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Surplus Facilities Management Program (SFMP)
Contract No. DE-AC05-81OR20722

NIAGARA FALLS STORAGE SITE ANNUAL SITE ENVIRONMENTAL MONITORING REPORT

Lewiston, New York

Calendar Year 1985

April 1986

Bechtel National, Inc.
Advanced Technology Division

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Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

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ABSTRACT

During 1985, an environmental monitoring program was continued at the Niagara Falls Storage Site (NFSS), a United States Department of Energy (DOE) surplus facility located in Niagara County, New York, presently used for the interim storage of low-level radioactive residues and contaminated soils and rubble. The monitoring program is being conducted by Bechtel National, Inc. Monitoring results show that the NFSS is in compliance with DOE concentration guides and radiation protection standards. Derived Concentration Guides (DCGs) represent the concentrations of radionuclides in air or water that would limit the radiation dose to 100 mrem/yr. The applicable limits have been revised since the 1984 environmental monitoring report was published. The limits applied in 1984 were based on a radiation protection standard of 500 mrem/yr; the limits applied for 1985 are based on a standard of 100 mrem/yr.

To determine whether the site is in compliance with DOE standards, environmental measurements are expressed as percentages of the applicable DCG, while the calculated doses to the public are expressed as percentages of the applicable radiation protection standard.

The monitoring program measured radon gas concentrations in air; uranium and radium concentrations in surface water, groundwater, and sediments; and external gamma dose rates. Environmental samples collected were analyzed to determine compliance with applicable standards. Potential radiation doses to the public were also calculated.

During 1985, annual average radon concentrations ranged from 8 to 19 percent of the DOE guide. The highest total average gamma dose rate measured at the NFSS was 65 percent of the radiation protection standard. The highest average annual concentrations of uranium in

surface water monitored at the NFSS was 3.2 percent of the DOE DCG and for radium-226 it was 1.3 percent of the applicable DCG. In groundwater, the highest annual average concentration of uranium was 10 percent of the DCG and for radium-226 it was 0.7 percent of the applicable DCG.

There are no specific limits for uranium or radium in sediments. However, the cleanup of radium at the NFSS is conducted in accordance with the DOE FUSRAP guidelines for radionuclides in soil. The average concentrations were below the guidelines.

Radon concentrations concentrations remained relatively constant from 1983 to 1985. The external gamma dose rates have trended downward as remedial action has progressed, and the 1985 level is approximately equal to the average background level. The uranium and radium-226 levels in surface water have risen since 1984, but are still below the DCG. The groundwater levels have trended downward and are below the applicable DCG. Uranium and radium-226 concentrations have trended downward as remedial action has been progressed, although the levels did increase compared to 1984 levels. Detailed explanations regarding radiation levels measured in 1985 can be found in Sections 2.0 (Summary) and 3.0 (Data, Collection, and Analysis).

The calculated radiation dose to the maximally exposed individual at the NFSS was 15 mrem, 15 percent of the radiation protection standard.

TABLE OF CONTENTS

Table of Contents (continued)

LIST OF FIGURES

List of Figures (continued)

LIST OF TABLES

1.0 INTRODUCTION

This report presents the findings of the environmental monitoring conducted at the Niagara Falls Storage Site (NFSS) during calendar year 1985. Environmental monitoring has been conducted at the NFSS since 1981. The NFSS is part of the United States Department of Energy (DOE) Surplus Facilities Management Program (SFMP), one of four remedial action programs under the direction of the DOE Division of Facility and Site Decommissioning Projects (DFSDP). In addition to the site, radioactively contaminated vicinity properties located adjacent to or near the NFSS are the responsibility of the Formerly Utilized Sites Remedial Action Program (FUSRAP), another DOE program under the direction of DFSDP.

1.1 LOCATION AND DESCRIPTION

The NFSS occupies approximately 77.4 ha (191 acres) located in northwestern New York within the Township of Lewiston (Niagara County). The site is approximately 6.4 km (4 mi) south of Lake Ontario, 16 km (10 mi) north of the city of Niagara Falls, and is in a generally rural setting. The NFSS and its regional setting are shown in Figure 1-1; Figure 1-2 is an aerial photograph of the site.

The NFSS is presently being developed as an interim waste storage area for low-level radioactive residues from pitchblende processing and radium-contaminated sand, soil, and building rubble. Work is scheduled to be complete in late 1986. At the end of the 1985 construction season, the site configuration was essentially complete except for completion of the cap over the residues in the Interim Waste Containment Facility (IWCF), demolition of Building 409, and removal of water treatment ponds.

The dominant feature of NFSS as presented in Figure 1-3 is the 4-ha (10-acre) IWCF. The IWCF is enclosed within a dike and cutoff wall, each constructed of compacted clay. The cutoff wall extends a minimum of 45 cm (18 in.) into an underlying gray clay unit. The

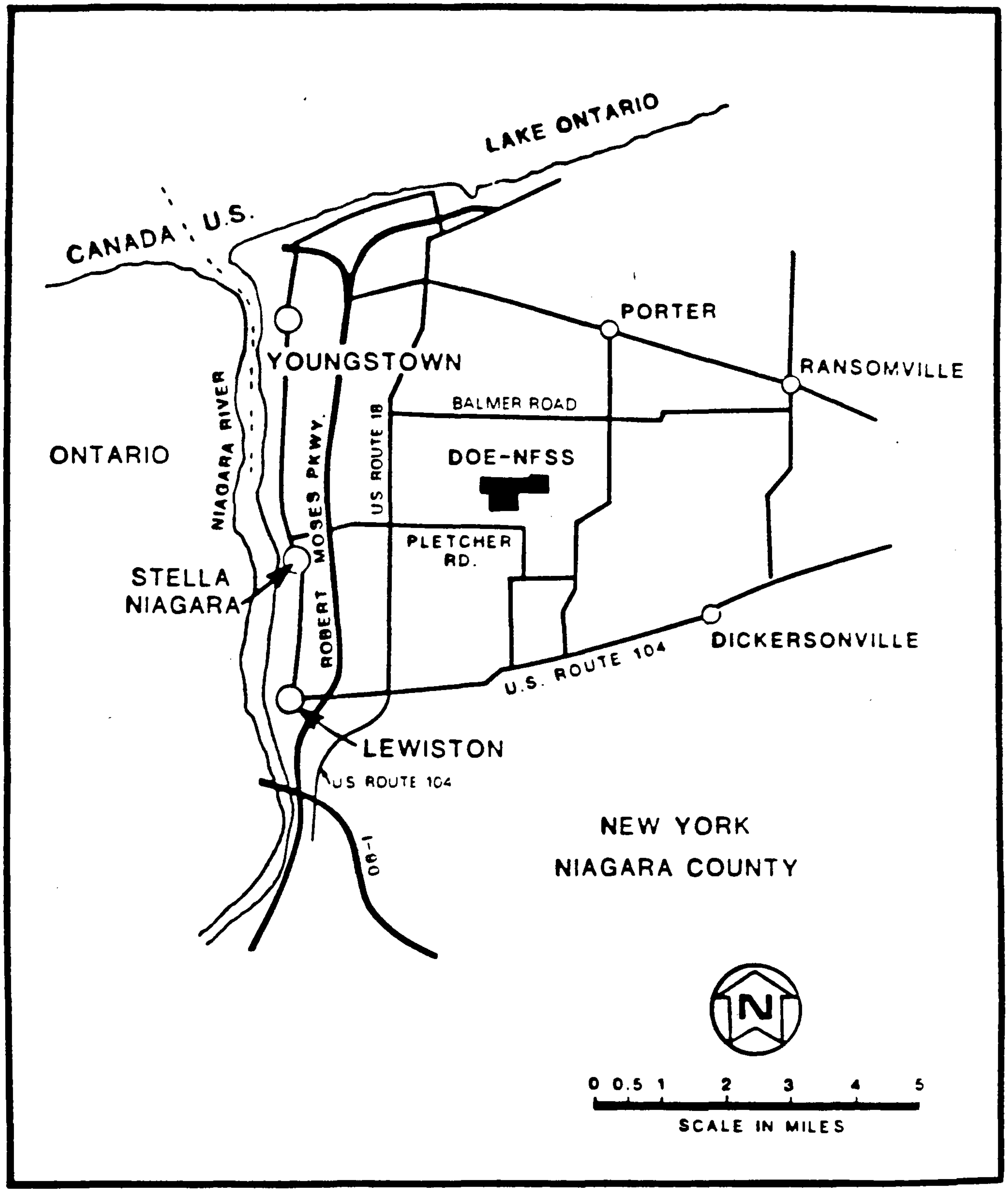


FIGURE 1-1 THE REGIONAL SETTING OF THE NFSS

FIGURE 1-2 AERIAL VIEW OF THE NFSS

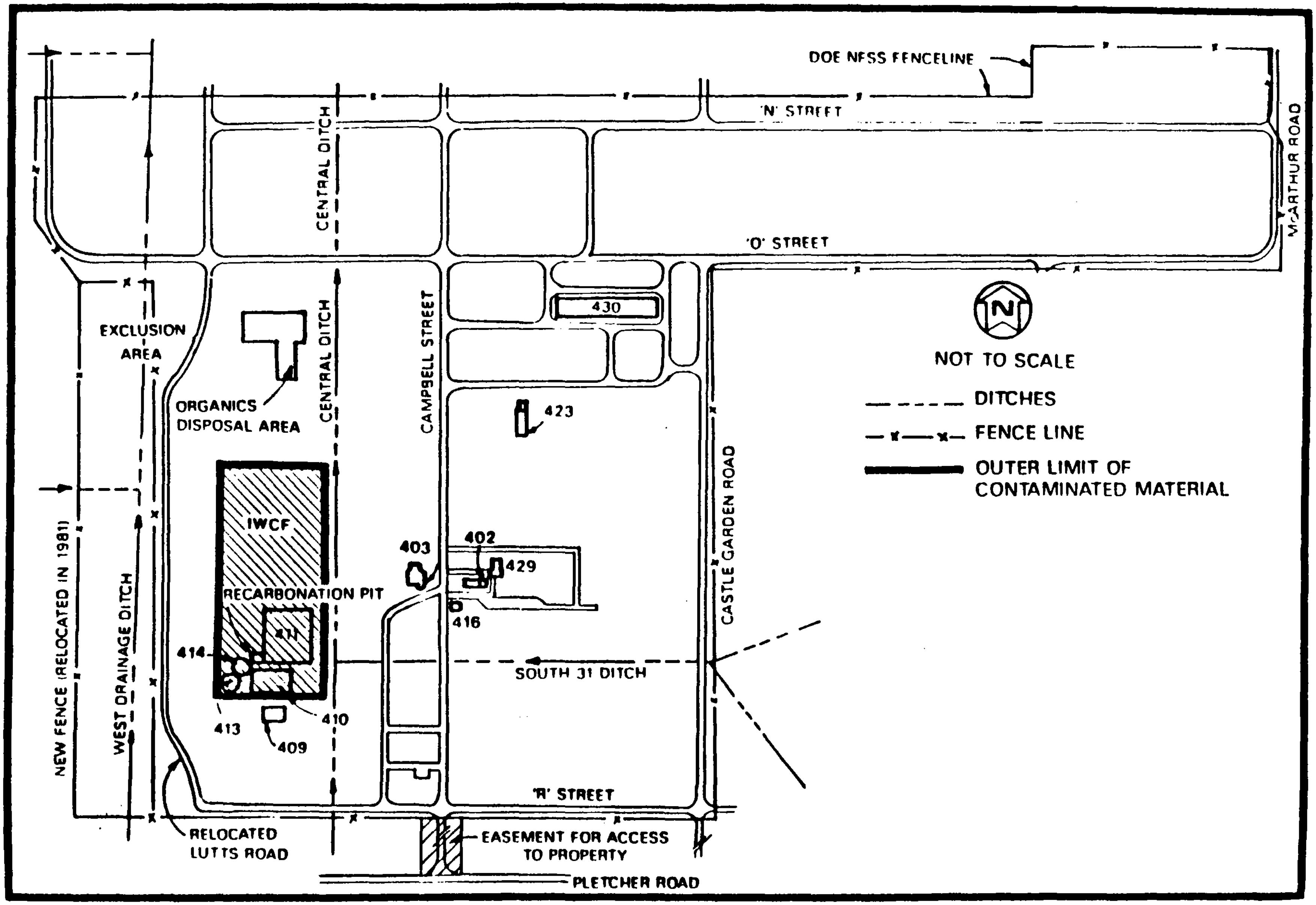


FIGURE 1-3 PRESENT CONFIGURATION OF THE NFSS

dike and cutoff wall, in conjunction with the engineered earthen drainage cover or cap, enclose the wastes in a clay envelope that provides a barrier to migration of radionuclides into both groundwater and surface water. More detailed information on the design of the IWCF is provided in Reference 1.

Ongoing site construction activities are designed to preclude the migration of contaminants from the NFSS into both groundwater and surface water. During construction, pollution control measures include the use of prudent engineering controls, e.g., use of sedimentation barriers in excavation areas and batch discharges of treated, impounded surface water in accordance with New York State Department of Environmental Conservation (NYSDEC) requirements.

The site is generally level but slopes gently to the northwest at elevations between 96.9 and 97.8 m (318 and 321 ft) above m.s.l. The site drains poorly because of the flatness of the terrain and soil characteristics. Soils at the NFSS are predominantly silt loams underlain by a clayey glacial till and a lacustrine clay. Sand-gravel inclusions are frequent. Bedrock lies 9.1 to 15.2 m (30 to 50 ft beneath the surface and consists of Queenston shale.

All surface water from the site currently discharges via the Central Drainage Ditch and its tributary ditches into Fourmile Creek, located northwest of the site. Groundwater is present in an aquifer at the bedrock surface (the primary aquifer beneath the site), in sand-gravel lenses, and in saturated clay zones at depths of 1.5 to 6.1 m (5 to 20 ft). Groundwater level contours indicate a slope of the primary aquifer to the north-northwest of approximately 3 m/km (10 ft/mi). The groundwater most likely discharges into the northern reaches of the Niagara River close to Lake Ontario (Ref. 2).

Surface water is the predominant source of potable water in the area surrounding the NFSS; approximately 90 percent of the population in Niagara and Erie Counties uses a surface water source. Water from Lake Erie serves 65 percent of the population and water from the upper Niagara River serves 25 percent of the population (Ref. 3).

Communities north of the Niagara Escarpment, including Lewiston and Porter Townships, receive much of their water from these sources.

Groundwater is used to supply approximately 10 percent of the population in Niagara and Erie Counties. The primary uses are for small domestic and farm supplies in rural sections. The dominant source of this water, the Lockport Dolomite aquifer, is absent north of the Niagara Escarpment where the NFSS is located. Wells in the vicinity of the NFSS are generally of low yield and supply water of poor quality. The upper aquifers in the glacial deposits near the NFSS are sometimes capable of supplying adequate groundwater for domestic use, although these sources may be depleted during dry seasons (Ref. 3).

The climate of the NFSS is classified as humid continental, with a considerable moderating influence from Lake Ontario. The normal temperature range is -3.9 to 24.4°C (25 to 76°F), with a mean annual temperature of 8.9°C (48°F). Mean annual precipitation is 80 cm (32 in.). Snowfall averages 140 cm/yr (56 in./yr), accounting for about 10 percent of the annual total precipitation (Ref. 4).

Wind speeds and directions recorded in the vicinity of the NFSS during 1985 are given in Figure 1-4. The data show that the wind originates predominantly from the southwest. The average monthly wind speed ranged from 15.9 to 23 km/h (9.9 to 14.3 mph) (Ref. 4).

The primary areas of population near the NFSS are the towns of Lewiston (population: 16,200), Niagara (population: 9,650), Porter (population: 7,250), and Niagara Falls City (population: 71,400) (Ref. 3). Almost three-fourths of the 227,000 people residing in Niagara County live in urban areas. Population density in Niagara County in 1980 was about 168 persons/km^2 (430 persons/mi^2) (Ref. 3). Land uses immediately adjacent to the site are varied and are presented in Figure 1-5. The site is bordered by a hazardous waste disposal site, a sanitary landfill, and land that is currently vacant.

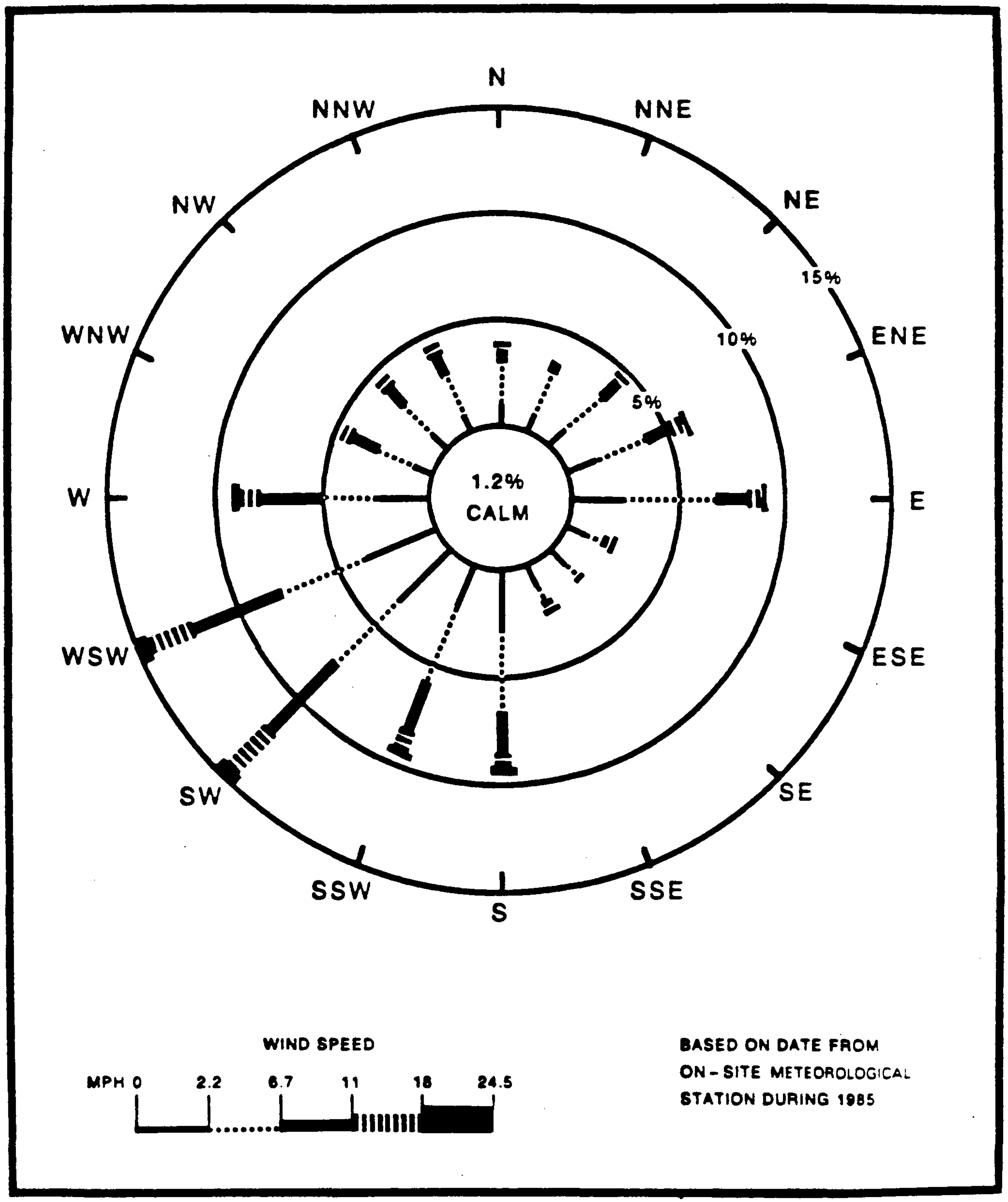


FIGURE 1-4 ANNUAL WIND ROSE FOR NFSS, 1985

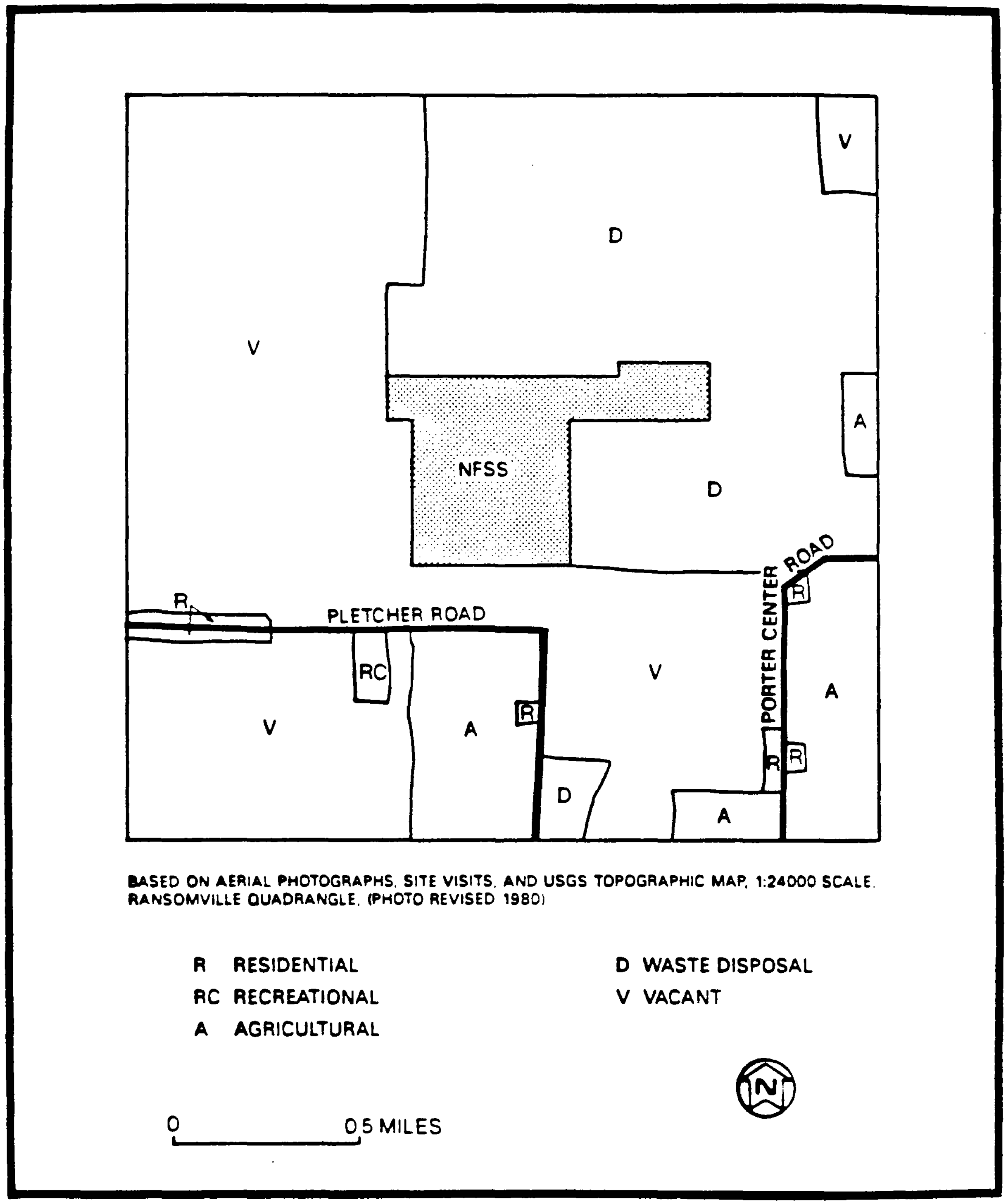


FIGURE 1-5 GENERALIZED LAND USE IN THE VICINITY OF THE NFSS

Land uses beyond those presented in Figure 1-5 are dominated by truck farms, orchards, and rural single-family dwellings. Lewiston-Porter Central Schools are located 3.1 km (1.5 mi) west of the site on Blairville/Creek Road, while the nearest permanent residence is 1.1 km (0.7 mi) southwest of the site.

1.2 SITE HISTORY

The NFSS is a remnant of the original 612-ha (1511-acre) site that was used during World War II by the Manhattan Engineer District (MED) project and was a portion of the Department of the Army's Lake Ontario Ordnance Works (LOOW). Except for nonradioactive boron-10 enriching operations during the periods 1954 to 1958 and 1964 to 1971, the site's major use from 1944 to the present has been for the storage of low-level radioactive residues produced as by-products of uranium production during the MED project and subsequent Atomic Energy Commission (AEC) projects.

The first materials to arrive at the site were low-grade residues and by-products from the Linde Air Products Division in Tonawanda, New York, (the L-30, L-50, and R-10 residues) and from the Middlesex Sampling Plant in Middlesex, New Jersey, (the F-32 residues). The L-30 and L-50 residues were stored in Buildings 411, 413, and 414, while the F-32 residues were stored in the Recarbonation Pit directly west of Building 411. The R-10 residues, as well as associated iron cake, were stored in an open area north of Building 411. These residues were subject to environmental processes, which transported contaminants into the soil and drainageways, resulting in the contamination of other portions of the site and off-site drainageways. The small quantity of Middlesex Sands resulting from decontamination activities at the Middlesex Sampling Plant were stored in Building 410. In 1949 pitchblende residues (the K-65 residues) resulting from uranium extraction conducted at a St. Louis plant were transported to the LOOW in drums. Some of these were stored outdoors along existing roads and rail lines; others were stored in Building 410. From 1950 to 1952, the K-65 residues were transferred to a renovated concrete water tower (Building 434).

The weight and volume of the residues and sands stored at the NFSS are summarized in Table 1-1. Buildings and other features of the NFSS before recent interim remedial actions are illustrated in Figure 1-6.

In 1979, Battelle Columbus Laboratories performed a comprehensive radiological survey of the NFSS. Battelle published its findings in June 1981 (Ref. 5), and the report served as the basis for initial interim remedial action planning at the site. Bechtel National, Inc. (BNI) was chosen by DOE as the Project Management Contractor (PMC) for the NFSS project in 1981. As part of its duties as PMC, BNI maintains the security of the site, performs maintenance as required, carries out the environmental monitoring program, and helps plan and execute the interim remedial action program for the site. Access to the site is controlled by a 2.1-m (7-ft) high fence that encloses the DOE property.

Since 1980, various steps have been taken at the NFSS to minimize potential radiological risks and prevent migration of residues. In the fall of 1980, the vent at the top of Building 434 (the former water tower in which the K-65 residues were stored) was capped to reduce radon emissions to the environment. Also during 1980, all pipes penetrating the walls of the residue storage buildings were sealed or resealed as necessary to prevent radionuclide migration.

Because radon levels at the site's western boundary were exceeding DOE limits, the site fence was relocated approximately 152.4 m (500 ft to the west in mid-1981, creating an exclusion area to protect the public from exposure to the higher radon levels. Radon levels at the new boundary were well below applicable guidelines. In 1981, remedial action was performed on a triangular-shaped area located just off the NFSS in an area bounded by Vine and O Streets

TABLE 1-1

RESIDUES STORED AT THE NFSS*

Residue	Weight (tons)	Volume [m^3 (yd^3)]
K-65	3891	3101 (4080)
L-30	8227	6050 (7960)
L-50	1878	1634 (2150)
F-32	138	334 (440)
R-10	8235	7144 (9400)
Middlesex Sands	2	174 (229)

*Battelle, 1981 (Ref. 5).

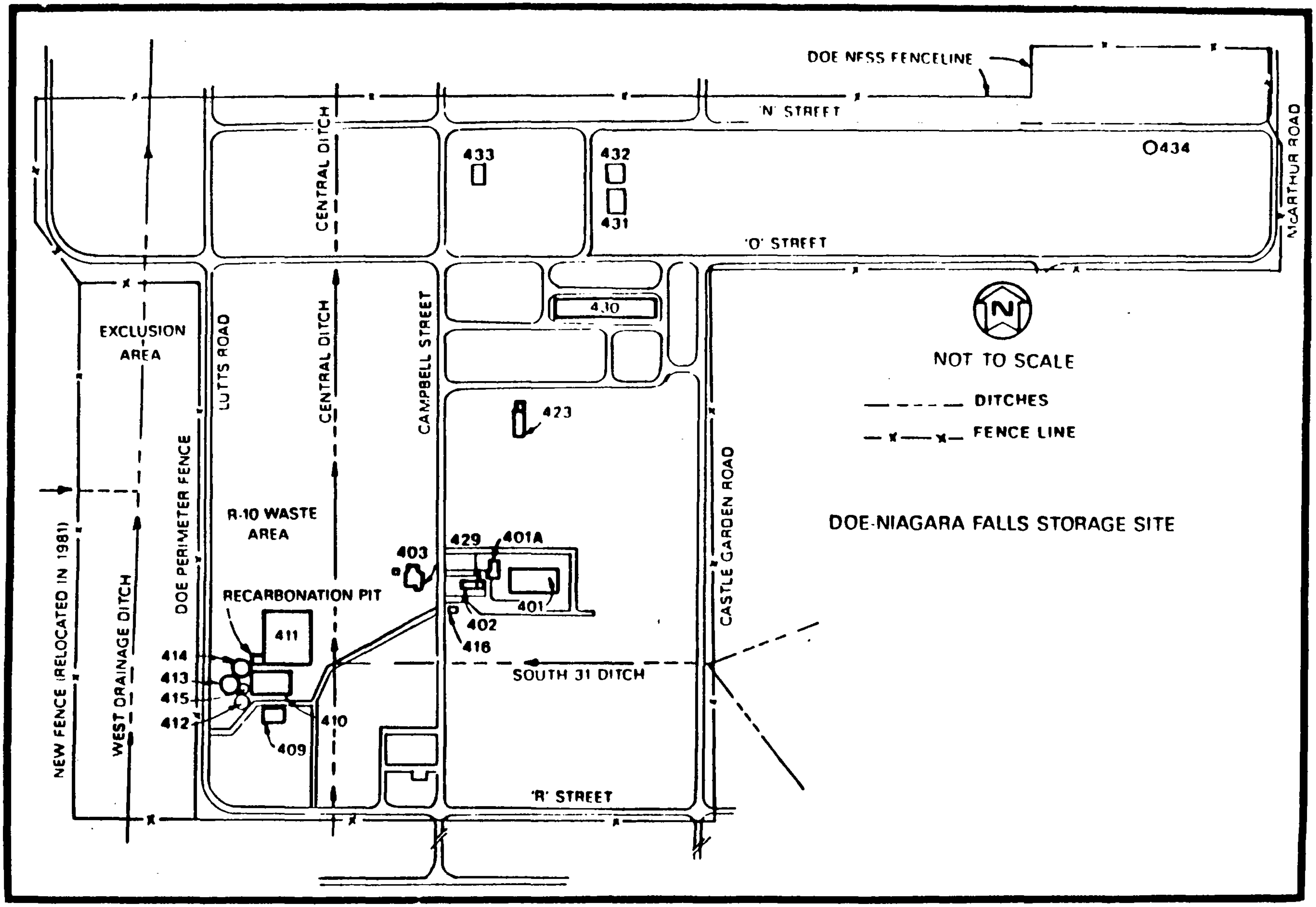


FIGURE 1-6 THE NFSS PRIOR TO INTERIM REMEDIAL ACTIONS

and Castle Garden Road. Approximately 342 m^3 (450 yd^3) of contaminated material were excavated from this vicinity property and were relocated to the R-10 waste storage area.

To further reduce the levels of radon emanating from the site, Buildings 413 and 414 (used for storing the L-50 residues) were upgraded and sealed in 1982. Also in 1982, to prevent further migration of residues, contaminated soil near the R-10 pile was moved onto the pile, and a dike and cutoff wall were constructed around the R-10 area. The R-10 pile was then covered with an ethylene propylene diene monomer (EPDM) liner, which markedly reduced radon emanation from the R-10 area. This action effectively reduced radon concentrations at the old site boundary (along Lutts Road) to below DOE guidelines.

In 1983 and 1984 the EPDM liner was removed, additional contaminated soils and rubble from on- and off-site areas were placed on the pile, and the pile was covered with the first layer of the interim clay cap. In 1984, 93 percent of the K-65 residues were transferred from Building 434 to Building 411.

Construction activities during 1985 included completion of the transfer of K-65 residues from Building 434 to the IWCF, demolition of Building 434, completion of remedial action on vicinity properties near the site, and continuation of installation of the cap over the wastes in the IWCF. These activities involved excavating approximately 10,640 m^3 (14,000 yd^3) of contaminated materials from on- and off-site areas, transferring 1102 m^3 (1450 yd^3) of building rubble to the IWCF, and discharging 12,732,000 liters (3,183,000 gal) of treated, impounded water in accordance with NYSDEC permit requirements.

2.0 SUMMARY OF MONITORING RESULTS

During 1985, the environmental monitoring program at the NFSS continued to sample air, water, and sediments, and external gamma rates were monitored to determine compliance with applicable limits. The limits specify the concentration of individual types of radioactive materials, called radionuclides, in air or water, that would limit the most highly exposed individual to 100 mrem/yr. The revised DOE Derived Concentration Guides for radioactive materials and the revised DOE radiation protection standards (Ref. 6) are provided in Appendix B. A discussion of the revisions is also included in Appendix B. Radiation doses were calculated to determine dose levels that can be compared to the radiation protection standard.

Radon gas concentrations at all monitoring locations were less than the DOE guideline of 3×10^{-9} uCi/ml (3 pCi/l). Annual average radon concentrations ranged from 8 to 19 percent of the guideline. The measured background concentration of radon was 13 percent of the guideline. Radon concentrations for the last 3 years, 1983, 1984, and 1985, have remained relatively constant. See Subsection 3.1.

External dose rates recorded at the NFSS boundary averaged 89 to 156 mrem/yr. These rates may be compared to the external exposure rate from naturally occurring background radiation in the vicinity of the NFSS, which was measured at 91 mrem/yr. The dose rate at the site boundary due to site operations ranges from zero to 65 mrem/yr. The maximum dose at the site boundary, assuming an occupancy factor of 40 h/wk, is 15 mrem. External dose rates are discussed in Subsection 3.2.

In surface waters (Subsection 3.3.1), all measured concentrations of uranium and radium-226 were a small fraction of the Derived Concentration Guides for release off-site. Uranium levels averaged less than 2 percent of the Derived Concentration Guide while radium-226 levels were less than 1.4 percent.

In groundwater, the highest concentration of uranium, based on an annual average in an on-site well was 12 percent of the Derived Concentration Guide. In off-site wells, the maximum uranium concentration was 0.5 percent of the Derived Concentration Guide. For radium-226, the maximum concentration measured in both on- and off-site wells was 1.3 percent of the Derived Concentration Guide (Subsection 3.3.2).

In stream sediments, the highest concentration, based on an annual average, was 4.9 pCi/g for uranium and 2.8 pCi/g for radium-226 (Subsection 3.4). While there are no Derived Concentration Guides for sediments, these levels are well below the DOE FUSRAP guidelines for cleanup of soils (Ref. 7).

Releases of radioactive materials to the environment during 1985 included releases of radon during construction activities and small concentrations of uranium and radium-226 in waters released under the New York State Pollutant Discharge Elimination System Permit. All releases were below applicable guideline values as determined by site and vicinity monitoring data for radon, and measured concentrations of uranium and radium-226 in waters discharged from on-site retention ponds.

Calculations were made of radiological doses received by a maximally exposed individual (Subsection 3.5.1). This individual is one who is assumed to remain adjacent to the site and who would, when all potential routes of exposure are considered, receive the greatest dose. Two exposure pathways were quantified: ingestion of contaminated surface water or groundwater and exposure to external gamma radiation.

The dose to an individual from ingestion of groundwater would result in a 50-yr dose commitment to the bone surface (the organ of the body receiving the greatest dose) of less than 7 mrem. The dose to a maximally exposed individual from external gamma radiation is 15 mrem. The total calculated dose would be 15.2 mrem, which is equal to 15.2 percent of the radiation protection standard. Detailed discussions are provided in Subsections 3.2 and 3.5.1.

As mentioned above, the external radiation dose recieved from radiological material at the NFSS is 15 mrem to the maximally exposed individual, and is less than 5 mrem based on the average measurement obtained by detectors at the site boundary. The dose to the maximally exposed individual is 15 mrem, which is equal to 15 percent of the radiation protection standard.

Results of the 1985 monitoring show that the NFSS is in compliance with DOE Derived Concentration Guides and the radiation protection standard.

3.0 DATA COLLECTION, ANALYSIS, AND EVALUATION

This section provides the results of 1985 environmental monitoring at the NFSS (Ref. 8) and states the extent to which these results comply with applicable DOE Derived Concentration Guides (DCGs) and radiation protection standard. A description is also given of the sampling, monitoring, and analytical procedures used. The DCGs, in most cases, specify the concentration of a radionuclide in air or water that would limit the dose to the most highly exposed individual to 100 mrem/yr. Radiation doses were calculated to determine hypothetical exposure levels, which were compared to this value. DOE DCGs for radionuclides of concern at NFSS and radiation protection standards are included in Appendix B. Appendix B also contains a discussion of the revised radiation protection standards and associated DCGs.

Data are presented in summary tables which include minimum and maximum values recorded, number of data points collected, average value, and percent of applicable standard or DCG. The average values listed in the individual tables are the arithmetic average of the sum of individual results. Individual sources of error (e.g., analytical error or sampling error) were not estimated. The "less than" notation (<) is used to denote sample analysis results that are below the limit of sensitivity of the analytical method based on a statistical analysis of parameters. In computing the averages, where values are less than the limit of sensitivity of the analytical method, values are considered as being equal to the limit of sensitivity and the "average" value is reported without the notation "less than."

During 1985, air, water, and sediment samples were collected by site personnel, and external radiation dose rates were measured to determine the radioactivity concentrations in the environs of the site. Supplemental radon monitoring was conducted at the NFSS and off-site areas by Mound Laboratory, operated for DOE by Monsanto Research Corporation, Miamisburg, Ohio, and the results are presented in Section 4.1.1.

Additional radon and external gamma monitoring were conducted during the transfer of the K-65 residues from Building 434 to IWCF, and a summary of the results of this program is provided in Subsection 4.1.2.

3.1 RADON GAS SAMPLING

Thirty-six radon gas detectors are maintained on-site and at site boundary locations, with three of the detectors (31, 32, and 33) designated as quality control stations. One location (30) is maintained some distance off-site to measure the background level. The locations of the radon monitors are shown in Figure 3-1.

Radon sampling locations were selected on the basis of the potential for elevated releases. Detectors are spaced along the site boundary to ensure adequate detection capability under most atmospheric conditions. At areas of higher potential for release, detectors are more concentrated. These include the area near Building 434 and the IWCF.

The radon gas monitors are Terradex Type-F Track-Etch detectors. Detectors are obtained from the Terradex Corporation, placed at the sampling locations, collected and exchanged monthly by site personnel, and then returned to Terradex for analysis.

Table 3-1 reports the measured concentrations of radon gas in the air recorded at site boundary monitoring locations and the background level location. Annual average concentrations ranged from 2.3×10^{-10} to 5.8×10^{-10} uCi/ml (0.23 to 0.58 pCi/l), with the highest annual average equal to 19 percent of the DOE guide of 3×10^{-9} uCi/ml (3 pCi/l) annual average. The annual average of background measurements was 3.8×10^{-10} uCi/ml (0.38 pCi/l), which is 12.7 percent of the DOE guide.

Radon levels were consistent from 1983 to 1985. Annual averages in 1983 ranged from 3.7×10^{-10} to 8.9×10^{-10} uCi/ml (0.37 to 0.89 pCi/l); in 1984, averages ranged from 3.4×10^{-10} to 1.04 x

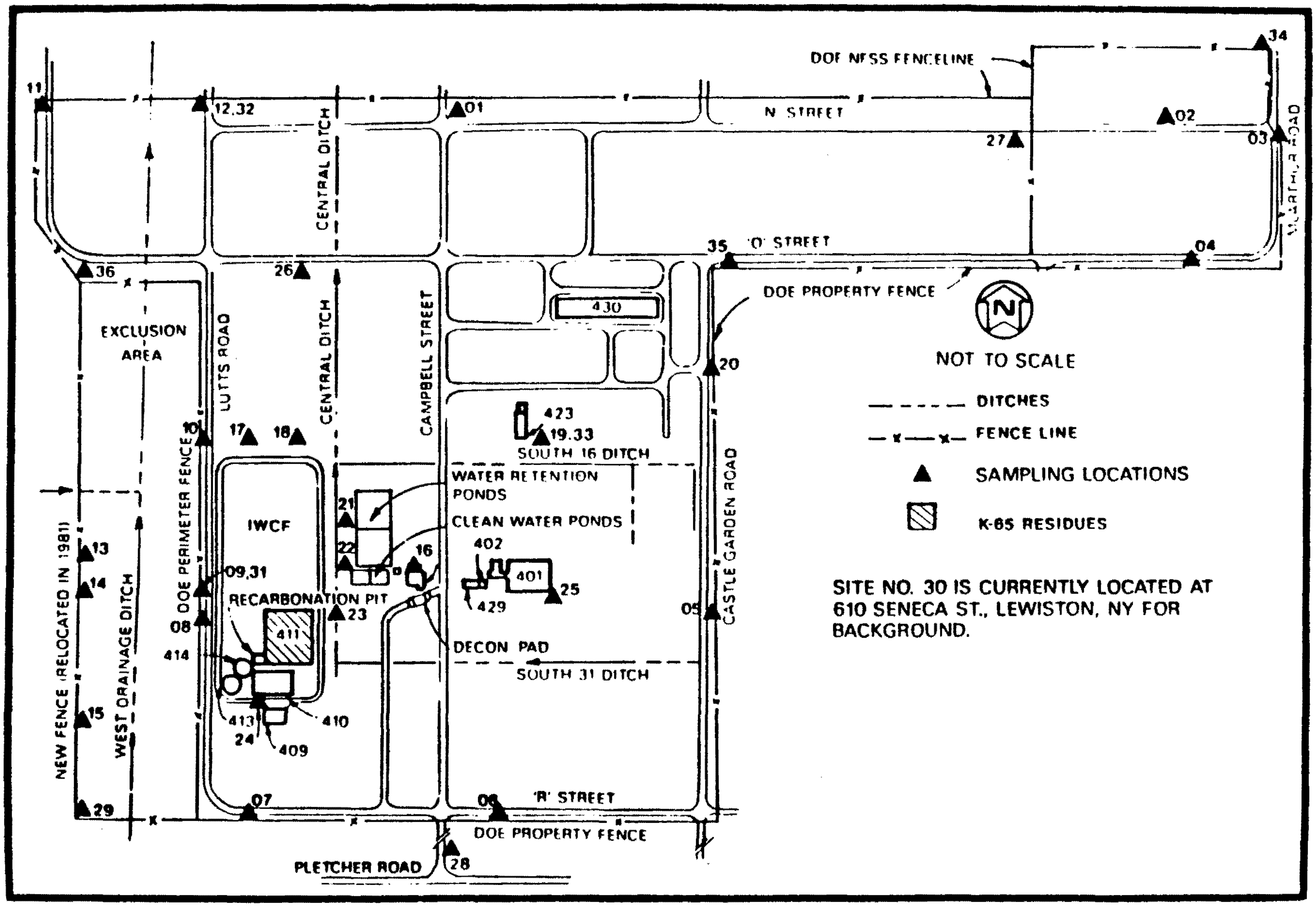


FIGURE 3-1 RADON AND EXTERNAL GAMMA MONITORING LOCATIONS AT THE NFSS

TABLE 3-1

ANNUAL AVERAGE RADON-222 CONCENTRATIONS MEASURED BY TERRADEX MONITORS AT THE NFSS BOUNDARY, 1985

Sampling Location[a]	Number of Samples[b]	Concentrations ($n \times 10^9$ uCi/ml)[c]			Percent of Standard[d] (Annual Average)
		Minimum	Maximum	Average	
Site Boundary					
1	10[e]	0.08	1.19	0.40	13
3	10[e]	0.20	0.76	0.45	15
4	10[e]	0.08	0.74	0.36	12
5	11	0.05	0.85	0.23	8
6	11	0.06	0.76	0.35	12
7	10[e]	0.08	1.03	0.58	19
11	11	0.08	1.19	0.39	13
12	11	0.08	1.02	0.37	12
13	10[f]	0.05	0.94	0.54	18
14	10[f]	0.05	0.59	0.29	10
15	9[f,g]	0.05	0.56	0.33	11
20	11	0.13	1.08	0.53	18
28	9[e]	0.06	0.85	0.38	13
29	10[h]	0.08	2.32	0.57	19
32[i]	11	0.08	1.04	0.35	12
34	11	0.06	1.88	0.54	18
35	11	0.08	0.60	0.31	10
36	11	0.06	0.87	0.41	14
Background[j]					
30	11	0.05	0.75	0.38	13

[a]Sampling locations are shown in Figure 3-1.
[b]Detectors not exchanged during the June exchange period.
[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.
[d]Based on a limit of 3×10^{-9} uCi/ml (3.0 pCi/l) for radon-222 in uncontrolled areas. See discussion in Appendix B.
[e]Detectors damaged by gunfire during hunting season.
[f]Detectors not exchanged during October because of flooding.
[g]Detector missing in November.
[h]Detector missing in July and August.
[i]Location 32 is a QC detector for Location 12 and Location 33 is a QC detector for Location 19.
[j]Background sampling location is at 610 Seneca St., Lewiston, NY.

10^{-10} uCi/ml (0.34 to 1.04 pCi/l); in 1985, averages ranged from 2.3×10^{-10} to 5.8×10^{-10} uCi/ml (0.23 to 0.58 pCi/l). Radon trends for the period 1981 through 1985 are presented in Figure 3-2. These trends were plotted using the mean value of each annual average of site boundary data. Radon concentrations trended downward through 1982; from 1983 through 1985 they have remained constant at near background levels.

Due to the nature of the radon source (i.e., large surface areas emanating radon at rates that vary widely with changes in climatic/atmospheric conditions), it is not feasible to determine the total quantity of radon released per year. Based on measured radon concentrations at the site boundary and surrounding environs, the on-site radon source has minimal effect on area radon concentrations.

3.2 EXTERNAL GAMMA DOSE RATES

External gamma dose rates were measured at 33 monitoring locations, 17 of which are on the site boundary, 3 on the perimeter of the exclusion area, and one is off-site. One of the 33 monitoring locations is located off-site to measure the background dose rate. All locations correspond to radon (Terradex) detector locations as shown in Figure 3-1. The locations ensure adequate mesurement of dose rates where the potential for exposure to members of the public is expected to be the highest.

The external gamma dose rates are measured using lithium fluoride (LiF) thermoluminescent dosimeters (TLDs), exchanged quarterly. Each monitor contains five TLD chips, the responses of which are averaged. Analysis is performed by Eberline Analytical Corporation.

The results for the 17 site boundary, one background, and one quality control external gamma monitoring locations are presented in Table 3-2. The measured background dose rate for the NFSS area (91 mrem) has been subtracted from the measured dose rates in

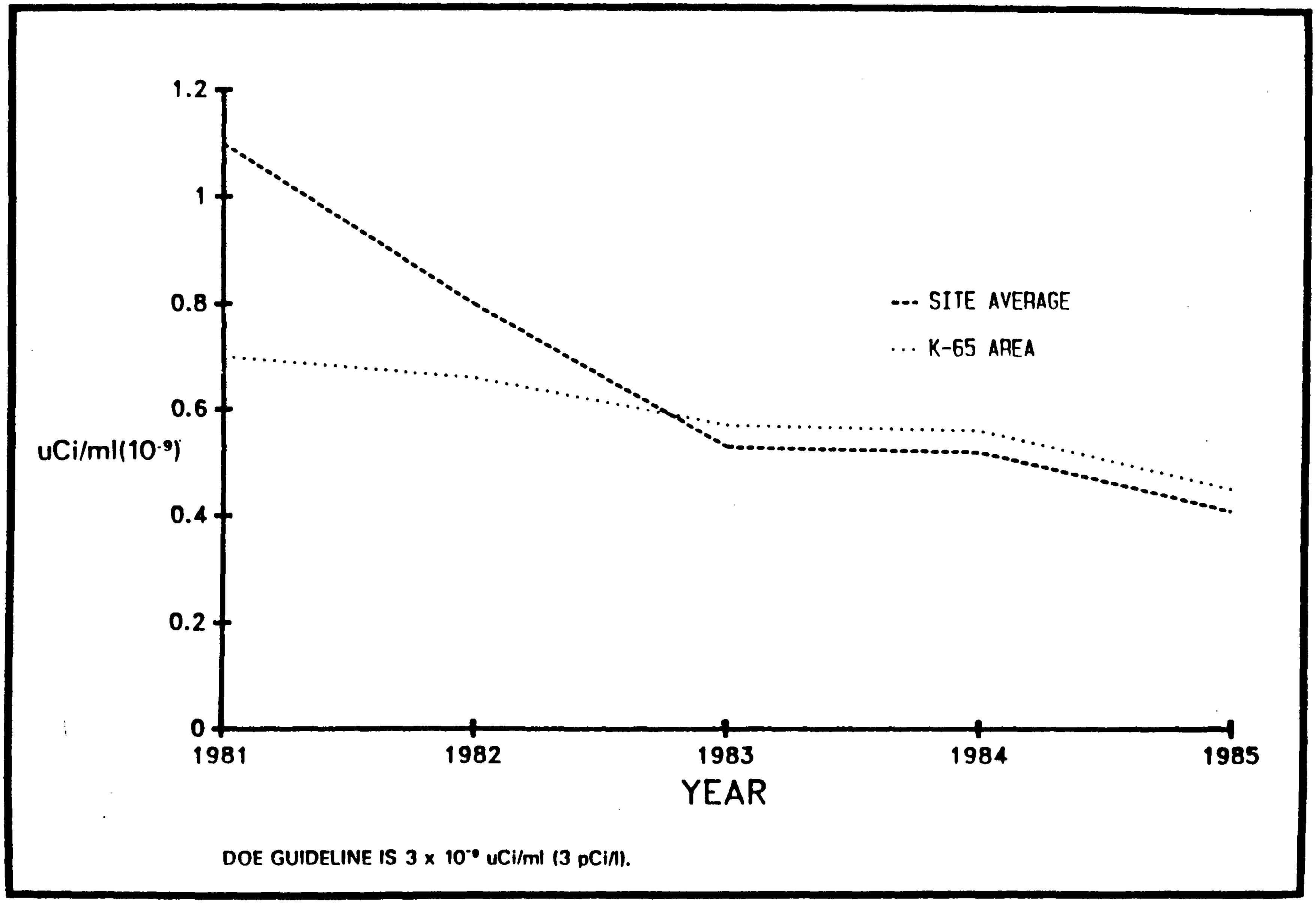


FIGURE 3-2 TREND IN RADON CONCENTRATIONS IN AIR AT THE NFSS 1981 TO 1985

TABLE 3-2

EXTERNAL GAMMA DOSE RATES FOR NFSS, 1985[a]

Sampling Location[b]	No. of Measurements	Dose Rate (mrem/qtr) Minimum	Maximum	Average	Total mrem/yr	Percent of Standard[c]
Site Boundary						
1	4	3.3	5.4	4.6	18	18
3	4	2.0	10.6	6.1	24	24
4	4	1.6	25.1	11.9	48	48
5	4	4.0	10.3	6.0	24	24
6	4	0	10.9	5.3	21	21
7	4	0	11.0	4.9	20	20
11	4	0	7.0	2.9	12	12
12	4	0.1	5.7	2.8	11	11
13	4	0	9.9	3.6	14	14
14	4	0	3.2	1.5	6	6
15	4	0	2.8	0.7	3	3
20	4	1.5	31.6	16.2	65	65
28	2[d]	0	7.2	3.6	14	14
29	4	3.1	3.5	3.4	14	14
32[e]	4	0	5.3	2.6	10	10
34	3[f]	3.3	4.5	3.9	16	16
35	4	0	9.9	3.9	16	16
36	4	0	2.4	1.5	6	6
Background[g]	4	20.3	26.0	22.7	91	91

[a]Site boundary locations only. Background has been subtracted. Dose rate is based on continuous occupancy.
[b]Sampling locations are shown in Figure 3-1.
[c]The DOE radiation protection standard is 100 mrem/yr (see Appendix B).
[d]TLD missing at the second and third quarter exchange.
[e]Location 32 is a Quality Control detector for Location 12.
[f]TLD missing at the third quarter exchange.
[g]Background sampling location is at 610 Seneca St., Lewiston, NY.

Table 3-2 to provide an estimate of the effect the site has had on measured dose rates at the site boundary. The two locations which had the highest dose rates are adjacent to a sanitary landfill where access is controlled by the owner. At these locations, the maximum annual dose rate was 65 mrem/yr above the measured background level of 91 mrem/yr. Based on a 40-h/wk occupancy factor in this area, the annual dose to workers at the landfill would be a maximum of 15 mrem or 15 percent of the radiation protection standard.

As presented in Figure 3-3, external dose rates at the site boundary have trended downward as remedial action activities progressed. The trend is based on each annual average. The 1985 average dose rate for all site boundary monitoring locations was statistically equal to the average background dose for the area.

3.3 WATER SAMPLING

During 1985, sampling was performed to determine the concentrations of uranium and radium in surface water and groundwater at both on-site and off-site locations. On-site sampling locations are shown in Figure 3-4 and off-site locations are shown in Figure 3-5. Results of uranium analyses for all sampling locations are presented in Table 3-3, and radium results are presented in Table 3-4.

3.3.1 Surface Water

Surface water samples were collected quarterly from the Central Drainage Ditch at Locations 10, 11, 12, and 20. Locations 12 and 20 are 1.6 and 3.2 km (1 mi and 2 mi) downstream, respectively, from the NFSS northern boundary.

Surface water collection locations were selected on the basis of contaminant migration potential and discharge routes from the site. Because surface water runoff from the site discharges via the Central Drainage Ditch, all sampling locations have been placed along the ditch.

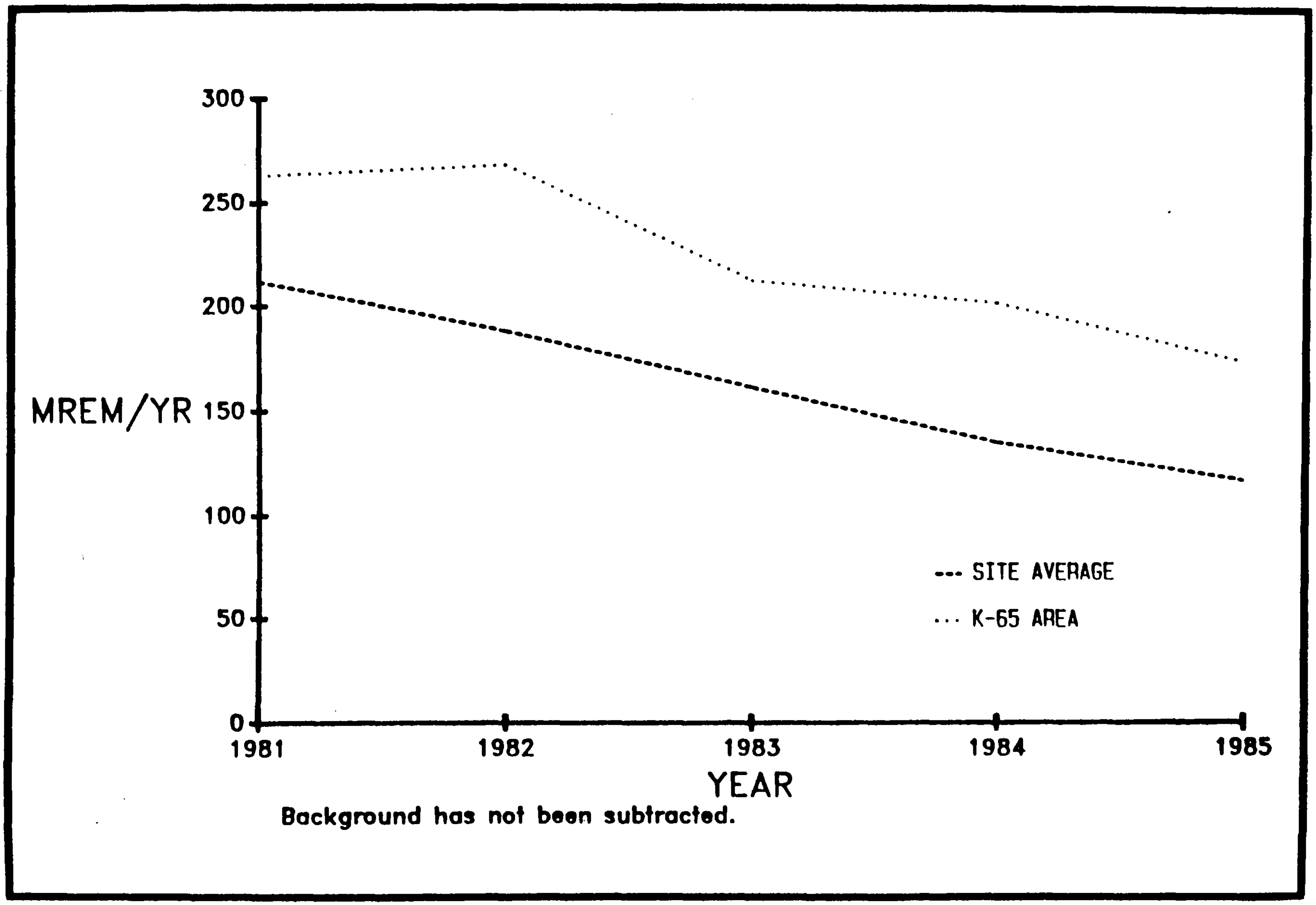


FIGURE 3-3 TREND IN AVERAGE EXTERNAL DOSE RATE AT THE NFSS, 1981 TO 1985

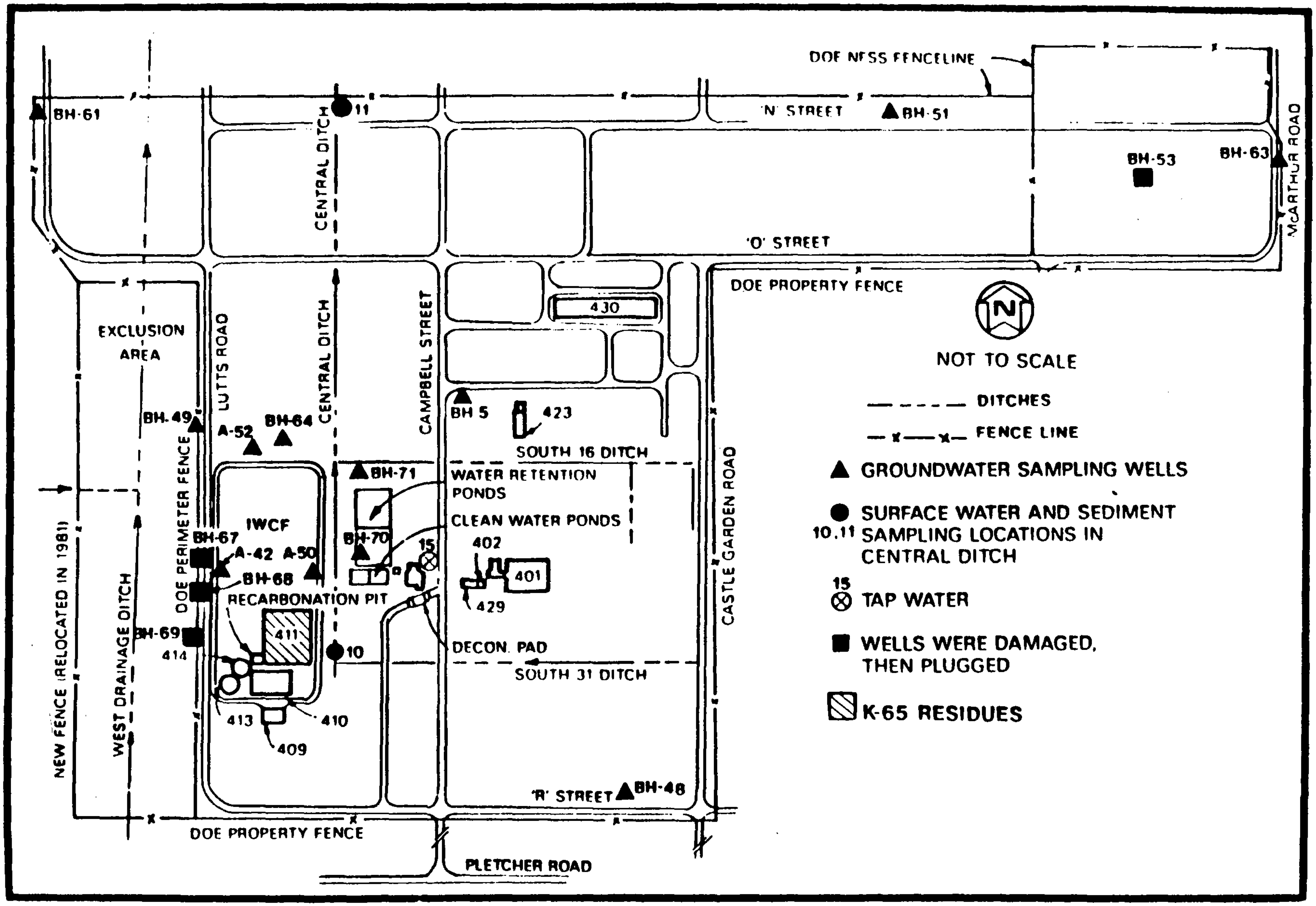


FIGURE 3-4 SURFACE WATER AND GROUNDWATER SAMPLING LOCATIONS AT THE NFSS

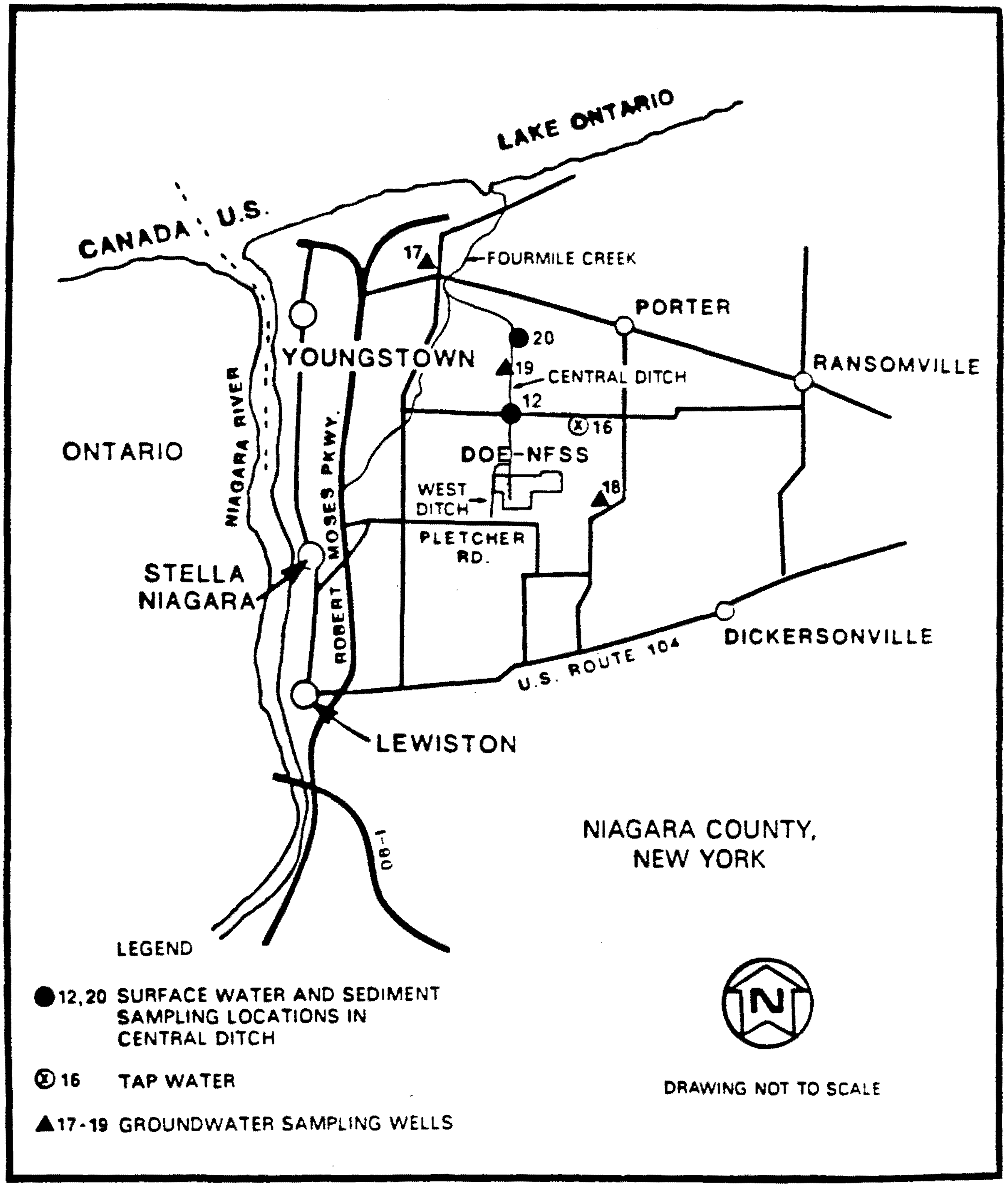


FIGURE 3-5 WATER SAMPLING LOCATIONS IN THE VICINITY OF THE NFSS

TABLE 3-3

CONCENTRATION OF DISSOLVED URANIUM IN NFSS WATER SAMPLES, 1985

Sampling Location[a]	Number of Samples	Concentration ($n \times 10^{9}$ uCi/ml)[b] Minimum	Maximum	Average	Percent of Standard[c] (Annual Average)
Groundwater[d]					
On-Site					
BH-5	4	<3	4	3	0.5
BH-48	4	<3	7	5	0.8
BH-61	4	<3	4	3	0.5
A-42	4	56	73	62	10.0
A-50	4	<3	<3	3	0.5
BH-49	4	<3	<3	3	0.5
BH-51	4	<3	18	11	1.8
BH-63	4	<3	<3	3	0.5
A-52	3[e]	<3	35	22	3.7
BH-64	4	9	21	15	2.5
BH-70	4	<3	5	4	0.7
BH-71	4	<3	4	3	0.5
Off-Site					
17	1[f]	-	-	3	0.5
18	1[f]	-	-	3	0.5
19	1[f]	-	-	3	0.5
Surface Water					
On-Site					
10	4	<3	36	15	2.5
11	4	11	28	19	3.2
Off-Site					
12	4	7	13	9	1.5
20	4	3	5	4	0.7

Table 3-3 (continued)

Sampling Location[a]	Number of Samples	Concentration ($n \times 10^9$ uCi/ml)[b] Minimum	Maximum	Average	Percent of Standard[c] (Annual Average)
Tap Water					
On-Site					
15	1[f]	-	-	3	0.5
Off-Site					
16	1[f]	-	-	3	0.5

[a]Sampling locations are shown in Figures 3-4 and 3-5.

[b]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[c]The DOE DCG for uranium in water is 6×10^{-7} uCi/ml (600 pCi/l). See Appendix B.

[d]Wells BH-53, -67, -68, and -69 were removed from the monitoring program and plugged after being damaged beyond repair.

[e]Wells could not be bailed in the fourth quarter.

[f]Annual samples only.

TABLE 3-4

CONCENTRATIONS OF DISSOLVED RADIUM-226 IN NFSS WATER SAMPLES, 1985

Sampling Location[a]	Number of Samples	Concentration ($n \times 10^9$ uCi/ml)[b] Minimum	Maximum	Average	Percent of Standard[c] (Annual Average)
Groundwater[d]					
On-Site					
BH-5	4	0.2	0.9	0.5	0.5
BH-48	4	0.4	0.8	0.6	0.6
BH-61	4	0.2	1.0	0.5	0.5
A-42	4	0.2	1.3	0.5	0.5
A-50	4	0.6	0.9	0.7	0.7
BH-49	4	0.3	0.8	0.4	0.4
BH-51	4	0.3	0.9	0.5	0.5
BH-63	4	0.3	0.6	0.4	0.4
A-52	3[e]	<0.1	0.4	0.2	0.2
BH-64	4	0.1	0.4	0.3	0.3
BH-70	4	0.4	0.7	0.6	0.6
BH-71	4	<0.1	0.9	0.4	0.4
Off-Site					
17	1[f]	-	-	0.2	0.2
18	1[f]	-	-	0.1	0.1
19	1[f]	-	-	0.1	0.1
Surface Water					
On-Site					
10	4	0.1	0.9	0.4	0.4
11	4	<0.1	1.7	0.7	0.7
Off-Site					
12	4	0.1	1.0	0.2	0.2
20	4	0.2	0.9	0.4	0.4

Table 3-4 (continued)

Page 2 of 2

Sampling Location[a]	Number of Samples	Concentration ($n \times 10^9$ uCi/ml)[b] Minimum	Maximum	Average	Percent of Standard[c] (Annual Average)
Tap Water					
On-Site					
15	1[e]	-	-	0.4	1.3
Off-Site					
16	1[e]	-	-	0.2	0.7

[a]Sampling locations are shown in Figures 3-4 and 3-5.

[b]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[c]The DOE DCG for radium in water is 1×10^{-7} uCi/ml (100 pCi/l). See Appendix B.

[d]Wells BH-53, -67, -68, and -69 were removed from the monitoring program and plugged after being damaged beyond repair.

[e]Well could not be bailed in the fourth quarter.

[f]Annual samples only.

Nominal 1-liter grab samples were collected to fill a 4-liter container. Samples were analyzed by Eberline Analytical Corporation (EAC). The concentration of total uranium was determined by a fluorometric method. Radium-226 concentrations were determined by precipitating radium-226 as the sulfate, transferring the sulfate to a radon bubbler where the radon-222 daughter is allowed to come to equilibrium, and then counting the radon-222 by alpha spectrometry to determine the amount of parent radium-226 activity originally present.

The DOE DCG for uranium in water is 6×10^{-7} uCi/ml (600 pCi/l). Measured concentrations at all sample locations were less than 3.2 percent of the DCG.

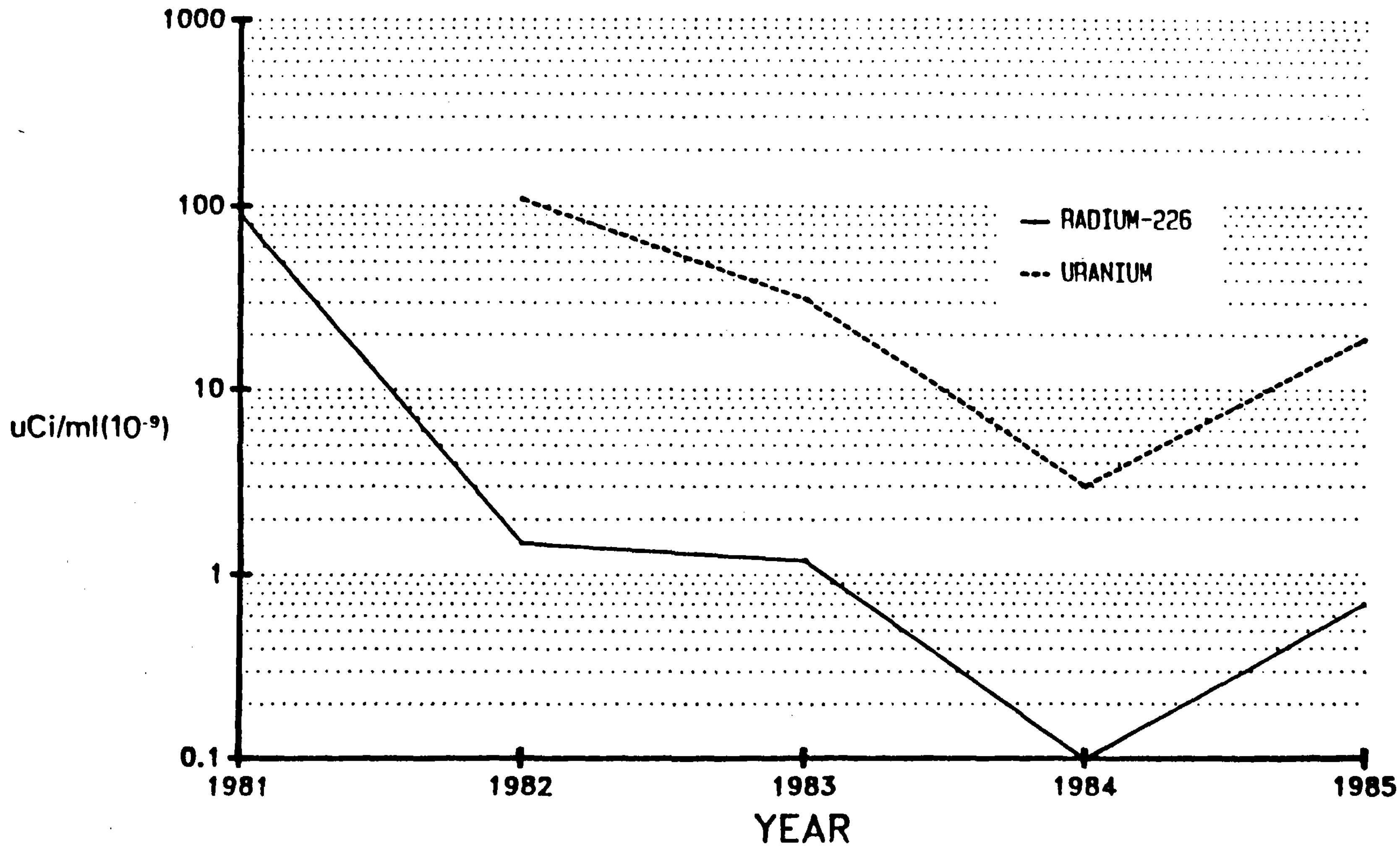
The concentrations of radium at all surface water sampling locations were less than 0.7 percent of the DOE DCG for radium, which is 1×10^{-7} uCi/ml (100 pCi/l).

Water was also sampled from taps supplied by a municipal water system. Location 15 samples the water on-site, and Location 16 samples the water off-site after the water line has passed through the NFSS. The concentrations of uranium and radium at both locations were 0.5 and 0.4 percent of the respective DOE DCG.

The trends for radium-226 and uranium are based on data from Location 11, because of its elevated measurements. From 1981 to 1984, radium-226 and uranium trended downward (Figure 3-6). Although the concentrations trended upward from 1984 to 1985, the levels are still below the DOE DCG.

3.3.2 Groundwater

During 1985, groundwater samples were collected quarterly from 16 on-site wells and annually from three off-site wells. Sampling locations were selected based on the inventory of radioactive materials in various areas of the site and available geohydrological



DCG FOR URANIUM IN WATER IS 6 x 10^{-7} uCi/ml (600pCi/l).

DCG FOR RADIUM IN WATER IS 1 x 10^{-8} uCi/ml (100pCi/l).

FIGURE 3-6 TRENDS IN URANIUM AND RADIUM CONCENTRATIONS IN SURFACE WATER AT THE NFSS, 1981 TO 1985 data. The majority of sample wells are located near the IWCF and Building 434. Other wells are located both upgradient and downgradient to provide background data and to monitor any migration of contaminants off-site.

Four on-site wells monitored during 1984 were damaged beyond repair in 1985 and were subsequently plugged to prevent potential contamination of groundwater. These wells (BH-53, BH-67, BH-68, and BH-69) have been removed from the program. Wells BH-5, BH-48, BH-51, BH-64, and BH-70 monitor the lower aquifer. Well BH-71 monitored the bedrock aquifer. Wells A-42, A-50, and A-52 monitor the upper aquifer around the IWCF. Well BH-48 is an upgradient (background) monitoring location and well BH-61 is a downgradient monitoring location.

Groundwater samples were collected after the wells had been bailed dry or two casing volumes had been removed. Nominal 1-liter grab samples were collected using a bailer to fill a 4-liter container. Samples were analyzed by EAC for total uranium and dissolved radium-226 using the methods applied to surface water analyses.

Results of analyses for uranium concentrations in groundwater are listed in Table 3-3, and radium results are given in Table 3-4. The highest annual average concentration of uranium in groundwater covering a complete year of sampling was 6.2×10^{-8} uCi/l (62 pCi/l), measured at on-site Well A-42. This reading is 10 percent of the DOE DCG for uranium. The highest uranium concentration at any off-site well was 0.5 percent of the DCG.

The highest annual average concentration of radium in groundwater was 7×10^{-10} (0.7 pCi/l), measured at well A-50. This concentration is equal to 2.3 percent of the DOE DCG for radium in water.

During the period from 1981 through 1985, the groundwater monitoring program has changed. In 1983, 16 new on-site wells were added to the program. In 1984 the nine original wells were removed from the program. While the new wells indicated higher uranium concentrations than the older wells, concentrations of both radium-226 and uranium within each group of wells has remained constant. Trends were plotted from the mean value of each annual average of all wells, and are presented in Figure 3-7.

3.4 SEDIMENT SAMPLING

During 1985, sediment samples consisting of approximately 500-g composites were collected on-site and off-site at surface water sampling Locations 10, 11, 12, and 20 (see Figures 3-4 and 3-5). The rationale for selecting sampling locations is as stated in Section 3.3.1.

EAC analyzed the samples for uranium and radium-226. The uranium concentration was obtained by summing the results from isotopic uranium analyses. Isotopic uranium was determined by alpha spectrometry, where the uranium has been leached and organically extracted and electroplated on a metal substrate. Radium-226 concentrations were determined by radon emanation.

There are no specific limits for uranium or radium in sediments. However, the cleanup of radium at the NFSS and the Central Drainage Ditch is conducted in accordance with the DOE FUSRAP guidelines for radionuclides in soil. For comparative purposes, the guideline for radium is 5 pCi/g in the upper 15 cm (6 in.) and 15 pCi/g below 15 cm (6 in.) (Ref. 7).

The analysis results for uranium, based on dry weight, and radium are presented in Table 3-5. Quarterly results for uranium ranged from 0.9 pCi/g to 12.6 pCi/g. The highest concentration was recorded during the third quarter at Location 11 at the site boundary. The highest annual average for uranium concentrations also was recorded at Location 11. The highest single reading for radium, 6.0 pCi/g, and the highest annual average, 2.8 pCi/g, were both obtained from Location 11.

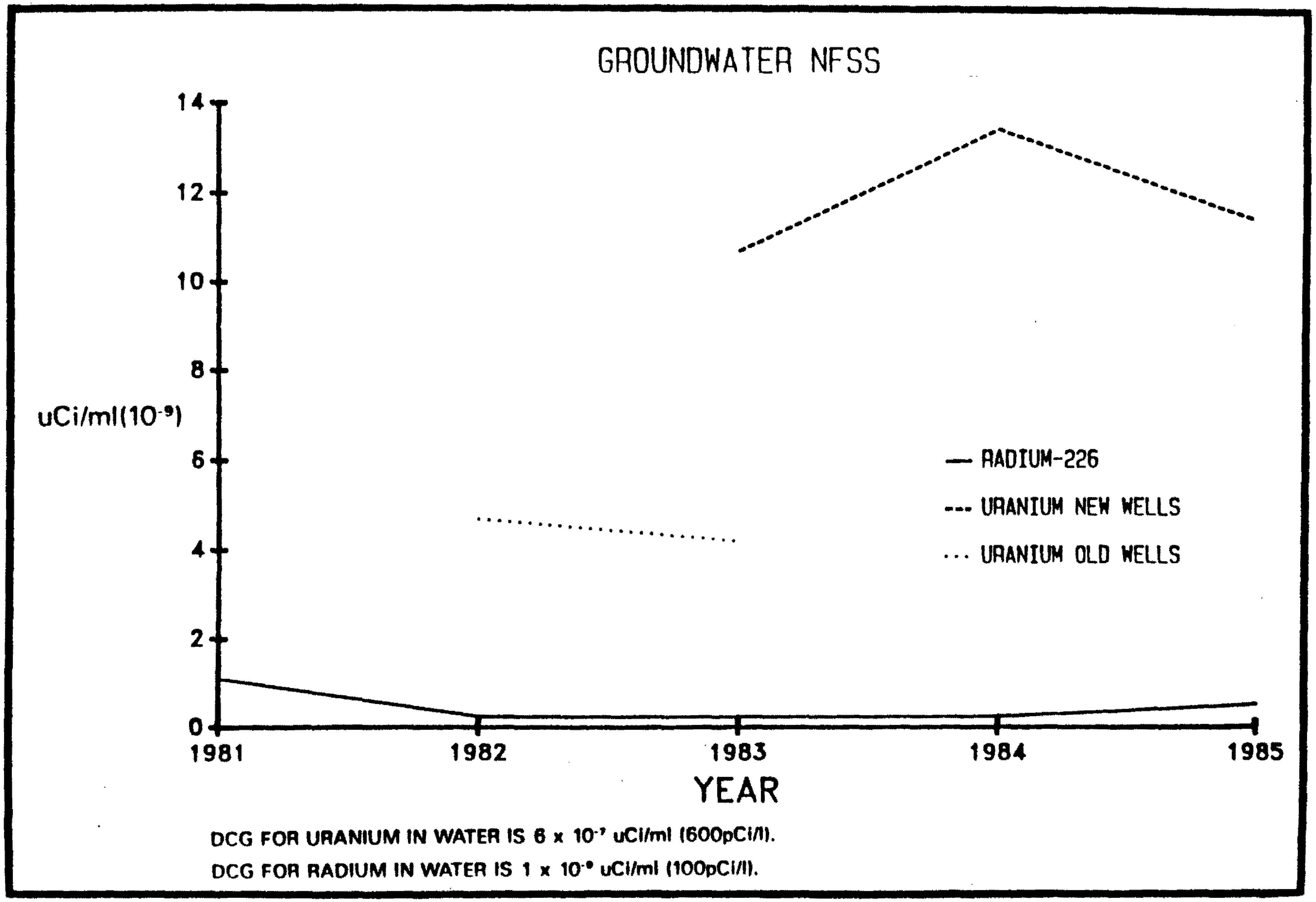


FIGURE 3-7 TRENDS IN AVERAGE URANIUM AND RADIUM CONCENTRATIONS IN GROUNDWATER AT THE NFSS, 1981 TO 1985

TABLE 3-5

URANIUM AND RADIUM-226 CONCENTRATIONS IN SEDIMENT SAMPLES, 1985

Sampling Location[a]	Concentration (pCi/g)[b]						
	Quarterly Results						
	1st	2nd	3rd	4th	Minimum	Maximum	Average
Uranium							
On-Site							
10	4.0	3.8	2.5	2.3	2.3	4.0	3.1
11	4.2	1.3	12.6	1.5	1.3	12.6	4.9
Off-Site							
12	0.9	1.2	3.3	0.9	0.9	3.3	1.6
20	3.1	1.5	2.6	1.2	1.2	3.1	2.1
Radium-226							
On-Site							
10	1.4	1.2	1.3	1.4	1.2	1.4	1.3
11	2.9	1.1	6.0	1.2	1.1	6.0	2.8
Off-Site							
12	1.1	0.8	0.9	1.3	0.8	1.3	1.0
20	1.5	0.8	0.7	1.4	0.7	1.5	1.1

[a]Sampling locations are shown in Figures 3-4 and 3-5.

[b]There are no specific limits for uranium or radium in sediment. For comparative purposes, however, the cleanup of radium from the Central Drainage Ditch was conducted following the DOE FUSRAP guideline of 5 pCi/g in the upper 15 cm (6 in.) of soil and 15 pCi/g below 15 cm (6 in.).

As presented in Figure 3-8, uranium and radium-226 concentrations in sediments have trended downward as on-site construction and cleanup of the Central Drainage Ditch progressed. The data for the trends were taken from Location 11. In 1985, uranium and radium-226 concentrations increased slightly compared to 1984 measurements.

3.5 RADIOLOGICAL EXPOSURE

To assess the health effects of the radioactive materials stored at the NFSS, the radiological exposure of a maximally exposed individual was evaluated for each monitoring location. This individual is one who is assumed to remain adjacent to a location and who would, when all potential routes of exposure are considered, receive the largest dose. An appraisal of potential pathways suggested that ingestion of water containing natural uranium and radium-226, and external gamma irradiation were the principal exposure modes.

For each of the pathways considered at a given monitoring location, almost all organs in the body receive some radiological exposure. However, certain organs receive a higher exposure than others, depending on the method of internal deposition and the chemical characteristics of the radionuclides. These are called "critical organs" because the effect of the exposure is maximized in them.

Radium and uranium taken into the body via ingestion tend to migrate and incorporate into the bone. This is the critical organ for the ingestion pathway. Establishing an internal dose to the bone by converting measured concentrations in water requires several assumptions. An intake rate must be postulated. For these calculations, the maximum water intake rate (730 ml of tap water per day) of Reference Man was used (Ref. 9). Radionuclide intakes were converted to internal doses to the bone using the methodology described in ICRP 26 and 30 (Refs. 10 and 11). All calculated doses are 50-yr dose commitments. The 50-yr dose commitment concept provides for the fact that an intake of a radionuclide with a long

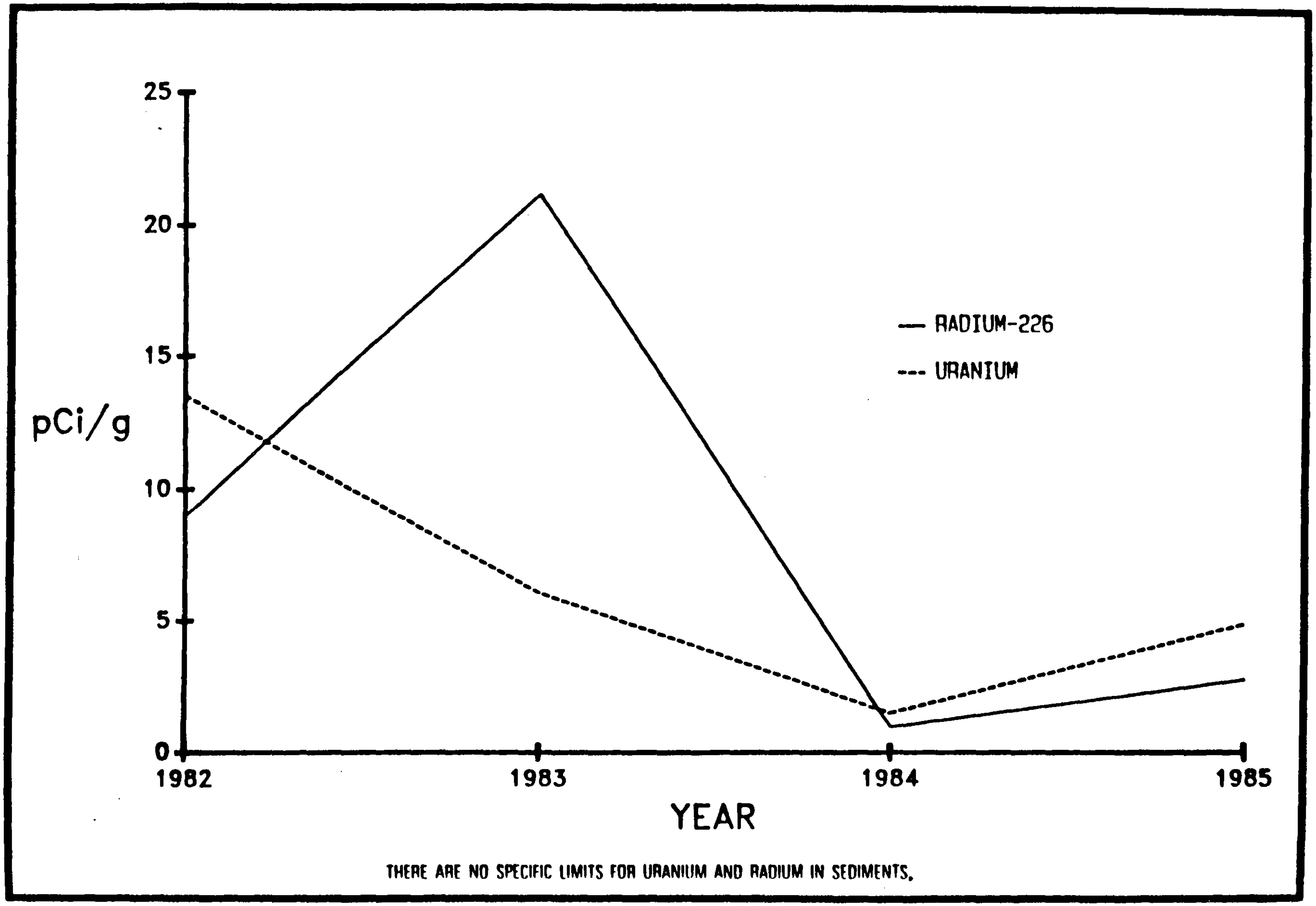


FIGURE 3-8 TRENDS IN AVERAGE URANIUM AND RADIUM CONCENTRATIONS IN SEDIMENTS, 1982 TO 1985

half-life (such as uranium and radium) may result in an internal exposure for many years.

Gamma radiation from external sources is assumed to irradiate the body uniformly. The total body is therefore the critical organ for external gamma exposure. Internal organs are assumed to be exposed to the same level as the entire body. Exposure to organs resulting from internal and external sources is additive.

Inhalation of radon and its radioactive daughters is also a pathway; however, an accurate, quantitative determination of dose is not possible because of uncertainties concerning the distribution of exposure. In Subsection 3.1, the measured radon concentration is compared to the DOE guideline, with the high annual average equal to 19 percent of the guideline.

3.5.1 Dose to Maximally Exposed Individual

To identify the individual in the vicinity of the NFSS who would receive the highest dose from on-site low-level radioactive materials, the combined dose from ingestion of water and exposure to external gamma radiation was calculated at various monitoring locations. The cumulative doses from these pathways were then reviewed with regard to land use and occupancy factors for areas adjacent to the monitoring points. From these calculations, it was determined that the highest overall dose would be received by an individual directly west of the site. Although measured concentrations and exposure rates at several locations are higher than those being used for the maximally exposed individual, access to these locations is controlled, and therefore, not realistic. Location 20 for surface water represents the largest potential exposure to the general public. Since this is not a residential area, the doses were based on an estimated 40-h/wk exposure period. For conservatism, the 730 ml/day water ingestion rate of Reference Man was used.

The dose to the maximally exposed individual contributed by ingesting surface water is based on data from Location 20. While there is no known domestic use of water from the Central Drainage Ditch, a dose due to ingestion of this water has been calculated to allow comparison with standards. Doses are based on data collected at surface water sample Location 20, which is the last sample location downstream from the site. Land downstream from Location 20 is privately owned. It is reasonable to assume that water from this source could be used for domestic purposes. The yearly average uranium and radium-226 concentrations at Location 20 were 4×10^{-9} and 4×10^{-10} uCi/ml (14 and 0.4 pCi/l), respectively. Ingestion of this water would result in a 50-yr dose commitment of less than 7 mrem to the critical organ (the bone surface). Because of the insignificance of this dose, no attempt was made to separately quantify the contribution of materials on the NFSS and natural background radionuclides. This can be compared to the 620 mrem dose that would be received if water were ingested that contained uranium concentrations equal to the DOE DCG [6×10^{-7} uCi/ml (600 pCi/l)].

Because the dose due to ingestion of water is small, a second pathway was also considered. This pathway is external dose from gamma emitting material on the site. For comparative purposes, the highest exposure rate measured is used. This is TLD Location 20, which is a totally different location than surface water sampling Location 20. The measured total dose at TLD Location 20 is 156 mrem/yr. While the range of the background dose rate for the Niagara Falls area can be expected to vary between 88 to 131 mrem/yr (Ref. 12), the measured value (Location 30) is 91 mrem/yr.

Using the measured background value, 91 mrem/yr, the average annual dose rate attributable to site activities is 65 mrem/yr. As presented in Figure 1-5, land adjacent to TLD Location 20 is used as a sanitary landfill. Dose to people in this area is therefore based on 40-h work week. Applying a 40-h/wk occupancy factor, the dose to landfill workers would be a maximum of 15 mrem. This dose assumes the worker remains at the site boundary adjacent to Location 20 for 2000 h/yr.

The 15-mrem dose from external gamma radiation (see Subsection 3.2) and the 7-mrem dose from ingestion are used to calculate the total dose. However, the 7-mrem dose is multiplied by the internal organ to whole body weighting factor of 0.03 (Ref. 10). This addition results in a total dose of 15.2 mrem to the maximally exposed individual.

3.5.2 Dose to Population

The dose to the population represents the conceptual cumulative radiation dose to all residents within a 80-km (50-mi) radius of a given site. This calculated dose includes contributions from all potential pathways. For the NFSS, these pathways are: direct exposure to gamma radiation, inhalation of radon gas, and ingestion of water containing radioactivity.

The contribution to the population dose made by gamma radiation from on-site radioactive materials is too small to be measured; gamma radiation levels decrease rapidly as distance from the source of contamination increases. For example, if the gamma dose rate at a distance of 0.9 m (3 ft) from the radioactive source were 10 times that allowable, the dose rate at a distance of 6.4 m (21 ft) from the source would be indistinguishable from naturally occurring background radiation.

Similarly, radon gas is known to dissipate rapidly as distance from the radon source increases (Ref. 13). Therefore, radon exposure does not contribute significantly to population dose.

On the basis of radionuclide concentrations measured in water leaving the site, it also appears that there is no predictable pathway by which ingestion of water could result in a significant dose to the population. As water migrates farther from the source, radionuclide concentrations are further reduced, thereby lowering potential doses to even less significant levels.

Since the contributions to population dose via all three potential exposure pathways are inconsequential, calculation of dose to the population is not warranted. The cumulative dose to the population within a 80-km (50-mi) radius contributed by on-site radioactive materials would be indistinguishable from the dose the same population would receive from naturally occurring radioactive sources.

4.0 ACTIVITIES AND SPECIAL STUDIES

4.1 ACTIVITIES

4.1.1 Supplemental Radon Monitoring

Mound Laboratories performed supplemental radon monitoring at NFSS during 1985 at 12 locations on the site perimeter, 2 locations in the exclusion area, and 30 off-site locations. Mound's program uses passive environmental radon monitors (PERMs), which have a TLD as the detection element. The TLDs are changed on a weekly basis.

Figure 4-1 shows the locations of the 14 site boundary and exclusion area PERMs and 22 of the off-site locations. The data for the 14 site boundary and exclusion area locations are given in Table 4-1. Annual averages ranged from 2.4×10^{-10} to 7×10^{-10} uCi/ml (0.24 to 0.70 pCi/l), with the highest annual average equal to 23 percent of the DOE DCG of 3×10^{-9} uCi/l (3 pCi/l) annual average for uncontrolled areas.

The locations of the remaining off-site PERM locations are shown in Figure 4-2. Results from these data are presented in Table 4-2. Annual averages for off-site monitors ranged from 1.4×10^{-10} to 3.2×10^{-10} uCi/ml (0.14 to 0.32 pCi/l). The highest annual average is equal to 11 percent of the DOE CG for release of radon to uncontrolled areas. The average natural background for the NFSS area, measured by Mound Laboratory with PERMs, was 2.2×10^{-10} uCi/ml (0.22 pCi/l).

4.1.2 Construction Monitoring Program

During the second half of 1984 and into 1985, uranium ore residues (K-65 residues) were transferred from Building 434 (also known as the K-65 Tower) to Building 411 within the IWCF. Because these residues contain high levels of radium-226, there was considered to be an increased risk for both workers and the environment.

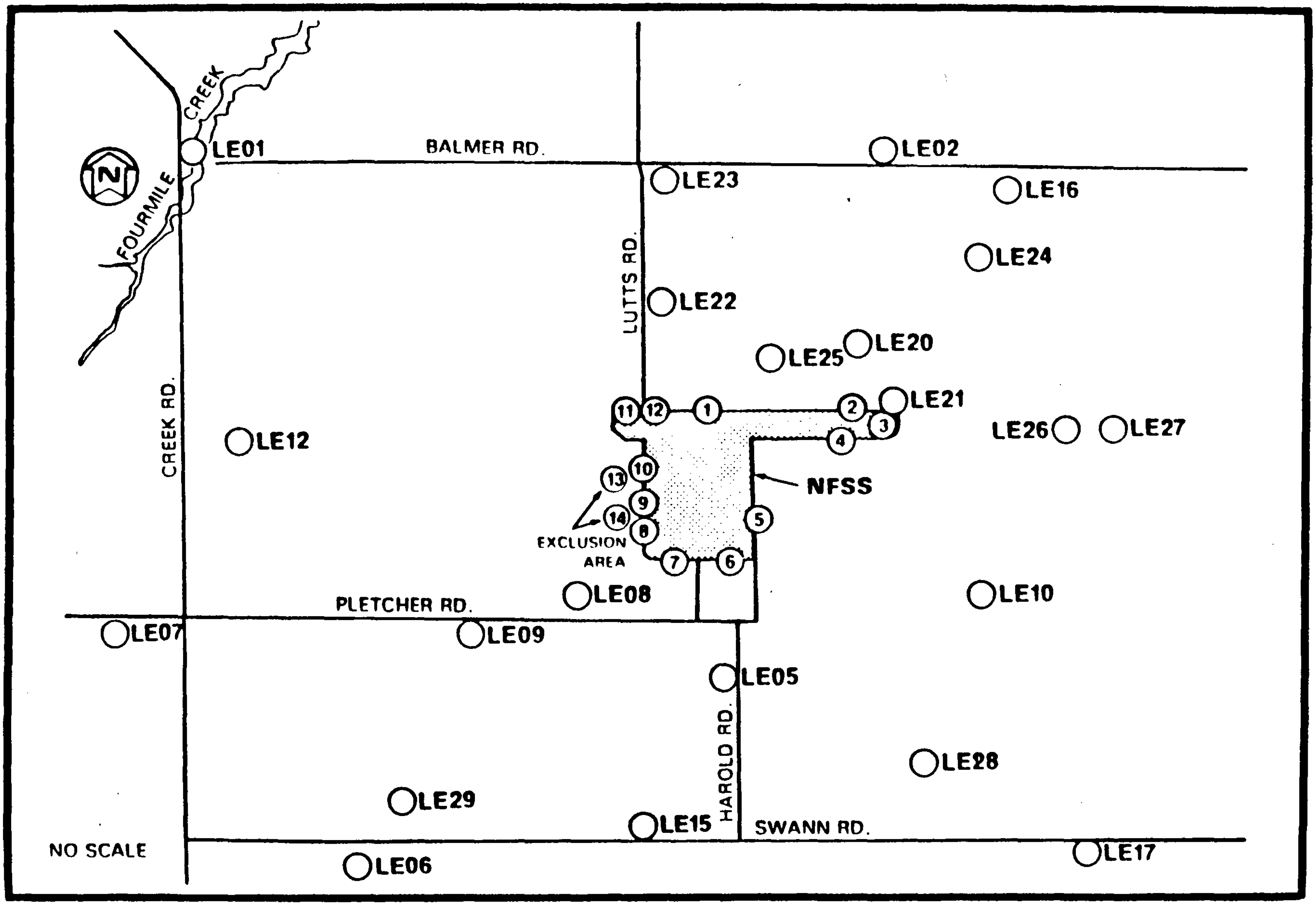


FIGURE 4-1 LOCATIONS OF PERMS AT THE NFSS BOUNDARY, IN THE EXCLUSION AREA, AND OFF-SITE

TABLE 4-1

SUMMARY OF RADON-222 DATA FOR PERMs IN THE VICINITY OF NFSS, 1985[a]

Sampling Location[b]	Concentration (n x 10^9 uCi/ml)[c] Quarterly Averages 1st	2nd	3rd	4th	Minimum	Maximum	Average	Percent of Standard[d] (Annual Average)
1	0.18	0.34	0.64	0.28	0.18	0.64	0.36	12
2	0.18	0.73	1.2	-e-	0.18	1.2	0.70	23
3	0.13	0.26	0.40	0.18	0.13	0.40	0.24	8
4	0.22	0.43	0.43	-e-	0.22	0.43	0.36	12
5	0.13	0.20	0.41	-e-	0.13	0.41	0.25	8
6	0.17	0.21	0.41	0.27	0.17	0.41	0.27	9
7	0.16	0.25	0.63	0.27	0.16	0.63	0.33	11
8[f]	0.17	0.36	0.89	-e-	0.17	0.89	0.47	16
9[f]	0.16	0.29	0.57	0.41	0.16	0.57	0.36	12
10[f]	0.21	0.22	0.48	-e-	0.21	0.48	0.30	10
11	0.16	0.19	0.45	0.26	0.16	0.45	0.27	9
12	0.12	0.30	0.60	-e-	0.12	0.60	0.34	11
13	0.15	0.28	0.51	-e-	0.15	0.51	0.31	10
14	0.12	0.22	0.73	-e-	0.12	0.73	0.36	12
Background	0.13	0.20	0.29	0.18	0.13	0.29	0.20	7

[a]Measurements by Mound Laboratory, Monsanto Research Corporation. These measurements are total radon concentrations and background has not been subtracted.

[b]Sampling locations are shown in Figure 3-2.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]The DOE DCG for radon-222 is 3 x 10^{-9} uCi/ml (3 pCi/l) annual average for uncontrolled areas.

[e]Because measurements at these locations were approximately equal to the background level and funding was decreased, measurements were not taken at these locations in the fourth quarter.

[f]Monitoring locations are within a controlled area where members of the public cannot enter.

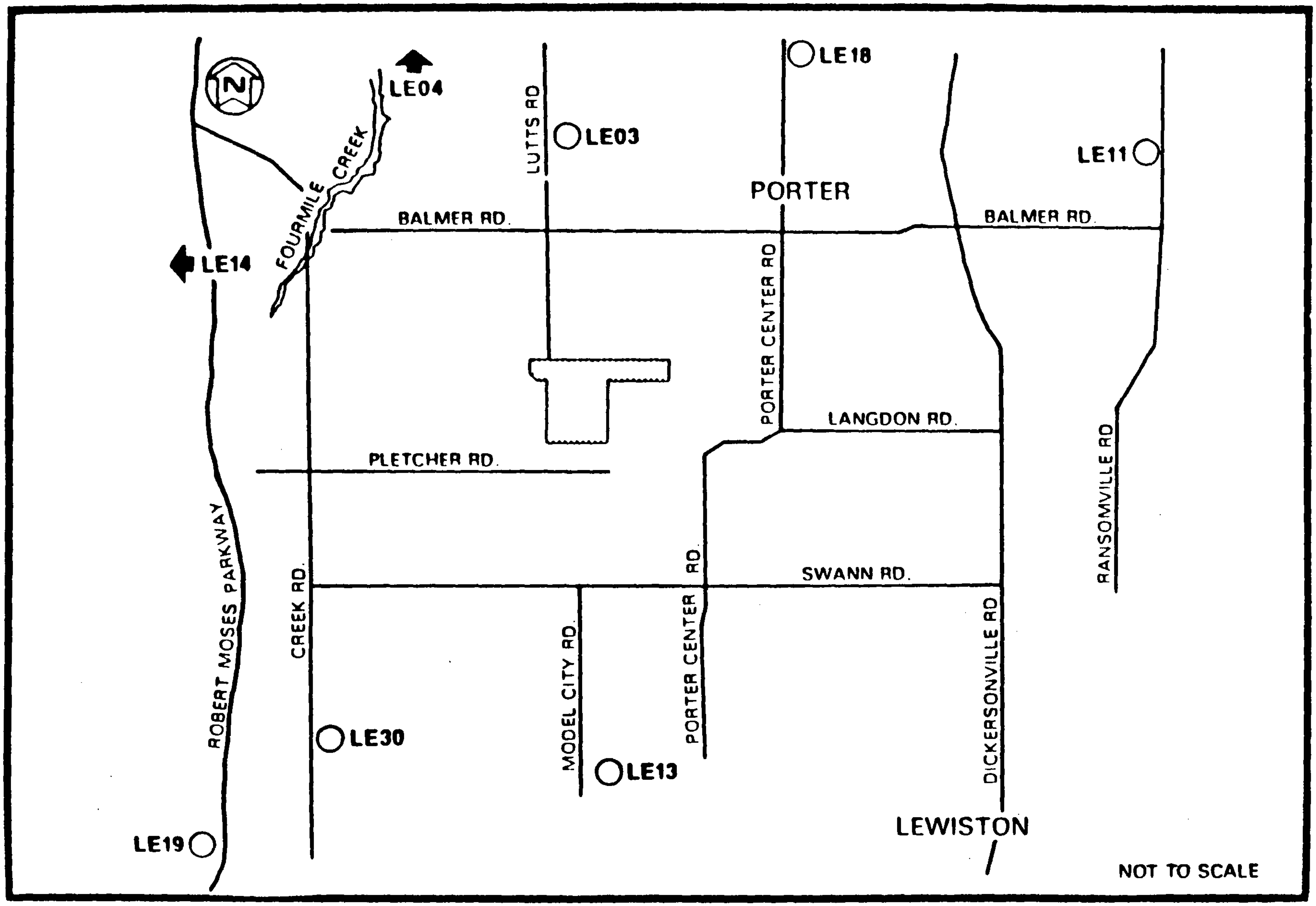


FIGURE 4-2 LOCATIONS OF OFF-SITE PERMS 2000 METERS OR FARTHER FROM THE NFSS

TABLE 4-2

SUMMARY OF RADON-222 DATA FOR PERMs IN THE VICINITY OF THE NFSS, 1985[a]

Sampling Location[b]	Concentration (n x 10^9 uCi/ml)[c]							Percent of Standard[d] (Annual Average)
	Quarterly Averages				Minimum	Maximum	Average	
	1st	2nd	3rd	4th				
LE01[e]	0.12	0.30	0.47	-f-	0.12	0.47	0.30	10
LE02	0.13	0.25	0.34	0.15	0.13	0.34	0.22	7
LE03	0.17	0.18	0.27	-f-	0.17	0.27	0.21	7
LE04[e]	0.10	0.18	0.20	-f-	0.10	0.20	0.16	5
LE05	0.18	0.29	0.46	0.24	0.18	0.46	0.29	10
LE06	0.12	0.25	0.37	-f-	0.12	0.37	0.25	8
LE07[e]	0.20	0.26	0.38	-f-	0.20	0.38	0.28	9
LE08	0.16	0.19	0.48	-f-	0.16	0.48	0.28	9
LE09	0.16	0.24	0.43	0.27	0.16	0.43	0.28	9
LE10	0.20	0.33	0.47	0.27	0.20	0.47	0.32	11
LE11[e]	0.14	0.19	0.25	-f-	0.14	0.25	0.19	6
LE12	0.13	0.23	0.39	0.19	0.13	0.39	0.24	8
LE13[e]	0.12	0.13	0.19	0.13	0.12	0.19	0.14	5
LE14[e]	0.14	0.16	0.21	-f-	0.14	0.21	0.17	6
LE15	0.13	0.17	0.31	-f-	0.13	0.31	0.20	7
LE16	0.13	0.14	0.39	-f-	0.13	0.39	0.22	7
LE17[e]	0.12	0.18	0.32	-f-	0.12	0.32	0.21	7
LE18[e]	0.12	0.25	0.30	-f-	0.12	0.30	0.22	7
LE19[e]	0.14	0.22	0.29	0.22	0.14	0.29	0.22	7
LE20	0.13	0.16	0.32	-f-	0.13	0.32	0.20	7
LE21	0.16	0.32	0.43	-f-	0.16	0.43	0.30	10
LE22	0.20	0.18	0.43	-f-	0.18	0.43	0.27	9
LE23	0.23	0.29	0.48	0.24	0.23	0.48	0.31	10
LE24	0.13	0.15	0.23	0.20	0.13	0.23	0.18	6
LE25	0.16	0.17	0.35	-f-	0.16	0.35	0.23	8
LE26	0.19	0.20	0.40	-f-	0.19	0.40	0.26	9
LE27	0.15	0.23	0.38	0.22	0.15	0.38	0.25	8
LE28	0.14	0.21	0.32	0.22	0.14	0.32	0.22	7
LE29	0.15	0.21	0.29	-f-	0.15	0.29	0.22	7
LE30[e]	0.10	0.17	0.28	-f-	0.10	0.28	0.18	6
Background	0.13	0.20	0.29	0.18	0.13	0.29	0.20	7

[a]Measurements by Mound Laboratory, Monsanto Research Corporation.

[b]Sampling locations are shown in Figures 3-3 and 3-4.

[c]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.

[d]The DOE CG for radon-222 is 3 x 10^{-9} uCi/ml (3 pCi/l) annual average for uncontrolled areas.

[e]These locations form a control group for measuring background radon levels.

[f]Because measurements at these locations were approximately equal to the background level and funding was decreased, measurements were not taken at these locations in the fourth quarter.

Consequently, during the residue transfer operation, additional on-site and off-site monitoring was implemented to measure radon concentrations and external gamma radiation levels (Ref. 14).

The monitoring locations used for the PERM and Terradex Track-Etch programs are shown in Figures 4-3 and 4-4. These were supplemented with 29 additional off-site Track-Etch stations shown in Figure 4-5. The data for these locations are summarized in Table 4-3. The DOE DCG for radon-222 is 3 x 10^{-9} (3 pCi/l). The results of these data showed that the average off-site airborne radon-222 concentrations ranged from 1.4 x 10^{-10} to 4.7 x 10^{-10} uCi/ml (0.14 to 0.47 pCi/l). This compares with a range of 0.36 to 1.57 pCi/l in 1984. These results show a continued downward trend in radon-222.

Table 4-3 also shows that the average off-site gamma dose rate ranged from 53 to 83 mrem/yr. The 1984 measurements ranged from 123 to 201 mrem/yr. The gamma exposure rate also shows a downtrend in 1985. The DOE radiation protection standard for gamma dose rates is 100 mrem/yr.

During the peak construction period in 1984, there was an increase in the gamma dose rate. However, maximum levels during this time remained below the standard and decreased to below pre-remedial action levels after completion (Ref. 13).

4.1.3 Water Discharges

Surface water discharges from the NFSS are regulated by the NYSDEC, under the New York State Pollutant Discharge Elimination System (SPDES). Permit No. NY-0110469 was issued May 1, 1983, and is in effect for a period of 5 years.

During 1985, 12.8 million liters (3.2 million gal) of treated waste water were released in seven separate discharge events. Discharges consisted of runoff water from the IWCF, washwater from the vehicle decontamination facility, and construction waste water. Water was

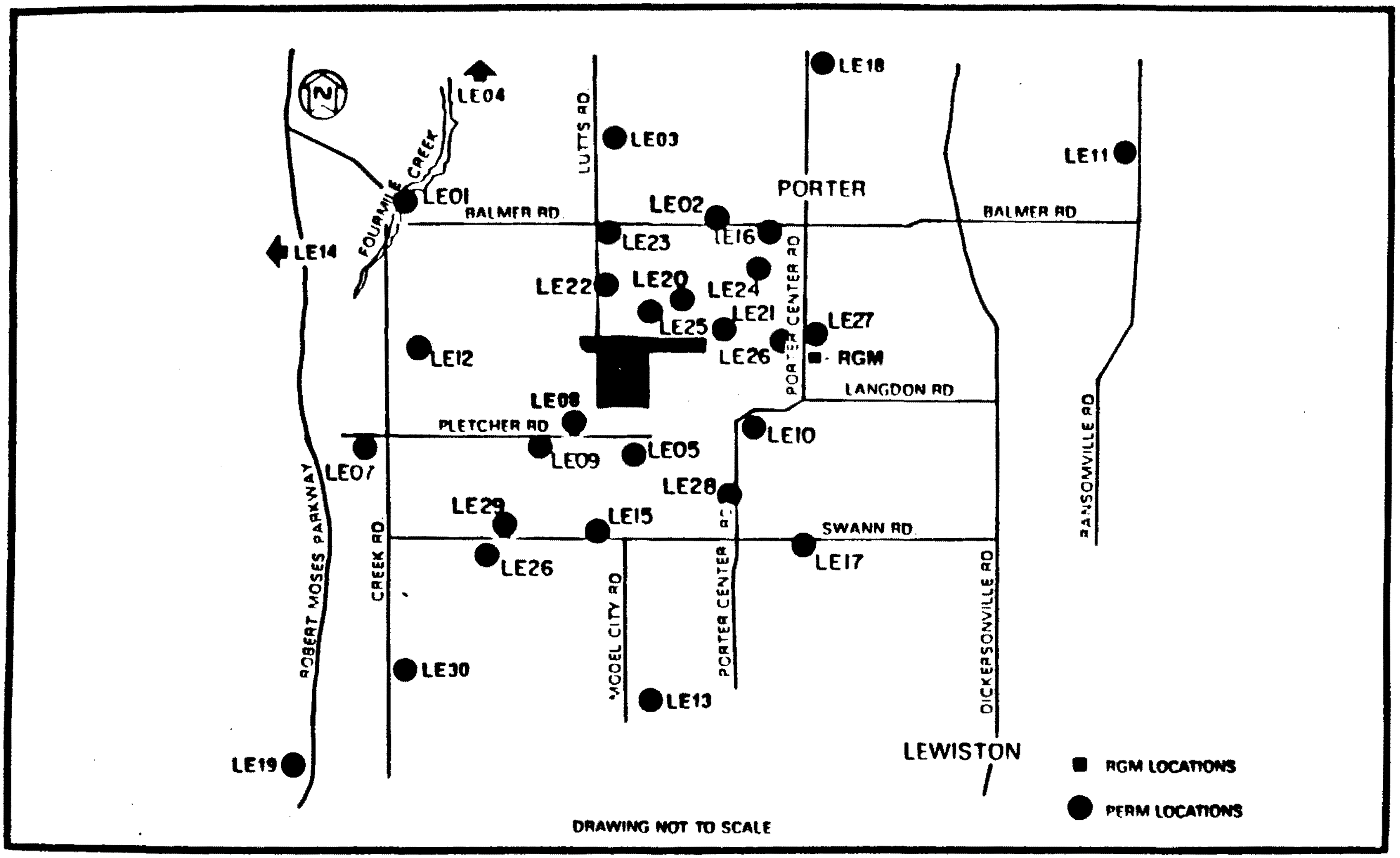


FIGURE 4-3 MONSANTO RESEARCH CORPORATION OFF-SITE MONITORING LOCATIONS

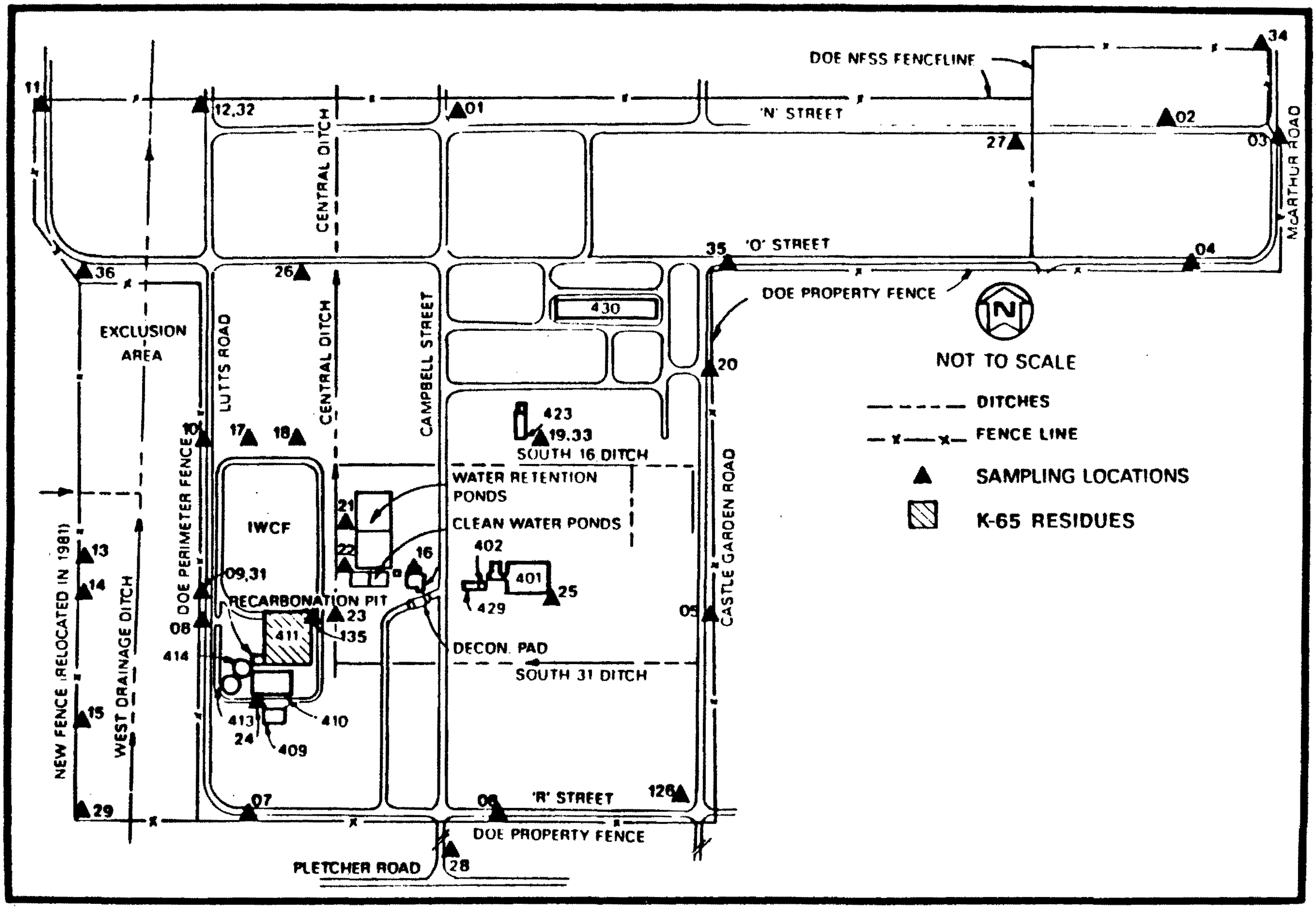


FIGURE 4-4 ON-SITE TERRADEX TRACK ETCH MONITORING STATIONS

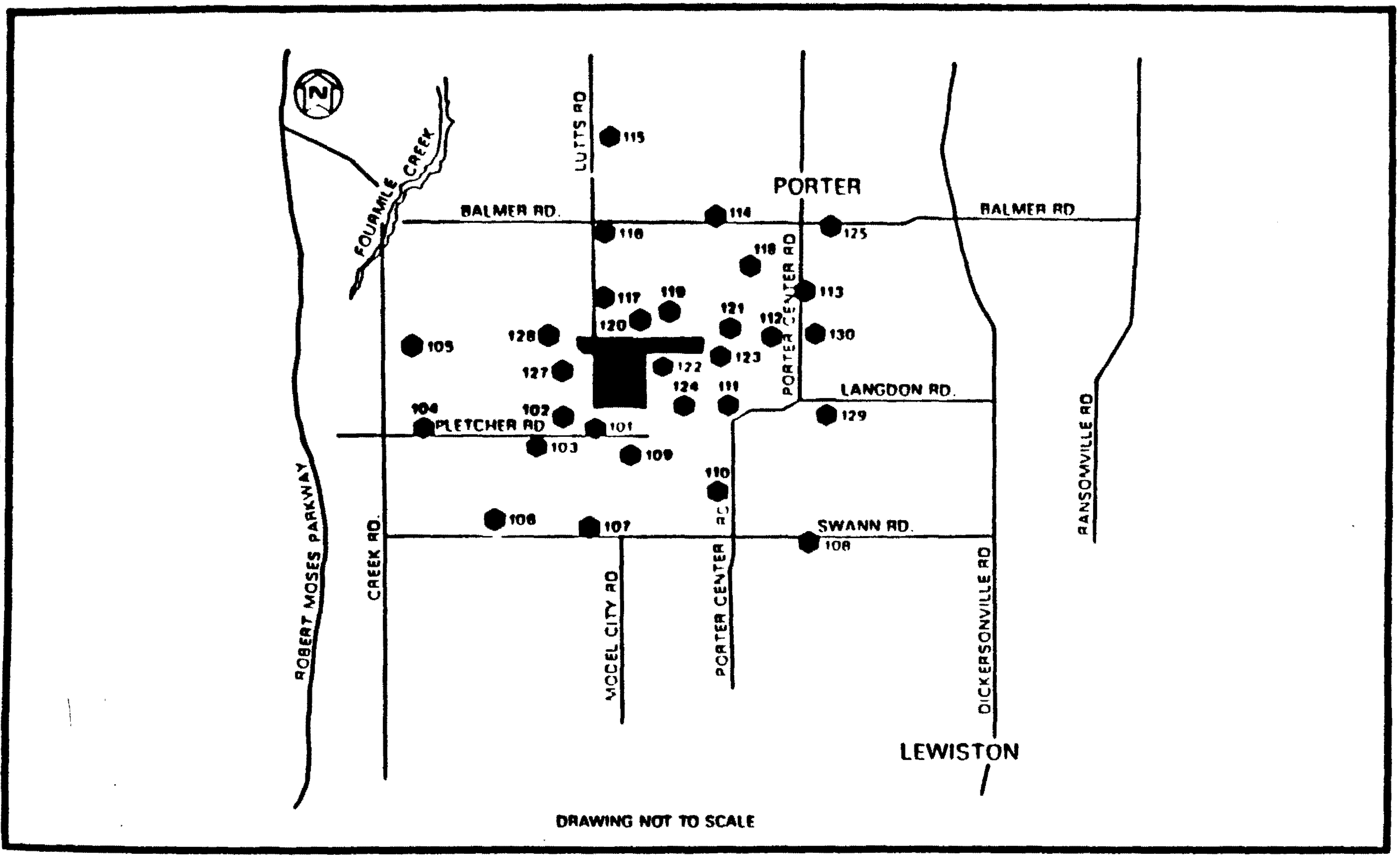


FIGURE 4-5 RADON (TRACK ETCH) AND DIRECT GAMMA (TLD) OFF-SITE MONITORING LOCATIONS

TABLE 4-3

RESULTS OF OFF-SITE CONSTRUCTION ENVIRONMENTAL MONITORING FOR RADON-222 AND DIRECT GAMMA RADIATION IN THE VICINITY OF THE NFSS, 1985

Monitoring Station Number	Concentrations[a] of Radon-222[b,c] ($n \times 10^9$ uCi/ml)[d]	Gamma Radiation[a] Dose Rate[c,e] (mrem/yr)
1	0.30	74
2	0.20	70
3	0.24	83
4	0.33	70
5	0.25	74
6	0.20	79
7	0.15	70
8	0.19	79
9	0.20	74
10	0.27	79
11	0.32	74
12	0.21	70
13	0.26	79
14	0.16	66
15	0.21	83
16	0.19	74
17	0.15	70
18	0.20	74
19	0.47	53
20	0.16	79
21	0.14	70
22	0.29	83
23	0.29	70
24	0.27	70
25	0.17	61
27	0.20	66
28	0.23	66
29	0.22	70
30	0.30	83

[a]These values may be compared with DOE guideline values of 3×10^{-9} uCi/ml (3 pCi/l) for radon-222 (when averaged over a year) and 100 mrem/yr for annual dose rates.
[b]The value presented here is the average of measurements from the first, second, and third quarters of 1985.
[c]Construction monitoring was phased out when the residue transfer work was complete.
[d]Multiply n (the listed concentration) by 10^9 to obtain uCi/ml.
[e]The value presented here is the average of measurements from the first and second quarters of 1985.

TABLE 4-4

1985 SPDES PERMIT PARAMETERS

Measured Parameter	Units	Permit Limits Bat	Water Quality
Arsenic	mg/l	0.33	0.05
Barium	mg/l	0.42	--
Cerium	mg/l	0.10	--
Chromium	mg/l	0.15	0.005
Cobalt	mg/l	0.10	0.005
Copper	mg/l	0.10	--
Cyanide	mg/l	--	0.10
Fluoride	mg/l	4.2	1.5
Iron	mg/l	0.42	0.3
Lanthanum	mg/l	0.10	--
Lead	mg/l	0.10	0.03
Lithium	mg/l	0.42	--
Manganese	mg/l	0.10	--
Mercury	mg/l	--	0.0004
Nickel	mg/l	0.10	0.03
Selenium	mg/l	4.00	--
Strontium	mg/l	0.42	--
Thallium	mg/l	--	0.02
Vanadium	mg/l	0.4	--
Zinc	mg/l	0.22	--
Zirconium	mg/l	0.10	--
Total Suspended Solids	mg/l	50	--
Settleable Solids	ml/l	0.30	--
pH	S.U.	6.0-9.0	--
Gross Alpha			
(as Uranium)	uCi/ml	--	6×10^{-7}
(as Radium-226)	uCi/ml	--	1×10^{-7}

Maximum discharge rate - 1,152,000 liters/day (288,000 gal/day)

*DOE limits for discharge.

discharged to the Central Drainage Ditch, which is a tributary of Fourmile Creek. Each discharge request was reviewed and approved by the NYSDEC.

All water discharged was analyzed before and during release for the applicable permit parameters presented in Table 4-4. For radioactivity, the DOE limits of 6 x 10^{-7} uCi/ml (600 pCi/l) for uranium and 1 x 10^{-7} uCi/ml (100 pCi/l) for radium-226 were applicable. All water released was within SPDES permit parameter limits and DOE radioactive release criteria. A total of 323 and 1300 uCi of radium-226 and uranium, respectively, were released in the 12.8 million liters (3.2 million gal) of water discharged during 1985.

4.2 SPECIAL STUDIES

In April 1986 the **Final Environmental Impact Statement for Long-Term Management of the Existing Radioactive Wastes and Residues at the Niagara Falls Storage Site** (Ref. 3) was published. As of this writing, the record of decision is scheduled to be issued during the Summer 1986.

The following reports relevant to environmental concerns at the NFSS were issued in 1985.

- **Design Report for the Waste Containment Facility at the Niagara Falls Storage Site** (Ref. 15)
- **Report on the Performance Monitoring System for the Interim Waste Containment at the Niagara Falls Storage Site** (Ref. 16)
- **Closure/Post-Closure Plan for the Interim Waste Containment Facility at the Niagara Falls Storage Site** (Ref. 17)
- **Environmental Monitoring Plan for the Niagara Falls Storage Site and the Interim Waste Containment Facility** (Ref. 18)

In Situ Permeability Tests on the Clay Cap

A large diameter, double-ring infiltrometer apparatus was used to perform two permeability tests on the clay cover of the IWCF. One test was performed on a section of the clay cap that had been exposed through one winter season then recompacted. A second test was performed on a section of the clay cap immediatley after it was installed. The very low permeabililty of the compacted clay required that a large clay surface be used for these tests in order to obtain measurable volumes from the test apparatus. The tests were operated for several weeks each to reach a saturated (or nearly saturated) condition in the clay cap. The results of both tests show that the installed clay has a permeability of 5×10^{-7} or lower.

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APPENDIX A
QUALITY ASSURANCE

APPENDIX A

QUALITY ASSURANCE

A comprehensive quality assurance program was maintained to ensure that the data collected were representative of actual concentrations in the environment. First, environmental data were obtained to prevent reliance on only a few results, which might not be representative of the existing range of concentrations. Second, newly collected data were compared with both recent results and historical data for each location and each environmental medium to ensure that deviations from previous conditions were identified and evaluated. Third, samples at all locations were collected using published procedures to ensure consistency in sample collection. Fourth, each analytical laboratory verified the quality of the data by conducting a continuing program of analytical quality control, participating in interlaboratory crosschecks, performing replicate analyses, and splitting samples with other recognized laboratories. Fifth, chain-of-custody procedures were implemented to maintain the traceability of samples and corresponding analytical results. This program ensures that the monitoring data can be used to evaluate accurately the environmental impacts from site operations.

The majority of the routine radioanalyses for the FUSRAP Environmental Monitoring Program were performed under subcontract by the Eberline Analytical Corporation (EAC), Albuquerque, New Mexico. This laboratory maintained an internal quality assurance program that involved routine calibration of counting instruments, source and background counts, routine yield determinations of radiochemical procedures, and replicate analyses to check precision. The accuracy of radionuclide determination was ensured through the use of standards traceable to the National Bureau of Standards, when available. The laboratory also participated in the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. In this program, samples of different environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts were prepared and distributed to the participating laboratories. After the samples were analyzed, the results were forwarded to EPA for comparison with known values and with the results from other laboratories. This program enabled the laboratory to regularly evaluate the accuracy of its analyses and take corrective action if needed.

Interlaboratory comparison of the TLD results was provided by participation in the International Environmental Dosimeter Project sponsored jointly by the Department of Energy, the Nuclear Regulatory Commission, and the EPA.

Assurance of the quality of dose calculations was provided in several ways. First, comparisons were made against past calculated doses and significant differences, if any, were verified. Second, all computed doses were double-checked by the originator and by an independent third party who also checked all input data and assumptions used in the calculation.

APPENDIX B
ENVIRONMENTAL STANDARDS

APPENDIX B
ENVIRONMENTAL STANDARDS

The radiation protection standards and associated Derived Concentration Guides (DCG) applicable to Department of Energy (DOE) installations have been modified (Ref. 6).

The radiation protection standard has been reduced from 500 mrem/yr to 100 mrem/yr. In conjunction with this reduction, evaluation of exposure pathways and resulting dose calculations are based on realistic assumptions. Realistic assumptions may include the use of occupancy factors in determining dose due to external gamma radiation; subtraction of background concentrations of radionuclides in air, water, and soil before calculating dose; closer review of water use, using the data that most closely represents actual exposure conditions rather than maximum values as applicable; and using average consumption rates of food and water per individual rather than maximums. Utilization of realistic assumptions will result in lower calculated doses than previous years. However, these doses will more accurately reflect the exposure potential from site activities.

The associated DCGs, which provide limits for the maximum permissible radioactivity in various environmental media, have also been revised. The new DCGs reflect changes to the radiation protection standard and new uptake models. On a case-by-case basis, the DCG for a given radionuclide may have increased, decreased, or remained unchanged. The DCGs for the common radionuclides at the NFSS are presented in Table B-1. For comparative purposes, the old and revised DCGs are presented. Conversion factors for the new reporting units are provided in Table B-2.

TABLE B-1

RADIATION PROTECTION STANDARD[a] AND
RADIOACTIVITY CONCENTRATION GUIDES FOR THE NFSS

Radionuclide	Transport Medium	Previous Guide (Uncontrolled Areas)	New Guide
Uranium-Natural	Water	600 pCi/l	Unchanged[b]
Radium-226	Water	30 pCi/l	1×10^{-7} uCi/ml (100 pCi/l)
Radon-222	Air	3 pCi/l	Unchanged[b]

[a]The radiation protection standard was changed from 500 mrem/yr to 100 mrem/yr.

[b]The values are the same as previous years, but are reported in different units.

TABLE B-2

CONVERSION FACTORS

1 year	=	8760 hours
1 liter	=	1000 ml
1 mrem	=	1000 uR
1 mrem/yr	=	11 uR/hr (assuming 8760 hours of exposure per year)
1 uCi	=	1,000,000 pCi
1 pCi	=	0.000001 uCi
1 pCi/l	=	10^{-9} uCi/ml
1 pCi/l	=	0.000000001 uCi/ml
1 uCi/ml	=	1,000,000,000 pCi/l
10^{-6}	=	0.000001
10^{-7}	=	0.0000001
10^{-8}	=	0.00000001
10^{-9}	=	0.000000001
10^{-10}	=	0.0000000001
7×10^{-10}	=	0.0000000007

APPENDIX C
ABBREVIATIONS

APPENDIX C
ABBREVIATIONS

cm	centimeter
cm/sec	centimeters per second
ft	foot
g	gram
gal	gallon
ha	hectare
in.	inch
km	kilometer
km/h	kilometers per hour
m	meter
m^3	cubic meters
mg	milligram
mg/l	milligrams per liter
mi	mile
ml	milliliter
mph	miles per hour
mrem	millirem
mrem/yr	millirem per year
m.s.l.	mean sea level
uCi/ml	microcuries per milliliter
uR/h	microroentgens per hour
pCi	picocurie
pCi/g	picocuries per gram
pCi/l	picocuries per liter
wk	week
yd^3	cubic yards
yr	year

APPENDIX D
DISTRIBUTION LIST FOR THE NIAGARA FALLS STORAGE SITE ANNUAL SITE ENVIRONMENTAL MONITORING REPORT

APPENDIX D

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