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POST-REMEDIAL ACTION REPORT FOR THE NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES—1985 AND 1986

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POST-REMEDIAL ACTION REPORT FOR THE NIAGARA FALLS STORAGE SITE VICINITY PROPERTIES - 1985 AND 1986

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By

M. E. Kaye and A. M. Feldman

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

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ABBREVIATIONS

cm*	centimeter
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
ft	foot
ft^2	square feet
g	gram
h	hour
in.	inch
m	meter
m^2	square meter
mi	mile
mrad/h	millirad per hour
mrem	millirem
mrem/yr	millirem per year
pCi	picocurie
pCi/g	picocurie per gram
uR/h	microroentgen per hour
WL	working level
yd^3	cubic yards
yr	year

*Words appearing in boldfaced print are explained in the glossary. Some words do not appear in boldfaced print in the text but are included in the glossary for additional explanation.

1.0 INTRODUCTION

The Niagara Falls Storage Site (NFSS) is a U.S. Department of Energy (DOE) facility. The site covers approximately 191 acres and is used for the storage of radioactive residues and contaminated soils and rubble. The site is located approximately 10 mi north of the City of Niagara Falls and lies within the Town of Lewiston, New York (Figure 1).

The NFSS is a remnant of the U.S. Army's original Lake Ontario Ordnance Works (LOOW), portions of which were used by the wartime Manhattan Engineer District (MED) for the storage and transshipment of radioactive materials. As a result of these operations, some portions of the former LOOW other than the present NFSS were also contaminated. In addition, some of the radioactive materials stored at the NFSS were subject to water and wind erosion over the years. As a result, radioactive materials migrated off-site, chiefly through on- and off-site drainage ditches. These radioactively contaminated areas located adjacent to or near the NFSS are referred to as "vicinity properties."

The contaminated materials in the off-site drainage ditches and on the vicinity properties are the responsibility of the Formerly Utilized Sites Remedial Action Program (FUSRAP). FUSRAP is a DOE effort to identify, decontaminate, or otherwise control sites where low-activity radioactive contamination remains from the early days of the nation's atomic energy program. Administratively, the vicinity properties are under the jurisdiction of FUSRAP. DOE also has established the Surplus Facilities Management Program (SFMP) to manage and plan the ultimate disposition of DOE-owned facilities such as the NFSS.

Bechtel National, Inc. (BNI), in its capacity as DOE's Project Management Contractor for the NFSS, removed radioactively contaminated soil from the vicinity properties. This report documents BNI's post-remedial action sampling of the properties cleaned up in 1985 and 1986 and briefly describes the origin of the

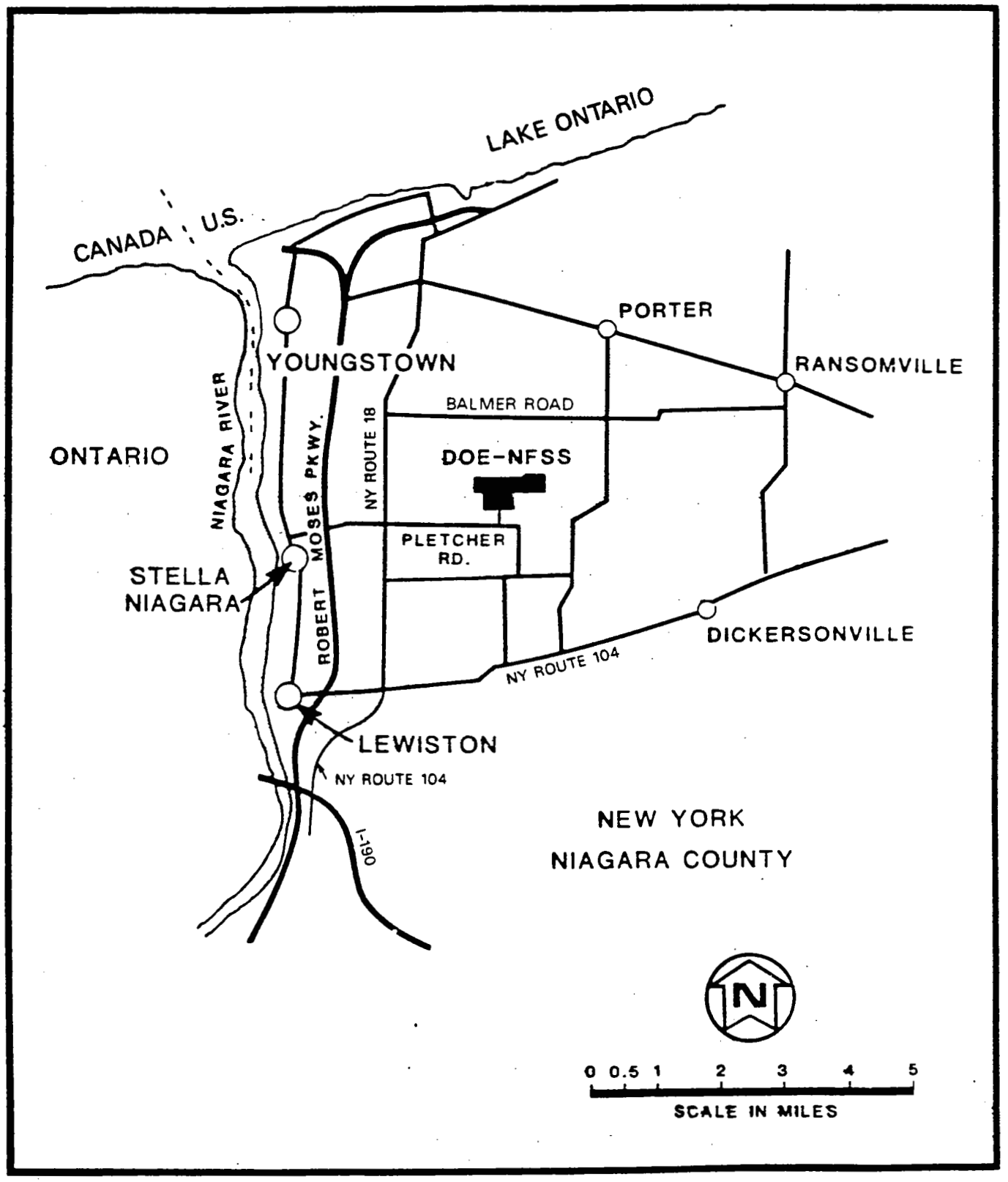

FIGURE 1 LOCATION OF THE NFSS

radioactive contamination on the properties, the methods used to determine the extent of contamination, and the types of remedial action performed. This report also provides the guidelines used in performing the remedial action and provides data on the current radiological status of the properties.

Background

The NFSS and adjacent vicinity properties were part of the U.S. Army's original 7,500-acre LOOW, which was constructed and used for TNT production early in World War II. When TNT production ceased, the LOOW was reassigned to the Army Corps of Engineers - MED.

From 1944 to 1947, the MED used the LOOW to store uranium ore processing residues from a ceramics plant operated by Linde Air Products in Tonawanda, New York. By 1948, 6,000 acres of the LOOW had been transferred or sold by the War Assets Administration, with ownership of the remaining 1,500 acres given to the newly formed Atomic Energy Commission (AEC). The AEC continued to use the 1,500-acre LOOW site to store additional residues from the Linde plant, as well as residues from the Mallinckrodt Chemical Works in St. Louis, Missouri.

In addition to storage of uranium ore processing residues, the LOOW was also used for interim storage of uranium metal billets (rods) manufactured at the Simonds Saw and Steel Company's plant in Lockport, New York, and as a disposal site for radioactive material wastes from the Knolls Atomic Power Laboratory in Schenectady, New York; the University of Rochester in Rochester, New York; and the MED-AEC's Middlesex Sampling Plant in Middlesex, New Jersey. Other probable sources of radioactive materials at the LOOW include the Harshaw Chemical Company in Cleveland, Ohio; Electromet in Niagara Falls, New York; Eldorado Mining and Refining, Ltd. in Port Hope, Ontario; Allegheny Ludlum Steel Company in Watervliet, New York; and Vitro Corporation of America in Grand Junction, Colorado.

On-site storage operations had ceased by 1953, and an on-site steam plant was modified to separate nonradioactive isotopes of boron.

The plant was in operation between 1953 and 1959 and again between 1965 and 1971. During the first period, a major cleanup of the site included consolidating and removing surface debris and shipping most of these wastes to Oak Ridge, Tennessee. Radioactively contaminated soils and residues were left at the site. After 1971, more than 1,300 acres of the LOOW were transferred or sold to private concerns, leaving 191 acres as the current NFSS (Figure 2). Responsibility for the NFSS was transferred from the AEC to the Energy Research and Development Administration, and then to DOE. In 1981, DOE chose BNI as the Project Management Contractor for the NFSS project. Since then, BNI has been custodian of the NFSS, with responsibility for conducting remedial action at the site and at the off-site or vicinity properties.

Radiological Surveys

During October 1970 and June 1971, radiological surveys of the approximately 1300 acres formerly held by the AEC indicated that about 6.5 acres exceeded the AEC exposure criterion of 50 uR/h. As a result of this survey, 15,000 to 20,000 yd^3 of contaminated soil and debris were removed and transported to the NFSS during 1972.

In 1971, an aerial survey of the greater Niagara Falls area was conducted by EG&G (Ref. 1). This survey identified several areas of elevated gamma radiation levels. Most of these areas were later shown to contain a slag-type material similar to wollastonite ($CaSiO_3$). This material was reported to be of natural origin, probably the by-product of a local phosphorous extraction process. Other areas identified as contaminated were locations of known contamination such as the Linde Plant and the NFSS.

In 1979 and 1980, Battelle Columbus Laboratories conducted a comprehensive radiological characterization of the NFSS, including the West Drainage Ditch and Central Drainage Ditch on- and off-site

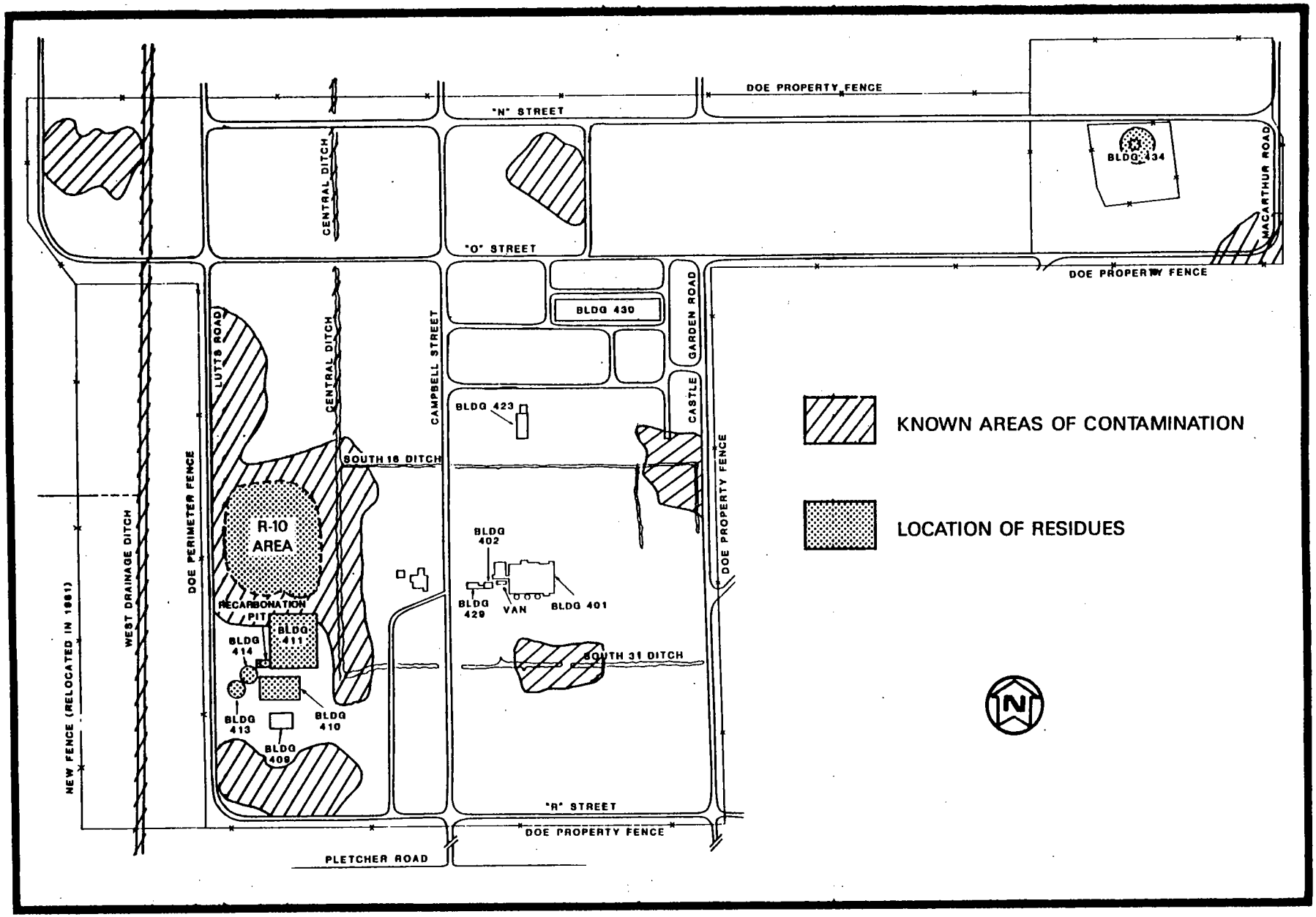

FIGURE 2 CURRENT BOUNDARIES OF THE NFSS AND LOCATIONS OF CONTAMINATION IN 1981

(Ref. 2). This survey identified contamination in excess of the DOE guidelines along the entire length of the West Drainage Ditch and most of the Central Drainage Ditch.

From 1981 to 1985, Oak Ridge Associated Universities (ORAU) and Oak Ridge National Laboratory (ORNL) performed radiological surveys of the approximately 1,300 acres, formerly a part of the AEC's LOOW, that lie outside of the current NFSS (Refs. 3-31). This area has been subdivided into letter-designated vicinity properties, as shown in Figure 3.

Twenty-four of these properties were surveyed by ORAU. Part of Property N/N' North, owned by Modern Landfill, Inc., and Property O, which was inaccessible until 1985 because of delays in obtaining an access permit, were surveyed by ORNL. Of the 25 properties, 21 were found to be contaminated in excess of DOE guidelines, 2 were found to be free of significant contamination, and 2 were too close to a uranium ore residue storage area to allow accurate measurement of the low-level radiation. Following removal of residues from the storage area, the two properties were surveyed and cleaned. In addition to these properties, the section of Pletcher Road between the entrance to the NFSS and Creek Road was decontaminated in 1985 based on results of an ORAU survey (Ref. 32).

Three more properties, one each in the City of Niagara Falls and the Towns of Niagara Falls and Lewiston, were designated for remedial action in late 1985 based on results from an ORNL scanning van survey (Ref. 33). These three properties are referred to in this report as Anomalies AA, BB, and CC and are shown in Figure 4.

2.0 REMEDIAL ACTION GUIDELINES

All soil contains trace amounts of uranium and thorium because these are naturally occurring elements. Typically, soils in the northeastern U.S. contain about 1 pCi/g each of uranium, radium, and thorium. These radionuclide concentrations are called background

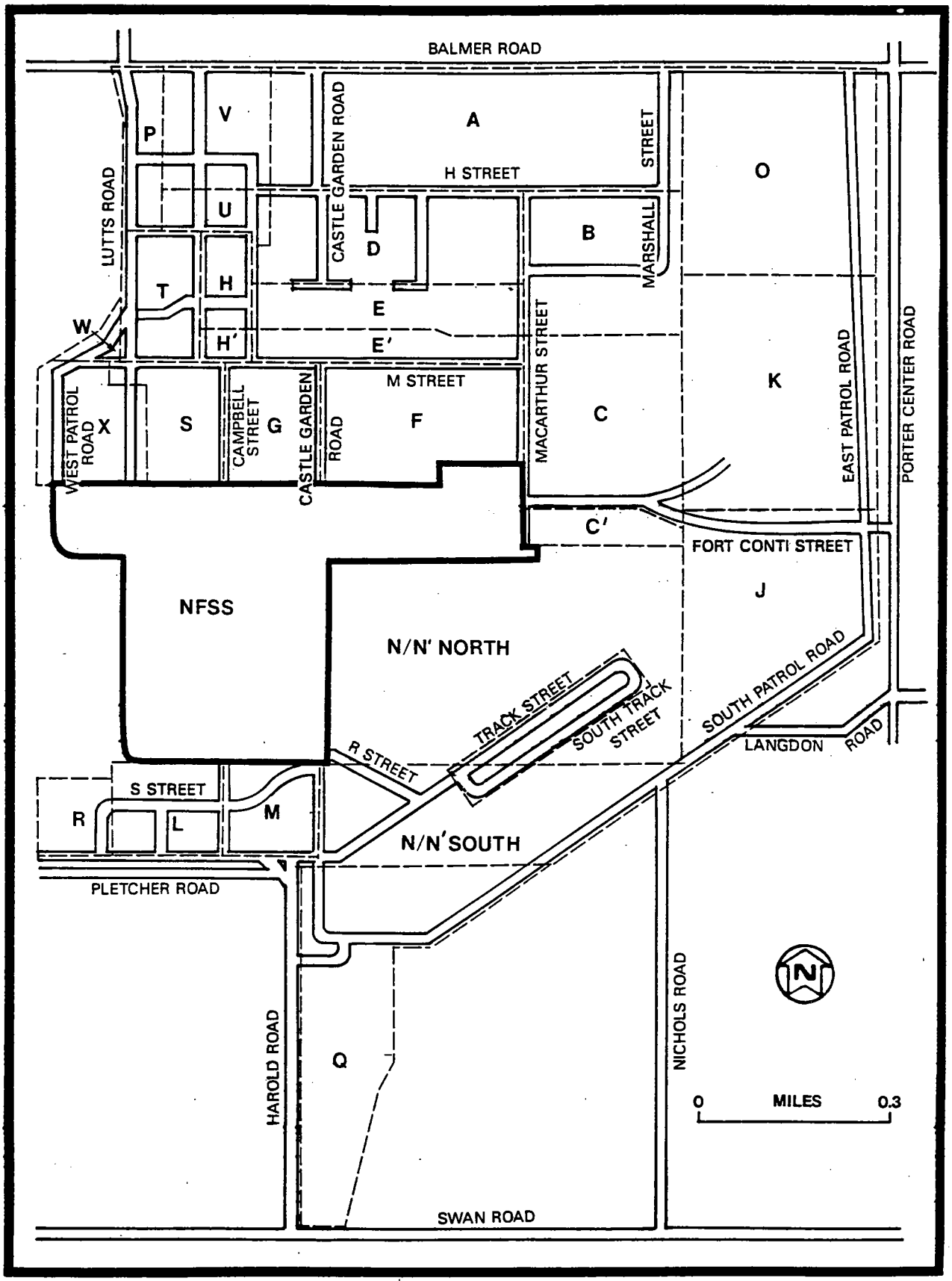

FIGURE 3 LETTER-DESIGNATED VICINITY PROPERTIES

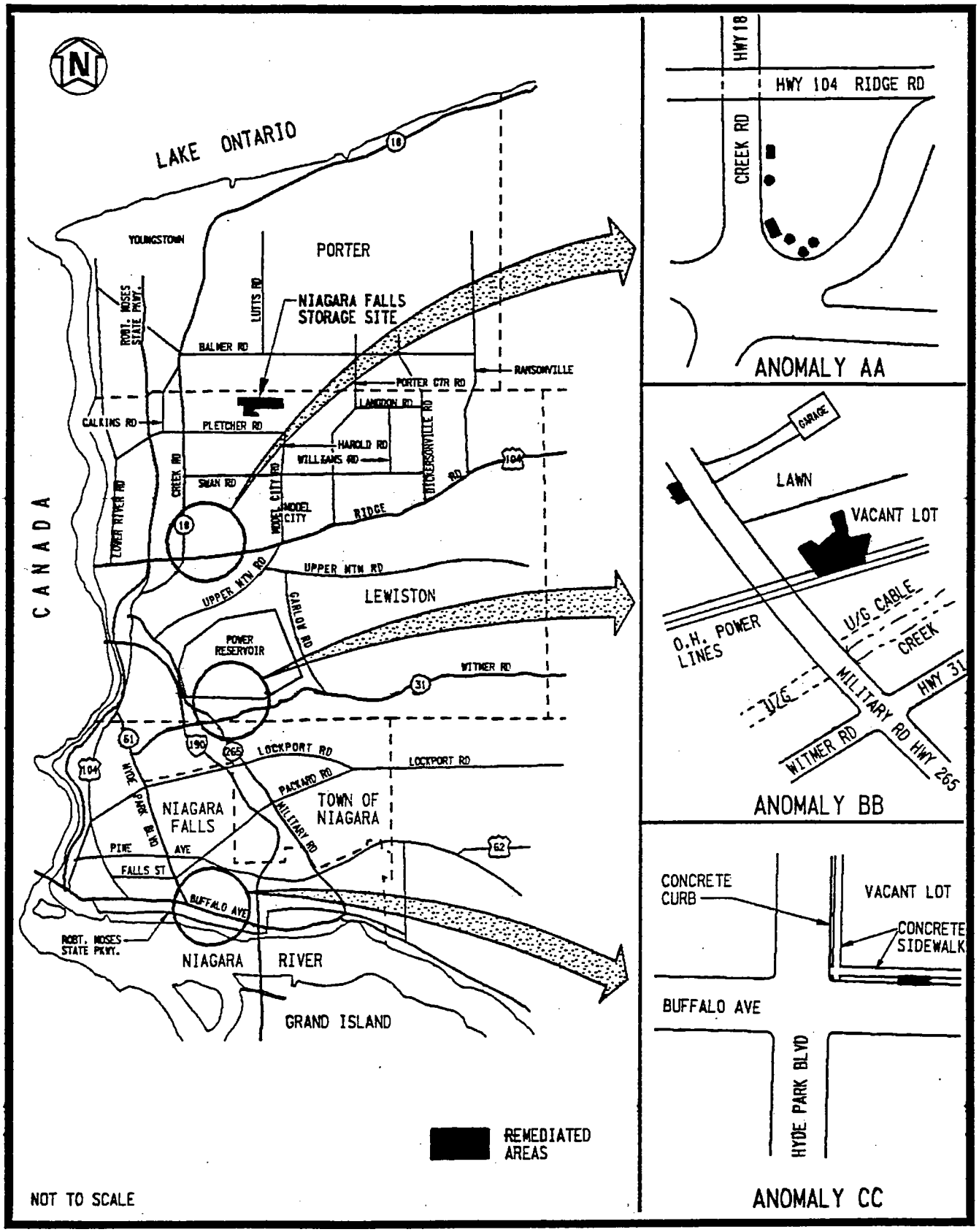

FIGURE 4 LOCATIONS OF ANOMALIES AA, BB, AND CC

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levels and do not originate from manufacturing operations using radioactive materials.

The DOE guideline for residual radioactivity from radium-226 (the principal contaminant at the NFSS), thorium-230, thorium-232, and radium-228 in soil is 5 pCi/g above background (see Table 1). The concentrations of these radionuclides are averaged over a 100-m^2 (1076-ft^2) area and to a depth of 15 cm (6 in.). Below the 15-cm (6-in.) depth, the guideline increases to 15 pCi/g above background for each successive 15-cm (6-in.) layer within the 100-m^2 (1076-ft^2) area (Ref. 34). For total uranium, the guideline was 90 pCi/g above background. For uranium-234, uranium-235, and uranium-238 (the isotopes comprising total uranium), the respective guidelines were 44 pCi/g, 2 pCi/g, and 44 pCi/g above background (Ref. 35).

Since the long-term land usage of Property B indicated that certain radiation exposure pathways were not realistic, pathways analyses were performed to develop specific guidelines for soils or structures on this property. The concentrations of radionuclides in the soils on Property B comply with the guidelines specified in Table 1. However, a warehouse contaminated with radium-226 and presently used for storing polychlorinated biphenyl (PCB) materials remains on the property. An analysis was performed to verify that the structure could be rubbled and buried in place without undesirable radiological effects.

3.0 REMEDIAL ACTION

A property was "designated" for remedial action if the results of the ORAU/ORNL survey showed that it was contaminated in excess of the DOE guidelines presented in Table 1. After a property was designated, BNI began engineering design work and activities to hire local subcontractors to perform the cleanup work (Refs. 36 and 37). Engineering drawings were prepared using the results from the ORAU/ORNL surveys to indicate the location(s) of the contamination on a given property. BNI's radiological support subcontractor,

TABLE 1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES FOR THE NFSS VICINITY PROPERTIES

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS)

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Total Uranium	90 pCi/g[d]
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS)

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that has no radiological restrictions on its use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[e] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restrictions on its use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

	Allowable Surface Residual Contamination[f] (dpm/100 cm^2)		
Radionuclide[g]	Average[h,i]	Maximum[i,j]	Removable[i,k]
Transuranics, radium-26, radium-28, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, radium-23, radium-24 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 α	15,000 α	1,000 α

TABLE 1 (Continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[g]	Allowable Surface Residual Contamination[f] (dpm/100 cm^2) Average[h,i]	Maximum[i,j]	Removable[i,k]
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β-γ	15,000 β-γ	1,000 β-γ

[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b]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.

[c]Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-m^2 area does not exceed these limits.

[d]Assumes 44 pCi/g uranium-234, 44 pCi/g uranium-238, and 2 pCi/g uranium-235. See Reference 35.

[e]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[f]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.

[g]Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[h]Measurements of average contamination 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.

[i]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[j]The maximum contamination level applies to an area of not more than 100 cm^2.

[k]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 measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

Thermo Analytical/Eberline (TMA/E), resurveyed the contaminated area to define the boundaries of the contamination. The contaminated area was then marked for the excavation subcontractor.

The excavation subcontractor removed the contaminated soil from the area(s) as shown on the engineering drawings. The soil was loaded into watertight trucks to prevent the spread of contamination to work areas and haul routes and was transported to the waste containment area at the NFSS. During excavation, the subcontractor was required to keep all work areas free from airborne dust. This was accomplished by spraying contaminated areas with water.

Personnel trained in radiation protection observed all operations to ensure that established safety procedures were followed. Haul trucks were surveyed for radioactive contamination before leaving the loading area. If found, contamination was removed before the truck was allowed to leave the loading area.

The remedial action performed in 1985 and 1986 consisted of excavating contaminated soils and rubble; each property was restored after the excavation was complete, i.e., excavated soil was replaced with clean fill material and the land returned to its original condition. Similar remedial action was performed on several other vicinity properties in 1983-84 (Ref. 38).

4.0 POST-REMEDIAL ACTION SAMPLING

After the contaminated soil was removed, another radiological survey was conducted to ensure that radiological conditions at each excavated area complied with remedial action guidelines before the area was backfilled. Three techniques were used for this survey:

- First, a near-surface scan of the entire area was performed with a gamma radiation detector to ensure that no significant areas of contamination were left after excavation. This process was repeated until the average concentrations were below the applicable DOE guideline values.

- Second, a sampling/measurement grid was established within each area excavated. Typically, grid intersections were spaced 3 m (10 ft) apart. Soil samples were obtained from alternate grid intersections [i.e., 6 m (20 ft) apart] and analyzed by the TMA/E laboratory for uranium, radium, and thorium using gamma spectrometry. The results of these analyses were used to demonstrate that remaining contamination, if any, averaged less than the DOE guidelines.

- Third, a directionalized (downward-looking only) radiation detector was used to obtain the gamma count rate at each grid intersection point. These measurements were made at 30 cm (12 in.) above the ground surface. By calibrating gamma count rate measurements with the results from laboratory analyses of soil samples, surface measurements provided a reliable estimate of radionuclide concentrations of the excavated areas.

Figures 5 through 51 show the vicinity properties that were cleaned and restored during the 1985 and 1986 work seasons. The locations shown in these figures indicate where the post-remedial action soil samples were collected and correspond to the grid coordinates given in Tables 2 through 15.

5.0 POST-REMEDIAL ACTION STATUS

Analysis results for the samples collected following removal of contaminated soils are presented in Tables 2 through 15. Unless specifically noted, background has not been subtracted from any of the listed data. Use of the "less than" (<) notation in reporting results indicates that the radionuclide was not present in concentrations that are quantitative with the instruments and techniques used. The "less than" value represents the lower bound of the quantitative capacity of the instrument and technique used and is based on various factors, including the volume, size, and weight of the sample; the type of detector used; the counting time, and the background count rate. The actual concentration of the radionuclide is less than the value indicated. In addition, since radioactive decay is a random process, a correlation between the rate of disintegration and a given radionuclide concentration cannot be precisely established. For this reason, the exact concentration of the radionuclide cannot be determined. As such, each value that

can be quantitatively determined has an associated uncertainty term (±), which represents the amount by which the actual concentration can be expected to differ from the value given in the table. The uncertainty term has an associated confidence level of 95 percent.

An independent review of the remedial action performed by BNI will be conducted by the ORAU Radiological Site Assessment Program before the properties can be officially certified and released from the FUSRAP. However, the BNI data show that these properties now comply with DOE remedial action guidelines. Summaries of data collected on each property are provided below.

In addition to surveying each property to ensure that contaminated material had been removed, BNI surveyed all haul roads after remedial action was complete to verify that no cross-contamination had occurred.

Property B

Seven small areas on Property B were decontaminated and backfilled (see Figures 5 through 7). Because several external radiation measurements taken near some of the excavations indicated that additional contamination might have been present, several samples were taken in unexcavated areas (see Figure 6). These samples were analyzed to verify that the concentration of radium-226 in surface soil was lower than the remedial action guideline of 5 pCi/g.

Results of soil sample analyses indicate that the remedial action guideline was met (Table 2). The average radium-226 concentration was 5.1 pCi/g, including a background concentration of 1 pCi/g. Thus, the average concentration was 4.1 pCi/g above background. This is well below the remedial action guideline of 15 pCi/g for radium-226 concentrations in soil more than 15 cm (6 in.) beneath the ground surface.

A warehouse on Property B is contaminated with radium-226 and PCBs. The building is being used to store PCB materials. In certain parts of the building, the levels of surface contamination exceed those permitted by the generic remedial action guidelines (see Table 1). Because of the toxicity problems presented by the presence of PCBs, the pathways analysis was performed to determine the appropriate remedial action response (Ref. 39).

The results of this analysis show that if the warehouse were to be demolished, the maximum concentration of radium-226 in the rubble would be 2.4 pCi/g. Actual concentrations, when averaged over 10-m by 10-m areas and a depth of 15 cm (6 in.), would be a fraction of this value. Demolition and burial of the warehouse at least 15 cm (6 in.) beneath the surface of the ground in an unrestricted burial area is therefore feasible from a radiological standpoint.

Property C'

Four small areas on Property C' were decontaminated (see Figures 8 and 9). These areas were not backfilled because they are in a wetlands area and were under water. Because several external radiation measurements taken near some of the excavations indicated that additional contamination might have been present, several samples were taken in unexcavated areas, as shown in Figure 9. These samples were analyzed to verify that the concentration of radium-226 in surface soil was below the remedial action guideline of 5 pCi/g.

Results of soil sample analyses indicate that the remedial action guideline was met (Table 3). The average radium-226 concentration in the four areas was 1.9 pCi/g, including a background concentration of 1 pCi/g. Thus, the average concentration was 0.9 pCi/g above background. This is well below the remedial action guideline of 5 pCi/g for radium-226 concentration in the top 15 cm (6 in.) of soil.

Although analysis results for two soil samples (E4723, N0169 and E4885, N0116) exceeded 5 pCi/g, a review of analysis results for soil and of near-surface gamma measurements obtained at locations contiguous with these two sampling locations indicated that the average concentrations per 100 m^2 were each less than 5 pCi/g. For the highest value (9.4 pCi/g at location E4885, N0116), the average concentration in the immediate area was 2.0 pCi/g. This value is the average of the values for three contiguous samples; background has been subtracted. Thus, the remedial action guideline for surface soil has been met throughout the decontaminated area.

Property D

Eight areas on Property D were decontaminated (see Figures 10 and 11). Data are presented in this report for six of the eight areas. Analysis results for soil from these six areas indicate that the remedial action guideline was met (Table 4). The average radium-226 concentration in the six areas was 2.3 pCi/g, including a background concentration of 1 pCi/g. Thus, the average concentration was 1.3 pCi/g above background. This is well below the remedial action guideline of 15 pCi/g for radium-226 concentrations in soil more than 15 cm (6 in.) beneath the ground surface.

The seventh area, centered at N3690, E1460 was part of a much larger area of contamination on Property U, which was decontaminated and backfilled as a part of remedial actions completed in 1984. The soil sample results for the small portion of the contamination that was on Property D were reported as part of the results for Property U in the Post-Remedial Action Report for the Niagara Falls Storage Site Vicinity Properties - 1983 and 1984 (Ref. 38).

The eighth area, located in an area bounded by N3083, N3132 and E1718, E1850, contained several 15- to 30-cm (6- to 12-in.) diameter pieces of a slag-like material with a uranium-to-radium ratio that was characteristic of MED/AEC materials. This material was removed by ORAU and BNI personnel during the verification survey. After the