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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/RAP-21

Chemical Technology Division

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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ENVIRONMENTAL DATA PACKAGE FOR ORNL WASTE AREA GROUPING 3 (WAG 3), SOLID WASTE STORAGE AREA 3 (SWSA 3)

R. R. Shoun

ABSTRACT

Oak Ridge National Laboratory (ORNL), as a U.S. Department of Energy facility, must be in compliance with federal and state regulations. The Environmental Protection Agency now enforces its regulatory requirements for remedial action in areas containing residual contamination through Section 3004(u) of the Resource Conservation and Recovery Act as amended in 1984.

As a part of ORNL's Remedial Action Program, the area has been divided into 20 Waste Area Groupings (WAGs). One of these, WAG 3, is addressed in this document. This environmental data package provides background information on geology, hydrology, soils, and ecology of the Solid Waste Storage Area 3, including the adjacent scrap metal area and the Contractor's Landfill nearby. Information concerning known releases and remedial actions or experimental programs is presented, and additional information needed to properly complete the Section 3004(u) requirements is noted.

1. INTRODUCTION

U.S. Department of Energy (DOE) facilities are required to be in full compliance with all federal and state regulations. In response to these requirements, the Oak Ridge National Laboratory (ORNL) has established a Remedial Action Program (RAP) to provide comprehensive management of areas where research, development, and waste management activities have resulted in residual contamination of facilities or the environment. The primary objective of the RAP is to clean up hazardous waste or hazardous constituents that threaten human health or the environment (Trabalka and Myrick in press; Boegly et al. 1987).

The initial ORNL remedial action strategy was based on the guidance of DOE Orders 5820.2 (Surplus Facilities Management) and 5480.14 [Comprehensive Environmental Restoration, Compensation, and Liability Act (CERCLA)]; the Resource Conservation and Recovery Act

(RCRA) was believed to apply to only a limited number of sites. As a part of this strategy, individual sites were investigated according to estimated priorities for site characterization, remedial actions, and decommissioning/closure planning. In 1984, the RCRA was amended to establish broad new authorities within the Environmental Protection Agency (EPA) RCRA programs. One of these new authorities was Section 3004(u), which requires that any hazardous waste management permit issued after November 8, 1984, require corrective action for all releases from solid waste management units at the facility. In a memorandum to DOE in April 1986, EPA expressed concern about the length of time required to implement DOE orders and elected to enforce regulatory requirements for remedial actions through its amended RCRA authority (Scarbrough 1986).

Before the Hazardous Solid Waste Amendments (HSWA) to RCRA, EPA's authority to require corrective action for releases of hazardous constituents was limited to groundwater releases from units that were covered by RCRA permits (Part 264, Subpart F). Since passage of the HSWA, EPA's authority has been extended to include releases to all media and all units at a RCRA facility regardless of when they were used or whether they are covered by an RCRA permit (EPA 1986).

Waste Area Grouping 3 (WAG 3) consists of only three Solid Waste Management Units (SWMUs): (1) the inactive Solid Waste Storage Area 3 (SWSA 3), (2) the active Contractor's Landfill, and (3) the closed scrap metal area now enclosed within the SWSA 3 fence.

2. GENERAL SITE DESCRIPTION OF WAG 3

2.1 HISTORY, PURPOSE, AND GEOGRAPHIC LOCATION OF WAG 3

Since 1943, solid, low-level radioactive wastes generated by ORNL (and in some cases other sources) have been deposited in shallow land burials at ORNL. SWSA-3 was the third of these successively larger disposal areas and the last one located in Bethel Valley (Fig. 1). The useful life of SWSA-3 extended from 1946 to 1951 for routine burial operations; however, aboveground storage of large items of contaminated equipment continued until 1979. Figures 2 and 3 show "before" and after" pictures of SWSA 3. Figure 1 shows the components of WAG 3 in relation to the ORNL area: SWSA-3 approximately 1 km west

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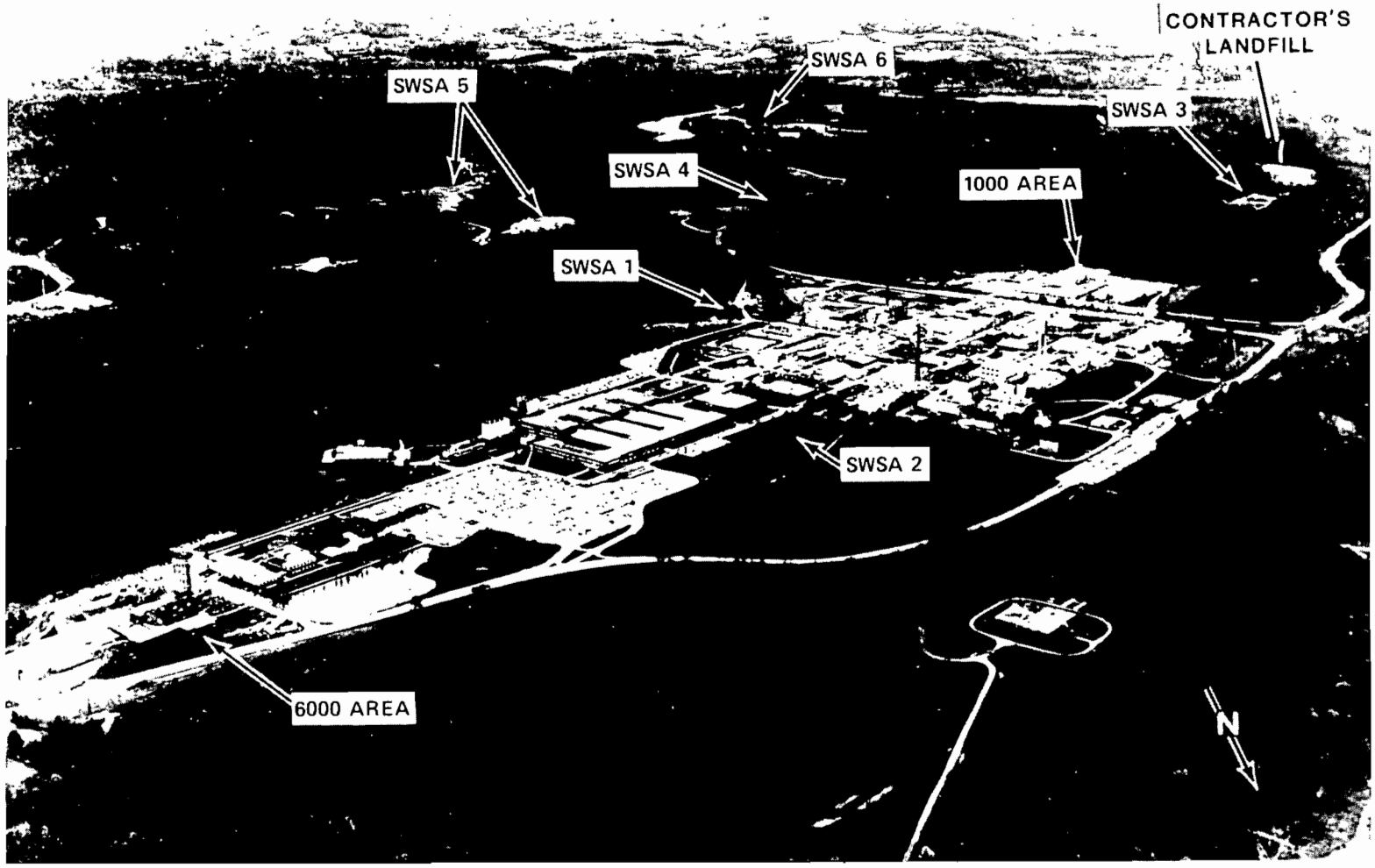

Fig. 1. Aerial view of Oak Ridge National Laboratory showing approximate locations of solid waste storage areas. SWSA 3 and the Contractor's Landfill are in the upper righthand corner.

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Fig. 2. SWSA 3 before 1978-1979 surface cleanup.

ORNL-PHOTO 5064-80

Fig. 3. SWSA 3 after 1978-1979 surface cleanup.

of the main ORNL complex, the closed scrap metal area adjoining the south boundary of SWSA 3 (Fig. 4), and the Contractor's Landfill southwest of SWSA 3.

The second component of the WAG 3 is the closed scrap metal area, which is a small, triangular-shaped section adjoining the south boundary of SWSA 3 for about 80 m. This area was found to contain buried contaminated metal in 1982 (Grizzard 1986), so a fence was constructed to enclose the area. The portion of the fence adjoining SWSA 3 was later removed, and the scrap metal area is now an integral part of SWSA 3. This area is grassed and is maintained with the rest of SWSA 3. A fill area to the south of this area contains uncharacterized construction materials.

The remaining component of WAG 3 is the Contractor's Landfill, which, as seen in Fig. 5, is just southwest of SWSA 3. This landfill (clay spoil area) receives earth materials from construction activities at the ORNL site. Two small areas (Fig. B-2) within this site have been identified as having some ^{137}Cs and ^{90}Sr contamination (Stueber et al. 1981).

2.2 GEOLOGY

The components of WAG 3, including SWSA 3, are located in Bethel Valley at the foot of Haw Ridge, and thus SWSA 3 is underlain by Chickamauga limestone of the Ordovician age.

Stockdale (1951) subdivided the Chickamauga limestone of Bethel Valley into eight distinct units based on variations in types of rock. Three of these units (E, F, and G) underlie SWSA 3, and their relationship is shown in Figs. 6 and 7. Units E and G are nondescript gray limestones 116 and 91 m thick, respectively. Unit F is 7.6-m-thick maroon calcareous siltstone and shale.

The limestones of units E and G are compact and have very little primary porosity. However, secondary openings, which developed from groundwater dissolution, have been identified from drill cores and are reported to be as large as 30 cm in diameter (Steuber et al. 1981).

Soils in the ORNL area (and thus SWSA 3) are silty, contain clay, and exhibit a pH of 4.5 to 5.7 (Cowser 1961). The weathered zone is thin (usually less than 3 m) in the area underlain by Chickamauga

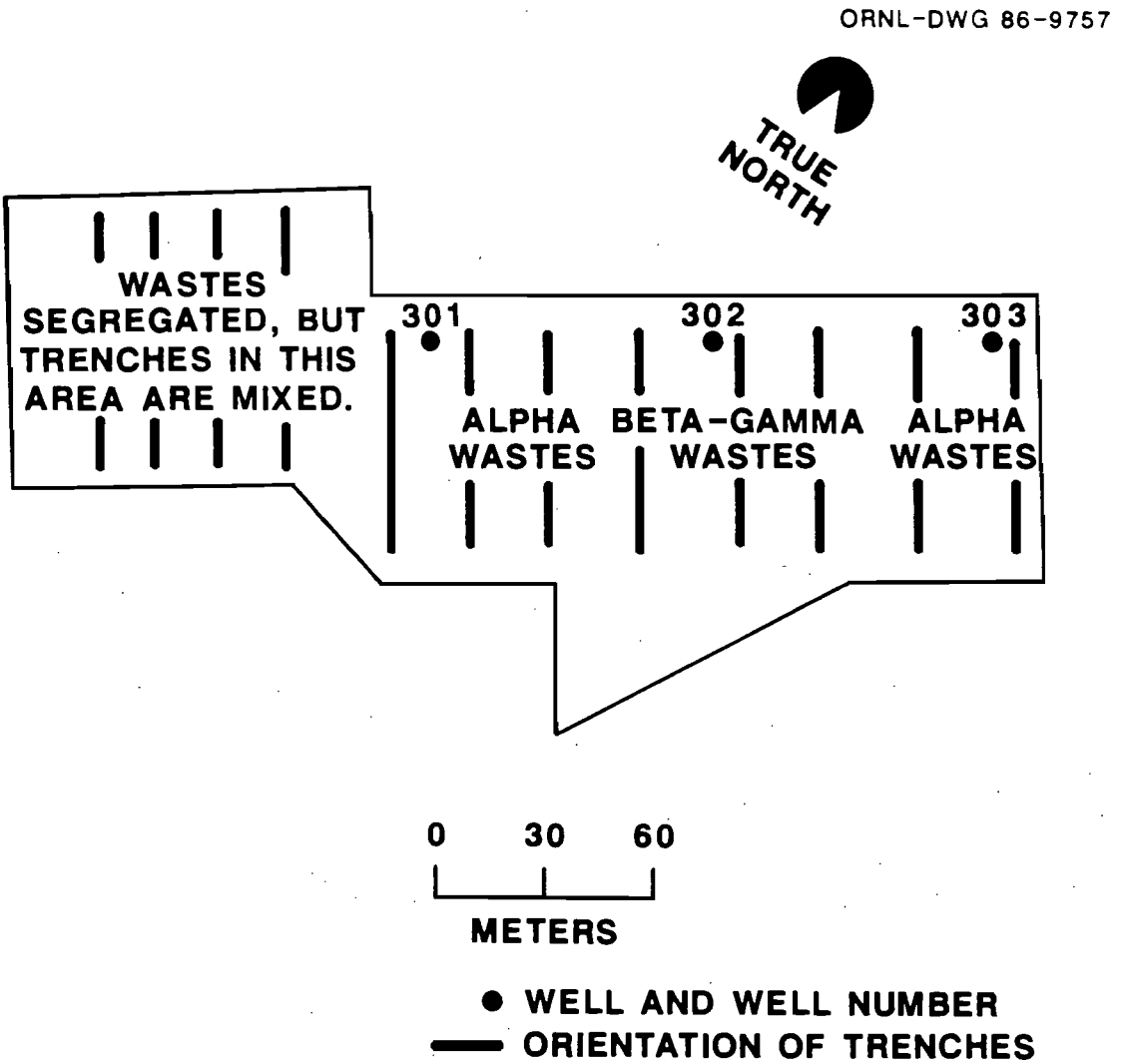

Fig. 4. SWSA 3 with the appended scrap metal area to the south.

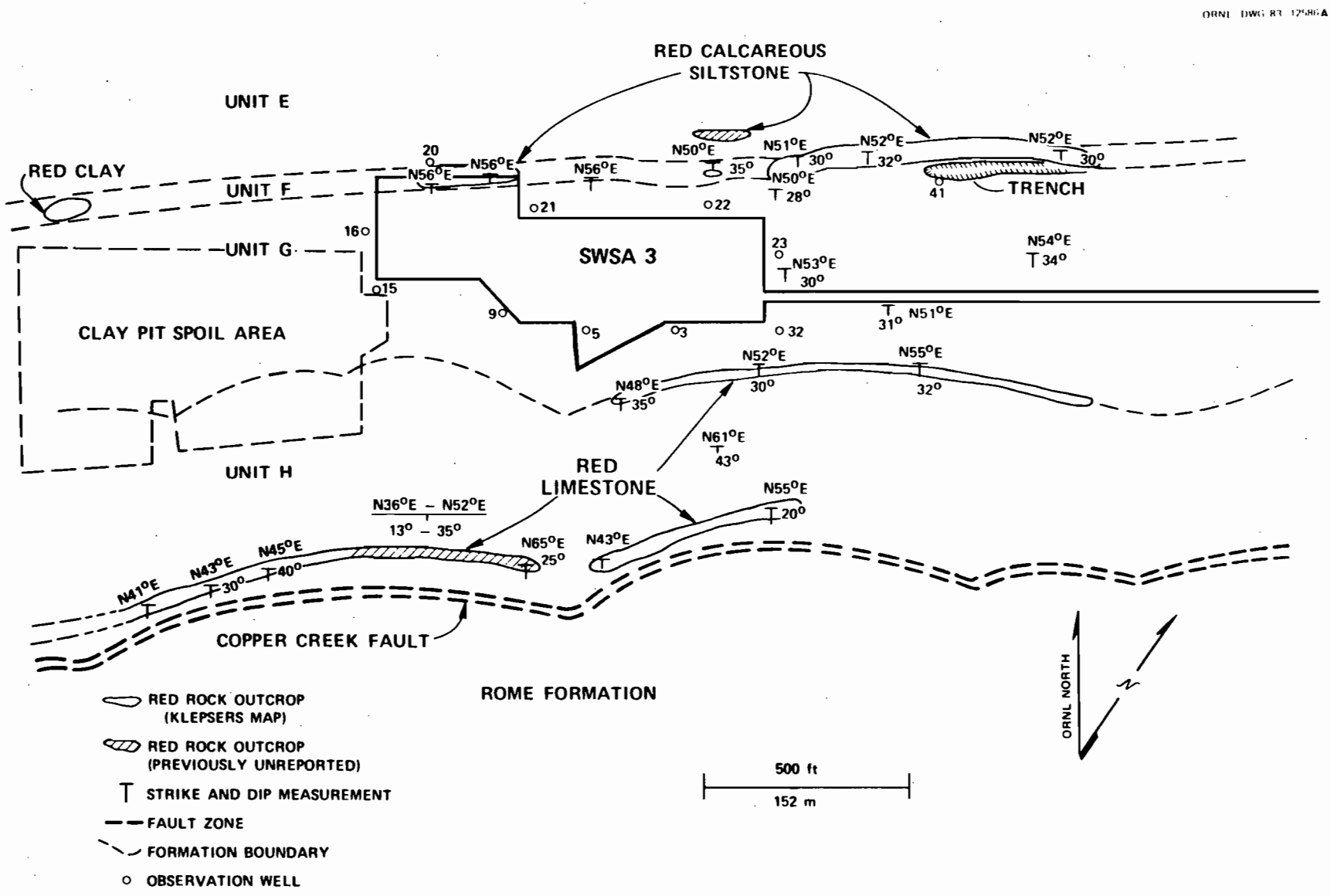

Fig. 5. Contractor's Landfill in relation to SWSA 3.

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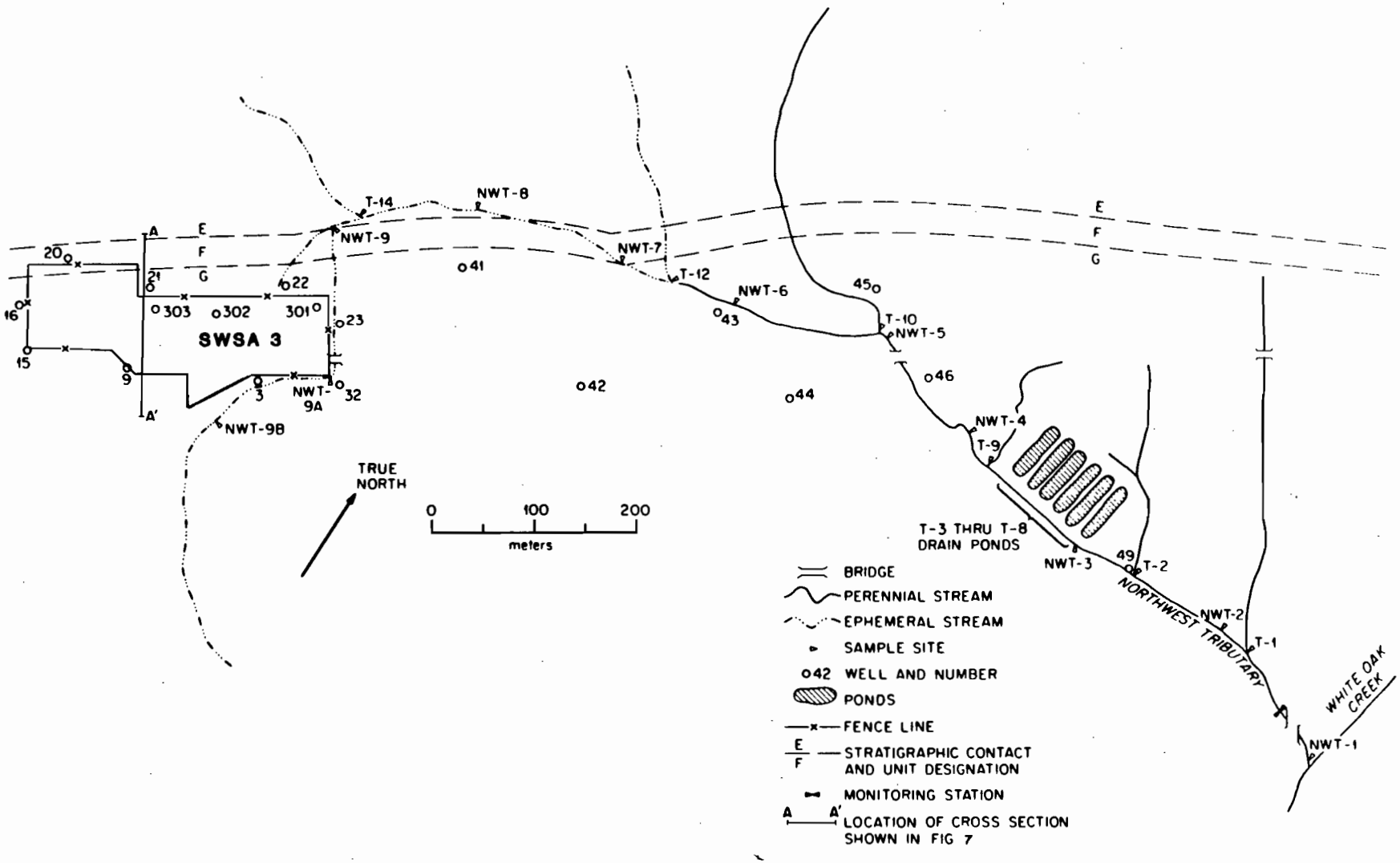

Fig. 6. The Northwest Tributary drainage basin, including surface water sampling sites, wells, and contacts of Chickamauga limestone bedrock units.

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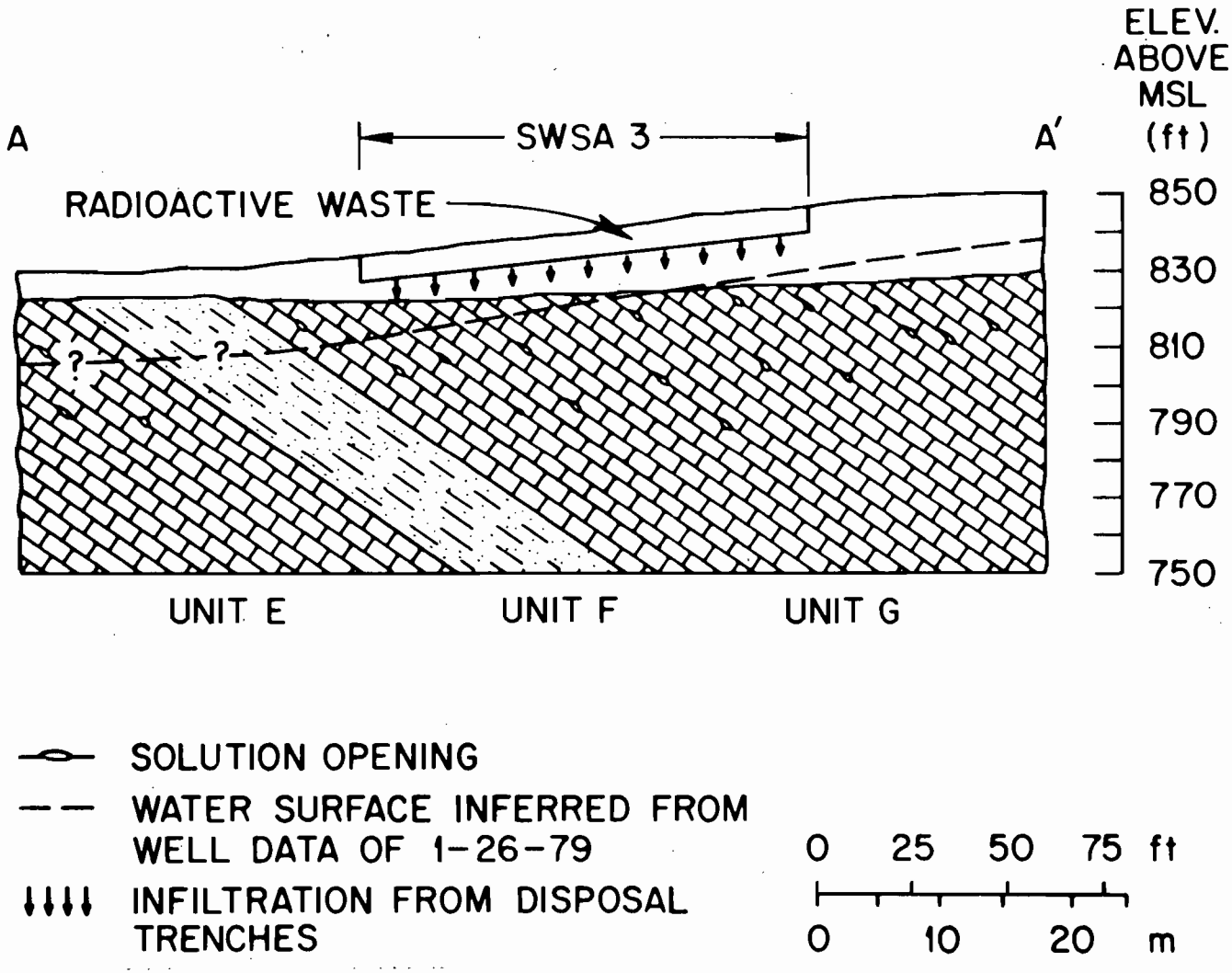

Fig. 7. Schematic cross section through SWSA 3 along line A-A' (Fig. 6) showing significant geologic and hydrologic features.

limestone. The sorptive properties of the various clay minerals have been shown to vary for specific radionuclides (Webster 1976).

2.3 HYDROLOGY

The groundwater hydrology of SWSA 3, as inferred from a 1950 water contour map, first indicates the presence of a groundwater divide in the west end of SWSA 3 (Stockdale 1951; Duguid 1975; Stueber et al. 1981). These data infer that groundwater east of the divide flows east to discharge in the White Oak Creek drainage system (Figs. 8,9). Groundwater west of the divide flows west to discharge in the Raccoon Creek drainage system. The surface water divide appears to occur just west of the disposal site (SWSA 3), so all surface water from SWSA 3 drains to White Oak Creek through the Northwest Tributary (Stueber et al. 1981).

The Northwest Tributary originates on the northwest flanks of Haw Ridge; runoff from this area is now diverted around the northeastern end of SWSA 3. The stream is ephemeral in the vicinity of SWSA 3, but becomes perennial about 400 m downstream from the disposal area (Fig. 6).

A 1979 water-level contour map (Fig. 9) suggests that the direction of groundwater flow below the northeastern portion of SWSA 3 is toward the northwest, and that beyond the northeastern boundary, the flow is generally to the north. Below the southwestern portion of SWSA 3, the hydraulic gradient slopes in two directions, indicating flow toward the northeast and toward the west (Stueber et al. 1981).

Hydrologic information for the Contractor's Landfill is sparse, and data indicate only that surface runoff from this area flows toward the headwaters of Raccoon Creek.

2.4 ECOLOGY

As with other SWSAs at ORNL, the primary vegetation surrounding the WAG-3 components is the oak-hickory association, which consists of extensive stands of mixed yellow pine and hardwoods, as well as oaks and hickories. After clearing the forest from the SWSA 3, completing the waste burial process, and covering the area with approximately 1 m of soil, SWSA 3 was seeded to prevent erosion. For several years,

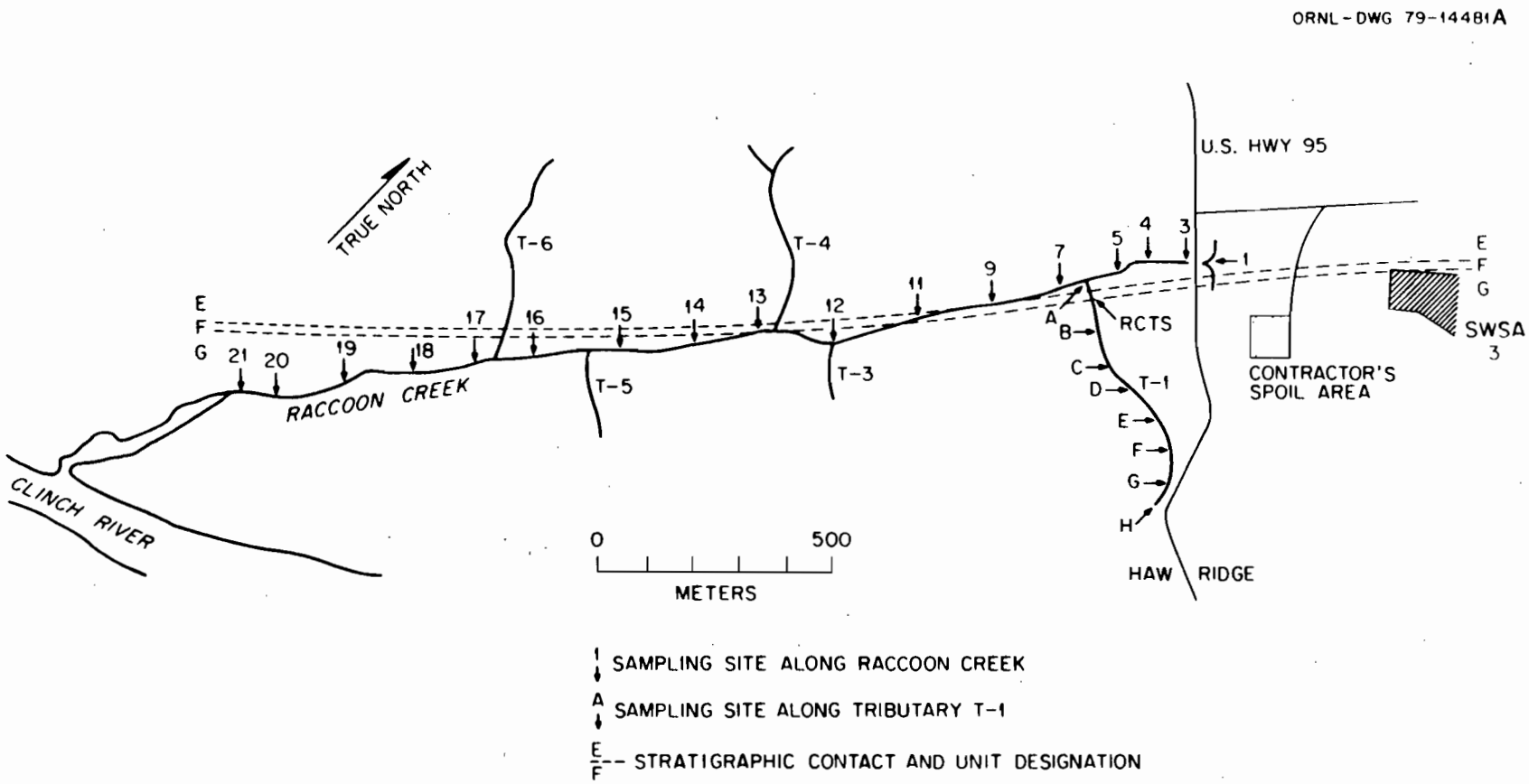

Fig. 8. The Raccoon Creek drainage basin, including surface water sampling sites and contacts of Chickamauga limestone bedrock units.

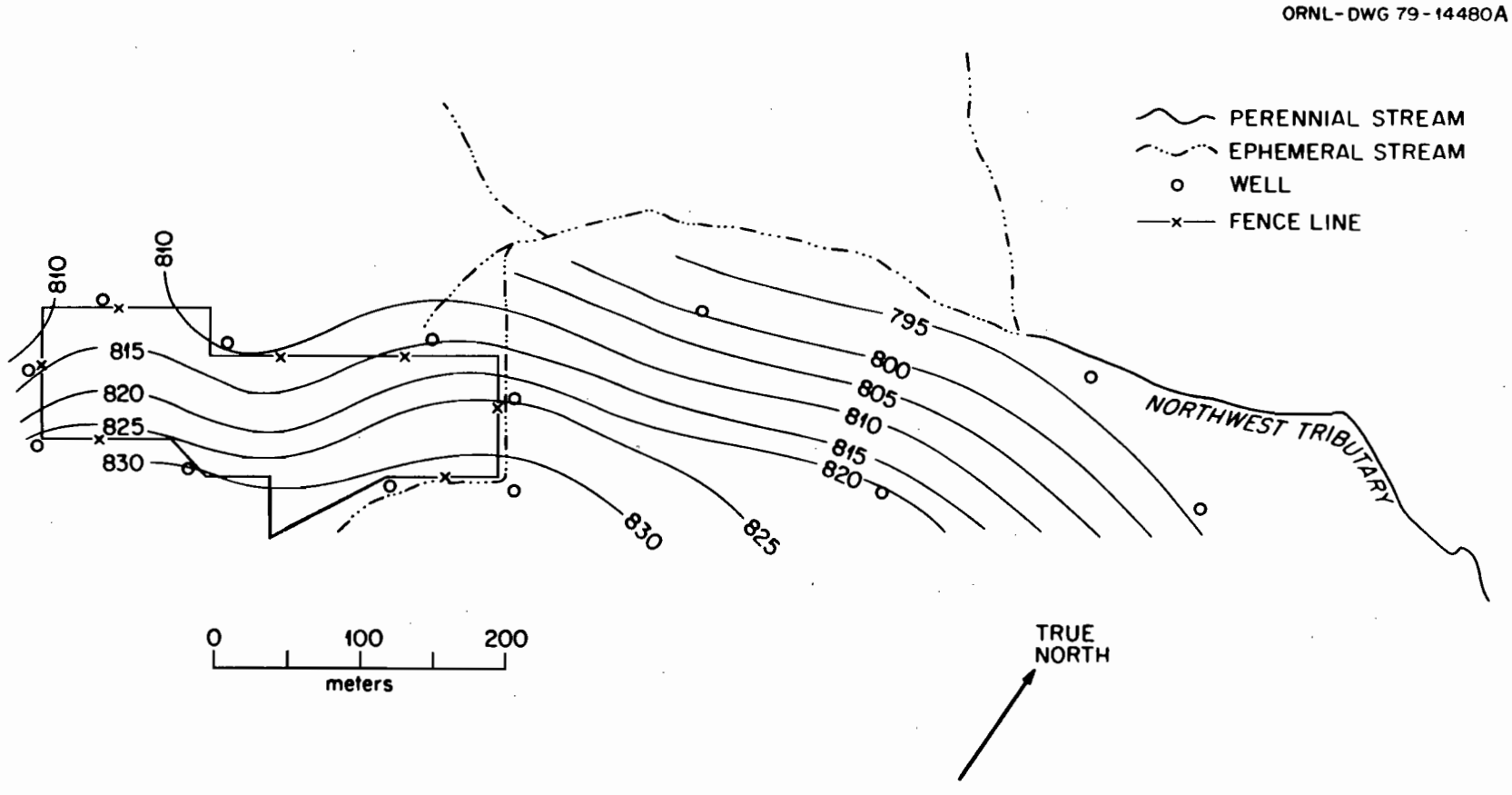

Fig. 9. Water level contour map based on January 1979 water levels.

trees and shrubs were allowed to revegetate SWSA 3, but the area was cleared during 1978-1979 cleanup operations. This area is now periodically mowed during the summer.

Small animals indigenous to the area would be expected to frequent SWSA 3 and the surrounding area. Such mammals as mice, chipmunks, land shrews, squirrels, opossums, rats, groundhogs, muskrats, foxes, and perhaps deer may inhabit portions of the SWSA. Groundhogs are particularly fond of using the old waste trenches for their dens.

2.5 LAND USE

2.5.1 Trench Burial in SWSA 3

SWSA 3 is a completely fenced area of approximately 2.8 ha located about 1 km west of the main ORNL complex at the foot of Haw Ridge (Fig. 1). Parallel trenches were excavated across the width of the area and are generally 4.4 m or less in depth (Fig. 4). During the early operation of the burial ground, alpha-contaminated wastes in drums were placed in concrete-lined trenches in the northeastern end of the area, but later they were placed in unlined trenches and covered with concrete (Webster 1976). Beta-gamma-contaminated wastes were buried in separate, unlined trenches and were backfilled with native soil (Webster 1976; Grizzard 1986).

As the site was extended westward, hard rock was encountered, making excavation difficult (Webster 1976; Myrick et al. 1984; Grizzard 1986). The area was covered with an average of 1 m of soil and grass is maintained to prevent surface erosion.

While no burial records are available, as many were destroyed in a 1958 fire at SWSA 5, an estimated 1.85 PBq (Bates 1983) of radioactivity was buried in a volume of approximately 2×10^4 m^3 of refuse. Alpha and beta-gamma wastes were generally segregated; however, the physical forms were varied and probably included some chemical wastes which may well have been reactive, corrosive, or toxic.

2.5.2 Construction Refuse in Contractor's Landfill

The Contractor's Landfill, southwest of SWSA-3, is an active storage area for construction materials removed during construction activities at the ORNL site. According to Dvon Brogan, the maximum amount of fill material in this area is 6 m (Stueber et al. 1981).

While this area is now fenced and secured and material to be dumped must be "green tagged," previous operations deposited some radioactive materials in landfill. Stueber et al. (1981) identified two areas in the northernmost and southwestern portions of the landfill that contain ^{137}Cs, ^{90}Sr, and ^{60}Co. The maximum estimated inventory of ^{90}Sr is 7.4 TBq. Data from this study are presented in Appendix B.

2.6 REMEDIAL ACTIONS, INVESTIGATIONS, AND EXPERIMENTAL PROJECTS

2.6.1 Radionuclide Release

Radionuclide release from SWSA 3 and the Contractor's Landfill was studied by Stueber et al. (1981) through the analysis of surface water and groundwater from local drainage areas. Water from SWSA 3 drains to the Northwest Tributary, which in turn flows to White Oak Creek. During a seven-month monitoring program, it was determined that ^{90}Sr was being discharged in the main stream in amounts varying from 7.8 to 41 mBq per month, with an average discharge of 24 mBq per month. The ^{90}Sr enters the tributary through base flow about 350 m from the disposal area.

The suggested groundwater divide moves water (and ^{90}Sr) from the southwestern end of SWSA 3 toward the Raccoon Creek drainage system. In this watershed, ^{90}Sr is detected as it discharges from a seep adjacent to a Raccoon Creek tributary about 640 m southwest of SWSA 3 and averages 1.8 mBq per month. An additional source of ^{90}Sr may be the Contractor's Landfill, 250 m southwest of SWSA 3, in which two small areas of contaminated fill material have been found.

The ^{90}Sr appears to be moving through groundwater flow to the northeast and southwest of SWSA 3 in a direction related to bedrock structure. A line passing through the two seeps also passes through the SWSA and is parallel to bedrock strike (Fig. 10). Core-hole logs and televiewer logs suggest that ^{90}Sr in groundwater may be moving through solution channels near the contact between Chickamauga limestone units F (calcareous siltstone and shale) and G (shaly limestone).

Data from these studies may be found in Appendix B, and more detailed discussion is in Stueber et al. (1981).

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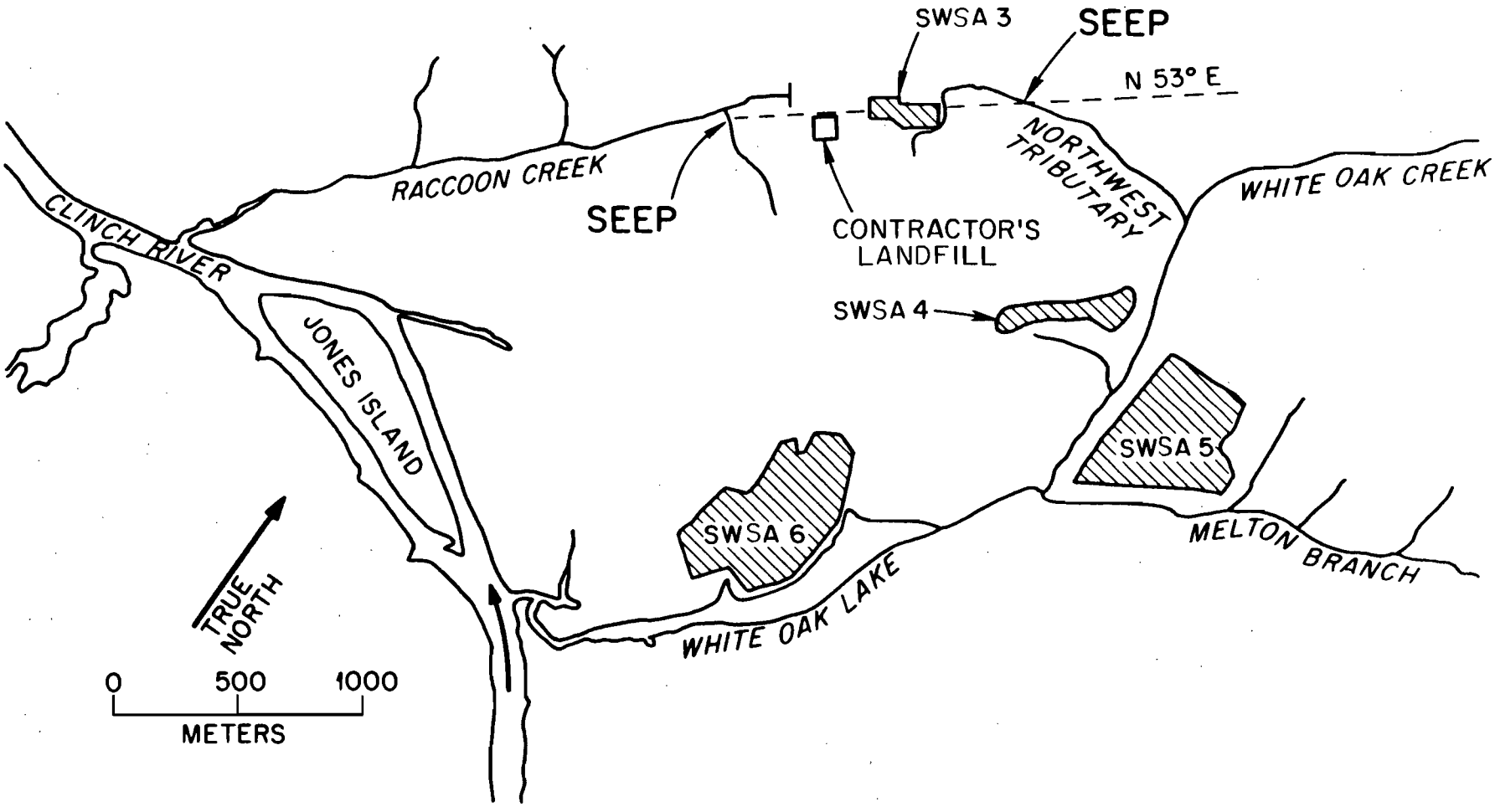

Fig. 10. Drainage systems in the vicinity of SWSA 3, including the two ^{90}Sr seeps and the trend of a line connecting them.

2.6.2 Geophysical Investigations

The desire for additional information about the geologic structure beneath SWSA 3 led to surveys utilizing very-low-frequency electromagnetic resistivity, electrical resistivity, and seismic refraction. Basic geophysical rock properties were measured as well as the depth of weathering and the configuration of the bedrock surface.

A number of geophysical anomalies were noted in the shallow subsurface, especially a linear feature running across the geologic strike in the western half of SWSA 3. Such a feature may conduct water in the subsurface.

None of the geophysical tests performed definitely confirm the presence of voids or fractures in the SWSA 3 area, but with complementary data from other studies, they may yield information necessary for confirmation of such structures. A more thorough discussion of the study may be found in Rothschild et al. (1985).

2.6.3 Dye Injections

In 1981 and 1982, J. Switek of the Environmental Sciences Division injected water, water-soluble fluorescein dye, and water-soluble rhodamine dye into wells near SWSA 3 in order to determine flow rates to various monitoring wells (Fig. 11). Water injected at well 21 was detected by the water level change at well 41 in 1.5 h, a distance of approximately 300 m to the east. A rhodamine dye injection at well 41 required only 21 min to reach the monitoring well approximately 200 m to the east. A fluorescein dye injection at well 493 was detected at a well approximately 550 m to the east in 7 d and also at a well approximately 900 m to the west in 21 d. The rates of movement for the water injection and the rhodamine are comparable to those expected for open channel flow.

2.6.4 Radionuclide Distribution to Streambed Gravel

Cerling and Spalding (1981) studied the association of ^{90}Sr, ^{60}Cs, and ^{137}Cs with streambed sediments as a method of identifying sources of radionuclides in waterways. High nuclide concentrations in sediments reveal locations where contamination begins. The ^{90}Sr, and,

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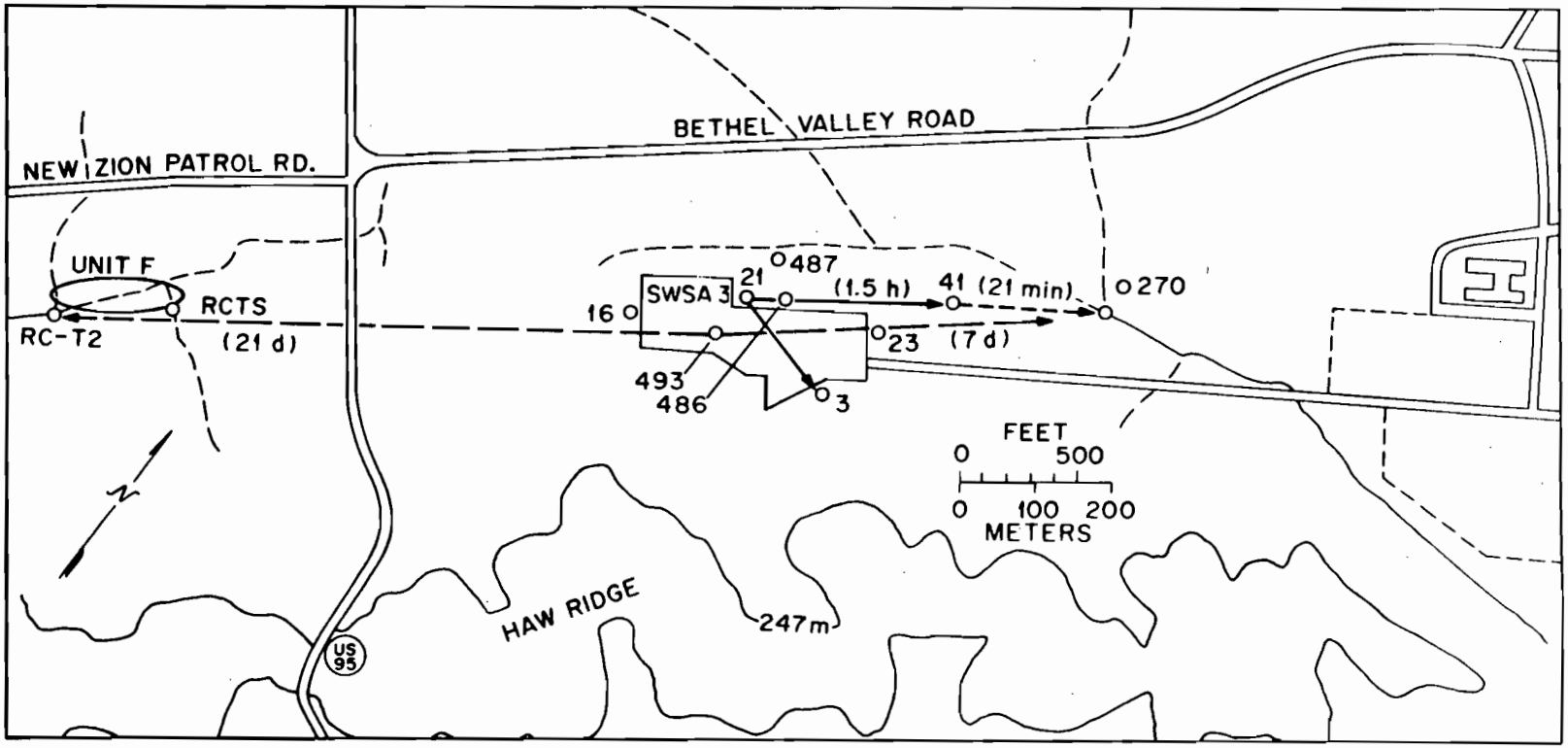

— — — DECEMBER 1982 RHODAMINE DYE AT WELL 41

——— 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.

to a lesser degree, ^{60}Co associate by ion exchange with the solid phase sediments, but the ^{137}Cs forms a complex with a mineral constituent that is stable until the compound is destroyed. Because of this, the ^{90}Sr and ^{60}Co concentrations in the sediments are roughly proportional to those in the water (distribution coefficient), but the ^{137}Cs may only be used as a flag for a source of contamination. From their studies, Cerling and Spalding (1981) estimated that, in 1978-1979, SWSA 3 contributed about 3% of the ^{90}Sr discharged from ORNL.

Figures representing the areal distribution of ^{90}Sr, ^{60}Co, and ^{137}Cs in White Oak Creek watershed gravel are found in Appendix C.

3. INFORMATION NEEDED

A review of information in this report indicates that, while the components of WAG-3 are not major contributors of radioactivity, there are several areas in which additional data and information are needed to complete the Remedial Investigation/Feasibility Study planning stages.

Source Term and Waste Inventory

- Precise location of waste trenches and transuranic waste
- Trench wall permeability characteristics
- Better definition of the existence of radionuclides and potentially contaminated material in the area south of SWSA 3 through more extensive surveys

Hydrology

- Better definition of groundwater divide (through additional wells)
- Definition of solution channeling (through additional pump tests or dye tests)

Geology and Geochemistry

- Location of voids and underground channels
- Soils map for SWSA 3 and Contractor's Landfill
- Soil sorption-desorption studies

This is not an exhaustive list, but it should indicate possible additions to the WAG 3 data that are needed.

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APPENDIX A. U.S. GEOLOGICAL SURVEY SWSA 3 MONITORING WELL DATA

Table A-1. Data of observation wells in and near Solid Waste Storage Area 3, Oak Ridge National Laboratory, Roane County, Tennessee

Well number	Location			Depth of well	Year completed	Casing		Finish		Altitude of land surface	Measuring Point		Depth to Water below land surface			Status of well 12/79
	Latitude (deg., m, s)	Longitude (deg., m, s)	ORNL Grid (ft) (ft)	(ft)		Diameter (in)	Type	Character	Depth interval (ft)	(ft above NGVD)	Distance above land surface (ft)	Date determined (m/d/yr)	Period of record (yrs)	Minimum (ft)	Maximum (ft)	
3[a]	35 55 07	84 19 42	N21630 E26428	251	1950	3 3/16	S	Opn	(?)	839.44	0.56	6/20/79	1975-79	4.51	10.58	A
9	35 55 03	84 19 49	N21671 E26010	99	1950	3 3/16	S	Opn	(?)	848.95	0.75	4/21/75	1975-79	16.95	21.23	A
15	35 55 03	84 19 52	N21726 E25698	100	1950	3 3/16	S	Opn	(?)	848.20	1.00	4/21/75	1975-79	19.34	32.82	A
16	35 55 04	84 19 54	N21871 E25668	100	1950	3 3/16	S	Opn	12-100	840.80	1.00	4/21/75	1975-79	18.98	28.75	A
20	35 55 07	84 19 53	N22013 E25821	99	1950	3 3/16	S	Opn	12-99	836.20	1.40	4/21/75	1975-79	20.63	21.01	A
21	35 55 08	84 19 49	N21925 E26076	100	1950	3 3/16	S	Opn	12-100	834.85	0.95	4/21/75	1975-79	24.30	25.59	A
22	35 55 10	84 19 44	N21934 E26510	100	1950	3 3/16	S	Opn	11-100	826.80	0.40	4/21/75	1975-79	8.05	16.04	A
23	35 55 10	84 19 43	N21807 E26679	100	1950	3 3/16	S	Opn	10-100	828.30	0.70	4/21/75	1975-79	0.04	6.40	A
32	35 55 09	84 19 40	N21621 E26682	99	1950	3 3/16	S	Opn	9-99	840.70	0.70	4/21/75	1975-79	4.99	11.54	A
41	35 55 13	84 19 39	N21990 E27070	33	1950	3 3/16	S	Opn	11-33	833.35	0.25	4/21/75	1975-79	31.39	32.47	A
42	35 55 12	84 19 32	N21613 E27449	49	1950	3 3/16	S	Opn	7-49	834.00	0.40	4/21/75	1975-79	10.90	20.90	A
43	35 55 16	84 19 30	N21849 E27885	46	1950	3 3/16	S	Opn	9-46	799.40	0.90	4/21/75	1975-79	1.21	5.92	A
44	35 55 15	84 19 26	N21575 E28113	49	1950	3 3/16	S	Opn	9-49	813.40	0.90	4/21/75	1975-79	17.66	19.46	A
45	35 55 19	84 19 24	N21841 E28475	24	1950	3 3/16	S	Opn	12-24	794.40	1.10	4/16/75	1975-79	0.53	4.08	A
46	35 55 18	84 19 22	N21634 E28552	50	1950	3 3/16	S	Opn	6-50	788.50	0.60	4/21/75	1975-79	1.04	3.88	A
49	35 55 17	84 19 12	N21079 E29188	47	1950	3 3/16	S	Opn	20-47	778.70	1.40	4/21/75	1975-79	0.77	2.72	A
301	35 55 07	84 19 50	N21856 E26106	14	1964	6 7/8	S	Prf	0-14	841.08	2.62	8/24/76	1975-79	4.81	12.58	A
302	35 55 08	84 19 47	N21837 E26293	6	1964	6 7/8	S	Prf	0-6	836.33	2.77	8/24/76	1976-79	0.57	6.20	A
303	35 55 10	84 19 45	N21855 E26612	6	1964	6 7/8	S	Prf	0-6	831.53	2.37	8/24/76	1976-79	0.75	5.73	B

[a]Casing had been removed to a point several inches below land surface prior to the initial inventory. During the period of record, the measuring point for this well was land surface, and the measuring point distance was 0.0 ft. In May 1979, the damaged casing stub was removed and a second of 4-in. I.D. plastic pipe was emplaced over the upper end of the steel casing. The new measuring point is 0.56 ft above land surface. 1 ft = 0.3048 m.

Source: Webster et al. (1981).

Table A-2. Monitoring well locations and elevations for SWSA 3 area

Well nos.	Location Coordinates		Elevation[a]
M481 (SN-1)	N21,646.6	E26,538.1	836.6 T.C.
M492	N21,767.9	E26,253.8	839.7 T.C.
M493 (SN-3)	N21,816.2	E26,001.7	845.0 T.C.
M494 (SN-4)	N21,868.1	E25,782.0	844.5 T.C.
M495	N21,855.0	E25,384.4	846.0 T.C.
M496	N21,968.1	E26,826.7	831.7 T.C.
M497	N21,778.1	E24,702.7	843.2 GRND.
M498	N21,798.9	E24,701.4	845.1 T.C.
M499	N21,954.7	E26,809.3	829.7 T.C.
M491 (SN-2)	N21,768.3	E26,512.8	834.0 T.C.
M482	N21,638.5	E26,201.6	846.4 T.C.
M483	N21,738.6	E25,829.4	849.7 T.C.
M484	N21,995.5	E25,703.8	838.9 T.C.
M485	N21,990.2	E26,054.7	835.0 T.C.
M486	N21,896.1	E26,302.5	838.6 T.C.
M487	N22,107.0	E26,218.0	833.3 T.C.
JS-1	N21,950.6	E26,172.2	835.5 T.C.
JS-2	N22,129.5	E25,182.1	839.5 T.C.
JS-3	N21,825.6	E24,601.6	842.7 T.C.

[a]T.C. indicates top of casing.

APPENDIX B. RADIONUCLIDE RELEASE DATA

Table B-1. Information regarding wells in the vicinity of SWSA 3

All measurements in feet[a] below land surface

Well	Bedrock units penetrated	Overburden thickness	Well depth	Depth to water 7-12-78	Depth to water 1-26-79
3	G, F	12.0	250.7	8.70	5.87
9	G	22.0	98.7	20.47	18.04
15	G	25.0	99.6	28.04	22.19
16	G, F, E	12.0	99.9	28.75	26.02
20	F, E	12.5	99.0	21.01	20.63
21	G, F, E	12.0	99.8	25.50	24.49
22	G, F, E	10.5	100.5	14.78	10.45
23	G	10.0	100.0	5.25	1.01
32	G	8.7	99.3	10.31	6.44
41	G, F	10.0	33.5	32.22	32.22
42	G	1.0	49.2	19.65	11.95
43	G	9.5	46.5	5.62	4.69
44	G	9.0	49.4	19.05	18.58
45	G	6.5	24.2	3.05	0.98
46	G	3.0	50.3	2.99	1.63
49	H	8.0	46.6	2.43	1.15
301			14.1	6.37	2.18
302			6.3	3.53	2.62
303			6.2	3.23	1.43

[a]1 ft = 0.3048 m.

Source: Stueber et al. (1981).

Table B-2. Strontium-90 concentrations in groundwater samples from wells in the vicinity of SWSA-3

For well locations see Fig. 6. All measurements in pCi/ml.

Well	11-13-73[a]	7-10-78	1-79
3	≤0.05	0.14[b]	0.01
9	1.49	0.05[c]	0.01
15	≤0.05	1.08	0.63
16	0.50	0.21	0.14
20	≤0.05	<0.01	<0.01
21	0.27	0.05	0.06
22	≤0.05	<0.01	0.01
23	≤0.09	<0.01	<0.01
32	≤0.05	≤0.01	0.01
41		1.98	0.77
42		<0.01	0.01
43		0.02	0.05
44		<0.01	<0.01
45		<0.01	<0.01
46		<0.01	0.02
49		0.01	0.01
301	0.14	0.07	<0.01
302	0.45	0.42	0.16
303	0.27	0.18	0.13

[a]Duguid 1975.
[b]Concentration of ^{137}Cs = 0.18 pCi/ml; ^{60}Co = 0.05 pCi/ml.
[c]Concentration of ^{137}Cs = 0.08 pCi/ml.

Source: Steuber et al. (1981).

Table B-3. Strontium-90 concentrations in water samples from the Raccoon Creek Tributary Stream

For sample locations, see Fig. 8. All measurements in pCi/ml.

Sample	^{90}Sr	Distance upstream (m)
T-1A	0.03	
TCTS	0.06	29
T-1B	<0.01	75
T-1C	<0.01	150
T-1D	<0.01	225
T-1E	<0.01	300
T-1F	<0.01	375
T-1G	0.01	450
T-1H	<0.01	468

Source: Steuber et al. (1981).

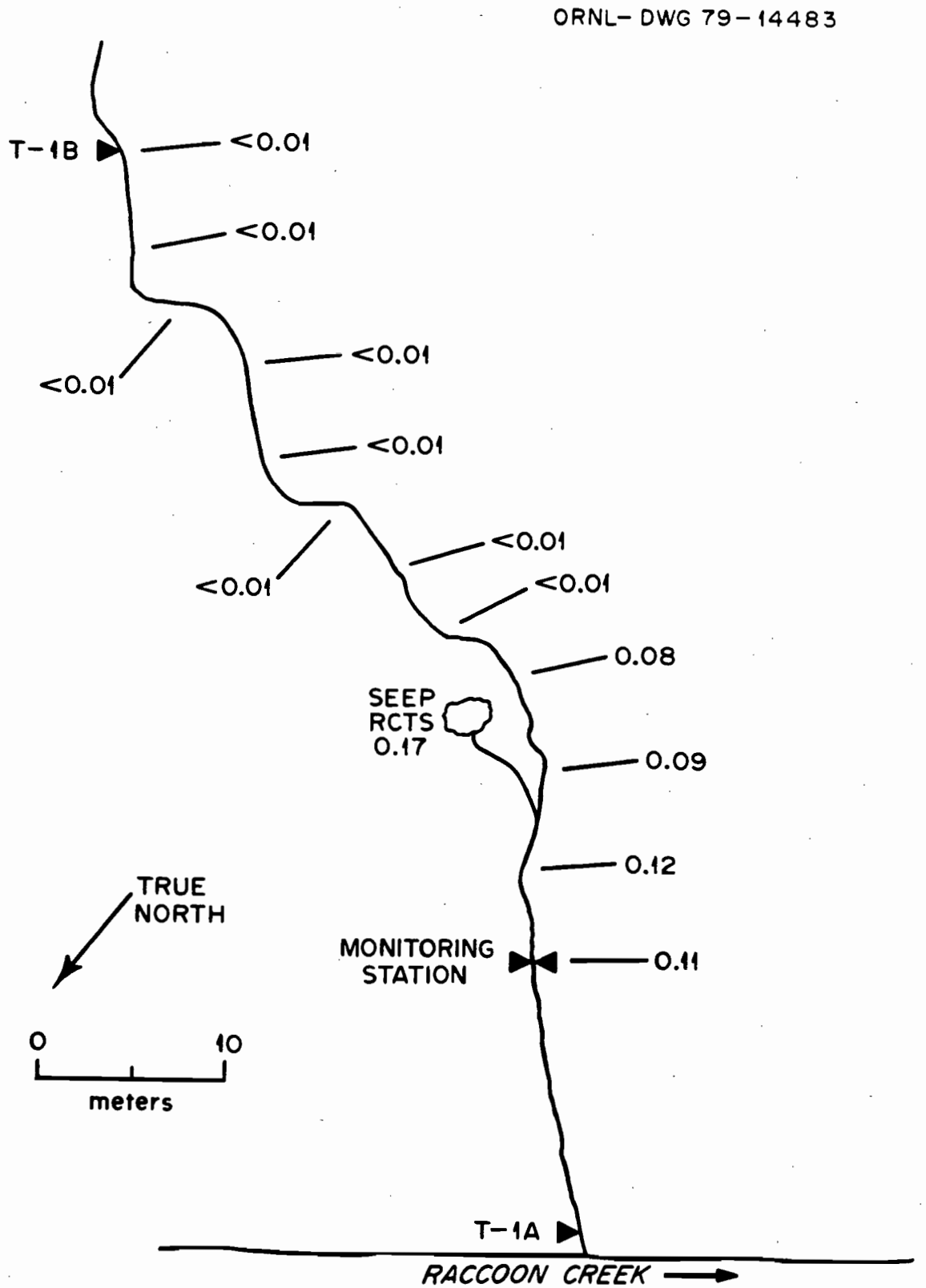

Fig. B-1. ^{90}Sr concentrations (pCi/ml) in the Raccoon Creek Tributary Stream at 5-m intervals near seep RCTS.

ORNL-DWG 79-14485A

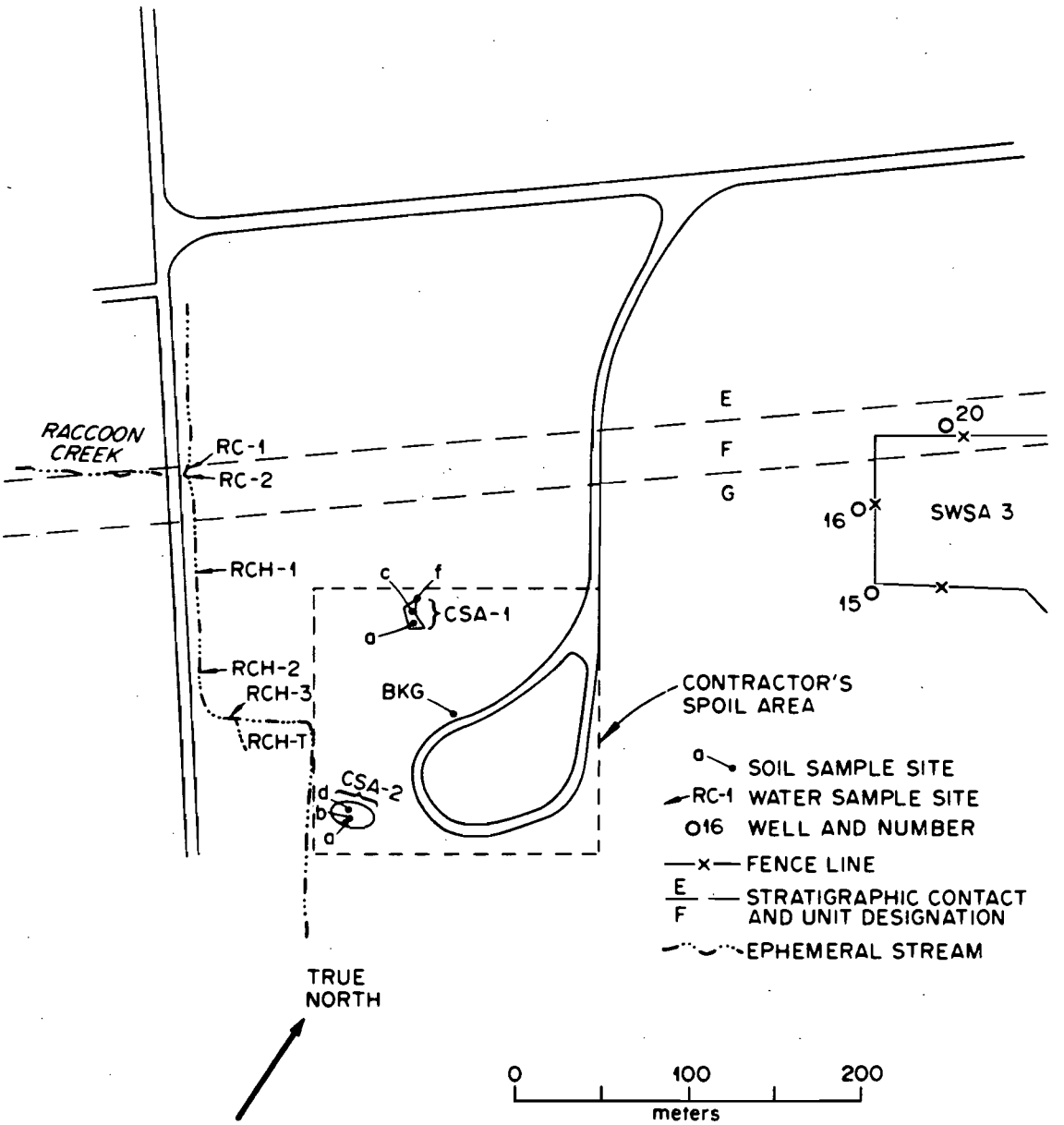

Fig. B-2. Soil sample locations and surface water sampling sites (or Contractor's Landfill) (see Table B-4).

Table B-4. Concentrations of ^{137}Cs, ^{60}Co, and ^{90}Sr in surface samples from the Contractor's Landfill

For sample locations, see Fig. B-2. All measurements in pCi/g.

Sample	^{137}Cs	^{60}Co	^{90}Sr
CSA-1-a			
Soil	1450	$\leq$0.20	257.0 ($\pm$27)
Gravel	2680	$\leq$0.17	
CS-1-c			
Soil	959	$\leq$0.17	14 ($\pm$8)
Gravel	1080	$\leq$0.10	
CSA-1-f			
Soil	9.5	$\leq$0.14	17 ($\pm$4)
Gravel	8650	$\leq$0.19	
CSA-2-a			
Soil	323	2.3	6.3 ($\pm$4)
CSA-2-b			
Soil	649	4.8	20 ($\pm$11)
CSA-2-d			
Soil	550	3.2	8.6 ($\pm$8)
CSA-BKG			
Soil	3.6	$\leq$0.16	1 ($\pm$0.9)

Source: Steuber et al. (1981).

Table B-5. Strontium-90 concentrations in surface runoff water samples collected near the Contractor's Landfill on February 23, 1979

For sample locations, see Fig. 8.

Sample	^{90}Sr (pCi/ml)
RC-1	0.01
RC-2	0.02
RCH-1	<0.01
RCH-2	<0.01
RCH-3	0.01
RCH-T	<0.01

Source: Steuber et al. (1981).

Table B-6. Strontium-90 analyses of surfacewater samples collected from the Northwest Tributary (NWT) and its tributary streams (T) in June 1978

For sample locations,[a] see Fig. 6.
All measurements in pCi/ml.

Sample	June 6, 1978	June 9, 1978
NWT-1	0.05	0.05
NWT-2	0.05	0.06
NWT-3		
NWT-4	0.35	0.09
NWT-5	0.40	0.10
NWT-6	2.93	0.12
NWT-7	0.03	0.09
NWT-7A	0.03	–
NWT-8	0.03	0.03
NWT-8A	0.03	
NWT-8B	0.05	
NWT-9		0.04
NWT-9-1	0.01	
NWT-9A	0.07	0.02
NWT-9A-1	0.01	
NWT-9B	0.01	<0.01
T-1	0.02	<0.01
T-2	<0.01	<0.01
T-3	<0.01	<0.01
T-4		0.03
T-5		0.01
T-6		0.02
T-8	<0.01	0.02
T-9	<0.01	<0.01
T-10		0.05
T-12		<0.01
T-14		<0.01

[a]The locations of most sampling sites designated with the suffix A, B, or 1 are not shown on Fig. 6. These samples were taken from pools of water in the streambed at points upstream from the 150-m site indicated by the sample number. For example, sample NWT-7A was collected at a point between sites NWT-7 and NWT-8; sample NWT-9-1 was taken at a point between sites NWT-9 and NWT-9A.

Source: Steuber et al. (1981).

Table B-7. Strontium-90 analyses of surface water samples collected from the Northwest Tributary (NWT) and its tributary streams (T) in January 1979

For sample locations, see Fig. 6 and footnote following Table B-6. All measurements in pCi/ml.

Sample	June 6, 1978	June 9, 1978
NWT-1	0.06	0.05
NWT-2	0.09	0.10
NWT-3	0.09	0.11
NWT-4	0.12	0.20
NWT-5	0.10	0.19
NWT-5A	0.29	1.13
NWT-5B	0.33	1.13
NWT-5C	0.33	1.13
NWT-5D	0.36	1.08
NWT-6	0.34	1.04
NWT-6A	0.37	1.04
NWT-6B	0.35	1.08
NWT-6C	<0.01	0.01
NWT-6D	<0.01	0.01
NWT-7	<0.01	0.01
NWT-7A	<0.01	0.02
NWT-7B	0.01	0.02
NWT-7C	0.02	0.01
NWT-7D	<0.01	0.01
NWT-8	<0.01	0.01
NWT-9	0.03	0.03
NWT-9A	<0.01	<0.01
NWT-9B	<0.01	0.01
T-1	0.01	0.01
T-2	<0.01	<0.01
T-9	<0.01	<0.01
T-10	<0.01	<0.01
T-12	<0.01	0.05
T-14	<0.01	0.05

Source: Stueber et al. (1981).

Table B-8. Strontium-90 analyses of surface water samples collected from Raccoon Creek (RC) and its tributary streams (T) on January 17, 1979

For sample locations, see Fig. 8.

Sample	^{90}Sr (pCi/ml)
RC-1	<0.01
RC-3	<0.01
RC-4	<0.01
RC-5	<0.01
RC-7	0.07
RC-9	0.05
RC-11	0.05
RC-12	0.03
RC-13	0.02
RC-14	0.02
RC-15	0.02
RC-16	0.02
RC-17	0.01
RC-18	0.01
RC-19	0.01
RC-20	0.01
RC-21	<0.01
T-1	0.09
T-3	<0.01
T-4	<0.01
T-5	<0.01
T-6	<0.01

Source: Stueber et al. (1981).

APPENDIX C. AREAL DISTRIBUTION OF ^{137}Cs, ^{60}Co, AND ^{90}Sr IN STREAMBED GRAVELS OF WHITE OAK CREEK WATERSHED

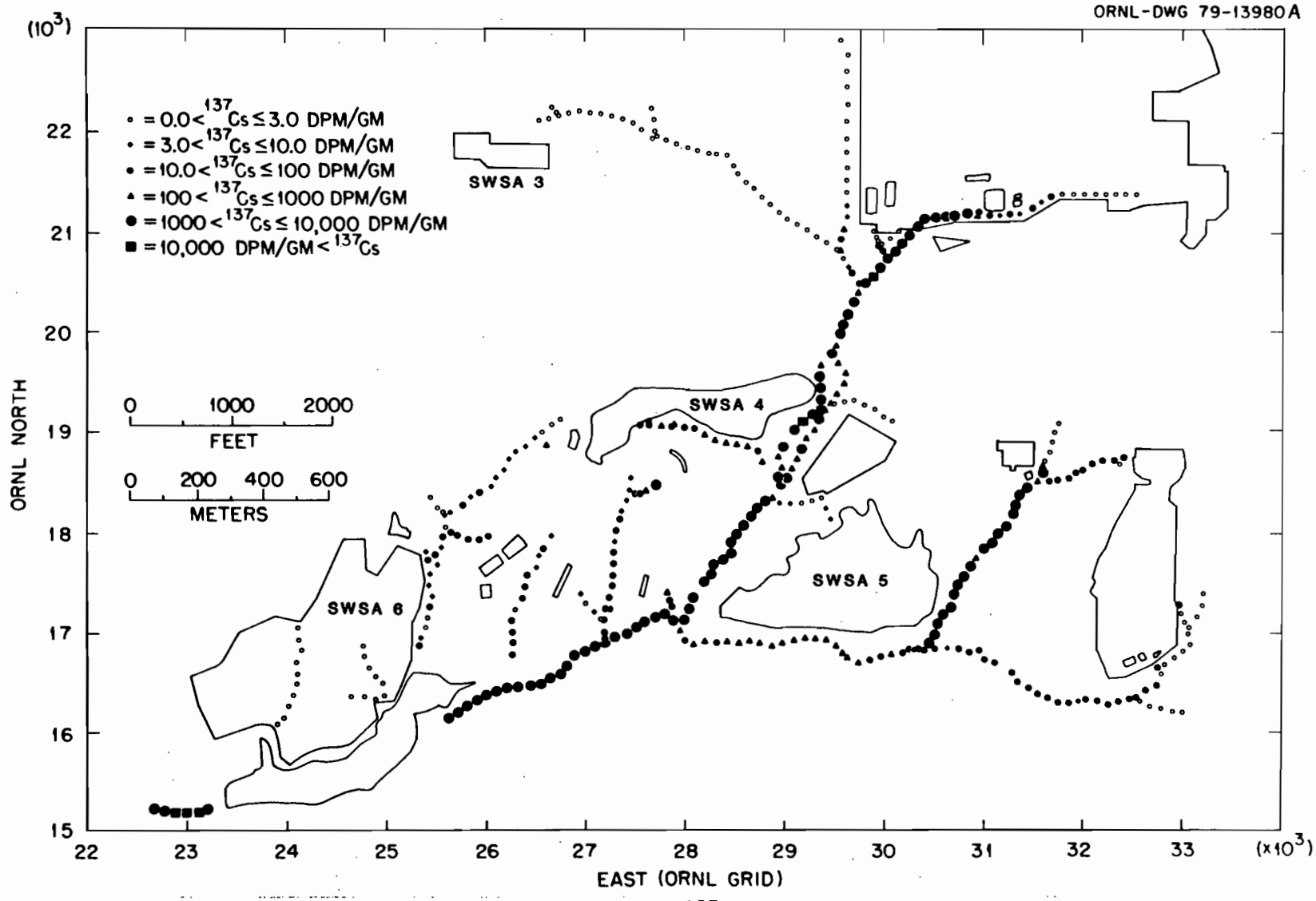

Fig. C-1. Areal distribution of ^{137}Cs activity in streambed gravels of the White Oak Creek watershed, expressed in disintegrations per minute per gram.

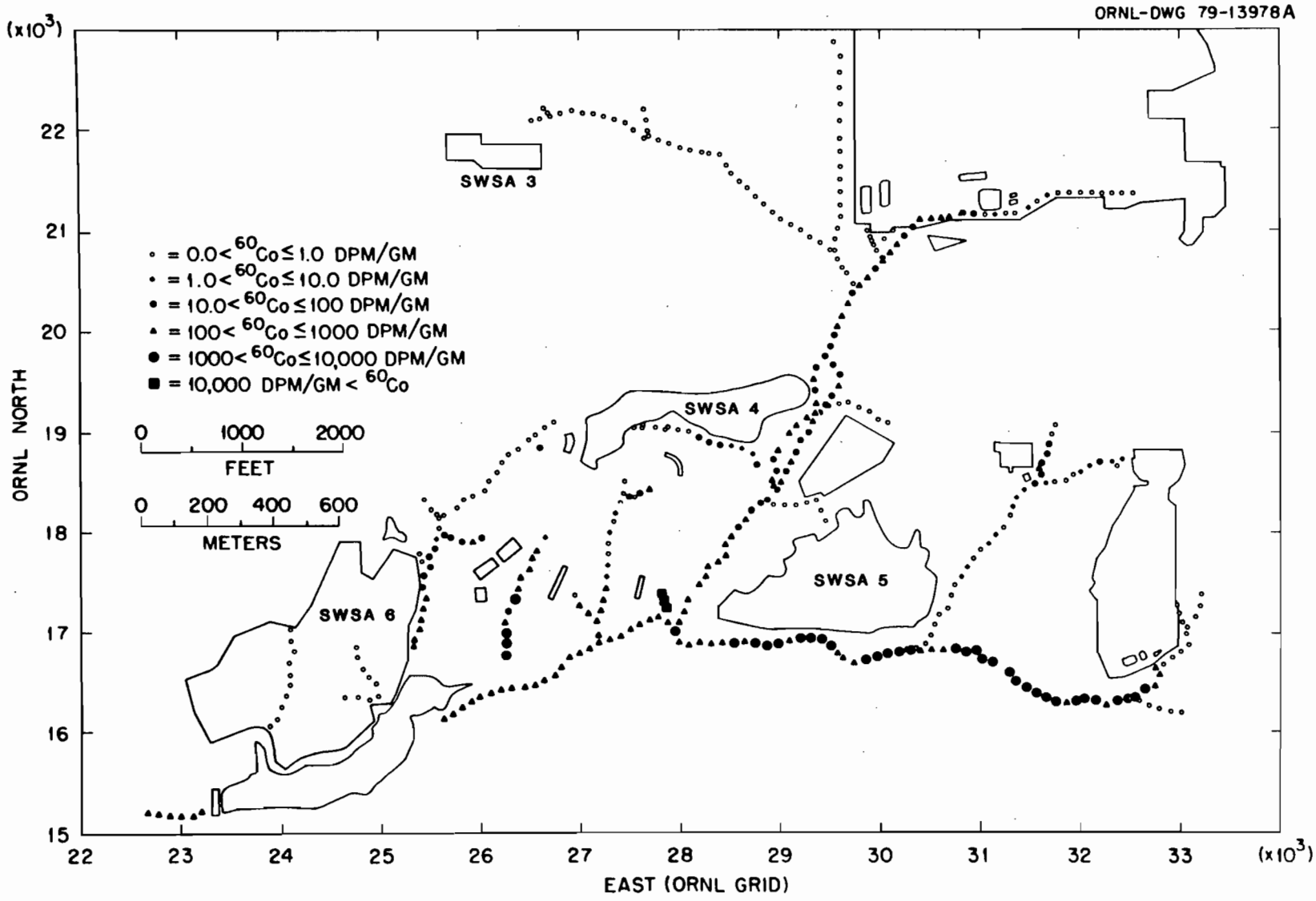

Fig. C-2. Areal distribution of ^{60}Co activity in streambed gravels of the White Oak Creek watershed, expressed in disintegrations per minute per gram.

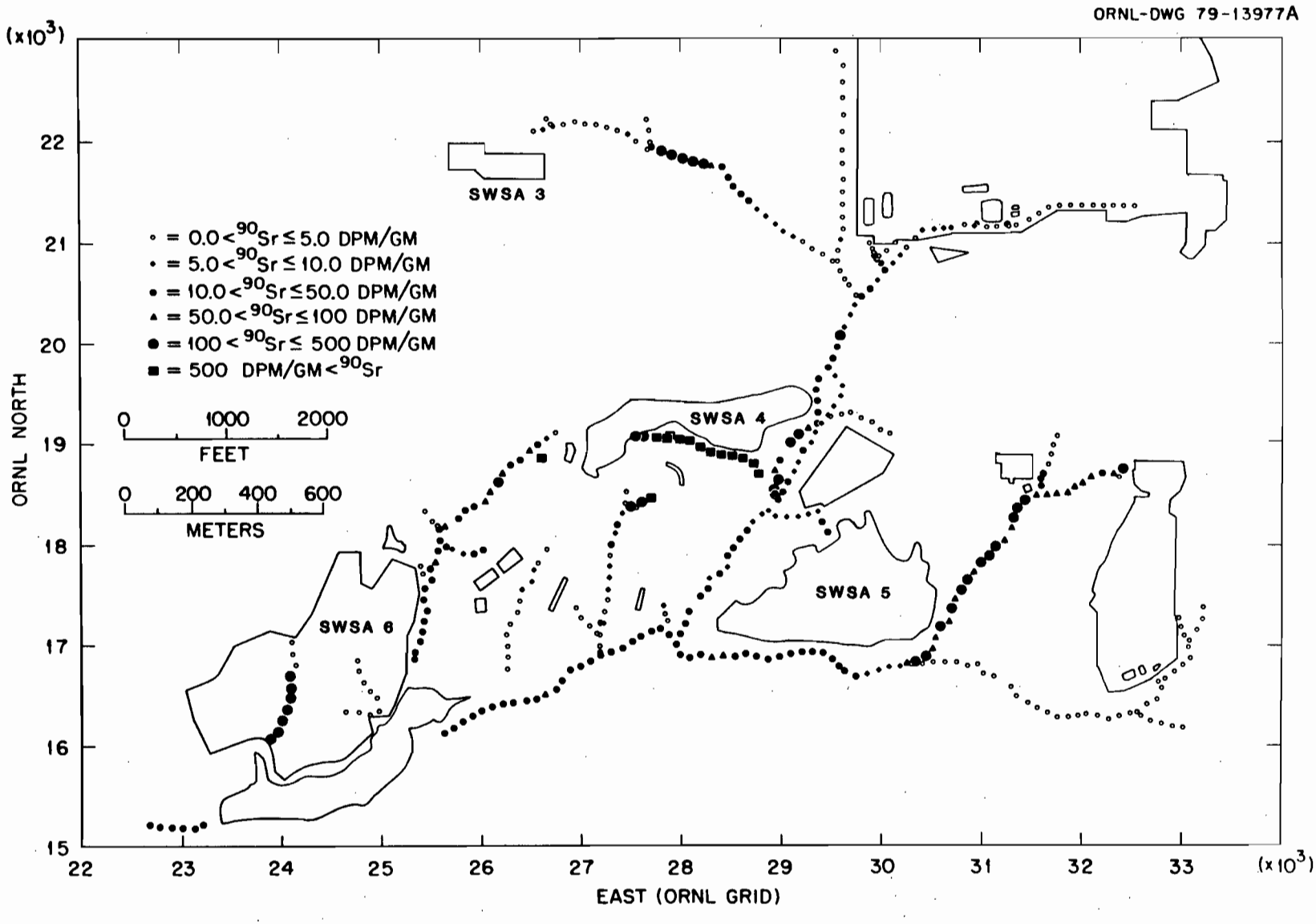

Fig. C-3. Areal distribution of ^{90}Sr activity in streambed gravels of the White Oak Creek watershed, expressed in disintegrations per minute per gram.

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