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Projects

U.S. Department
of Energy

COMPREHENSIVE RADIOLOGICAL SURVEY

OFF-SITE PROPERTY C

NIAGARA FALLS STORAGE SITE

LEWISTON, NEW YORK

J. D. BERGER

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

FINAL REPORT

March 1984

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Prepared for

U.S. Department of Energy
as part of the
Formerly Utilized Sites -- Remedial Action Program

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COMPREHENSIVE RADIOLOGICAL SURVEY

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INTRODUCTION

Beginning in 1944, the Manhattan Engineer District and its successor, the Atomic Energy Commission (AEC), used portions of the Lake Ontario Ordnance Works (presently referred to as the Niagara Falls Storage Site (NFSS) and off-site properties), approximately 3 km northeast of Lewiston, New York, for storage of radioactive wastes. These wastes were primarily residues from uranium processing operations; however, they also included: contaminated rubble and scrap from decommissioning activities, biological and miscellaneous wastes from the University of Rochester, and low-level fission-product waste from contaminated-liquid evaporators at the Knolls Atomic Power Laboratory (KAPL). Receipt of radioactive waste was discontinued in 1954, and, following cleanup activities by Hooker Chemical Co., 525 hectares of the original 612-hectare site were declared surplus. This property was eventually sold by the General Services Administration to various private, commercial, and governmental agencies.[1]

SCA Chemical Services, Inc. (SCA) is the current owner of a tract from the NFSS, identified as off-site property C (see Figure 1). A radiological survey of that tract, conducted during August and September 1983, is the subject of this report.

SITE DESCRIPTION

Figure 2 is a plot plan of off-site property C. The property is approximately square (about 498 m x 498 m) and occupies 25.2 hectares. It is bounded on the west by MacArthur Street and on the east and north by out-of-service railroad tracks. A haul road parallels the south boundary fence, which separates the SCA property from that belonging to Modern Landfill, Inc. A major portion of this property is occupied by active landfills and liquid treatment and retention ponds. Areas in the south central part of the property are used as sources of fill for various SCA

construction and landfill activities. The southeastern portion is overgrown with brush and trees and contains some swampy areas. There are no structures on the property.

Radiological History

A review of the site history, conducted by Aerospace Corp., did not indicate evidence of contaminated waste burials or storage on property C.[1] The 1971-72 AEC survey, however, identified surface contamination near the southwest corner of the property (decontamination operations were subsequently performed in this area).[2] This finding suggests possible storage or shallow burial of contaminated material may have occurred. Conversations with a previous site employee confirm this possibility.[3] It is likely that any surface contamination which may have been present on this property as a result of AEC/MED operations, has been relocated or is covered and inaccessible due to the waste treatment and construction operations of the current property occupants.

The 1980 ORNL mobile scan identified elevated direct radiation levels along MacArthur Street and along the railroad tracks on the northern boundary.[4] Elevated direct radiation levels are also present in the southwest corner of the property as a result of shine from the K-65 residue storage tower on the adjacent Niagara Falls Storage Site.

SURVEY PROCEDURES

The comprehensive survey of off-site property C was performed by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU), during the period of August-September 1983. The survey was in accordance with a plan dated December 29, 1983, approved by the Department of Energy's Office of Nuclear Energy. The objectives and procedures from that plan are presented in this section.

Objective

The objective of the survey was to provide a comprehensive assessment of the radiological conditions and associated potential health effects, if any, on property C. Radiological information to be collected included:

1. direct radiation exposure rates and surface beta-gamma dose rates,
2. locations of elevated surface residues,
3. concentrations of radionuclides in surface and subsurface soil, and
4. concentrations of radionuclides in ground water.

Procedures

1. Brush and weeds were cleared as needed to provide access for gridding and surveying and a 40 m system was established. These operations were performed by McIntosh and McIntosh of Lockport, NY, under subcontract. The grid system is shown on Figure 3.

2. Gamma exposure rate measurements were made at the surface and at 1 m above the surface at 40 m grid intervals. Measurements were performed using portable gamma NaI (Tl) scintillation survey meters. Conversion of these measurements to exposure rates in microroentgens per hour (μR/h) was in accordance with cross calibration with a pressurized ionization chamber.

3. Beta-gamma dose rate measurements were performed 1 cm above the surface at 40 m grid intervals. These measurements were conducted using thin-window (<7 mg/cm^2) G-M detectors and portable scaler/ratemeters. Measurements were also obtained with the detector shielded to evaluate contributions of non-penetrating beta and low-energy gamma radiations. Meter readings were converted to dose rates in microrads per hour (μrad/h) based on cross calibration with a thin-window ionization chamber.

4. Surface (0-15 cm) soil samples of approximately 1 kg each were collected at 40 m grid intervals. Because generally elevated radiation levels over the southwest section of the property prevented reliance on direct in-situ measurements to identify small areas of surface contamination, additional soil samples were collected at 20 m intervals in this region.

5. Walkover surface scans were conducted at 2-5 m intervals over all accessible areas of the property to identify locations of elevated contact radiation levels. Portable gamma scintillation survey meters were used for these scans.

6. Detection Sciences Group of Carlisle, MA, performed ground penetrating radar surveys in the area of possible previous burial or storage bounded by grid lines 363S, 423S, 1102E, and 1137E. Ground radar was also performed at locations of proposed boreholes to identify the presence of underground piping or utilities which would preclude drilling.

7. Boreholes were drilled to provide a mechanism for logging subsurface direct radiation profiles and collecting subsurface soil and water samples. Fourteen boreholes were drilled by Site Engineers, Inc., of Cherry Hill, NJ, and Earth Dimensions of Aurora, NY, using truck mounted 20 cm diameter hollow-stem augers. The locations of these boreholes are shown on Figure 4.

   A gamma scan of the boreholes was performed to identify elevated radiation levels, which would indicate subsurface residues. Radiation profiles in the boreholes were determined by measuring gamma radiation at 15-30 cm intervals between the surface and the hole bottom. A collimated gamma scintillation detector and portable scaler were used for these measurements.

   Samples of the ground water were collected from six of the boreholes using a hand bailer. Soil samples of approximately 1 kg each were collected from various depths in the holes by

scraping the sides of each borehole with an ORAU designed sampling tool.

8. Twenty soil samples and seven water samples were collected from the Lewiston area (but not on the NFSS or associated off-site properties) to provide baseline concentrations of radionuclides for comparison purposes. Direct background radiation levels were measured at locations where baseline soil samples were collected. The locations of the baseline samples and background measurements are shown on Figure 5.

Sample Analyses and Interpretation of Results

Soil and sediment samples were analyzed by gamma spectrometry. Radium-226 was the major radionuclide of concern, although spectra were reviewed for U-235, U-238, Cs-137, Th-232, and other gamma emitters. Water was analyzed for gross alpha and beta concentrations, and one sample exceeding 15 pCi/l of gross alpha was also analyzed for Ra-226 content.

Additional information concerning analytical equipment and procedures is contained in Appendix A.

Results of this survey were compared to the applicable guidelines for formerly utilized radioactive materials handling sites, which are presented in Appendix B.

RESULTS

Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil, determined for 20 locations (Figure 5) in the vicinity of the NFSS, are presented in Table 1-A. Exposure rates ranged from 6.8 to 8.8 μR/h (typical levels for this area of New York). Concentrations of radionuclides in soil were: Ra-226, <0.09 to 1.22 pCi/g (picocuries per gram); U-235, <0.14 to 0.46 pCi/g; U-238, <2.20 to 6.26 pCi/g; Th-232, 0.32

to 1.18 pCi/g; and Cs-137, <0.02 to 1.05 pCi/g. These concentrations are typical of the radionuclide levels normally encountered in surface soils.

Radioactivity levels in baseline water samples are presented in Table 1-B. The gross alpha and gross beta concentrations ranged from 0.55 to 1.87 pCi/l (picocuries per liter) and <0.63 to 14.3 pCi/l, respectively. These are typical of concentrations normally occurring in surface water.

Direct Radiation Levels

Direct radiation levels, systematically measured at 40 m grid intervals, are presented in Table 2. The gamma exposure rates at 1 m above the surface ranged from 6 to 31 μR/h (average 11 μR/h). At surface contact, the rates ranged from 7 to 30 μR/h (average 11 μR/h). Beta-gamma dose rates ranged from 7 to 56 μrad/h (average 22 μrad/h). Dose rate measurements, performed with the detector shielded, averaged approximately 20% less than those with the unshielded detector. This indicates only a small portion of the surface dose rate is due to nonpenetrating beta or low-energy photon radiations. Levels were generally higher in the southwest corner of property C where it borders the Department of Energy's Niagara Falls Storage Site. The source of the elevated radiation levels is the water tower on the DOE property which contains a large quantity of Ra-226 contaminated residues. The 20 and 30 μR/h isopleths are indicated on Figure 6.

The walkover surface scan did not identify any areas having contact radiation levels above the ambient values. This indicates the absence of isolated surface areas with significant concentrations of radionuclides.

Radionuclide Concentrations in Surface Soil

Table 3 lists the concentrations of radionuclides measured in surface soil from 40 m and 20 m grid intervals. These samples contained Ra-226 concentrations ranging from 0.41 to 3.10 pCi/g. The highest level was in the sample from grid point 457S,1020E, in the extreme southwest corner of the property. Samples from the vicinity of the railroad tracks along the

eastern property boundary also contained Ra-226 concentrations slightly above the levels in baseline soil. Although levels of other radionuclides also exceeded the ranges of baseline concentrations in a small fraction of the samples, none of these individual samples contained concentrations above the cleanup guidelines.

Ground-Penetrating Radar Findings

The subcontractor's report, summarizing the ground-penetrating radar survey results for property C, is provided as Appendix C. Subsurface anomalies, indicating subsurface metallic objects were noted near grid locations 363S, 1101-1105E, and 403S, 1102-1114E. These objects are approximately 1.2-1.5 m deep. That is approximately the depth of the fill dirt which has been placed over this general area, suggesting the objects may have been on the surface and were simply covered during recent construction operations.

Borehole Gamma Logging Measurements

Gamma scintillation measurements performed in boreholes did not indicate regions of subsurface contamination. Gamma logging data was not used to quantify radionuclide concentrations in the subsurface soil because of the varying ratios of Ra-226, U-235, U-238, and Cs-137 occurring in soils from this site.

Radionuclide Concentrations in Borehole Soil

Table 4 presents the radionuclide concentrations measured in soil samples from the fourteen boreholes. Concentrations of Ra-226 above the baseline levels were noted in holes H2 (3.03 pCi/g at 1.2 m), H5 (2.28 pCi/g at 1.0 m, and H6 (1.88 pCi/g at 0.3 m). Other samples contained radionuclide concentrations either in the range of baseline samples or less than the minimum detectable activity. It should be noted Boreholes H10-H14, drilled into the area identified as a possible previous burial site and at locations where ground radar indicated subsurface metal objects did not contain elevated radionuclide concentrations.

Radionuclide Concentrations in Water

Water collected from borehole H8 (sample W6) contained 47.5 pCi/l of gross alpha activity and 30.0 pCi/l of gross beta (see Table 5). The Ra-226 concentration, however was <0.13 pCi/l. Gross alpha levels in other borehole water samples were also above the range in baseline samples but were within the EPA Interim Drinking Water Standards of 15 pCi/l.

COMPARISON OF RESULTS WITH GUIDELINES

The guidelines applicable to cleanup of the off-site properties at NFSS are presented in Appendix B. Although exposure rates at 1 m above the ground surface on property C range up to 31 μR/h in the southwest corner of the property, the maximum and average levels (11 μR/h) are well within the 60 μR/h criteria established by the Nuclear Regulatory Commission for open land areas. No areas of surface contamination were identified by the walkover scan.

The radionuclide concentrations in all surface soil samples were within the criteria established for formerly utilized sites.

Borehole measurements and sampling did not identify areas of subsurface contamination. Ground-penetrating radar indicates metal objects about 1.2-1.5 m below the surface at two locations in an area suggested as a possible previous burial site; however, boreholes in these areas yielded negative results.

The radionuclide concentration in water from one borehole exceeded the EPA Interim Drinking Water Standard of 15 pCi/l for gross alpha. The Ra-226 concentrations was <0.13 pCi/l - well below the EPA Standard of 5 pCi/l total radium. It should be noted that the EPA standards are presented here only for comparison purposes. These standards apply only to community drinking water systems and are therefore not applicable to water which is not a drinking water supply.

SUMMARY

A comprehensive survey of off-site property C at the Niagara Falls Storage Site was conducted during August-September, 1983. The survey included surface radiation scans, measurements of direct radiation levels, and analyses of radionuclide concentrations in surface and subsurface soil samples and in subsurface water.

No areas of surface contamination were identified by the walkover scan; however, elevated direct radiation levels are present on the southwestern portion of the property, due to materials stored on the adjacent Department of Energy site. These direct levels and the concentrations of radionuclides in surface and subsurface soil are within the criteria established for release of the property for public use. The elevated radiation levels do not pose potential health risks and there is no indication that contamination is migrating from the site or adversely affecting the ground water.

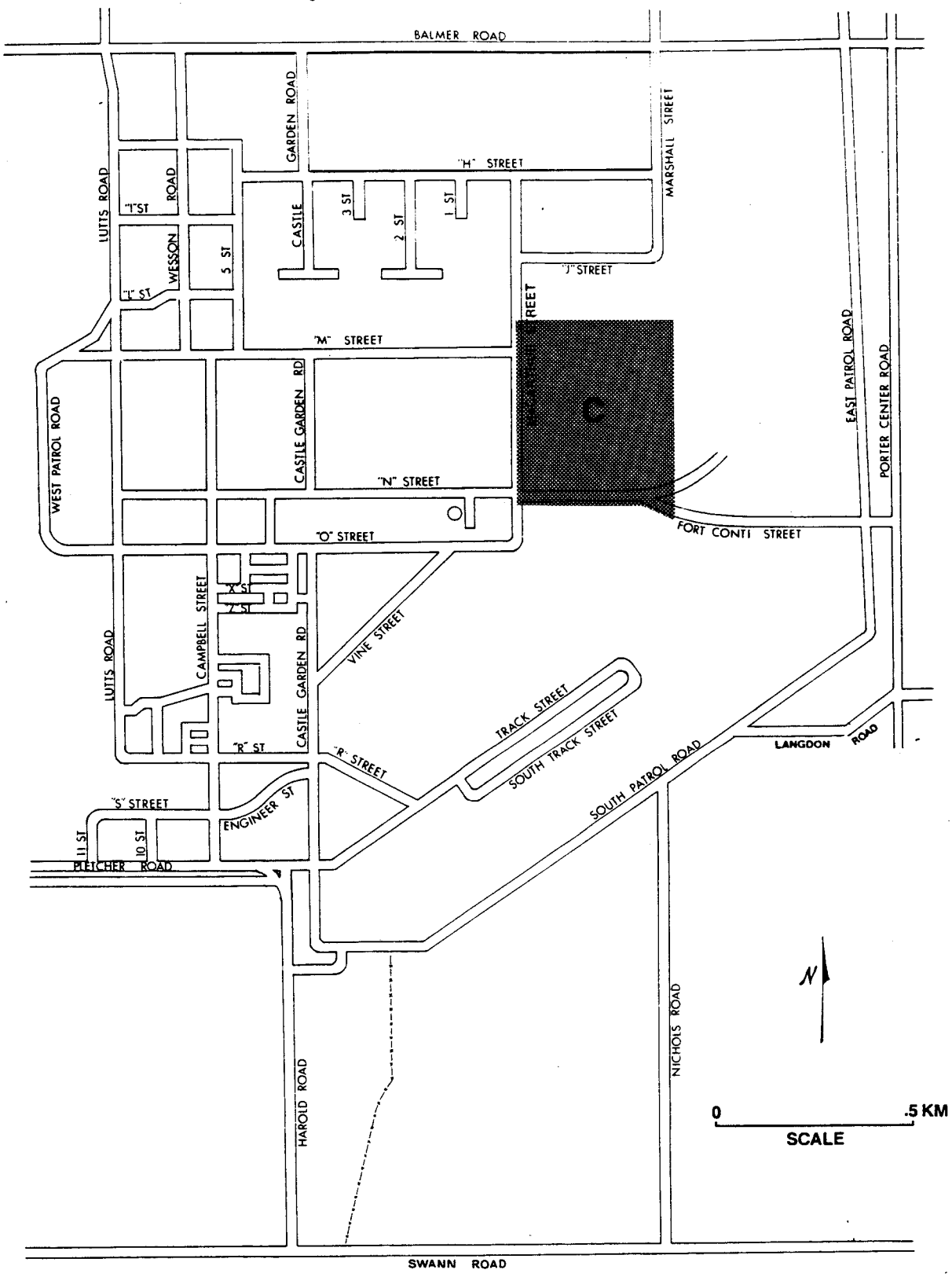

FIGURE 1. Map of Niagara Falls Storage Site and Off-Site Properties, Lewiston, New York, Indicating the Location of Off-Site Property C.

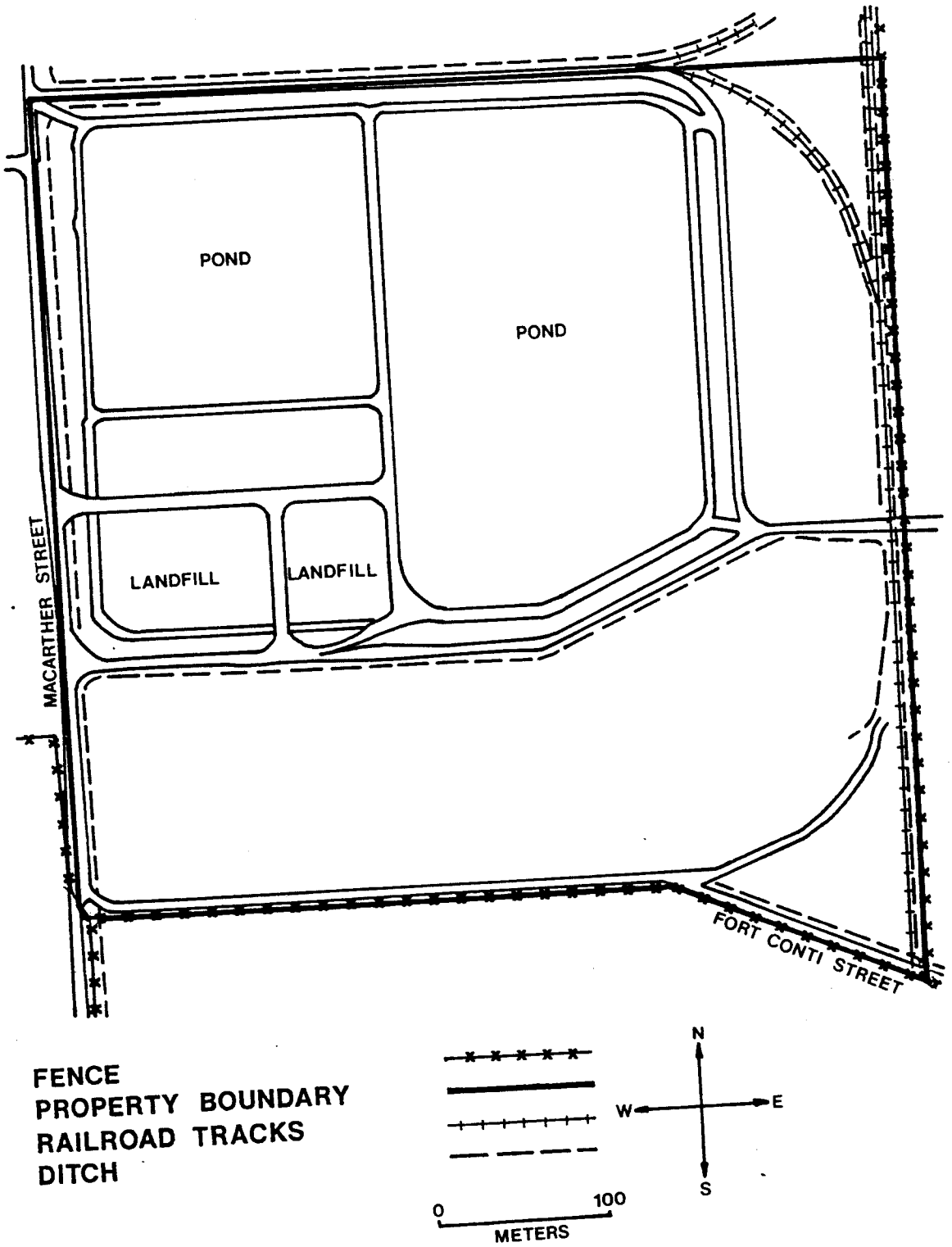

FIGURE 2. Plan View of NFSS Off-Site Property C Indicating Prominent Surface Features.

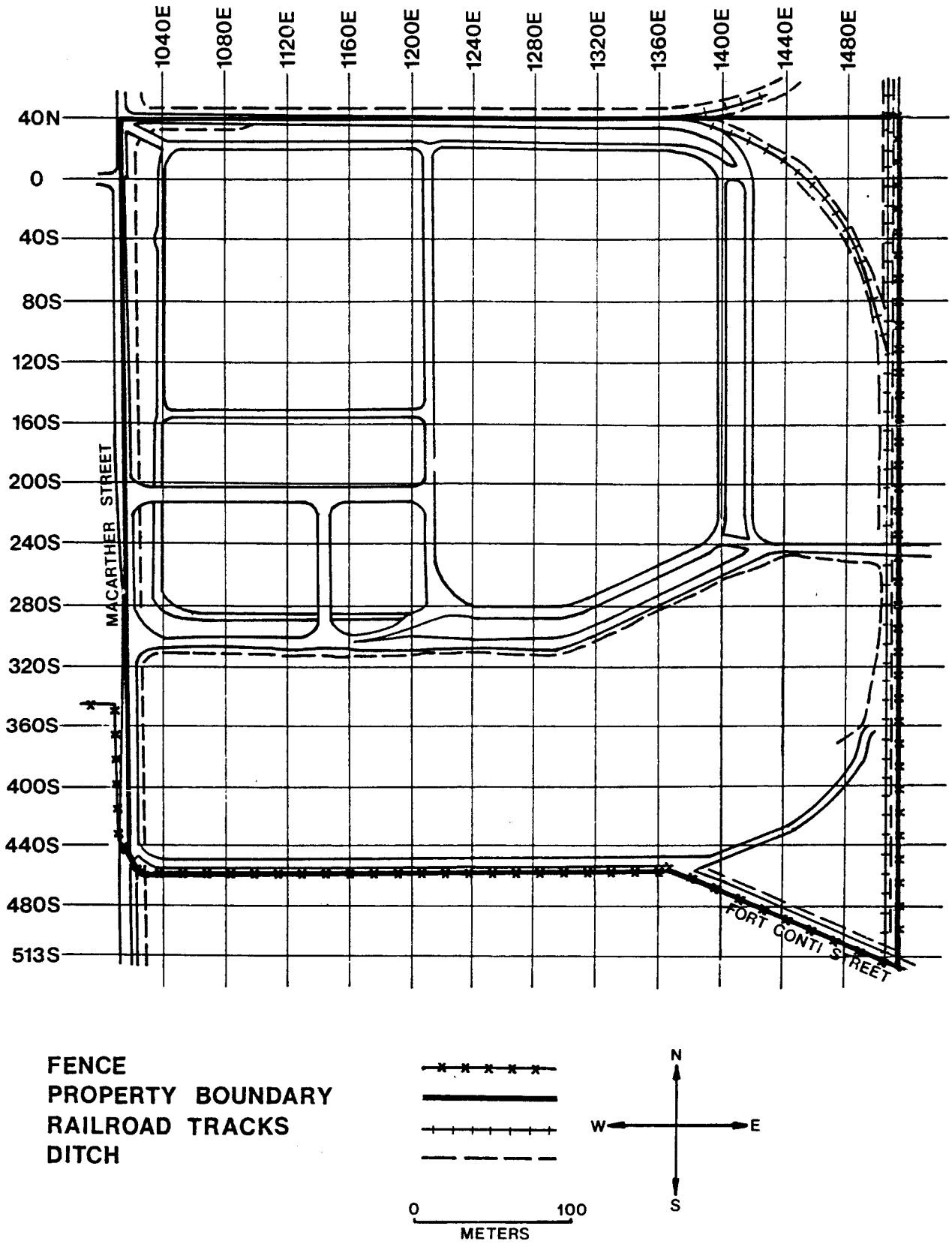

FIGURE 3. Plan View of NFSS Off-Site Property C Indicating the Grid System Established for Survey Reference.

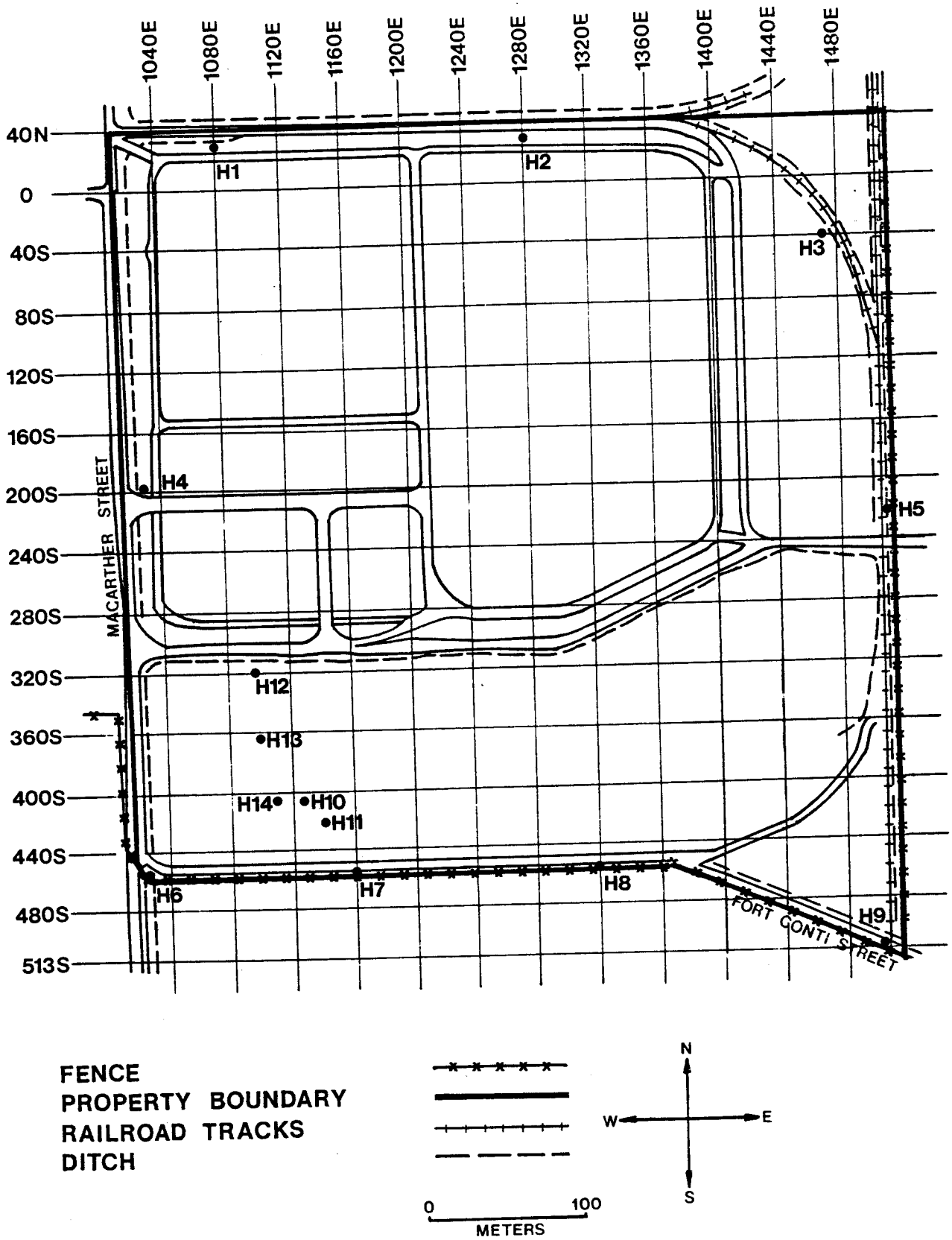

FIGURE 4. Locations of Boreholes for Subsurface Investigations.

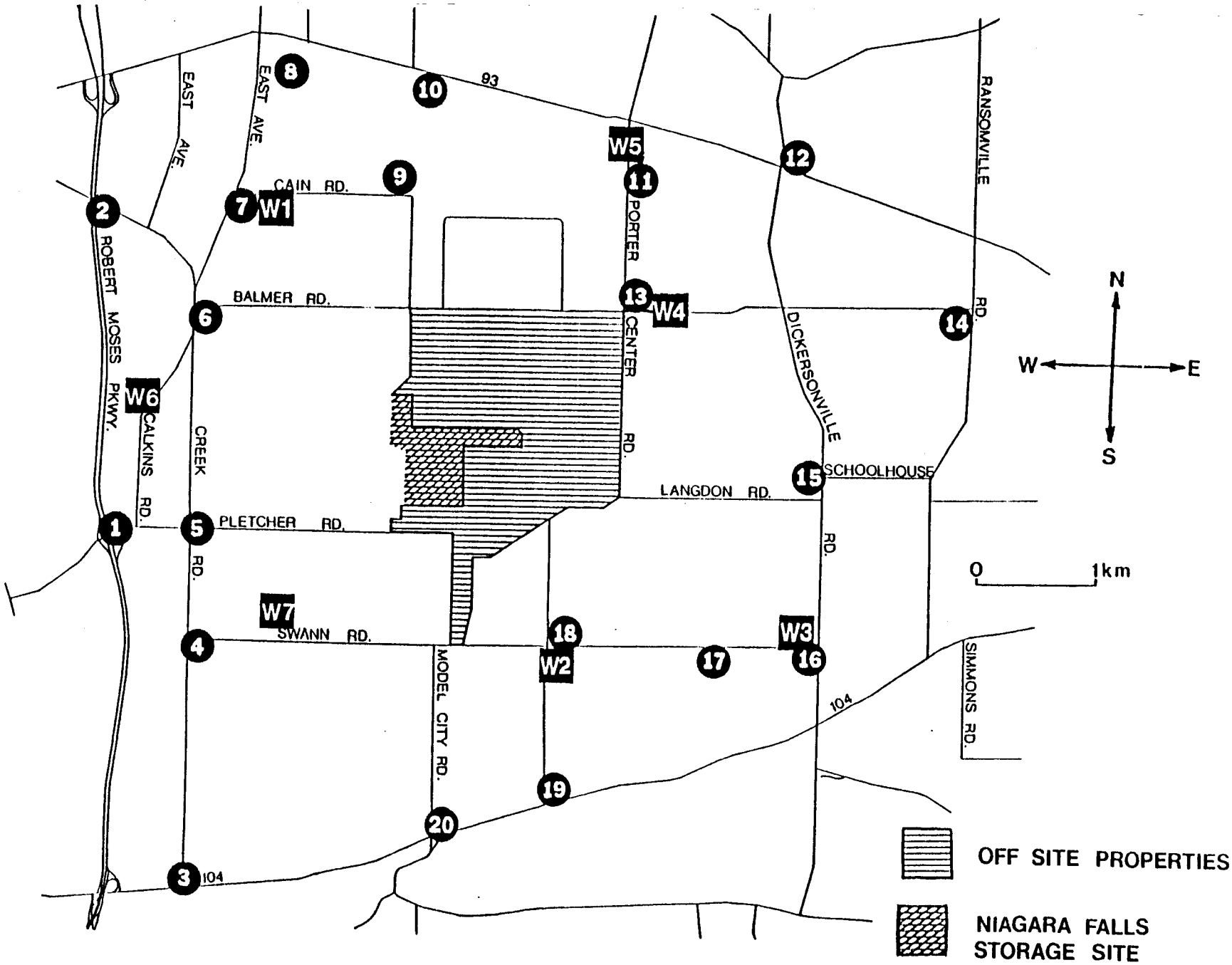

FIGURE 5. Map of Northern Niagara County, New York, Showing Locations of Background Measurements and Baseline Samples. (#1-20: soil samples and direct measurements; W1-W7: water samples.)

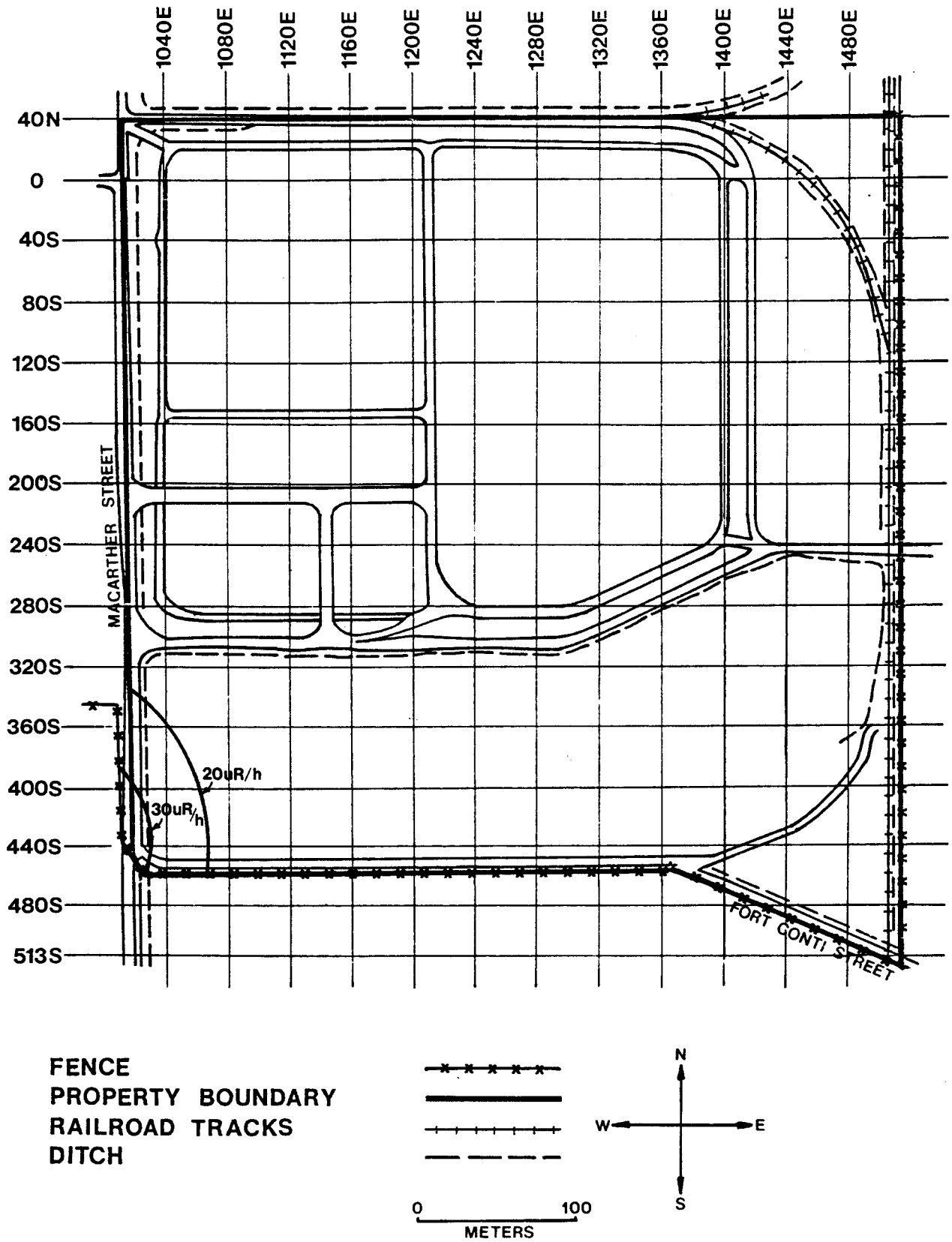

FIGURE 6. Map of NFSS Off-Site Property C Showing Areas of Elevated Gamma Exposure Rates.

TABLE 1-A

BACKGROUND EXPOSURE RATES
AND
BASELINE RADIONUCLIDE CONCENTRATIONS IN SOIL

Location[a]	Exposure Rate[b] (μR/h)	Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Th-232	Cs-137
1	6.8	0.74 ± 0.16[c]	<0.19	<2.89	0.70 ± 0.46	0.29 ± 0.08
2	6.8	0.75 ± 0.19	<0.19	<3.35	0.84 ± 0.24	0.24 ± 0.08
3	8.3	0.71 ± 0.18	0.46 ± 0.41	<3.72	0.88 ± 0.33	0.34 ± 0.09
4	7.9	0.67 ± 0.18	<0.22	<4.10	1.18 ± 0.35	0.12 ± 0.07
5	7.3	0.70 ± 0.16	<0.17	<3.34	0.68 ± 0.24	0.14 ± 0.07
6	7.7	0.50 ± 0.15	<0.16	<2.33	0.52 ± 0.38	0.17 ± 0.09
7	7.7	0.63 ± 0.13	<0.17	<2.73	0.83 ± 0.24	0.35 ± 0.08
8	7.6	0.59 ± 0.12	<0.14	<2.20	0.54 ± 0.23	<0.02
9	7.1	0.63 ± 0.20	<0.23	<4.16	0.83 ± 0.38	0.69 ± 0.11
10	7.1	0.70 ± 0.16	<0.19	<2.98	0.59 ± 0.25	0.69 ± 0.10
11	6.7	<0.09	<0.19	<2.83	0.49 ± 0.31	0.48 ± 0.14
12	7.1	0.48 ± 0.13	<0.16	<2.84	0.65 ± 0.26	0.68 ± 0.10
13	6.7	0.57 ± 0.14	<0.17	<2.36	0.49 ± 0.26	0.41 ± 0.08
14	6.8	0.68 ± 0.17	<0.19	<3.24	0.67 ± 0.25	0.70 ± 0.10
15	8.2	0.65 ± 0.14	<0.17	<3.20	0.72 ± 0.35	0.23 ± 0.08
16	7.4	0.91 ± 0.17	<0.71	<3.58	0.83 ± 0.28	0.61 ± 0.09
17	7.0	0.48 ± 0.14	<0.16	<2.73	0.32 ± 0.22	0.38 ± 0.08
18	7.7	0.73 ± 0.16	<0.18	6.26 ± 9.23	1.01 ± 0.44	0.32 ± 0.12
19	8.8	1.22 ± 0.22	<0.23	<3.79	1.08 ± 0.49	1.05 ± 0.13
20	8.6	0.83 ± 0.17	<0.21	<3.59	0.84 ± 0.29	0.08 ± 0.07
Range	6.8 to 8.8	<0.09 to 1.22	<0.14 to 0.46	<2.20 to 6.26	0.32 to 1.18	<0.02 to 1.05

[a] Refer to Figure 5.
[b] Measured at 1 m above the surface.
[c] Errors are 2σ based on counting statistics.

TABLE 1-B

RADIONUCLIDE CONCENTRATIONS IN BASELINE WATER SAMPLES

Location[a]	Radionuclide Concentrations (pCi/l)	
	Gross Alpha	Gross Beta
W1	0.95 ± 0.93[b]	4.79 ± 1.15
W2	0.95 ± 0.94	9.17 ± 1.31
W3	0.55 ± 0.78	2.73 ± 1.05
W4	0.63 ± 0.89	5.37 ± 1.17
W5	0.73 ± 0.68	<0.64
W6	1.87 ± 1.84	14.3 ± 2.4
W7	1.16 ± 0.66	<0.63
Range	0.55 to 1.87	<0.63 to 14.3

[a] Refer to Figure 5.
[b] Errors are 2σ based on counting statistics.

TABLE 2

DIRECT RADIATION LEVELS SYSTEMATICALLY MEASURED AT 40 M GRID INTERVALS

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
40N 1015E	7	8	8
40N 1040E	7	7	9
40N 1080E	7	8	8
40N 1120E	7	7	7
40N 1160E	7	8	22
40N 1200E	8	8	42
40N 1240E	8	8	15
40N 1280E	8	8	10
40N 1320E	8	8	21
40N 1360E	9	13	30
40N 1400E	9	9	22
40N 1440E	8	8	15
40N 1480E	7	7	16
40N 1505E	9	9	19
0 1049E	6	8	18
0 1080E	a	a	a
0 1120E	a	a	a
0 1160E	a	a	a
0 1200E	a	a	a
0 1240E	a	a	a
0 1280E	a	a	a
0 1320E	a	a	a
0 1360E	a	a	a
0 1400E	7	8	8
0 1440E	9	9	26
0 1480E	7	7	9
0 1505E	9	8	19
40S 1040E	8	8	45
40S 1080E	a	a	a
40S 1120E	a	a	a
40S 1160E	a	a	a
40S 1200E	a	a	a
40S 1240E	a	a	a
40S 1280E	a	a	a
40S 1320E	a	a	a
40S 1360E	a	a	a
40S 1400E	7	7	13
40S 1440E	8	8	25
40S 1480E	10	9	12
40S 1505E	11	12	46

TABLE 2, cont.

DIRECT RADIATION LEVELS SYSTEMATICALLY MEASURED AT 40 M GRID INTERVALS

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
80S 1040E	10	9	28
80S 1080E	a	a	a
80S 1120E	a	a	a
80S 1160E	a	a	a
80S 1200E	a	a	a
80S 1240E	a	a	a
80S 1280E	a	a	a
80S 1320E	a	a	a
80S 1360E	a	a	a
80S 1400E	7	8	28
80S 1440E	8	8	8
80S 1480E	8	8	18
80S 1505E	12	13	26
120S 1040E	10	10	37
120S 1080E	a	a	a
120S 1120E	a	a	a
120S 1160E	a	a	a
120S 1200E	a	a	a
120S 1240E	a	a	a
120S 1280E	a	a	a
120S 1320E	a	a	a
120S 1360E	a	a	a
120S 1400E	7	8	25
120S 1440E	8	8	18
120S 1480E	8	8	21
120S 1505E	10	11	35
160S 1040E	10	10	30
160S 1080E	a	a	a
160S 1120E	a	a	a
160S 1160E	a	a	a
160S 1200E	a	a	a
160S 1240E	a	a	a
160S 1280E	a	a	a
160S 1320E	a	a	a
160S 1360E	a	a	a
160S 1400E	7	8	19
160S 1440E	8	8	24
160S 1480E	8	8	8
160S 1505E	11	12	18
200S 1040E	11	12	25

TABLE 2, cont.

DIRECT RADIATION LEVELS SYSTEMATICALLY MEASURED AT 40 M GRID INTERVALS

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
200S 1080E	a	a	a
200S 1120E	a	a	a
200S 1160E	a	a	a
200S 1200E	a	a	a
200S 1240E	a	a	a
200S 1280E	a	a	a
200S 1320E	a	a	a
200S 1360E	a	a	a
200S 1400E	8	8	24
200S 1440E	9	8	28
200S 1480E	8	8	17
200S 1505E	8	8	8
240S 1040E	13	13	30
240S 1080E	a	a	a
240S 1120E	a	a	a
240S 1160E	a	a	a
240S 1200E	a	a	a
240S 1240E	a	a	a
240S 1280E	a	a	a
240S 1320E	a	a	a
240S 1360E	a	a	a
240S 1400E	8	8	19
240S 1440E	8	8	11
240S 1480E	8	8	17
240S 1505E	12	11	20
280S 1040E	14	14	30
280S 1080E	12	13	14
280S 1120E	10	12	26
280S 1160E	11	11	14
280S 1200E	10	10	10
280S 1240E	9	8	18
280S 1280E	8	8	8
280S 1320E	8	8	28
280S 1360E	8	9	23
280S 1400E	8	8	17
280S 1440E	8	8	10
280S 1480E	8	8	11
280S 1505E	12	10	30
320S 1040E	16	17	18
320S 1080E	18	14	15
320S 1120E	13	12	26

TABLE 2, cont.

DIRECT RADIATION LEVELS SYSTEMATICALLY MEASURED AT 40 M GRID INTERVALS

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
320S 1160E	11	11	34
320S 1200E	9	10	10
320S 1240E	9	9	14
320S 1280E	8	8	27
320S 1320E	9	8	24
320S 1360E	8	8	25
320S 1400E	8	8	13
320S 1440E	8	8	29
320S 1480E	6	8	15
320S 1505E	10	10	11
360S 1009E	26	25	54
360S 1040E	20	20	20
360S 1080E	14	14	30
360S 1120E	13	13	34
360S 1160E	12	12	38
360S 1200E	10	11	11
360S 1240E	9	10	21
360S 1280E	10	10	19
360S 1320E	9	9	22
360S 1360E	11	10	10
360S 1400E	10	9	22
360S 1440E	9	9	20
360S 1480E	10	12	21
360S 1505E	10	10	10
400S 1009E	30	27	44
400S 1040E	22	23	23
400S 1080E	17	17	37
400S 1120E	13	14	34
400S 1160E	12	12	31
400S 1200E	10	11	18
400S 1240E	9	11	17
400S 1280E	8	10	30
400S 1320E	9	8	8
400S 1360E	9	8	10
400S 1400E	8	8	8
400S 1440E	9	8	8
400S 1480E	10	9	20
400S 1505E	8	9	11
440S 1011E	31	30	41
440S 1040E	25	25	45
440S 1080E	16	16	19

TABLE 2, cont.

DIRECT RADIATION LEVELS SYSTEMATICALLY MEASURED AT 40 M GRID INTERVALS

Grid Location	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)	Beta-Gamma Dose Rates at 1 cm Above the Surface (μrad/h)
440S 1120E	14	14	24
440S 1160E	12	12	15
440S 1200E	10	11	24
440S 1240E	10	10	39
440S 1280E	9	9	9
440S 1320E	10	9	9
440S 1360E	10	11	12
440S 1400E	9	10	17
440S 1440E	9	8	12
440S 1480E	9	8	8
440S 1505E	10	11	34
457S 1020E	29	27	33
457S 1040E	22	23	56
457S 1080E	17	17	17
457S 1120E	14	14	25
457S 1160E	12	12	29
457S 1200E	12	12	36
457S 1240E	8	8	17
457S 1280E	10	10	26
457S 1320E	11	12	18
457S 1360E	10	10	19
463S 1400E	10	9	25
480S 1440E	8	11	27
480S 1480E	8	8	8
480S 1506E	11	12	31
487S 1440E	10	9	16
510S 1480E	10	8	18
513S 1507E	10	11	35

[a] Grid point not accessible due to landfills and treatment ponds.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
40N	1016E	1.13 ± 0.24[a]	<0.20	1.43 ± 1.28	<0.04	0.63 ± 0.32
40N	1040E	0.80 ± 0.22	<0.29	<4.51	<0.04	1.07 ± 0.37
40N	1080E	0.79 ± 0.23	<0.14	0.95 ± 0.45	0.03 ± 0.30	0.82 ± 0.30
40N	1120E	0.75 ± 0.24	<0.18	0.30 ± 0.48	0.09 ± 0.07	0.91 ± 0.35
40N	1160E	2.71 ± 0.29	<0.17	0.82 ± 0.98	0.05 ± 0.04	0.78 ± 0.35
40N	1200E	0.81 ± 0.23	<0.24	1.09 ± 1.48	0.06 ± 0.08	0.92 ± 0.38
40N	1240E	0.79 ± 0.24	<0.20	1.88 ± 1.30	0.07 ± 0.06	0.86 ± 0.67
40N	1280E	0.79 ± 0.26	<0.20	1.91 ± 1.45	0.15 ± 0.10	0.87 ± 0.37
40N	1320E	0.81 ± 0.24	<0.27	<0.85	<0.03	1.07 ± 0.30
40N	1360E	1.03 ± 0.33	<0.28	1.61 ± 0.90	<0.04	1.11 ± 0.37
40N	1400E	1.21 ± 0.30	<0.35	<1.14	<0.07	1.09 ± 0.47
40N	1440E	1.06 ± 0.31	<0.21	<0.79	0.67 ± 0.14	0.64 ± 0.36
40N	1480E	0.68 ± 0.25	<0.23	1.35 ± 1.61	0.67 ± 0.15	0.86 ± 0.57
40N	1507E	0.65 ± 0.18	<0.14	<0.38	0.36 ± 0.10	0.74 ± 0.30
20N	1015E	0.95 ± 0.19	<0.12	1.04 ± 0.64	0.07 ± 0.06	0.71 ± 0.32
20N	1040E	0.69 ± 0.23	<0.16	1.07 ± 1.15	<0.04	0.75 ± 0.23
20N	1080E	0.71 ± 0.18	<0.20	1.05 ± 1.28	<0.03	0.70 ± 0.24
20N	1120E	0.80 ± 0.20	<0.19	1.29 ± 1.35	<0.03	0.83 ± 0.27
20N	1160E	0.90 ± 0.20	<0.19	1.13 ± 1.05	<0.03	0.89 ± 0.27
20N	1200E	1.03 ± 0.25	<0.20	<0.63	<0.02	0.62 ± 0.38
20N	1240E	0.86 ± 0.21	<0.28	2.56 ± 1.10	0.13 ± 0.10	1.26 ± 0.39
20N	1280E	0.95 ± 0.25	<0.31	<1.00	0.20 ± 0.09	1.16 ± 0.42
20N	1320E	0.98 ± 0.24	<0.20	1.21 ± 1.41	<0.05	0.88 ± 0.49
20N	1360E	0.66 ± 0.23	<0.14	1.28 ± 0.43	0.06 ± 0.07	0.83 ± 0.29
20N	1400E	1.14 ± 0.35	<0.27	0.38 ± 1.50	<0.05	1.54 ± 0.47
20N	1440E	0.95 ± 0.23	<0.17	0.89 ± 1.13	0.52 ± 0.13	1.04 ± 0.49
0	1025E	0.85 ± 0.20	<0.31	2.66 ± 1.46	<0.04	1.20 ± 0.56

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
0	1040E	0.94 ± 0.31	<0.28	2.03 ± 1.04	<0.04	0.91 ± 0.40
0	1400E	0.76 ± 0.23	<0.13	<0.39	0.0 ± 0.04	0.85 ± 0.39
0	1440E	0.93 ± 0.24	<0.30	1.22 ± 1.72	<0.03	1.04 ± 0.41
0	1480E	0.95 ± 0.30	<0.30	2.82 ± 1.32	0.84 ± 0.15	1.73 ± 0.38
0	1507E	0.60 ± 0.18	<0.23	1.32 ± 1.50	<0.03	<0.10
40S	1025E	0.61 ± 0.19	0.33 ± 0.29	0.79 ± 0.78	<0.03	0.72 ± 0.29
40S	1040E	0.86 ± 0.23	<0.14	1.11 ± 0.51	<0.03	0.61 ± 0.27
40S	1210E	0.75 ± 0.24	<0.28	1.82 ± 2.13	<0.04	1.14 ± 0.48
40S	1400E	0.83 ± 0.36	<0.25	0.93 ± 0.82	0.31 ± 0.08	0.72 ± 0.48
40S	1440E	0.78 ± 0.19	<0.13	0.23 ± 0.32	<0.03	0.54 ± 0.28
40S	1480E	0.73 ± 0.24	<0.28	1.79 ± 0.95	0.18 ± 0.06	0.89 ± 0.35
40S	1509E	0.95 ± 0.29	<0.26	0.92 ± 0.87	0.88 ± 0.22	0.83 ± 0.51
80S	1025E	0.69 ± 0.23	<0.15	<0.38	<0.30	0.83 ± 0.36
80S	1040E	1.00 ± 0.27	<0.29	0.88 ± 1.74	<0.04	1.01 ± 0.37
80S	1400E	1.08 ± 0.26	<0.27	1.29 ± 1.80	0.20 ± 0.06	1.33 ± 0.39
80S	1440E	0.94 ± 0.25	<0.16	1.47 ± 0.54	0.10 ± 0.05	0.65 ± 0.37
80S	1480E	0.98 ± 0.23	<0.16	1.44 ± 0.60	0.08 ± 0.04	0.71 ± 0.32
80S	1509E	1.19 ± 0.34	<0.23	1.68 ± 0.78	1.34 ± 0.21	0.76 ± 0.35
120S	1025E	0.58 ± 0.23	<0.14	1.22 ± 0.45	<0.03	0.96 ± 0.43
120S	1040E	0.80 ± 0.18	<0.15	1.49 ± 0.56	<0.03	0.71 ± 0.32
120S	1400E	0.95 ± 0.23	<0.16	1.82 ± 0.80	0.06 ± 0.06	0.73 ± 0.28
120S	1440E	0.76 ± 0.24	0.21 ± 0.37	0.94 ± 0.55	0.12 ± 0.09	0.88 ± 0.30
120S	1480E	0.73 ± 0.20	<0.16	1.02 ± 0.56	<0.03	1.01 ± 0.33
120S	1509E	0.89 ± 0.29	<0.20	0.98 ± 1.72	0.79 ± 0.16	1.00 ± 0.44
155S	1100E	0.65 ± 0.20	<0.15	0.69 ± 0.73	<0.03	0.83 ± 0.30
160S	1025E	0.76 ± 0.25	<0.14	1.05 ± 0.54	<0.02	0.67 ± 0.28
160S	1040E	0.66 ± 0.20	<0.14	5.77 ± 0.99	<0.02	1.49 ± 0.39

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
160S	1210E	0.58 ± 0.21	<0.11	0.71 ± 0.44	<0.03	0.67 ± 0.31
160S	1400E	0.85 ± 0.31	<0.17	2.19 ± 0.62	0.20 ± 0.07	0.97 ± 0.38
160S	1440E	1.03 ± 0.24	<0.31	1.28 ± 2.06	0.12 ± 0.06	0.99 ± 0.45
160S	1480E	0.85 ± 0.25	<0.15	1.14 ± 0.62	0.21 ± 0.07	0.96 ± 0.40
160S	1509E	1.19 ± 0.28	<0.27	1.86 ± 1.00	0.67 ± 0.14	0.60 ± 0.28
200S	1025E	0.41 ± 0.14	<0.13	1.32 ± 0.86	<0.03	0.73 ± 0.29
200S	1040E	0.68 ± 0.24	<0.13	0.79 ± 0.47	<0.02	0.81 ± 0.26
200S	1400E	0.65 ± 0.20	<0.15	0.49 ± 1.51	<0.03	1.19 ± 0.38
200S	1440E	0.95 ± 0.33	<0.29	<0.88	<0.04	0.94 ± 0.40
200S	1480E	1.15 ± 0.39	0.69 ± 0.59	1.96 ± 1.63	0.12 ± 0.09	0.72 ± 0.29
200S	1509E	0.85 ± 0.18	<0.13	1.01 ± 0.90	<0.03	0.88 ± 0.25
210S	1100E	0.70 ± 0.18	<0.19	0.71 ± 1.14	<0.03	0.66 ± 0.30
240S	1025E	0.95 ± 0.24	<0.29	<1.02	<0.05	1.14 ± 0.52
240S	1040E	0.70 ± 0.23	<0.15	1.57 ± 0.75	<0.04	0.93 ± 0.29
240S	1210E	0.61 ± 0.23	<0.14	1.29 ± 0.74	<0.03	0.82 ± 0.30
240S	1400E	0.84 ± 0.22	<0.28	2.12 ± 1.11	<0.05	0.70 ± 0.41
240S	1440E	0.89 ± 0.19	<0.15	1.25 ± 0.58	<0.03	0.94 ± 0.34
240S	1480E	0.80 ± 0.28	<0.30	<0.88	<0.04	1.32 ± 0.39
240S	1509E	0.96 ± 0.28	<0.20	1.74 ± 0.65	0.69 ± 0.15	1.15 ± 0.35
280S	1025E	0.96 ± 0.22	<0.16	1.26 ± 0.50	<0.02	0.84 ± 0.34
280S	1040E	1.14 ± 0.23	<0.33	2.00 ± 2.07	<0.05	1.15 ± 0.40
292S	1080E	1.23 ± 0.24	<0.31	8.76 ± 2.04	<0.04	1.45 ± 0.44
292S	1120E	1.11 ± 0.25	<0.28	1.71 ± 1.25	<0.03	1.14 ± 0.47
292S	1160E	1.05 ± 0.25	<0.29	1.22 ± 1.62	<0.06	0.74 ± 0.38
292S	1200E	0.85 ± 0.25	<0.15	1.33 ± 0.76	<0.04	0.80 ± 0.35
280S	1240E	0.80 ± 0.23	<0.34	2.05 ± 2.48	0.47 ± 0.13	1.10 ± 0.38
280S	1280E	1.05 ± 0.28	<0.28	1.26 ± 0.85	0.14 ± 0.11	1.11 ± 0.33

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
280S	1320E	1.08 ± 0.23	<0.33	<1.00	<0.06	1.01 ± 0.35
280S	1360E	0.78 ± 0.28	<0.16	0.84 ± 0.50	<0.04	1.00 ± 0.32
280S	1400E	1.00 ± 0.26	<0.28	1.37 ± 1.34	<0.03	0.66 ± 0.23
280S	1440E	0.55 ± 0.19	<0.15	1.00 ± 0.71	<0.03	0.59 ± 0.33
280S	1480E	0.83 ± 0.20	<0.11	<0.32	<0.03	0.52 ± 0.29
280S	1509E	1.14 ± 0.33	<0.46	6.20 ± 3.18	1.82 ± 0.25	1.46 ± 0.80
320S	1020E	1.01 ± 0.25	<0.29	1.48 ± 1.37	0.08 ± 0.08	0.99 ± 0.61
320S	1040E	0.81 ± 0.23	<0.13	1.12 ± 0.97	<0.03	0.81 ± 0.43
320S	1060E	0.75 ± 0.23	<0.17	1.12 ± 0.52	<0.03	0.64 ± 0.33
320S	1080E	0.99 ± 0.22	<0.31	<0.95	<0.04	1.07 ± 0.40
320S	1120E	0.89 ± 0.24	<0.18	0.83 ± 0.82	<0.03	0.95 ± 0.39
320S	1160E	1.09 ± 0.25	<0.29	2.50 ± 1.14	0.09 ± 0.07	0.97 ± 0.32
320S	1200E	0.85 ± 0.22	<0.14	<0.43	0.11 ± 0.07	0.71 ± 0.25
320S	1240E	0.66 ± 0.26	<0.15	0.68 ± 0.78	0.10 ± 0.08	1.00 ± 0.27
320S	1280E	0.94 ± 0.23	<0.26	<0.93	<0.04	1.15 ± 0.38
320S	1320E	0.86 ± 0.25	<0.15	0.99 ± 0.64	<0.02	0.70 ± 0.32
320S	1360E	0.91 ± 0.22	<0.26	1.04 ± 1.75	<0.03	1.02 ± 0.30
320S	1400E	0.86 ± 0.19	0.19 ± 0.28	1.40 ± 0.51	<0.03	0.90 ± 0.32
320S	1440E	0.88 ± 0.26	<0.28	1.64 ± 1.65	<0.04	1.42 ± 0.34
320S	1480E	0.85 ± 0.26	<0.13	0.63 ± 0.78	<0.04	0.86 ± 0.28
320S	1509E	1.90 ± 0.38	<0.23	0.99 ± 0.76	1.37 ± 0.21	1.12 ± 0.40
340S	1009E	1.85 ± 0.26	<0.31	<0.96	<0.04	0.88 ± 0.40
360S	1009E	1.18 ± 0.23	<0.16	1.26 ± 0.86	<0.03	0.77 ± 0.31
360S	1020E	1.40 ± 0.30	<0.31	<0.92	0.17 ± 0.09	0.75 ± 0.35
360S	1040E	0.73 ± 0.25	<0.14	0.84 ± 0.45	<0.03	0.75 ± 0.34
360S	1060E	0.86 ± 0.20	<0.15	0.70 ± 0.46	<0.02	0.87 ± 0.24
360S	1080E	1.18 ± 0.28	<0.28	<0.89	<0.04	1.12 ± 0.35

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
360S	1100E	0.86 ± 0.19	<0.15	0.88 ± 0.76	<0.03	0.89 ± 0.25
360S	1120E	0.85 ± 0.30	<0.29	<0.93	<0.04	1.16 ± 0.49
360S	1140E	0.80 ± 0.25	<0.13	0.78 ± 0.93	<0.03	0.74 ± 0.27
360S	1160E	0.88 ± 0.29	<0.30	4.60 ± 1.86	0.13 ± 0.09	1.33 ± 0.63
360S	1200E	0.79 ± 0.21	<0.14	0.77 ± 0.87	<0.03	0.85 ± 0.44
360S	1240E	1.10 ± 0.24	<0.31	<0.88	<0.05	0.76 ± 0.27
360S	1280E	0.75 ± 0.34	<0.17	1.07 ± 0.77	<0.03	0.90 ± 0.54
360S	1320E	0.73 ± 0.18	<0.25	<0.86	<0.04	1.15 ± 0.38
360S	1360E	0.54 ± 0.26	<0.14	1.79 ± 0.61	<0.03	1.06 ± 0.40
360S	1400E	0.59 ± 0.15	<0.32	<0.99	<0.04	0.82 ± 0.37
360S	1440E	0.74 ± 0.28	0.26 ± 0.28	0.41 ± 0.50	0.06 ± 0.06	0.85 ± 0.28
360S	1480E	1.38 ± 0.25	<0.35	3.47 ± 1.30	<0.05	1.61 ± 0.49
360S	1509E	2.36 ± 0.48	<0.23	1.92 ± 1.77	0.33 ± 0.14	1.10 ± 0.71
380S	1009E	1.23 ± 0.35	<0.32	<0.98	0.91 ± 0.17	0.85 ± 0.45
400S	1009E	0.96 ± 0.23	<0.17	1.60 ± 0.59	0.22 ± 0.10	0.79 ± 0.43
400S	1020E	0.94 ± 0.19	0.33 ± 0.54	<0.84	0.16 ± 0.09	1.17 ± 0.42
400S	1040E	0.93 ± 0.18	<0.14	0.87 ± 0.47	<0.03	0.91 ± 0.30
400S	1060E	1.55 ± 0.30	<0.37	3.54 ± 1.55	<0.04	2.27 ± 0.47
400S	1080E	0.78 ± 0.18	<0.15	0.87 ± 0.76	<0.03	0.88 ± 0.34
400S	1100E	0.99 ± 0.26	<0.31	<0.84	<0.05	0.75 ± 0.24
400S	1120E	0.74 ± 0.20	<0.13	0.79 ± 0.73	<0.03	0.69 ± 0.26
400S	1140E	0.88 ± 0.21	<0.30	<0.86	<0.03	1.07 ± 0.32
400S	1160E	0.91 ± 0.31	0.34 ± 0.24	0.97 ± 0.52	<0.03	0.84 ± 0.34
400S	1200E	1.06 ± 0.24	<0.29	2.94 ± 0.95	<0.03	1.22 ± 0.32
400S	1240E	0.74 ± 0.24	<0.13	1.10 ± 0.79	<0.03	0.93 ± 0.36
400S	1280E	0.89 ± 0.30	<0.30	<0.93	0.74 ± 0.15	1.11 ± 0.34
400S	1320E	0.95 ± 0.24	<0.18	2.56 ± 1.18	0.56 ± 0.13	0.92 ± 0.38

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
400S	1360E	1.10 ± 0.26	<0.35	3.34 ± 1.81	0.19 ± 0.13	1.35 ± 0.43
400S	1400E	1.16 ± 0.40	<0.24	2.49 ± 0.86	0.86 ± 0.20	1.22 ± 0.43
400S	1440E	1.06 ± 0.23	<0.33	4.37 ± 1.28	<0.06	1.37 ± 0.39
400S	1480E	1.21 ± 0.34	<0.21	3.00 ± 0.79	0.92 ± 0.15	0.74 ± 0.59
400S	1509E	1.66 ± 0.43	<0.51	3.24 ± 1.86	2.10 ± 0.30	2.84 ± 1.08
420S	1009E	1.38 ± 0.26	<0.17	0.78 ± 0.79	0.09 ± 0.07	0.91 ± 0.45
440S	1009E	1.14 ± 0.26	<0.28	3.91 ± 1.37	0.23 ± 0.10	0.83 ± 0.36
440S	1020E	1.06 ± 0.25	<0.14	0.29 ± 0.34	<0.04	0.68 ± 0.36
440S	1040E	1.00 ± 0.29	<0.29	1.15 ± 1.39	<0.04	1.12 ± 0.29
440S	1060E	0.74 ± 0.26	<0.14	0.77 ± 0.72	<0.04	0.75 ± 0.34
440S	1080E	0.90 ± 0.34	<0.29	<0.88	<0.04	0.89 ± 0.37
440S	1100E	0.89 ± 0.23	<0.16	0.37 ± 0.34	<0.02	0.77 ± 0.32
440S	1120E	0.85 ± 0.23	<0.31	<0.94	<0.05	1.20 ± 0.36
440S	1140E	0.85 ± 0.20	<0.14	0.79 ± 0.46	<0.02	0.60 ± 0.32
440S	1160E	0.88 ± 0.26	<0.29	1.98 ± 1.72	<0.04	1.11 ± 0.29
440S	1200E	1.10 ± 0.25	<0.14	0.82 ± 0.47	<0.03	0.85 ± 0.36
440S	1240E	1.15 ± 0.25	<0.31	<0.99	0.31 ± 0.10	0.93 ± 0.37
440S	1280E	0.98 ± 0.50	<0.29	1.40 ± 1.46	4.97 ± 0.42	0.57 ± 0.33
440S	1320E	1.19 ± 0.45	<0.50	1.43 ± 3.12	1.92 ± 0.25	1.19 ± 0.89
440S	1360E	1.33 ± 0.35	<0.22	1.31 ± 0.69	1.80 ± 0.23	0.96 ± 0.60
440S	1400E	1.63 ± 0.64	<0.73	7.40 ± 3.62	3.26 ± 0.47	2.45 ± 1.11
440S	1440E	0.86 ± 0.26	<0.17	1.67 ± 0.65	0.24 ± 0.11	0.84 ± 0.32
440S	1480E	1.13 ± 0.34	<0.45	9.27 ± 2.77	0.88 ± 0.17	1.76 ± 0.47
440S	1509E	1.23 ± 0.40	0.22 ± 0.25	2.65 ± 0.82	1.38 ± 0.21	1.16 ± 0.37
457S	1020E	3.10 ± 0.45	<0.45	3.69 ± 2.10	1.01 ± 0.16	1.31 ± 0.62
457S	1040E	1.08 ± 0.24	<0.16	1.22 ± 0.99	<0.04	0.98 ± 0.48
457S	1060E	1.23 ± 0.21	<0.29	<0.84	0.14 ± 0.07	1.24 ± 0.28

TABLE 3, cont.

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM 40 M AND 20 M GRID INTERVALS

Grid Location		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-235	U-238	Cs-137	Th-232
457S	1080E	0.86 ± 0.23	<0.28	2.20 ± 1.00	<0.04	1.01 ± 0.32
457S	1100E	1.08 ± 0.25	<0.15	0.91 ± 0.50	0.07 ± 0.08	0.92 ± 0.36
457S	1120E	0.68 ± 0.40	<0.26	1.13 ± 1.26	0.66 ± 0.11	0.76 ± 0.29
457S	1140E	0.64 ± 0.20	<0.14	0.90 ± 0.45	0.54 ± 0.10	0.57 ± 0.21
457S	1160E	1.64 ± 0.26	<0.34	1.50 ± 2.07	0.64 ± 0.13	1.48 ± 0.42
457S	1200E	0.86 ± 0.25	<0.14	0.78 ± 0.63	0.25 ± 0.09	0.57 ± 0.32
457S	1240E	1.04 ± 0.24	<0.28	1.92 ± 1.66	<0.04	0.86 ± 0.41
457S	1280E	0.90 ± 0.20	<0.14	2.57 ± 0.83	0.63 ± 0.13	0.54 ± 0.42
457S	1320E	0.69 ± 0.19	<0.27	<0.86	0.40 ± 0.09	0.94 ± 0.39
457S	1360E	1.14 ± 0.33	<0.14	0.99 ± 0.81	0.35 ± 0.10	1.42 ± 0.43
480S	1440E	0.85 ± 0.20	<0.17	1.48 ± 0.52	0.08 ± 0.04	0.78 ± 0.31
480S	1480E	1.53 ± 0.41	<0.44	10.1 ± 3.1	1.81 ± 0.25	2.17 ± 0.73
480S	1509E	2.39 ± 0.41	<0.21	1.78 ± 0.71	0.59 ± 0.14	0.77 ± 0.35
510S	1480E	1.03 ± 0.40	<0.34	2.22 ± 2.02	<0.05	1.24 ± 0.69

[a] Errors are 2σ based on counting statistics.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.[a]	Grid Location	Depth (m)	Radionuclide Concentrations (pCi/g)				
			Ra-226	U-235	U-238	Cs-137	Th-232
H1	32N 1080E	Surface	1.08 ± 0.19[b]	<0.25	1.26 ± 1.12	<0.03	0.60 ± 0.20
		0.5	0.98 ± 0.24	<0.14	0.93 ± 0.95	<0.03	0.95 ± 0.32
		1.0	0.81 ± 0.28	<0.16	0.86 ± 1.37	<0.03	0.92 ± 0.29
H2	30N 1280E	Surface	0.89 ± 0.20	<0.23	3.47 ± 1.42	<0.03	0.74 ± 0.21
		0.5	1.05 ± 0.24	<0.13	0.80 ± 0.73	<0.03	0.82 ± 0.34
		1.2	3.03 ± 0.35	<0.35	6.69 ± 1.96	<0.04	1.14 ± 0.35
		2.0	1.01 ± 0.23	<0.22	<0.83	<0.04	1.12 ± 0.59
H3	40S 1470E	Surface	0.68 ± 0.23	<0.14	1.01 ± 0.45	0.13 ± 0.07	0.88 ± 0.26
		0.5	0.58 ± 0.17	<0.16	<0.46	<0.02	0.33 ± 0.35
		1.0	0.88 ± 0.19	<0.30	1.59 ± 1.30	<0.04	1.01 ± 0.35
H4	200S 1025E	Surface	0.81 ± 0.19	<0.12	<0.30	<0.03	0.66 ± 0.28
		0.5	0.90 ± 0.33	<0.25	2.29 ± 1.84	<0.04	0.66 ± 0.32
		1.0	0.88 ± 0.26	<0.20	1.57 ± 0.99	<0.03	0.87 ± 0.42
H5	219S 1511E	Surface	0.89 ± 0.23	<0.17	1.59 ± 0.55	<0.03	1.21 ± 0.27
		0.5	1.05 ± 0.24	<0.22	<0.79	<0.04	0.98 ± 0.41
		1.0	2.28 ± 0.46	0.33 ± 0.58	2.82 ± 2.16	0.13 ± 0.10	2.06 ± 0.57
H6	455S 1025E	Surface	1.06 ± 0.31	<0.23	1.21 ± 1.57	0.08 ± 0.07	1.28 ± 0.36
		0.3	1.88 ± 0.25	0.22 ± 0.35	1.07 ± 0.69	<0.03	0.60 ± 0.39
		2.1	0.93 ± 0.24	<0.29	<0.83	<0.03	1.01 ± 0.32
H7	456S 1160E	Surface	0.80 ± 0.22	<0.16	<0.62	0.07 ± 0.06	0.85 ± 0.51
		0.5	0.64 ± 0.14	<0.11	0.58 ± 0.42	<0.02	0.74 ± 0.32
		1.2	1.01 ± 0.24	<0.30	<0.90	<0.04	1.19 ± 0.42

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.	Grid Location		Depth (m)	Radionuclide Concentrations (pCi/g)				
				Ra-226	U-235	U-238	Cs-137	Th-232
H8	455S	1320E	Surface	0.75 ± 0.15	<0.11	0.88 ± 0.41	0.25 ± 0.06	0.55 ± 0.17
			0.5	0.75 ± 0.28	<0.17	0.86 ± 1.30	<0.03	0.80 ± 0.37
			2.0	0.53 ± 0.24	<0.18	1.38 ± 1.17	<0.03	0.74 ± 0.31
H9	510S	1503E	Surface	0.74 ± 0.18	0.39 ± 0.51	1.23 ± 1.28	0.14 ± 0.09	0.83 ± 0.29
			0.5	1.10 ± 0.40	<0.29	3.78 ± 2.37	<0.04	0.86 ± 0.45
			2.1	0.96 ± 0.31	<0.18	1.70 ± 1.04	<0.04	1.50 ± 0.54
H10	404S	1122E	Surface	0.78 ± 0.18	<0.13	1.29 ± 0.45	<0.02	0.71 ± 0.32
			1.0	0.84 ± 0.22	<0.18	1.58 ± 0.76	<0.03	0.61 ± 0.31
			2.0	1.05 ± 0.23	<0.27	<0.83	<0.03	0.96 ± 0.46
H11	424S	1137E	Surface	0.93 ± 0.24	<0.28	2.01 ± 0.85	<0.04	1.12 ± 0.44
			0.5	1.11 ± 0.361	<0.40	<1.11	0.25 ± 0.11	1.20 ± 0.49
			2.1	0.76 ± 0.22	<0.13	1.49 ± 0.85	0.15 ± 0.09	0.97 ± 0.33
H12	320S	1100E	Surface	0.70 ± 0.24	0.25 ± 0.54	<0.69	<0.04	0.84 ± 0.34
			0.9	0.73 ± 0.24	<0.21	1.78 ± 1.45	<0.03	1.01 ± 0.37
			1.8	0.69 ± 0.20	<0.23	<0.70	<0.02	0.81 ± 0.30
			3.3	0.68 ± 0.18	<0.12	0.62 ± 0.60	<0.02	0.77 ± 0.23
H13	363S	1103E	Surface	0.63 ± 0.19	0.32 ± 0.42	0.71 ± 1.33	<0.02	0.49 ± 0.26
			0.6	0.74 ± 0.20	<0.17	<0.56	<0.03	0.75 ± 0.32
			1.5	0.80 ± 0.19	<0.22	<0.69	<0.03	0.76 ± 0.24
			3.3	0.54 ± 0.35	<0.16	0.86 ± 0.79	0.03 ± 0.03	0.54 ± 0.27

TABLE 4, cont.

RADIONUCLIDE CONCENTRATIONS IN BOREHOLE SOIL SAMPLES

Borehole No.	Grid Location		Depth (m)	Radionuclide Concentrations (pCi/g)				
				Ra-226	U-235	U-238	Cs-137	Th-232
H14	403S	1109E	Surface	0.68 ± 0.41	<0.23	2.16 ± 1.50	<0.05	0.82 ± 0.41
			0.3	0.80 ± 0.20	<0.15	<0.56	<0.03	0.61 ± 0.31
			1.8	0.86 ± 0.24	<0.23	<0.64	<0.03	0.57 ± 0.18
			3.3	0.93 ± 0.25	<0.20	<0.50	<0.04	0.84 ± 0.53

[a] Refer to Figure 4.
[b] Errors are 2σ based on counting statistics.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES

Sample Identification	Sample Type	Grid Location[a]		Radionuclide Concentrations (pCi/l)		
				Gross Alpha	Gross Beta	Ra-226
W1	Subsurface, Borehole H1	32N	1080E	6.50 ± 2.13	4.71 ± 1.64	----[c]
W2	Subsurface, Borehole H2	30N	1280E	3.94 ± 1.21	2.78 ± 0.93	----
W3	Subsurface, Borehole H3	40S	1470E	8.10 ± 1.60	8.30 ± 1.22	----
W4	Subsurface, Borehole H4	200S	1320E	3.84 ± 3.03	5.01 ± 2.76	----
W5	Subsurface, Borehole H6	455S	1025E	4.94 ± 1.74	2.47 ± 1.36	----
W6	Subsurface, Borehole H8	455S	1320E	47.5 ± 9.2[b]	30.0 ± 5.8	<0.13

[a] Refer to Figure 4.
[b] Errors are 2σ based on counting statistics.
[c] Dash indicates analyses not performed.

REFERENCES

1. E.A. Vierzba and A. Wallo, Background and Resurvey Recommendations for the Atomic Energy Commission Portion of the Lake Ontario Ordnance Works, Aerospace Corp., November 1982.

2. Oak Ridge Operations, U.S. Atomic Energy Commission, Radiation Survey and Decontamination Report of the Lake Ontario Ordnance Works Site, Oak Ridge, TN, January 1973.

3. Personal Communication with Mr. J. Kirchue of Niagara Falls, NY, August 1983.

4. T.E. Myrick, et al., Preliminary Results of the Ground-Level Gamma-Ray Scan Survey of the Former Lake Ontario Ordnance Works Site - Draft Report, ORNL, Oak Ridge,TN, 1981.

APPENDIX A

INSTRUMENTATION AND ANALYTICAL PROCEDURES

APPENDIX A

Instrumentation and Analytical Procedures

Gamma Scintillation Measurement

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Count rates were converted to exposure rates (μR/h) using factors determined by comparing the response of the scintillation detector with that of a Reuter Stokes model RSS-111 pressurized ionization chamber at locations on the Niagara Falls Storage Site and off-site properties.

Beta-Gamma Dose Rate Measurements

Measurements were performed using Eberline "Rascal," Model PRS-1, portable scaler/ratemeters with Model HP-260 thin-window, pancake G-M, beta probes. Dose rates (μrad/h) were determined by comparison of the response of a Victoreen Model 440 ionization chamber survey meter to that of the G-M probes.

Borehole Logging

Borehole gamma radiation measurements were performed using a Victoreen Model 489-55 gamma scintillation probe, connected to a Ludlum Model 2200 portable scaler. The scintillation probe was shielded by a 1.25 cm thick lead shield with four 2.5 cm x 7 mm holes evenly spaced around the region of the scintillation crystal. The probe was lowered into each hole using a tripod holder with a small winch. Measurements were performed at 15-30 cm intervals in all holes. The logging data was used to identify regions of possible residues and guide the selection of subsurface soil sampling locations. Due to the varying ratios of Ra-226, U-235, U-238, Th-232, and Cs-137, there was no attempt to estimate soil radionuclide concentrations directly from the logging results.

Soil and Sediment Sample Analysis

Soil and sediment samples were dried, mixed, and a portion placed in a 0.5 liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 800 g of soil. Net soil weights were determined and the samples counted using intrinsic germanium and Ge(Li) detectors (Princeton Gamma Tech) coupled to a Nuclear Data model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Ra-226 - 0.609 MeV from Bi-214 (corrected for equilibrium conditions)
U-235 - 0.143 MeV
U-238 - 0.094 MeV from Th-234 (secular equilibrium assumed)
Th-232 - 0.911 MeV from Ac-228 (secular equilibrium assumed)
Cs-137 - 0.662 MeV

Water Sample Analysis

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45 μm membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid. A known volume of each sample was evaporated to dryness and counted for gross alpha and gross beta using a Tennelec Model LB 5100 low-background proportional counter.

Analysis for Ra-226 was performed using the standard technique EPA 600/4-80-032 (August 1980).

Calibration and Quality Assurance

With the exception of the exposure and dose rate conversion factors for portable survey gamma and beta-gamma meters, all survey and laboratory

instruments were calibrated with NBS-traceable standards. The calibration procedures for these portable instruments are described above.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA Quality Assurance Program.

APPENDIX B

SUMMARY OF RADIATION GUIDELINES APPLICABLE TO OFF-SITE PROPERTIES AT THE NIAGARA FALLS STORAGE SITE

U. S. DEPARTMENT OF ENERGY

INTERIM RESIDUAL CONTAMINATION AND WASTE CONTROL GUIDELINES FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP) AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP) SITES

(Review Within DOE Continuing)

Presented here are the residual contamination cleanup and waste control guidelines of general applicability to the FUSRAP project and remote SFMP sites[1/]. A site-specific analysis will be prepared for each FUSRAP and remote SFMP site prior to determining residual contamination guidelines for a specific site. In addition, it is the policy of the DOE to decontaminate sites in a manner consistent with DOE's as-low-as-reasonably-achievable (ALARA) policy. ALARA will be considered in reducing levels of residual contamination below applicable dose limits. ALARA will be implemented using cost/benefit considerations, and applied on a site-specific basis.

The soil residual contamination guidelines were developed on the basis of limiting maximum individual radiation exposure to DOE limits specified in DOE Order 5480.1A exclusive of exposure from natural background radiation or medical procedures. The radium-226 and thorium-230 guidelines include an additional limitation for buildup of radon-222 decay products in buildings. The aggregate of the contribution from all major pathways, based on scenarios for permanent intrusion, e.g., establishing residences on the site, was assumed. In most circumstances, the probability is low that such an intrusion will occur. Also, conservative assumptions were used in deriving these guidelines to ensure that a particular dose limit would not be exceeded. Use of these guidelines is additionally conservative because the pathways considered in the derivation of the guidelines assume all water intake and most food intake is from the site. Also, the FUSRAP and remote SFMP sites often have limited agricultural capability and the contamination is generally not homogeneous. The combined effect of these factors is such that the probable radiation exposure to the average population on, or in the vicinity of, FUSRAP or remote SFMP sites decontaminated to these guidelines will not be appreciably different from that normally received from natural background radiation.

The residual contamination guidelines for surface contamination of structures were adapted from guidelines developed by the U. S. Nuclear Regulatory Commission (NRC) for decontamination of facilities and equipment prior to release for unrestricted use or termination of licenses for byproduct, source, or special nuclear material[2/]. The waste control guidelines are consistent with applicable DOE Orders and EPA's regulations for inactive uranium milling sites, 40 CFR Part 192.

[1/] A remote SFMP site is one that is excess to DOE programmatic needs and is

located outside a major operating DOE R&D or production area. Remote sites are more likely to be released to the public or excessed to other government agencies after decontamination than are sites located with major R&D or production areas.

2/ U. S. Nuclear Regulatory Commission 1982 Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC.

A. RESIDUAL CONTAMINATION GUIDELINES FOR FORMERLY UTILIZED SITES AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

The following guidelines represent the maximum residual contamination limits for unrestricted use of land and structures contaminated with radionuclides related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. A site-specific analysis will be prepared for each site prior to determining residual contamination guidelines for a specific site. It is the policy of DOE to decontaminate sites to contamination levels at or below the limits and in a manner consistent with DOE's as-low-as-is-reasonably-achievable (ALARA) policy on a site-specific basis. Site-specific guidelines and ALARA policy will be determined by DOE on a site-specific basis and an ALARA report filed on completion of remedial action at a site. Existing state and federal standards will be applied for water protection. Residual contamination limits for other nuclides will be developed when required using the same methodology 1/ as was used for those represented here.

1. Soil (Land) Guidelines (Maximum Limits for Unrestricted Use)

Radionuclide	Soil Criteria 2/,3/,4/ (pCi/g above background)
U-Natural 5/	75
U-238 6/	150
U-234 6/	150
Th-230 7/	15
Ra-226	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15 cm thick soil layers more than 15 cm below the surface and less than 1.5m below the surface.
U-235 6/	140
Pa-231	40
Ac-227	190
Th-232	15
Am-241	60
Pu-241 8/	2400
Pu-238, 239, 240	300
Cs-137	80

Sr-90	300
H-3 (pCi/ml soil moisture)	5,200

1/ Described in ORO-831 and ORO-832.

2/ In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its guideline shall be determined, and the sum of these fractions shall not exceed 1. There are two special cases for which this rule must be modified:

(a) If Ra-226 is present, then the fraction for Ra-226 should not be included in the sum if the Ra-226 concentration is less than or equal to the Th-230 concentration. If the Ra-226 concentration exceeds the Th-230 concentration, then the sum shall be evaluated by replacing the Ra-226 concentration by the difference between the Ra-226 and Th-230 concentrations.

(b) If Ac-227 is present, then the same rule given in (a) for Ra-226 relative to Th-230 applies for Ac-227 relative to Pa-231.

3/ Except for Ra-226, these guidelines represent unrestricted-use residual concentrations above background averaged across any 15 cm thick layer to any depth and over any contiguous 100 m^2 surface area. The same conditions prevail for Ra-226 except for soil layers beneath 1.5 m; beneath 1.5 m, the allowable Ra-226 concentration may be affected by site-specific conditions and must be evaluated accordingly.

4/ Localized concentrations in excess of these guidelines are allowable provided that the average over 100 m^2 is not exceeded. However, DOE ALARA policy will be considered on a site-specific basis when dealing with elevated localized concentrations.

5/ A curie of natural uranium means the sum of 3.7×10^{10} disintegrations per second (dis/s) over any 15cm thick layers from U-238 plus 3.7×10^{10} dis/s from U-234 plus 1.7×10^{9} dis/s from U-235. One curie of natural uranium is equivalent to 3,000 kilograms or 6,600 pounds of natural uranium.

6/ Assumes no other uranium isotopes are present.

7/ The Th-230 guideline is 15 pCi/g to account for ingrowth of Ra-226 as Th-230 decays. Ra-226 is a limiting radionuclide because its decay product is Rn-222 gas.

8/ The Pu-241 guideline was derived from the Am-241 concentration.

2. Structure Guidelines (Maximum Limits for Unrestricted Use)

a. Indoor Radon Decay Products

A structure located on private property and intended for unrestricted use shall be subject to remedial action as necessary

to ensure the annual average concentration of radon decay products is less than 0.03 WL within the structure.

b. Indoor Gamma Radiation

The indoor gamma radiation after decontamination shall not exceed 20 microroentgen per hour (20 R/h) above background in any occupied or habitable building.

c. Indoor/Outdoor Structure Surface Contamination

Radionuclides 2/	Allowable Surface Residual Contamination +1 (dpm/100 cm^2) Average 3/,4/	Maximum 4/,5/	Removable 4/,6/
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
U-Natural, Th-232, Sr-90, Fr-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000	15,000	1,000
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000	15,000	1,000

1/ As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

2/ Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides shall apply independently.

3/ Measurements of average contaminant should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

4/ The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should

not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.

5/ The maximum contamination level applies to an area of not more than 100 cm^2.

6/ The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels shall be reduced proportionately and the entire surface shall be wiped.

B. CONTROL OF RADIOACTIVE WASTES AND RESIDUES FROM FUSRAP AND REMOTE SFMP SITES

Specified here are the control requirements for radioactive wastes and residues related to the nuclear fuel cycle at FUSRAP and remote SFMP sites. It is the policy of DOE to store radioactive wastes in a manner representing sound engineering practices consistent with DOE's ALARA policy.

1. Interim Storage

All operational and control requirements specified in the following DOE Orders and other items shall apply:

a. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations.

b. 5480.2, Hazardous and Radioactive Mixed Waste Management.

c. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities.

d. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements.

e. 5484.2, Unusual Occurrence Reporting System.

f. 5820, Radioactive Waste Management.

g. Control and stabilization features will be designed to ensure, to the extent reasonably achievable, an effective life of 50 years, and in any case, at least 25 years.

h. Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not (1) exceed 100 pCi/l at any given point, or an average concentration of 30 pCi/l for the facility site, or (2) exceed an average Rn-222 concentration at or above any location outside the facility site of 3.0 pCi/l (above background).

i. For water protection, use existing state and federal standards; apply site-specific measures where needed.

2. Long-Term Management

a. All operational requirements specified for Interim Storage Facilities (B.1) will apply.

b. Control and stabilization features will be designed to ensure to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years. Other disposal site design features shall conform with 40 CFR Part 192 performance guidelines/requirements.

c. Rn-222 emanation to the atmosphere from facility surfaces or opening shall not (1) exceed an average release rate of 20 $pCi/m^2/s$, or (2) increase the annual average Rn-222 concentration at or above any location outside the facility site by more than 0.5 pCi/l.

d. For water protection, use existing state and federal standards; apply site-specific measures where needed.

e. Prior to placement of any potentially biodegradable contaminated wastes in a Long-Term Management Facility, such wastes will be properly conditioned to (1) ensure that the generation and escape of biogenic gases will not cause the requirement in paragraph 2.c. to be exceeded, and (2) ensure that biodegradation within the facility will not result in premature structural failure not in accordance with the requirements in paragraph 2.b.. If biodegradable wastes are conditioned by incineration, incineration operations will be carried out in compliance with all applicable federal, state, and local air emission standards and requirements, including any standards for radionuclides established pursuant to 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants (NESHAPS).

C. EXCEPTIONS

Exceptions may be made to the guidelines presented herein following analysis of the site-specific aspects of a candidate site. Specific situations that warrant consideration for modifying these guidelines are:

1. Where remedial actions would pose a clear and present risk of injury to workers or members of the public, notwithstanding reasonable measures to avoid or reduce risk.

2. Where remedial actions would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future, notwithstanding reasonable measures to limit damage to the environment. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

3. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and the residual radioactive materials do not pose a clear present or future hazard. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this hazard. Remedial actions will generally not be necessary where residual radioactive materials have been placed semipermanently in a location where site-specific factors limit their hazard and from which they are costly or difficult to remove, or where only minor quantities of residual radioactive materials are involved. Examples are residual radioactive materials under hard surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. Supplemental standards shall not be applied at such sites, however, if individuals are likely to be exposed for long periods of time to radiation from such materials at levels above those that would prevail in Subpart A.

4. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be affected by remedial actions, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of less costly remedial methods than removal of residual radioactive materials.

5. Where there is no known remedial action.

D. GUIDELINE SOURCE

Guideline	Source
Residual Contamination Criteria[1/]	
Soil Guideline	DOE Order 5480.1A, 40 CFR Part 192[2/]
Structure Guideline	40 CFR Part 192, NRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material (July 1982).
Control of Radioactive Wastes and Residues	
Interim Storage Long-Term Management	DOE Order 5480.1A 40 CFR Part 192

1/ The bases of the residual contamination guidelines are developed in ORO-831 and ORO-832.

2/ Based on limiting the concentration of Ra-222 decay products to 0.03 WL within structures.

APPENDIX C

REPORT OF GROUND-PENETRATING RADAR SURVEY OF OFF-SITE PROPERTY C AT THE NIAGARA FALLS STORAGE SITE

DETECTION SCIENCES GROUP
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FINAL REPORT

GROUND-PENETRATING RADAR SURVEY
AREA C
FORMER LAKE ONTARIO ORDNANCE WORKS
LEWISTON, NEW YORK

Prepared for

OAK RIDGE ASSOCIATED UNIVERSITIES, INC.
Oak Ridge, Tennessee 37830

Purchase Order No. C-29943-007, September 2, 1983
Amendment No. C-29943-007-A, September 30, 1983
Letter Release No. 7

Report No. J163-83

September, 1983

DETECTION SCIENCES GROUP

INTRODUCTION AND SUMMARY

On September 7, 1983, **Detection Sciences Group** performed a ground-penetrating radar survey of the systematic borehole locations on Property **C** at the former Lake Ontario Ordnance Works, Lewiston, New York. The survey was performed in accordance with Oak Ridge Associated Universities, Inc. Purchase Order No. C-29932-007, Letter Release No. 7, dated September 2, 1983 and Amendment No. C-29943-007-A dated September 30, 1983. The survey work was conducted under the field direction and instructions of O.R.A.U. personnel.

On Property **C**, a total of 9 boring locations were inspected. (This procedure has been described in detail in the **Final Report** on Property **G**, dated August, 1983, and will not be iterated here.) Potential drilling obstacles were found at 4 of the 9 locations. The proposed locations for the 9 borings and the final locations of the borings are listed in **Table** I (attached).

The designations of the borings, C1 through C9 for the systematic borings, are designations assigned by **Detection Sciences Group** in accordance with the sequence in which the borings were inspected, and are not designations assigned by O.R.A.U.

On September 8, 1983, a grid-survey was made on Area C. The survey ran from 364S to 424S covering 1102E to 1137E, as illustrated on **Figure 1**. There is a cluster of buried metal objects located at 363S, between 1101.5E and 1105E at a depth of 5.0 feet. There is buried material at 403S, running between 1104E and 1115E, at a depth of 4.0 feet. There is a buried pipe at 423S, 1137E at a depth of 4.5 feet. Table II summarizes the locations of these features.

A separate binding, titled "Radar Graphic Charts", contains all of the radar charts made in Area C. The proposed location of the boring is the centerpoint of each chart, shown by a pair of vertical dashed lines. The final location of each boring is shown by the arrow at the top of each chart. The vertical scale for all charts is 1 inch = 1 foot. The horizontal scale is in meters, as marked at the top of the charts. The radar graphic charts for the grid surveys have a vertical scale of 1" = 2 feet.

TABLE I

BORING LOCATIONS DETERMINED BY RADAR

AREA C - SYSTEMATIC BORINGS

Boring Number	Direction of Relocation	Proposed Location	Final Location
C1	Move 1m South	32N, 1080E	31N, 1080E
C2	-	30N, 1280E	30N, 1280E
C3	-	40S, 1470E	40S, 1470E
C4	-	40S, 1018E	40S, 1018E
C5	Move 1m East	200S, 1024E	200S, 1025E
C6	-	455S, 1025E	455S, 1025E
C7	-	456S, 1160E	456S, 1160E
C8	Move 1m East	455S, 1320E	455S, 1321E
C9	Move 1m West	510S, 1503E	510S, 1502E

Table II.

AREA C

LOCATIONS OF RADAR ANOMALIES

Chart	Line	Location	Depth, Ft.	Description
#7	363S	1101.5E - 1105E	5.0'	Buried Metal
#3	403S	1104E - 1115E	4.0'	Buried Material
#1	423S	1137E	4.5'	Buried Pipe

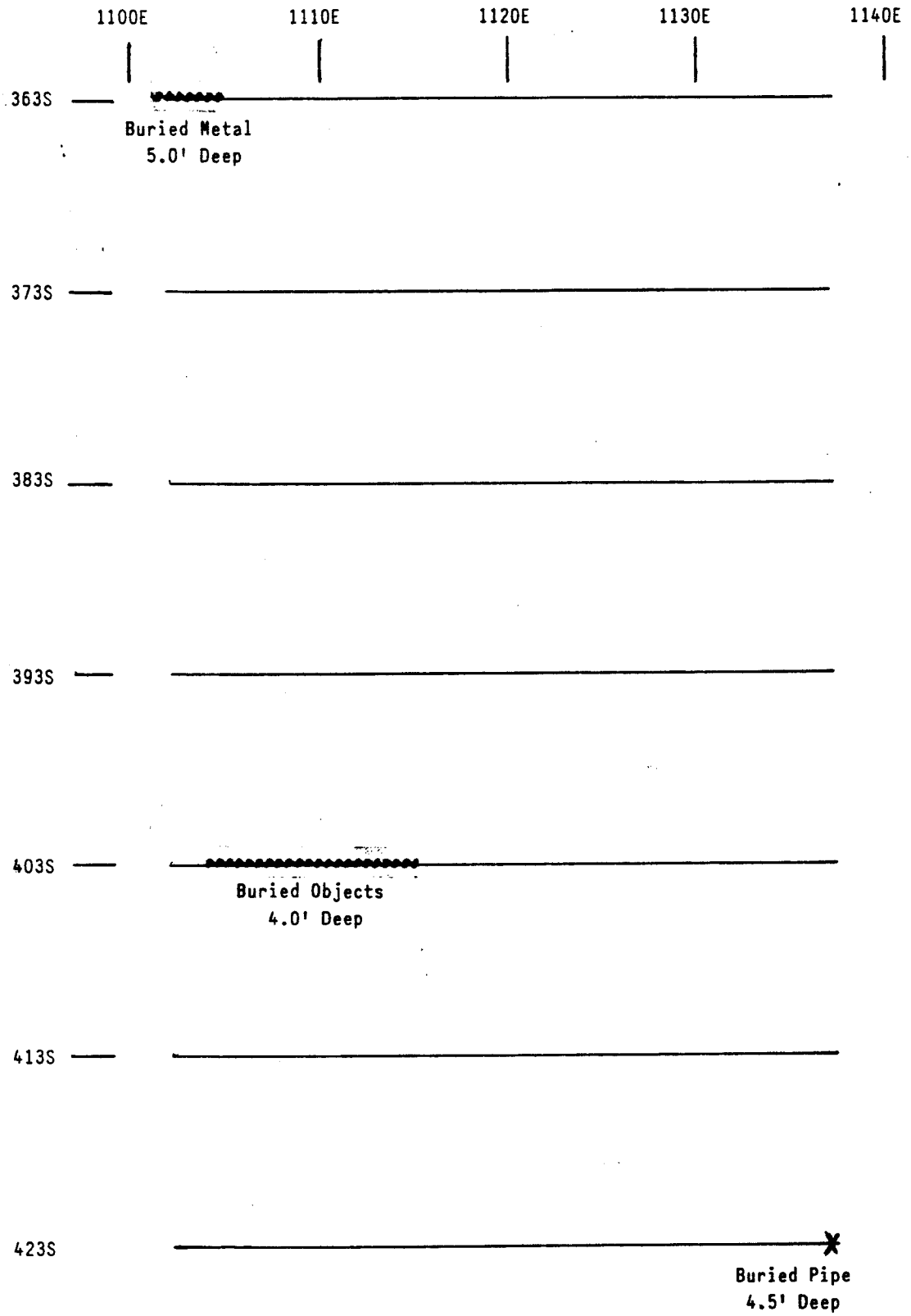

Figure 1.

AREA C

RADAR TRANSECT LINES AND ANOMALIES