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DATA SUMMARY PACKAGE FOR THE BETHEL VALLEY AREA DQO WORKSHOP

WASTE AREA GROUPING 3

FINAL

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WASTE AREA GROUPING 3 DQO Data Package

I. Introduction

II. Source Information

III. Data Summary

IV. Conceptual Site Model

V. Risk Assessment

VI. Other

VII. References

1.0 INTRODUCTION

PURPOSE

This data package provides a summary of waste management and environmental data associated with waste burial activities in the White Oak Creek Watershed (WOCW) at the Oak Ridge National Laboratory in Oak Ridge, Tennessee. The intent of this data package is to support the Data Quality Objectives (DQO) process for the proposed WOCW Remedial Investigation/Feasibility Study (RI/FS).

The seven primary steps of the DQO development process, as defined by the Environmental Protection Agency (EPA), are:

- state the problem,
- *identify decisions to be made,*
- identify inputs to the decision (data uses).
- define the study boundaries,
- develop the decision rule (if/then),
- specify limits on uncertainty, and
- optimize design for obtaining data.

In the DQO process, the *decisions to be made* and documented in a WOCW Record of Decision (ROD) will set the stage for evaluating the completeness of the available data. Identification of these decisions will occur at a scoping meeting prior to a DQO workshop, or at the start of the DQO workshop. The information in this package is meant to be used during the last step of the DQO process to determine if available data are sufficient for making target decisions on WOCW waste sources or if additional data must be obtained.

A premise of the proposed WOCW project is that available data likely are sufficient for decision-making at a level of detail agreed upon by the Department of Energy (DOE), the EPA and the Tennessee Department of Environment and Conservation (TDEC). It is recognized that additional data may be required at a later date for designing a remedial action. This data summary package provides available data to project managers, scientists, engineers, and regulators for critical review so that interested parties can determine if the available data are sufficient, or if not, what additional data are required before a ROD can be developed.

OBJECTIVES OF THE WHITE OAK CREEK WATERSHED RI/FS

The primary objective of the proposed WOCW RI/FS is to document the watershed-wide approach for remediating waste sources, in-effect, tearing down the "Waste Area Grouping (WAG) walls" that have been an integral part of the environmental restoration strategy at ORNL. In doing so, decisions can be made on discreet waste sources or D&D facilities in the context of what is best for the entire watershed, which in turn, should lead to more timely and effective remediation projects.

The RI/FS will attempt to accomplish the following tasks:

- Clearly document the problems (waste sources and releases) in the WOCW;

- Estimate the risks associated with current and potential future releases from the waste units and compare the release concentrations to ARARs;

- Estimate the risk reduction benefit and cost associated with representative process options that could be implemented to reduce risks;

- Balance benefits and costs from a watershed-wide perspective to help determine the optimal set and sequence of actions in WOCW and the possible need to obtain waivers from complying with existing regulations.

WAG 3 INFORMATION SUMMARY

- Known or suspected WAG 3 radiological contaminants are: H^3, Sr^{90}, Cs^{137}, and TRU waste.
- WAG 3 contributes Sr^{90} and Cs^{137} to the Northwest tributary (< 2% of total risk at WOD), and radiological, organic, and possibly inorganic contaminants to groundwater.
- SWSA 3 covers approximately 6.1 acres. The number of waste trenches in SWSA 3, their contents and their exact locations are unknown.
- An estimated waste inventory (at disposal) for SWSA 3 is 44,000 — 56,000 Ci of radioactivity.
- At least some trenches in the northeast quarter of SWSA 3 are perennially inundated (assuming 15' trench depth).
- The exact boundaries of the closed scrap metal area and the nature and origin of material it contains are unknown.
- Explosives may be buried at WAG 3 (containers containing explosive materials were removed from surface storage at WAG 3).
- The surface of the WAG 3 site has higher-than-background gamma radiation levels.
- The following parameters exceed drinking water MCLs in at least one groundwater well at WAG 3: H^3, total Sr, alpha, beta, TCE, Hg, and pH.
- Based on results of dye traces, groundwater from SWSA 3 feeds spring RCTS which is a major source of contaminants to Raccoon Creek.
- A tributary that previously flowed across SWSA 3 has been re-routed. Because this ditch is unlined, it is likely that subsurface flow still follows the old pathway.
- A large (>3 ft) concrete culvert runs under SWSA 3 on the south end of the site and appears to capture all the surface flow from the next swale east (along Haw Ridge) from the described in the previous bullet. This area is presently inside a surface contamination zone. It must play a role in recharge to the SWSA 3 subsurface. (Dale Huff, review comments, 4/28/97)
- Potential risk in WAG 3 perimeter wells is as high as 7.96E-4 and is increasing in some wells (1994 vs 1995 comparison).
- Results of supplemental surface soil sampling conducted at WAG 3 in 1996 showed elevated levels of inorganic (arsenic, cobalt, zinc, manganese, and iron), PCBs (Aroclor 1260), and radionuclide (lead ^{214}, lead ^{212}, alpha activity, and U^{238}) contaminants.

DATA SUMMARY SHEET FOR WASTE AREA GROUPING 3
CERCLA Status:

Waste Unit Description	Unit Type	Status	Size/ Capacity	Ownership	Waste Forms	Inventory					Contaminant Releases				Hydrologic Model		Potential Risk			
																	Human		Ecological	
						RAD	TRU	PCB	Hg	Other*	Surface Water	Groundwater	Soil	Sediment	Hydrologic Class	Transport Pathways	Current	Future	Current	Future
SWSA 3	BW	I	~7 acres	EMEF	GW/SdW	X					◒	◒	◒	◒	◒	◒	◒	O	O	O
Closed Metal Scrap Area	BW	I	~4 acres	EMEF	SdW						O	◒	O	O	◒	◒	◒	O	O	O
Contractors' Landfill	BW	I	~7 acres	EMEF	SdW						◒	◒	◒	O	◒	◒	◒	O	O	O

Unit Types:
B = Building
T = Tank
R = Reactor
P = Pipeline
DD = D&D Facility
BW = Buried Waste
I = Impoundment
CS = Contaminated Soil
CG = Contaminated Groundwater
CW = Contaminated Surface Water

Status:
A = Active
T = Transition
I = Inactive
R = Remediated

Ownership:
(See Attachment 1)

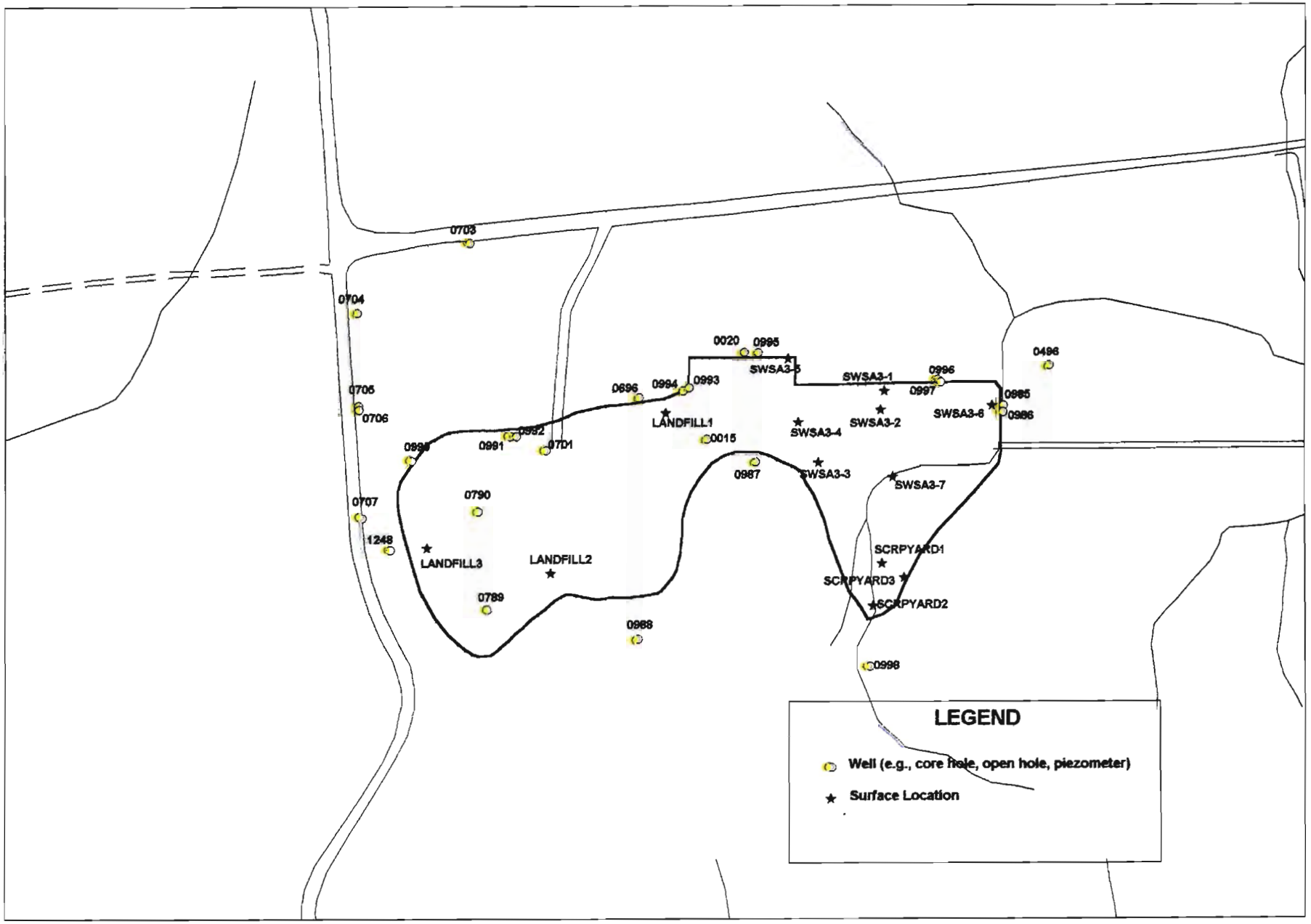
Waste Forms:
G = Gas
GW = Groundwater
SW = Surface Water
SD = Sediment
SL = Sludge
SS = Surface Soil
SB = Subsurface Soil
L = Liquid
SdW = Solid Waste

*** Other:**
VOA
Metals

Well Defined: ●
Partially Defined: ◒
Not Defined: O

000007

WAG 3 MONITORING LOCATIONS



600009

DOCUMENTS REVIEWED

An Investigation of Radionuclide Release From Solid Waste Disposal Area 3, Oak Ridge National Laboratory. ORNL/TM-7323. August, 1981.

Annual Report of the Environmental Restoration Monitoring and Assessment Program for FY 1992 at Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL/ER-124. September, 1992.

Environmental Data Package for ORNL Waste Area Grouping 3, Solid Waste Storage Area 3. ORNL/RAP-21. September 1987.

Fourth Annual Environmental Restoration Monitoring and Assessment at Oak Ridge National Laboratory. DOE/OR/01-1490&D1. September, 1995.

Remedial Investigation Plan for WAG 3. ORNL/RAP/Sub-87/99053/22. September 1988.

Remedial Investigation Plan for Waste Area Grouping 3: Summary. November 1988.

Remedial Investigation Plan for the Groundwater Operable Unit at Oak Ridge National Laboratory. DOE/OR-01/1252&D1. March 1994.

Site Descriptions of Environmental Restoration Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee. ORNL/ER-391. February, 1997.

Third Annual Environmental Restoration Monitoring and Assessment at Oak Ridge National Laboratory. DOE/OR/01-1290&D1. September, 1994.

Life Cycle Baseline Summaries for the Environmental Restoration Program at Oak Ridge National Laboratory, Volume 3: ADS–Waste Area Grouping 3. ORNL/ER/INT-20/V3. August 1992.

Surveillance and Maintenance Plan for Waste Area Groupings at Oak Ridge National Laboratory for FY 1993-2003. ORNL/ER-39. December 1992.

Validated Analytical Data Summary Report for White Oak Creek Watershed Remedial Investigation Supplemental Sampling, Oak Ridge National Laboratory. ORNL/ER-381. September 1996.

Bethel Valley RI/FS Historical Data Review

Form Completed by: J. Chason
Date: 3/7/97

Document Reviewed: Site Descriptions of ER Units at ORNL
Doc ID: ORNL/ER-391
Author/Date: Kuhaida + Parker, 1997

Comments: Good summaries of current info.
No actual analytical data included.

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Closed Scrap Metal Area	SWSA 3	4 acres type = Contaminated Soil status = Inactive			N/A →				
3	Contractor's Landfill	CLF	7 acres type = Contaminated Soil/Buried Waste status = Active (TDEC permit)			N/A →				

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
G = grab
SG = stormflow grab
BG = baseflow grab
FC = flow composite
SC = spatial composite
V = vertical profile
S = site survey

Analytical Fraction:
I = Inorganics
O = Organics
P = PCBs/Pesticides/Herbicides
GR = gross alpha/beta
ISO = isotopic rads
B/G = beta/gamma survey
FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000013

Bethel Valley RI/FS Historical Data Review

Form Completed by: J. Chasm
Date: 3/10/97

Document Reviewed: An Investigation of Rad Release from SWSA 3
Doc ID: ORNL/TM-7323
Author/Date: Stuebar et al., August 1981

Comments: Summarized in the RI Workplan.

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Duguid, 1975	all		73,78,79	GW	3,9,15,16, 20-23,32, 41-46,301, 302,303	G	ISO	2A	M
3	CSA surface sampling	CSA (CLF)	Depth of fill ≤ 6m	79?	Surf soil		Biased G	ISO	2C	M
3	Contractors Spoil Area (CSA) surface runoff	CLF		1979	SW	RC-1, RC-2 RCH-1... RCH-3 RCH-T	G	ISO	2A	M

General:
NA = Not Available
NR = Not Researched
(blank) = Unknown

Sampling Media:
surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

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2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000015

Bethel Valley RI/FS Historical Data Review

Form Completed by: J. Chason
Date: updated 3/7/97

Document Reviewed: Remedial Investigation Plan for WAG 3
Doc ID: ORNL/RAP/SUB-87/99053/22
Author/Date: MMES, September 1988

Comments:

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Inventory of above-ground storage	SWSA 3	6.1 acres	1979	Waste	SWSA 3	NA	—	1C	M-L
3	Historical data	SWSA 3		1964, '73	GW			ISO	2A	L
3	Sludge sampling	Cont. LF		1986	Waste	CLF		I, O, P, TOX	1C	
3	Stveber-soil sampling	SWSA 3		1978	Surf. S.	SWSA 3, NWT		ISO	2C	L-M
3	Rad survey	SWSA 3		1987	[illegible]	SWSA 3	S	B/G	2C	
3	Rad survey	CLF		1981?	NA	CLF	S	~~ISO~~ B/G	2C	
3	SW Monitoring	all		86-87	SW	RC, NWT	FC	ISO	2A	
	"	all		1961, 79	SW	NWT		ISO	2A	
	"	all		1979	Seep	RCTS	TC	ISO	2A	
3	Surface Runoff Smplng	CLF		1981?	SW	CLF	G	ISO	2A	
3	Streambed gravel srvy	all		81, 85, 86	Sed	NWT (2)	G	I, ISO	2D	
	"	all		85, 86	Sed	RC (2)	G	I, ISO	2D	
3	GW Sampling (Stokdale)	all		1950	GW	~19 wells	G	I, FLD	2A	
3	GW Sampling	SWSA 3		8/95	GW	301-303	G	I, ISO	2A	
		CLF		7/86	GW	789		I, ISO, FLD	2A	

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(blank) = Unknown

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surface soil
subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

Sampling Protocol:
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FLD = field measurements

Decision Rule / Hypothesis
1 = Source characteristics
1A = design/operation
1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps/SW
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000017

Bethel Valley RI/FS Historical Data Review

Form Completed by: J. Chason
Date: 8/10/97 updated

Document Reviewed: Environmental Data Package ORNL WAG 3, SWSA 3
Doc ID: ORNL/RAP-21
Author/Date: MMES, September 1987

Comments: Much of this is included in the RI Workplan

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Cross section	SWSA 3		1/79	GW	water levels		NA	1D	M
3	Stueber, 1981	SWSA 3, CLF		78-79	SW, GW			ISO	2A, 2B	
3	Geophysical study	SWSA 3		1985?		NA	S	NA	1D, 1E	
3	Tracer study	SWSA 3		81-82	GW	wells 41, 21, 493→456, 16, 23, 270, RC-T2				M
3	Streambed gravel study	all			Sed	NWT	G	ISO	2D	M

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subsurface soil
surface water
groundwater
seep or spring
sediment
waste
biota

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1B = leachate
1C = waste inventory
1D = waste unit hydrology
1E = other FS information
2 = Current releases
2A = shallow groundwater, seeps
2B = deep groundwater
2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000019

Bethel Valley RI/FS Historical Data Review

Form Completed by: J. Chasm

Date: updated 3/10/97

Document Reviewed: Remedial Investigation Plan For WAG 3 — SUMMARY

Doc ID:

Author/Date: MMES, November 1988

Comments: Includes a table summarizing media-specific data found in the RI Workplan

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence

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3 = Current risk
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3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000021

Bethel Valley RI/FS Historical Data Review

Form Completed by: M. Collins Shyone
Date: 4/9/97

Document Reviewed: Life Cycle Baseline Summary for EM Management at ORNL
Doc ID: ORNL/ER/INT-20/V3
Author/Date: UT-BS / Aug. 1995

Comments: Discussion of activities planned for WAG 3 including Early Action Demonstration, Phase RI, FS/PP/ROD

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence

General:
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3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

000033

Bethel Valley RI/FS Historical Data Review

Form Completed by: M. Collins / S. Lagoma
Date: 4/9/97

Document Reviewed: S+M Plan for WAG 5 at ORNL FY 1993-2002
Doc ID: ORNL/ER-39
Author/Date: Ford, Bacon & Davis / Dec 1992

Comments: Brief description of closed Contractor Landfill and schedule of S+M activities.

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Closed Contractor Landfill S+M activities	CCL	INACTIVE / WMRAP	NA						

General:
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2C = soil around waste units
2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

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0000326

Bethel Valley RI/FS Historical Data Review

Form Completed by: M. Collins Stegard
Date: 4/9/97

Document Reviewed: Validated Analytical Data Summary Report for WOC RI Supp Sampl
Doc ID: ORNL/ER-381
Author/Date: CDM / 9/96

Comments:

WAG	Description of Study	Waste Unit	Waste Unit Characteristics	Sampling Dates	Sampling Media	Sampling Locations	Sampling Protocol	Analytical Fraction	Decision Rule(s)	Quality or Confidence
3	Suppl. Soil Sampling	CLF		96	SS	CLP	G	I, PCB, GR/ISO	1C	H
		SWSA3		96	SS	SWSA3	G	I/PCB/GR/ISO	1C	H
		CMS		96	SS	CMS	G	I/PCB	1C	H

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surface soil
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surface water
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seep or spring
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2B = deep groundwater
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2D = sediment
2E = cummulative @ integration point
3 = Current risk
4 = Modeling for future risk
3A/4A = human health risk
3B/4B = ecological risk

Waste Unit Characteristics:
type?
status?
size/capacity?
ownership?

Sampling Locations:
List specific locations if possible.
Otherwise, indicate scope of sampling effort.

Confidence:
H = High
M = Medium
L = Low

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UNIT NAME: SWSA 3 (1001)

Unit Number: 03.01

Project Status: Remedial Investigation/Feasibility Study. (ORNL 1990)

Unit Location: SWSA 3 is located in Bethel Valley in a fenced area at the foot of Haw Ridge about 0.6 mile (1.0 km) west of the ORNL main complex. ORNL grid coordinates are N 21,760 ft and E 26,200 ft. (ORNL 1990)

Approximate Dimensions and Capacity: Approximate total area is 7 acres (2.8 ha). It is estimated that 44,000 to 56,000 Ci of radioactive waste was buried in SWSA 3; an estimated 600,000 cu ft of radioactive waste was buried. (ORNL 1990)

Dates Operated: Site commissioned: 1946. Taken out of service: 1951. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: The site was used as a landfill for the storage of low-level solid radioactive waste from 1946 to 1951. Aboveground storage of large items of contaminated equipment continued until 1979. (Shoun 1987). The site was also used to store scrap metal. The purpose of the site was to serve as an aboveground storage site for contaminated metal. (ORNL 1990)

Waste Characteristics: Little is known about the kinds of wastes stored at this site. Large items were stored aboveground within the fenced-in area. Alpha wastes contained in drums were deposited in concrete-lined trenches and covered with concrete. Beta-gamma wastes were buried in unlined trenches and backfilled with soil. (ORNL 1990)

Release Data: In 1964, well water samples were analyzed and indicated the presence of small amounts of trivalent rare earths (TRE), Sr-90, and H-3. Well water samples collected in 1973 indicated Sr-90 levels up to 3.0 dpm/mL. Soil samples analyzed in 1978 indicated levels higher than natural background. Geologic and hydrologic factors of this area favor a complex pattern of radionuclide movement. Fractures and solution cavities in the limestone bedrock represent potential pathways for groundwater movement and radionuclide migration. A connection from SWSA 3 to Raccoon Creek has also been demonstrated and is thought to represent a solution channel that allows rapid transmission of water during storms. The quantities of radionuclides transported are small. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern: Groundwater, Soil

Comments: In response to a condition of the National Pollutant Discharge Elimination System (NPDES) permit issued to Oak Ridge National Laboratory (ORNL) on April 1, 1986, a Biological Monitoring and Abatement Program (BMAP) was developed for White Oak Creek (WOC); selected tributaries of WOC, including Fifth Creek, First Creek, Melton Branch, and Northwest Tributary; and the Clinch River (Loar et al. 1986). The BMAP currently consists of six major tasks that address both radiological and nonradiological contaminants in the aquatic and terrestrial environs onsite and the aquatic environs offsite. These tasks are: (1) toxicity monitoring,k (2) bioaccumulation monitoring of nonradiological contaminants in aquatic biota, (3) biological indicator studies, (4) instream ecological monitoring, (5) assessment of contaminants in the terrestrial environment, and (6) radioecology of WOC and White Oak Lake (WOL). (ORNL 1990)

References:

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Shoun, R.R., 1987. *Environmental Data Package for ORNL Waste Area Grouping (WAG 3), Solid Waste Storage Area 3 (SWSA 3)*, ORNL/RAP-21, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Date Prepared: December 1996

Photo: 3579_90.JPG

UNIT NAME: Closed Scrap Metal Area (1562)

Unit Number: 03.02

Project Status: Remedial Investigation/Feasibility Study (ORNL 1990)

Unit Location: A triangle-shaped section (approximately 4 acres [1.6 ha]) is situated south of a portion of the fenced area of SWSA 3 and is called the Scrap Metal Area. ORNL grid coordinates are N 21,270 ft and E 26,290 ft. (ORNL 1990)

Approximate Dimensions and Capacity: The area covers about 4 acres (1.6 ha). (ORNL 1990)

Dates Operated: Site commissioned: 1951. Site inactive: 1976. (ORNL 1990)

Present Function: Not in operation.

Life Cycle Operation: The purpose of the site was to serve as an aboveground storage site for contaminated metal. (ORNL 1990)

Waste Characteristics: Some contaminated tanks and equipment are still stored aboveground. Tanks may be contaminated. The amount of material stored is not reported. (ORNL 1990)

Release Data: Health Physics surveys of the area indicated that a radioactive tank is buried near the SWSA 3 boundary. One area showed gross radioactivity or Cs-137 levels significantly above background. It is suspected that this contamination came from runoff from SWSA 3. Surveys indicate that contamination of the scrap metal is very low, if present at all. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern: Soil

Comments: Most of the scrap metal has been removed and buried in other SWSAs (1984), and the area is posted. (ORNL 1990) No new information received since the 1990 Contaminated Site Summary Sheet was obtained.

References:

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation*, DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Date Prepared: December 1996

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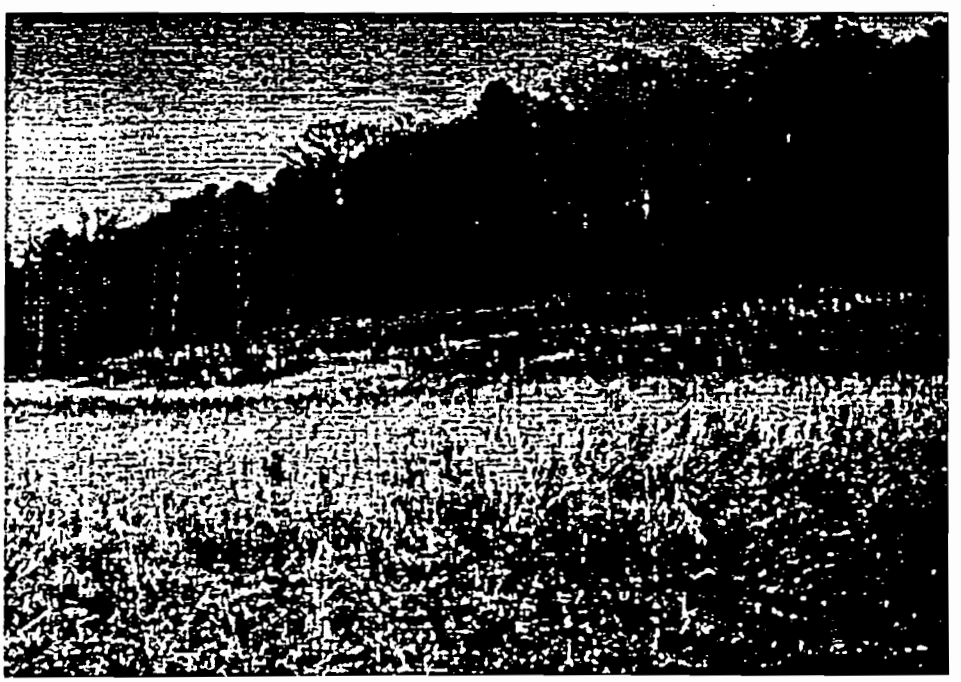

UNIT NAME: Contractors' Landfill (1554)

Unit Number: 03.03

Project Status: Remedial Investigation/Feasibility Study. (ORNL 1990)

Unit Location: The site is located west of SWSA 3, which is located west of the main ORNL plant area. ORNL grid coordinates are N 21,420 ft and E 25,000 ft. (ORNL 1990)

Approximate Dimensions and Capacity: The area of the site is approximately 7 acres (2.8 ha). Access is limited by a locked gate. (ORNL 1990)

Dates Operated: Opened: 1975. (ORNL 1990) Site was closed. (Kuhaida 1996)

Present Function: The purpose of the landfill is disposal of debris from construction sites and noncontaminated demolition activities. The site is also used as a disposal area for fly ash from the ORNL steam plant. (ORNL 1990)

Life Cycle Operation:

Waste Characteristics: This facility is now permitted by Tennessee Department of Health and Environment. Only noncontaminated debris and construction materials are allowed in the landfill. No hazardous or radioactive wastes are allowed. Prior to permitting, it is believed that similar materials were disposed of in the Contractors' Landfill; however, there is no documentation to support this and it is possible that contaminated soil from construction activities in the main plant was disposed of here. Monthly inspections are conducted to ensure compliance. (ORNL 1990)

Release Data: No releases reported. (ORNL 1990)

Site Status: CERCLA (ORNL 1990)

Media of Concern:

Comments: Two small areas were identified as having some Cesium-137 and Strontium-90 contamination. (Shoun 1987). The source of this information was Stueber et al 1981.

References:

FFA, effective date January 1, 1992. EPA, DOE and TDEC, *Federal Facility Agreement for the Oak Ridge Reservation,* DOE/OR-1014, Appendix C (updated February 13, 1996), Oak Ridge, Tennessee.

Kuhaida, Jerry, November 1996. LMES Project Manager, review comments.

Oak Ridge National Laboratory, September 1990. Contaminated Site Summary Sheet, Oak Ridge, Tennessee.

Shoun, R.R., 1987. *Environmental Data Package for ORNL Waste Area Grouping (WAG 3), Solid Waste Storage Area 3 (SWSA 3)*, ORNL/RAP-21, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Date Prepared: December 1996

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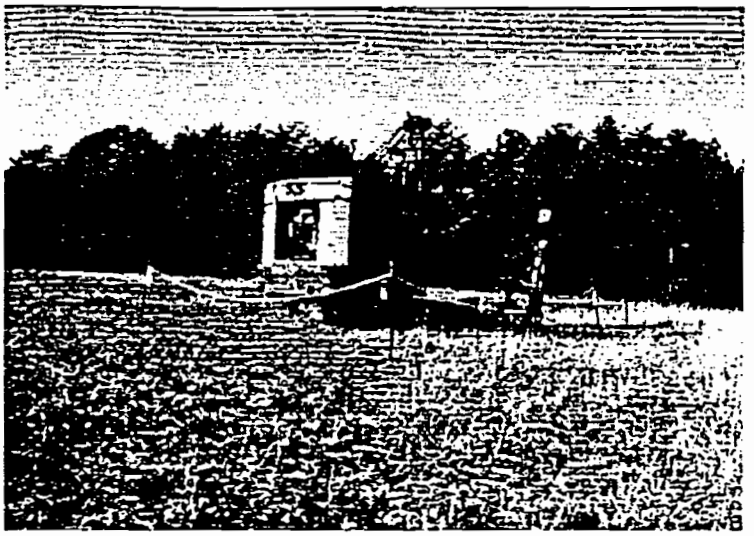

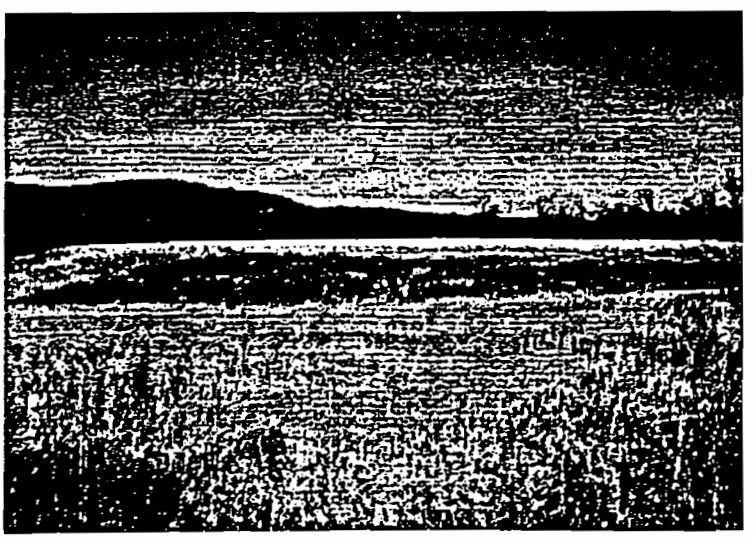

Annual Report of the Environmental Restoration Monitoring and Assessment Program for FY 1992 at Oak Ridge National Laobratory, Oak Ridge, Tennessee. ORNL/ER-124. September, 1992.

WAG 3

WAG 3 is located in Bethel Valley about 1 km (0.6 mile) west of the west entrance to the ORNL main plant area (Fig.1.1). WAG 3 drains into the Northwest Tributary (NWT) of WOC. The NWT enters WOC downstream from the main plant area and could contaminate the lower reach of WOC within WAG 1 and ultimately the lower reaches of WOC and WOL (WAG 2) as well as the Clinch River. Monitoring data (Energy Systems 1990) and historical studies (Steuber et al. 1981) suggest that WAG 3 contributes small quantities of ^{90}Sr and ^{137}Cs to the NWT. However, no data are available on heavy metal or organic contamination. Additional monitoring and characterization data will be required to determine whether WAG 3 is a source of contaminants other than ^{90}Sr and ^{137}Cs.

Third Annual Environmental Restoration Monitoring and Assessment at Oak Ridge National Laboratory. DOE/OR/01-1290&D1. September, 1994.

WAG 3 Results. Analytical results for 1993 at WAG 3 are similar to those obtained in the previous 2 years. WAG 3 is located on a north-facing slope with its upgradient wells to the south. The long axis of the site runs east to west; consequently, most of the downgradient wells are along the northern border.

Total radioactive strontium is present along the entire northern perimeter of the site. Values exceeding the primary drinking water standard for total radioactive strontium and gross beta activity have consistently been observed at four wells in every sampling event. Apparently, the gross beta signatures are mainly attributable to radioactive strontium. The data for the eastern and northeastern boundaries show evidence of radioactive contamination, including ^{3}H and gross alpha activity. The data for the northwest boundary show the presence of ^{3}H.

A few of the wells had volatile organics detected but at levels within five times the analytical detection limit. Trichloroethene has consistently been detected above drinking water standards in every sampling event at one well located in the northeast part of the WAG. The values have always been less than five times the analytical detection limit for the analysis method used.

The WAG 3 RI planning process is predicated on an iterative approach, an example of which is illustrated in Figure 1-4. In an iterative process, data can be collected in stages. With initial RI activities generally focused on developing a good understanding of the site, subsequent iterations can be focused on filling data gaps. The iterative process allows identification of key data needs as early in the process as possible and ensures that data collection is directed toward providing information necessary for selection of a remedial action.

1.2.2 Project Objectives

The project objectives of this RI are to evaluate the adequacy of existing data, and consequently, to specify the means for collecting additional data as appropriate (EPA, 1987a). These data will be used to establish whether or not WAG 3 represents a significant hazard to human health or the environment and to provide an assessment of potential remedial alternatives.

To achieve the project objectives, the following additional data needs have been identified:

- Nature of the Contaminants - Information concerning the inventories of radionuclides and/or hazardous chemical constituents in WAG 3 is virtually nonexistent. Wastes once buried in SWSA 2 were exhumed and reburied in SWSA 3. The exact volume and composition of these wastes were not known, but it is known that some stainless steel and black iron drums containing alpha-contaminated liquids were placed in SWSA 3 when it first became operable in 1946. In addition, plutonium contaminated soils were included in the wastes transferred to SWSA 3. Unspecified beta-gamma emitters, as well as alpha-contaminated materials, were buried in trenches in SWSA 3. Generally, it is believed that these waste forms were segregated from each other, but presently there is no documentation to support this contention. Trenches need to be located, and those containing TRU waste should be identified. The surface of SWSA 3 was used for storage of various radioactively contaminated materials for over 20 years. A 1978 soil survey in SWSA 3 indicated the presence of cesium-137, strontium-90, plutonium-238 and -239, americium-241, and curium-244. A subsequent radiological survey conducted in 1988 confirmed the continuing presence of radioactive contamination on the surface of SWSA 3. While it

is reasonable to assume that chemical constituents can also be found on the surface, no data have been collected to identify or quantify potential contaminants. No information is available on the possible radiological or chemical contaminants present in the Closed Scrap Metal Area. Similarly, little information has been collected on the Contractors' Landfill, even though two areas in the northern and southwestern portions have been identified as having measurable amounts of strontium-90, cesium-137, and cobalt-60 contaminated soils. The remaining area of the landfill needs to be characterized during the RI.

- Extent of Contamination - Radiological walkover surveys have indicated that surface radiological contamination has occurred both on and off-site from SWSA 3. Some radioactive contaminants have been detected in stream surface waters adjacent to the WAG 3 sites, as well as in the stream sediments. Strontium-90 has been detected as water discharges from seeps in both Raccoon Creek and Northwest Tributary.

- Evaluation of Migration Pathways - Data indicates that contaminants migration via the groundwater flow both to the northeast and southwest of SWSA 3 in a direction related to bedrock structure. Additional data is needed to better define the groundwater divide in the vicinity of SWSA 3 and identify which contaminants, if any, are being transported off-site. The depth to bedrock, and thus the thickness of the overburden, is needed for adequate hydrogeological characterizations.

These objectives will be accomplished by implementing a sampling program to collect the data needed to define the human health and environmental assessment and to develop the remedial action alternatives. Data quality objectives (DQOs) (EPA, 1987a) have been established for each element of the sampling program based on the intended use of data in meeting the project objectives. These DQOs are outlined in the WAG 3 QAPP (Appendix B). The general types of information to be collected during the field sampling phase are discussed below.

- Electromagnetic and/or magnetometer surveys will be used to define the location of SWSA 3 trenches and/or other subsurface objects.

- Conventional surface radiological surveys will be conducted as needed to supplement or complement efforts by ORNL personnel. These surveys also will be conducted beyond the WAG boundary to the north to determine if radionuclide

3.3.2 Current and Planned Site Operations

Currently, the only active operating facility within WAG 3 is the Contractors' Landfill. After July 20, 1988, the Contractors' Landfill accepted only fly ash and stabilized sludge from the coal yard sludge treatment facility (Story, 1988). The fly ash and stabilized sludge will continue to be accepted for disposal at the Contractors' Landfill until the Y-12 Plant landfill receives approval for disposal of these two wastes. Presently, ORNL is trying to gain approval to expand the present borrow area located south of the active portion of the Contractors' Landfill to obtain the required 2 ft of soil cover for closure. Closure requirements are outlined in the operation report (Eisenhower and Turner, 1984) and the operation permit (Lenhard, 1986).

3.3.3 Current Regulatory Status

The three SWMUs within WAG 3 are currently being addressed to satisfy regulations under RCRA Section 3004(u), as described previously in Section 1.1. Also, the Contractors' Landfill is operating under an operations permit issued on February 13, 1986, (Lenhard, 1986). No other regulatory requirements have been identified for SWMUs in WAG 3.

3.3.4 History of Corrective Action

Stockdale (1951) recognized that radioactively contaminated material should not be buried or stored in Bethel Valley due to the solution channels present in the underlying rock which could provide a network of migration paths in the subsurface. At Stockdale's recommendation, and because rock was encountered in the near-surface (making trench excavation difficult), burial of radioactively contaminated materials was terminated at SWSA 3 in 1951.

The recognition of the problems associated with the migration of contaminants at WAG 3 subsequent to Stockdale's evaluation prompted several investigators to install monitoring wells, conduct

geophysical and surface radiological surveys, and sample surface water. The results of these investigations are reported in Duguid (1973), Mortimore (1987), Rothschild et al. (1985), Switek (1983), and Uziel, et al. (1988).

Since its inception in 1946, there have been only limited corrective actions taken at SWSA 3. In 1978 and 1979 all above-ground stored items (Section 3.2.1), whether contaminated or not, were removed to other areas. If these items had detectable contamination they were taken to SWSA 6 in Melton Valley and buried. If they were not contaminated they were taken to the SWSA 5, also in Melton Valley, and buried. Items that had been tagged for continued storage but were radioactively contaminated were taken to an area just west of SWSA 4 in WAG 7 Storage Area 7841 (BNI, 1988c) and stored above ground. Following the removal of surface-stored items at SWSA 3, the east side was covered with about 8 in. of soil and sown with grass. Also, a diversion ditch was installed inside the fence at the southeast portion of the SWSA. This ditch diverts surface runoff to WOC. Trees and small shrubs were also removed from SWSA 3 at this time. In 1982, a small, radioactively contaminated area on the south side of SWSA 3 was fenced in and became part of the original area. This additional area was leveled, seeded with grass, and fertilized.

There have been no documented corrective actions at either the Contractors' Landfill or the Closed Scrap Metal Area.

4.3.2 Characterization and Inventory of Wastes

On the whole, the wastes stored and buried in the SWSA 3 are poorly defined in terms of location and inventory of constituents. The major radiological contaminants are believed to be strontium-90, tritium, cesium-137, and cobalt-60, but concentrations or totals are unavailable. Other radionuclides are believed present (plutonium, ruthenium, uranium, and TRU isotopes) but are inadequately characterized. Characterization of chemical contaminants has not been made.

4.3.3 Release Potential from Contaminant Sources

On the basis of available data, each of the SWMUs in WAG 3 has been categorized as to their potential for release of contaminated The information status of each key assessment factor for each SWMU in WAG 4 is presented in Table 4-5, as determined from the data evaluation described previously in Section 3.0, "Description of Current Situation."

Table 4-5 indicates the availability of information for each SWMU and estimates the level of uncertainty (low, moderate, or high) associated with each assessment factor. Definitions of low, moderate, and high uncertainty are described on Table 4-6. materials to the environment. The potential for releases from WAG 3 SWMUs are as follows:

- Known Releases: SWMU 3.1, SWSA 3
  SWMU 3.3, Contractors' Landfill
- Potential for Release: SWMU 3.2, Closed Scrap Metal Area

Releases from the WAG 3 SWMUs have or could have contaminated the surrounding environment. The contamination associated with each of the environmental media is discussed in the following section.

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4.3.4 Contamination of the Environment

Release of contaminants from the WAG 3 SWMUs has resulted in the known or suspected contamination of soils, sediments, groundwater and surface water within WAG 3. Known contamination is supported by analytical data. Areas of suspected contamination are based on site visits, information from ORNL staff, and professional judgment. This is presented in the following listing:

SOILS: SURFACE, AND SUBSURFACE

- o Known Contamination
  - SWSA 3 Site
  - Contractors' Landfill
- o Suspected Contamination
  - Closed Scrap Metal Area

SEDIMENTS

- o Known Contamination
  - Northwest Tributary
  - Raccoon Creek

SURFACE WATER

- o Known Contamination
  - SWSA 3 Seeps
  - Northwest Tributary
  - Raccoon Creek

GROUNDWATER

- o Known Contamination
  - SWSA 3
- o Suspected Contamination
  - Closed Scrap Metal Area
  - Contractors' Landfill

Quantification of the extent of known contamination and the resolution of suspected releases and/or environmental contamination will require the collection of additional data. The rationale and logistic plans for obtaining these data are discussed in Section 5.0 and the WAG 3 Field Sampling Plan (Appendix A).

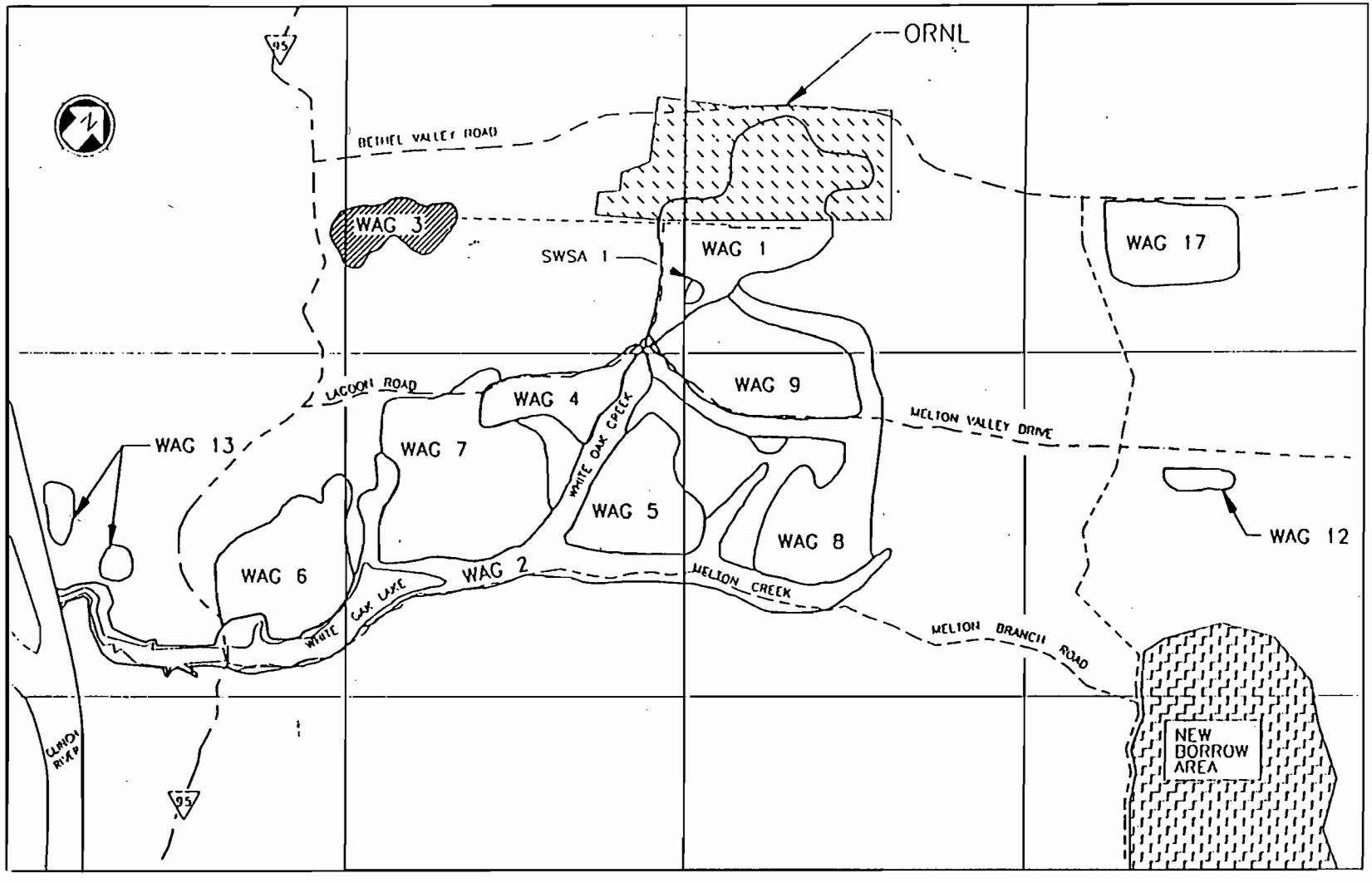

Figure 1.1 ORNL Waste Area Groupings.

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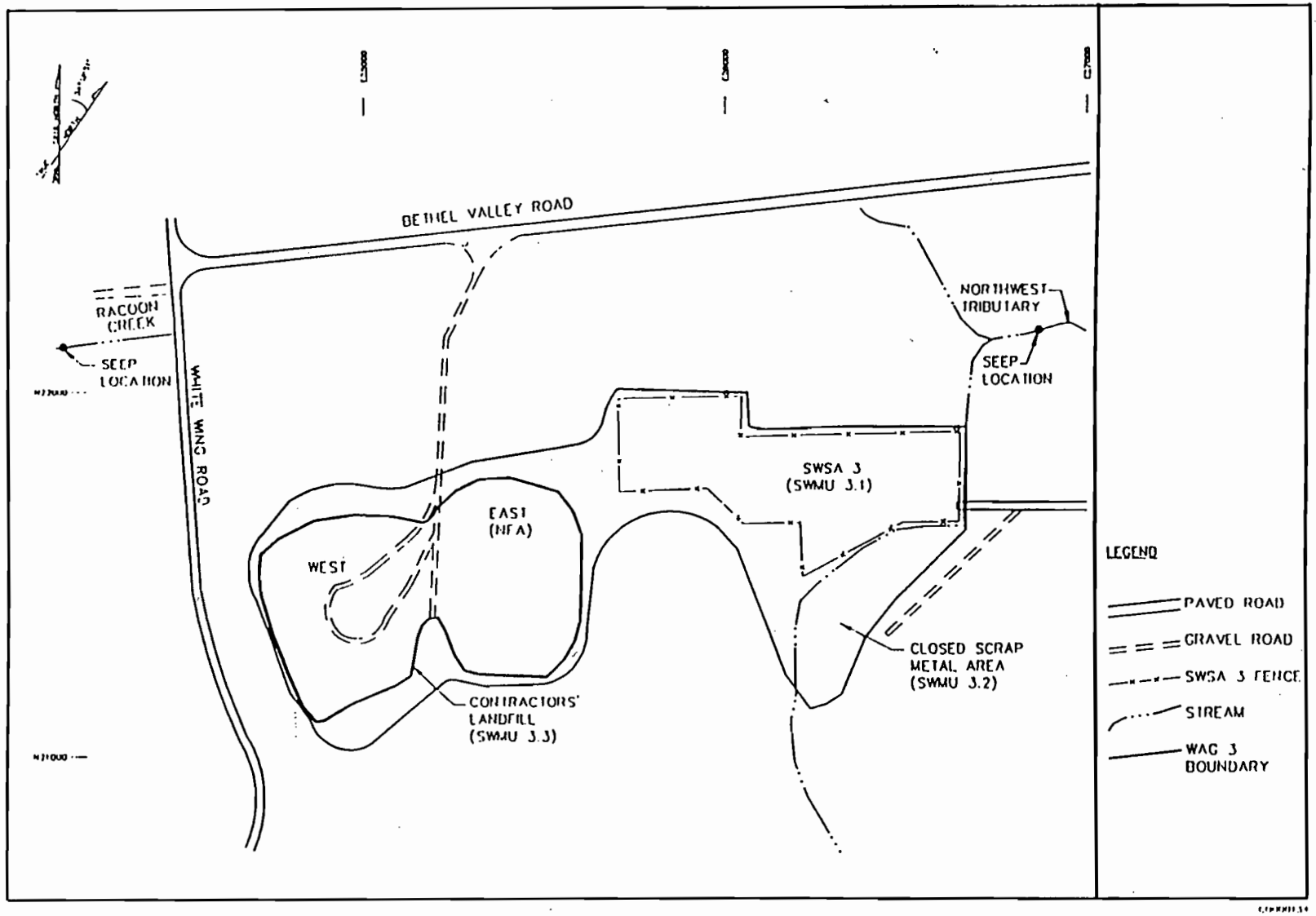

Figure 1.2 Waste Area Grouping 3.

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A.2.2 Closed Contractor's Landfill (7658)

1. SITE NAME: Closed Contractor's Landfill (7658).

2. LOCATION: 1.4 miles east-southeast of the main plant area at intersection of MV Access Road and Ramsey Drive.

3. SERVICE DATES: Early 1960s to 1975.

4. STATUS: Inactive; controlled by WMRAD (L. Holder, Jr.). Temporary storage area for P&E Division.

5. DESCRIPTION:

   (a) Operating History—The road into the area was built in the 1960s, and the landfill area at the top of the hill (north) was opened at this time. In the mid-1960s the area on top of the hill was closed, and the landfill area at the bottom of the hill was opened. In 1975 when another landfill was opened, the Contractor's Landfill was closed. The landfill was then graded level and seeded. Ramsey Drive was later built over outcroppings of the southernmost part of the landfill. When the pavement in these areas collapsed, the buried material was dug up, moved to the northern part of the site, and replaced with fill dirt to support the road.

   (b) Physical Description—The site is ~3 acres and is ~500 ft long and 260 ft wide. The original land surface sloped from north to south so that the depth of fill probably ranges from less than 6 ft on the north side to ~30 ft on the south.

   (c) Current Condition—The site has a gravel surface and is presently used as aboveground storage for noncontaminated scrap metal dumpsters.

   (d) Radiological Hazards—Records indicate that the Closed Contractor's Landfill does not represent a source of release of radioactive or hazardous materials. Aerial and walkover radiation surveys have not detected radiation levels above background. No visible leakage or seeps have been observed or documented.

6. SECURITY/PROTECTION SYSTEMS: The Contractor's Landfill is located in a limited access area in MV.

7. SURVEILLANCE ACTIVITIES: See Table A.2.2-1 for details of surveillance activities.

8. ROUTINE MAINTENANCE: No maintenance activities are conducted or anticipated.

9. ANTICIPATED REPAIRS/IMPROVEMENTS: None.

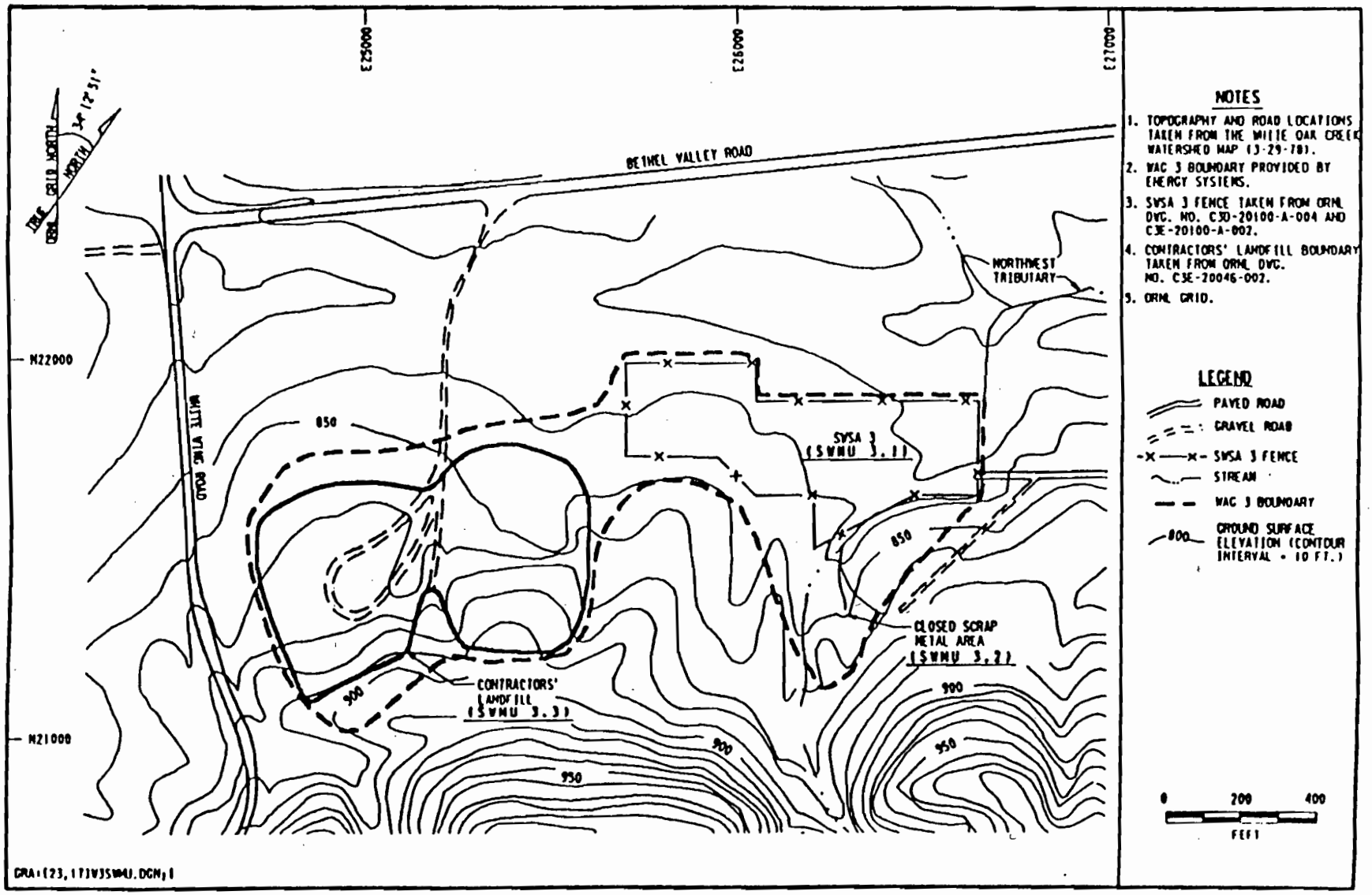

FIGURE 3-8
LOCATION MAP OF WAG 3 SWMUs

3.2 CHARACTERIZATION OF SOLID WASTE MANAGEMENT UNITS

WAG 3 contains the SWMUs shown in Figure 3-8, including the SWSA 3 site (SWMU 3.1), the Closed Scrap Metal Area (SWMU 3.2), and the Contractors' Landfill (SWMU 3.3). The most significant SWMU in terms of potential contamination is SWSA 3, with a surface area of approximately 6.1 acres. SWSA 3 was used as a disposal site for low-level solid radioactive waste, including TRU waste, between 1946 and 1951, when active disposal of waste was terminated. Subsequently, scrap metal was stored above ground at the area until it was removed in 1979.

The Closed Scrap Metal Area, approximately 4 acres, was used as a burial site for contaminated metal. The Contractors' Landfill occupies approximately 7 acres and is currently used for the disposal of construction debris, fly ash, and noncontaminated demolition products.

These three SWMUs are described in detail in the following subsections. A summary of the radiological and chemical contaminants associated with WAG 3 are presented in Section 3.2.4.

3.2.1 SWSA 3 (SWMU 3.1)

As shown in Figure 3-8, SWSA 3 is a fenced, roughly rectangular area, elongated from east to west, relative to the ORNL grid. It is located in Bethel Valley about 0.6 mi west of the main ORNL complex, at the foot of Haw Ridge. The ORNL grid coordinates for SWSA 3 are N21760 and E26200.

SWSA 3 was commissioned in May 1946 to receive various solid, radioactively contaminated wastes for routine burial. These wastes included contaminated trash, laboratory equipment, and other discarded materials (Coobs and Gissel, 1986). The site was closed for below-ground storage of waste in early 1951 but remained open until 1979 for above-ground storage of large items of slightly contaminated equipment that were either salvageable or too awkward to bury. The inventory and the estimated volume of material stored on the surface of SWSA 3 as of March 1, 1979, is shown in Table 3-4. This inventory represents the storage status prior to initiation of cleanup.

SWSA 3 was the third and last of successively larger land disposal areas to be located in Bethel Valley. The location was originally chosen because of its close proximity to ORNL but relatively obscure location, and the area's soil was easily excavated (Coobs and Gissel, 1986). Ironically, the site was closed in 1951 for below ground storage due to excavation difficulties resulting from shallow bedrock at the west end of the site. Also, Stockdale (1951) reported that Melton Valley would be better suited for below ground waste disposal due to the fact that Melton Valley is underlain by shale.

Several sources including Shoun (1987), Stueber et al. (1981), and Grizzard (1986), report that disposal records for SWSA 3 were destroyed by fire in 1957. Bates (1983) estimated that SWSA 3 was used at a rate of 1.5 acres per year and that at closure in 1951, disposal amounted to a volume of 600,000 to 725,000 ft^3 of LLW containing approximately 44,000 to 56,000 Ci of radioactivity. The

TABLE 3-4

INVENTORY OF MATERIALS AND EQUIPMENT STORED ABOVEGROUND AT SWSA 3, MARCH 1, 1979

Items	No. Items or Groups	Estimated Volume (ft^3)
Drums	500	4,000
Tanks	177	20,000
Hoods, Gloves Boxes	72	3,000
Concrete Blocks	47	2,500
1 Beam and Tank	1	3,000
Shelters	9	7,000
TS Moderator Structure	1	1,000
Elect Furnaces, Blowers, Budracks	11	1,000
Boxes and Unidentified Crates	18	2,000
Casks	18	1,500
Pumps, Motors	15	200
SS Odd Containers, Buckets, Sinks	28	1,000
SS Racks with Filters & Angle Iron Structures	10	1,600
Pipe and Duct	20	1,400
GI Cans	50	150
Other	263	11,000
Lead Bricks, Sheets, Etc.	38	(130 Tons)
SUBTOTAL	1,278	60,350
ESTIMATED 10% MISSED	128	6,000
TOTAL	1,406	66,350

Source: King (1979).

trenches were excavated parallel to each other across the width of the SWSA, with each trench 15 ft deep or less (Shoun, 1987). Stockdale (1951) described the disposal process as removing the soil down to bedrock, generally less than 15 ft deep, dumping the wastes into the excavation, and then covering with the soil, except in the case of alpha-contaminated materials, which were first covered with concrete before backfilling with excavated soil. Figure 3-9 shows the orientation and general content classification of trenches in SWSA 3. The number and exact locations of the trenches is unknown; however, the process of trench disposal supposedly began at the eastern end of the area and proceeded west.

SWSA 3 received "special hot materials" from off-site waste producers for several months prior to the official opening of the area for routine burial (Webster, 1976). Some possibly hazardous chemical wastes are probably buried in SWSA 3, since there are no available records to the contrary (Shoun, 1987). Additional contaminated wastes buried at SWSA 3 included material from other AEC-project producers and users of AEC-distributed isotopes (Stockdale, 1951).

After closure of SWSA 2, all the waste was reported to have been exhumed and placed in at SWSA 3. Sometime between 1946 and 1949, stainless steel drums with liquid plutonium waste were removed intact from SWSA 2 and reportedly placed in SWSA 3 (Webster 1946, ORNL, 1987). Some black iron drums with beta-gamma waste that had been buried in trenches in SWSA 2 had deteriorated to the point that the surrounding soil was removed also, and both drums and soil were buried in SWSA 3.

The drums of alpha-contaminated wastes from SWSA 2 were encased in a concrete-lined trench in SWSA 3. This trench is located reportedly in the northeast portion of the SWSA (Webster, 1976). In later operations, alpha wastes in drums were put into unlined trenches and then covered with concrete. Beta-gamma contaminated wastes were buried in separate unlined trenches and covered with native soil.

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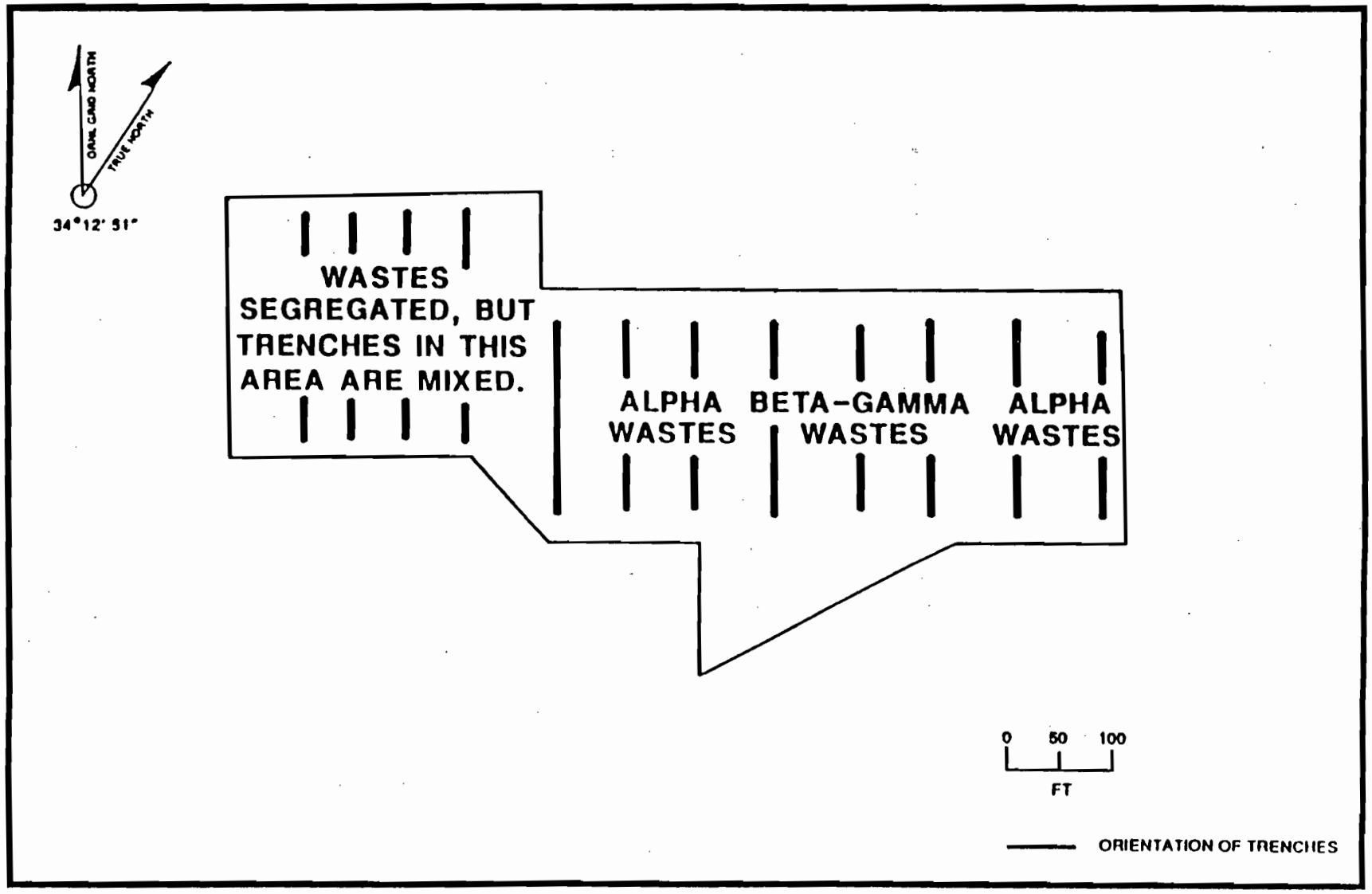

SOURCE: Grizzard (1986).

FIGURE 3-9

GENERALIZED ORIENTATION AND CONTENTS OF TRENCHES IN SWSA 3

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000060

RVFS WAG 3

According to Baughn (1987), the trenches in SWSA 3 were not free draining; therefore, water accumulated in them. It is not known whether the water was surface water or groundwater. If, in fact, the trenches are 15 ft deep, then the wastes in the bottom of the trenches in the northeast quarter of the SWSA are perennially saturated (Stueber et al., 1981).

Two known seeps (Section 3.3.1.5) are associated with SWSA 3 (Stueber, et al., 1981). One seep is located about 1148 ft east of SWSA 3 on the Northwest Tributary of WOC. Strontium-90 is entering this drainage and is also discharging from a second seep on Raccoon Creek approximately 2100 ft southwest of SWSA 3, at a rate of about 0.5 mCi per month. A straight line connecting the two seeps has a trend through SWSA 3 that closely approximates the strike of bedrock in Bethel Valley (Stueber et al., 1981).

Groundwater samples collected in 1964 showed small amounts of trivalent rare earths (TRE), strontium-90, strontium-89, and tritium (Uziel el al., 1988). In 1973, ground water samples indicated the presence of elevated strontium-90 levels.

In 1978 and 1979, SWSA 3 was cleaned-up by removing the items stored on the surface. Figures 3-10 and 3-11 depict "before and after" photographs, respectively, of the area relating to the cleanup operation. Details of this cleanup can be found in Section 3.3.4.

In 1982, a small triangular-shaped area south of SWSA 3 (Figure 3-8) of about 0.4 acres was found to contain contaminated material (Uziel et al., 1988). It is believed that the contamination is a storage tank that may be buried within this area. This remains to be confirmed during the RI Phase I work. This tank may contain radioactively contaminated solvents from 135 drums previously stored on the surface of SWSA 3. It was suggested "that the safest compromise was to sorb the solvent in these drums on vermiculite in a buried tank, fill any freeboard remaining in the tank with earth, seal the manhole, and cover the tank" (Robinson, 1979). A stainless steel tank in SWSA 3 was large enough to handle the volume of waste,

ORNL PHOTO 1372-79

FIGURE 3-10
VIEW OF THE EAST END OF SWSA 3 BEFORE SURFACE CLEAN UP - 1979

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000062

ORNL PHOTO 5064-80

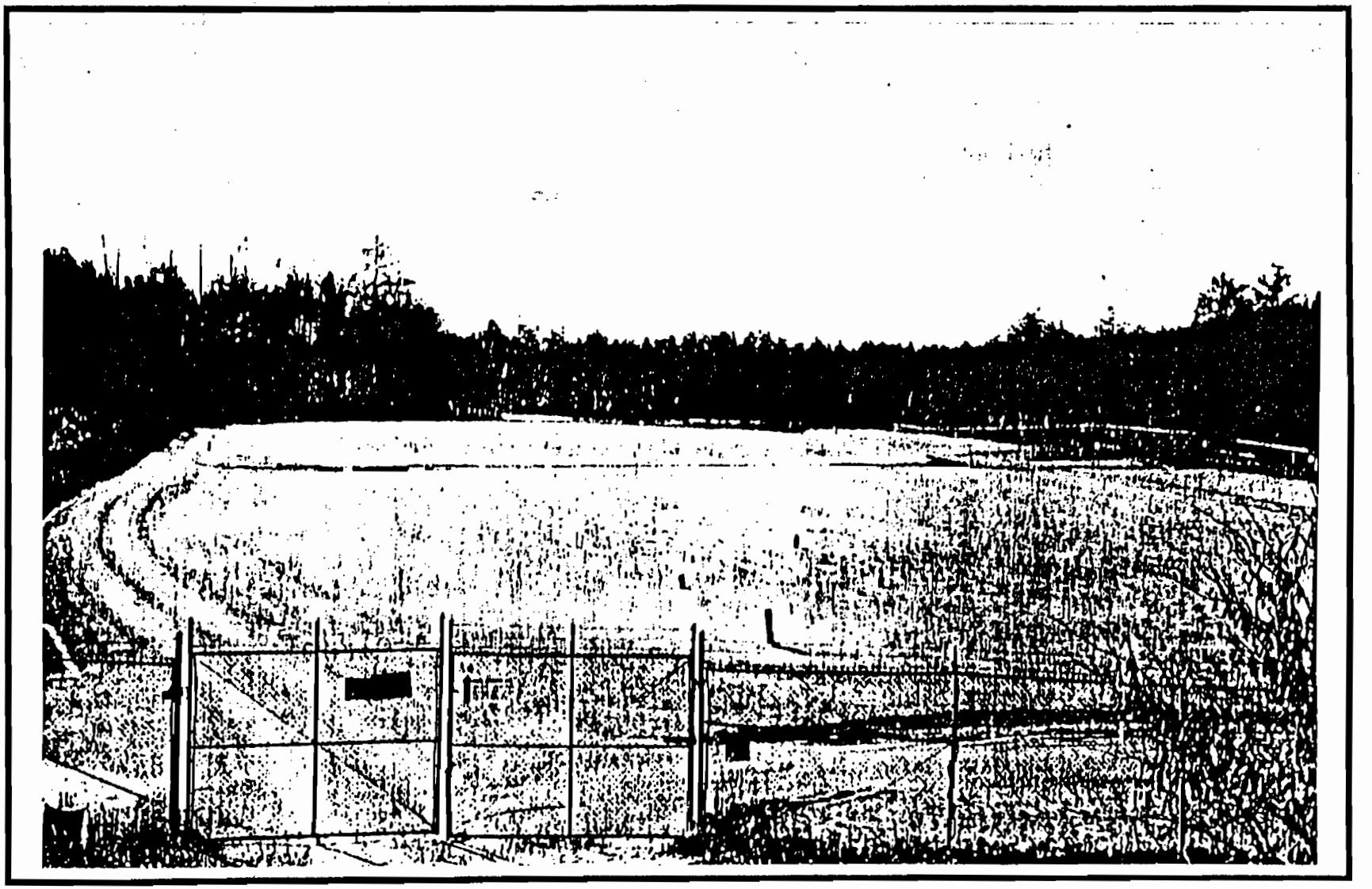


FIGURE 3-11
VIEW OF THE EAST END OF SWSA 3 AFTER SURFACE CLEAN UP - 1980

000019
000063

and since it was contaminated internally it could have been utilized for this purpose. It is unknown if this tank was already in the ground at the time or whether it was stored aboveground and subsequently buried. This area was subsequently fenced and became an integral part of SWSA 3 (Figure 3-8) when the fence was removed between the original area of SWSA 3 and the new area. This annexed area was graded, fertilized, and seeded with grass. It is now maintained as part of SWSA 3.

In 1987, Uziel et al. (1988) conducted a surface radiological investigation at SWSA 3 to determine the level and extent of surface contamination and to recommend corrective actions if necessary. They found 74 areas and 24 point sources of higher-than-background gamma exposure (Section 3.3.1.3).

3.2.2 Closed Scrap Metal Area (SWMU 3.2)

The Closed Scrap Metal Area (SWMU 3.2) covers approximately 4 acres and is a graded, filled, and grassed area: the exact boundaries of which are unknown. This SWMU, located on a hillside south of SWSA 3 (Figure 3-8), was operated as a contractors' landfill between the early 1950s and the mid 1960s. After reaching its capacity, the fill area was used for storage of scrap metal, the nature and origin of which are undocumented. No other data are available for this area.

3.2.3 Contractors' Landfill (SWMU 3.3)

The Contractor's Landfill is a 7-acre area located about 130 feet west of SWSA 3 (Figure 3-8) that has been in operation since 1975. Currently, the landfill is used as a disposal area under a permit issued January 23, 1986 by the Tennessee Department of Health and Environment (TDHE) Division of Solid Waste Management. Disposal of the following is allowed under the permit: concrete block masonry, roofing, plastic, fly ash, pasteboard, plaster, paper and wood wastes, noncontaminated soil, electrical wiring, and piping. In addition, TDHE determined that the stabilized sludge from the coal

yard runoff treatment facility was suitable for disposal in the landfill (Maupin, 1986). Data provided to TDHE by ORNL on the characteristics of the stabilized sludge are shown in Tables 3-5 and 3-6. Analysis for radioactivity in the coal yard basin sludge indicated that the radionuclides present in the samples were from natural sources rather than man-made isotopes. No contaminants such as cobalt or europium showed up in the analysis and the levels of cesium-137 were comparable to remote off-site concentration (Story, 1988a). Uranium and thorium were present in the samples but are naturally high in coal materials.

The permit for the Contractors' Landfill does not allow any excavations below grade except in areas upgradient from the fill area. Excavations from these areas are used as cover material. Therefore, all disposals at the landfill have to be made above existing grade. The permit does not allow disposal of putrescible, readily degradable or leachable wastes, or wastes containing free liquids. Surface runoff is required to be diverted around the fill area. Any material deemed to be hazardous according to the Tennessee Hazardous Waste Management Act cannot be disposed of at the landfill. Liquid wastes, industrial special wastes, or wastes requiring special handling can be disposed of at this facility, but only after written permission for each individual case is obtained from TDHE.

TDHE has permitted the facility since 1984; however, prior to the 1986 permit, no controls were exercised over the disposal of materials in the landfill, so it is possible that materials presently prohibited from the landfill were buried. A radiation walkover survey conducted by Stueber et al. (1981) located two areas of elevated radioactivity levels were found. The first area consisted of a mixture of contaminated soil and gravel, and the second area consisted solely of contaminated soil. In both areas the principal radionuclide was cesium-137 (Section 3.3.1.3).

TABLE 3-5

CHARACTERISTICS OF THE STABILIZED SLUDGE
CONTAINED IN CONTRACTORS' LANDFILL

1. Physical Characteristics
   State: Stabilized Sludge
   Color: Black
   Density: 5.743 g/cc
   Moisture by volume: 20.9%

2. Chemical Characteristics

   a) Comparison of concentrations in EP Tox extract from Coal Yard Sludge with EP Tox Limits

	Concentration (mg/l)	EP Tox Limit (mg/l)
Silver	<0.05	5.0
Arsenic	<0.10	5.0
Barium	0.82	100.0
Cadmium	0.13	1.0
Chromium	<0.04	5.0
Lead	<0.20	5.0
Selenium	<0.20	1.0
Mercury	<0.0005	0.2
Endrin	<0.0002	0.02
Lindane	0.002	0.4
Methoxychlor	<0.008	10.0
Toxaphene	<0.005	0.5
2, 4-D	<0.010	10.0
2, 4, 5-TP	<0.010	1.0

   b) Ignitability: negative; flash point >70°C
      Corrosivity: negative; pH=10.16
      Reactivity: negative; Cyanide 0.05 µg/g
      Sulfide <0.01 mg/g

   c) Organic compounds measured above detection limits:
      Methyene chloride 16 µg/l

3. Generation source:

   Reserve coal is stored on approximately four acres of land. Rainfall produces an acidic leachate at an average yearly rate of 4.76 million gallons. This discharge is directed to the coal yard runoff and for treatment. The treatment system collects coal yard runoff in a settling basin until the volume is sufficient to operate the treatment system. The wastewater is pumped to a tank where it is neutralized, then the neutralization tank overflows into a clarifier where solids are allowed to settle and oils removed. The water which overflows the clarifier is monitored and recycled or discharged to a catch basin which discharges to White Oak Creek.

TABLE 3-5 (continued)

3. Generation source (continued):

The sludge which builds up in the clarifier is transferred to a sludge holding tank. The sludge is then pumped from the tank to a vacuum drum filter where the excess water is removed. The composition of the stabilized sludge is approximately 90 percent lime and coal yard sludge and 10 percent diatomaceous earth which is used as the filtering material.

a) Quantity: 12 cu. yd./month
b) Frequency: 6 cu. yd. dumpster/2 weeks

4. Disposal:

The resulting stabilized sludge cake will be disposed of in the permitted ORNL Contractors' Landfill (Reg. No. DML 731030015). The disposal will occur on the current active portion of the lift and will be worked into the lift face in a manner similar to any other debris.

Source: Rohwer (1986).

00023

TABLE 3-6

TOTAL CONCENTRATIONS OF PARAMETERS MEASURED IN THE STABILIZED SLUDGE DISPOSED IN CONTRACTORS' LANDFILL

Parameter	Concentration (µg/g)
Silver	<4.6
Aluminum	6300
Arsenic	70
Boron	21
Barium	42
Beryllium	4.3
Calcium	6500
Cadmium	11
Cobalt	60
Chromium	11
Copper	390
Gallium	<23
Lithium	<18
Manganese	380
Molybdenum	<3.7
Sodium	780
Nickel	150
Phosphorus	290
Lead	34
Antimony	<18
Selenium	<18
Silicon	780
Strontium	2
Titanium	21
Vanadium	15
Zinc	870
Zirconium	<1.8
Tin	<4.6
Iron +2	8300
Magnesium +2	7500
Mercury	0.013
2.4-D	<10
2.4.5-TP	<10
Endrin	<0.2
Lindane	<2
Methoxychlor	<8
Toxaphene	<5

Source: Rohwer (1986).

3.2.4 Inventories of Major Contaminants in WAG 3 SWMUs

The quantities of radiological and chemical contaminants in WAG 3 SWMUs is unknown. Information on the types of wastes handled at the WAG 3 SWMUs is discussed in the following paragraphs.

3.2.4.1 SWSA 3 (SWMU 3.1). The SWSA 3 site consists of buried waste containing trash, scrap, carcasses, soil, rubble, filters, oils, asbestos, lumber, equipment, shielding, and containerized waste, with the major radiological contaminants present including strontium-90, cesium-137, tritium, TRE, and TRU isotopes (Bates, 1983; Trabalka, 1987). The estimated total volume of buried waste in SWSA 3 is between 600,000 and 725,000 ft^3 with a radioactivity volume between 44,000 and 56,000 Ci (Trabalka, 1987). Radioactivity levels associated with specific radionuclides have not been quantified, nor have volumes been determined. A 1978 soil survey indicated the presence of cesium-137, strontium-90, plutonium-238 and -239, americium-241, and curium-244. A subsequent radiological survey in 1988 confirmed the continuing presence of radioactive contamination on the surface of SWSA 3. Chemical constituents of the waste have not been identified or quantified. Explosives may have been buried on-site, since J. Bolinski (1988) indicated during the site tour that some containers with explosive materials had been recovered from the surface of SWSA 3 during the 1978-1979 cleanup. However, types and quantities are unknown.

As shown in Table 3-7, the estimated inventory of TRU contaminants in WAGs 1, 3, 4 and 5 is 270 Ci, constituting a total volume of 219,000 ft^3 (TRU Waste Program, 1987). These historical estimates have been derived from accountability records and back-extrapolation using reasonable assumptions of trench size and number of trenches. The total volume of contaminated soils resulting from solid waste burials in the ORNL SWSAs was estimated to range from 424,000 ft^3 to 2,119,000 ft^3 (DOE, 1985).

3.2.4.2 Closed Scrap Metal Area (SWMU 3.2). The composition of any potential chemical or radiological wastes buried in the Closed

TABLE 3-7

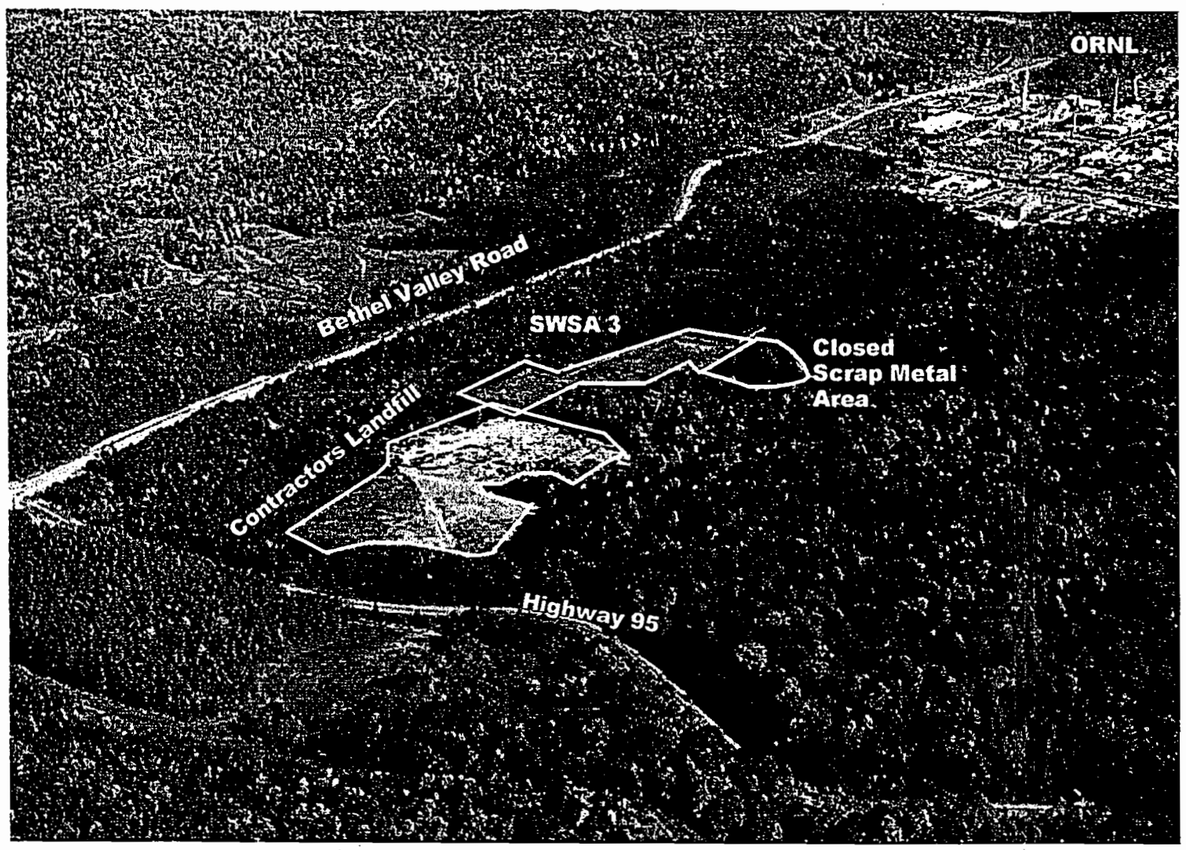
ESTIMATED VOLUME AND TRU RADIOACTIVITY CONTENT OF BURIED WASTE AND CONTAMINATED SOIL AT ORNL

Waste Site and Description	Contaminant	Inventory [Ci (lb)]	Volume (ft^3)
WAGs 1, 3, 4, and 5			
Buried TRU-Contaminated Wastes	^{233}U and ^{239}Pu	270 (12.3)[a]	219,000[a]
Contaminated Soil Proximate to Wastes	TRU	N/A	424,000-2,119,000[b]

(a) Historical estimates obtained through the use of accountability records (inventories) and back-extrapolations (volumes) (DOE, 1985).

(b) Historical estimates which are based on multiples (2 to 10) of the buried TRU waste volume estimate. This estimate also assumes that TRU-contaminated sites are isolable from LLW sites.

Source: TRU Waste Program (1987).



Aerial of WAG 3 looking Northeast (photo #: 7769-80)

Waste Area Grouping 3 (WAG 3) Information Sheet

Historical Summary: WAG 3 includes Solid Waste Storage Area 3 (SWSA 3), the Closed Scrap Metal Area, and the Contractors Landfill. The most significant area is SWSA 3, which was used for land disposal of low-level radioactive and transuranic (TRU) waste. Subsequently, surplus equipment and drums were stored on top of the burial site until it was removed in 1979. The Closed Scrap Metal Area was used as a burial site for contaminated metal and the Contractors Landfill was used for the disposal of construction debris.

Status: The WAG 3 Remedial Investigation Plan was issued in September 1988. It summarized site data and identified data needs, but was never implemented. Soil samples were collected in the area in 1995 in a sampling effort associated with the Melton Valley Area Remedial Investigation. Future remediation decisions for this area will be included in the Bethel Valley Record of Decision.

Risk Summary: The risks associated with surface soils and groundwater in the WAG 3 area exceed the EPA's target risk range for a residential use scenario but would probably be acceptable for a recreational use scenario.

Impacts to Watershed: The seep on the Northwest Tributary contributes less than 1% of the Strontium-90 at White Oak Dam (1993-1994 data)

WAG 3 Data Summary Table

Unit Name	Dates of Operation	Surface Area (acres)	Waste Volume (ft^3)*	Radionuclide Inventory (Ci) *	Current Releases
SWSA 3	1946-1951	5.5	Placed waste = 600,000 Contaminated Soil = 3,000,000	56,000 at disposal	Seeps in Raccoon Creek and Northwest Tributary
Closed Scrap Metal Area	1951-1976	3	Unknown	Negligible	Some surface soil contamination
Contractors Landfill	1975-?	12	Unknown	Negligible	None reported

* Note: Waste volume and inventory are current best estimates and may change as additional data are available; numbers are rounded.

References:

(1) *Site Descriptions of Environmental Restoration Units at ORNL, Oak Ridge, Tennessee* (ORNL/ER-391), February 1997.

(2) *Remedial Investigation Plan For Waste Area Grouping 3* (ORNL/RAP/Sub-87/99053/22), September 1988.

(3) *Fourth Annual Environmental Restoration Monitoring and Assessment Report (FY 1995), ORNL, Oak Ridge, Tennessee* (DOE/OR/01-1413&D1), September 1995.

Friday, April 18, 1997
File Name: WAG3fact

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Scrap Metal Area has not been identified. Presumably, some of the scrap metal was contaminated with radioactivity on the surface, but there are no records of the type of scrap metal, its origins, or possible contaminants. The same is true for potential chemical wastes, although since the area was used as a contractors' landfill with uncontrolled access for 15 years, it is conceivable that residuals from paint or solvent containers were buried there.

3.2.4.3 Contractors' Landfill (SWMU 3.3). The active Contractors' Landfill is known to have 2 acres where soil contaminated with strontium-90, cesium-137, and cobalt-60 has been deposited (Stueber et al., 1981). No other potential contaminant sources have been identified.

3.3 WAG 3 SITE DESCRIPTION AND CHARACTERIZATION

3.3.1 Site Description

3.3.1.1 Bethel Valley Geology. WAG 3 is located in Bethel Valley, which is within the White Oak Mountain Thrust Block and is immediately underlain by strata of the Middle and Late Ordovician Chickamauga Group. This section summarizes the findings of selected studies that have contributed to the understanding of the bedrock geology of Bethel Valley. Although these studies were not performed within WAG 3, their findings may be applied to the interpretation of site-specific data collected at WAG 3 in the future.

The bedrock formations beneath Bethel Valley--Haw Ridge to the southeast and Chestnut Ridge to the northwest--are marine sedimentary rocks of Early Cambrian to Late Ordovician Age (McMaster and Waller, 1965) (Figure 3-12). The Chickamauga Group, which directly underlies Bethel Valley at ORNL, is primarily composed of Middle and Upper Ordovician limestone, although shale, siltstone, and chert are also present. The Chickamauga Group cannot be measured in its entirety at any single outcrop in Bethel Valley; however, composite thickness measurements from several localities and from 51 boreholes in or near Bethel Valley (Stockdale, 1951)

Examples of strata-bound flow at ORNL have been identified from the distribution of contaminants in plumes and from groundwater elevation measurements. The following are presently-known examples of preferred flow paths at the ORNL site:

- Groundwater contamination has been identified at WAG 3 in Bethel Valley in monitoring wells and in surface water bodies that drain the site. Contamination in surface water appears in two distinct areas, one in the northwest tributary of White Oak Creek and a second in an unnamed tributary to Raccoon Creek. Studies of these tributaries have identified specific reaches that appear to be the sources of each stream's contamination. The hypothesis that strata-bound flow in the Witten Formation is controlling the distribution of contamination at WAG 3 comes from the observation that a line drawn between the seeps along each stream runs approximately parallel to strike and passed through SWSA 3, the expected main contributor to groundwater contamination in WAG 3. The distribution of contaminants in monitoring wells at this site is difficult to explain. The hypothesis for preferential flow needs to be further developed and tested for this site.

Groundwater and surface water contamination at WAG 3 serves as an example of how identification of surface water contamination can lead to a better understanding of the nature of groundwater contamination and provide information on the flow paths in groundwater. WAG 3 straddles the surface water divide between White Oak Creek and Raccoon Creek in Bethel Valley and straddles the apparent shallow groundwater divide between these two drainage systems. Groundwater quality data for this area are sporadic and analysis of groundwater at three wells in the vicinity of the WAG has identified the main contaminant in groundwater as ^{90}Sr, with one analysis of Cd above maximum contaminant levels (MCLs).

Contamination with ^{90}Sr has been identified in the northwest tributary of White Oak Creek and in Raccoon Creek. A 30.5 m (100-ft) reach of the northwest tributary of White Oak Creek and a similar reach in an unnamed tributary at the headwaters of Raccoon Creek have been reported as the primary sources of this contamination. A line drawn connecting these discharge points is parallel to geologic strike and passes through SWSA 3, the primary source of this contaminant.

Using this preliminary evidence derived from limited groundwater data and stream data, it is possible to infer that the primary groundwater and contaminant flow paths from WAG 3 are strata-bound and discharge to the surface water where the flow paths intersect the stream valleys. This will allow the investigation at WAG 3 to be more focused.

3.4 WAG 3

3.4.1 Site Location, Description, and Background

WAG 3 is located in Bethel Valley ~915 m (3000 ft) west of the main ORNL plant west gate and is composed of an estimated 8.9 ha (22 acres) (Fig. 3.12). This WAG contains 3 SWMUs: (1) the Contractors' Landfill, which is presently in operation; (2) the Closed Scrap Metal Area; and (3) SWSA 3, which is not currently in use.

3.4.1.1 Contractors' Landfill

The Contractors' Landfill is located ~40 m (130 ft) west of SWSA 3 and is composed of ~2.8 ha (7 acres). The operating conditions of the landfill permit for this SWMU restrict the types of waste that may be disposed of here to concrete block, masonry, roofing, plastic, fly ash, pasteboard, plaster, paper and wood wastes, noncontaminated soil, electrical wiring, and piping. Prior to permitting, it is believed that similar materials were disposed of in the landfill; however, there is no documentation to support this assumption. It is possible that contaminated soil from construction activities in the main plant area was disposed of at the site. A beta-gamma survey of the area identified two small areas of contamination where the principal contaminants were determined to be ^{90}Sr and ^{137}Cs with lesser amounts of ^{60}Co.

3.4.1.2 Closed Scrap Metal Area

The Closed Scrap Metal Area consists of an estimated 1.6 ha (4 acres) of graded fill maintained in grass. Its general location is adjacent to and southeast of SWSA 3; however, its exact boundaries are not known. This SWMU was operated as a contractors' landfill for an estimated 15 years. After reaching its capacity, the fill area was reportedly used for storage of scrap metal, the nature and origin of which are not documented. Ultimately, this area was closed and much of the scrap material is believed to have been buried on site. Because the nature of the wastes disposed of in this area were not well known, health physics surveys of the site were conducted. The surveys indicated activity levels above background in the section where the scrap metal area adjoins SWSA 3. Details on the level and exact location of activity are sketchy, though there is some information suggesting that the contaminated area(s) may have been related to a scrapped and buried storage tank and/or runoff from SWSA 3.

The health physics survey also included soil, vegetation, and biological sampling. Of all the samples collected, only one soil sample taken near the SWSA 3 fenceline showed significant activity of ^{137}Cs at a depth of 20 cm (8 in). The general conclusion of the health physics survey was that contamination levels in the buried scrap metal were low, if present at all. It was inferred that the contaminated areas in the Closed Scrap Metal Area adjacent to SWSA 3 are probably related to sources within SWSA 3, with the possible exception of the buried storage tank/contaminated metal.

3.4.1.3 SWSA 3

SWSA 3 is composed of ~2.8 ha (7 acres), appearing in plan view as two offset rectangles with a triangular protrusion on the southeastern side. This SWMU is located northeast of the Closed Scrap Metal Area and is presently planted in grass and enclosed by a chain link fence. SWSA 3 was used for the disposal of contaminated trash and laboratory equipment; however, it also received some waste transplanted from the closure of SWSA 2. The area was operational from 1946 to 1951; although several

3.4.2 Characterization of Groundwater Contamination

3.4.2.1 Groundwater monitoring system

The groundwater monitoring system in and around WAG 3 includes 19 monitoring wells installed in 1950 or 1964, 21 piezometers installed in 1986, and 26 additional monitoring wells installed between 1987 and 1990. The 19 older monitoring wells were installed as part of the pre-RAP and were constructed as open boreholes or were stabilized with perforated steel casing running the entire length of the borehole. The piezometers were constructed of 5-cm or 10-cm (2-in. or 4-in.) ID PVC casing and screens. Sandpack was placed around the screens, and a bentonite seal was placed above the sandpack. The remaining annulus was grouted, and each piezometer was completed with a cap and protective cover.

The 26 additional wells at WAG 3 were installed as part of a groundwater quality monitoring well installation program at ORNL. These wells were constructed of 5-cm or 10-cm (2-in. or 4-in.) ID stainless steel casing and screens. The remainder of the well construction was the same as described for the piezometers. Each well was completed with a steel protective casing, locking cap, steel guardposts, and a concrete pad. The locations of the monitoring wells or piezometers within WAG 3 for which groundwater quality data were evaluated for this summary are presented in Fig. 3.13, and a summary of the total depths for these installations is presented in Table 3.3.

3.4.2.2 Contamination nature and extent

Two principal source documents were used to develop an understanding of groundwater contamination at WAG 3. These documents were the *Preliminary Geohydrologic Site Characterization and Proposed Water Quality Well Locations for WAGs 4, 5, and 3, and SWSA 1* (Energy Systems 1987a) and the *Oak Ridge Reservation Environmental Report for 1991* (Energy Systems 1992b). The Preliminary Geohydrologic Site Characterization report summarized results from two previous studies regarding groundwater contamination at WAG 3. The first study reported results for groundwater samples collected from monitoring wells 0301, 0302, and 0303 located in SWSA 3. Analyses indicated that all three wells contained ^{90}Sr contamination, but the parameters ^{137}Cs, ^{60}Co, ^{125}Sb, and tritium were below detection limits. Only one occurrence of metals contamination was indicated (Well 0303—0.012 ppm cadmium) above MCLs.

The second study reported results for water samples collected from two distinct areas of ^{90}Sr contamination. The first area was associated with the northwest tributary of White Oak Creek where a 30.5-m (100-ft) reach located ~350 m (1150 ft) northeast of SWSA 3 was identified as the principal source of contamination. The second area was associated with an unnamed tributary of Raccoon Creek where a seep and a 10-m (33-ft) reach adjacent to the seep located ~640 m (2100 ft) southwest of SWSA 3 were identified as the principal source of contamination. Activity levels of ^{90}Sr averaged about 6.4 mCi per month at the White Oak Creek site and 0.5 mCi per month at the Raccoon Creek site. The study concluded that both streams appeared to be receiving contaminated groundwater in the form of base flow and that the contamination may be related to leaching of waste from either SWSA 3 or the Contractors' Landfill with subsequent transport occurring in bedrock along strike-oriented solution channels.

Table 3.3. Summary of WAG 3 groundwater monitoring system wells

Well no.	Total depth (ft)
pre-RAP wells	
0301	14.00
0302	6.00
0303	6.00
Groundwater quality wells	
0985	35.00
0986	82.50
0987	48.20
0988	46.00
0990	40.80
0991	85.00
0992	53.50
0993	45.00
0994	80.50
0995	48.50
0996	62.50
0997	33.50
0998	20.70
1248	72.50

The *Oak Ridge Reservation Environmental Report for 1991* (Energy Systems 1992b) summarized results for groundwater samples collected during August of 1991 from 15 of the groundwater quality wells at WAG 3. Well 1247 was dry during the sampling period and thus results for only 14 wells were reported. Four of the perimeter wells were found to have total strontium activities in excess of MCLs: Wells 0992 (5.3 Bq/L), 0993 (5.5 Bq/L), and 0994 (24 Bq/L) located along the northwest perimeter of the WAG, and Well 0997 (3.8 Bq/L pCi/L) located near the northeast corner of SWSA 3. Well 0994 also contained tritium at an activity of 1199 Bq/L. Well 0985 was found to contain trichloroethene (18.0 μg/L) and Well 0998 tetrachloroethene (15 μg/L) in excess of MCLs. Subsequent sampling of these wells in August and September of 1992 indicated the presence of similar concentrations of the noted contaminants, with the exceptions that no tetrachloroethene was detected in Well 0998, and a total strontium concentration of 0.8 Bq/L was detected in Well 1248. The irregular occurrences of strontium contamination [between ~10 and 24 m (33 and 80 ft) below ground level] within the various perimeter wells at WAG 3 suggest that multiple contamination sources may be present at the site; or that contamination is migrating along preferential flow pathways, which may include strike-oriented solution channels.

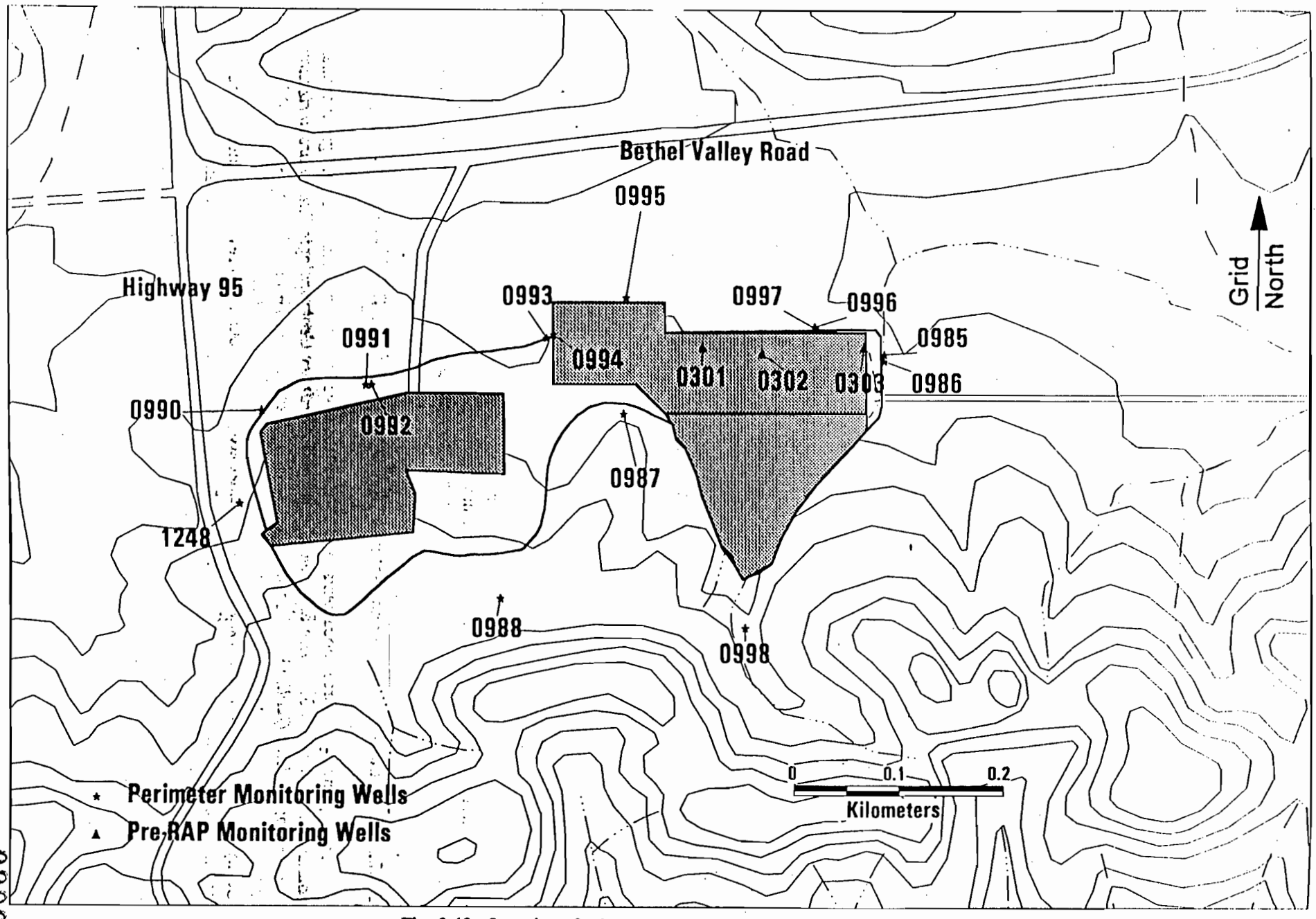

Fig. 3.13. Location of selected monitoring wells within WAG 3.

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980000

7.4.3.5 Metal detection

Aerial geophysical information is of primary importance to metal detection. Aerial methods are sensitive to buried metal; however, resolution is not always sufficient for adequate characterization. If this is the case, then other techniques such as magnetic, EM, and SP must be employed. Typically, magnetic should be the technique of choice. Depending on survey objectives, it may be prudent to collect EM and/or SP data in conjunction with magnetic data. Although data collection, analysis, and interpretation of all of these methods are quick and inexpensive, magnetic surveys are probably the quickest and least expensive.

7.4.3.6 Hydrogeologic process investigations

The hydrogeologic processes that best lend themselves to investigation by geophysical techniques are subsurface stormflow and groundwater seepage processes. The geophysical characteristic which is affected by groundwater flow, and makes these hydrogeologic processes measurable, is the ambient electrical potential that results from the process of electrofiltration. Thus, the SP technique is the primary technique for subsurface groundwater flow. Appropriate geophysical techniques for other hydrogeologic processes will be developed when a particular data need is identified and an appropriate means of investigation identified.

7.4.4 Piezometric Measurements and Well Sampling

Measuring hydraulic head in the GWOU is critical to addressing many of the data needs identified in Sect. 2. For example, hydraulic head measurements in a series of well-spaced wells over a particular area can determine horizontal changes in hydraulic head and, from this, the hydraulic gradient of the area can be determined. Hydraulic gradient indicates the direction of groundwater flow which is important information for addressing data needs such as those associated with boundary integrity issues. Vertical hydraulic head measurements are accomplished using nested piezometers (closely spaced wells that bottom at different depths) or multiport sampling in a single well. Vertical head measurements are needed for addressing data needs related to deep groundwater flow, the effectiveness of the Knox aquifer pressure barrier at the north and south boundaries, and in characterizing the mechanisms of shallow groundwater flow in the GWOU.

Collecting water samples from wells is a critical step in characterizing contaminant flux and in defining flow systems in the GWOU. Understanding contaminant flux within and out of the GWOU is a necessary step in calculating risk to potential receptors. Defining flow systems is necessary for characterizing the mechanism of groundwater flow which is part of developing a model to serve as a predictive tool for fate and transport. The impact of collecting water samples on this process is that, often, contaminants are important tracers in the groundwater system. For example, the ^{90}Sr plumes at WAG 3 define a distinct flow system which would not have been apparent were it not for the presence of a contaminant. In other instances, parameters such as conductivity or temperature may relate wells to each other or wells to springs via the same flow system. The topographic divide at the west end of Bethel Valley, including WAG 3, is an important location for these types of investigations because contaminants have been observed in surface waters of Raccoon Creek and its tributaries which almost certainly have their origin in WAG 3. However, observations of these contaminants have raised questions about the nature and extent of contaminant flux out of Bethel Valley. That is, is the source for contaminants in the Raccoon Creek basin all of WAG 3 or only one part of it? Also, is there any other source of contaminant flux under the topographic divide such as WAG 1?

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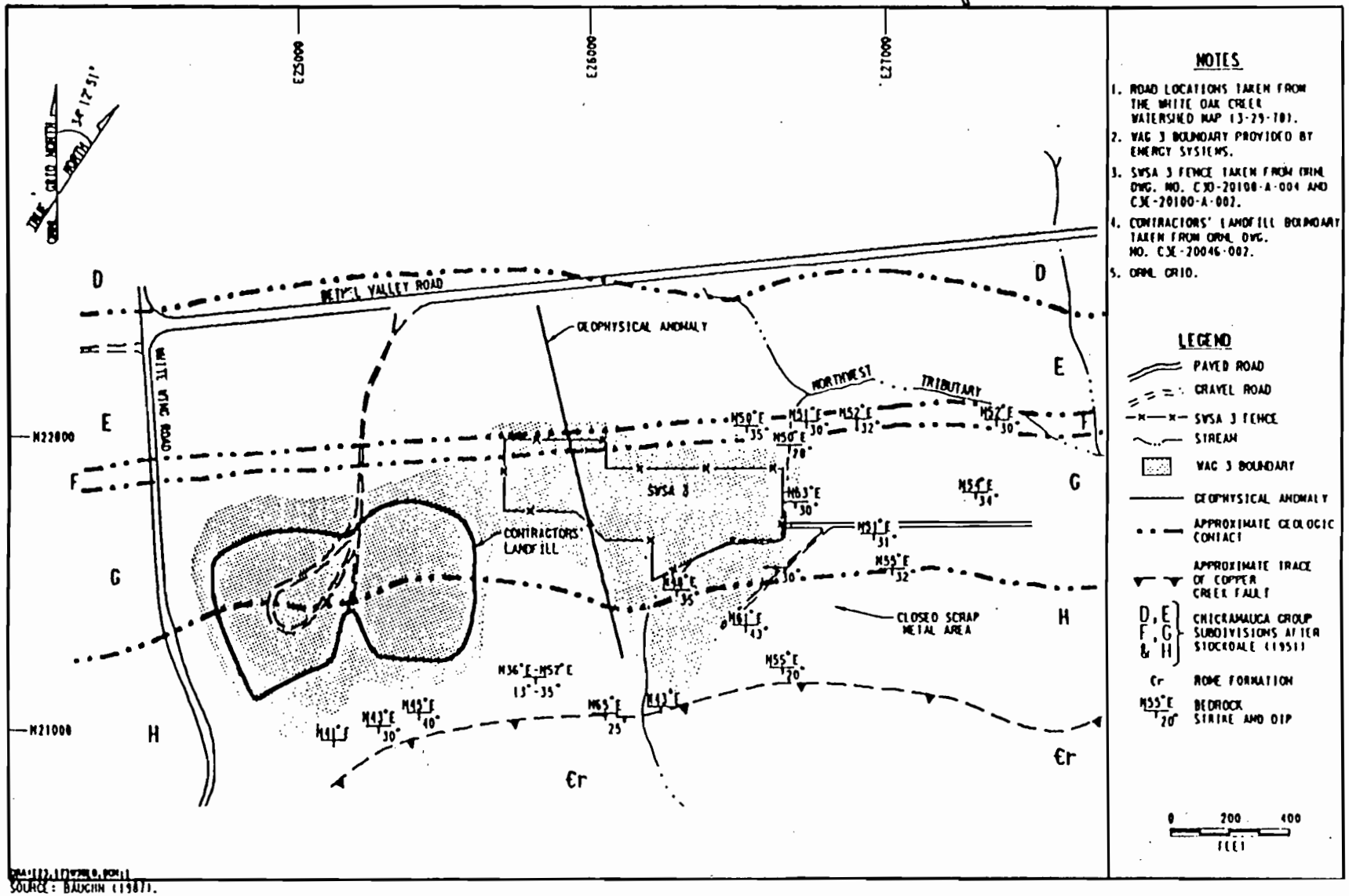

FIGURE 3-15
GENERALIZED GEOLOGIC MAP OF WAG 3

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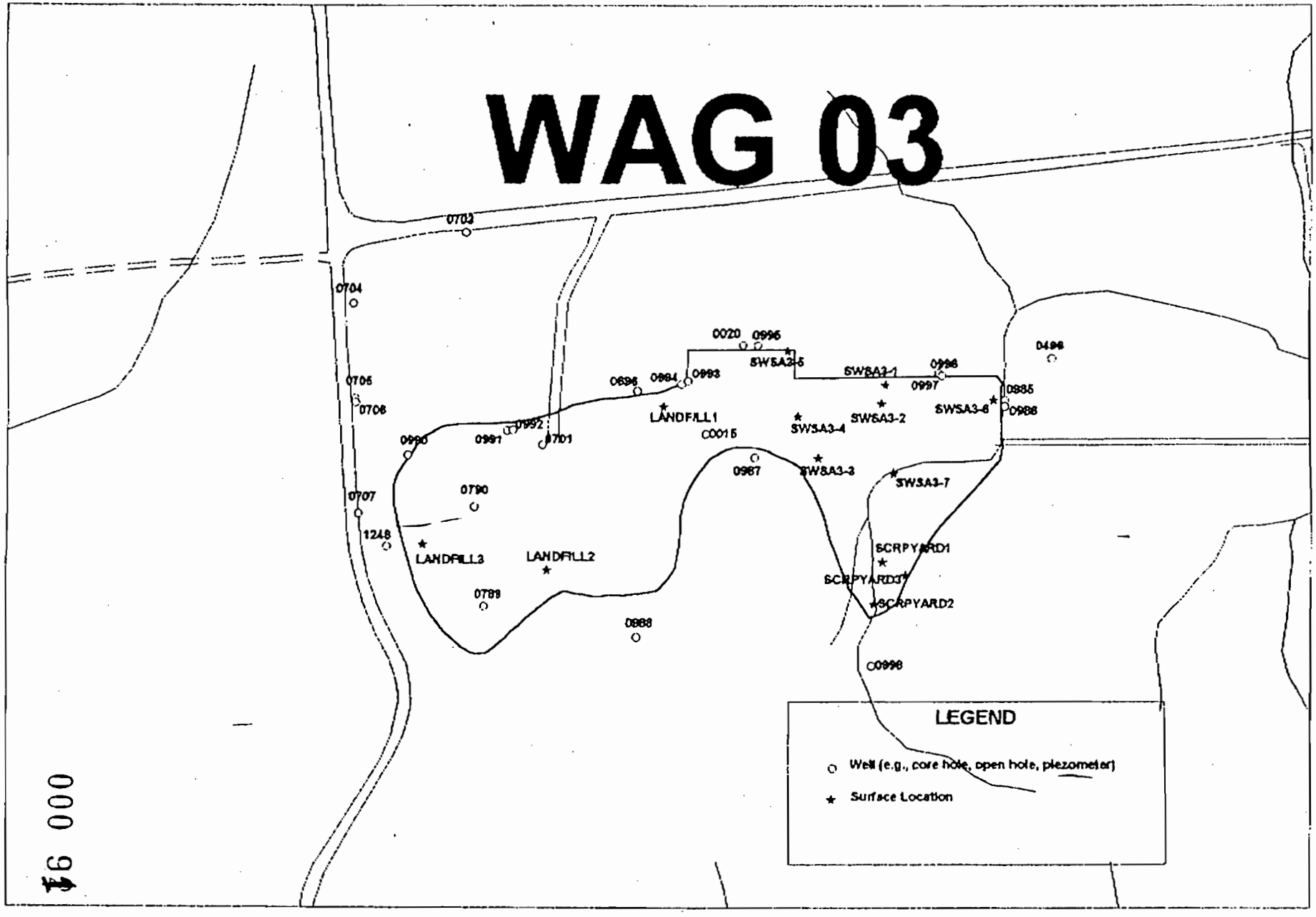
000089

000030


WAG 03
0703
0704
0705
0706
0707
0790
1248
LANDFILL3
LANDFILL2
0789
0988
0991
0992
0701
0993
0994
0995
0020
0996
SWSA3-5
SWSA3-1
0997
0998
0985
0986
SWSA3-6
SWSA3-2
SWSA3-4
LANDFILL1
C0015
0987
SWSA3-3
SWSA3-7
SCRPYARD1
SCRPYARD3
SCRPYARD2
C0998
0496
LEGEND
Well (e.g., core hole, open hole, piezometer)
Surface Location

WAG 3 WELLS SAMPLED
SINCE 1981

The table below describes the wellls that have been sampled since 1981. Most of the wells were sampled in March 1996, with the exception of the wag perimeter wells that were sampled for RADS only, in: August 1991, September 1992, November 1993, and October 1994.

WELL	EASTING	NORTHING	GROUND ELEVATION	RADS	METALS	OTHERS
0015	25697.75	21725.65	848.2	Y	Y	Y
0020	25821	22013	836.2	Y	Y	Y
0496	26827	21968	830.1	Y	Y	Y
0696	25473.89	21863.87	842.08	Y	Y	Y
0701	25166.8	21691.08	857.42	Y	Y	Y
0703	24916.77	22375.66	844.01	Y	Y	Y
0704	24542.95	22146.27	827.02	Y	Y	Y
0705	24548.26	21837.32	833.62	Y	Y	Y
0706	24550.12	21824.67	833.98	Y	Y	Y
0707	24560.86	21470.22	851.97	Y	Y	Y
0789	24975.9	21174	887.67	Y	Y	Y
0790	24944.39	21491.53	870.08	Y	Y	Y
0985	26675.61	21833.81	829.97	Y		
0986	26674.67	21813.16	830.56	Y		
0987	25857.89	21650.14	857.11	Y		
0988	25471.29	21075.73	910.97	Y		
0990	24723.62	21657.34	853.91	Y		
0991	25051.49	21736.64	854.79	Y		
0992	25069.69	21737.04	854.54	Y		
0993	25619.08	21884.35	840.39	Y		
0994	25639.92	21895.03	840.41	Y		
0995	25867.56	22011.41	837.17	Y		
0996	26458.18	21920.17	830.31	Y		
0997	26467.5	21911.04	830.24	Y		
0998	26235.94	20984.59	872.17	Y		
1248	24654.08	21366.92	860.66	Y		

000 92

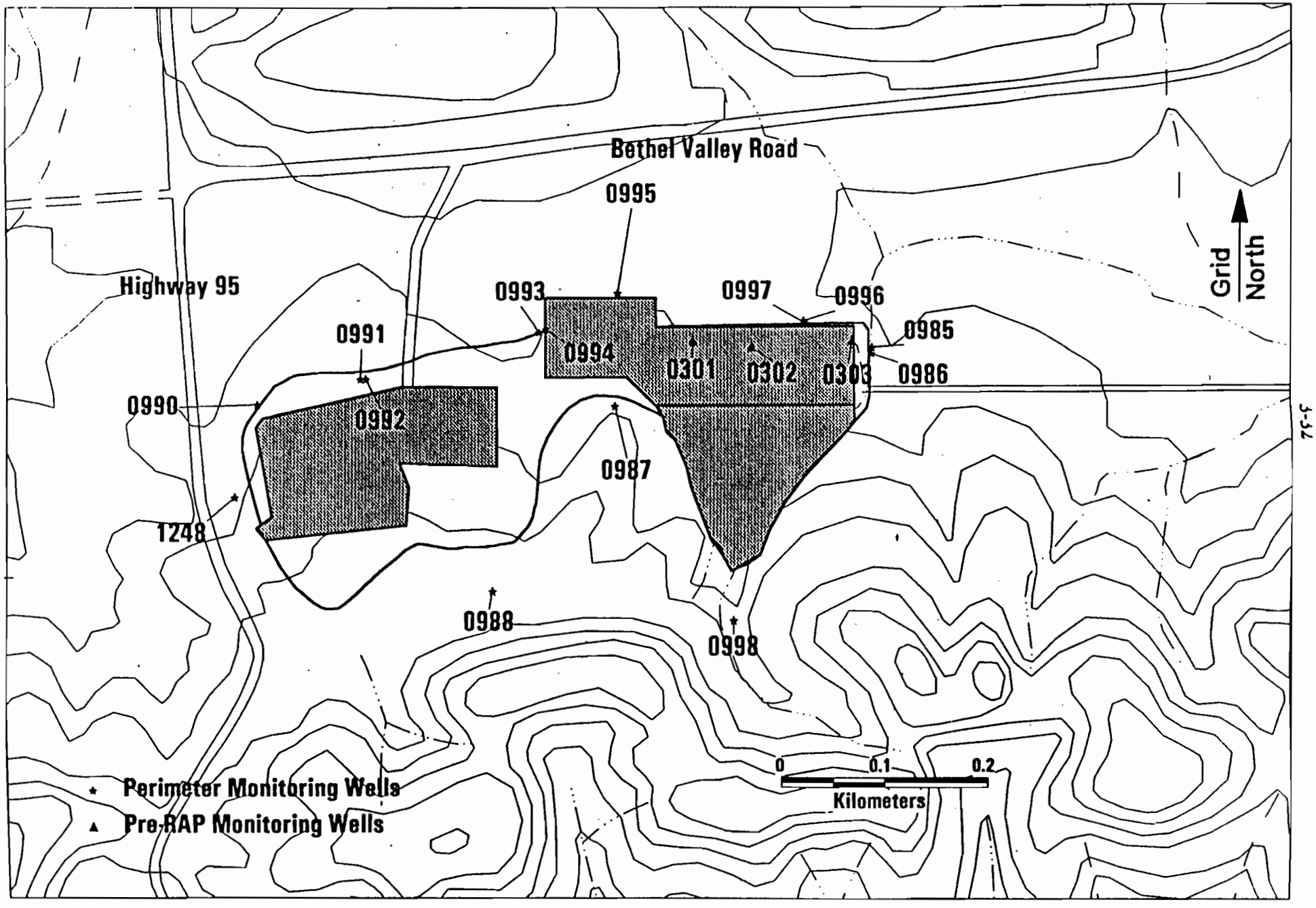


Fig. 3.13. Location of selected monitoring wells within WAG 3.

000 93 00031

WAG 3

WELL	ANALYZED COC	FREQ/DET	PRG (1E-4)	AVG	RISK	%
985	TRICHLOROETHENE	2/2	1.1E-01	1.4E-02	1.2E-05	52%
985	CS-137	2/2	1.7E+02	8.9E+00	5.2E-06	23%
985	CO-60	2/2	3.2E+02	1.4E+01	4.4E-06	19%
				Total Risk	2.3E-05	
986	BE	1/2	2.0E-03	2.1E-03	1.1E-04	94%
				Total Risk	1.2E-04	
987	CS-137	2/2	1.7E+02	1.4E+01	8.3E-06	63%
987	CO-60	2/2	3.2E+02	8.4E+00	2.6E-06	20%
987	TOTAL SR	2/2	1.3E+02	1.7E+00	1.3E-06	10%
				Total Risk	1.3E-05	
988	TOTAL SR	2/2	1.3E+02	1.6E+00	1.2E-06	52%
988	TRITIUM	2/2	8.8E+04	9.9E+02	1.1E-06	48%
				Total Risk	2.3E-06	
990	CO-60	2/2	3.2E+02	8.2E+00	2.6E-06	55%
990	TRITIUM	2/2	8.8E+04	1.2E+03	1.4E-06	29%
990	TOTAL SR	2/2	1.3E+02	9.9E-01	7.5E-07	16%
				Total Risk	4.8E-06	
991	TOTAL SR	2/2	1.3E+02	4.2E+00	3.2E-06	56%
991	CO-60	2/2	3.2E+02	3.6E+00	1.1E-06	19%
991	BIS(2-ETHYLHEXYL)PHTHALATE	1/2	6.1E-01	5.5E-03	9.0E-07	16%
				Total Risk	5.7E-06	
992	BE	1/2	2.0E-03	2.1E-03	1.1E-04	53%
992	TOTAL SR	2/2	1.3E+02	1.3E+02	9.6E-05	46%
				Total Risk	2.1E-04	
993	TOTAL SR	2/2	1.3E+02	1.7E+02	1.3E-04	95%
				Total Risk	1.4E-04	
994	TOTAL SR	2/2	1.3E+02	6.4E+02	4.8E-04	92%
				Total Risk	5.2E-04	
995	CS-137	2/2	1.7E+02	5.3E+00	3.1E-06	47%
995	TOTAL SR	2/2	1.3E+02	1.9E+00	1.5E-06	23%
995	TRITIUM	2/2	8.8E+04	8.0E+02	9.0E-07	14%
995	CO-60	2/2	3.2E+02	2.4E+00	7.7E-07	12%
				Total Risk	6.6E-06	
996	TOTAL SR	2/2	1.3E+02	5.4E+00	4.1E-06	68%
996	TRITIUM	2/2	8.8E+04	1.4E+03	1.6E-06	26%
				Total Risk	6.1E-06	
997	TOTAL SR	2/2	1.3E+02	6.6E+01	5.0E-05	94%
				Total Risk	5.3E-05	
998	TOTAL SR	2/2	1.3E+02	1.6E+00	1.2E-06	38%
998	METHYLENE CHLORIDE	1/2	1.1E+00	1.3E-02	1.1E-06	34%
998	TRITIUM	2/2	8.8E+04	8.0E+02	9.0E-07	28%
				Total Risk	3.2E-06	
1248	BE	1/2	2.0E-03	2.0E-03	1.0E-04	67%
1248	CS-137	2/2	1.7E+02	2.8E+01	1.7E-05	11%
1248	CHLOROFORM	1/2	2.7E-02	4.0E-03	1.5E-05	10%
1248	TOTAL SR	2/2	1.3E+02	1.2E+01	9.2E-06	6%
				Total Risk	1.5E-04	

5.3 SURVEYS OF CONTAMINATED SOILS

5.3.1 Gamma Radiation Surveys

Measurements of gamma radiation intensity made with hand-held or airborne instruments can provide useful clues about the quantity and distribution of this "historical" sediment-bound contamination. Where gamma-emitting radioisotopes, especially ^{137}Cs and ^{60}Co, are bound to surficial soil and sediment materials, measurements of gamma radiation intensity may provide a direct estimate of the contaminant inventory. In the Soil and Sediment Task, staff are trying to estimate the ^{137}Cs inventory from gamma survey data. The estimated inventory will be useful information in ER Program planning and will be used in contaminated sediment transport modeling study.

Gamma radiation does not provide a direct measure of buried waste. A one-meter thick layer of clean soil covering soil contaminated with ^{137}Cs will reduce the dose-rate for a person standing on the surface by a factor of roughly 100,000, and effectively block all alpha, beta, and lower energy gamma radiation (Kocher and Sjoreen 1985). The shielding power of soil and rock is one of the principal reasons radioactive waste is typically buried. For environmental site characterization, this unfortunately means that the location of buried radioactive material can rarely be determined from surface or airborne gamma radiation measurements.

Gamma radiation data collected by helicopter over the ORNL plant and surrounding lands in 1992 shows that the stream sediments deposited on the banks of White Oak Creek are contaminated with radionuclides (Fig. 5.3). At this scale, several general sources of contaminant radiation can be seen:

Main Plant Area: The tank storage area and the holding pond areas result in two local radiation maxima.

Other plant facilities: The High Flux Isotope Reactor in Melton Branch, the Molten Salt Reactor, waste tanks associated with the Hydrofracture facilities, all in Melton Valley.

Waste disposal areas: WAG 3 at the west end of Bethel Valley, the north end of WAG 5 in Melton Valley (The WAG 5 anomaly is associated with waste drums stored on a pad on the surface. Tritium such as that released from seeps located the lower end of WAG 5 cannot be detected by gamma surveys.).

The 0800 Area: Adjacent to the Clinch River, experiments where ^{137}Cs was spread on the land led to significant gamma radiation and potential exposure for individuals boating on the river. In 1993, as an early action the contaminated soil was removed, placed in containers, and disposed

Table 3.1. Chemical carcinogens detected at least once in Oak Ridge National Laboratory waste area grouping perimeter monitoring well network

Chemical of concern	Number of wells	Well	WAG	Range of concentrations (mg/L; pCi/L)
1,1-Dichloroethene	4	954, 958, 1190,1201	2, 4, 17	0.017-0.044
1,2,3-Trichloropropane	2	818, 819	1	0.005
1,2-Dibromo-3-chloropropane	2	818, 819	1	0.01
1,2-Dibromoethane	2	818, 819	1	0.005
1,4-Dioxane	2	818, 819	1	5.0
2-Propenenitrile	2	818, 819	1	0.01
3,3'-Dimethyl-benzidine	1	814	1	0.085
Aroclor-1254	1	854	6	0.001
Beryllium	58	745, 806, 807, 808, 809, 810, 811, 812, 813, 814, 816, 818, 824, 827, 828, 829, 830, 831, 832, 833, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 986, 992, 1071, 1074, 1076, 1079, 1084, 1145, 1194, 1195, 1245, 1248	1, 2, 3, 6, 7, 11	0.001-0.025
Bis(2-ethylhexyl)phthalate	1	977	1	3.1
Carbon tetrachloride	1	842	6	0.0614
^{60}Co	3	1078, 1243, 1244	2, 6, 7	432-915
N-Nitroso-di-n-propylamine	1	809	1	0.008
^{226}Ra	1	973	5	77.4
^{90}Sr	13	806, 812, 956, 969, 973, 975, 992, 993, 994, 1087, 1096, 1097, 1191	1, 2, 3, 4, 5, 8	140-7,900
^{99}Tc	1	1078	7	11,000
Tritium	31	841, 842, 843, 847, 848, 849, 854, 954, 955, 956, 957, 958, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 981, 1076, 1079, 1084, 1152, 1156, 1191, 1243	2, 4, 5, 6, 7	93,800-290,000,000
^{234}U	1	812	1	346
Vinyl chloride	16	818, 819, 825, 830, 849, 853, 854, 954, 955, 958, 969, 973, 975, 978, 981, 1201	1, 4, 5, 6, 17	0.005-5.5

Table 5.1 Chemical carcinogens detected at least once in GWOU wells

Chemical of potential concern	Number of wells	Wells in which the chemicals were detected	WAGs in which the chemicals were detected	Range of average detected concentrations (mg/L; pCi/L)
1,1-Dichloroethane	6	833, 842, 978, 958, 954, 1190	2, 4, 5, 6	0.0044–0.018
Beryllium	30	806, 807, 808, 809, 810, 811, 812, 813, 814, 824, 827, 828, 829, 830, 831, 832, 837, 840, 841, 842, 843, 846, 855, 856, 857, 858, 992, 986, 1145, 1248	1, 3, 6, 11	0.002–0.013
Bis(2-chloroethyl)ether	2	975, 977	5	0.0073–1.0
Carbon tetrachloride	1	842	6	0.0053
Chloroform	1	842	6	0.0052
Cobalt-60	1	1078	7	650
Cobalt-61	1	1244	2	350
N-nitroso-di-n-propylamine	1	809	1	0.009
Total strontium	11	806, 812, 994, 956, 969, 975, 993, 1087, 1096, 1097, 1191	1, 2, 3, 4, 5, 6, 8	140–7700
Trichloroethene	2	969, 974	5	0.00013–0.00025
Tritium	26		2, 4, 5, 6, 7	12000–190,000,000
Uranium-234	1	812	1	300
Vinyl chloride	10	825, 830, 954, 958	1, 4, 5	0.0076–4.6

Table 1.1. Contaminants known or suspected to have been released from each WAG

WAG	Contaminants[a]
1	^{60}Co, ^{90}Sr, ^{137}Cs, ^{15X}[b]Eu, ^{232}Th, ^{23X}U, ^{23X}Pu, ^{241}Am, ^{244}Cm, other radionuclides, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Zn, TRE, PCBs, chlordane
2	^{3}H, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{137}Cs, ^{15X}Eu, ^{23X}U, ^{23X}Pu, ^{241}Am, ^{244}Cm, Ag, Cd, Cr, Cu, Hg, Pb, Se, TRE, PCBs, chlordane, VOCs, nitrates
3	^{3}H, ^{90}Sr, ^{137}Cs, TRE
4	^{3}H, Co, ^{3}H, ^{60}Co, ^{90}Sr, ^{106}Ru, ^{137}Cs, ^{23X}Pu, other radionuclides, TRE
5	^{3}H, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{233}U, ^{23X}Pu, ^{241}Am, ^{244}Cm, other radionuclides, Cr, Hg, PCBs, Ni, Pb, Zn, PCBs
6	^{3}H, ^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{15X}Eu, ^{23X}U, Cr, Cu, Hg, Mo, Ni, Pb, Zn, VOCs, nitrates
7	^{3}H, ^{60}Co, ^{90}Sr, ^{99}Tc, ^{106}Ru, ^{137}Cs, ^{233}U, Cr, Ni, Zn, nitrates
8	^{60}Co, ^{90}Sr, ^{137}Cs, Cr, Cu, Zn
9	^{60}Co, ^{90}Sr, ^{137}Cs, Cr, Zn
10	^{90}Sr, ^{137}Cs, ^{244}Cm, TRU isotopes
11	^{238}U, Cd, Cu, Zn, Cr, organics
13	^{137}Cs
17	^{137}Cs, Cd, Cr, Cu, Zn, fuel-derived hydrocarbons, and solvents

[a]Based primarily on data in ORNL RCRA Facility Investigation (unpublished and environmental data packages for each WAG. Ruthenium-106 and TRE have short half-lives (e.g., ~1 year) and should have decayed to trivial levels by this time.

[b]X represents the radioactive isotope series.

Table 3.3. Summary of detected contaminant analytes whose median values exceed drinking water standard MCLs (unfiltered samples)

Analyte type	Analyte	WAG 1	WAG 2	WAG 3	WAG 4	WAG 5	WAG 6	WAG 7	WAG 8	WAG 9	WAG 11	WAG 17
Anions	Fluoride							1[a]				
	Nitrate		1					2				
Metals	Cd										1	
	Cr		1								1	
	Hg			1							1	
	Ni		1		3			2				
	Se				1							
Organics	1,1-Dichloroethene				2							1
	1,2-Dichloroethane						1					
	Benzene					1						1
	Carbon tetrachloride						1					
	Trichloroethylene	1		1	2	2	2			1	2	2
	Vinyl chloride	1			2	3						1
Radionuclides	G-Alpha	1		1	1	2		1			1	
	G-Beta	3	1	4	3	5		5	1	2	1	
	Tritium		4	1	6	12	6	4	1			
	^{60}Co							1				
	Total Sr	5	2	4	2	7			2	2		
	^{234}U	1										
General	pH	1	5	2	5	5	5	2	4			
	TDS		1			6		6				
Total wells sampled		26	20	15	15	22	16	16	9	2	11	8
Total wells exceeding MCLs		8	11	7	10	16	11	9	6	2	3	2

[a]Number of wells for which median analyte concentrations exceed the MCL.

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Table 3.4. Summary of detected contaminant analytes whose median values exceed drinking water standard MCLs (filtered samples)

Analyte type	Analyte	WAII 1	WAII 3	WAII 5	WAII 4	WAII 5	WAII 6	WAII 7	WAII 8	WAII 9	WAII 11	WAII 17
Metals	Ni		1*		5			2				
	Pb					1						
Radionuclides	G-Alpha	1	1		1	3	1	1				1
	G-Beta	3	1	4	4	4	1	4	1	2		
	Tritium	1	4	1	6	12	10	4	1		1	
	^{90}Sr						2	1				
	^{99}Tc							1				
	Total Sr	5	1	4	2	5			3	2	1	
	^{234}U	1										
General	TDS	6		5	5	7		6	2			
Total wells sampled		26	20	15	15	22	16	16	9	2	11	8
Total wells exceeding MCLs		10	5	6	9	16	10	8	5	2	2	1

*Number of wells for which median analyte concentrations exceed the MCL.

000100
~~00042~~

TABLE 1

INFORMATION MATRIX INDICATING MEDIA-SPECIFIC DATA
LOCATED WITHIN THE WAG 3 RI PLAN

Media	Location/SWMU	Parameter	Section in WAG 3 RI Plan	Source
Geology	Bethel Valley	Structural geology	3.3.1.1	McMaster and Waller (1965)
Geology	Bethel Valley	Structural geology	3.3.1.1 Table 3-8	Stockdale (1951)
Geology	Bethel Valley	Structural geology; stratigraphic geology	3.3.1.1 Figures 3-13 and 3-14 Table 3-8	Lee and Ketelle (1988)
Geology	Bethel Valley	Structural geology; hydrogeology	3.3.1.1	Switek (1983)
Geology	SWMU 3.1	Structural geology	3.3.1.1	Rothschild et al. (1985)
Geology	SWMUs 3.1, 3.2, and 3.3	Structural geology; topography	3.3.1.1 and 3.3.1.2 Figures 3-15 and 3-16	Baughn (1987)
Soils	SWMUs 3.1, 3.2, and 3.3	Soil type; soil thickness	3.3.1.3	Baughn (1987)
Soils	SWMU 3.1	RAD contaminant concentrations	3.3.1.3 Figure 3-17 Table 3-9	Steuber (1979)
Soils	SWMU 3.1	Walkover survey	3.3.1.3 Figure 3-18	Uziel et al. (1988)
Soils	SWMU 3.3	RAD contaminant concentrations	3.3.1.3 Figure 3-17 Table 3-13	Steuber et al. (1981)
Air	Bethel Valley WAG 3 vicinity	Gross alpha, gross beta in air samples (1987); RAD from ORR air monitoring stations	3.3.1.4 Figure 3-19 Tables 3-11 and 3-17	Energy Systems (1988)
Air	Bethel Valley WAG 3 vicinity	Quarterly external gamma radiation measurements	3.3.1.4 Figure 3-19 Table 3-13	Energy Systems (1988)

3057m

000101

~~000043~~

TABLE 1 (continued)

Media	Location/SWMU	Parameter	Section in WAG 3 RI Plan	Source
Surface Water/ Sediments	WAG 3	RAD (strontium-90, cesium-137, cobalt-60)	3.3.1.5 Tables 3-14 and 3-17	Energy Systems (1987; 1988)
Surface Water/ Sediments	WAG 3	Water quality from Northwest Tributary	3.3.1.5 Tables 3-15 and 3-16	Loar (1988)
Surface Water/ Sediments	WAG 3	RAD (strontium-90), Northwest Tributary, and Racoon Creek	3.3.1.5 Figures 3-23, 3-24, 3-25 3-26, and 3-27 Tables 3-18, 3-19, and 3-20	Steuber et al. (1981)
Surface Water/ Sediments	WAG 3	RAD contaminants--stream gravels	3.3.1.5	Cerling and Spalding (1981) Morrison and Cerling (1987)
Groundwater	Bethel Valley	Groundwater circulation	3.3.1.6	Lee et al. (1988)
Groundwater	Bethel Valley	Groundwater flow	3.3.1.6 Figure 3-28	Stockdale (1951)
Groundwater	Bethel Valley	Groundwater flow	3.3.1.6	Webster (1976); Steuber et al. (1981); Ketelle et al. (1986); Baughn (1987)
Groundwater	WAG 3	Location of existing groundwater monitoring wells	3.3.1.6 Figure 3-29	Webster et al. (1981); Voorhees (1987); Baughn (1987)
Groundwater	WAG 3	Pre-RAP well construction details	3.3.1.6 Table 3-21	Webster et al. (1981)
Groundwater	WAG 3	RAP piezometers well construction details	3.3.1.6 Figures 3-30, 3-31, 3-32, and 3-33 Table 3-22	Mortimore (1987); Voorhees (1987); Baughn (1987)
Groundwater	WAG 3	Water quality data from pre-RAP wells	3.3.1.6 Table 3-23	Stockdale (1951)
Groundwater	SWMU 3.1	Dye tests to determine groundwater divide	3.3.1.6	Switek (1983)
Groundwater	WAG 3	Water level data	3.3.1.6 Figures 3-35, 3-36, and 3-37 Table 3-34	Voorhees (1987)

3057m

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Stueber (1979) reported radionuclide data obtained from soil core samples taken from SWSA 3 and the Northwest Tributary in 1978. The soil core locations are shown in Figure 3-17 and the radioactivity for three soil depths for different radionuclides is presented in Table 3-9. All the soil samples were analyzed by gamma-ray spectrometry for cesium-137 and cobalt-60. Since the surficial soil samples had the highest concentration of contaminants, the soil sampling results indicate that the radionuclide contamination in the soil cores is most likely from leaching of contaminants from equipment or leakage from drums stored on the ground surface in SWSA 3.

A surface radiological investigation of SWSA 3 was conducted by Uziel et al. (1988) on August 19, 1987. The results of the surface radiological investigation (Figure 3-18) indicated gamma exposure rates above-background levels at 98 areas, totaling 960 yds^2, inside the SWSA 3 fence. A 45-ft^2 area along the south fence had the highest gamma exposure rate of 10,000 μR/hr at the surface and 1,000 μR/hr at 3.2 ft above the ground surface. Other areas of elevated radiation levels inside the fence ranged from 17 to 1400 μR/hr, except for seven scattered spots that had readings of 2 or 3 mR/hr. Three areas of elevated radiation levels ranging from 17 to 340 uR/hr were defined on the outside of the north fence. Beta activity was detected in the leaves of several small saplings growing inside the fence, and in some leaves of trees adjacent to these saplings.

Closed Scrap Metal Area (SMWU 3.2)

There have been no reported soil surveys conducted at the Closed Scrap Metal Area.

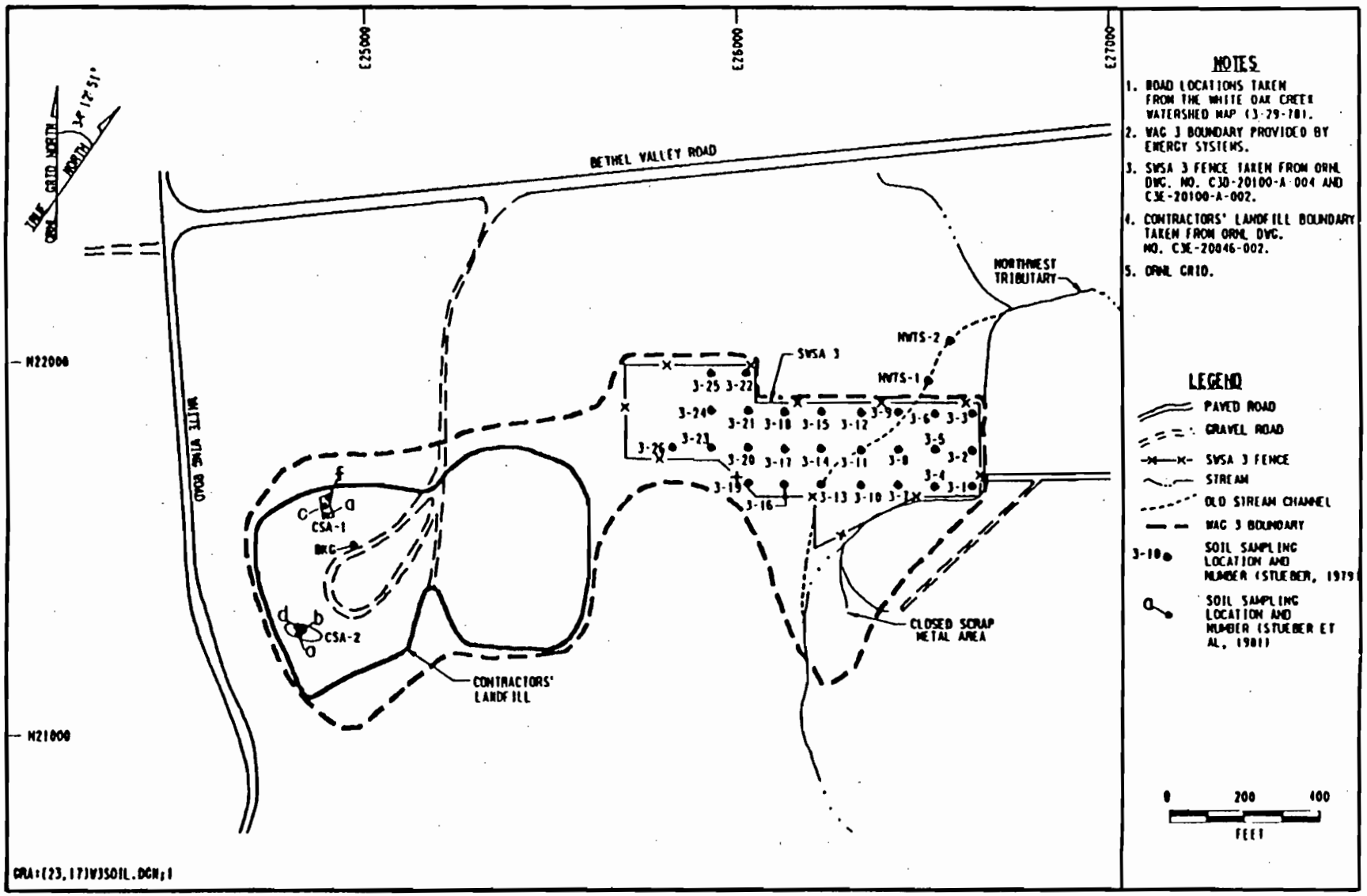

FIGURE 3-17
SOIL SAMPLING SITES IN WAG 3

000104 00046

Table 3-9
RADIONUCLIDE ANALYSES OF SOIL CORES FROM SWSA 3

Sample[b] Number	Radioactivity (pCi/g)[a] Cesium-137 0-5"	Cesium-137 5-10"	Cesium-137 10-15"	Strontium-90 0-5"	Strontium-90 5-10"	Strontium-90 10-15"	Plutonium-239 0-5"	Plutonium-239 5-10"	Plutonium-239 10-15"	Plutonium-238 0-5"	Plutonium-238 5-10"	Plutonium-238 10-15"	Americium-241 0-5"	Americium-241 5-10"	Americium-241 10-15"	Curium-244 0-5"	Curium-244 5-10"	Curium-244 10-15
3-1	0.5	11.6	0.2	1.7	1.8	1.1	0.04	0.79	0.00	<0.001	0.011	<0.011	0.23	0.04	0.001	0.005	0.005	0.00
3-2[c]	38.3	0.2	—	19.2	2.9	—	0.93	0.01	--	0.045	<0.001	—	0.075	0.004	—	0.006	0.005	—
3-3	16.8	--[d]	—	16.3	5.4	1.2	15.3	0.05	0.00	0.041	<0.001	<0.001	0.28	0.004	<0.001	0.013	0.003	0.00
3-4	52.9	2.5	0.5	7.3	3.1	0.4	1.72	0.07	0.01	0.014	<0.001	0.001	0.13	0.009	0.002	0.006	0.009	<0.00
3-5	4.9	1.5	0.9	11.2	0.7	<0.02	0.16	0.01	0.01	0.002	<0.001	0.001	0.021	0.005	0.007	0.015	0.005	0.00
3-6	123	2.0	2.1	138	50.0	29.5	18.8	0.17	0.45	0.311	0.004	0.012	2.5	0.038	0.061	0.045	0.005	0.00
3-7	3.3	—	—	1.4	0.5	0.3	2.96	0.01	<0.01	0.006	0.005	0.001	4.0	0.013	0.011	0.067	0.020	0.00
3-8	17.2	0.3	0.9	14.0	2.1	0.8	3.24	0.10	0.23	0.13	<0.002	0.005	0.81	0.049	0.023	0.013	0.002	0.00
3-9	35.4	3.4	0.5	151	41.4	15.1	27.7	0.41	0.29	0.50	0.004	0.009	2.9	0.054	0.059	0.009	0.003	0.00
3-10	2.01	0.9	0.3	33.2	10.4	1.2	6.44	0.01	0.01	0.068	0.013	<0.001	0.003	0.599	0.26	0.024	0.011	0.00
3-11	47.7	4.3	1.6	40.4	21.7	59.5	86.0	10.6	2.03	1.35	0.28	0.054	8.1	0.95	0.32	0.021	0.022	0.03
3-12	10.4	2.5	0.6	7.1	3.4	4.6	2.16	0.39	0.08	0.034	0.009	0.005	0.25	0.063	0.016	0.005	0.009	0.00
3-13	10.1	1.0	—	9.3	1.9	0.5	16.5	0.12	0.05	0.27	0.003	0.001	33.8	0.067	0.031	0.18	0.024	0.01
3-14	325	9.7	0.2	19.4	38.2	2.8	22.2	0.29	0.07	0.27	0.008	<0.013	0.49	0.013	0.003	0.016	0.027	0.03
3-15	391	2.8	2.9	123	12.0	7.7	7.03	0.04	0.11	0.22	<0.005	0.018	0.054	0.011	0.005	0.016	0.011	0.00
3-16	13.7	0.9	0.8	2.7	3.4	1.9	0.84	0.04	0.04	0.014	0.002	0.005	0.072	0.005	0.011	0.010	0.014	0.00
3-18	59.4	1.1	—	19.4	7.0	1.9	3.35	0.04	0.02	0.022	<0.001	<0.001	0.068	0.003	0.001	0.006	0.005	0.00
3-19	13.2	—	—	14.7	1.4	0.5	0.17	0.01	<0.01	0.003	0.001	<0.001	0.045	<0.001	<0.001	0.014	0.001	0.00
3-20	159	4.1	2.0	11.5	5.4	2.3	1.93	0.28	0.06	0.009	0.002	0.001	0.043	0.018	0.012	0.015	0.009	0.02
3-21	3.2	2.8	4.0	1.9	2.0	1.5	0.13	0.14	0.08	0.009	0.004	0.002	0.013	0.013	0.014	0.014	0.022	0.01
3-23[e]	25.7	2.2	2.0	4.4	1.6	1.9	0.32	0.01	0.03	0.017	0.001	0.002	0.063	0.011	0.016	0.013	0.021	0.01
3-24[e]	883	6.5	6.2	24.4	5.6	1.3	0.30	0.01	0.04	0.008	<0.001	0.007	0.063	0.001	0.010	0.023	0.014	0.01
3-26	24.4	0.7	0.6	50.5	9.0	1.7	1.24	0.02	<0.01	0.018	0.002	<0.001	0.15	0.009	<0.001	0.007	0.014	0.00
NWTS-1	204	53.6	15.7	109	95.0	84.7	40.8	12.0	3.42	0.77	0.22	0.067	1.1	1.4	0.42	0.010	0.010	<0.00
NWTS-2	191	40.2	23.9	117	106	90.5	42.8	10.0	5.09	0.85	0.17	0.077	6.4	1.2	0.63	0.010	0.009	<0.00

[a] Radioactivity for cobalt-60 was below the detection limit (0.2 pCi/g) for all samples except for four (3-10, 3-15, 3-18, 3-20), which had activities of 29.1, 1.8, 13.9, and 0.5 pCi/g, respectively, in the top 5 in. of soil.
[b] See Figure 3-17 for sample location
[c] Radioactivity was not reported for sample number 3-2 for soil depth of 10-15 in.
[d] A dash (—) indicates that the radioactivity is below the detection limit of 0.2 pCi/g.
[e] Radioactivity ranging from 0.0004 to 1.5 pCi/g was detected for a soil depth of 15-20 in. in sample numbers 3-23 and 3-24.

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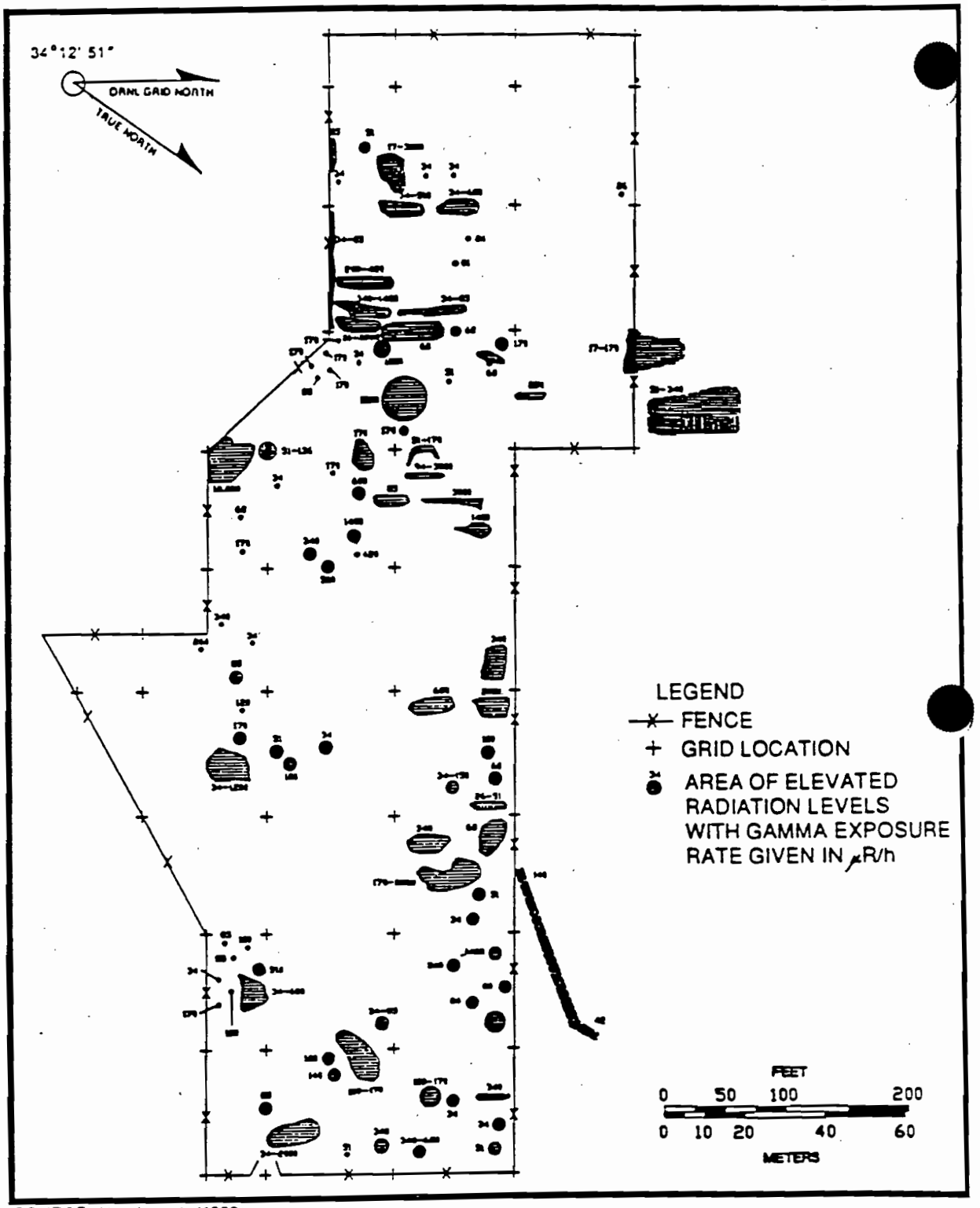

SOURCE: Utziel et al. (1988).

FIGURE 3-18
LOCATION OF SURFACE CONTAMINATION
AT SWSA 3 (AUGUST 1987)

Contractors' Landfill (SWMU 3.3)

A beta-gamma survey was conducted by Stueber et al. (1981) at the Contractors' Landfill. Two small areas having radioactivity greater than background (BKG) level were located (Figure 3-17); the first area (CSA-1) consists of a mixture of soil and gravel, and the second area (CSA-2) consists of soil. All the soil samples were analyzed by gamma-ray spectrometry for cesium-137 and cobalt-60 and the soil was also analyzed for strontium-90 activity (Table 3-10). The principal radioactive contaminant in both areas was cesium-137.

3.3.1.4 Air. Results of the air monitoring program at ORNL are presented annually in DOE/ORO Environmental Surveillance Reports (Energy Systems, 1988). Two ORR air monitoring stations (A3 and A9) are located in Bethel Valley in the vicinity of WAG 3; these stations are shown in Figure 3-19. Table 3-11 presents the annual gross alpha and beta concentrations in air samples collected from these two stations during 1987. A summary of iodine-131 and tritium in the air samples from these stations is shown in Table 3-12. External gamma radiation measurements are made routinely to confirm that radioactive effluents from ORNL are not significantly increasing above background levels. The locations of the measurements coincide with the air monitoring locations shown in Figure 3-19. Table 3-13 presents the quarterly summaries of external gamma radiation from ORNL perimeter air monitoring, ORR air monitoring, and remote air monitoring stations.

3.3.1.5 Surface Water/Sediments. Pertinent information on aspects of surface water and/or sediments as related to WAG 3 is presented in the following paragraphs.

Surface Water Hydrology

WAG 3 lies in the drainage basins of the Northwest Tributary, a tributary of WOC, and of Raccoon Creek, a tributary of the Clinch River (Figure 3-20). The drainage divide of the two basins is to

TABLE 3-10

RADIONUCLIDE CONCENTRATIONS[a] IN SOIL SAMPLES TAKEN FROM THE CONTRACTORS' LANDFILL

Sample Number[b]	Cesium-137	Cobalt-60	Strontium-90
CSA-1-a			
Soil	1450	≤0.20	257.0 (± 27)
Gravel	2680	≤0.17	
CSA-1-c			
Soil	959	≤0.17	14 (± 8)
Gravel	1080	≤0.10	
CSA-1-f			
Soil	9.5	≤0.14	17 (± 4)
Gravel	8650	≤0.19	
CSA-2-a			
Soil	323	2.3	6.3 (± 4)
CSA-2-b			
Soil	649	4.8	20 (± 11)
CSA-2-d			
Soil	550	3.2	8.6 (±
BKG[c]			
Soil	3.6	<0.16	1 (± 0.9)

[a]Radionuclide concentration given in pCi/g.
[b]For sample location, see Figure 3-17.
[c]BKG = Background.

Source: Stueber et al. (1981).

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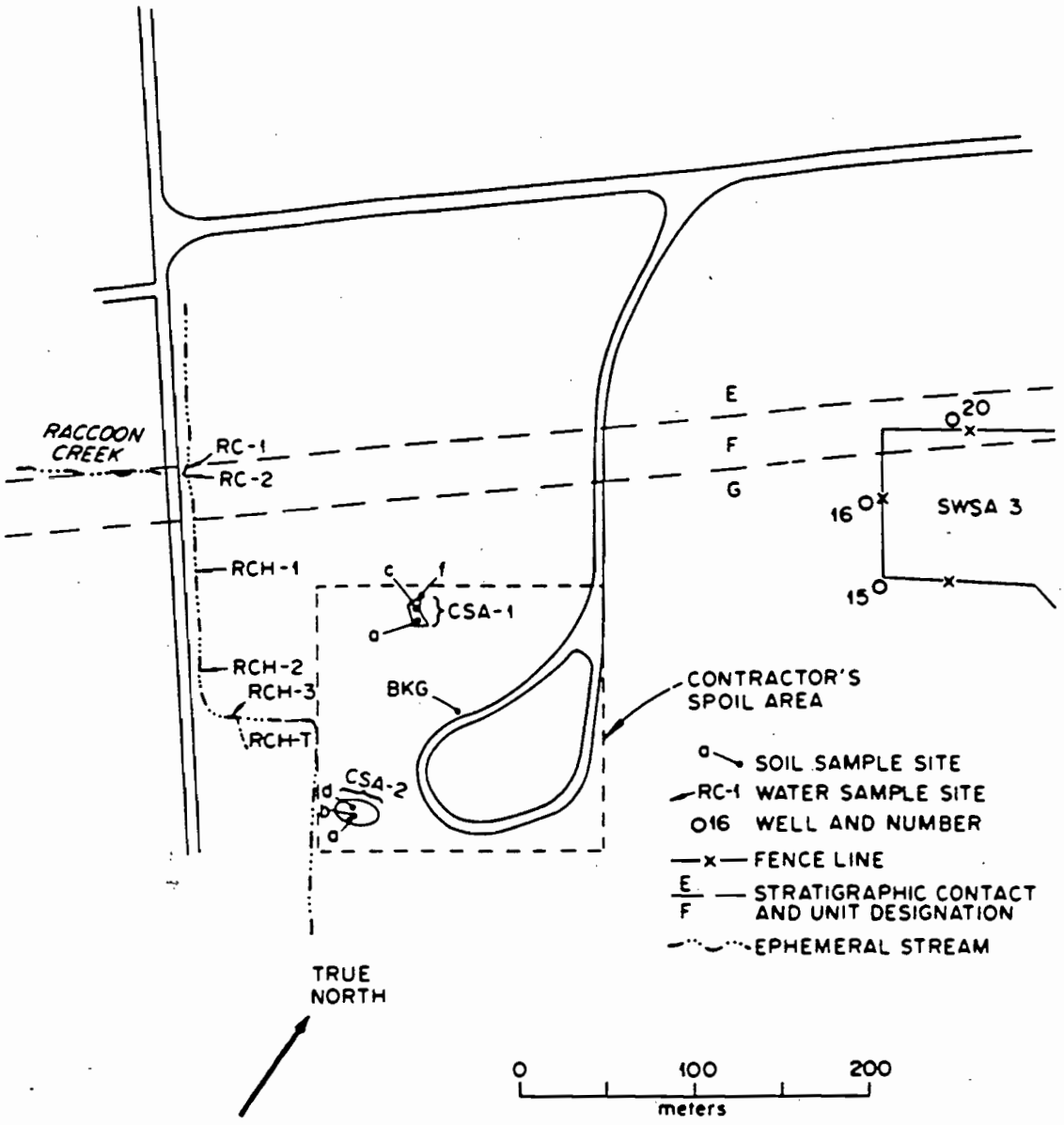

Fig. B-2. Soil sample locations and surface water sampling sites (or Contractor's Landfill) (see Table B-4).

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the west of SWSA 3, thus draining most of WAG 3 into Northwest Tributary, except for the western-most portion of the Contractors' Landfill.

The Northwest Tributary, which runs east toward WOC, drains the slopes of Chestnut Ridge and Haw Ridge. The portion of Northwest Tributary draining Haw Ridge originally passed through what is now SWSA 3. It was diverted around the northeastern end of SWSA 3 (Figure 3-21). The stream in this area is ephemeral, becoming perennial about 1300 ft downstream.

Surface drainage from the Closed Scrap Metal Area and the eastern section of the Contractors' Landfill also flows toward Northwest Tributary. Raccoon Creek drains the western-most portion of the Contractors' Landfill. The creek has its headwaters on the northeast side of U.S. Highway 95 (Figure 3-22). It flows southwestward over a distance of about 7000 ft and enters the Clinch River at approximately Clinch River Mile (CRM) 19.5.

Even though SWSA 3 lies outside the drainage basin of Raccoon Creek, it is believed that the creek receives contaminants that originate in SWSA 3. These contaminants may be transported by groundwater through bedrock structural and solution features eventually emerging at the surface as seeps. A seep (RCTS) is located near the easternmost tributary (T-1) of Raccoon Creek (Figure 3-22) and has been found to be the major source of contaminants for Raccoon Creek.

Surface Water Monitoring

A surface water quality monitoring station is located on Northwest Tributary before its confluence with First Creek (Figure 3-20). The monitoring station is composed of a broad-crested, 127° triangular weir and a water level recording and sampling station. The station is operated by the ORNL Environmental Monitoring and Compliance Department. Flow-proportional samples are collected weekly and analyzed monthly for gamma emitters and total strontium.

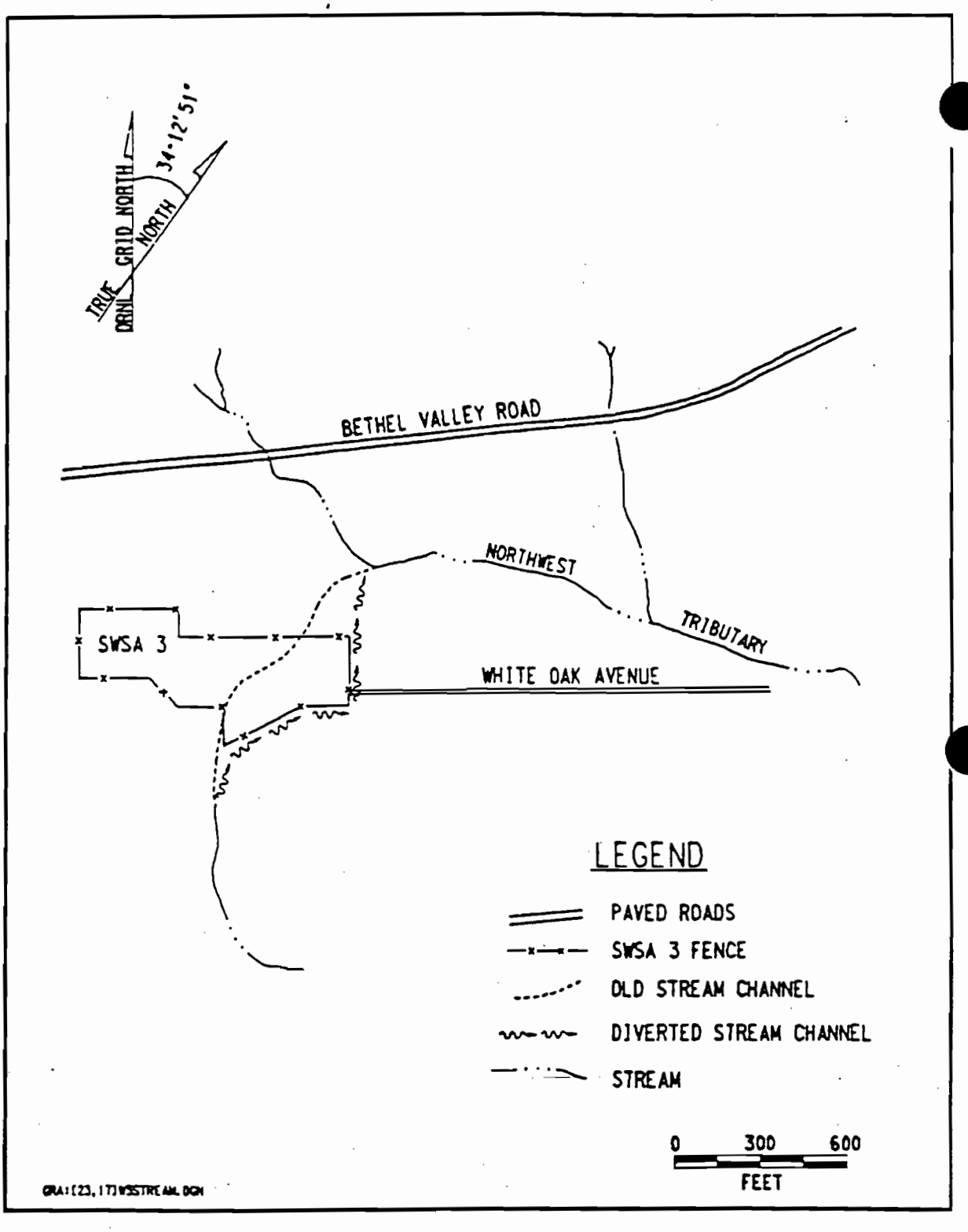
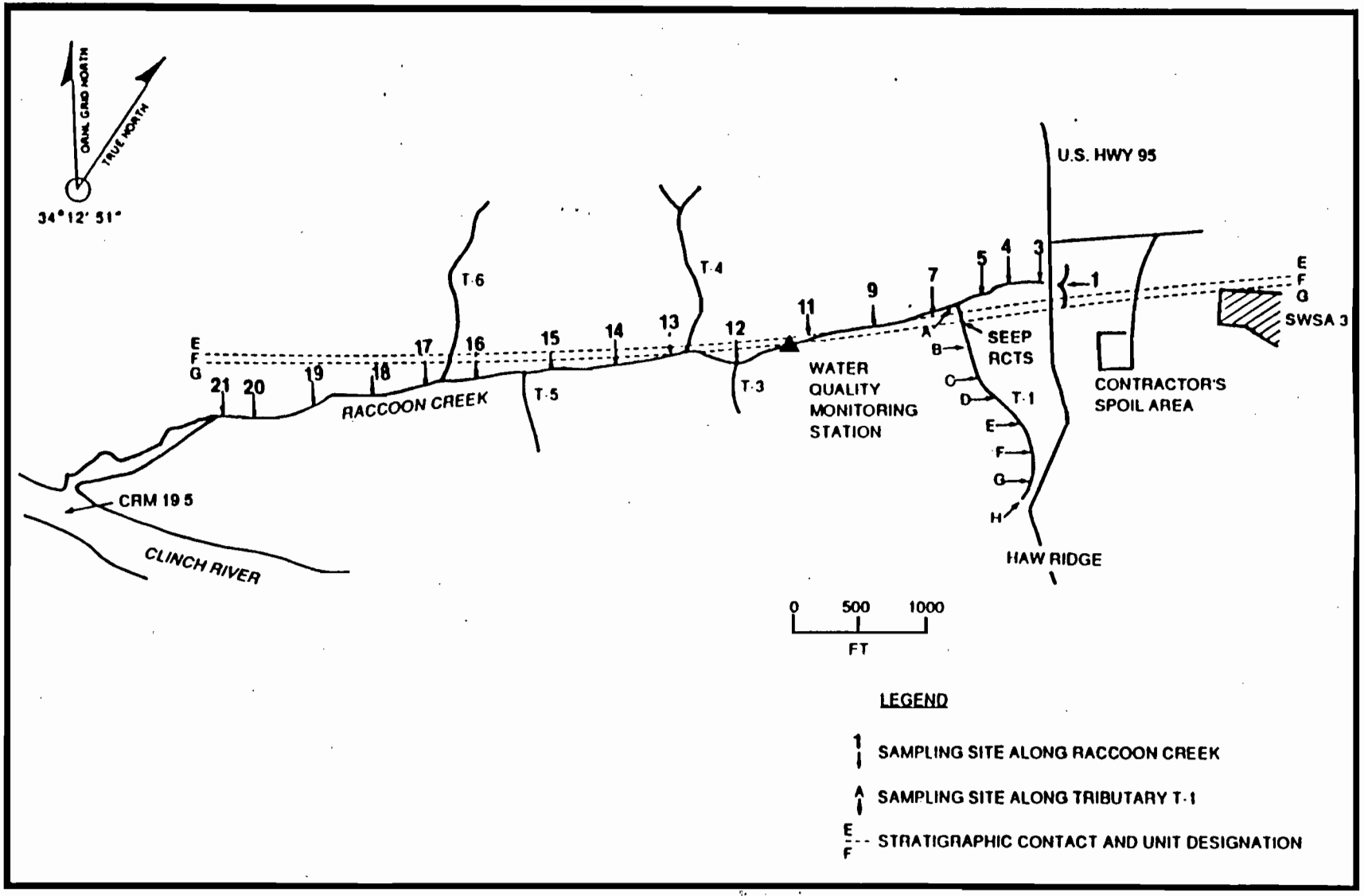


FIGURE 3-21
DIVERSION OF STREAM CHANNEL
AROUND SWSA 3

ORNL-DWG 79-14481A



SOURCE: Slueber et al. (1981).

FIGURE 3-22
SURFACE WATER SAMPLING SITES IN THE
RACCOON CREEK DRAINAGE BASIN

000113 00055

Raccoon Creek has a water quality monitoring station (Figure 3-20 and 3-22), completed in 1985, that is composed of a triangular weir flanked by two rectangular weirs for flow measurement and sampling. Grab samples are collected weekly and analyzed monthly for gamma emitters and total strontium. In the past, USGS had maintained a partial-duration station on Raccoon Creek (Latitude 35°54'16", Longitude 84°21'29") for which limited flow and water quality data are available (McMaster, 1967). The drainage area of Raccoon Creek at this station is 0.94 mi^2. The ORNL station on Raccoon Creek is located upstream of the USGS station.

Surface Water Quality Characterization -- Northwest Tributary

Water samples routinely are collected from the Northwest Tributary water quality station as a part of the requirements of the NPDES radiological monitoring plan. Table 3-14 summarizes the radiological data for the years 1986 and 1987 (Energy Systems 1987; 1988). Of the three radionuclides--cobalt-60, cesium-137, and total strontium (89 and 90)--only the latter is found in any substantial concentrations. No significant change in strontium concentration apparent between the two years. The maximum concentration of 78 pCi/L observed in the year 1987 represents 7.3 percent of the derived concentration guide (DCG) promulgated in Draft DOE Order 5480.

Table 3-15 shows the mean, standard deviation, and range of concentrations of water quality parameters for Northwest Tributary for the year 1987, based on 12 monthly water samples acquired as part of the ORNL Biological Monitoring and Abatement Program (Loar, 1988).

Table 3-16 shows the mean, standard deviation, and range of concentrations of dissolved solids at the Northwest Tributary monitoring stations. These are based on inductively coupled plasma (ICP) analysis of discrete water samples collected quarterly during 1987.

In an investigation of radionuclide releases from SWSA 3, Stueber et al. (1981) monitored the strontium-90 discharge from both Northwest Tributary and Raccoon Creek. Northwest Tributary was monitored for a period of 7 months at a point about 200 ft above its confluence with WOC. The amount of strontium-90 discharged through Northwest Tributary ranged from 2.1 to 11.1 mCi per month for the 7 months of monitoring. The data of Lomenick et al. (1962) for a 5-month period in 1961 yielded a mean value of 6.6 mCi per month. These figures suggest that SWSA 3 acts as a continuing active source of strontium-90.

To locate the sources of strontium-90 input to Northwest Tributary, water samples were collected on two days in June 1978 and two days in January 1979, from points (NWT-1 through NWT-9) at about 500-ft intervals from the stream's confluence with WOC to its origin above SWSA 3 (Figure 3-23). All tributaries were also sampled just above their points of confluence with the stream (T-1 through T-10, T-12, and T-14). Figures 3-24 and 3-25 show longitudinal profiles of strontium-90 concentration with distance upstream from the mouth of the Northwest Tributary. The greatest concentrations were found near Station NWT-6, where base flow first appears in the stream; this suggests that subsurface flow is the source of contamination. The January samplings concentrated on more precisely defining the reach of the stream that was most contaminated. Closely spaced samples from either side of Station NWT-6 were collected and analyzed. It is clear from Figure 3-25 that a 100-ft reach between Tributaries T-10 and T-12, which receives discharge from a groundwater seep, had the highest concentration of strontium-90; the concentration downstream from T-10 decreased due to dilution. The June 1978 set of samples were also analyzed for gamma activity; all samples had gamma activity levels below 0.2 pCi/mL.

Surface Water Characterization--Raccoon Creek

Radiological data from grab samples collected monthly at the water quality monitoring station (Figure 3-22) for 1986 and 1987 are summarized in Table 3-17. The concentrations of strontium-90 are

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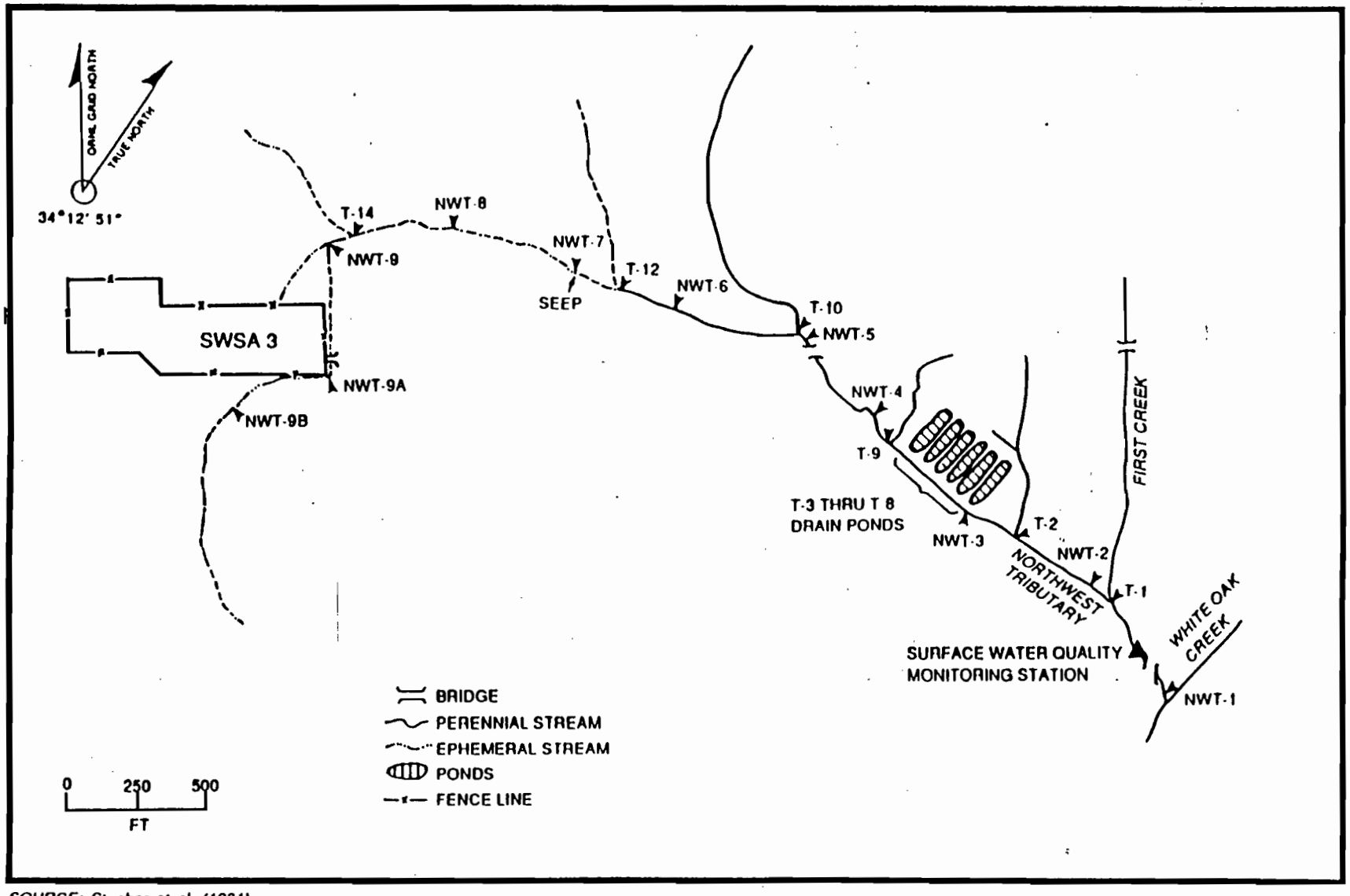

SOURCE: Stueber et al. (1981).

FIGURE 3-23
NORTHWEST TRIBUTARY DRAINAGE BASIN

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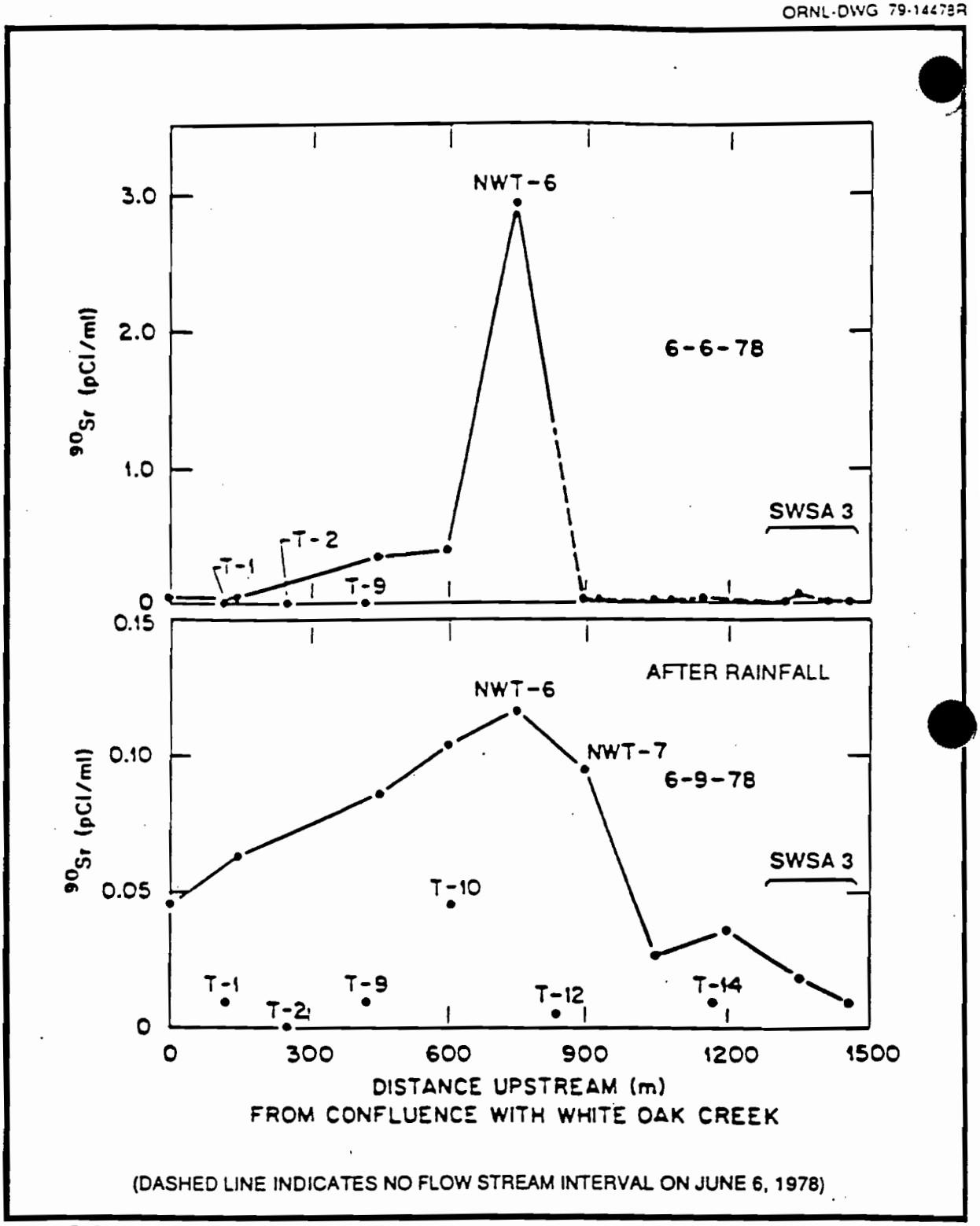
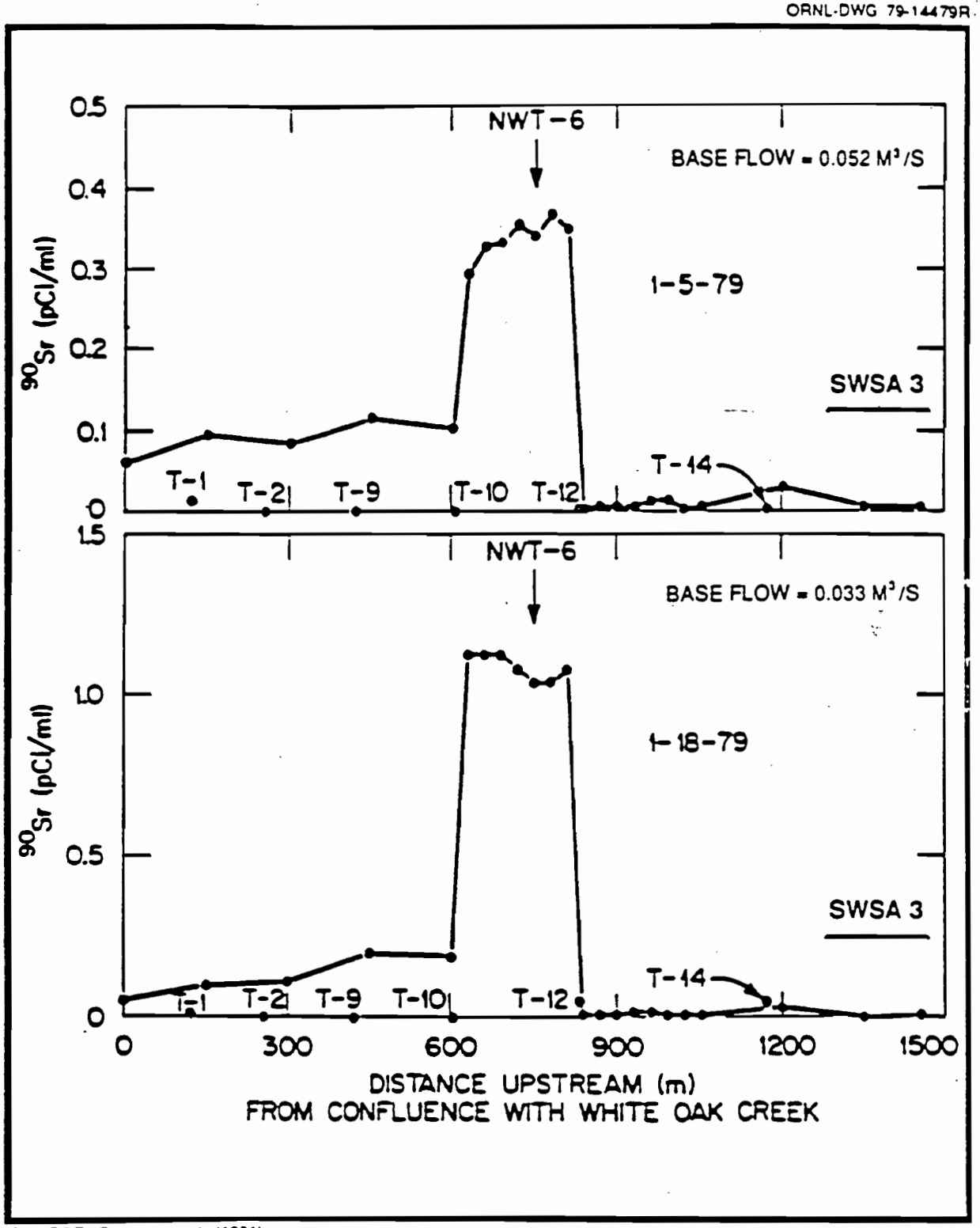


(DASHED LINE INDICATES NO FLOW STREAM INTERVAL ON JUNE 6, 1978)

SOURCE: Stueber et al. (1981).

FIGURE 3-24
LONGITUDINAL ACTIVITY PROFILES OF STRONTIUM-90
IN THE NORTHWEST TRIBUTARY FOR JUNE 1978.



SOURCE: Stueber et al. (1981).

FIGURE 3-25
LONGITUDINAL ACTIVITY PROFILES OF STRONTIUM-90
IN THE NORTHWEST TRIBUTARY FOR JANUARY 1979

TABLE 3-17

RADIONUCLIDE CONCENTRATIONS IN RACCOON CREEK WATERS (pCi/L)

Radio-nuclide	1986 Number of Samples	1986 Max	1986 Min	1986 Avg	1986 95% CC[a]	1987 Number of Samples	1987 Max	1987 Min	1987 Avg	1987 95% CC[a]
Cobalt-60	12	<11	<1.9	<4.6	1.6	12	<8.1	<2.7	<5.2	1.0
Cesium-137	12	<11	<1.4	<4.5	1.6	12	<5.4	<2.7	<4.7	0.71
Total Strontium	12	180	25	91	31	12	200	32	110	36

[a]Ninety-five percent confidence coefficient about average.

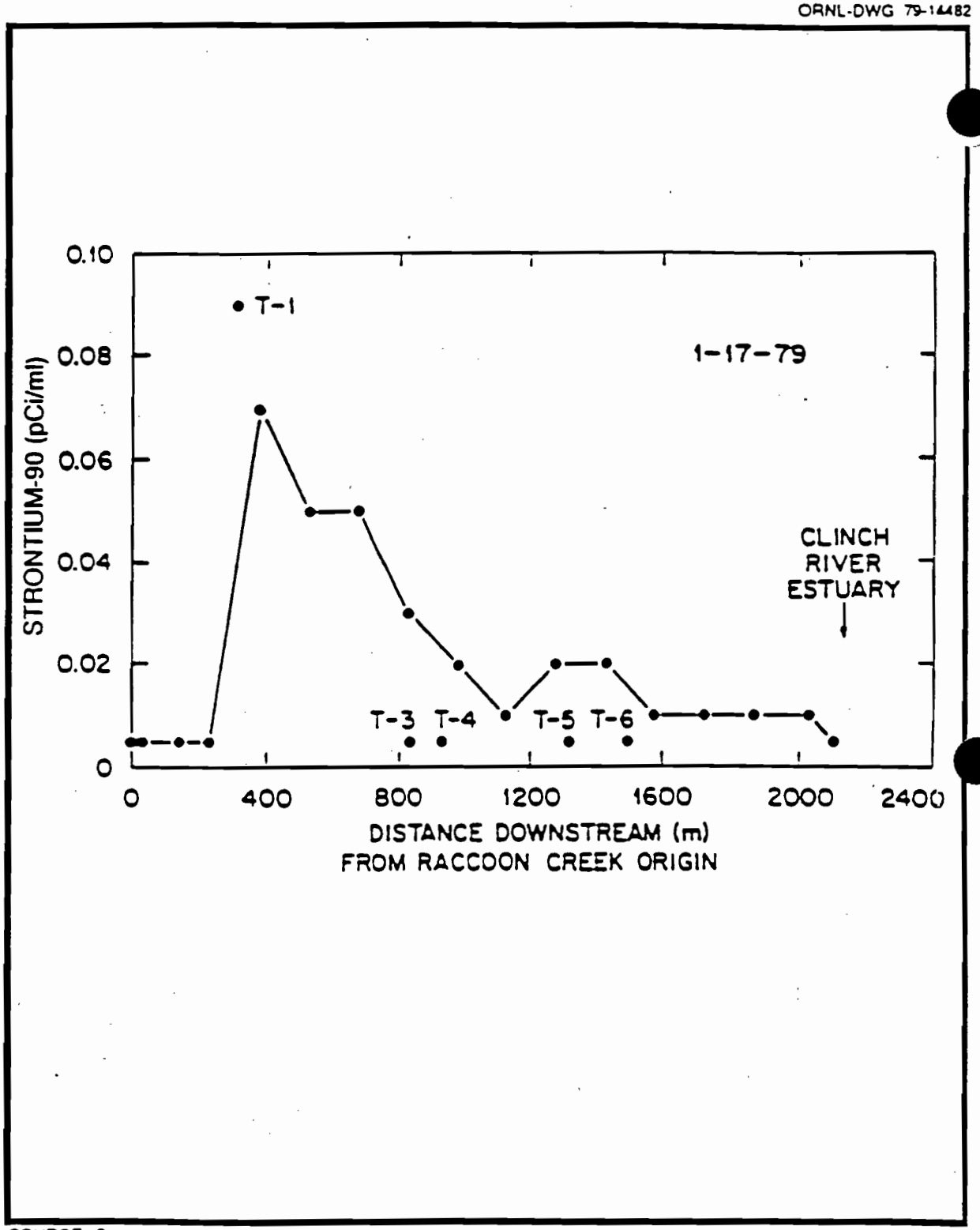
Source: Energy Systems (1987; 1988).

almost three times higher than those found in Northwest Tributary waters (see Table 3-14). The maximum concentration of total strontium represents 35 percent of the DCG. Cobalt-60 and cesium-137 concentrations are approximately the same as found at the Northwest Tributary Station.

Stueber et al. (1981) collected a suite of 17 water samples from Raccoon Creek from the its origin to its confluence with the Clinch River on January 17, 1979. Each of the five tributaries to Raccoon Creek was sampled at a point just above the tributary's confluence with Raccoon Creek (Figure 3-22). The longitudinal profile of strontium-90 concentrations (Figure 3-26) showed radioactivity levels to be at background (<0.01 pCi/mL) from the origin of Raccoon Creek to a point about 1200 ft downstream, where a concentration of 0.07 pCi/mL was detected. Further downstream the activity gradually decreased, reaching background level again near the Clinch River estuary.

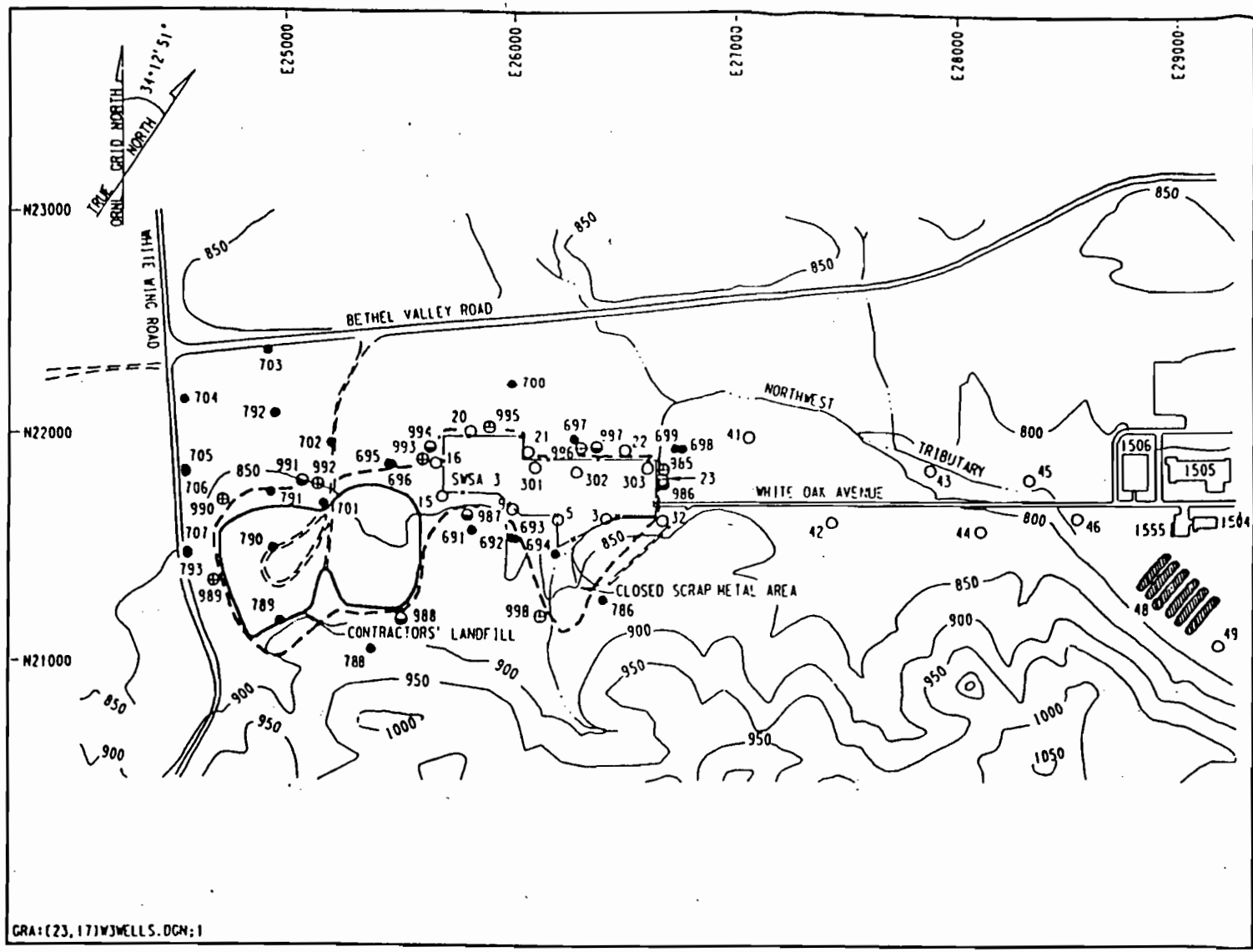
The strontium-90 in Raccoon Creek is believed to be introduced through a seep (RCTS) located on Tributary T-1 (Figure 3-22 and 3-27), which had a concentration of 0.09 pCi/mL when the suite of samples was collected. On March 1, 1979, water samples were collected at regular intervals from this stream confluence with Raccoon Creek to its headwaters on Haw Ridge (Figure 3-22). The strontium-90 analyses (Table 3-18) indicated that the activity was discharging from Seep RCTS along Raccoon Creek Tributary T-1, about 100 ft upstream from Raccoon Creek.

A temporary monitoring station was established on the Raccoon Creek tributary below the strontium-90 seep (Figure 3-27). An earthen dam was constructed so that stream flow could be monitored with a 10.6 gal collection vessel and stopwatch. Flow readings and water samples were taken daily over a 3-month period, and the monthly strontium-90 (Table 3-19) was determined. The discharge appears to be fairly constant at about 0.5 mCi per month, even though the monthly streamflow varied by as much as a factor of two.



SOURCE: Stueber et al. (1981).

FIGURE 3-26
LONGITUDINAL ACTIVITY PROFILE OF STRONTIUM-90
IN RACCOON CREEK ON JANUARY 17, 1979



NOTES

1. TOPOGRAPHY, BUILDING AND ROAD LOCATIONS TAKEN FROM THE WHITE OAK CREEK WATERSHED MAP (3-29-78).
2. WAG 3 BOUNDARY PROVIDED BY ENERGY SYSTEMS.
3. NO. SWSA 3 FENCE TAKEN FROM ORNL DW C3D-20100-A-004 AND C3E-20100-A-002
4. CONTRACTORS' LANDFILL BOUNDARY TAKE FROM ORNL DWG. NO. C3E-20046-002.
5. ORNL GRID.
6. ALL PRE-RAP AND RAP WELL LOCATIONS WERE TAKEN FROM THE SAS DATA SET (VOORHEES, 1987) EXCEPT PRE-RAP WELLS NUMBERS 16, 20, 21, AND 22 (WHICH WERE FOUND IN WEBSTER ET AL. (1981).
7. THE EXISTING WATER QUALITY WELL LOCATIONS WERE TAKEN FROM BAUGHN (1987).

LEGEND

- 1555 — BUILDING AND NUMBER
- PAVED ROAD
- GRAVEL ROAD
- SWSA 3 FENCE
- STREAM
- POND
- WAG 3 BOUNDARY
- 800 — GROUND SURFACE ELEVATION (CONTOUR INTERVAL = 50 FT.)
- 985 — EXISTING WATER QUALITY WELL WITH NO. (SHALLOW)
- 986 — EXISTING WATER QUALITY WELL WITH NO. (DEEP)
- 41 — PRE-RAP WELL AND NUMBER
- 700 — RAP-PIEZOMETER WELL AND NUMBER

0 400 800
FEET

FIGURE 3-29
EXISTING GROUNDWATER WELLS IN THE VICINITY OF WAG 3

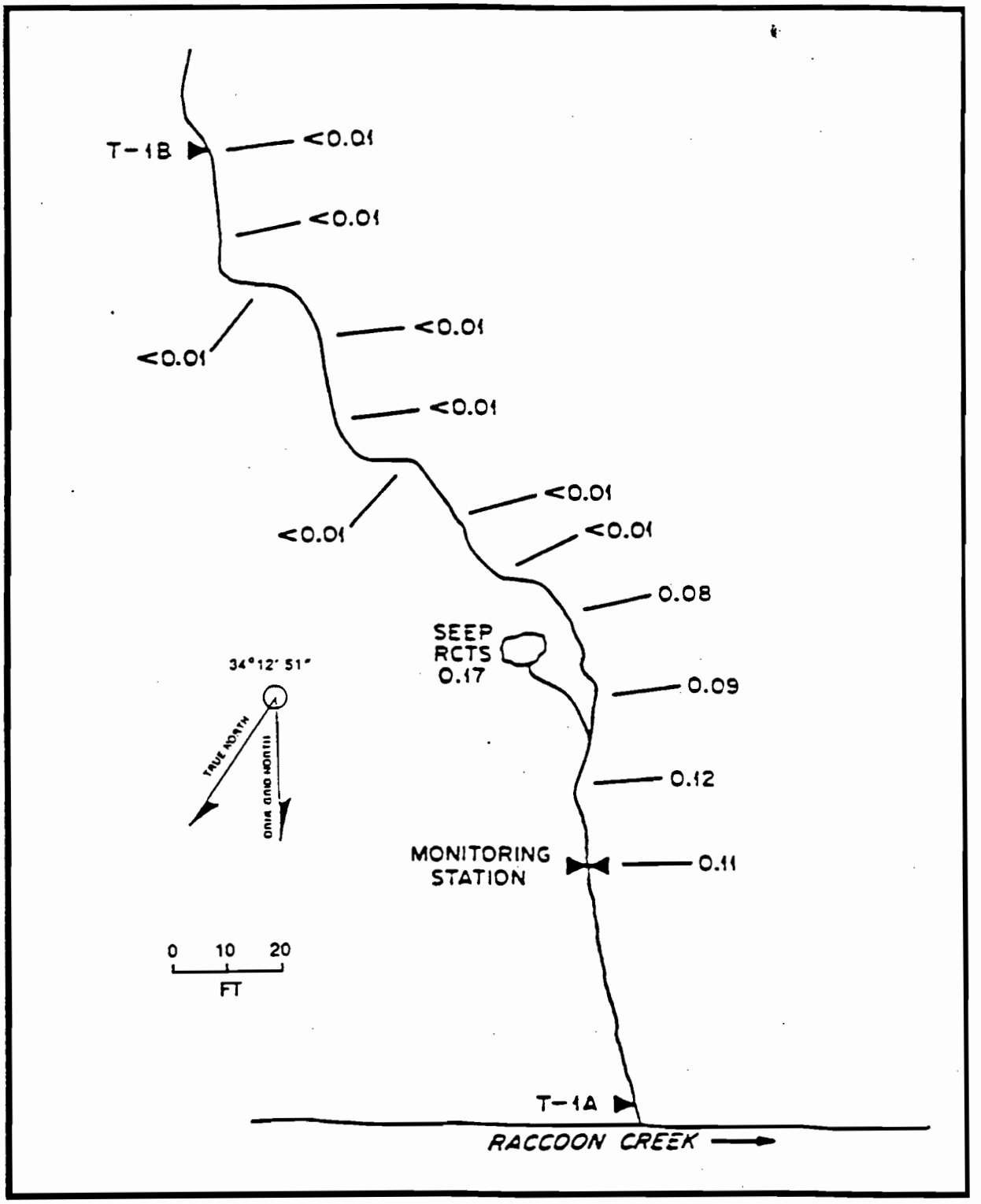
3-92

S 079 36 WAG 3

000123

000667

0001124



SOURCE: Steuber et al. (1981).

FIGURE 3-27
MAP SHOWING STRONTIUM-90 CONCENTRATIONS (pCi/ml)
IN THE RACCOON CREEK TRIBUTARY T-1
AT 5-M INTERVALS NEAR SEEP RCTS

During May 1979, the seep was sampled on a daily basis and composite water samples were prepared for the same time periods covered by daily samples taken at the monitoring station. The strontium-90 analysis (Table 3-20) shows that the water discharging from the seep has a relatively constant activity level, which is being diminished to varying degrees by tributary streamflow. The lower strontium-90 activity of the seep effluent for the last composite sample is probably due to dilution by surface runoff water during a period of high rainfall.

The investigation of the Raccoon Creek watershed by Stueber et al. (1981) demonstrated that strontium-90 was being introduced to the surface waters of this drainage basin by groundwater discharge at a single location. The strontium-90 discharge, while of very low absolute magnitude, appears to be quite constant. If the radioactive waste in SWSA 3 is the ultimate source of this activity, strontium-90 migration over a distance of approximately 2100 ft is indicated (Figure 3-22).

Surface runoff from the Contractors' Landfill area was also sampled at several locations near the headwaters of Raccoon Creek (Stueber et al., 1981). The strontium-90 activity was above detection limits (<0.02 pCi/ml) in three of six samples, but was below the detection limit in the other three.

Sediments

As part of the streambed gravel survey of the WOC watershed, Cerling and Spalding (1981) analyzed the bed gravel samples from Northwest Tributary for strontium-90, cobalt-60 and cesium-137 contamination. Cobalt-60 and cesium-137 contamination was found to be negligible. However, strontium-90 concentrations ranged from less than 5 dpm (83 Bq/kg) to as high as 215 dpm/g (3583 Bq/kg).

Streambed gravel surveys were also performed in 1985 an 1986. In the latter survey (Morrison and Cerling, 1987) streambed gravels

from two Northwest Tributary locations were collected and analyzed for three radionuclides and a limited suite of metals.

Strontium-90 was found in the samples, as was nickel. The remaining analyses were at or below analytical detection limits or were found to be essentially equal to background (Morrison and Cerling, 1987).

The Raccoon Creek sediments were not sampled in the original survey of Cerling and Spalding (1981). The scoping survey conducted by Morrison and Cerling (1987) included Sites 40 and 41 within Raccoon Creek for streambed gravel collection and analysis. Once again, strontium-90 appears to be the dominant radionuclide of concern. The RFA (ORNL, 1987) states that "average 1986 concentrations of strontium-90 were 2.9 and 6.8 Ci for sites 40 and 41, respectively." The numbers and units for strontium-90 concentrations appear to be erroneous. No corrected data are currently available.

3.3.1.6 Groundwater. Information regarding the occurrence of groundwater beneath WAG 3 is derived from studies that are either regional in nature (i.e., on the scale of the ORNL facility or Bethel Valley) or specific to WAG 3. Of those that are specific to WAG 3, data are generally derived from wells and seeps.

Groundwater Occurrence

Groundwater occurs in both the regolith and within the bedrock of the Chickamauga Group, although the two flow systems are recognized as hydraulically interconnected (with flow from zones of higher hydraulic head to those that are lower). The groundwater table, which varies seasonally, generally occurs near the soil/bedrock interface (Lee et al., 1988). The Chickamauga Group receives local recharge from infiltration of precipitation and from surface streamflows that originate in adjacent valleys in the Knox Group to the northwest. Recharge occurs in upland areas and discharge in low lying areas.

The water quality wells are being installed at WAG 3 as part of the ORNL facility-wide RCRA water quality monitoring well network. The water quality well locations, as proposed by Baughn (1987), are shown in Figure 3-29. QA/QC guidelines, including decontamination practices, have been established as part of the well installation effort. Split-spoon samples and rock cores are not routinely collected as part of this well installation effort.

Fourteen wells were originally proposed by Baughn (1987), but due to lack of funding only 10 were completed (Howze, 1988). The four wells not completed would have provided data from the northeast portion of SWSA 3. These wells are shown on Figure 3-29 since it is assumed that they will be installed prior to initiating the WAG 3 Field Sampling Plan. To date, none of the 10 wells that were installed have been developed due to lack of funding (Howze, 1988).

Another set of wells, further east of WAG 3, provides information on the hydrology of Bethel Valley. The five wells that transect Bethel Valley in the X-10 plant area are described in Section 3.3.1.1 of this RI plan and in Lee and Ketelle (1988). Geohydraulic packer testing was completed and the results described by Lozier and Pearson (1987). A summary of the findings is discussed in the following section.

Groundwater Monitoring Data

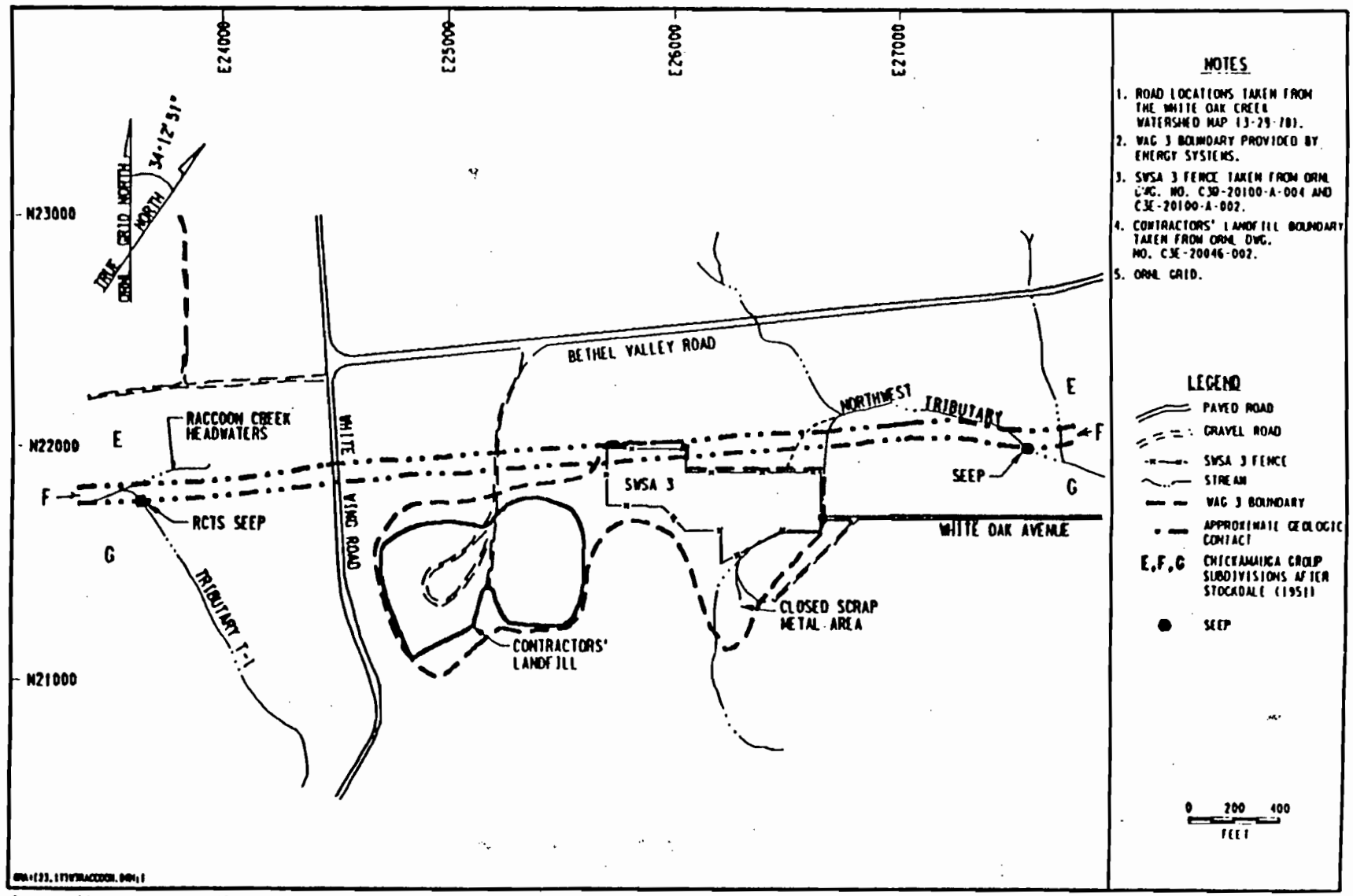
Groundwater monitoring data collected in the vicinity of or applicable to WAG 3 include water level measurements, aquifer properties, and water quality data.

The first water quality and water level data collected in Bethel Valley, specifically in the vicinity of SWSA 3, are described by Stockdale (1951). Stockdale determined that a groundwater divide existed beneath the western portion of SWSA 3. This divide caused groundwater to flow to the southwest into Raccoon Creek and to the northeast into the Northwest Tributary. Stockdale also provided chemical and radiological analysis of groundwaters in the pre-RAP

wells at SWSA 3. The results of these analyses are shown in Table 3-23.

Stueber et al. (1981) concluded, after seven months of stream monitoring on Northwest Tributary and Raccoon Creek, that strontium-90 is entering these streams through two groundwater seeps. Figure 3-34 shows the locations of the seeps and the contact of units F and G in the study area. The seep on Northwest Tributary is directly related to northeast flowing groundwater from beneath SWSA 3; the seep on Tributary T-1 of Raccoon Creek may be coming from SWSA 3 and/or the Contractors' Landfill southwest of SWSA 3. Stueber et al. (1981) postulated that the trend of contaminated groundwater movement and the associated seeps are related to bedrock structure. In particular, water movement along solution features near the stratigraphic contact of units F and G of the Chickamauga Group may be responsible for the seeps.

Switek (1983) performed dye tracer and water injection tests at SWSA 3. The results of these tests confirmed Stockdale's (1951) theory of a groundwater divide in the western portion of SWSA 3 and verified the locations of the seeps on the Northwest Tributary and near Raccoon Creek first postulated by Stueber et al. (1981). Lozier and Pearson (1987) conducted geohydraulic packer testing in Bethel Valley in five coreholes that penetrate the Chickamauga Group east of WAG 3 near the main ORNL complex. Thirty-eight packer tests were completed, with hydraulic conductivity values ranging from 6×10^{-9} cm/s to 1×10^{-4} cm/s. The static head distribution across Bethel Valley between the coreholes shows a general upward gradient resulting from significant artesian pressures at depth. Lozier and Pearson also theorized that areas on top of Haw Ridge and Chestnut Ridge are recharge zones, with a downward overall flow pattern into Bethel Valley. It was also noted that permeability increases northwestward (updip) across Bethel Valley from the Rome Formation to the Knox Formation. This is significant because SWSA 3 lies in the stratigraphically lower, and more permeable, sections of the Chickamauga Group.



Source: Stauber et al, (1981).

FIGURE 3-34
RACCOON CREEK AND THE NORTHWEST TRIBUTARY INTERACTION WITH THE CHICKAMAUGA LIMESTONE BEDROCK UNITS

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Recent water level data are derived from five of the 24 RAP piezometers installed in 1986 and 1987. Figure 3-35 through 3-37 are corresponding hydrographs displaying graphically the water level fluctuations of the five wells. Wells 701, 790, and 791 monitor groundwater moving along the interface between the residuum and the bedrock; Well 694 monitors a zone approximately 45 ft below the interface; Well 789 monitors a zone just a few ft below the interface. A qualitative appraisal of the well hydrograph follows; however, no correlation between precipitation and well water levels has been made. The hydrographs suggest that there is a circulation of meteoric waters to the depths monitored by the wells as evidenced by relatively sharp peaks in each of the wells. Apparent relative time lags (i.e., hydrographs do not peak at the same time) and muted/exaggerated relative responses (i.e., hydrographs do not fluctuate to the same degree) suggest that the response times for precipitation events and the relatively long term seasonal fluctuations need to be evaluated for the potentially different flow regimes (residuum, residuum/bedrock interface, bedrock). Water quality information has been gathered from piezometer 789 and pre-RAP Wells 301, 302, and 303. These data are shown in Tables 3-24 and 3-25. Water level and water quality data from the 10 water quality wells do not exist, as the wells have not yet been developed.

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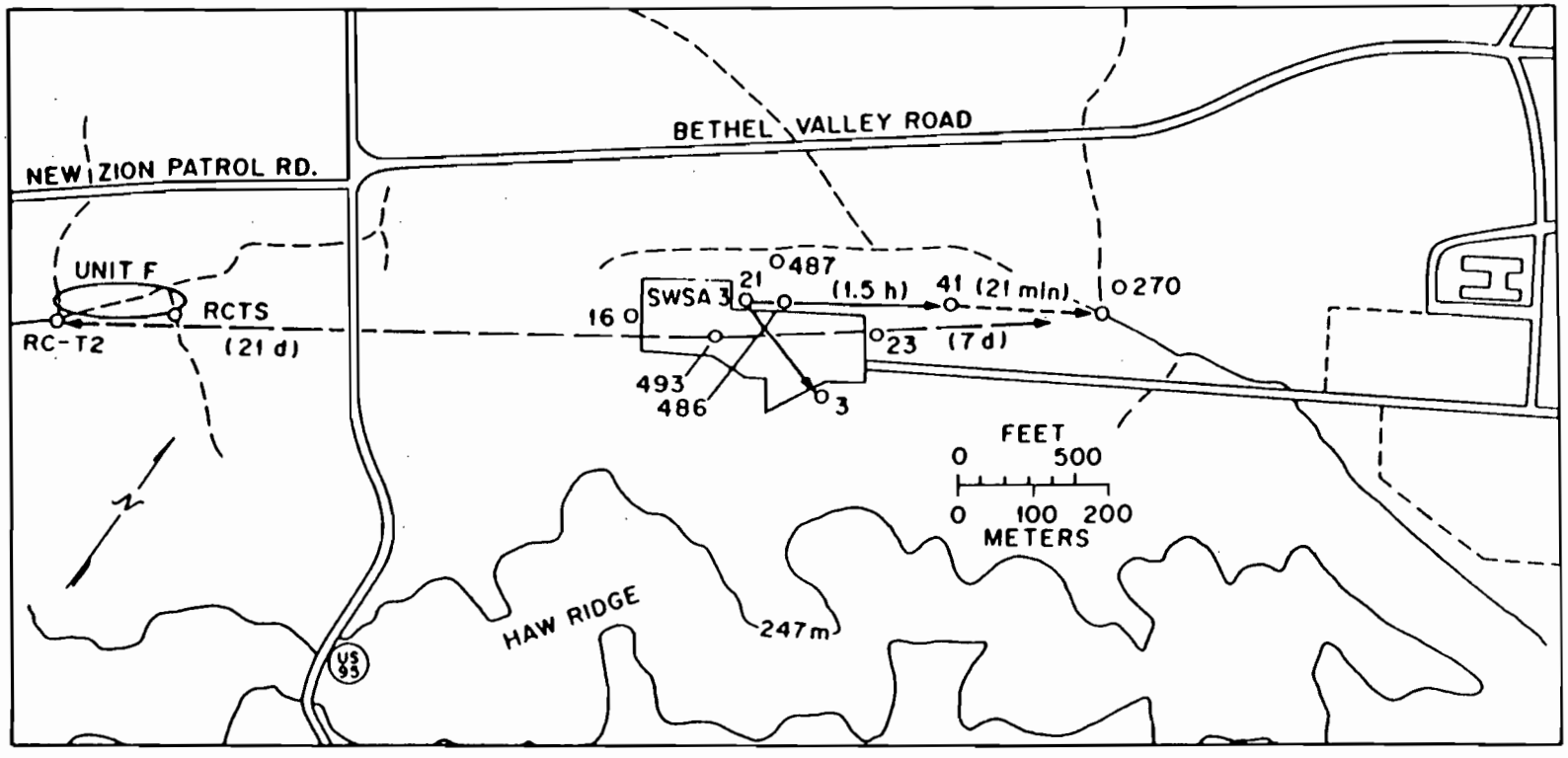

— — — DECEMBER 1982 RHODAMINE DYE AT WELL 41

——— JULY 1981 WATER INJECTION AT WELL 21

— — JUNE 1982 FLUORESCEIN DYE AT WELL 493

Fig. 11. Results of dye trace and water injection tests done in and near SWSA 3.

1. INTRODUCTION

CDM Federal Programs Corporation (CDM Federal) was tasked by the Environmental Restoration Program of Lockheed Martin Energy Systems Inc. (Energy Systems), to collect supplemental surface soil data for the remedial investigation/feasibility study (RI/FS) for the White Oak Creek (WOC) watershed. The WOC watershed RI/FS is being conducted to define a remediation approach for complying with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) at Oak Ridge National Laboratory (ORNL). The data generated from these supplemental sampling activities will be incorporated into the RI/FS to aid decision makers and stakeholders with the selection of remedial alternatives and establish remediation goals for the WOC watershed.

A series of Data Quality Objective (DQO) meetings were held in February 1996 to determine data needs for the WOC watershed RI/FS. The meetings were attended by representatives from the Tennessee Department of Environment and Conservation, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), and contractors to DOE. During the DQO meetings, it was determined that the human health risk associated with exposure to radionuclides was high enough to establish a baseline for action; however, it was also determined that the impacts associated with other analytes (mainly metals) were insufficient for determining the baseline ecological risk. Based on this premise, it was determined that additional sampling would be required at four of the Waste Area Groupings (WAGs) included in the WOC watershed to fulfill this data gap.

1.1 SITE DESCRIPTIONS

ORNL is located approximately 25 miles from Knoxville, Tennessee. The facility is currently managed by Energy Systems for DOE and is part of the Oak Ridge Reservation in Oak Ridge, Tennessee. The WOC watershed is composed of WAGs 2, 3, 4, 5, 6, 7, 8, 9, and 10, and adjacent uncontaminated areas. Supplemental sampling activities were conducted at WAGs 3, 4, 7, and 9. Figure 1.1 shows the location of ORNL and each of the WAGs that were addressed during the supplemental sampling effort. A brief description of each of these WAGs will be provided in subsequent sections.

1.1.1 WAG 3 – Solid Waste Storage Area 3

WAG 3 is located in Bethel Valley, approximately 0.6 mile west of the west entrance to the laboratory complex. WAG 3 is composed of three solid waste management units (SWMUs): the Closed Scrap Metal Area, Solid Waste Storage Area (SWSA) 3, and the Contractors Landfill. The Closed Scrap Metal Area functioned as the contractors landfill from the early 1950s to the mid-1960s. After reaching capacity the fill area was used for the surface storage of scrap metal. SWSA 3 was opened in 1946 for the disposal of radioactively contaminated waste. The area was closed in 1951 but remained in use until 1979 for the aboveground storage of equipment exhibiting low-level radioactive contamination. The Contractors Landfill was opened in 1975 for the disposal of construction debris and fly ash from the ORNL steam plant and currently remains in operation.

SWSA 3 is known to contain solid waste in the form of sanitary waste, scrap, rubble, filters, oils, asbestos, lumber, equipment, shielding, and containerized wastes. The primary radiological contaminants are ^{90}Sr, ^{137}Cs, tritium, trivalent rare earths, and transuranic isotopes (Bates 1983). A 1978 soil survey found ^{238}Pu, ^{239}Pu, ^{241}Am, and ^{244}Cm in addition to the isotopes listed above. A 1988 survey confirmed the presence of radioactive contamination in the surface soils at SWSA 3. In addition to the radiological contaminants listed above, hazardous chemical wastes are also believed to have been buried at SWSA 3 and possibly at the Contractors' Landfill.

Radiation Walkover Survey. Radiation walkover surveys were conducted at WAGs 3, 7, and 9 by the MAD Group from ORNL. The objective of these surveys was to locate and mark "hot spots" identified during previous sampling activities at the selected WAGs. The hot spots were located using gamma scintillators, GM probes, and microrem meter. The data were reported in millirems/hour at the surface and 1 m above the surface. Table 2.1 summarizes the readings for each of the locations marked during the walkover surveys. Each location was marked with a wooden survey stake so that the field team could find the location during sample collection activities.

WAG 4 sampling locations were identified by the Energy Systems technical lead based on seep locations and existing nonradiological data needs rather than a radiological walkover survey. The *Site Investigation Report for Waste Area Grouping 4*, ORNL/ER-279 (Energy Systems 1994) provides the necessary radiological characterization for WAG 4.

2.3.2 Supplemental Sampling Activities

Surface Soil Sample Collection. Field operations for surface soil sampling were conducted in accordance with SOP-ESP-003.11, "Surface Soil Sampling with Spade, Trowel, Knife, Spoon, or Spatula." All samples were collected with a stainless steel scoop from a depth of 0 to 6 in. Individual sample aliquots were placed in a stainless steel bowl and composited before being placed into the prelabeled sample containers. All sampling locations were screened for alpha, beta, and gamma activity by a representative from the MAD Group before and during the sample collection process. The activity measured for each type of radiation was recorded in the field logbook and has been included in the sample summary Table 2.1. All equipment and personnel were also scanned/frisked before leaving a given site to ensure that contamination was not removed from the site.

Table 2.1. Summary of dose rates at sampling locations identified during radiation walkover surveys

Location ID	Stake ID	Dose rate (mrem/h)[a]		Description of location
		1 m above ground surface	Ground surface	
WAG 3[b]				
SWSA3-1	WG3-2	0.4	2	90° W of true N, 266' from well 491
SWSA3-2	WG3-3	5	6	10° W of true N, 52' from well 492
SWSA3-3	WG3-5	0.8	5.5	120° E of true N, 177' from well 493
SWSA3-4	WG3-7	0.2	2	15° E of true S, 22' from well 493
SWSA3-5	WG3-8	0.05	0.1	77° E of true N, 97' from well 995, (6.5' from SWSA-3 fence)
Landfill 2	WG3-12	0.03	0.05	10° E of true S, 250' from well 790
Landfill 3	WG3-11	0.03	0.05	50° W of true N, 114' from well 1247

2.4 SUMMARY OF SAMPLE COLLECTION REQUIREMENTS

A total of 56 samples were collected (including quality assurance/QC samples) during the WOC watershed RI/FS supplemental sampling effort. Sections 2.4.1–2.4.4 provide a summary of the sample collection requirements for each of the four WAGs addressed during the supplemental sampling effort. Table 2.2 provides a summary of relevant information pertaining to each of the samples collected during the WOC watershed RI/FS supplemental sampling effort, including sample IDs, stake numbers, locations, beta/gamma activities, and dose rate measured during collection of the samples, and the grid coordinate locations based on the GPS survey. The unvalidated analytical data for all samples collected and analyzed during the supplemental sampling effort have been included as Appendix A.

2.4.1 WAG 3 – Solid Waste Storage Area 3

Sampling at WAG 3 was started on June 5, 1996, and completed on June 6, 1996. A total of 19 samples (including QC samples) were collected during this period. Sampling locations are shown in Fig. 2.1. WAG 3 is divided into three waste units: SWSA 3, the Metals Scrap Yard, and the Contractors Landfill. A total of eight samples (seven locations) were collected from the SWSA 3 area, which included one duplicate sample from sample location SWSA3-7. Four of the samples were collected from hot spots identified during the radiation walkover survey. The remaining three sample locations were random non-hot spot locations. A total of four samples (three locations) were collected from the Contractors Landfill Area, which included one matrix spike/matrix spike duplicate (MS/MSD) sample from sample location Landfill 1. Samples collected from SWSA 3 and the Contractors Landfill were analyzed for gross alpha, gross beta, gamma, isotopic uranium, Contract Laboratory Program (CLP) metals, and CLP polychlorinated biphenyls (PCBs). Three locations were sampled in the Metals Scrapyard (total of five samples—three samples, one MS/MSD, and one duplicate). Samples from the Metals Scrapyard were analyzed for CLP metals and CLP PCBs only. In addition to the samples described above, a source water sample was collected from the deionized water system located at the FOF and an equipment rinseate sample was collected from the sampling equipment after the equipment had been decontaminated. Elevated beta/gamma activity and dose rate were measured during sampling at several of the sampling locations within SWSA 3.

Table 2.2. Sample summary table for WOC Watershed RI/FS Supplemental Sampling (1996)

Location ID	Stake ID	Collection date	Radiological field screening results		Grid coordinates[a]
			Beta/gamma (cpm)	Dose rate (mR/h)	
WAG 3					
SWSA3-1	WG3-2	6/5/96	10,000	2-3	N 26,281.37 E 21,883.17
SWSA3-2	WG3-3	6/5/96	400,000	60	N 26,269.21 E 21,822.52
SWSA3-3	WG3-5	6/5/96	30,000	8	N 26,063.86 E 21,649.79
SWSA3-4	WG3-7	6/5/96	4,000	0.3	N 25,998.28 E 21,782.22
SWSA3-5	WG3-8	6/6/96	700	0.1	N 25,964.59 E 21,993.63
SWSA3-6	SWSA3-6	6/6/96	60	NR	N 26,637.77 E 21,835.15
SWSA3-7	SWSA3-7	6/6/96	70	NR	N 26,308.35 E 21,601.34
Landfill 1	WG3-13	6/6/96	70	NR	N 25,560.71 E 21,813.66
Landfill 2	WG3-12	6/6/96	300	NR	N 25,181.67 E 21,291.97
Landfill 3	WG3-11	6/6/96	250	NR	N 24,774.05 E 21,373.38
Scrapyd-1	Scrapyd-1	6/6/96	70	NR	N 26,273.21 E 21,319.94
Scrapyd-2	Scrapyd-2	6/6/96	60	NR	N 26,244.75 E 21,182.60
Scrapyd-3	Scrapyd-3	6/6/96	60	NR	N 26,347.39 E 21,274.67

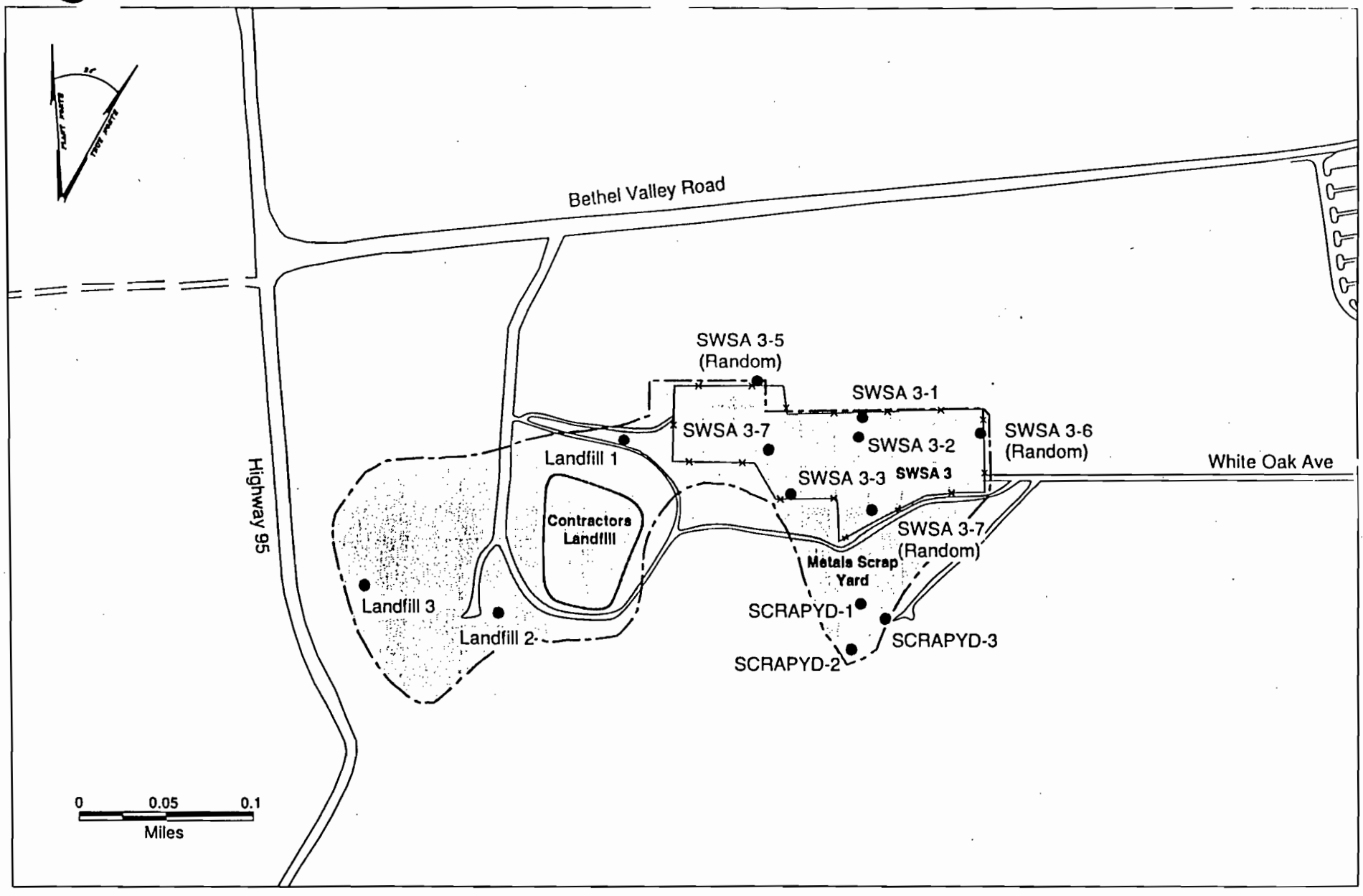

Fig. 2.1. Supplemental surface soil sampling locations for WAG 3

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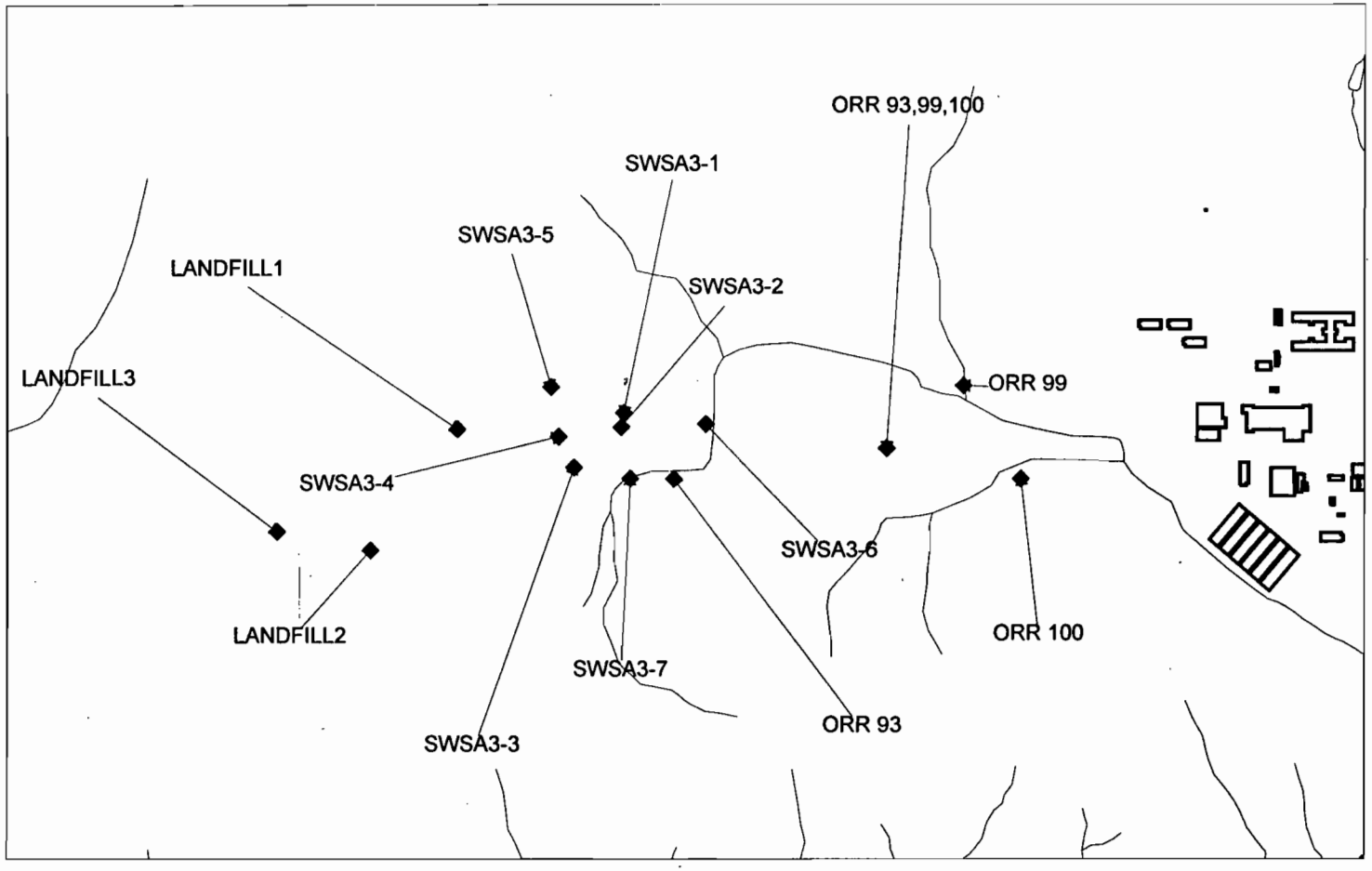
Soil Sampling Locations at WAG 3



Location	Sample ID	Parameter Name	Result	Qual	Units
LANDFILL	B00004	PCB-1260	17	U	UG/KG
		PCB-1254	17	U	UG/KG
		PCB-1242	17	U	UG/KG
		PCB-1016	17	U	UG/KG
		PCB-1232	17	U	UG/KG
		PCB-1221	17	U	UG/KG
		PCB-1248	17	U	UG/KG
LANDFILL	B00007	Nickel	17.6	U	MG/KG
		Potassium	2100		MG/KG
		Calcium	5480		MG/KG
		Vanadium	29.4		MG/KG
		Thallium	1.3	U	MG/KG
		Arsenic	6.9		MG/KG
		Cadmium	1.3	U	MG/KG
		Barium	62		MG/KG
		Aluminum	23400		MG/KG
		Zinc	921	U	MG/KG
		Sodium	471		MG/KG
		Silver	1.8	U	MG/KG
		Lead	31.3		MG/KG
		Cobalt	13.9		MG/KG
		Antimony	0.76	U	MG/KG
		Magnesium	2010		MG/KG
		Iron	41800		MG/KG
		Chromium	27.4		MG/KG
		Beryllium	0.78		MG/KG
		Copper	25.3		MG/KG
		Manganese	464		MG/KG
		Selenium	0.76	U	MG/KG
LANDFILL	B00011	PCB-1260	51		UG/KG
		PCB-1242	15	U	UG/KG
		PCB-1232	15	U	UG/KG
		PCB-1221	15	U	UG/KG
		PCB-1248	15	U	UG/KG
		PCB-1016	15	U	UG/KG
		PCB-1254	15	U	UG/KG
LANDFILL	B00012	Nickel	14.7	U	MG/KG
		Calcium	36300		MG/KG
		Zinc	47.9	U	MG/KG
		Sodium	412		MG/KG
		Silver	1.6	U	MG/KG
		Lead	27.7		MG/KG
		Cobalt	14.3		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	93.2		MG/KG
		Arsenic	4.9		MG/KG
		Iron	24500		MG/KG
		Chromium	24.1		MG/KG
		Beryllium	0.73		MG/KG
		Copper	13.2		MG/KG
		Manganese	1200		MG/KG
		Aluminum	18700		MG/KG
		Antimony	0.7	U	MG/KG
		Thallium	1.2	U	MG/KG
		Magnesium	6610		MG/KG
		Vanadium	25.7		MG/KG
		Selenium	0.7	U	MG/KG
LANDFILL	B00012	Potassium	1560		MG/KG
LANDFILL	B00014	PCB-1260	160		UG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
		PCB-1254	17		UG/KG
		PCB-1232	17		UG/KG
		PCB-1221	17		UG/KG
		PCB-1016	17		UG/KG
		PCB-1248	17		UG/KG
		PCB-1242	17		UG/KG
LANDFILL	B00015	Nickel	16.1	U	MG/KG
		Selenium	0.84	U	MG/KG
		Calcium	7940		MG/KG
		Magnesium	2150		MG/KG
		Arsenic	4.3		MG/KG
		Cadmium	1.4	U	MG/KG
		Lead	26.6		MG/KG
		Sodium	291		MG/KG
		Silver	2	U	MG/KG
		Iron	21600		MG/KG
		Chromium	20.3		MG/KG
		Beryllium	0.79		MG/KG
		Copper	17.6		MG/KG
		Manganese	574		MG/KG
		Aluminum	13300		MG/KG
		Zinc	69.1		MG/KG
		Cobalt	9.4		MG/KG
		Barium	158		MG/KG
		Antimony	0.84	U	MG/KG
		Thallium	1.4	U	MG/KG
		Vanadium	20.8		MG/KG
		Potassium	1920		MG/KG
SCRPYARD	B00016	Nickel	18.1	U	MG/KG
		Zinc	58.1		MG/KG
		Sodium	342		MG/KG
		Silver	1.7	U	MG/KG
		Lead	28.7		MG/KG
		Cobalt	10.2		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	173		MG/KG
		Arsenic	3.4		MG/KG
		Iron	23500		MG/KG
		Chromium	19.6		MG/KG
		Beryllium	1		MG/KG
		Copper	18.1		MG/KG
		Mercury	0.13	U	MG/KG
		Manganese	443		MG/KG
		Aluminum	15400		MG/KG
		Antimony	0.74	U	MG/KG
		Thallium	1.2	U	MG/KG
		Magnesium	2530		MG/KG
		Vanadium	21.3		MG/KG
		Selenium	0.74	U	MG/KG
		Calcium	5920		MG/KG
		Potassium	2080		MG/KG
SCRPYARD	B00019	Nickel	15.3	U	MG/KG
		Zinc	46.7		MG/KG
		Sodium	329		MG/KG
		Silver	1.6	U	MG/KG
SCRPYARD	B00019	Lead	27.7		MG/KG
		Cobalt	6.3		MG/KG
		Cadmium	1.1	U	MG/KG
		Barium	113		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
		Arsenic	7.6		MG/KG
		Iron	31200		MG/KG
		Chromium	27.1		MG/KG
		Beryllium	1.3		MG/KG
		Copper	13.1		MG/KG
		Mercury	0.12	U	MG/KG
		Manganese	313		MG/KG
		Aluminum	11200		MG/KG
		Potassium	1220		MG/KG
		Calcium	1810		MG/KG
		Magnesium	1280		MG/KG
		Antimony	0.68	U	MG/KG
		Thallium	1.1	U	MG/KG
		Vanadium	34.6		MG/KG
		Selenium	0.68	U	MG/KG
SCRPYARD	B00020	Nickel	12.4	U	MG/KG
		Zinc	48.6		MG/KG
		Silver	1.6	U	MG/KG
		Lead	37.5		MG/KG
		Cobalt	6		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	126		MG/KG
		Arsenic	2.1		MG/KG
		Antimony	0.7	U	MG/KG
		Thallium	1.2	U	MG/KG
		Iron	16200		MG/KG
		Chromium	15.4		MG/KG
		Beryllium	0.81		MG/KG
		Copper	16.2		MG/KG
		Mercury	0.18		MG/KG
		Manganese	267		MG/KG
		Aluminum	11800		MG/KG
		Sodium	413	U	MG/KG
		Magnesium	1690		MG/KG
		Vanadium	17.3		MG/KG
		Potassium	1630		MG/KG
		Selenium	0.7	U	MG/KG
		Calcium	2430		MG/KG
SCRPYARD	B00021	Nickel	15.5	U	MG/KG
		Thallium	1.1	U	MG/KG
		Magnesium	2240		MG/KG
		Zinc	53.3		MG/KG
		Sodium	374		MG/KG
		Silver	1.6	U	MG/KG
		Lead	26		MG/KG
		Cobalt	8.1		MG/KG
		Cadmium	1.1	U	MG/KG
		Barium	168		MG/KG
		Arsenic	3.4		MG/KG
		Iron	23700		MG/KG
		Chromium	19.6		MG/KG
		Beryllium	1		MG/KG
		Copper	17.1		MG/KG
SCRPYARD	B00021	Mercury	0.21		MG/KG
		Manganese	314		MG/KG
		Aluminum	14800		MG/KG
		Antimony	0.68	U	MG/KG
		Vanadium	24.1		MG/KG
		Potassium	2020		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
		Selenium	0.68	U	MG/KG
		Calcium	2960		MG/KG
SWSA3-1	B00023	PCB-1260	16	U	UG/KG
		PCB-1242	16	U	UG/KG
		PCB-1248	16	U	UG/KG
		PCB-1232	16	U	UG/KG
		PCB-1221	16	U	UG/KG
		PCB-1016	16	U	UG/KG
		PCB-1254	16	U	UG/KG
SWSA3-1	B00024	Nickel	23.3	U	MG/KG
		Iron	51000		MG/KG
		Chromium	25.9		MG/KG
		Beryllium	1		MG/KG
		Copper	26.6		MG/KG
		Manganese	1220		MG/KG
		Aluminum	27400		MG/KG
		Zinc	66.1		MG/KG
		Sodium	401		MG/KG
		Silver	1.8	U	MG/KG
		Lead	44.1		MG/KG
		Cobalt	23.3		MG/KG
		Cadmium	1.3	U	MG/KG
		Barium	84.4		MG/KG
		Arsenic	7.5		MG/KG
		Antimony	0.76	U	MG/KG
		Thallium	1.3	U	MG/KG
		Magnesium	1500		MG/KG
		Vanadium	31.1		MG/KG
		Selenium	0.76	U	MG/KG
		Calcium	1160		MG/KG
		Potassium	2350		MG/KG
SWSA3-2	B00026	PCB-1260	18	U	UG/KG
		PCB-1254	18		UG/KG
		PCB-1248	18		UG/KG
		PCB-1221	18		UG/KG
		PCB-1232	18		UG/KG
		PCB-1016	18		UG/KG
		PCB-1242	18		UG/KG
SWSA3-2	B00027	Nickel	14.9	U	MG/KG
		Potassium	1990		MG/KG
		Selenium	0.78	U	MG/KG
		Calcium	2980		MG/KG
		Iron	44800		MG/KG
		Chromium	26.2	-	MG/KG
		Beryllium	0.79		MG/KG
		Copper	19.6		MG/KG
		Manganese	936		MG/KG
		Aluminum	21800		MG/KG
		Zinc	45.5		MG/KG
		Sodium	378	U	MG/KG
		Silver	1.8	U	MG/KG
SWSA3-2	B00027	Lead	36.7		MG/KG
		Cobalt	12.9		MG/KG
		Cadmium	1.3	U	MG/KG
		Barium	57.6		MG/KG
		Arsenic	6.9		MG/KG
		Antimony	0.78	U	MG/KG
		Thallium	1.3	U	MG/KG
		Magnesium	1380		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
		Vanadium	30.8		MG/KG
SWSA3-3	B00029	PCB-1260	28		UG/KG
		PCB-1254	17	U	UG/KG
		PCB-1248	17	U	UG/KG
		PCB-1221	17	U	UG/KG
		PCB-1232	17	U	UG/KG
		PCB-1016	17	U	UG/KG
		PCB-1242	17	U	UG/KG
SWSA3-3	B00030	Nickel	14.7	U	MG/KG
		Potassium	2070		MG/KG
		Thallium	1.2	U	MG/KG
		Magnesium	1330		MG/KG
		Chromium	22.8		MG/KG
		Beryllium	0.7		MG/KG
		Copper	16.7		MG/KG
		Manganese	1440		MG/KG
		Aluminum	19000	U	MG/KG
		Zinc	43.4		MG/KG
		Sodium	346	U	MG/KG
		Silver	1.7	U	MG/KG
		Lead	28.5		MG/KG
		Cobalt	13.8		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	56.5		MG/KG
		Arsenic	6.2		MG/KG
		Iron	39600		MG/KG
		Antimony	0.72	U	MG/KG
		Vanadium	28.1		MG/KG
		Selenium	0.72	U	MG/KG
		Calcium	1660		MG/KG
SWSA3-4	B00032	PCB-1260	17	U	UG/KG
		PCB-1221	17	U	UG/KG
		PCB-1232	17	U	UG/KG
		PCB-1016	17	U	UG/KG
		PCB-1254	17	U	UG/KG
		PCB-1242	17	U	UG/KG
		PCB-1248	17	U	UG/KG
SWSA3-4	B00033	Nickel	14.1	U	MG/KG
		Potassium	1780		MG/KG
		Iron	25800		MG/KG
		Chromium	11.9		MG/KG
		Beryllium	2.4		MG/KG
		Copper	21.8		MG/KG
		Manganese	1210		MG/KG
		Aluminum	16300		MG/KG
		Zinc	48.3		MG/KG
		Lead	31		MG/KG
		Cobalt	13.2		MG/KG
		Cadmium	1.3	U	MG/KG
SWSA3-4	B00033	Barium	61.9		MG/KG
		Arsenic	5.6		MG/KG
		Antimony	0.78	U	MG/KG
		Thallium	1.3	U	MG/KG
		Magnesium	950		MG/KG
		Sodium	399	U	MG/KG
		Silver	1.8	U	MG/KG
		Vanadium	1.8	U	MG/KG
		Selenium	0.78	U	MG/KG
		Calcium	3190		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
SWSA3-5	B00035	PCB-1260	17	U	UG/KG
		PCB-1221	17	U	UG/KG
		PCB-1232	17	U	UG/KG
		PCB-1016	17	U	UG/KG
		PCB-1254	17	U	UG/KG
		PCB-1242	17	U	UG/KG
		PCB-1248	17	U	UG/KG
SWSA3-5	B00036	Nickel	24.2		MG/KG
		Magnesium	2190		MG/KG
		Vanadium	30.7		MG/KG
		Iron	44700		MG/KG
		Chromium	32.7		MG/KG
		Beryllium	1.7		MG/KG
		Copper	20.4		MG/KG
		Manganese	1110		MG/KG
		Aluminum	22200		MG/KG
		Zinc	77.9		MG/KG
		Sodium	420	U	MG/KG
		Silver	1.7	U	MG/KG
		Lead	37.3		MG/KG
		Cobalt	21.1		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	98.8		MG/KG
		Arsenic	7.1		MG/KG
		Antimony	0.71	U	MG/KG
		Thallium	1.2	U	MG/KG
		Selenium	0.71	U	MG/KG
		Calcium	20800		MG/KG
		Potassium	2260		MG/KG
SWSA3-6	B00038	PCB-1260	17	U	UG/KG
		PCB-1221	17	U	UG/KG
		PCB-1232	17	U	UG/KG
		PCB-1016	17	U	UG/KG
		PCB-1254	17	U	UG/KG
		PCB-1242	17	U	UG/KG
		PCB-1248	17	U	UG/KG
SWSA3-6	B00039	Nickel	7.5		MG/KG
		Selenium	0.73	U	MG/KG
		Iron	24200		MG/KG
		Chromium	15.9		MG/KG
		Beryllium	0.53		MG/KG
		Copper	13.3		MG/KG
		Manganese	777		MG/KG
		Aluminum	13800		MG/KG
		Zinc	38.8		MG/KG
		Sodium	359	U	MG/KG
		Silver	1.7	U	MG/KG
SWSA3-6	B00039	Lead	24.1		MG/KG
		Cobalt	9.3		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	60		MG/KG
		Arsenic	4.9		MG/KG
		Antimony	0.73	U	MG/KG
		Thallium	1.2	U	MG/KG
		Magnesium	990		MG/KG
		Vanadium	20.7		MG/KG
		Calcium	2510		MG/KG
		Potassium	1880		MG/KG
SWSA3-7	B00042	PCB-1260	19		UG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
		PCB-1221	15	U	UG/KG
		PCB-1232	15	U	UG/KG
		PCB-1016	15	U	UG/KG
		PCB-1254	15	U	UG/KG
		PCB-1242	15	U	UG/KG
		PCB-1248	15	U	UG/KG
SWSA3-7	B00043	PCB-1260	16	U	UG/KG
		PCB-1254	16	U	UG/KG
		PCB-1232	16	U	UG/KG
		PCB-1221	16	U	UG/KG
		PCB-1016	16	U	UG/KG
		PCB-1248	16	U	UG/KG
		PCB-1242	16	U	UG/KG
SWSA3-7	B00044	Nickel	20.7	U	MG/KG
		Selenium	0.73	U	MG/KG
		Calcium	22300		MG/KG
		Magnesium	3190		MG/KG
		Antimony	0.73	U	MG/KG
		Barium	161		MG/KG
		Cobalt	15.4		MG/KG
		Silver	1.7	U	MG/KG
		Lead	37.1		MG/KG
		Iron	31700		MG/KG
		Chromium	22		MG/KG
		Beryllium	1.2		MG/KG
		Copper	19.3		MG/KG
		Manganese	1200		MG/KG
		Aluminum	19700		MG/KG
		Zinc	75.4		MG/KG
		Sodium	280	U	MG/KG
		Cadmium	1.2	U	MG/KG
		Arsenic	4.7		MG/KG
		Thallium	1.2	U	MG/KG
		Vanadium	26.2		MG/KG
		Potassium	2700		MG/KG
SWSA3-7	B00045	Nickel	22.1	U	MG/KG
		Potassium	2900		MG/KG
		Iron	36800		MG/KG
		Chromium	23.3		MG/KG
		Beryllium	1.3		MG/KG
		Copper	20.5		MG/KG
		Manganese	842		MG/KG
		Aluminum	21400		MG/KG
		Zinc	81		MG/KG
		Sodium	534	U	MG/KG
SWSA3-7	B00045	Silver	1.7	U	MG/KG
		Lead	35.8		MG/KG
		Cobalt	13		MG/KG
		Cadmium	1.2	U	MG/KG
		Barium	172		MG/KG
		Arsenic	4.8		MG/KG
		Antimony	0.74	U	MG/KG
		Thallium	1.2	U	MG/KG
		Magnesium	2980		MG/KG
		Vanadium	28.5		MG/KG
		Selenium	0.74	U	MG/KG
		Calcium	7190		MG/KG

Location	Sample ID	Parameter Name	Resul	Qual	Units
LANDFILL1	B00001	Thallium-208	0.55		PCI/G
		Lead-214	1.02		PCI/G
		Bismuth-214	0.84		PCI/G
		Cesium-137	0.044	U	PCI/G
		Uranium-235	0.1	U	PCI/G
		Alpha activity	20.5		PCI/G
		Potassium-40	25.6		PCI/G
		Europium-155	0.108	U	PCI/G
		Europium-154	-0.04	U	PCI/G
		Lead-212	1.63		PCI/G
		Uranium-238	1.01		PCI/G
		Europium-152	0.005	U	PCI/G
		Cobalt-57	0.015	U	PCI/G
		Cesium-134	0.032	U	PCI/G
		Uranium-233/23	0.9		PCI/G
		Thorium-234	2.08		PCI/G
		Beta activity	30.2		PCI/G
		Cobalt-60	-0.01	U	PCI/G
		Actinium-228	1.54		PCI/G
		Uranium-235	0.071		PCI/G
LANDFILL2	B00010	Thallium-208	0.44		PCI/G
		Uranium-238	0.8		PCI/G
		Europium-152	0.078	U	PCI/G
		Cobalt-57	-0.03	U	PCI/G
		Cesium-134	0.052	U	PCI/G
		Europium-154	-0.03	U	PCI/G
		Lead-212	1.29		PCI/G
		Europium-155	0.15	U	PCI/G
		Uranium-233/23	0.78		PCI/G
		Potassium-40	16.9		PCI/G
		Thorium-234	1.3	U	PCI/G
		Alpha activity	16.6		PCI/G
		Beta activity	89		PCI/G
		Lead-214	1.05		PCI/G
		Bismuth-214	0.86		PCI/G
		Cesium-137	82.9		PCI/G
		Uranium-235	0.045		PCI/G
		Uranium-235	0.09	U	PCI/G
		Cobalt-60	0.041	U	PCI/G
		Actinium-228	1.08		PCI/G
LANDFILL3	B00013	Thallium-208	0.326		PCI/G
		Uranium-238	1.09		PCI/G
		Uranium-232	0.015	U	PCI/G
		Europium-152	0.018	U	PCI/G
		Cobalt-57	0.005	U	PCI/G
		Cesium-134	0.003	U	PCI/G
		Europium-154	0.017	U	PCI/G
		Lead-212	1.01		PCI/G
		Europium-155	0.04	U	PCI/G
		Uranium-233/23	1.09		PCI/G
		Potassium-40	14.1		PCI/G
		Thorium-234	2.27		PCI/G
		Alpha activity	20.8		PCI/G
		Beta activity	111.6		PCI/G
		Uranium-235	0.098		PCI/G
		Uranium-235	-0.03	U	PCI/G
		Cesium-137	85.3		PCI/G
		Cobalt-60	0.106		PCI/G
		Lead-214	0.72		PCI/G

Location	Sample ID	Parameter Name	Resul	Qual	Units
LANDFILL3	B00013	Bismuth-214	0.535		PCI/G
		Actinium-228	1.05		PCI/G
SWSA3-1	B00022	Thallium-208	0.535		PCI/G
		Uranium-238	1.76		PCI/G
		Europium-154	-0.03	U	PCI/G
		Lead-212	1.67		PCI/G
		Europium-155	0.09	U	PCI/G
		Uranium-233/23	1.23		PCI/G
		Potassium-40	22.9		PCI/G
		Thorium-234	1.8		PCI/G
		Alpha activity	19.8		PCI/G
		Beta activity	141		PCI/G
		Uranium-232	0.04	U	PCI/G
		Europium-152	0.06	U	PCI/G
		Cobalt-57	-0.01	U	PCI/G
		Cesium-134	0.051	U	PCI/G
		Uranium-235	0.082	U	PCI/G
		Uranium-235	-0.01	U	PCI/G
		Cesium-137	38.6		PCI/G
		Cobalt-60	-0.01	U	PCI/G
		Bismuth-214	0.74		PCI/G
		Actinium-228	1.59		PCI/G
		Lead-214	0.71		PCI/G
SWSA3-2	B00025	Thallium-208	0.65		PCI/G
		Uranium-233/23	1.46		PCI/G
		Potassium-40	23.2		PCI/G
		Thorium-234	-0.1		PCI/G
		Alpha activity	24.2		PCI/G
		Beta activity	8010		PCI/G
		Uranium-235	0.37		PCI/G
		Uranium-235	0.095		PCI/G
		Cesium-137	853		PCI/G
		Uranium-238	1.48		PCI/G
		Uranium-232	0.065	U	PCI/G
		Europium-152	0.09	U	PCI/G
		Cobalt-57	0.12	U	PCI/G
		Cesium-134	0.064	U	PCI/G
		Europium-154	0.069	U	PCI/G
		Lead-212	1.33		PCI/G
		Europium-155	0.01	U	PCI/G
		Cobalt-60	0.002	U	PCI/G
		Bismuth-214	0.67		PCI/G
		Actinium-228	1.78		PCI/G
		Lead-214	1		PCI/G
SWSA3-3	B00028	Thallium-208	54.8		PCI/G
		Lead-214	-0.1	UJ	PCI/G
		Actinium-228	193		PCI/G
		Cobalt-60	11.81		PCI/G
		Cobalt-57	-0.4	U	PCI/G
		Cesium-134	-0.8	U	PCI/G
		Europium-154	0.44	U	PCI/G
		Lead-212	165		PCI/G
		Europium-155	0	U	PCI/G
		Uranium-233/23	60.4		PCI/G
		Potassium-40	22.5		PCI/G
		Thorium-234	-2	U	PCI/G
		Alpha activity	3280		PCI/G
		Beta activity	55000		PCI/G
		Uranium-238	3.8		PCI/G

Location	Sample ID	Parameter Name	Resul	Qual	Units
SWSA3-3	B00028	Uranium-232	7.2		PCI/G
		Europium-152	-0.5	U	PCI/G
		Uranium-235	0.3	U	PCI/G
		Uranium-235	3.1		PCI/G
		Cesium-137	28000		PCI/G
		Bismuth-214	-2.8	U	PCI/G
SWSA3-4	B00031	Thallium-208	0.431		PCI/G
		Lead-214	1.1		PCI/G
		Alpha activity	16.7		PCI/G
		Beta activity	206		PCI/G
		Europium-152	0.026	U	PCI/G
		Cobalt-57	-0.01	U	PCI/G
		Cesium-134	0.031	U	PCI/G
		Europium-154	0.046	U	PCI/G
		Lead-212	1.41		PCI/G
		Europium-155	0.11	U	PCI/G
		Uranium-233/23	1.12		PCI/G
		Potassium-40	15.2		PCI/G
		Uranium-238	1.19		PCI/G
		Thorium-234	1.23	U	PCI/G
		Uranium-235	0.12	U	PCI/G
		Uranium-235	0.046		PCI/G
		Cesium-137	7.49		PCI/G
		Cobalt-60	0.011	U	PCI/G
		Bismuth-214	0.92		PCI/G
		Actinium-228	1.45		PCI/G
SWSA3-5	B00034	Thallium-208	0.52		PCI/G
		Uranium-238	1.83		PCI/G
		Uranium-232	0.106	UJ	PCI/G
		Europium-152	-0.05	U	PCI/G
		Cobalt-57	0.004	U	PCI/G
		Cesium-134	0	U	PCI/G
		Europium-154	-0.03	U	PCI/G
		Lead-212	1.77		PCI/G
		Europium-155	0.01	U	PCI/G
		Uranium-233/23	1.67		PCI/G
		Potassium-40	18.3		PCI/G
		Thorium-234	0.5		PCI/G
		Alpha activity	20.9		PCI/G
		Beta activity	465		PCI/G
		Uranium-235	0.34	U	PCI/G
		Uranium-235	0.065		PCI/G
		Cesium-137	325		PCI/G
		Cobalt-60	4.2		PCI/G
		Bismuth-214	0.66		PCI/G
		Actinium-228	1.36		PCI/G
		Lead-214	1.31		PCI/G
SWSA3-6	B00037	Thallium-208	0.55		PCI/G
		Uranium-238	1.1		PCI/G
		Europium-152	0.007	U	PCI/G
		Cobalt-57	-0.01	U	PCI/G
		Cesium-134	0.026	U	PCI/G
		Europium-154	0.036	U	PCI/G
		Lead-212	1.66		PCI/G
		Europium-155	0.181		PCI/G
		Uranium-233/23	1.15		PCI/G
		Potassium-40	16.1		PCI/G
		Thorium-234	2.18		PCI/G
		Alpha activity	24.3		PCI/G

Location	Sample ID	Parameter Name	Resul	Qual	Units
SWSA3-6	B00037	Beta activity	31.9		PCI/G
		Uranium-235	0.09	U	PCI/G
		Uranium-235	0.052		PCI/G
		Cesium-137	0.221		PCI/G
		Cobalt-60	0	U	PCI/G
		Bismuth-214	0.9		PCI/G
		Actinium-228	1.46		PCI/G
		Lead-214	1.08		PCI/G
SWSA3-7	B00040	Thallium-208	0.457		PCI/G
		Uranium-238	0.96		PCI/G
		Europium-152	0.01	U	PCI/G
		Cobalt-57	-0.01	U	PCI/G
		Cesium-134	0.02	U	PCI/G
		Europium-154	0.039	U	PCI/G
		Lead-212	1.33		PCI/G
		Europium-155	0.057	U	PCI/G
		Uranium-233/23	1.53		PCI/G
		Potassium-40	23.9		PCI/G
		Thorium-234	1.54		PCI/G
		Alpha activity	10.4		PCI/G
		Beta activity	37.6		PCI/G
		Uranium-235	0.04	U	PCI/G
		Uranium-235	0.115		PCI/G
		Cesium-137	0.826		PCI/G
		Cobalt-60	-0.01	U	PCI/G
		Bismuth-214	0.589		PCI/G
		Actinium-228	1.28		PCI/G
		Lead-214	0.721		PCI/G
SWSA3-7	B00041	Thallium-208	0.397		PCI/G
		Uranium-238	0.99		PCI/G
		Europium-152	0.004	U	PCI/G
		Cobalt-57	-0.01	U	PCI/G
		Cesium-134	0.024	U	PCI/G
		Europium-154	-0.02	U	PCI/G
		Lead-212	1.23		PCI/G
		Europium-155	0.039	U	PCI/G
		Uranium-233/23	1.46		PCI/G
		Potassium-40	24.1		PCI/G
		Thorium-234	0.93	U	PCI/G
		Alpha activity	14.8		PCI/G
		Beta activity	35.3		PCI/G
		Uranium-235	0.06	U	PCI/G
		Uranium-235	0.087		PCI/G
		Cesium-137	0.98		PCI/G
		Cobalt-60	-0.01	U	PCI/G
		Bismuth-214	0.602		PCI/G
		Actinium-228	1.35		PCI/G
		Lead-214	0.733		PCI/G

Location	Sample ID	Parameter Name	Result	Qual	Units
LANDFILL1	B00007	Arsenic	6.9		MG/KG
		Cobalt	13.9		MG/KG
		Manganese	464		MG/KG
		Iron	41800		MG/KG
LANDFILL2	B00011	PCB-1260	51		UG/KG
LANDFILL2	B00012	Arsenic	4.9		MG/KG
		Manganese	1200		MG/KG
		Iron	24500		MG/KG
		Cobalt	14.3		MG/KG
LANDFILL3	B00014	PCB-1260	160		UG/KG
LANDFILL3	B00015	Zinc	69.1		MG/KG
		Iron	21600		MG/KG
		Manganese	574		MG/KG
SCRPYARD1	B00016	Arsenic	3.4		MG/KG
		Cobalt	10.2		MG/KG
		Iron	23500		MG/KG
		Manganese	443		MG/KG
		Zinc	58.1		MG/KG
SCRPYARD2	B00019	Arsenic	7.6		MG/KG
		Cobalt	6.3		MG/KG
		Zinc	46.7		MG/KG
		Manganese	313		MG/KG
		Iron	31200		MG/KG
SCRPYARD3	B00020	Zinc	48.6		MG/KG
		Iron	16200		MG/KG
		Manganese	267		MG/KG
SCRPYARD3	B00021	Arsenic	3.4		MG/KG
		Iron	23700		MG/KG
		Manganese	314		MG/KG
		Zinc	53.3		MG/KG
		Cobalt	8.1		MG/KG
SWSA3-1	B00024	Arsenic	7.5		MG/KG
		Iron	51000		MG/KG
		Manganese	1220		MG/KG
		Zinc	66.1		MG/KG
		Cobalt	23.3		MG/KG
SWSA3-2	B00027	Arsenic	6.9		MG/KG
		Zinc	45.5		MG/KG
		Iron	44800		MG/KG
		Manganese	936		MG/KG
		Cobalt	12.9		MG/KG
SWSA3-3	B00029	PCB-1260	28		UG/KG
SWSA3-3	B00030	Cobalt	13.8		MG/KG
		Iron	39600		MG/KG
		Zinc	43.4		MG/KG
		Manganese	1440		MG/KG
SWSA3-4	B00033	Arsenic	5.6		MG/KG
		Iron	25800		MG/KG
		Manganese	1210		MG/KG
		Zinc	48.3		MG/KG
		Cobalt	13.2		MG/KG
SWSA3-5	B00036	Arsenic	7.1		MG/KG
		Cobalt	21.1		MG/KG
		Zinc	77.9		MG/KG
		Iron	44700		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
SWSA3-5	B00036	Manganese	1110		MG/KG
SWSA3-6	B00039	Arsenic	4.9		MG/KG
		Iron	24200		MG/KG
		Zinc	38.8		MG/KG
		Manganese	777		MG/KG
SWSA3-7	B00042	PCB-1260	19		UG/KG
SWSA3-7	B00044	Arsenic	4.7		MG/KG
		Cobalt	15.4		MG/KG
		Manganese	1200		MG/KG
		Iron	31700		MG/KG
		Zinc	75.4		MG/KG
SWSA3-7	B00045	Arsenic	4.8		MG/KG
		Iron	36800		MG/KG
		Manganese	842		MG/KG
		Zinc	81		MG/KG
		Cobalt	13		MG/KG

Location	Sample ID	Parameter Name	Result	Qual	Units
LANDFILL1	B00001	Lead-214	1.02		PCI/G
		Alpha activity	20.5		PCI/G
		Uranium-238	1.01		PCI/G
		Lead-212	1.63		PCI/G
LANDFILL2	B00010	Lead-214	1.05		PCI/G
		Alpha activity	16.6		PCI/G
		Uranium-238	0.8		PCI/G
		Lead-212	1.29		PCI/G
LANDFILL3	B00013	Lead-214	0.72		PCI/G
		Alpha activity	20.8		PCI/G
		Uranium-238	1.09		PCI/G
		Lead-212	1.01		PCI/G
SWSA3-1	B00022	Lead-214	0.71		PCI/G
		Uranium-238	1.76		PCI/G
		Alpha activity	19.8		PCI/G
		Lead-212	1.67		PCI/G
SWSA3-2	B00025	Lead-214	1		PCI/G
		Uranium-238	1.48		PCI/G
		Lead-212	1.33		PCI/G
SWSA3-3	B00028	Uranium-238	3.8		PCI/G
		Lead-212	165		PCI/G
SWSA3-4	B00031	Lead-214	1.1		PCI/G
		Alpha activity	16.7		PCI/G
		Uranium-238	1.19		PCI/G
		Lead-212	1.41		PCI/G
SWSA3-5	B00034	Lead-214	1.31		PCI/G
		Uranium-238	1.83		PCI/G
		Lead-212	1.77		PCI/G
		Alpha activity	20.9		PCI/G
SWSA3-6	B00037	Lead-214	1.08		PCI/G
		Lead-212	1.66		PCI/G
		Uranium-238	1.1		PCI/G
		Alpha activity	24.3		PCI/G
SWSA3-7	B00040	Lead-214	0.721		PCI/G
		Uranium-238	0.96		PCI/G
		Lead-212	1.33		PCI/G
		Alpha activity	10.4		PCI/G
SWSA3-7	B00041	Lead-214	0.733		PCI/G
		Uranium-238	0.99		PCI/G
		Lead-212	1.23		PCI/G
		Alpha activity	14.8		PCI/G

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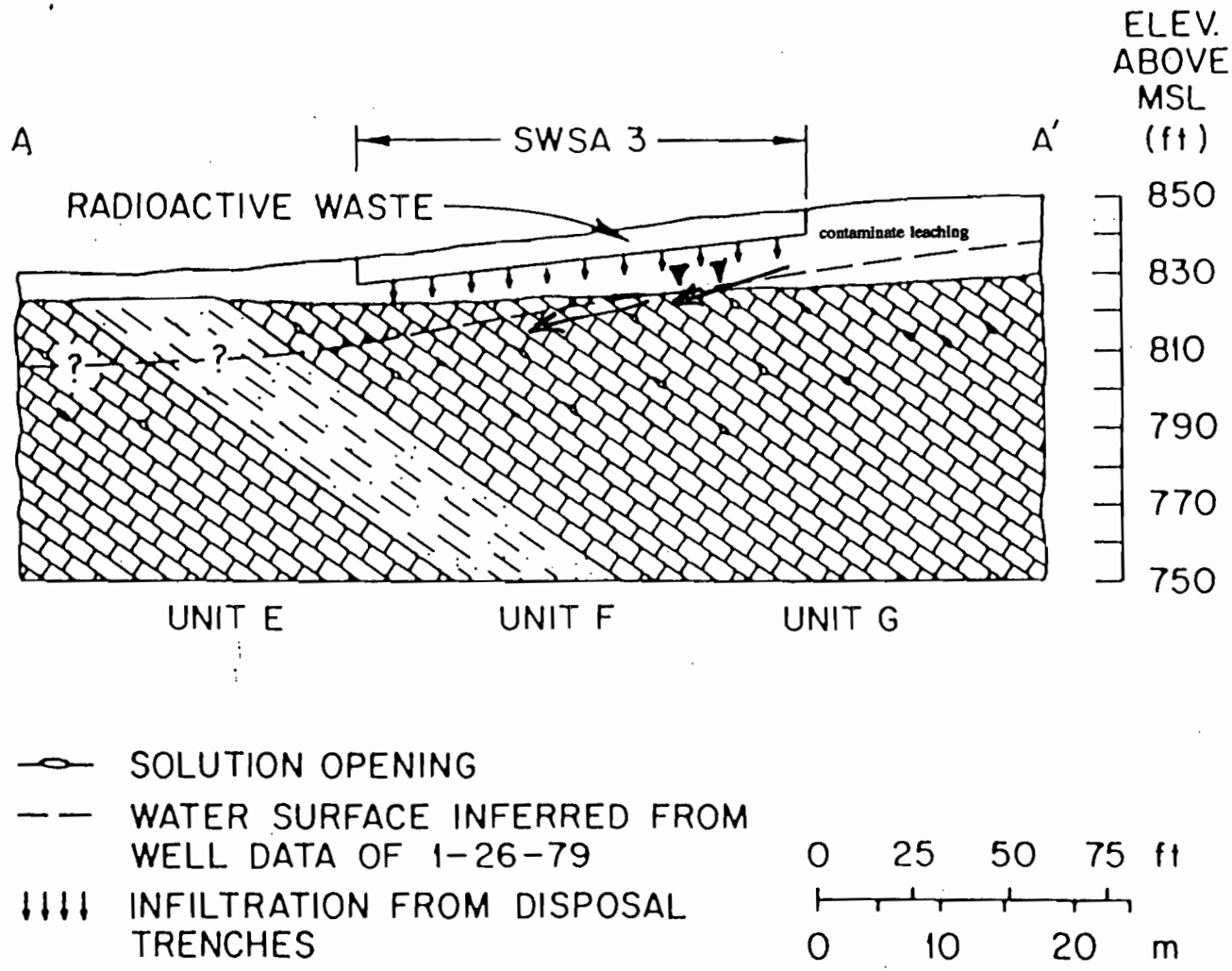

Fig. 7. Schematic cross section through SWSA 3 along line A-A' (Fig. 6) showing significant geologic and hydrologic features.

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Table B.2 Potential risk histories for selected* WAG perimeter wells

Well	94 Risk	95 Risk	Delta Risk	WAG
973	0.281	0.386	0.105	5
978	0.196	0.191	-0.005	5
974	0.0907	0.0854	-0.0053	5
969	0.0223	0.0151	-0.0072	5
977	0.0087	0.00732	-0.00138	5
812	0.00665	0.00699	0.00034	1
1201	0.00658	0.00646	-0.00012	17
843	0.00312	0.00232	-0.0008	6
1243	0.00232	0.00223	-9×10^{-5}	6
842	0.00165	0.000237	-0.001413	6
1076	0.00151	0.000411	-0.001099	7
971	0.00137	0.00163	0.00026	5
970	0.00132	0.00122	-0.0001	5
841	0.00129	0.000116	-0.001174	6
825	0.00103	0.000829	-0.000201	1
1191	0.000887	0.000687	-0.0002	2
1079	0.000825	0.000672	-0.000153	7
1097	0.000801	0.000207	-0.000594	8
1190	0.000716	0.000107	-0.000609	2
1096	0.000695	0.00241	0.001715	8
806	0.000658	0.000166	-0.000492	1
1078	0.00062	0.000488	-0.000132	7
1087	0.000605	0.000669	0.000064	8
994	0.000548	0.000796	0.000248	3
1242	0.000513	0.000406	-0.000107	6
847	0.000474	0.00017	-0.000304	6
844	0.000417	0.000183	-0.000234	6
1084	0.000306	0.000134	-0.000172	7
1244	0.000293	0.000134	-0.000159	6
993	0.000164	0.000368	0.000204	3
986	0.000131	0.000163	0.000032	3
1074	0.000117	0.000125	0.000008	7
996	0.0000075	0.000187	0.000795	3

*Wells included are those for which analytical results were available between May 1994 and April 1995 and for which potential risk exceeded 1×10^{-4}.

Table B.1. Prioritization of Individual Wells Based on Groundwater Risk

WELL	WAG	DCEE11	VINYL_CH	CO_60	TOTAL_SR	TRITIUM	BE	U_234	TC_99	Total Risk
812	1	0.00E+00	0.00E+00	2.25E-06	8.66E-03	4.87E-06	0.00E+00	3.02E-04	.	6.99E-03
825	1	0.00E+00	8.25E-04	0.00E+00	3.17E-06	1.01E-06	0.00E+00	.	.	8.29E-04
806	1	0.00E+00	0.00E+00	0.00E+00	1.65E-04	1.26E-06	0.00E+00	.	.	1.66E-04
830	1	0.00E+00	0.00E+00	0.00E+00	3.49E-05	2.11E-05	0.00E+00	.	.	5.60E-05
946	1	0.00E+00	0.00E+00	0.00E+00	2.06E-05	1.62E-06	0.00E+00	.	.	2.22E-05
829	1	0.00E+00	0.00E+00	1.29E-06	1.81E-05	1.74E-06	0.00E+00	.	.	2.11E-05
947	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-05	0.00E+00	.	.	2.03E-05
818	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.46E-05	0.00E+00	.	.	1.73E-05
821	1	0.00E+00	0.00E+00	0.00E+00	1.08E-05	3.94E-06	0.00E+00	.	.	1.47E-05
823	1	0.00E+00	0.00E+00	0.00E+00	5.08E-06	3.86E-06	0.00E+00	.	.	8.93E-06
811	1	0.00E+00	0.00E+00	0.00E+00	8.88E-06	0.00E+00	0.00E+00	.	.	8.88E-06
810	1	0.00E+00	0.00E+00	2.90E-06	1.71E-06	2.03E-06	0.00E+00	.	.	8.79E-06
820	1	0.00E+00	0.00E+00	0.00E+00	5.39E-06	2.39E-06	0.00E+00	.	.	7.79E-06
815	1	0.00E+00	0.00E+00	0.00E+00	2.38E-06	0.00E+00	0.00E+00	.	.	6.68E-06
816	1	0.00E+00	0.00E+00	3.11E-06	3.17E-06	0.00E+00	0.00E+00	.	.	6.47E-06
822	1	0.00E+00	0.00E+00	0.00E+00	1.55E-06	4.87E-06	0.00E+00	.	.	6.42E-06
809	1	0.00E+00	0.00E+00	0.00E+00	4.12E-06	2.19E-06	0.00E+00	.	.	6.32E-06
807	1	0.00E+00	0.00E+00	0.00E+00	3.81E-06	2.43E-06	0.00E+00	.	.	6.24E-06
819	1	0.00E+00	0.00E+00	2.04E-06	1.90E-06	2.07E-06	0.00E+00	.	.	6.01E-06
808	1	0.00E+00	0.00E+00	1.82E-06	3.81E-06	0.00E+00	0.00E+00	.	.	5.63E-06
827	1	0.00E+00	0.00E+00	0.00E+00	1.90E-06	1.54E-06	0.00E+00	.	.	3.45E-06
814	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-06	0.00E+00	.	.	3.31E-06
828	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.03E-06	0.00E+00	.	.	2.03E-06
1191	2	0.00E+00	0.00E+00	2.90E-06	4.12E-04	2.72E-04	0.00E+00	.	.	6.87E-04
1190	2	0.00E+00	0.00E+00	0.00E+00	5.71E-06	1.01E-04	0.00E+00	.	.	1.07E-04
1186	2	0.00E+00	0.00E+00	0.00E+00	2.92E-05	1.34E-06	0.00E+00	.	.	3.05E-05
1192	2	0.00E+00	0.00E+00	0.00E+00	8.88E-06	1.06E-05	0.00E+00	.	.	2.36E-05
1187	2	0.00E+00	0.00E+00	0.00E+00	2.47E-06	8.52E-07	0.00E+00	.	.	1.68E-05
1188	2	0.00E+00	0.00E+00	0.00E+00	1.21E-05	1.62E-06	0.00E+00	.	.	1.51E-05
1194	2	0.00E+00	0.00E+00	3.43E-06	1.59E-06	0.00E+00	0.00E+00	.	.	8.79E-06
1195	2	0.00E+00	0.00E+00	2.04E-06	3.81E-06	1.01E-06	0.00E+00	.	.	6.86E-06
1189	2	0.00E+00	0.00E+00	0.00E+00	1.81E-06	3.90E-06	0.00E+00	.	.	5.70E-06
994	3	0.00E+00	0.00E+00	0.00E+00	7.61E-04	3.08E-05	0.00E+00	.	.	7.96E-04
993	3	0.00E+00	0.00E+00	0.00E+00	3.49E-04	1.87E-05	0.00E+00	.	.	3.68E-04
996	3	0.00E+00	1.77E-04	1.07E-06	5.39E-06	2.03E-06	0.00E+00	.	.	1.87E-04
986	3	0.00E+00	1.61E-04	0.00E+00	0.00E+00	2.31E-06	0.00E+00	.	.	1.63E-04
992	3	0.00E+00	0.00E+00	1.50E-06	6.66E-05	1.83E-06	0.00E+00	.	.	7.00E-05
997	3	0.00E+00	0.00E+00	1.29E-06	3.49E-05	1.54E-06	0.00E+00	.	.	3.77E-05
991	3	0.00E+00	0.00E+00	0.00E+00	5.08E-06	1.87E-06	0.00E+00	.	.	1.12E-05
985	3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.52E-06	0.00E+00	.	.	4.82E-06
990	3	0.00E+00	0.00E+00	0.00E+00	2.06E-06	1.79E-06	0.00E+00	.	.	3.85E-06
998	3	0.00E+00	0.00E+00	0.00E+00	3.49E-06	0.00E+00	0.00E+00	.	.	3.49E-06
988	3	0.00E+00	0.00E+00	0.00E+00	1.97E-06	1.26E-06	0.00E+00	.	.	3.23E-06
995	3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-06	0.00E+00	.	.	1.50E-06
987	3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-06	0.00E+00	.	.	1.42E-06
973	4	0.00E+00	7.47E-04	0.00E+00	2.09E-04	3.86E-01	0.00E+00	.	.	3.86E-01
974	4	0.00E+00	0.00E+00	0.00E+00	3.49E-05	8.54E-02	0.00E+00	.	.	8.54E-02
971	4	0.00E+00	0.00E+00	0.00E+00	6.03E-06	1.62E-03	0.00E+00	.	.	1.63E-03
972	4	0.00E+00	0.00E+00	0.00E+00	1.49E-06	1.83E-05	0.00E+00	.	.	1.98E-05
953	4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	.	.	7.68E-06
952	4	0.00E+00	0.00E+00	2.25E-06	1.62E-06	0.00E+00	0.00E+00	.	.	3.87E-06
978	5	7.30E-05	1.91E-01	0.00E+00	0.00E+00	6.49E-05	0.00E+00	.	.	1.91E-01
969	5	0.00E+00	0.00E+00	0.00E+00	6.35E-04	1.45E-02	0.00E+00	.	.	1.51E-02
977	5	0.00E+00	0.00E+00	0.00E+00	9.20E-06	7.30E-03	0.00E+00	.	.	7.32E-03
970	5	0.00E+00	0.00E+00	0.00E+00	2.06E-06	1.22E-03	0.00E+00	.	.	1.22E-03
981	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.71E-05	0.00E+00	.	.	7.71E-05
979	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.46E-05	0.00E+00	.	.	5.34E-05
968	5	0.00E+00	0.00E+00	3.00E-06	0.00E+00	2.52E-06	0.00E+00	.	.	2.05E-05
983	5	0.00E+00	0.00E+00	1.07E-06	0.00E+00	8.93E-06	0.00E+00	.	.	1.27E-05
965	5	0.00E+00	0.00E+00	0.00E+00	6.03E-06	1.30E-06	0.00E+00	.	.	7.33E-06
984	5	0.00E+00	0.00E+00	0.00E+00	6.35E-06	0.00E+00	0.00E+00	.	.	6.35E-06
966	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.79E-06	0.00E+00	.	.	4.48E-06
967	5	0.00E+00	0.00E+00	0.00E+00	2.25E-06	1.91E-06	0.00E+00	.	.	4.16E-06

Table 8.6 Groundwater Contaminants of Concern

Name	# Analyzed	# > 1×10^{-4}	# > 1×10^{-4}
Hydrogen-3	125	17	92
Strontium-90[1]	125	10	80
Vinyl Chloride	125	6	7
Technetium-99	4	1	3
1,1-Dichloroethene	125	1	2
Cobalt-60	125	1	35
Uranium-234	1	1	1
Total Risk	125	31	122

[1]Analysis conducted for total strontium (^{89}Sr and ^{90}Sr) and slope factor used for ^{90}Sr and ^{90}Y.

8.4.2 Prioritization of WAGs and Individual Wells

The EPA recommends taking the average of the representative exposure concentrations when aggregating analytical data from multiple wells within an exposure unit. Table 8.7 lists the average risk for each of the WAGs with wells analyzed for the time period April 1994–March 1995 based on this criteria. These risk results are not comprehensive as not all of the available RCRA perimeter wells were analyzed in the time period April 1994–May 1995. However, they are in good general agreement with the ranking of the WAGs in terms of their contributions to the surface water risk at White Oak Dam.

Table 8.7 Prioritization of WAGs based on Groundwater Risk

WAG	Carcinogenic Risk
4	8×10^{-3}
5	1×10^{-3}
17	8×10^{-4}
8	4×10^{-4}
1	4×10^{-4}
6	2×10^{-4}
7	1×10^{-4}
3	1×10^{-4}
2	2×10^{-5}
11	4×10^{-6}

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Table 8.5 Contaminants exceeding risk criteria in RCRA perimeter wells

	CONTAMINANTS		
WAG	Radionuclides	Metals	Organics
1	^{90}Sr, ^{234}U, ^{60}Co, ^{137}Cs, ^{3}H, ^{235}U, ^{238}U		Vinyl Chloride, Chloroform
2	^{90}Sr, ^{60}Co, ^{137}Cs, ^{3}H		
3	^{90}Sr, ^{60}Co, ^{137}Cs, ^{3}H		Vinyl Chloride, Trichloroethene
4	^{90}Sr, ^{60}Co, ^{3}H		Vinyl chloride, Bis(2-Ethylhexyl)pthalate, 1,2-Dichloroethane
5	^{90}Sr, ^{60}Co, ^{137}Cs, ^{3}H		Vinyl chloride, Bis(2-Ethylhexyl)pthalate, Benzene, 1,1-Dichloroethane
6	^{90}Sr, ^{60}Co, ^{3}H		
7	^{90}Sr, ^{60}Co, ^{137}Cs, ^{3}H	Be	
8	^{90}Sr, ^{60}Co, ^{3}H		Vinyl Chloride, Bis(2-Ethylhexyl)pthalate, Trichloroethene
11	^{90}Sr, ^{60}Co		Trichloroethene
17	^{90}Sr, ^{60}Co, ^{3}H		Vinyl Chloride, 1,1-Dichloroethene, Trichloroethene

[1]Underlined contaminants exceed a carcinogenic risk of 1×10^{-4}; the remaining contaminants are within the 1×10^{-4} to 1×10^{-6} risk range.

Table 6.2 Contaminants exceeding risk criteria in RCRA perimeter wells

WAG	Contaminants[a]		
	Radionuclides	Metals	Organics
1	^{90}Sr, ^{234}U	As, Ba, Be, Cd, Mn, Sb	Vinyl Chloride, N-Nitroso-Di-N-Propylamine, Carbon Disulfide, 1,2,3 Trichloropropane, 1,2 Dibromo-3-chloropropane, 1,2 Dibromomethane, 1,4 Dioxane, 2-Propenenitrile, 3,3'-Dimethylbenzidine
2	^{3}H, ^{90}Sr, ^{60}Co	Be, As, Mn	1,1 Dichloroethene, Chlorobenzene, Carbon Disulfide
3	^{90}Sr	Be, Mn	
4	^{3}H, ^{90}Sr	As, Mn	1,1 Dichloroethene, Vinyl Chloride, 1,2 Dichlorobenzene
5	^{3}H, ^{90}Sr, ^{226}Ra	Mn	Vinyl Chloride, Bis-2-ethylhexyl pthalate 1,2 Dichlorobenzene, Carbon Disulfide
6	^{3}H, ^{90}Sr, ^{60}Co	Be	1,2 Dichloroethane, Chloroform, Trichloroethene, Aroclor-1254, Vinyl Chloride, Carbon Tetrachloride, Carbon Tetrachloride, Carbon Disulfide, Acetone
7	^{3}H, ^{99}Tc, ^{60}Co	Be, Mn	
8	^{90}Sr	As, Mn	
11		Be, Mn	
17			Vinyl Chloride, 1,1 Dichloroethene, 1,2 Dichlorobenzene

[a]Underlined contaminants exceed the noncarcinogenic hazard index of 1, the remaining contaminants exceed a calculated carcinogenic risk of 1E-4.

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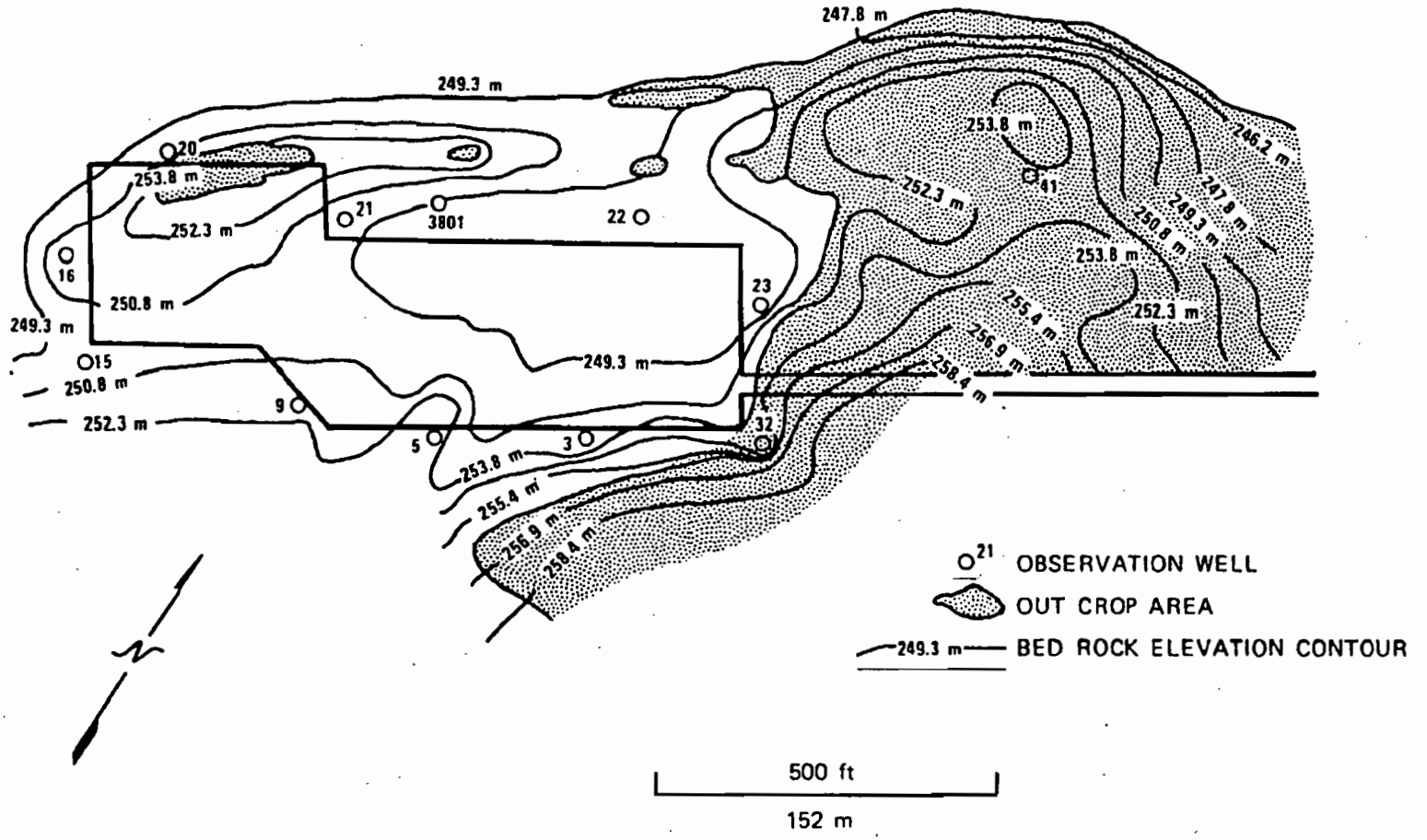

Figure 15. Bedrock topography map of Solid Waste Storage Area 3.

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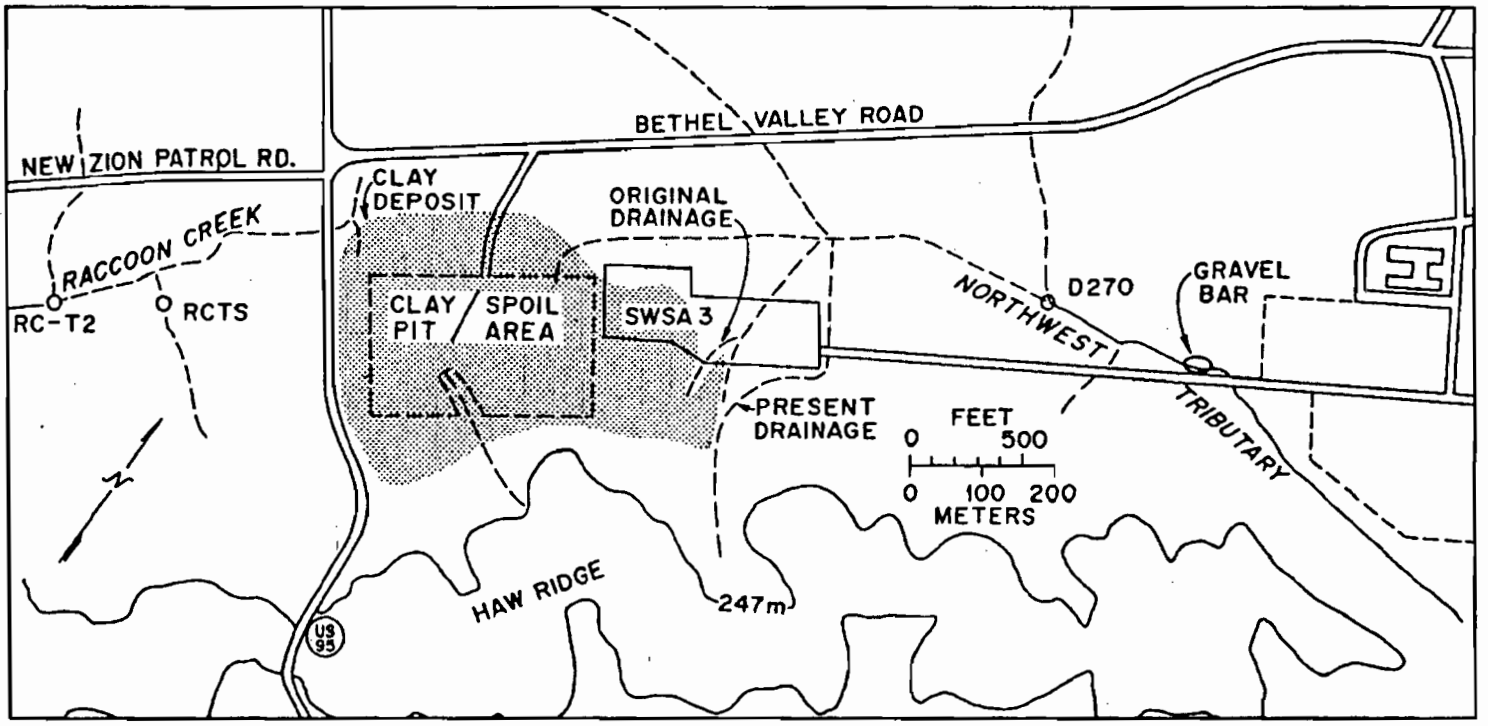

O CONTAMINATED SPRINGS

Figure 1. Plan map of Solid Waste Storage Area 3 and surrounding vicinity in Bethel Valley, Roane County, Tennessee. Shown are locations of various features discussed in the text.

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ORNL/ER-391

Energy Systems Environmental Restoration Program

Site Descriptions of Environmental Restoration Units at Oak Ridge National Laboratory, Oak Ridge, Tennessee

A. J. Kuhaida, Jr.
A. F. Parker

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Oak Ridge, Tennessee 37831
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

REMEDIAL INVESTIGATION PLAN
FOR WASTE AREA GROUPING 3

SUMMARY

NOVEMBER 1988

OAK RIDGE NATIONAL LABORATORY
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

Prepared by
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under
Subcontract 30B-99053C

for

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

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ORNL/RAP/Sub-87/99053/22

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REMEDIAL INVESTIGATION PLAN FOR WASTE AREA GROUPING 3

SEPTEMBER 1988

OAK RIDGE NATIONAL LABORATORY
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

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ORNL
ENVIRONMENTAL RESTORATION
DOCUMENT

for

Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831

Operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

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Energy Systems Environmental Restoration Program
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Remedial Investigation Work Plan for the Groundwater Operable Unit at Oak Ridge National Laboratory, Oak Ridge, Tennessee

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OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
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Environmental Data Package for ORNL Waste Area Grouping 3 (WAG 3), Solid Waste Storage Area 3 (SWSA 3)

R. R. Shoun

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ORNL/TM-7323

Contract No. W-7405-eng-26

AN INVESTIGATION OF RADIONUCLIDE RELEASE FROM SOLID WASTE DISPOSAL AREA 3, OAK RIDGE NATIONAL LABORATORY

A. M. Stueber,[1] D. A. Webster,[2] I. L. Munro,
N. D. Farrow, and T. G. Scott[3]

ENVIRONMENTAL SCIENCES DIVISION
Publication No. 1530

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ENVIRONMENTAL
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R. B. Clapp, Editor

September, 1992

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Energy Systems Environmental Restoration Program
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Environmental Restoration Division
ORNL Environmental Restoration Program

LIFE CYCLE BASELINE SUMMARIES FOR THE ENVIRONMENTAL RESTORATION PROGRAM AT AT OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENNESSEE

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Oak Ridge, Tennessee 37831-6285
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U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

ORNL/ER-39

Energy Systems Environmental Restoration Program
ORNL Environmental Restoration Program

Surveillance and Maintenance Plan for Waste Area Groupings at Oak Ridge National Laboratory, Oak Ridge, Tennessee, for FY 1993–2002

M. K. Ford
L. Holder, Jr.
R. G. Jones

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Energy Systems Environmental Restoration Program

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Environmental Management Activities at the
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