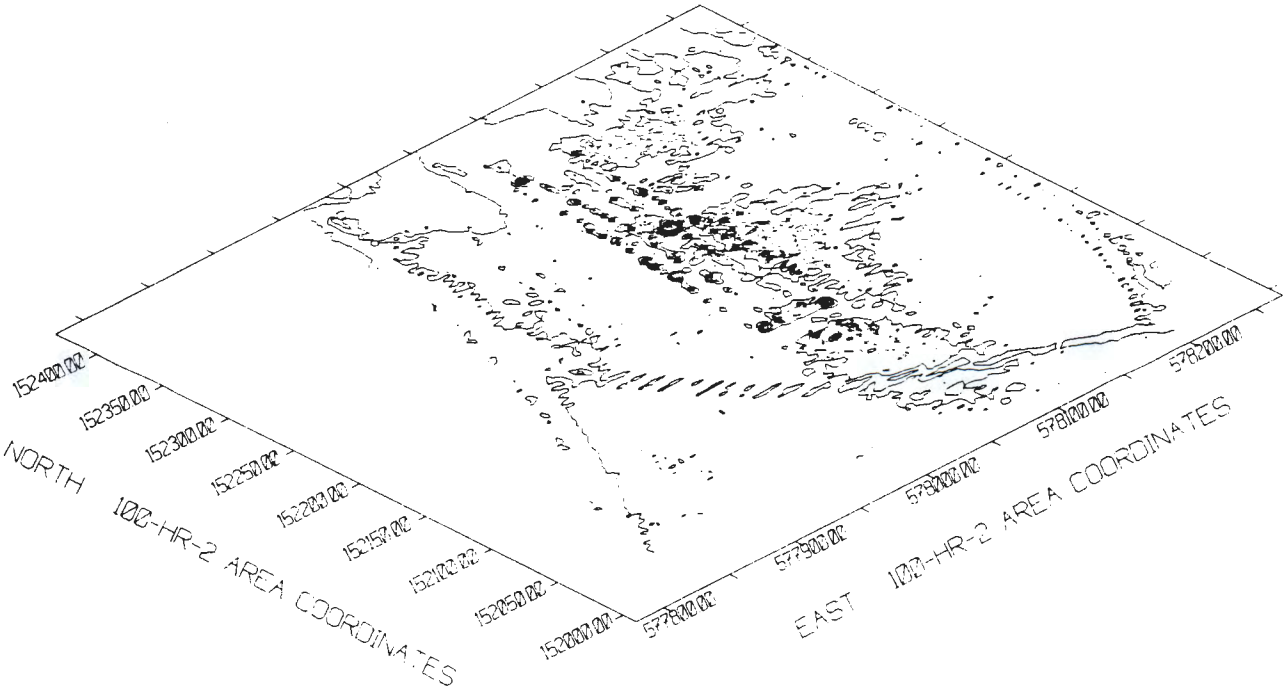
0 25 50 100 200

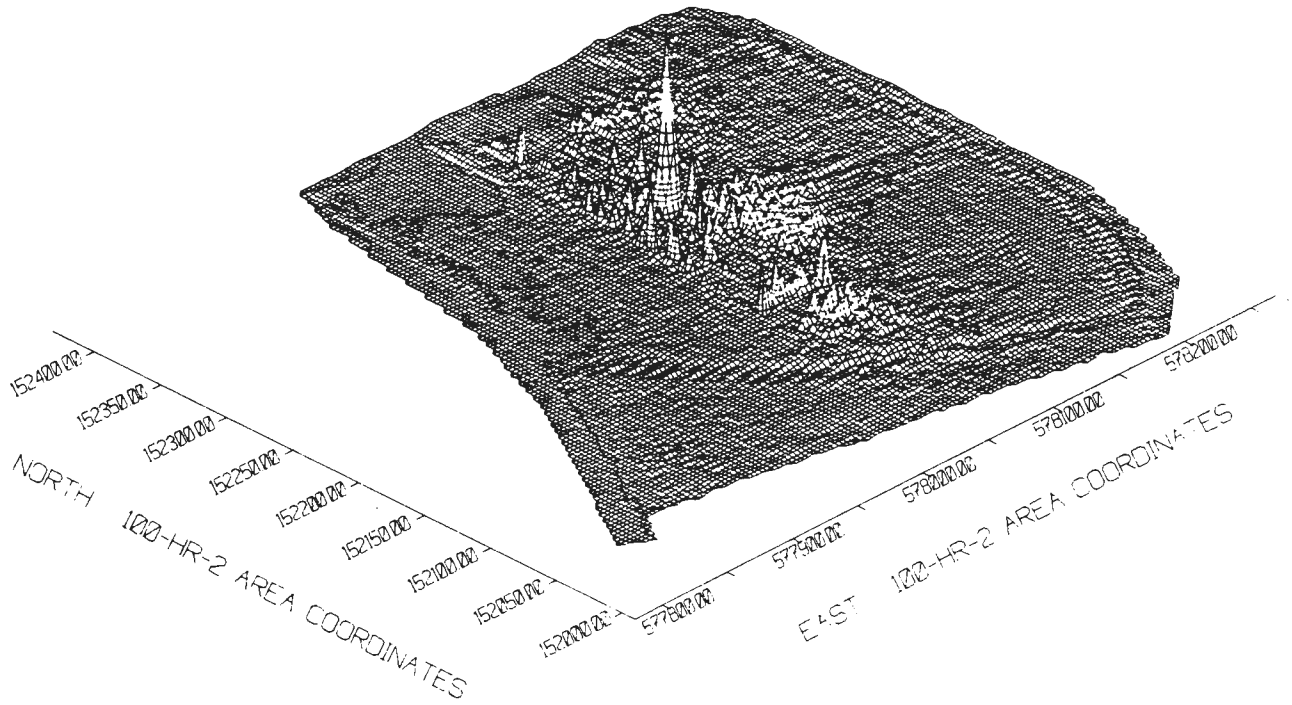
MAP SCALE (METERS)

FIGURE 3

MSCM-II SURVEYS
ERHP/Site Investigative Surveys

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEY
RADIOLOGICAL PROFILE





MSCM-II SURVEYS
ERRP/Site Investigative Surveys

COLOR KEY

	17K - 18.5K
	14K - 16K
	10K - 13K
	5000 - 9000
	2500 - 5000
	400 - 2000
	100 - 300

FIGURE 4

WHC-SD-EN-RPT-025

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS
SECTION 1 - LOCATION OF CONTAMINATED AREAS

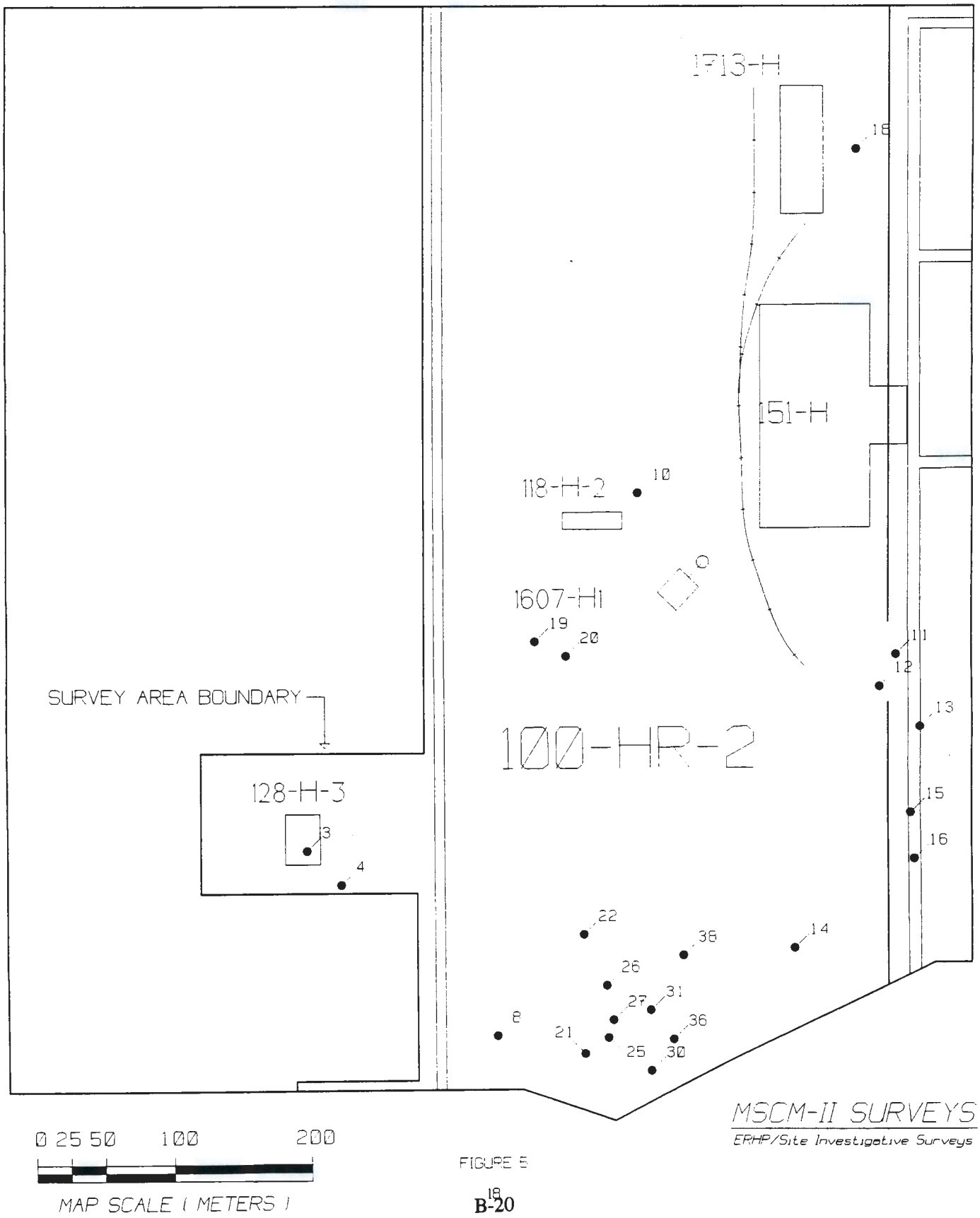


FIGURE 5

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS
SECTION 2 - LOCATION OF CONTAMINATED AREAS

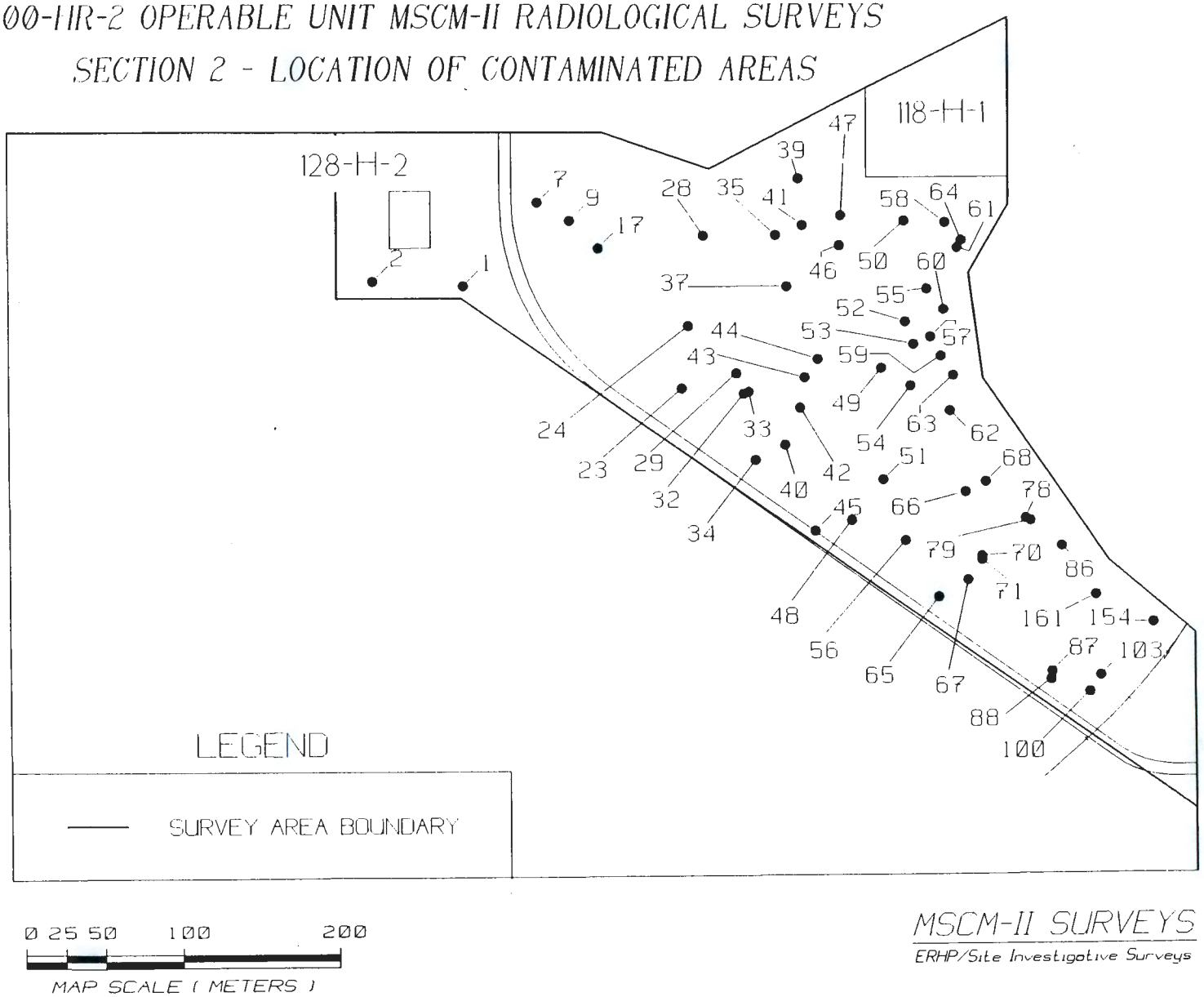


FIGURE 6

WHC-SD-EN-RPT-026

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS
SECTION 3 - LOCATION OF CONTAMINATED AREAS

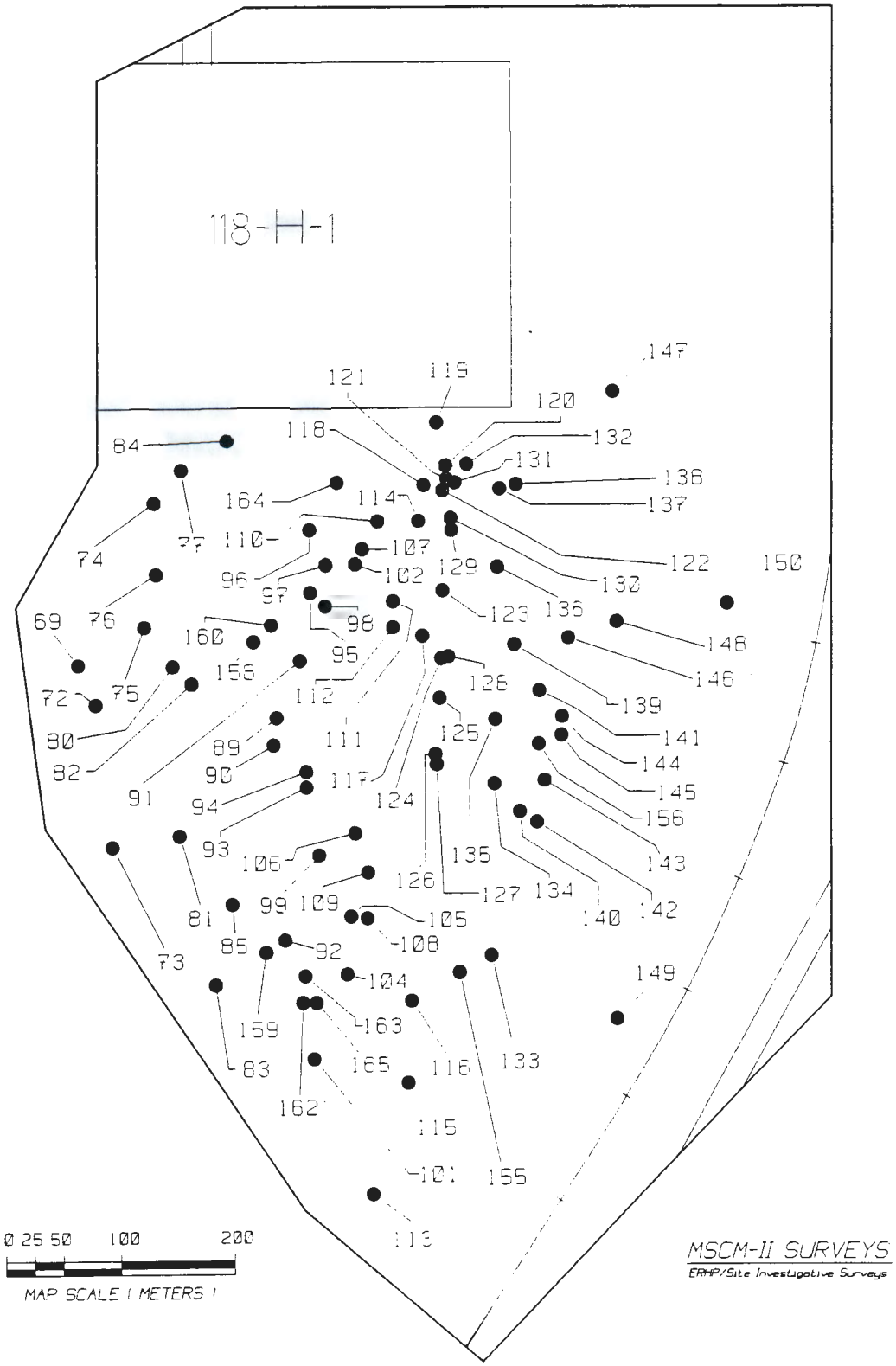


FIGURE 7

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS
SECTION 4 - LOCATION OF CONTAMINATED AREAS

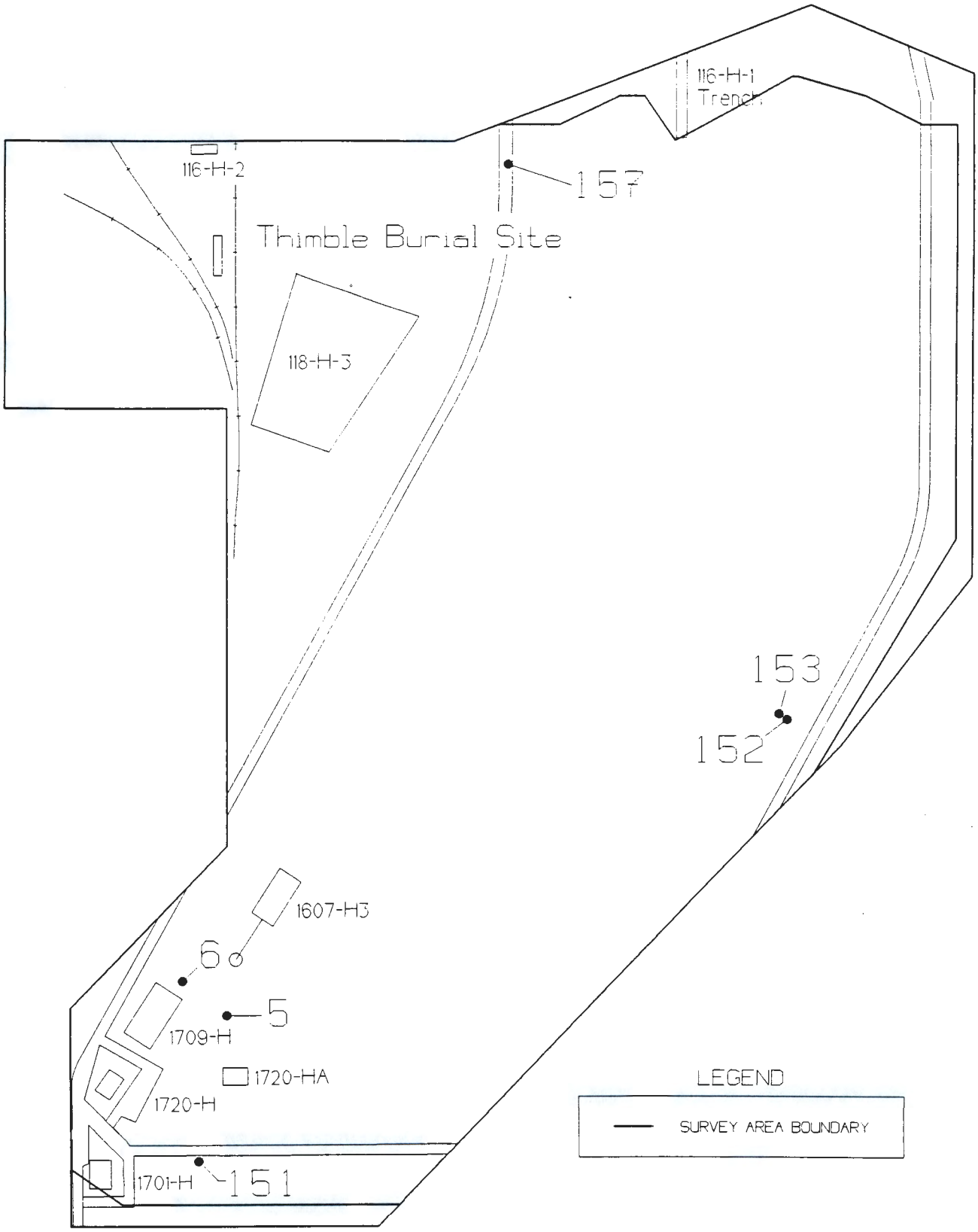
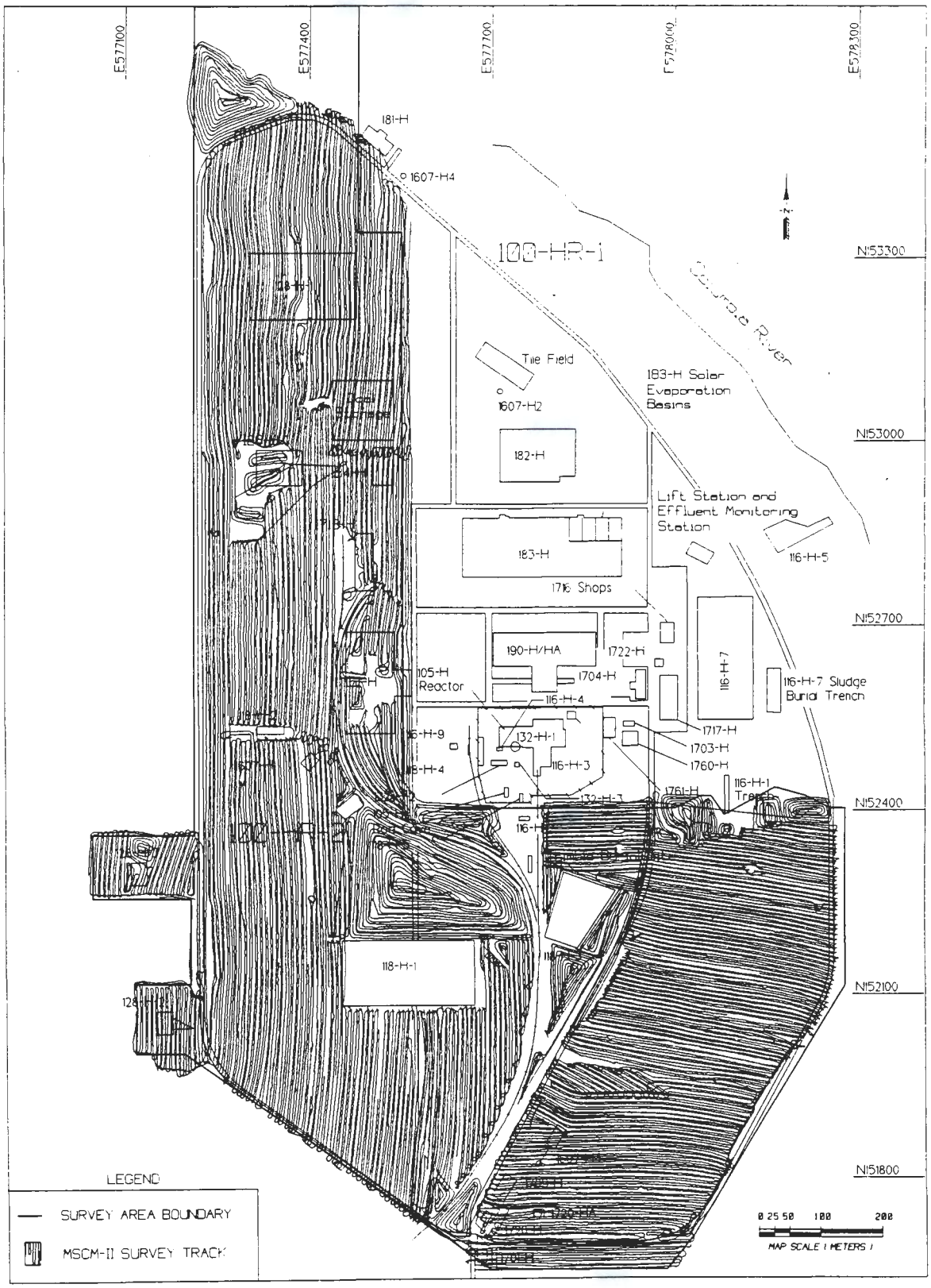


FIGURE 6

MSCM-II SURVEYS
ERAP/Site Investigative Surveys

WHC-SD-EN-RPT-026

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEY COMPOSITE SURVEY TRACK MAP



MSCM-II SURVEYS

FIGURE 9

9513360.2130

DOE/RL-94-53
Rev. 0

WHC-SD-EN-RPT-026

APPENDIX B

100-HR-2 OPERABLE UNIT MSCM-II RADIOLOGICAL SURVEYS

In Situ Gamma Spectroscopy Measurements

Prepared by

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Engineering and Environmental Demonstration Laboratory
Westinghouse Hanford Company

INTRODUCTION

The E&EDL (Engineering and Environmental Demonstration Laboratory) employed a portable gamma spectroscopy system to perform in situ measurements at the 100-HR-2 operable unit. These measurements were conducted as a follow-up to the large area surveys performed by the MSCM-II (Mobile Surface Contamination Monitor-II). The objective of the measurements was to gather additional data relating to contamination and radiological anomalies identified by the MSCM-II.

Measurements were taken using two different methods. The first method is the qualitative identification of the gamma emitting isotopes present based on the position of their photopeaks in the gamma energy spectrum. The second is a quantitative analysis performed using the EML 1-meter method originally developed by the Department of Energy's Environmental Measurements Laboratory (Beck et al, 1972). This technique determines the average activity of natural and man made radionuclides distributed on the surface and within the soil matrix over a finite area.

SYSTEM DESCRIPTION

The portable gamma spectroscopy system consists of a Ortec Nomad[1] Plus MCA (multi-channel analyzer), notebook computer, germanium detectors and a suite of software applications. The Nomad is a ruggedized portable multi-channel analyzer designed specifically for field measurements. The unit can be powered by a variety of external sources and is capable of eight hours continuous operation using internal batteries. The Nomad's front-end electronics are comprised of a spectroscopy amplifier, analog to digital convertor, digital spectrum stabilizer and a detector bias supply. The amplifier can be configured for either high count rate or high resolution applications. The analog to digital convertor is a successive approximation type with a fixed conversion time of 5 uS and a resolution of 16384 channels. The digital spectrum stabilizer circuit is used to correct zero and gain shifts during long counting intervals. The high voltage power supply provides 0 to 5000 volts DC for detector bias.

The notebook computer communicates with the NOMAD-Plus system via a dual port memory interface. The computer controls spectrum acquisition; determines amplifier, digital stabilizer and high voltage power supply settings; and provides a real time display of spectral data. Gamma spectra obtained with the system can be analyzed immediately in the field or saved to a disk file for archival purposes or more in depth analysis.

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[1]Nomad is a registered trademark of EG&G Ortec Nuclear Instruments, Oak Ridge, TN.

The detectors used with the Nomad Plus system are HPGe (high purity germanium) types that have been specially configured for field applications.

Calibrations

Prior to use in the field, the portable gamma spectroscopy system was operationally checked and calibrated. A 0.35 uCi Eu-152 source was used to determine the energy calibration coefficients, peak shape coefficients and pole zero setting for the detector. A detector efficiency calibration is not performed because it is not required for gamma peak identification.

A separate energy/peak shape analysis is performed using the GDR (gamma data reduction) software supplied with the M-1. The detector efficiency calibration curves for the EML method are derived by the M-1 software using calibration factors developed at the Environmental Measurements Laboratory (Hefler and Miller, 1988). The only information required are the detector's specifications (relative efficiency, germanium crystal dimensions, etc.) supplied by the detector's manufacturer.

Qualitative Analysis

The contaminated areas associated with surplus production reactors at Hanford contain a mixture of fission products, activation products and transuranic isotopes such as Cs-137, Co-60 and Pu-239. Also present are naturally occurring radionuclides such as K-40 along with Th-232, U-235, U-238 and their progeny. Many radionuclides emit characteristic gamma rays as part of their radioactive decay schemes. These radionuclides can be identified by gamma spectroscopy provided that the gamma rays they emit are of sufficient energy and intensity to be detected.

This method does have limitations. With the exception of Am-241, most transuranic isotopes are generally not detectable in the presence of other radionuclides because of their extremely long half lives and relatively low branching ratios for gamma radiation. Pure beta emitters, such as Sr-90, also cannot be detected by gamma spectroscopy. However, their presence can be intimated by detection of the bremstraalung radiation produced as the beta particles interact with matter (Brodzinski 1983). Because separations activities did not take place at the surplus production reactor sites, those radionuclides not detectable by gamma spectroscopy are always associated with other fission and activation products that are readily detectable.

During the course of a large area survey, the HPTs (health physics technicians) will mark contaminated areas or hot spots detected with the MSCM-II vehicle. A hand held instrument is then used to determine the highest count rate in a contaminated

area or the exact location of a hot spot. The germanium detector can be mounted on a tripod or placed directly on the ground depending on the physical characteristics and radiological conditions at the site. If measurements are required near liquid disposal cribs, burial grounds or similar areas with high background radiation levels, then a lead shield and collimator are used.

Qualitative identification of the gamma emitting radionuclides present is accomplished with the EG&G Ortec GammaVision[2] software package. This package provides an MCA emulation capability for hardware control, data acquisition and spectrum display. The peak search and peak identification components of the package are used to locate and identify the gamma photopeaks in the spectrum. The calibration component of the package is used to create and maintain energy calibration parameter files for each of the detectors used with the Nomad-2 system. Gamma energy spectra recorded with the system can be analyzed in the field, but are generally saved in a disk file for later analysis.

EML Method (Quantitative Analysis)

The Nomad-Plus portable system has been equipped with the EG&G Ortec M-1 software package. The M-1 software is essentially a commercial implementation of the in situ quantitative analysis technique commonly referred to as the EML 1-meter method. For these measurements the germanium detector is mounted on a tripod with the face of the detector nominally 1 meter above the ground and looking downward. At this height the detector effectively sees an circular area with a radius of approximately ten meters and a depth of 15-30 cm (depending on the source energy).

An important parameter affecting the accuracy of the in situ measurements using the EML method is determination of the alpha/rho factor for the site. The alpha/rho factor is a function of the density, moisture content and distribution of radionuclides in the soil. Lacking this detailed knowledge, there are two general models for the distribution of radionuclides that can be applied in most situations: (1) uniform distribution; and (2) negative exponential distribution for both aged and new fallout.

The uniform distribution model is applied to naturally occurring radionuclides and to man-made radionuclides where uniform distribution can be assumed. For the uniform distribution model, the M-1 software reports the radionuclide concentrations in activity units per gram of soil. The exponential distribution model applies to radioactive fallout such as may result from

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[2]GammaVision is a trademark of EG&G Ortec Nuclear Instruments, Oak Ridge, TN.

above ground nuclear detonations, accidents or routine releases from nuclear facilities. The aged fallout case is used for radionuclides that were deposited on the surface at some point in the past and over time have migrated deeper into the soil matrix. The new fallout case is only applicable to recent depositions in which the contamination is distributed on an undisturbed surface. This case assumes that 63% of the activity is in the top 1 mm of soil. For either case of the exponential distribution model, the M-1 software reports the concentration in activity units per square meter.

Qualitative Measurement Results

Qualitative measurements were performed at three different areas in the 100-HR-2 operable unit. Because visual interpretation of the gamma energy spectra can yield a better understanding than tables of numbers, the plots of the spectra recorded at these areas are attached.

A series of measurements were recorded at four different locations within the suspected URM (underground radioactive material) area located just south of 116-H-1 trench (figures 1 through 4). Based on the MSCM-II survey maps, this area appears to be generally contaminated with activity concentrated along parallel lines running north to south. As these gamma energy spectra show, the radionuclides primarily responsible for this activity are Eu-152 and Cs-137, both of which are characteristic of the single pass reactor sites. Due to the fact that the 100-H Reactor was deactivated nearly thirty years ago (DeNeal 1970), many of the short lived activation and fission products have already decayed below detection limits. Also present in the gamma energy spectra, but as insignificant contributors, are the gamma energy lines of Am-241 and Co-60.

Two measurements were taken at a second area approximately 100 meters south of the suspected URM (figures 5 and 6). This area does not have wide spread contamination, however, several small hot spots or contamination specs were located. The gamma energy spectra recorded in this area are quite different from those recorded in the suspect URM. In these spectra Eu-152 is only a minor contributor to the activity. The gamma energy line associated with Cs-137 is responsible for the majority of the activity.

The third area in which qualitative measurements were taken is located northwest of the H Reactor. The MSCM-II periodically detected elevated count rates in this area but no contamination or hot spots were identified using hand held instruments. The entire area is littered with pieces of coal, coal dust, and chunks of an aggregate material resembling furnace slag. The gamma energy spectra recorded in this area is quite distinct from the other two areas (figure 7). The major gamma energy lines in

the spectra are U-235, and the U-238 daughters including Bi-214 and Pb-214. A sample of the aggregate material was taken to the 183-KE Health Physics Laboratory for further analysis. The laboratory performed an eight hour count of the specimen and subtracted the laboratory background contribution from the resulting spectrum (figure 8). The results were identical to the field measurements, and the ratios of the daughter nuclides indicated that the uranium was naturally occurring.

In Situ Quantitative Measurement Results

The EML 1-meter method was employed at two locations in the 100-HR-2 operable unit. At the suspect URM area the system's detector was positioned within the area of general contamination but away from the areas of higher activity which were marked with flags. After a one hour counting period, the resulting gamma energy spectrum was analyzed using the Ortec M-1 software. The analysis was performed using two separate radionuclide distribution profiles. The summary reports generated by the M-1 program are attached as figures 9 and 10.

The second measurement was taken in the area northwest of the H-Reactor which exhibited elevated background activity apparently due to presence of natural uranium. The detector was placed in the center of a flat relatively undisturbed area and a one hour count was started. During the counting interval a visual survey of the surrounding area confirmed the initial impression that the coal products and aggregate material identified previously were indeed uniformly scattered throughout the site. The gamma energy spectra recorded was analyzed using the M-1 software. Only the uniform distribution case was assumed and a summary of the results are presented in figure 11. A comparison of the results from both sites is provided in the following table.

Isotope	Area northwest of 100-H Reactor Activity pCi/g	Area south of 116-H-1 Trench Activity pCi/g
U-235	5.86e-03	Not Detected
Ac-228	8.79e-02	5.95e-01
Tl-208	3.30e-01	2.02e-01
Bi-214	1.21e+00	6.82e-01
Cs-137	2.20e-01	6.19e-01
K-40	5.85e+00	1.19e+01

Conclusions

The gamma energy spectra recorded in the three areas at the 100-HR-2 operable unit show that these areas are unique from a radiological perspective. The suspect URM area is contaminated with radionuclides characteristic of single pass reactor effluent. It's proximity to the 116-H-1 liquid disposal trench suggests a possible source. Based on the in situ measurements, most of this area probably has levels of contamination barely above the natural background. The majority of the contamination then is concentrated in the parallel lines of high activity that run north to south in the area.

Despite its proximity to the suspect URM, the hot spots that were identified just to the south are quite different in nature. As can be clearly seen by comparison of the gamma energy spectra plots, the ratio of Eu-152 and Cs-137 in the two areas is quite different. Also, the contamination in the suspect URM is spread out over a large area where the hot spots are extremely small and widely separated. This seems to indicate that the hot spots are due to a different source and different mechanism than is responsible for the contamination at the suspect URM.

The area of elevated background located northwest of 100-H area is fairly unique, even for the Hanford Site. The activity is due to the presence of natural uranium. The general character of the site suggests that a coal fired steam plant, furnace, foundry or some other non-nuclear facility occupied the site in the past, possible pre-dating the construction of the 100-H reactor.

References

Beck, H. L., De Campo, J., and Gogolak, C. V., 1972, *In Situ Ge(Li) and Na(Tl) Gamma-Ray Spectrometry*, HASL-258, U. S. Department of Energy, Environmental Measurements Laboratory, New York.

Brodzinski, R. L., 1983, *Portable Instrumentation for Quantitatively Measuring Radioactive Contamination Levels and for Monitoring the Effectiveness of Decontamination and Decommissioning Activities*, PNL-4744, Battelle Memorial Institute, Pacific Northwest Laboratory, Richland, Washington.

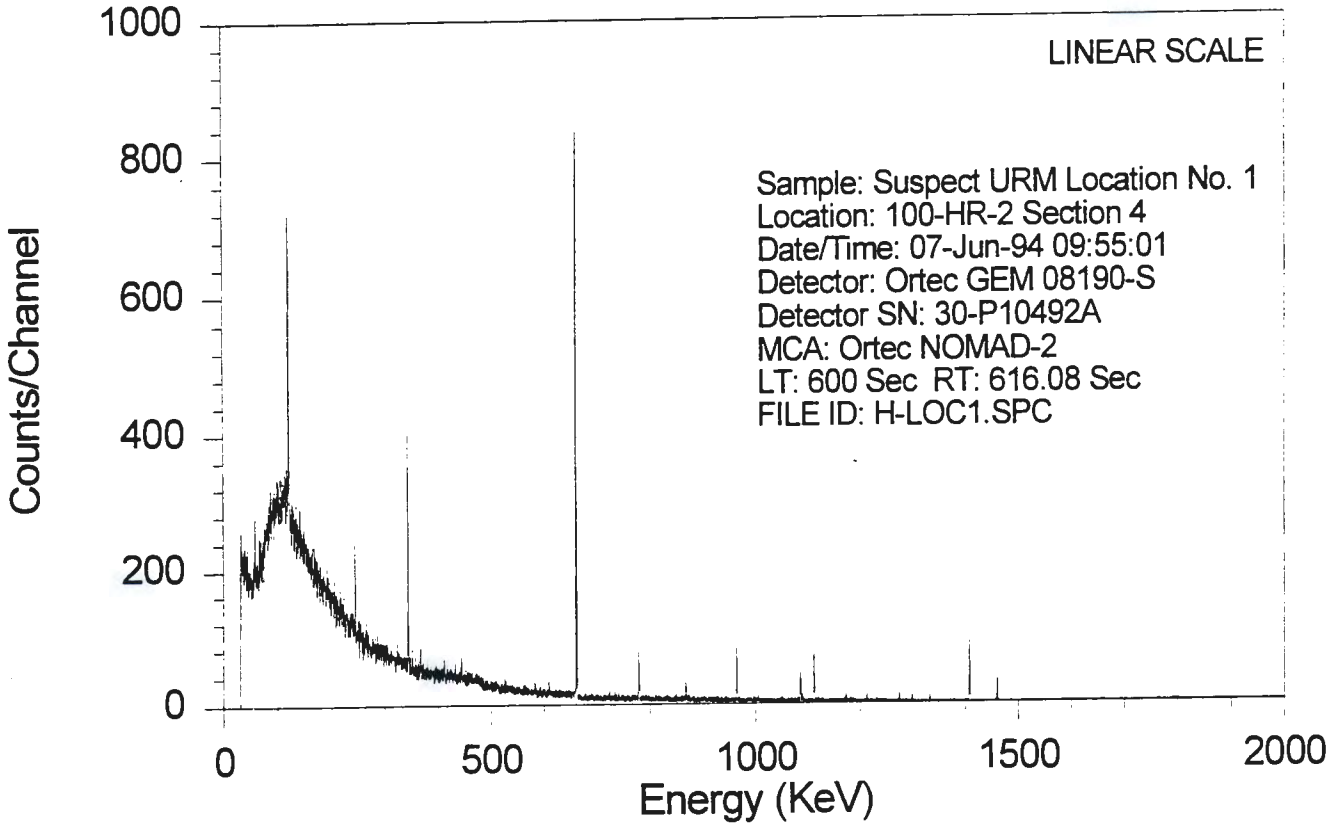
DeNeal, D. L., 1970, *Historical Events - Single Pass Reactors and Fuels Fabrication*, DUN-6888, Douglas United Nuclear, Richland, Washington.

Helfer, I. K. and Miller, K. M., 1988, "Calibration Factors for Ge Detectors used for Field Spectrometry," *Health Physics*, Vol. 55, No. 1, pp 15-29.

Figure 1

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Suspect URM Location 1



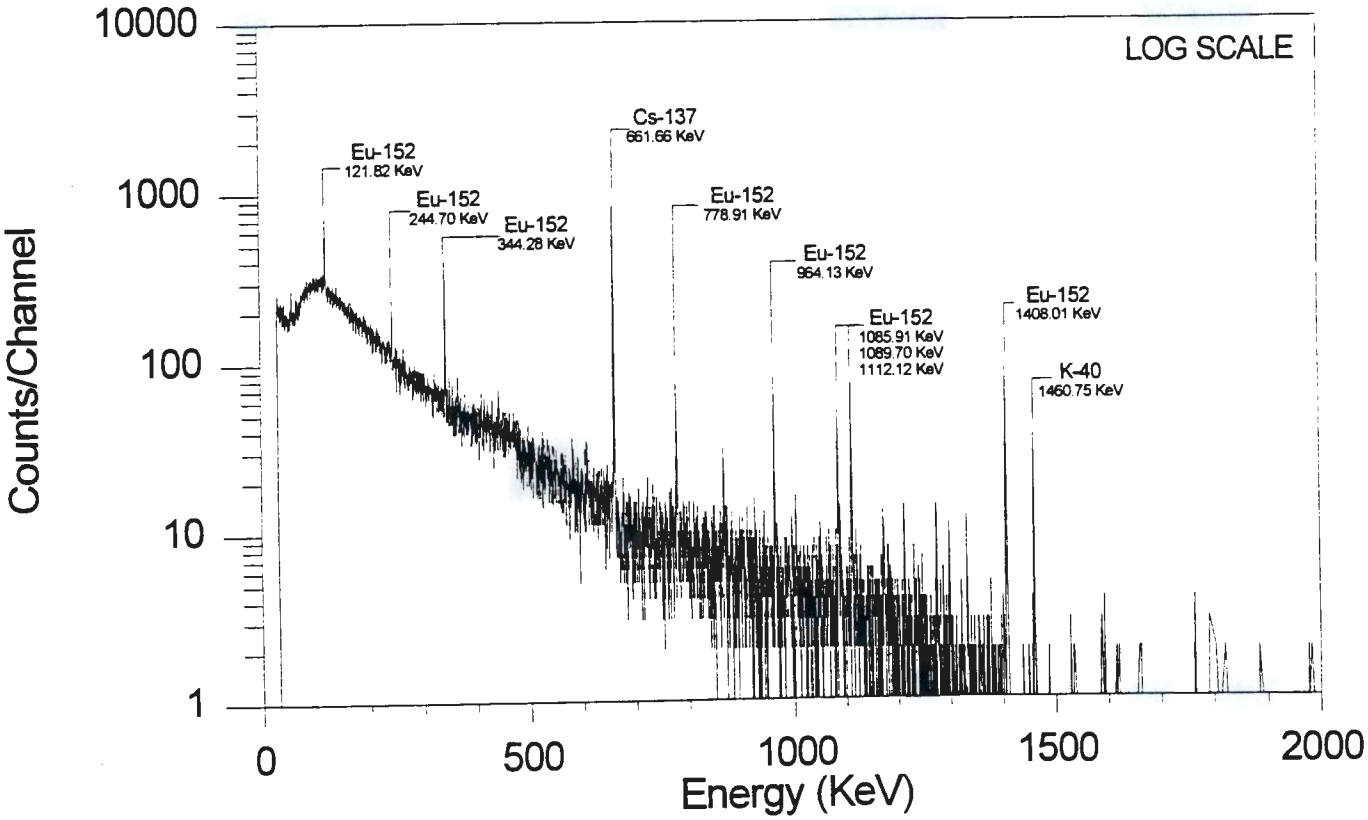
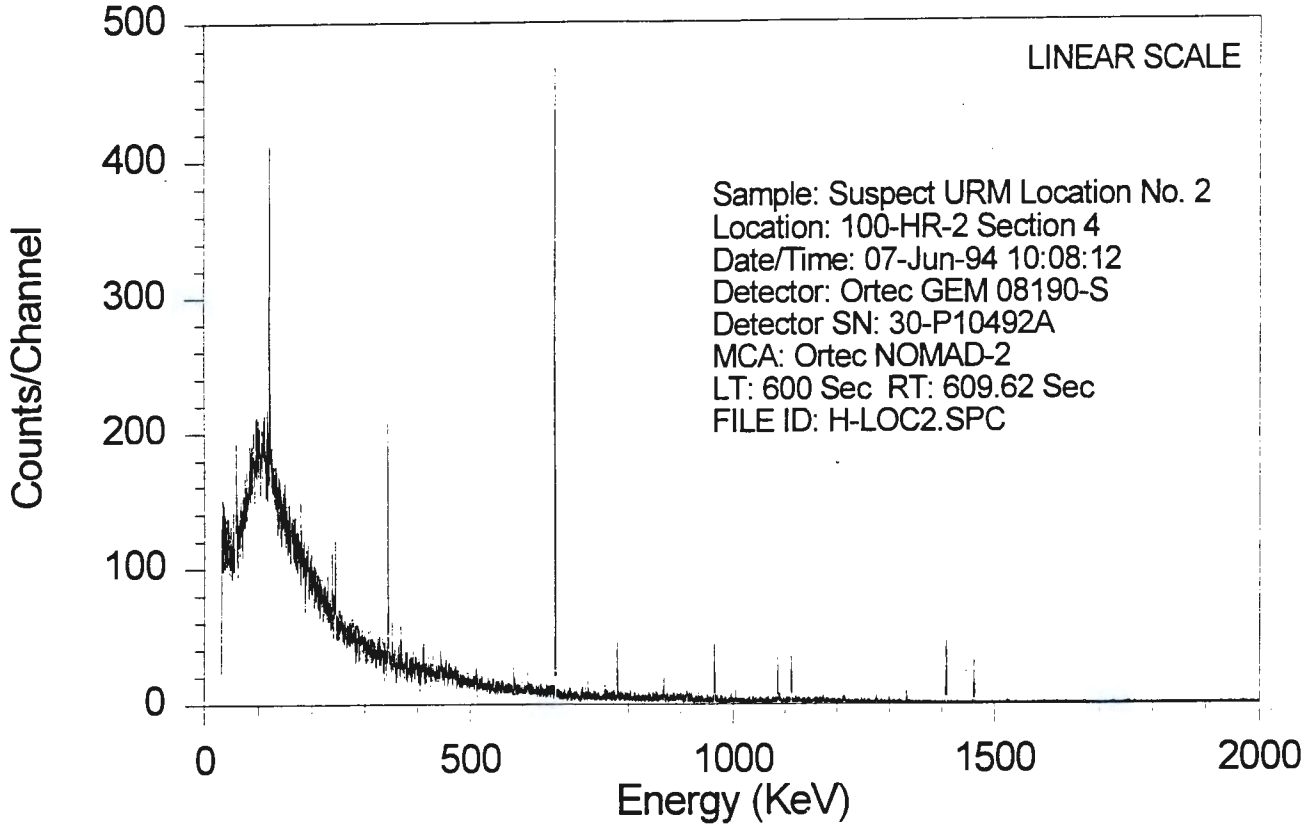


Figure 2

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Suspect URM Location 2



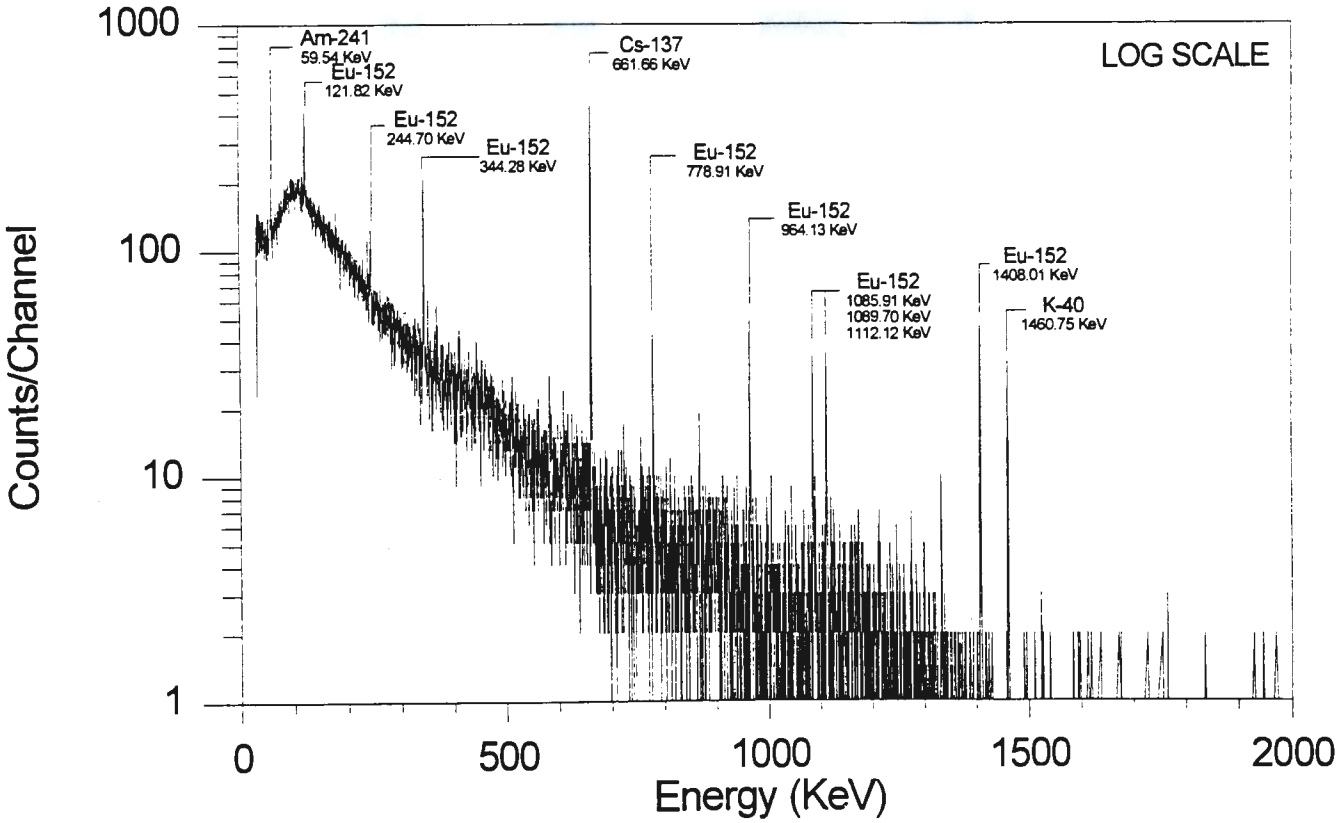
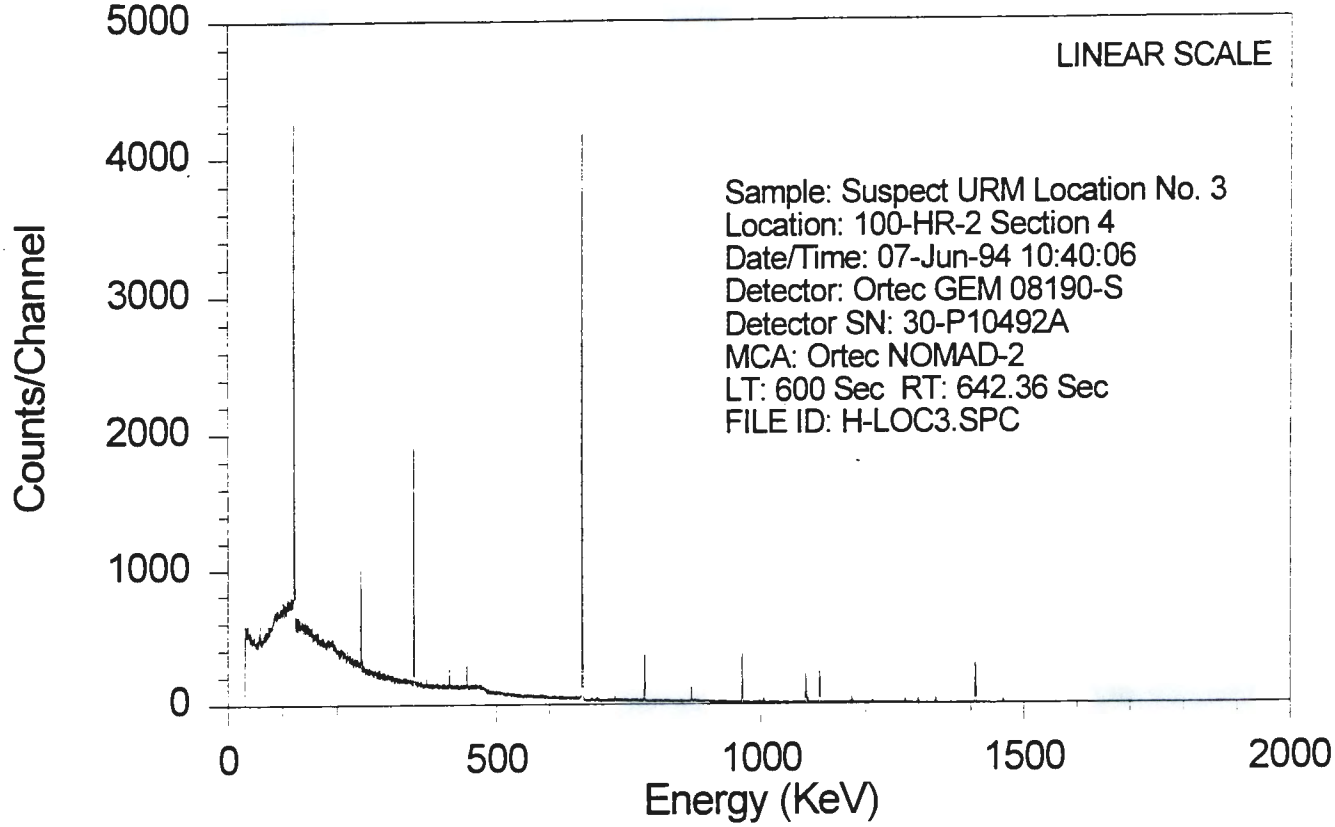


Figure 3

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Suspect URM Location 3



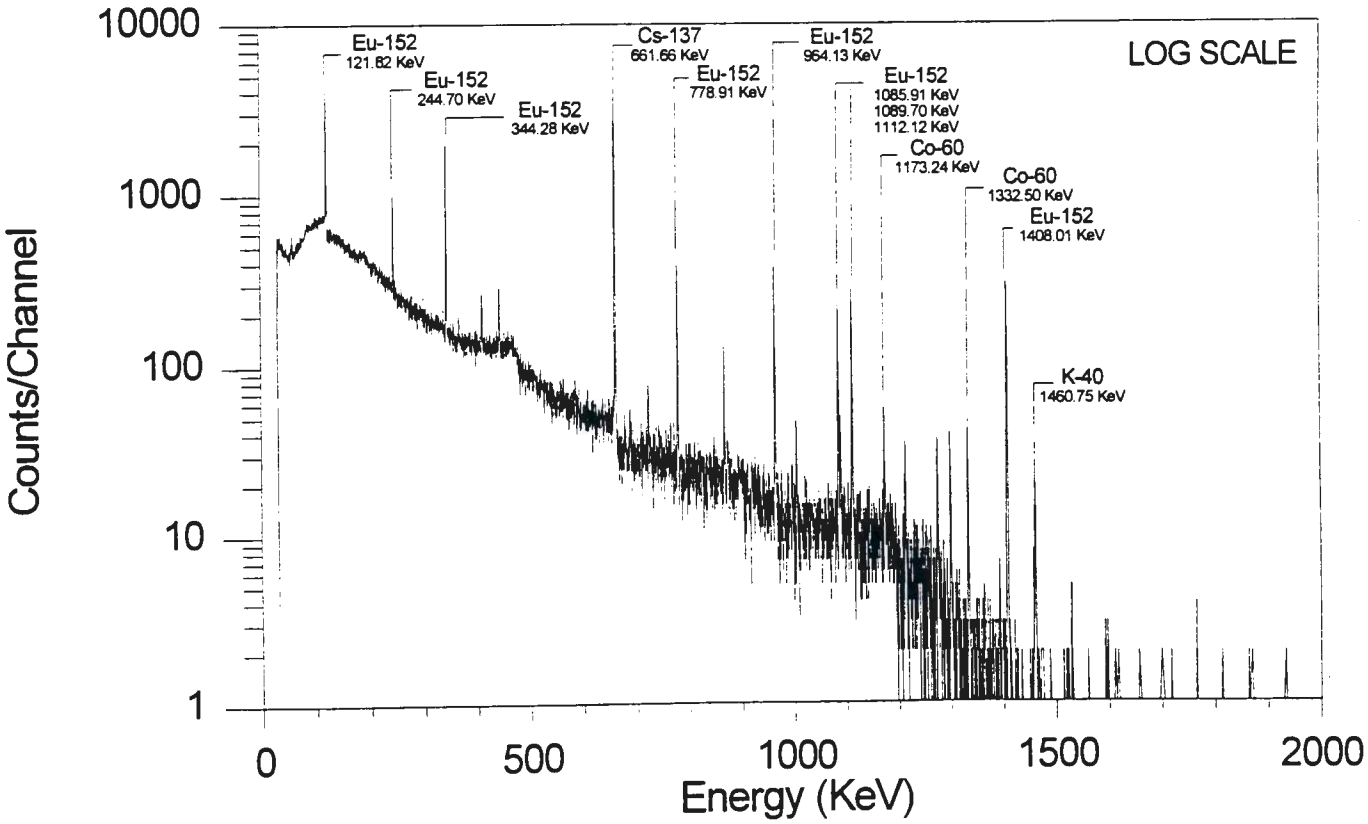
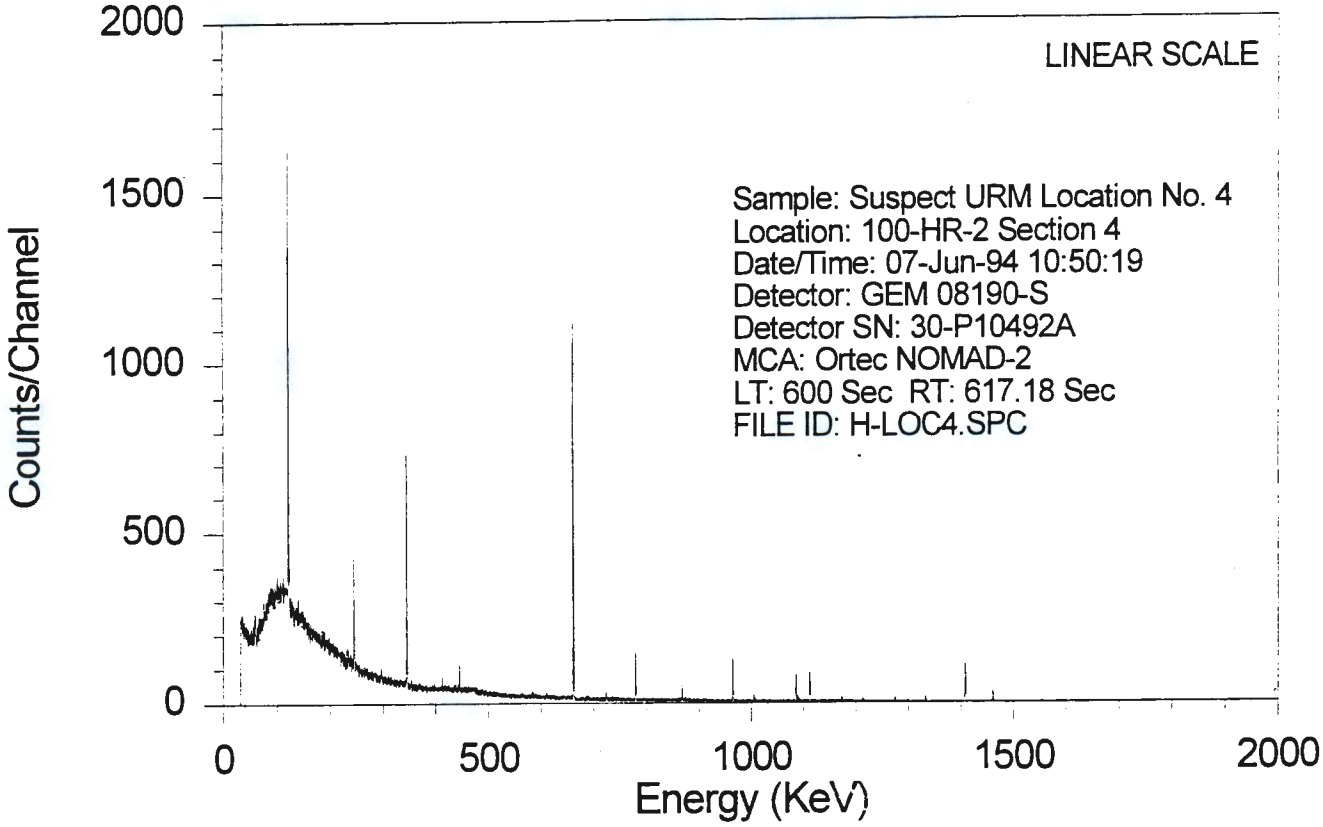


Figure 4

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Suspect URM Location 4



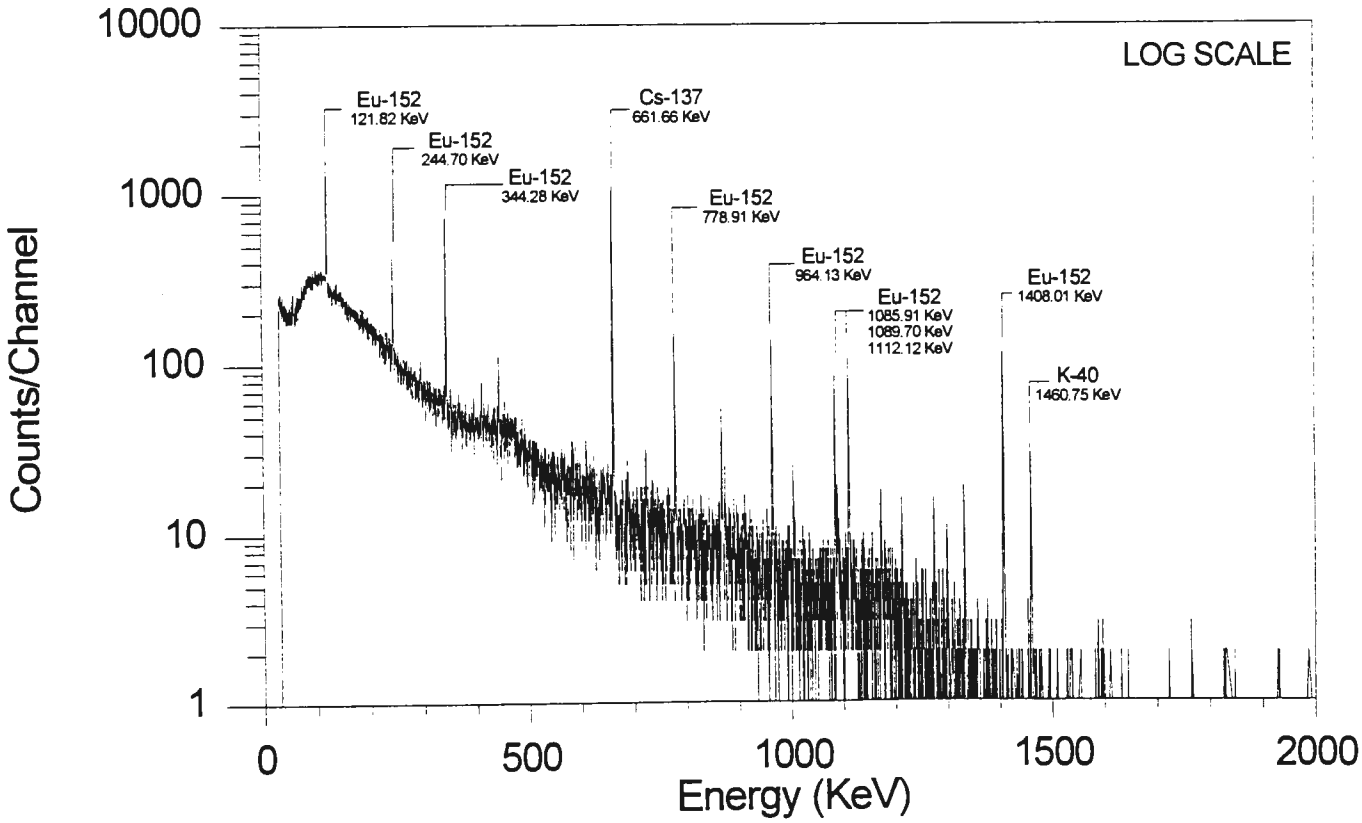
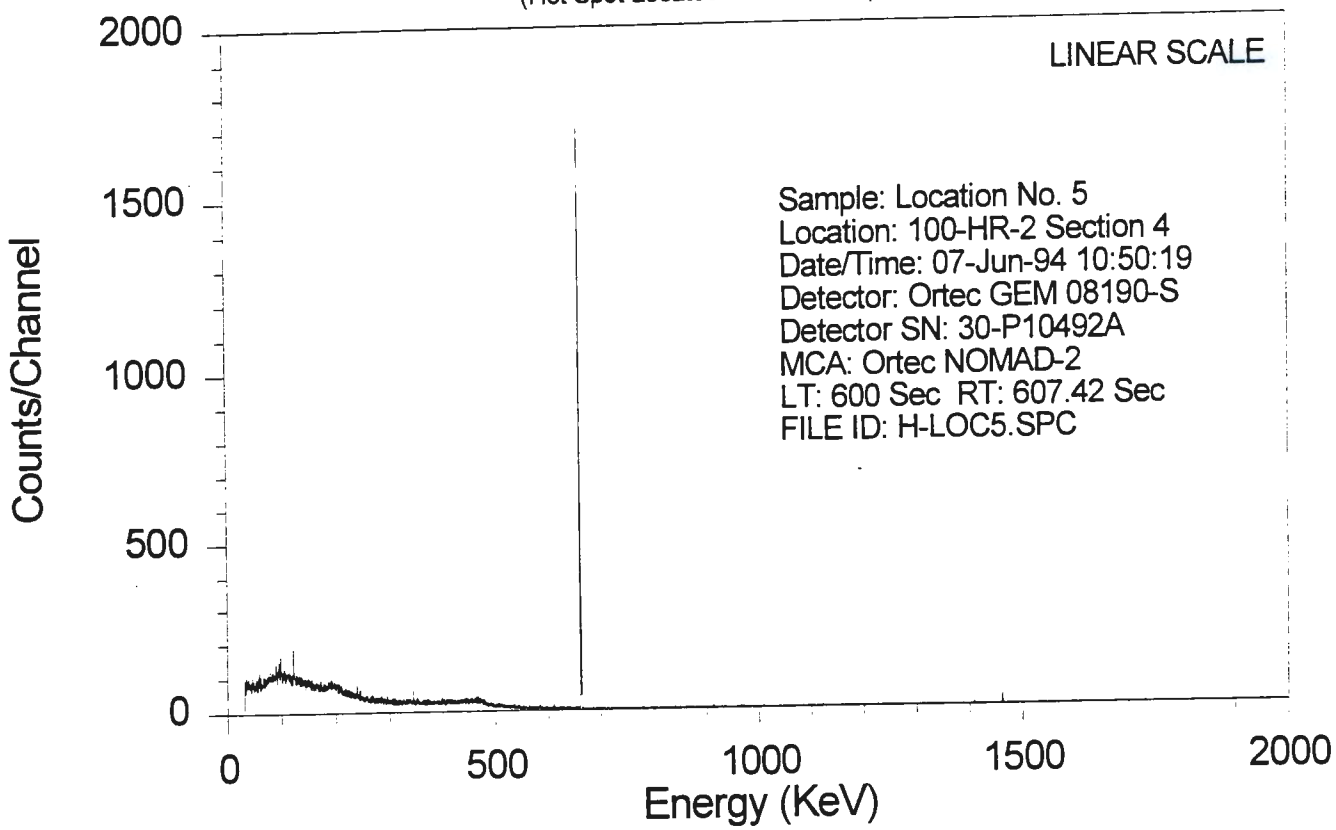


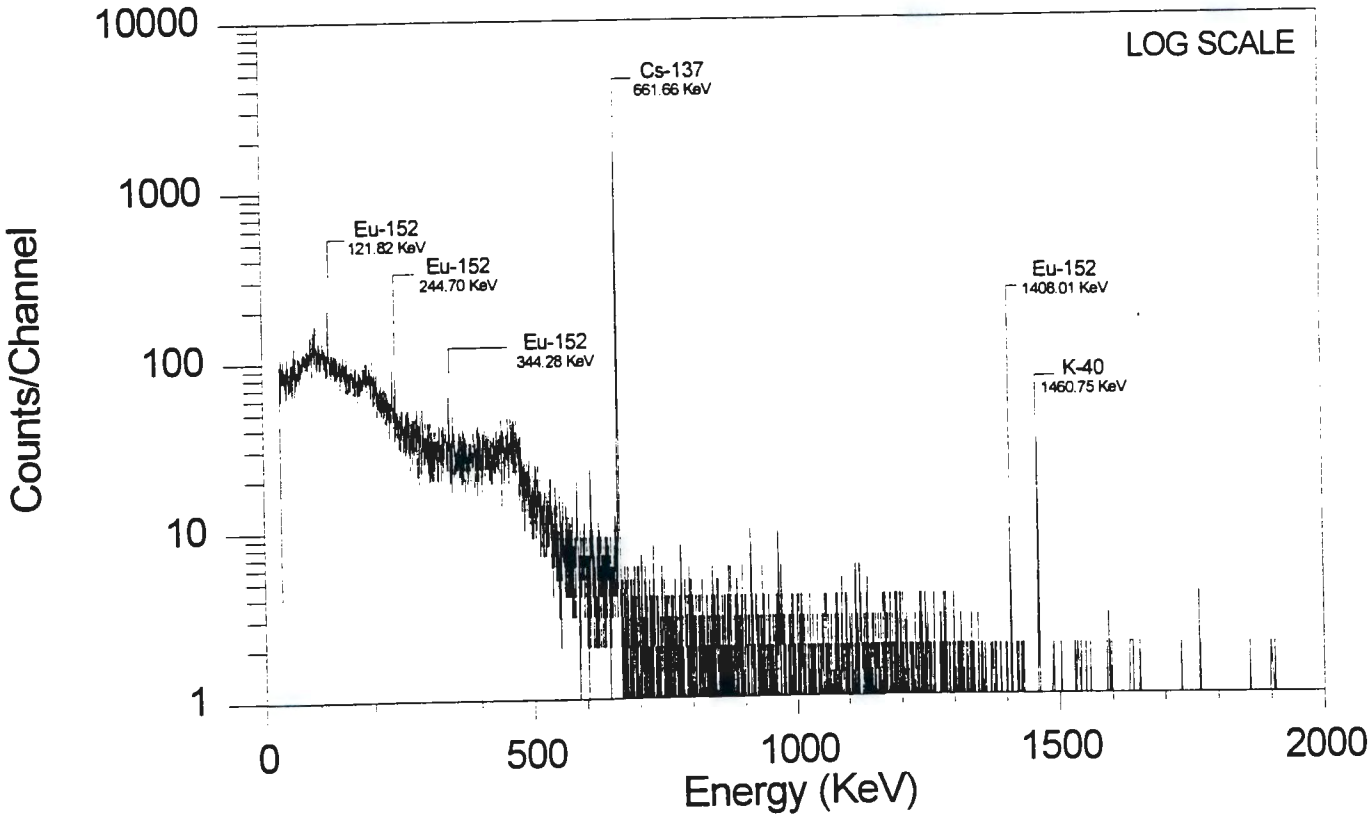
Figure 5

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Location 5

(Hot Spot Located South of Suspect URM)





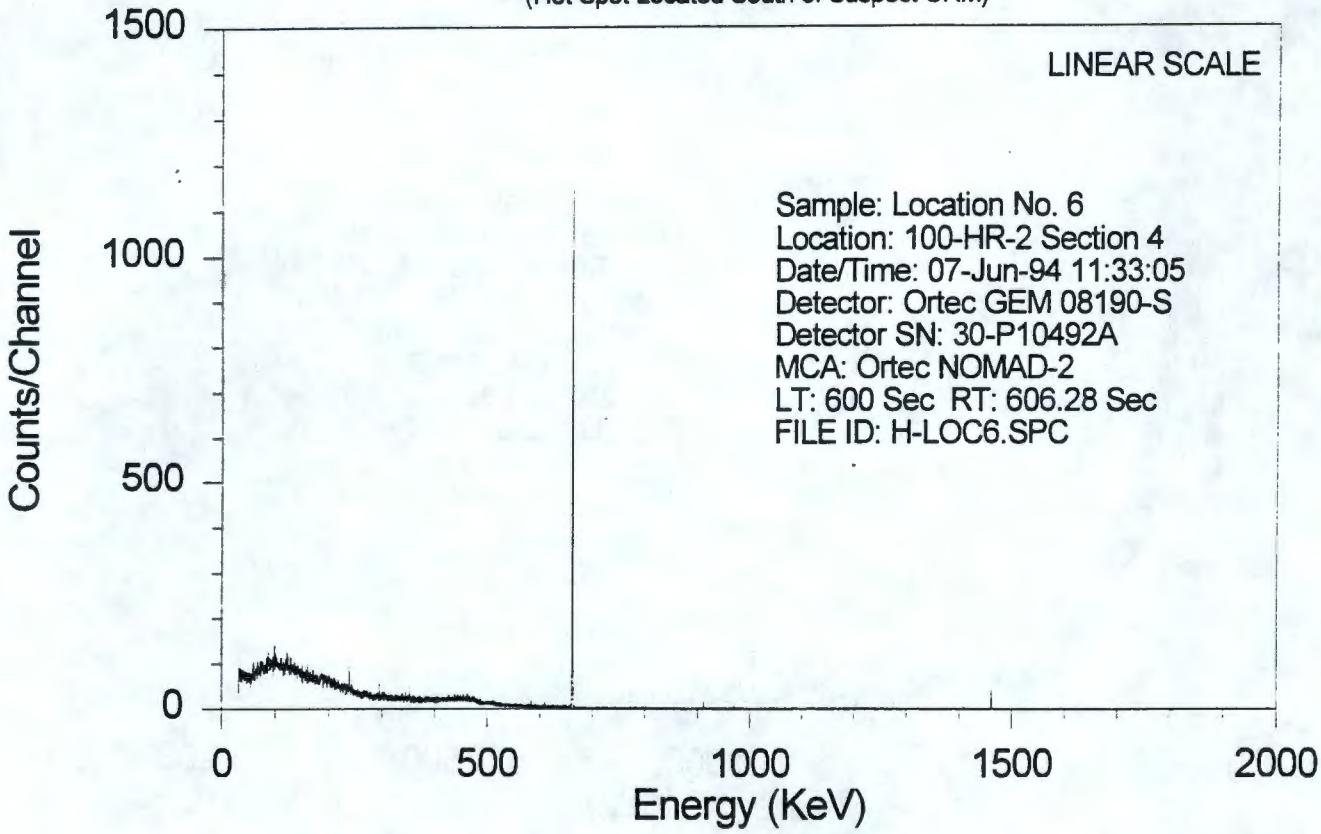
9513360.2136

Figure 6

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 4 - Location 6

(Hot Spot Located South of Suspect URM)



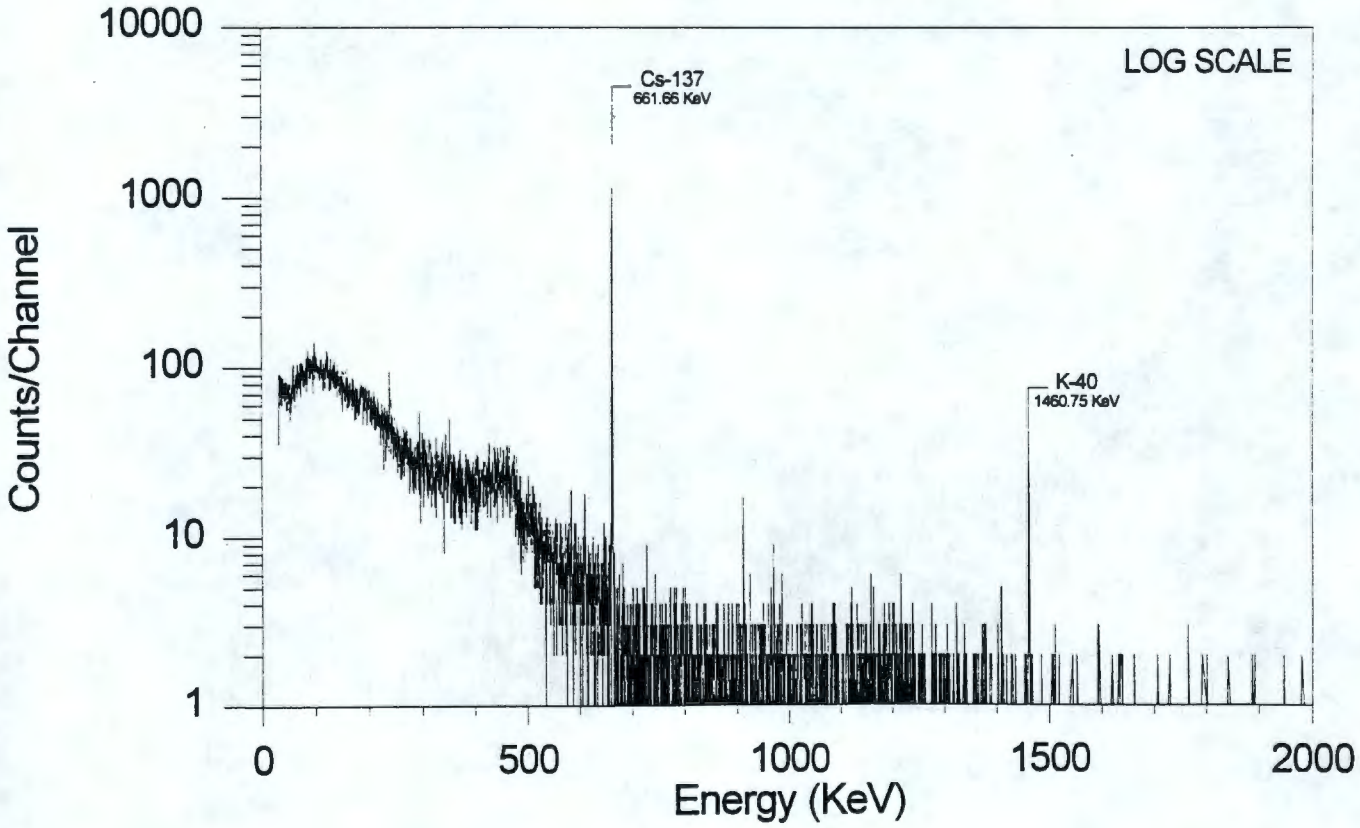
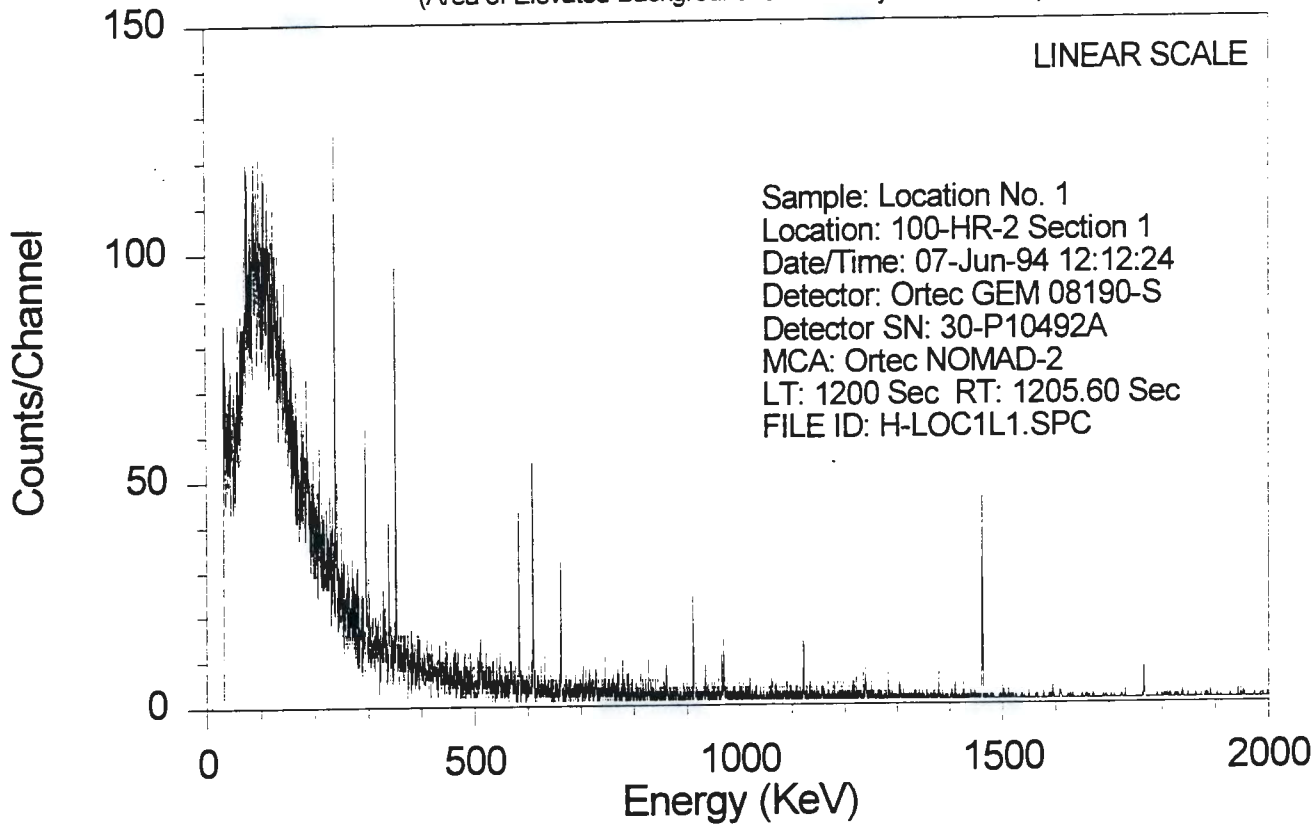


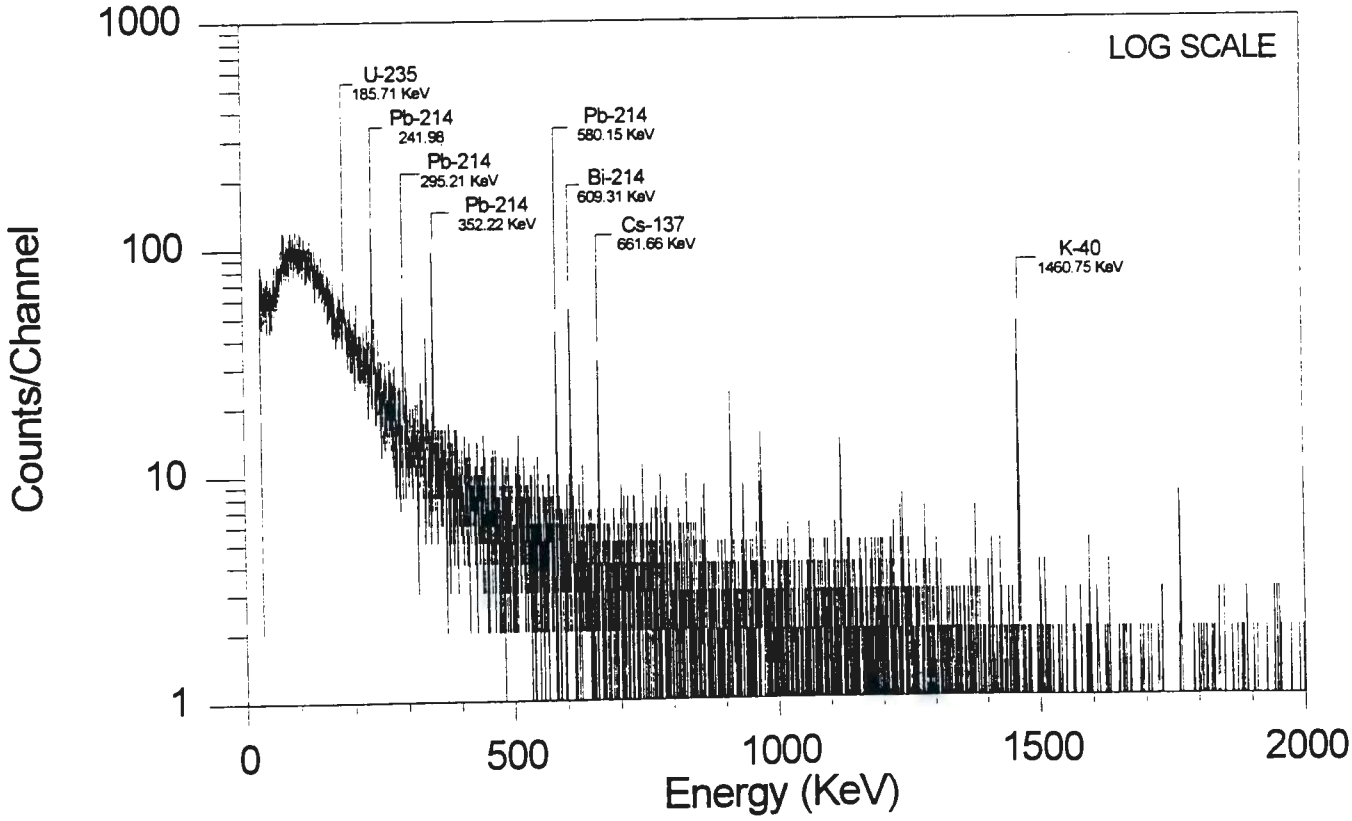
Figure 7

Gamma Energy Spectrum

Recorded at 100-HR-2 - Section 1 - Location 1

(Area of Elevated Background Identified by the MSCM-II)

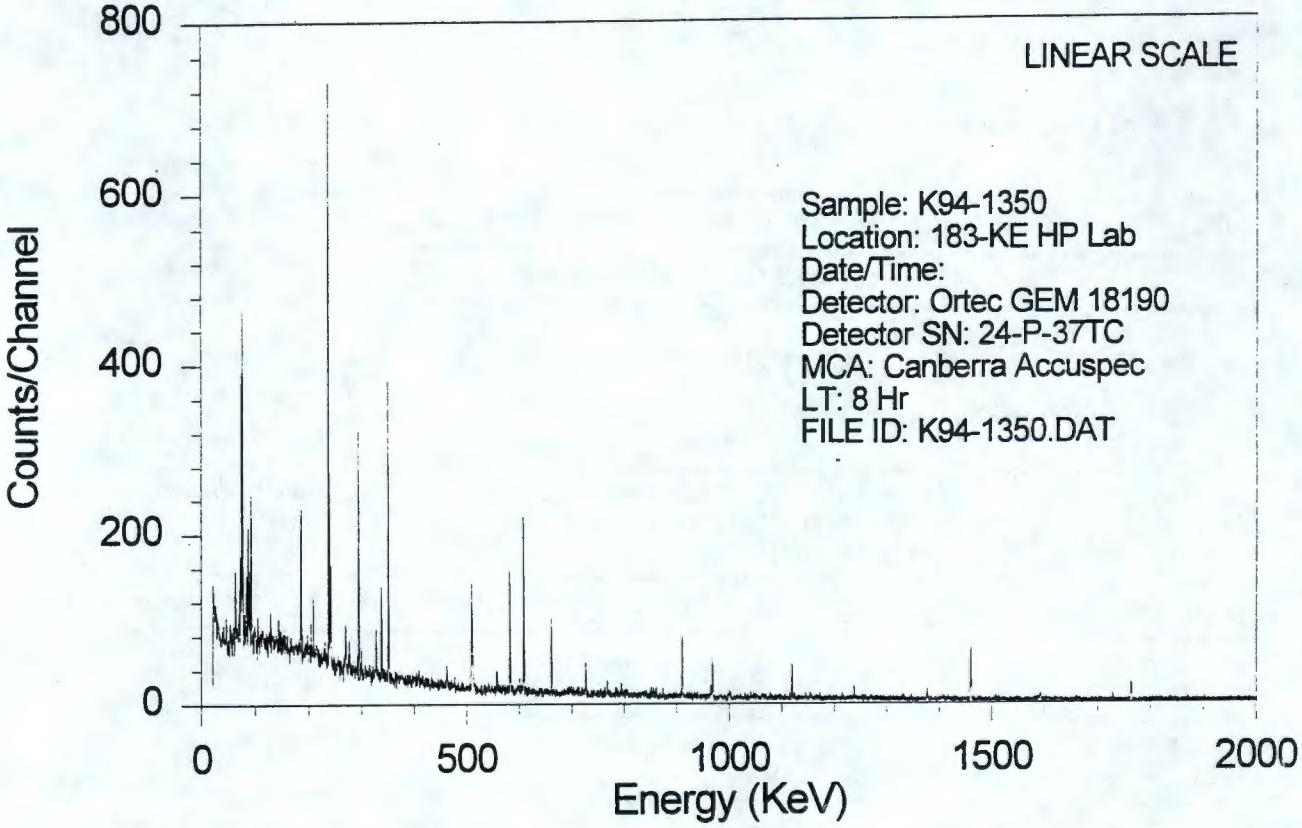




9513360.2137

Gamma Energy Spectrum

Specimen Taken From Elevated Background Area



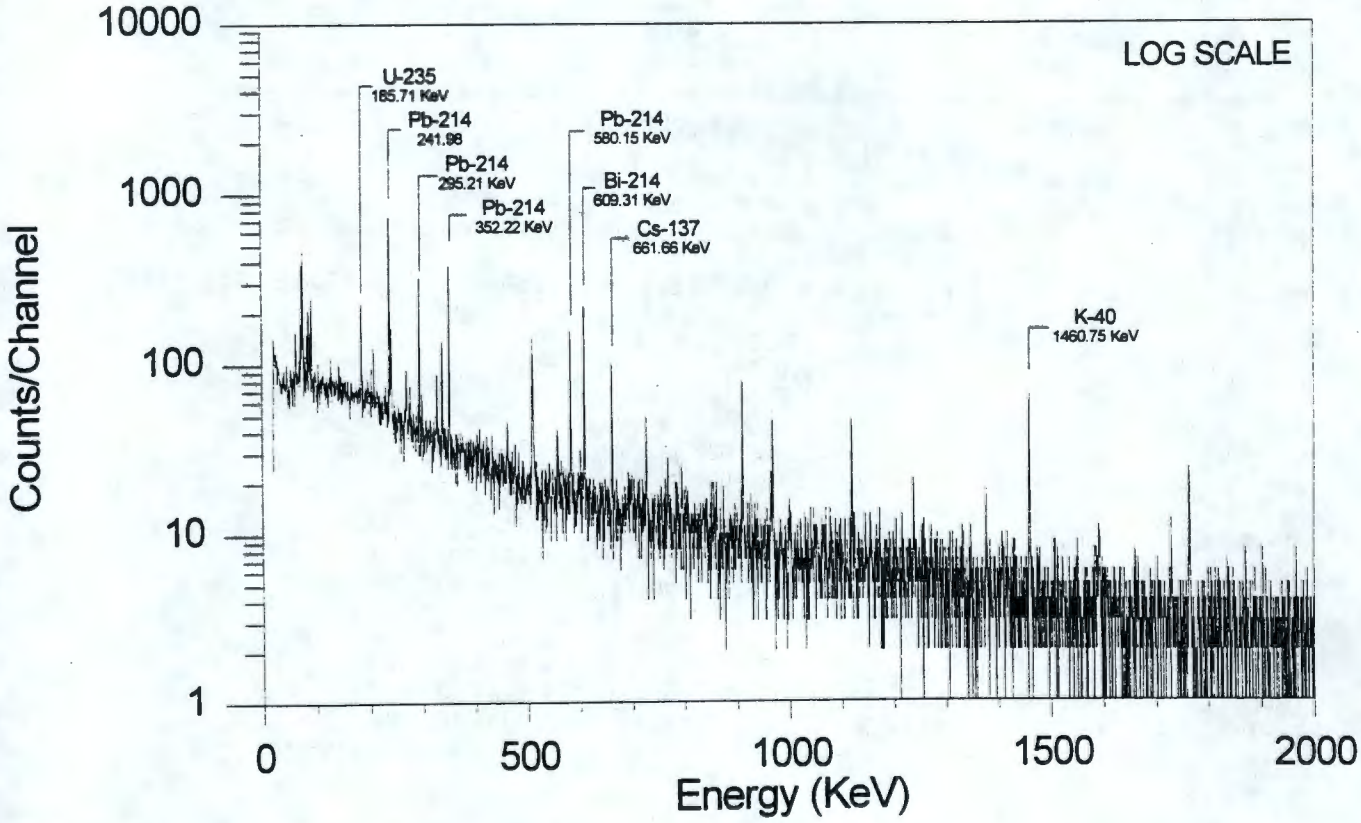


Figure 9 - M-1 Summary Report for Suspect URM - Uniform Distribution Model

```
==================================================================================
M1/PC    Engineering and Environmental Demonstration Laboratory    Ver. 1.00a
==================================================================================
                        1-Meter NUCLIDE ACTIVITY SUMMARY
==================================================================================

Spectrum ID: Suspect URM - South of 116-H-1 Trench

Location:    100-HR-2 SECTION 4

----------------------------------------------------------------------------------
Counting Start. . . . .06-10-94 08:23 ¦ Spectrum File . . . . . . . .100HS4.SPC
Decay Date  . . . . . .00-00-00 00:00 ¦ Decay Time [OFF]. . . . . 0.00e+000 Hrs
Current Date. . . . . .06-12-94 00:15 ¦
----------------------------------------------------------------------------------
Library File. . . . . . . . 100-h.LIB ¦ ID.. . . . . 1 Meter Analysis Library
----------------------------------------------------------------------------------
Aspect Ratio = . . . . . . . . . . 1.2 ¦ Orientation = . . . .                UP
Detector Efficiency . . . . .  19.1 % ¦ Alpha/Rho File . . . . . .UNIFORM.RHO
----------------------------------------------------------------------------------
Gamma Fraction Limit >= . . . 80.00 % ¦ Decay Limit <=. . . .   8.000 Halflives
Library Energy Tolerance. . .   2.00
----------------------------------------------------------------------------------
----------------------------------------------------------------------------------
```

FINAL ACTIVITY REPORT

Nuclide	Energy (keV)	Conc +- 1.00sigma		Halflife (hrs)	Peaks Found
Ac-228	338.40	I.D.Only	pCi/gm	6.13e+000	3 of 3
	911.07	5.95e-001 +-5.28e-002			
	968.90	I.D.Only			
Rn-222	510.00	I.D.Only	pCi/gm	9.18e+001	1 of 1
Tl-208	583.14	2.02e-001 +-1.92e-002	pCi/gm	5.17e-002	2 of 3
	860.47	I.D.Only			
Bi-214	609.32	6.82e-001 +-3.97e-002	pCi/gm	3.32e-001	6 of 8
	768.36	I.D.Only			
	1120.28	I.D.Only			
	1238.11	I.D.Only			
	1377.65	I.D.Only			
	1764.51	I.D.Only			
Cs-137	661.62	6.19e-001 +-2.38e-002	pCi/gm	6.75e+008	1 of 1
K-40	1460.75	1.19e+001 +-2.62e-001	pCi/gm	1.12e+013	1 of 1
Pa-234	98.44	< 6.77e-001	pCi/gm	6.70e+000	MDA
Pb-212	238.63	< 3.40e-001	pCi/gm	1.06e+001	MDA
Pb-214	351.99	< 2.99e-001	pCi/gm	4.47e-001	MDA
Be-7	477.56	< 1.04e+000	pCi/gm	1.28e+003	MDA
Bi-212	727.17	< 6.93e-001	pCi/gm	1.01e+000	MDA
Po-210	803.00	< 8.17e+002	pCi/gm	1.00e+012	MDA
Co-60	1173.22	< 9.58e-002	pCi/gm	4.62e+004	MDA
Co-60	1332.49	< 5.72e-002	pCi/gm	4.62e+004	MDA
Eu-152	1408.08	< 2.97e-001	pCi/gm	1.11e+005	MDA

Figure 10 - M-1 Summary Report for Suspect URM - Aged Fallout Model

```
==============================================================================
M1/PC    Engineering and Environmental Demonstration Laboratory    Ver. 1.00a
==============================================================================
                        1-Meter NUCLIDE ACTIVITY SUMMARY
==============================================================================

Spectrum ID: Suspect URM - South of 116-H-1 Trench

Location:    100-HR-2 SECTION 4

------------------------------------------------------------------------------
Counting Start. . . . .06-10-94 08:23 | Spectrum File . . . . . .100HS4.SPC
Decay Date  . . . . . .00-00-00 00:00 | Decay Time [OFF]. . . . . 0.00e+000 Hrs
Current Date. . . . . .06-12-94 00:16 |
------------------------------------------------------------------------------
Library File. . . . . . . . 100-h.LIB | ID.. . . . . 1 Meter Analysis Library
------------------------------------------------------------------------------
Aspect Ratio =  . . . . . . . . . . 1.2 | Orientation = . . . .              UP
Detector Efficiency . . . . .  19.1 % | Alpha/Rho File . . . . . . . . aged.RHO
------------------------------------------------------------------------------
Gamma Fraction Limit >= . . . 80.00 % | Decay Limit <=. . . .   8.000 Halflives
Library Energy Tolerance. . .   2.00
------------------------------------------------------------------------------
------------------------------------------------------------------------------
```

FINAL ACTIVITY REPORT

Nuclide	Energy (keV)	Conc +- 1.00sigma		Halflife (hrs)	Peaks Found
Ac-228	338.40	I.D.Only	pCi/gm	6.13e+000	3 of 3
	911.07	5.95e-001 +-5.28e-002			
	968.90	I.D.Only			
Rn-222	510.00	I.D.Only	pCi/gm	9.18e+001	1 of 1
Tl-208	583.14	2.02e-001 +-1.92e-002	pCi/gm	5.17e-002	2 of 3
	860.47	I.D.Only			
Bi-214	609.32	6.82e-001 +-3.97e-002	pCi/gm	3.32e-001	6 of 8
	768.36	I.D.Only			
	1120.28	I.D.Only			
	1238.11	I.D.Only			
	1377.65	I.D.Only			
	1764.51	I.D.Only			
Cs-137	661.62	1.36e+005 +-5.22e+003	pCi/m2	6.75e+008	1 of 1
K-40	1460.75	1.19e+001 +-2.62e-001	pCi/gm	1.12e+013	1 of 1
Pa-234	98.44	< 6.77e-001	pCi/gm	6.70e+000	MDA
Pb-212	238.63	< 3.40e-001	pCi/gm	1.06e+001	MDA
Pb-214	351.99	< 2.99e-001	pCi/gm	4.47e-001	MDA
Be-7	477.56	< 1.04e+000	pCi/gm	1.28e+003	MDA
Bi-212	727.17	< 6.93e-001	pCi/gm	1.01e+000	MDA
Po-210	803.00	< 8.17e+002	pCi/gm	1.00e+012	MDA
Co-60	1173.22	< 2.27e+004	pCi/m2	4.62e+004	MDA
Co-60	1332.49	< 1.38e+004	pCi/m2	4.62e+004	MDA
Eu-152	1408.08	< 7.23e+004	pCi/m2	1.11e+005	MDA

Figure 11 - M-1 Summary Report for Area of High Background - Uniform Dist.

M1/PC Engineering and Environmental Demonstration Laboratory Ver. 1.00a

1-Meter NUCLIDE ACTIVITY SUMMARY

Spectrum ID: Area of high background NW of 100-H

Location: 100-HR-2 Section 1

Counting Start. 06-10-94 09:43	Spectrum File 100HS1.SPC
Decay Date 00-00-00 00:00	Decay Time [OFF]. . . . . 0.00e+000 Hrs
Current Date. 06-12-94 00:18	
Library File. 100-h.LIB	ID.. . . . . 1 Meter Analysis Library
Aspect Ratio = ... 1.2	Orientation = ... UP
Detector Efficiency . . . . . 19.1 %	Alpha/Rho File . . . . . .uniform.rho
Gamma Fraction Limit >= . . . 80.00 %	Decay Limit <=. . . . 8.000 Halflives
Library Energy Tolerance. . . 2.00	

FINAL ACTIVITY REPORT

Nuclide	Energy (keV)	Conc +- 1.00sigma		Halflife (hrs)	Peaks Found
U-235	185.72	5.86e-003 +-1.71e-003	pCi/gm	6.17e+012	1 of 1
Ra-226	185.99	I.D.Only	pCi/gm	1.40e+007	1 of 4
Ac-228	338.40	I.D.Only	pCi/gm	6.13e+000	3 of 3
	911.07	8.79e-001 +-5.20e-002			
	968.90	I.D.Only			
Rn-222	510.00	I.D.Only	pCi/gm	9.18e+001	1 of 1
Tl-208	583.14	3.30e-001 +-2.00e-002	pCi/gm	5.17e-002	2 of 3
	860.47	I.D.Only			
Bi-214	609.32	1.21e+000 +-4.35e-002	pCi/gm	3.32e-001	8 of 8
	768.36	I.D.Only			
	934.05	I.D.Only			
	1120.28	I.D.Only			
	1238.11	I.D.Only			
	1377.65	I.D.Only			
	1729.60	I.D.Only			
	1764.51	I.D.Only			
Cs-137	661.62	2.20e-001 +-2.01e-002	pCi/gm	6.75e+008	1 of 1
K-40	1460.75	5.85e+000 +-1.90e-001	pCi/gm	1.12e+013	1 of 1
Pa-234	98.44	< 6.69e-001	pCi/gm	6.70e+000	MDA
Pb-212	238.63	< 3.36e-001	pCi/gm	1.06e+001	MDA
Pb-214	351.99	< 3.07e-001	pCi/gm	4.47e-001	MDA
Be-7	477.56	< 9.62e-001	pCi/gm	1.28e+003	MDA
Bi-212	727.17	< 6.79e-001	pCi/gm	1.01e+000	MDA
Po-210	803.00	< 8.99e+002	pCi/gm	1.00e+012	MDA
Co-60	1173.22	< 8.58e-002	pCi/gm	4.62e+004	MDA
Co-60	1332.49	< 6.98e-002	pCi/gm	4.62e+004	MDA
Eu-152	1408.08	< 3.49e-001	pCi/gm	1.11e+005	MDA