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SURFACE RADIOLOGICAL INVESTIGATIONS AT SOLID WASTE STORAGE AREA 3 (SWSA 3)

M. S. Uziel
J. A. Roberts
J. K. Williams

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OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
POST OFFICE BOX X, OAK RIDGE, TENNESSEE 37831

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TO: L. D. Bates

FROM: M. S. Uziel, 2001, MS-050 (6-0569)
J. A. Roberts, 7503, MS-382 (4-5841)
J. K. Williams, 2001, MS-050 (4-7752)

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SURFACE RADIOLOGICAL INVESTIGATIONS AT SOLID WASTE STORAGE AREA 3 (SWSA 3)

M. S. Uziel, J. A. Roberts, and J. K. Williams

Date of Issue – February 1988

Investigation Team

B. A. Berven – Environmental Assessments Program Manager
J. A. Roberts – Field Survey Supervisor

Survey Team Members

B. A. Berven	N. Ozluoglu
A. C. Butler	D. A. Roberts
W. D. Cottrell	I. Uslu
D. E. Fields	J. K. Williams
S. D. Jones	W. Winton
J. E. Nyquist	M. G. Yalcintas

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Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
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ABSTRACT

Solid Waste Storage Area 3 (SWSA 3), located in a fenced area 1 km west of the west entrance to Oak Ridge National Laboratory (ORNL), was surveyed to determine the level and extent of surface radiological contamination. Inside the fence, gamma exposure rates above background levels were identified at 98 areas totaling ~800 m^2. Of most immediate concern was a 38-m^2 area by the south fence that had gamma exposure rates of 1 mR/h at 1 m above the ground surface and 10 mR/h at the surface. Beta activity was detected in the leaves of several small saplings growing in this area, and some spillover of contaminated leaves outside the fence was evident.

Other elevated areas inside the fence ranged from 17 μR/h to 1400 μR/h, except for seven scattered spots that had readings of 2 or 3 mR/h. No contamination was found outside the fence on the west, south, and east sides. Three areas of contamination ranging from 17 to 340 μR/h were defined outside the fence on the north side. Recommendations for corrective actions are included.

SURFACE RADIOLOGICAL INVESTIGATIONS AT SOLID WASTE STORAGE AREA 3 (SWSA 3)

INTRODUCTION

A surface radiological investigation of Solid Waste Storage Area 3 (SWSA 3) was conducted on August 19, 1987, by the Environmental Assessments group of the Health and Safety Research Division (HASRD) of the Oak Ridge National Laboratory (ORNL) at the request of the Remedial Action Program (RAP) of ORNL. The purpose of this survey was (1) to determine the level and the extent of surface radiological contamination and (2) to recommend corrective actions if areas of significant gamma radiation were identified.

SWSA 3 has been assigned to Waste Area Group (WAG) 3 and to Solid Waste Management Unit (SWMU) 3.3 by the ORNL RAP.[1]

SITE HISTORY

SWSA 3 is located in Bethel Valley in a fenced area at the foot of Haw Ridge about 1 km (0.6 mi) west of the west entrance to the laboratory complex at ORNL grid coordinates (measured in feet) North 21,760 and East 26,200.[1,2] The site was presumably chosen because of its proximity to ORNL, its inconspicuous location, and the fact that the soil could easily be excavated.[3] SWSA 3 was opened in May 1946 and closed during the early part of 1951.[4] During this period the area was used at a rate of 6070 m^2 (1.5 acres) per year[4] primarily for the disposal of contaminated trash, laboratory equipment, and other discarded materials.[5] Figures 1 and 2 show the location of SWSA 3 in relation to other SWSAs and the main ORNL complex.

The trenches at SWSA 3 were cut parallel to each other across the width of the site[6] (see Fig. 3). The soil mantle was removed down to bedrock, generally less than 4.6 m (15 ft) deep, and waste was dumped into the excavation.[4] During the early operation of SWSA 3, alpha waste in drums was deposited in concrete-lined trenches in the northeast end of the burial ground. Later, alpha waste was placed directly into unlined trenches and covered with concrete as the burial ground was extended to the west. Beta-gamma waste was buried in separate, unlined trenches and backfilled with the excavated soil.[3] The site was expanded westward until hard rock was encountered, making excavation difficult.[6] SWSA 3 was closed in 1951 after ~28,330 m^2 (7 acres) had been used to bury ~16,990 m^3 (600,000 ft^3) of low-level waste (LLW) containing ~44,000 to 56,000 Ci of radioactivity.[1]

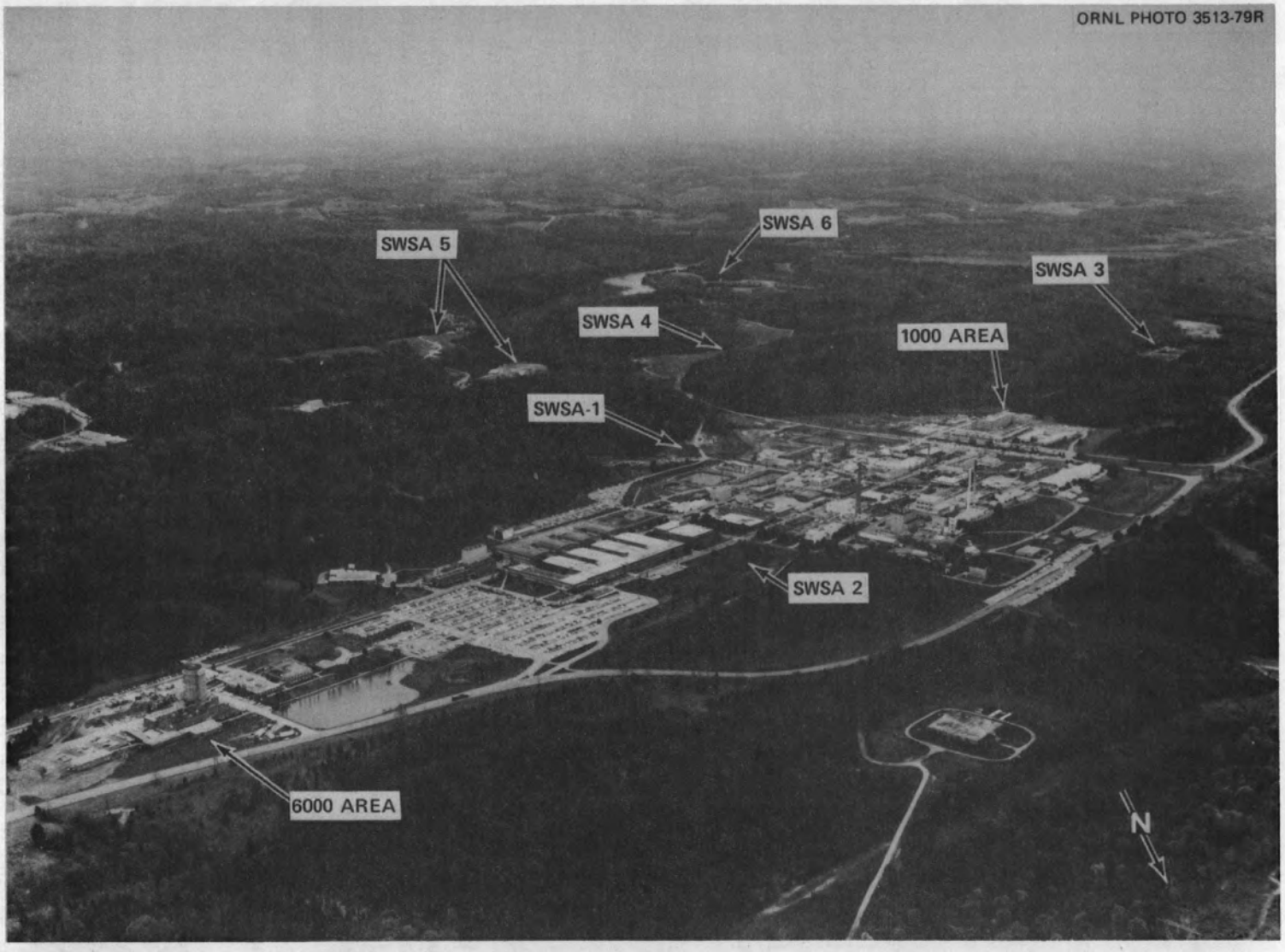

Fig. 1. Aerial view of the Solid Waste Storage Areas at ORNL.

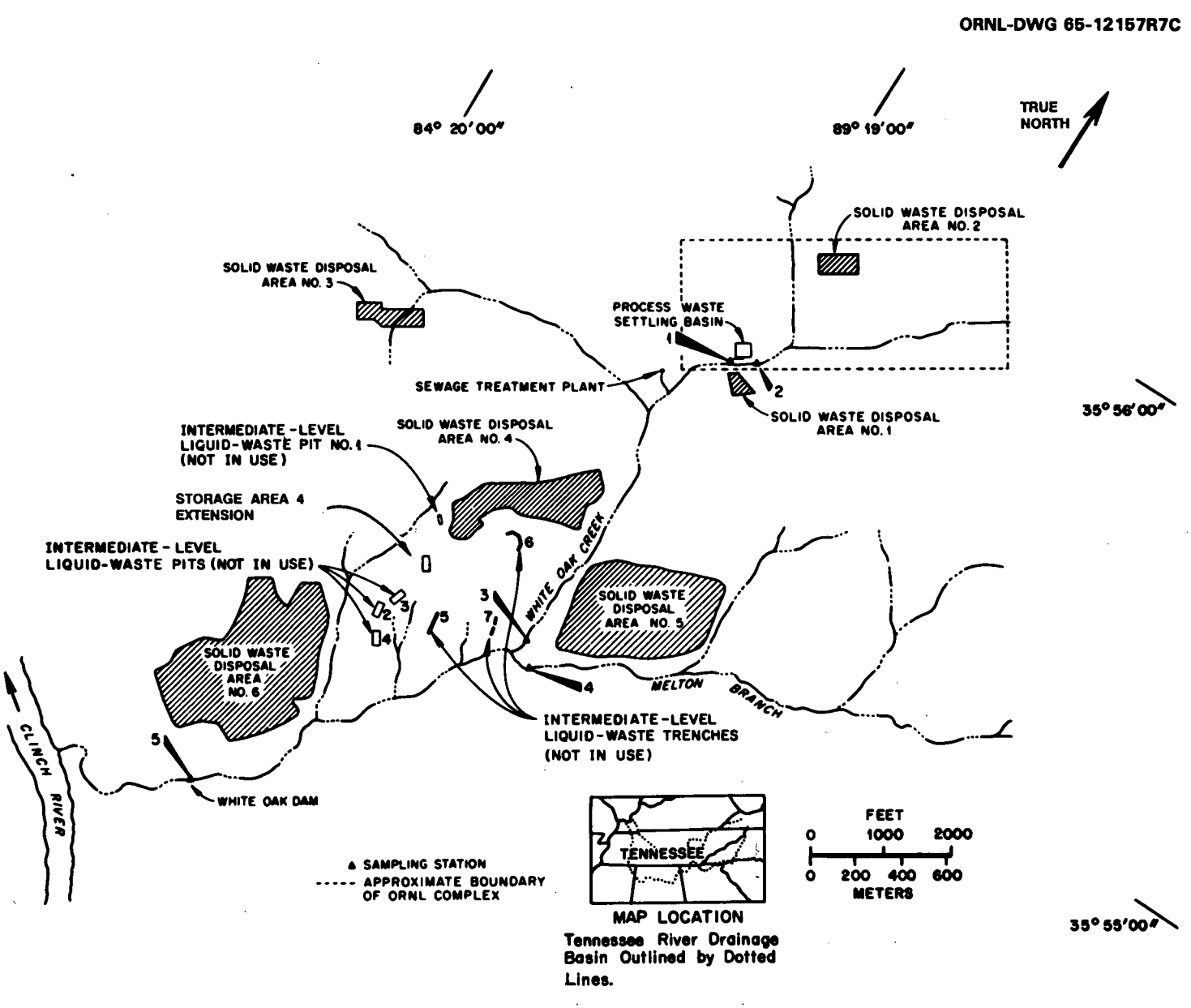

Fig. 2. Map of White Oak Creek drainage, monitoring station locations, and principal waste disposal areas for ORNL.

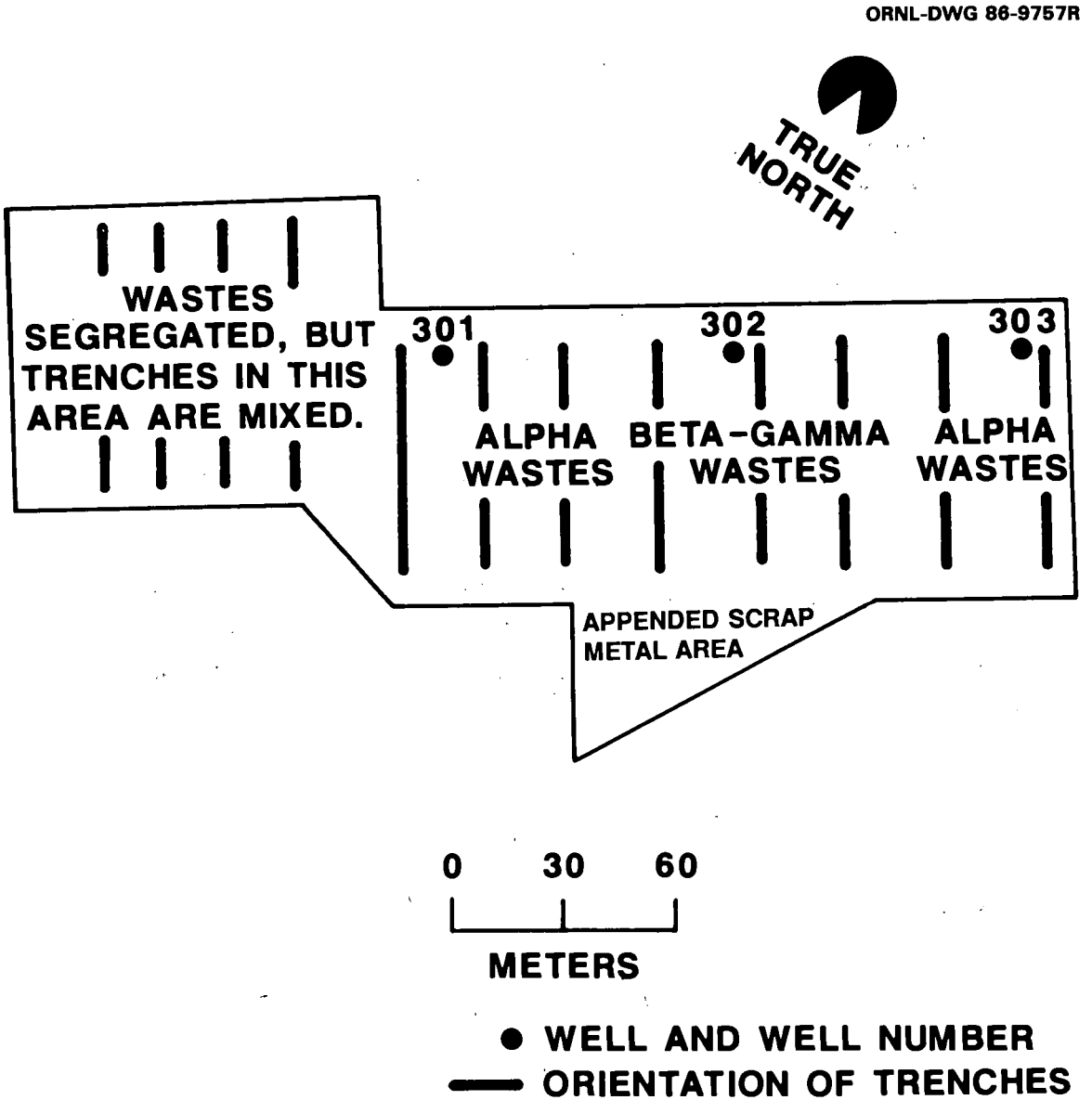

Fig. 3. Schematic diagram showing the orientation and general location of radioactive waste trenches in SWSA 3.

After the site was closed, it was used for the temporary storage of large items of slightly contaminated equipment that either were too awkward to bury or were salvageable[5] (see Fig. 4). These items were stored within the fence surrounding the burial ground area and above ground, allowing precipitation to mobilize surface radioactive contaminants.[7] During 1978 and 1979, a cleanup program was initiated to remove the aboveground material.[3] Stored items with detectable contamination levels were removed and buried in trenches in SWSA 6. Stored items with contamination levels undetectable by field survey instruments were buried in a landfill in SWSA 5. Radioactively contaminated items that were tagged for continued storage were removed to a fenced aboveground storage area just west of SWSA 4 called Storage Area 4 Extension[8] (see Fig. 2).

After removal of aboveground stored items (see Fig. 5), the east section of SWSA 3 was covered with about 0.2 m (8 in.) of dirt and sown with grass. A ditch was dug along part of the south fence line to divert runoff from across the surface of the area. All trees growing in the area were removed.[8]

In 1982, a small triangular-shaped section just south of the fenced area was found to contain buried contaminated metal. A fence was constructed to enclose this additional area. Upon completion of the new fence, the section of original fence between SWSA 3 and the new area was removed. The addition was leveled, fertilized, and seeded with grass and is now maintained along with the rest of SWSA 3 (see Fig. 3).[8]

In 1964, well-water samples were found to contain small amounts of trivalent rare earths (TRE), ^{90}Sr, ^{89}Sr, and ^{3}H.[3] Well-water samples collected in 1973 indicated ^{90}Sr levels up to 3.0 dpm/mL. Soil samples analyzed in 1978 indicated higher than natural soil background levels of ^{90}Sr.[2,9,10]

Analysis of surface water and groundwater in 1979 indicated that ^{90}Sr was moving through groundwater flow to the northeast and to the southwest of SWSA 3. Seven months of stream monitoring showed that ^{90}Sr was entering the Northwest Tributary of White Oak Creek about 350 m (1148 ft) from the disposal area at a rate of 2.1 to 11.1 mCi per month (average 6.4 mCi per month). Strontium-90 activity was also discharging from a seep adjacent to a Raccoon Creek tributary stream about 640 m (2100 ft) southwest of SWSA 3 at a rate of ~0.5 mCi per month. The trend of a line connecting the two seeps passes through the disposal area and is parallel to bedrock strike[7] (see Fig. 6).

SWSA 3 is currently fenced, covered with grass, and showing no significant sign of erosion (see Fig. 7). Runoff is directed to White Oak Creek via shallow drainage ditches located immediately outside the fence on both the east and west ends of the site.[5]

SURVEY METHODS

Beta-gamma measurements were taken with a portable Technical Associates (TA) mini-scaler/rate meter model RRS-3 with an HP-210 end-window (pancake) detector (2 mg/cm^2 window thickness). A portable survey meter with a NaI scintillation probe was used to detect contamination associated with gamma radiation. The scintillation probe was connected to a Victoreen Model 470 Thyac III rate meter.

Fig. 4. View of the east end of SWSA 3 looking west before 1978–1979 surface cleanup.

ORNL PHOTO 5064-80

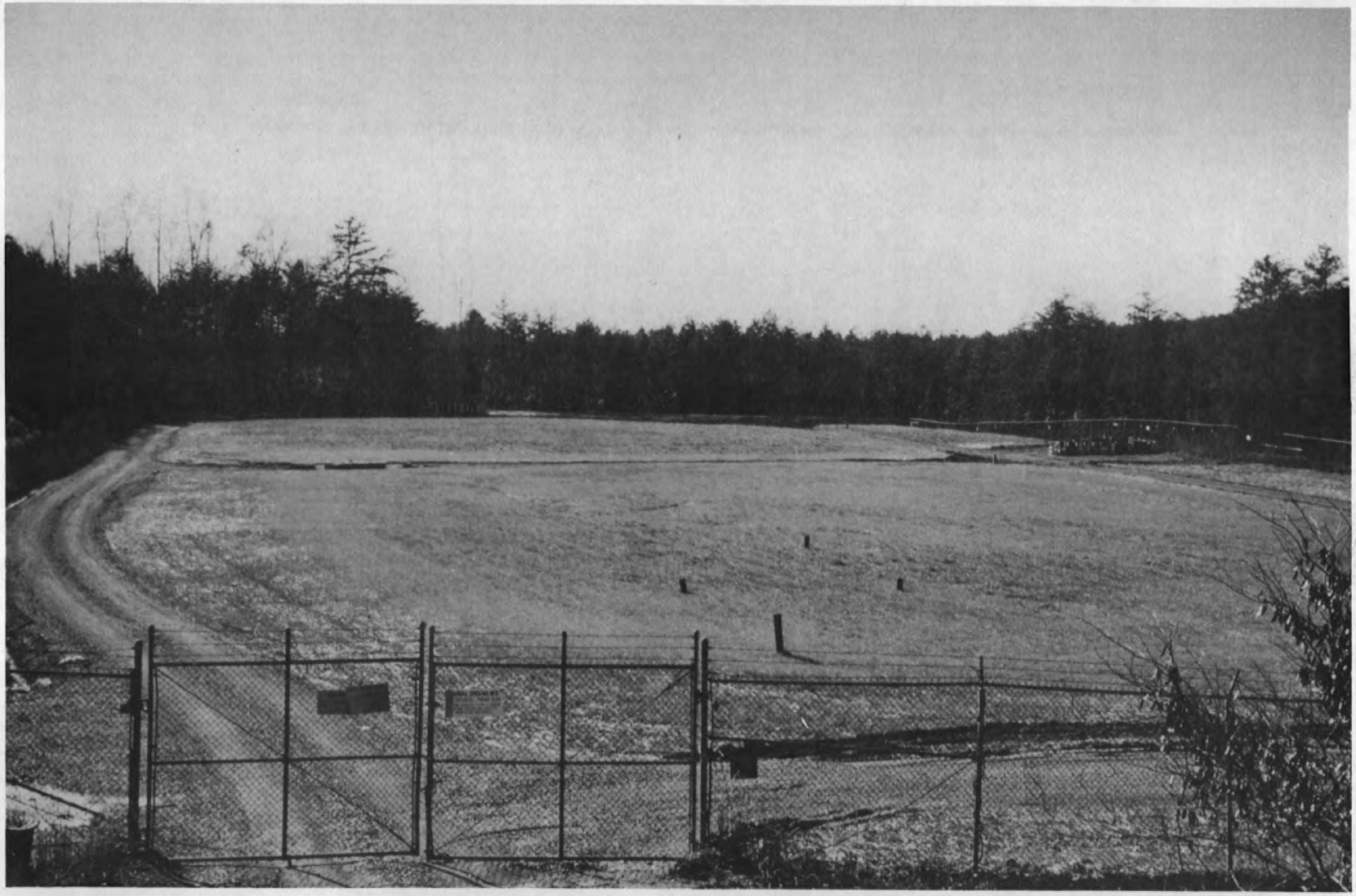

Fig. 5. SWSA 3 after 1978–1979 surface cleanup.

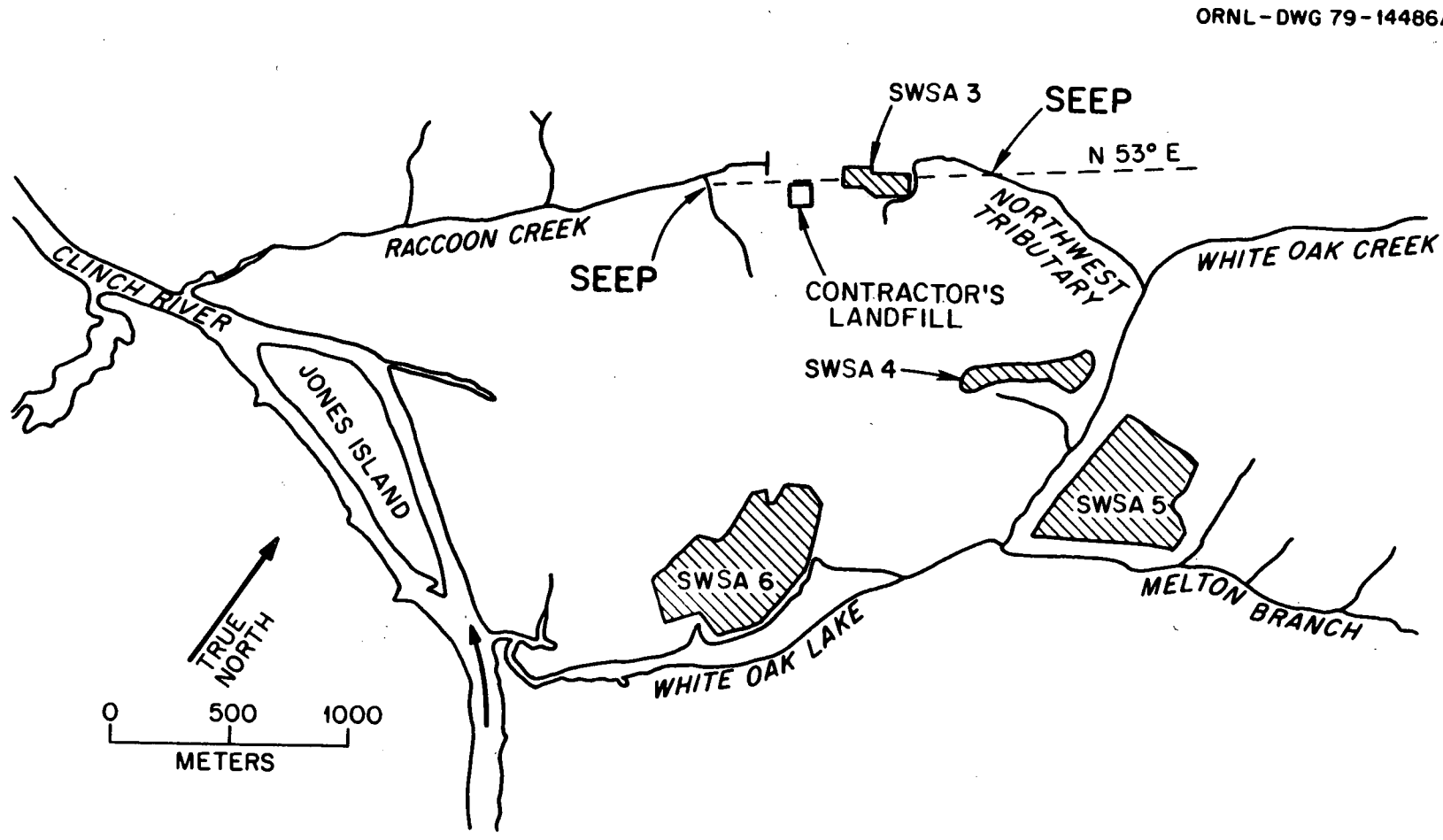

Fig. 6. Drainage systems in the vicinity of SWSA 3, including the two ^{90}Sr seeps and the trend of a line connecting them.

ORNL PHOTO 6304-87

Fig. 7. View of the east end of SWSA 3 looking west (August 1987).

Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels made with these instruments must be normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates. The function developed for these conversions is:

$$y = x/\mathrm{CF}$$

where

y = the exposure rate in μR/h,

x = the scintillometer measurements in counts per minute (cpm),

CF = the conversion factor determined in the field through a direct correlation between a selected number of PIC measurements and scintillometer measurements in cpm/(μR/h).

For this site, CF = 588 cpm/(μR/h).

For convenience in reporting results, the entire outdoor area was divided into 30.5-m (100-ft) grid blocks as shown in Fig. 8. The grid blocks are identified by the intersection of two perpendicular lines. The first coordinate identifies 100-ft distances from point 0 plus two digits representing any additional number of feet (e.g., 1+00 = 100 ft or 9+35 = 935 ft). The second coordinate is derived from distance to the right or left of the baseline, BL (e.g., 100 ft to the R = 100R).

A comprehensive description of the survey methods and instrumentation is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).[11]

SURVEY RESULTS

BACKGROUND LEVELS

Background gamma exposure rates measured at uncontaminated outdoor areas on the Oak Ridge Reservation are listed in Table 1. Eighteen measurements taken at nine random locations ranged from 8 to 13 (average 10) μR/h at 1 m (3.3 ft) and from 10 to 17 (average 13) μR/h at the surface. A map showing the location of these uncontaminated outdoor areas is given in Fig. 9. All measurements presented in this report are gross readings; background radiation levels have not been subtracted.

GAMMA EXPOSURE RATE MEASUREMENTS

Gamma exposure rates measured at grid points at SWSA 3 are shown in Table 2 and Fig. 10. The range of surface gamma exposure rate measurements in grid blocks is shown in Table 3 and Fig. 11. Gamma exposure rates above background levels were

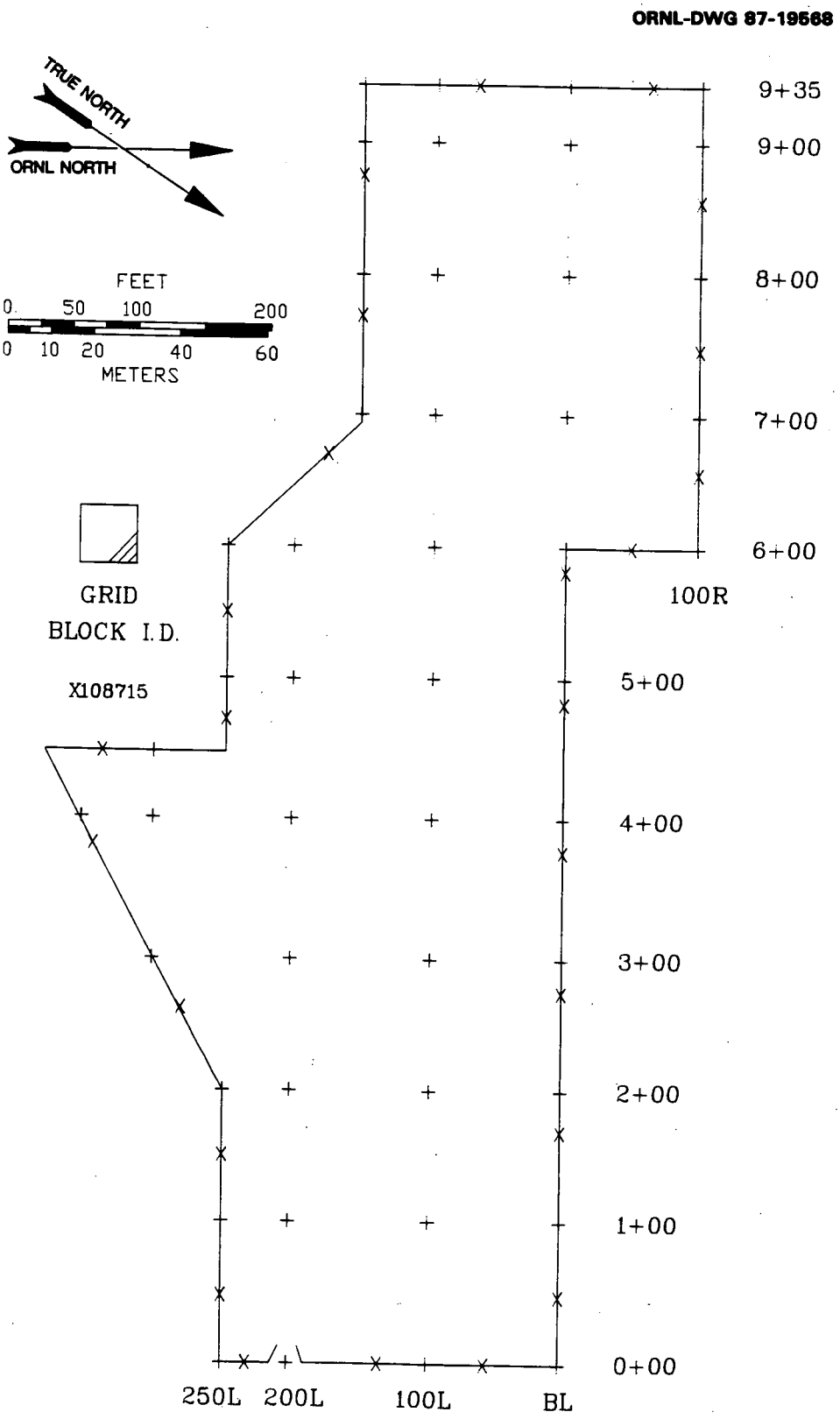

Fig. 8. Diagram showing grid point and grid block locations at SWSA 3.

Table 1. Radiation levels measured in uncontaminated areas on the Oak Ridge Reservation

Type of radiation[a]	Radiation level	
	Range	Average
Gamma exposure rate at 1 m above ground surface (μR/h)	8-13	10
Gamma exposure rate at ground surface (μR/h)	10-17	13

[a]Values were obtained from 18 measurements taken from 9 random locations on the Oak Ridge Reservation. (See Fig. 9 for locations.)

identified at 74 areas and 24 point sources totaling ~800 m^2. Most of the elevated gamma exposure rates ranged from 17 μR/h to 1400 μR/h. Levels of 2000 or 3000 μR/h were noted in eight widely scattered areas involving seven grid blocks.

Of particular concern is a 38-m^2 area on the south side of the SWSA near the fence at the intersection of grid blocks 5+00,200L and 6+00,200L. Gamma exposure rates 1 m (3.3 ft) above the ground surface were 1000 μR/h. Gamma exposure rates on contact with the ground surface and with a soil sample that had been removed from the area to eliminate background interference were 10,000 μR/h. Beta activity was detected in the leaves of several small saplings growing just inside the fence. Some spillover of contaminated leaves outside the fence was evident.

Gamma exposure rate measurements taken outside the fence indicated no contamination on the west, south, and east sides of SWSA 3, but three areas of contamination were identified on the north side. Just north of grid block 6+00,100R is a 90-m^2 area that originates inside the fence and extends outside the fence. Surface gamma exposure readings in this area ranged from 17 to 170 μR/h. A second area, also north of grid block 6+00,100R, originates outside the fence and extends further north. This 220-m^2 area has gamma levels of 51 to 340 μR/h. A third contaminated area, located just north of grid block 2+00,BL, extends along a ditchline in a northeasterly direction. Gamma readings range from 140 μR/h near the fence to 42 μR/h about 6 m (20 ft) down the ditch. Part of this surface contamination was covered over when a gravel road was constructed in the area.

RECOMMENDATIONS FOR CORRECTIVE ACTIONS

The most immediate surface contamination problem inside the fence was identified at a ~38-m^2 area on the south side of SWSA 3 (at the intersection of grid blocks 5+00,200L and 6+00,200L). Gamma exposure rates up to 1 mR/h were measured at

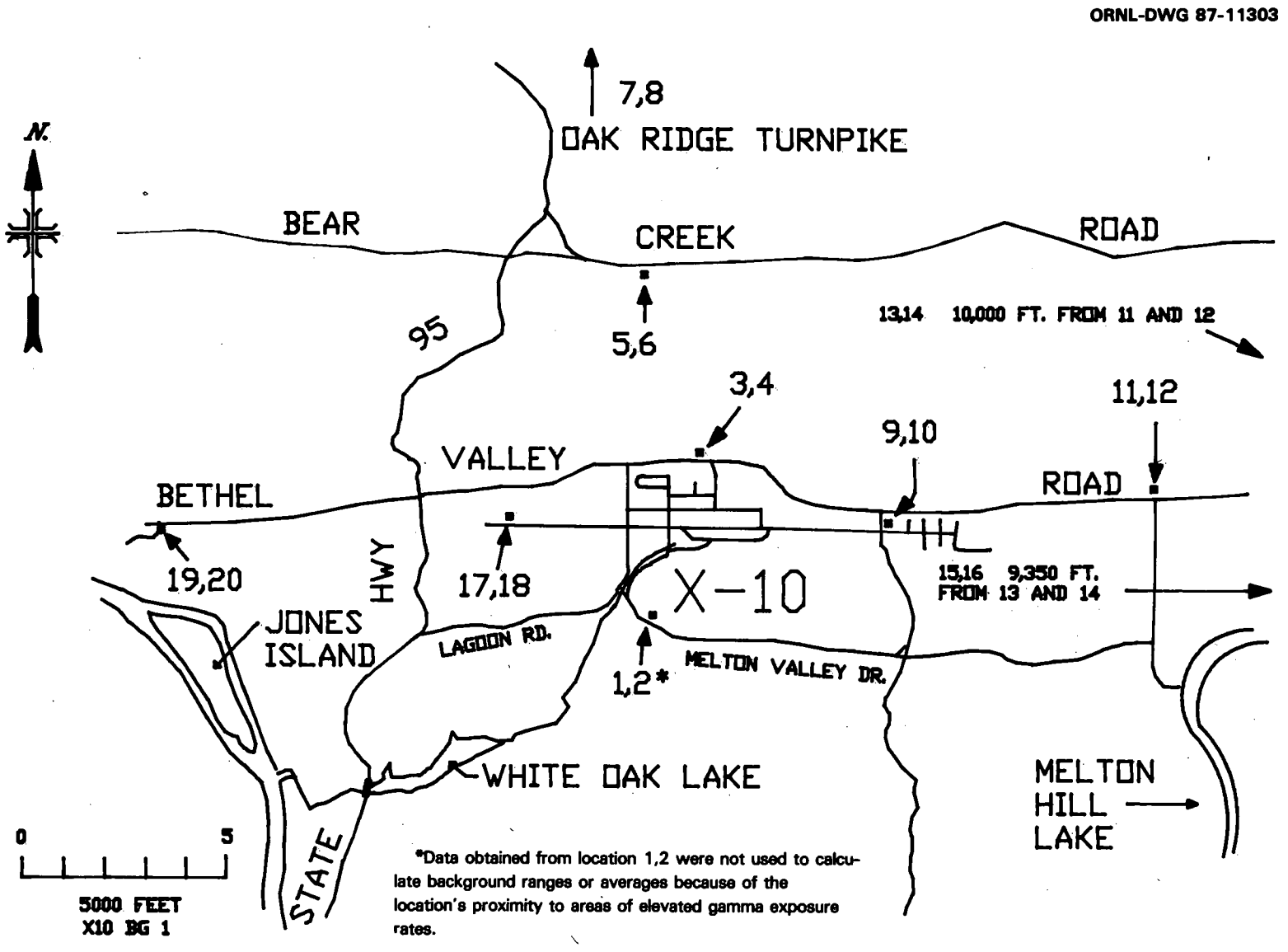

Fig. 9. Locations of gamma exposure rate measurements in uncontaminated areas on the Oak Ridge Reservation.

Table 2. Gamma exposure rate measurements at grid points at SWSA 3

Grid point[a]	Grid point measurements (μR/h)[b]	
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface
0+00,BL	19	15
1+00,BL	26	54
2+00,BL	15	12
3+00,BL	22	27
4+00,BL	46	29
5+00,BL	12	12
6+00,BL	12	11
7+00,BL	15	20
8+00,BL	9	10
9+00,BL	8	8
9+35,BL	8	10
6+00,100R	12	10
7+00,100R	37	51
8+00,100R	11	9
9+00,100R	10	11
9+35,100R	9	11
0+00,100L	8	9
1+00,100L	8	10
2+00,100L	9	10
3+00,100L	10	11
4+00,100L	22	24
5+00,100L	17	17
6+00,100L	10	11
7+00,100L	20	20
8+00,100L	20	19
9+00,100L	9	10
9+35,100L	8	8

Table 2 (continued)

Grid point[a]	Grid point measurements (μR/h)[b]	
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface
7+00,150L	34	34
8+00,150L	17	34
9+00,150L	10	11
9+35,150L	8	10
0+00,200L	6	6
1+00,200L	17	17
2+00,200L	8	10
3+00,200L	9	11
4+00,200L	10	10
5+00,200L	10	10
6+00,200L	26	34
0+00,250L	7	9
1+00,250L	8	8
2+00,250L	11	10
5+00,250L	15	20
6+00,250L	360	540
3+00,300L	8	8
4+00,300L	8	8
4+50,300L	10	11
4+00,350L	13	10

[a]Grid locations are shown on Fig. 8.
[b]Grid point measurements are shown on Fig. 10.

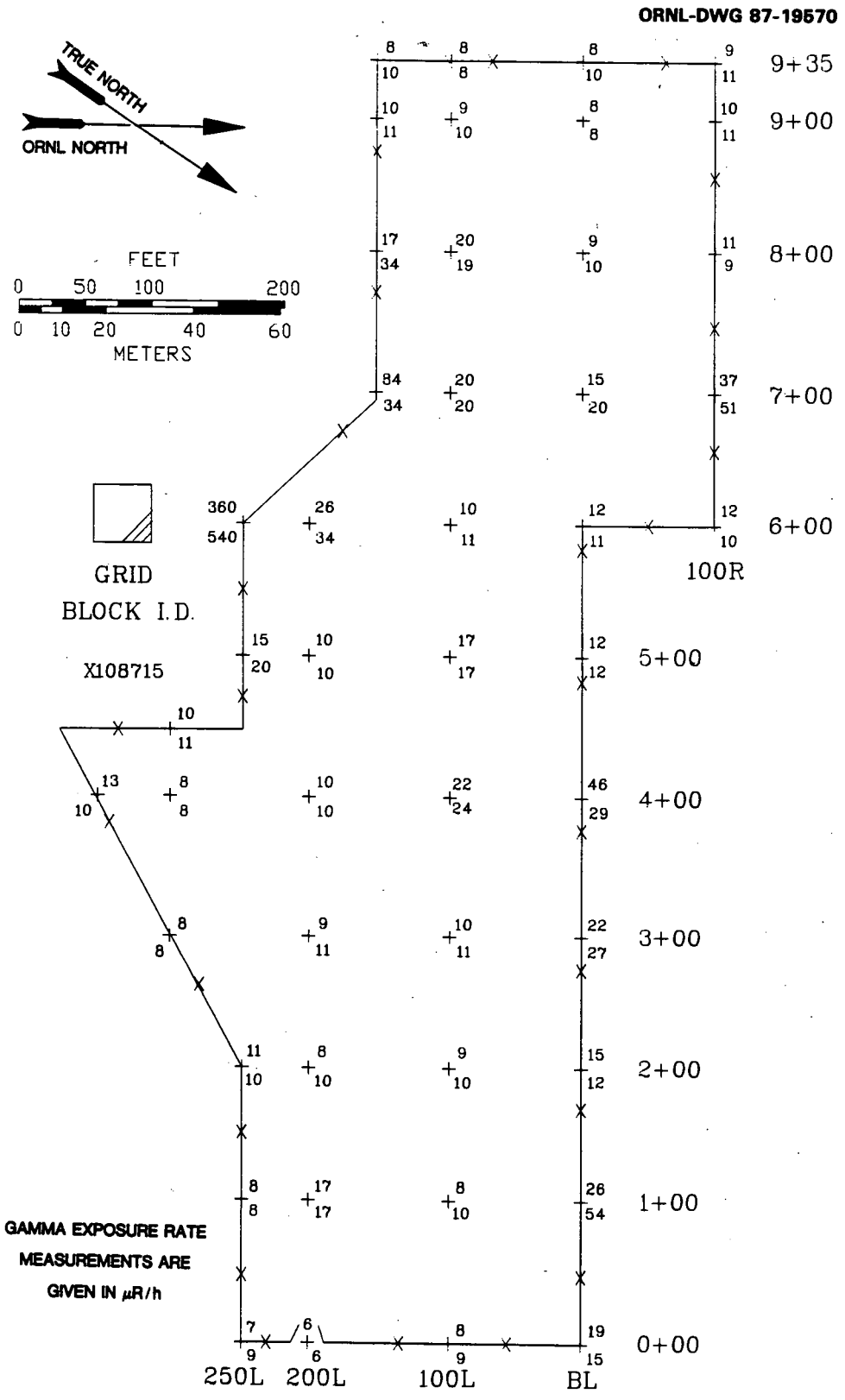

Fig. 10. Gamma exposure rate measurements at grid points at SWSA 3 (upper number = 1 meter; lower number = surface).

Table 3. Range of surface gamma exposure rate measurements in grid blocks at SWSA 3

Grid location[a]	Number of anomalies[b]	Description of anomaly[c]	Gamma exposure rates (μR/h)
0+00,BL	6	5-m^2 Area	51
		<1-m^2 Area	34
		<1-m^2 Area	34
		<1-m^2 Area	340-680
		6-m^2 Area	100-170
		2-m^2 Area	340
1+00,BL	5	3-m^2 Area	3,000
		<1-m^2 Area	34
		<1-m^2 Area	68
		<1-m^2 Area	340
		3-m^2 Area	1,400
2+00,BL	5	<1-m^2 Area	34
		<1-m^2 Area	51
		14-m^2 Area	170-3,000
		16-m^2 Area	340
		15-m^2 Area	68
3+00,BL	6	6-m^2 Area	26-51
		2-m^2 Area	34-150
		3-m^2 Area	68
		<1-m^2 Area	100
		32-m^2 Area	680
		19-m^2 Area	2,000
4+00,BL	1	14-m^2 Area	340
5+00,BL	5	23-m^2 Area	1,400
		6-m^2 Area	3,000
		3-m^2 Area	94-3,000
		11-m^2 Area	51-170
		8-m^2 Area contiguous with 5+00,100L	85
6+00,BL	7	20-m^2 Area	1,200
		<1-m^2 Area	170
		1-m^2 Area	68
		4-m^2 Area	68
		<1-m^2 Area	170
		37-m^2 Area contiguous with 7+00,BL;6+00,100L; and 7+00,100L	68
		Point source	51

Table 3 (continued)

Grid location[a]	Number of anomalies[b]	Description of anomaly[c]	Gamma exposure rates (μR/h)
7+00,BL	5	25-m^2 Area	34-85
		18-m^2 Area contiguous with 8+00,BL	34-680
		18-m^2 Area contiguous with 8+00,BL;7+00,100L; and 8+00,100L	34-510
		Point sources (2)	34-51
8+00,BL	3	50-m^2 Area contiguous with 8+00,100L	17-3,000
		Point sources (2)	34
9+00,BL	0	Background	<17
6+00,100R	2	9-m^2 Area	850
		90-m^2 Area extending outside fence	17-170
7+00,100R	0	Background	<17
8+00,100R	1	Point source	26
9+00,100R	0	Background	<17
0+00,100L	7	5-m^2 Area	340
		23-m^2 Area	34-2,000
		1-m^2 Area	85
		<1-m^2 Area	100
		<1-m^2 Area	140
		21-m^2 Area contiguous with 1+00,100L	100-170
		Point source	51
1+00,100L	1	2-m^2 Area	34-85
2+00,100L	0	Background	<17

Table 3 (continued)

Grid location[a]	Number of anomalies[b]	Description of anomaly[c]	Gamma exposure rates (μR/h)
3+00,100L	3	<1-m^2 Area	100
		<1-m^2 Area	51
		<1-m^2 Area	34
4+00,100L	0	Background	<17
5+00,100L	9	1-m^2 Area	510
		1-m^2 Area	340
		<1-m^2 Area	1,400
		1-m^2 Area	680
		17-m^2 Area contiguous with 6+00,100L	170
		4-m^2 Area contiguous with 6+00,100L;5+00,200L; and 6+00,200L	51-136
		Point sources (3)	34-420
6+00,100L	7	5-m^2 Area	1,000
		Point sources (6)	34-170
7+00,100L	4	39-m^2 Area	51-3,000
		28-m^2 Area	340-1,400
		38-m^2 Area	260-420
		13-m^2 Area near fence	34-85
8+00,100L	3	<1-m^2 Area	51
		2-m^2 Area near fence	85
		Point source	34
9+00,100L	0	Background	<17
0+00,200L	0	Background	<17
1+00,200L	8	30-m^2 Area	34-600
		<1-m^2 Area	510
		Point sources (6)	34-170
2+00,200L	0	Background	<17

Table 3 (continued)

Grid location[a]	Number of anomalies[b]	Description of anomaly[c]	Gamma exposure rates (μR/h)
3+00,200L	3	32-m^2 Area	34-1,200
		<1-m^2 Area	170
		Point source	120
4+00,200L	3	1-m^2 Area	85
		Point sources (2)	34-340
5+00,200L	3	38-m^2 Area near fence	10,000
		Point sources (2)	68-170
4+00,250L	1	Point source	260

[a]Grid locations are shown on Fig. 8.
[b]Anomalies are shown on Fig. 11.
[c]All m^2 values are approximations.

1 m (3.3 ft) above the ground surface and 10 mR/h on contact with the surface. It is believed that residual surface contamination at SWSA 3 is the result of the vertical (upward) movement of radionuclides through the soil from buried radioactive waste.

Corrective action suggestions for SWSA 3 involve ground-surface measures to limit human exposures, minimize the dispersion of surface contamination, and monitor any further dispersion of radioactivity. Corrective actions would not necessarily involve the implementation of all recommendations listed below; rather, the recommendations are to be considered individually, although a combination of measures might be selected. Soil sampling and radionuclide analyses would be required to fully characterize the radiological status of SWSA 3 and determine the most appropriate methods for effective corrective and/or remedial measures.

- Leave contaminated soil in place and cover with at least 0.3 m (1 ft) of clean uncontaminated soil. This recommendation is based on radiological soil handling criteria proposed by the Environmental Compliance and Health Protection Division of ORNL (see Attachment, Ref. 12). This corrective action would reduce the exposure rate by a factor of 100 where surface beta-gamma activity levels are less than 5 mrad/h.[12] Although these proposed guidelines are specifically for soil excavation operations, they are referenced for this nonexcavated site because their implementation would provide for personnel health protection consistent with the intent of the guidelines. It is essential that ORNL Health Physics personnel be present to monitor all activities associated with any disturbance of soil at SWSA 3.

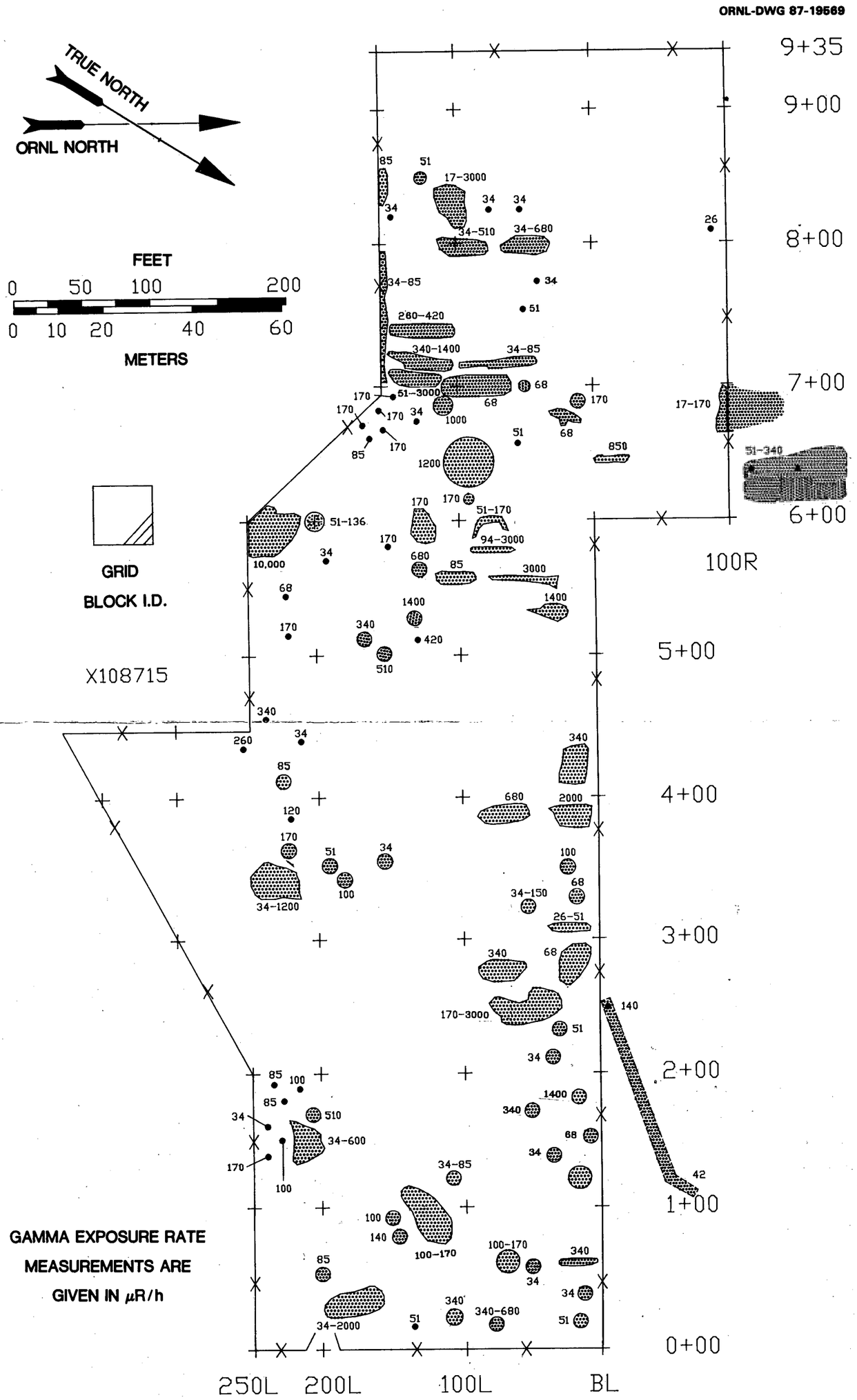

Fig. 11. Regions of elevated surface gamma exposure rates at SWSA 3.

- Implement existing radiation control measures, as stated in the *ORNL Health Physics Manual* for contaminated regions which extend outside the perimeter of the SWSA 3 fence. A permanent physical boundary, such as a metal chain attached to metal posts, should extend beyond the radiological perimeters of these regions, and "Radiation Hazard – Keep Out" signs should be attached to the boundary markers. This type of sign is recommended by ORNL Health Physics personnel for use "in areas outside the main confines of the Laboratory and where members of the general public should be warned" (see Sect. 2.3 of Ref. 13).
- Maintain institutional control of SWSA 3 for a specified period of time to allow for radioactive decay. Periodic monitoring of surface soil and water, vegetation, and groundwater should be performed.
- Identify contaminated trees in the SWSA 3 area with yellow or magenta paint using a predetermined configuration placed at some specific height on the tree trunk. Contaminated trees could additionally be identified with a "Contaminated Foliage" tag denoting the radiation hazard and date. A beta-gamma activity level of 1 mrad/h (measured on contact with any part of the tree) is suggested as the criterion level for such action.
- Minimize the dispersion of radioactivity by leaves from contaminated trees. One option is to chemically kill the contaminated trees, leave them standing, and periodically monitor the contamination in and around the trees.

A detailed discussion of contaminated land cleanup methodologies, estimates of cleanup costs, and the importance of establishing cleanup priorities is given by Baes et al.[14]

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ATTACHMENT

Appendix B of *Health, Safety, and Environmental Protection Procedure for Excavating Operations,* ORNL/M-116/R1.

APPENDIX B

RADIOLOGICAL SOIL HANDLING CRITERIA, FLOWCHART, and BASIS

Radiological Soil Handling Criteria

Category 1 This soil has unrestricted use on the Oak Ridge Reservation. Direct measurements taken at the surface of the soil are less than 300 dpm/100 cm^2 alpha and less than 0.02 mrad/h beta/gamma. Smear counts from equipment that contacted the soil are less than 20 dpm/100 cm^2 alpha and less than 200 dpm/100 cm^2 beta/gamma. If there is historical evidence of alpha or low-energy beta contamination, the soil should be analyzed in the laboratory.

If laboratory analyses indicate alpha activity greater than 0.33 Bq/g or beta/gamma activity greater than 1.8 Bq/g, the soil may not be used in an unrestricted manner but must be considered "contaminated" soil.

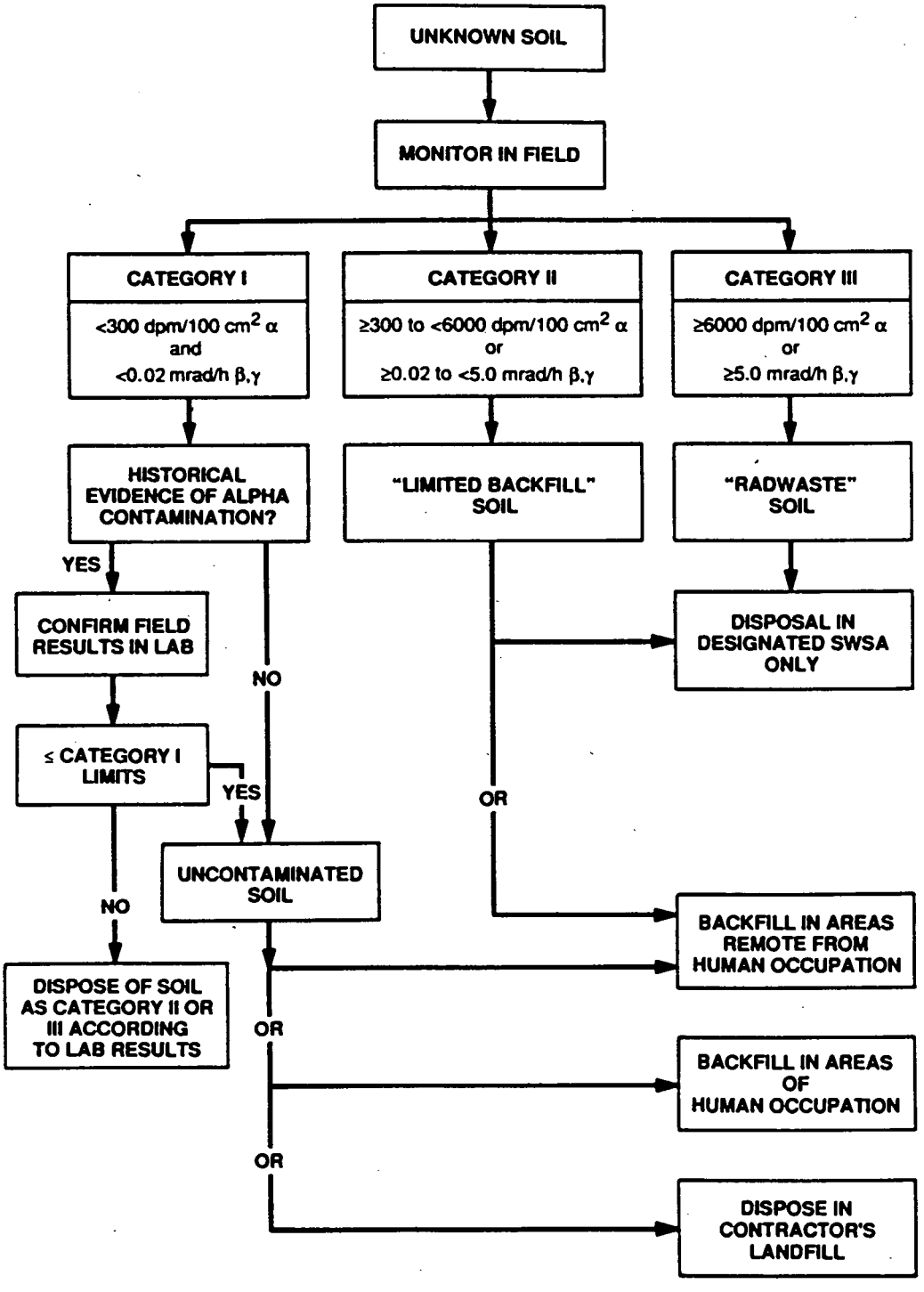
Category 2 Soil in this category may be used for limited backfilling. Measurements at the surface of this soil are equal to or greater than 300 and less than 6000 dpm/100 cm^2 alpha and equal to or greater than 0.02 and less than 5.0 mrad/h beta/gamma. If laboratory analyses have been conducted, soil having alpha activities less than 0.75 Bq/g and beta-gamma activities less than 450 Bq/g may be used for limited backfilling.

Soil in this category may be used for backfill at the site of origin or in a contaminated zone of similar radiation levels, provided that the area to be backfilled is not intended for continuous human occupation. In each location where Category 2 soil is used as backfill, at least one foot of clean uncontaminated soil must be placed over the contaminated backfill, and the site must be identified as a maintained area and marked on maps that are kept updated. In no case should contaminated soil be used as backfill in uncontaminated areas.

Soil not needed for backfill shall be considered as radwaste (Category 3) and sent, after proper packaging, to the designated SWSA.

Category 3 Soil in this category may not be used for backfill but will be considered as radwaste and sent to the designated SWSA. Surface readings are equal to or greater than 6000 dpm/100 cm^2 alpha and equal to or greater than 5.0 mrad/h beta/gamma. If soil has been analyzed in the laboratory, activities equal to or greater than 0.75 Bq/g alpha and equal to or greater than 450 Bq/g beta/gamma indicates the soil qualifies as radwaste.

ORNL-DWG 88-6101



FLOWCHART FOR HANDLING POTENTIAL RADIOLOGICALLY CONTAMINATED SOIL

Basis for Radiological Soil Handling Criteria

These soil handling criteria were developed to provide a safe and practical methodology for dealing with contaminated soil in the field. Radiological characteristics for Category 1 soil are based on current "green tag" limits. Radiological characteristics for Category 2 soil are based on an exposure rate reduction factor of 100 through use of at least one foot of uncontaminated backfill. Category 2 soil should not be used as backfill in areas where continuous human habitation is anticipated.

These criteria define radiological limits which are measurable with field instrumentation and provide an acceptable level of radiation safety for workers and persons exposed to this soil when used as backfill. THESE CRITERIA ARE INTENDED ONLY FOR SOILS LOCATED ON AND REMAINING ON THE OAK RIDGE RESERVATION WHERE INSTITUTIONAL CONTROL IS IN PLACE.

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