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Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

POST-REMEDIAL ACTION REPORT FOR THE MIDDLESEX MUNICIPAL LANDFILL SITE

Middlesex, New Jersey

February 1987

NOTE: The remedial action guidelines in Table 1 of this report have been superseded by those given in Appendix A to Exhibit I of the certification docket.

Bechtel National, Inc.

DOE/OR/20722-135

POST-REMEDIAL ACTION REPORT
FOR THE
MIDDLESEX MUNICIPAL LANDFILL SITE
MIDDLESEX, NEW JERSEY

FEBRUARY 1987

Prepared for

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OAK RIDGE OPERATIONS OFFICE
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ABBREVIATIONS

cm	centimeter
dpm	**disintegrations per minute**
ft	foot
g	**gram**
h	hour
µR	**microroentgen**
µR/h	microroentgens per hour
µCi/ml	**microcuries per milliliter**
m	meter
mi	mile
mrem	**millirem**
mrem/yr	millirem per year
urem	**microrem**
pCi	**picocuries**
pCi/g	picocuries per gram
WL	**Working Level**
yd^3	cubic yards
yr	year

*Words appearing in boldfaced print are explained in the glossary.

1.0 INTRODUCTION

The purpose of this report is to document post-remedial action sampling performed by Bechtel National, Inc. (BNI) on the Middlesex Municipal Landfill (MML) in Middlesex, New Jersey. The MML site is located in the Borough of Middlesex, Middlesex County, New Jersey, approximately 18 mi southwest of Newark (Figure 1). The Middlesex Sampling Plant (MSP) is located about 0.5 mi southeast of the landfill. Remedial action was conducted at the MML from 1984 through 1986 under the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy (DOE) effort to identify, decontaminate, or otherwise control sites where low-level radioactive contamination (exceeding current guidelines) remains from the early days of the nation's atomic energy program. FUSRAP is currently managed by DOE's Oak Ridge Operations Office. As the Project Management Contractor, BNI acts as DOE's representative in the planning, management, and implementation of FUSRAP.

This report briefly describes the origin of the radioactive contamination on the MML property, the method used to determine its extent, and the type of remedial action performed. It also provides the guidelines used in performing the remedial action, summarizes the data on the current radiological status of the property, and presents final excavation limits and depths.

Background

The MSP was used for the assaying of uranium and thorium ores between 1943 and 1955. During the operation of the MSP, some radioactively contaminated soil containing pitchblende (a naturally occurring uranium ore) was shipped to the MML. Although there is no documentation to indicate when the contamination of the landfill occurred, a review of MSP files

documenting operations conducted from 1946 to 1966 indicates the contaminated soil was probably shipped to the landfill between November 1947 and October 1948 (Ref. 1). Construction of a drainage ditch and paved storage area at the sampling plant took place during this period; it is believed that some of the material deposited at the landfill may have resulted from these construction activities. During landfill operations conducted in subsequent years, layers of cover material of various thicknesses were placed on top of the contaminated materials. The landfill has not been used for solid waste disposal since 1974.

During a local civil defense exercise in May 1960, monitors detected elevated **radiation** levels in the landfill. A radiological survey was conducted, and the results confirmed elevated **gamma radiation** levels (several times background) over a fairly consolidated area covering less than a half acre.

In 1961 the Atomic Energy Commission (AEC) removed the top layer of material from the landfill and covered the area with a 2-ft layer of clean dirt. The contaminated soil (approximately 650 yd^3) was taken to the AEC laboratories in New Brunswick, New Jersey.

In 1974, the AEC conducted a radiological survey of the area (Ref. 2). Survey results confirmed the existence of a contaminated area lying between Middlesex Presbyterian Church and properties owned by the Borough of Middlesex. The Oak Ridge National Laboratory (ORNL) conducted another radiological survey in 1978 (Ref. 3).

Based on survey results and on the configuration and usage of the landfill, it was concluded that the MML did not present a significant potential radiation hazard to the public. However, it was further concluded that if the area were to be developed for residential or commercial purposes at some future date, exposure of workers or the public in excess of guideline levels

could result if remedial action were not taken.

An engineering evaluation of remedial action alternatives and an environmental assessment were performed by Ford, Bacon, and Davis in 1979 (Refs. 4, 5). Remedial action began at the MML in 1984 and was completed in 1986.

2.0 REMEDIAL ACTION GUIDELINES

The principal radionuclides of concern at the MML were radium-226, thorium-232, and uranium-238. Table 1 lists the DOE residual contamination guidelines governing the release of the property for **unrestricted use** (Ref. 6). DOE implemented these guidelines on the basis of their compatibility with the criteria used for the same purpose by the Environmental Protection Agency (EPA) (Ref. 7). Since compliance with the remedial action guideline for radium ensures that the concentration of residual uranium is also acceptably low, a site-specific guideline for uranium was not calculated. However, if typical (as opposed to site-specific) values are used as the basis for calculating a guideline for uranium, this guideline would be approximately 75 pCi/g. Where the guidelines in Table 1 were exceeded, contaminated soil was removed from the property until radionuclide concentrations were within guidelines. On the basis that these guidelines have been met, the property can be released for unrestricted use.

3.0 REMEDIAL ACTION

After it was determined on the basis of radiological surveys that the MML was contaminated, DOE "designated" it for remedial action. This means that the landfill was found to be contaminated in excess of DOE guidelines and was therefore eligible for remedial action under FUSRAP. The Borough of Middlesex (owner of the landfill) was notified at this time, and BNI began the engineering design and related activities to hire local subcontractors to perform the cleanup work (Ref. 8).

Cleanup/Decontamination Activities

When the design work had been completed and a local subcontractor hired, drawings showing the extent of the contamination in the soil on the property were given to the excavation subcontractor. Figure 2 shows the areas excavated in 1984 and 1986. The subcontractor removed the soil as indicated in the engineering drawings, placed it in dump trucks, and transported it to the storage pile at the MSP site, where it will be stored until a permanent disposal site is selected.

Contamination Control During the Cleanup

During the cleanup, several measures were taken to control the radioactive materials being removed from the MML site. These measures were designed to keep nearby residents from being exposed to radiation in excess of applicable standards during remedial action. The primary pathway by which residents and workers could be exposed to radiation was from dust released during excavation. To prevent such exposure, the subcontractor was required to keep all excavations and work areas free from dust by keeping the soil moistened.

To keep uncontaminated areas clean during the course of excavation work, haul trucks were kept draped with tarpaulins before they were loaded. This kept contaminated dirt from getting on the exteriors of trucks and later falling off the trucks and onto clean property. If a truck was parked on a clean area while being loaded, the ground was also covered with a tarpaulin and the truck pulled onto it before being loaded. If contaminated soil was spilled during the loading of the truck, the tarpaulin prevented the contamination of clean ground. Measures were taken to prevent the leakage of contaminated material onto city streets; these measures included the installation of gaskets around the tailgates of the trucks.

To prevent soil from falling off the truck and onto clean ground or roadways, all trucks hauling contaminated soil were covered before leaving the site. The haul trucks were also monitored for removable surface contamination. Any truck found to contain surface contamination exceeding allowable limits was decontaminated in the vehicle washdown facility before leaving the site (Figure 2).

The combination of these measures effected control of the contamination and prevented its spread onto areas accessible to the general public. Continuous air sampling was performed along the perimeter of the site during excavation to monitor the presence of alpha-emitting radionuclides in the air. The average concentration of these radionuclides in the 84 air samples collected was less than 1.3×10^{-14} μCi/ml. The most restrictive DOE guideline for the radionuclides present at the site would be the thorium-230 guideline of 8×10^{-14} μCi/ml.

4.0 POST-REMEDIAL ACTION SAMPLING

The contaminated portion of the MML was found to cover an area of approximately 3 acres, with contamination extending from a depth of approximately 1 ft below the ground surface to a depth of about 18 ft. Surface contamination was found to be below guideline levels based on radiological surveys of the ground surface.

Remedial action was conducted at the MML in accordance with the sorting procedure shown in Figure 3 for separating contaminated materials from clean materials. The contaminated subsurface materials were excavated in distinct lifts, each of which was 30 ft wide and 1 ft deep. The lift extending from the surface to a depth of 1 ft is designated Lift 1; the lift extending from a depth of 1 ft to a depth of 2 ft is Lift 2, and so on. Lift 17 was the final lift to be excavated. Each lift was removed in two 15-ft strips. Each strip of each lift was radiologically surveyed prior to excavation and classified as either

contaminated or clean. The contaminated materials were transported to the contaminated waste storage pile at the MSP; the clean soil was stockpiled and used to backfill the excavation after remedial action was confirmed as complete.

After the contaminated soil was removed, the sides and bottoms of the excavations were radiologically surveyed and sampled to ensure that the property was indeed clean (exhibited no radionuclide concentrations in excess of the DOE guidelines).

Surface Gamma Radiation Scans

Following removal of each lift, two types of gamma radiation scans were conducted to determine whether all radioactively contaminated soil had been removed. First, a walkover scan was performed. In conducting this scan, the surveyor held the radiation detector a few inches above the ground surface and slowly moved it back and forth while walking over the excavated area. This type of survey was performed to detect areas of residual contamination exceeding DOE guidelines for subsurface areas. The advantage of the walkover survey is that the detector quickly scans the area as the excavation proceeds.

The second type of gamma radiation scan was performed after all contamination detected by the walkover scan was removed. In performing this scan, the surveyor used a detector with lead shielding around all portions of the detector except the surface parallel to the ground. The purpose of the lead shielding is to ensure that any radiation detected is emanating from the ground directly under the detector. At the MML, the surveyor took systematic measurements at intervals of approximately 7.5 ft in the excavated areas to ensure that the area had been cleaned of radioactively contaminated soils.

If either of these two types of gamma radiation scans revealed contamination at the MML in concentrations exceeding DOE

guidelines, additional soil was removed, and both types of scans were performed again. This process was repeated until DOE guidelines were met.

Soil Sampling

An extensive soil sampling program was conducted in addition to the two types of gamma radiation scans described above. Post-remedial action sampling comprised the collection of 4,800 soil samples at 15-ft intervals. To ensure that the excavation was deep enough to remove contamination exceeding DOE guidelines, samples were collected from each lift following removal of the previous lift. For instance, after Lift 1 was removed, samples were collected at a depth of 1 to 2 ft. The processes of removing each lift and sampling the 1-ft soil layer below it were conducted alternately until the lower limit of contamination was reached. Two samples were collected at each 15-ft interval of each lift: one from the vertical midpoint of the lift, and one from the bottom of the lift. Sampling locations are shown in Figures 4-20. Figure 21 shows overall excavation depths.

The soil samples were analyzed to determine the concentrations of radium-226, thorium-232, and uranium-238. Results of these analyses are summarized below; individual results for each sampling location are contained in Reference 9. Of the 4,800 samples collected, only 32 samples exceeded the 15-pCi/g cleanup guideline. Each of these 32 samples was individually investigated. In accordance with DOE guidance, average concentrations were calculated for these samples and were found in all cases to fall within the 15-pCi/g limit for 100-m^2 areas (Table 1). Analysis results for radium-226 indicated concentrations ranging from 0.1 to 43.2 pCi/g, with an average concentration of 1.9 pCi/g. For thorium-232, concentrations ranged from 0.1 to 32.0 pCi/g, with an average concentration of 1.6 pCi/g. Uranium-238 concentrations ranged from 0.3 to 37.6 pCi/q, with an average concentration of 6.5 pCi/g.

Exposure Rate Measurements

Pressurized Ionization Chamber (PIC) readings were taken to measure the gamma radiation **exposure rate** after the contamination was removed and the excavation backfilled with clean material. The PIC was set up at the locations shown in Figure 22. As shown in Table 2, all exposure rates 1 m above the surface of the backfilled excavation were less than or equal to the background radiation level for the New Jersey area. The values in the table were calculated from measured exposure rates and assume continuous exposure.

5.0 POST-REMEDIAL ACTION STATUS

As shown in Table 2, gamma radiation exposure rate measurements taken after removing the radioactive materials show that there is no area in which radioactive contamination remains in concentrations sufficient to result in a dose in excess of the DOE radiation protection standard of 100 mrem/yr. An independent assessment of the remedial action conducted at the Middlesex Municipal Landfill site, Middlesex, New Jersey was performed by the Oak Ridge Associated Universities (ORAU) under the Radiological Site Assessment Program. The purpose of the assessment was to verify the BNI data supporting the adequacy of the remedial action and to confirm that radiological conditions at the landfill are in compliance with DOE remedial action guidelines.

In addition to the surveys performed on behalf of DOE, monitoring of remedial action activities was conducted by the New Jersey Department of Environmental Protection. This included observing on-site operations and procedures, and analyzing archived soil samples.

Based on all data collected, the Middlesex Municipal Landfill site conforms to all applicable DOE radiological guidelines established for release of this site for unrestricted use.

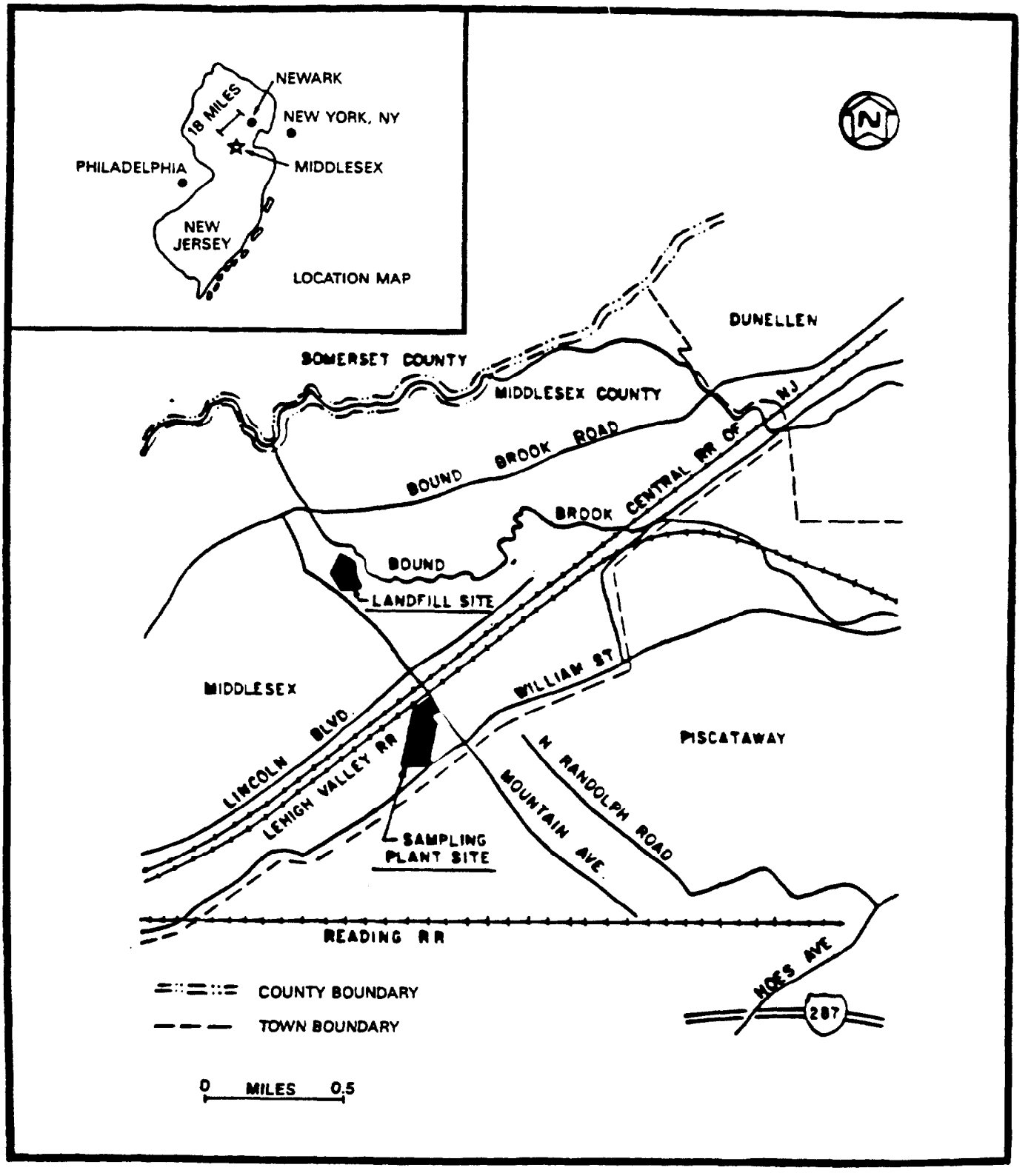

FIGURE 1 LOCATION OF THE MIDDLESEX MUNICIPAL LANDFILL SITE

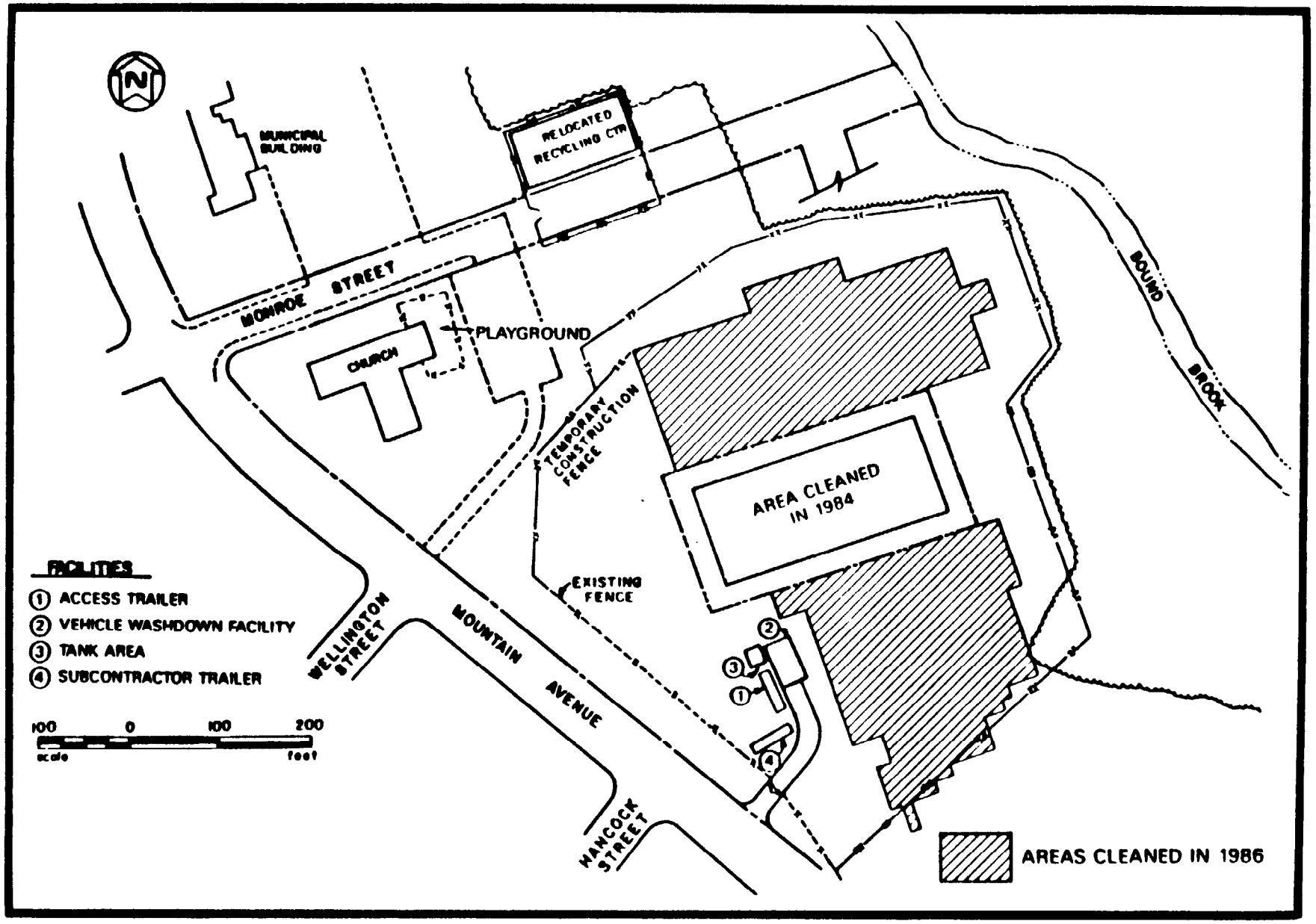

FIGURE 2 REMEDIAL ACTION AREAS AT THE MIDDLESEX MUNICIPAL LANDFILL

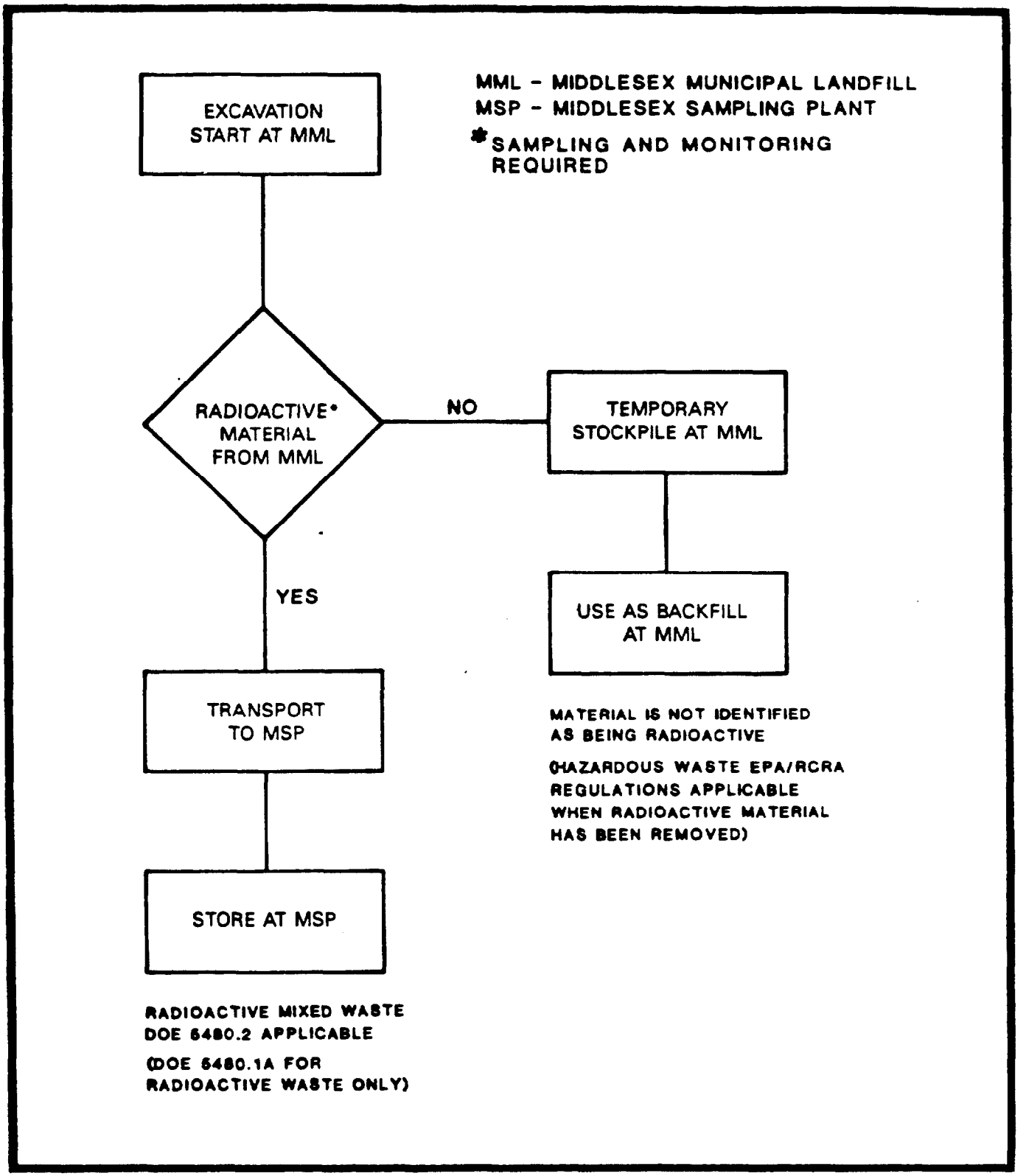

FIGURE 3 LOGIC DIAGRAM FOR SORTING MATERIALS EXCAVATED FROM MIDDLESEX MUNICIPAL LANDFILL

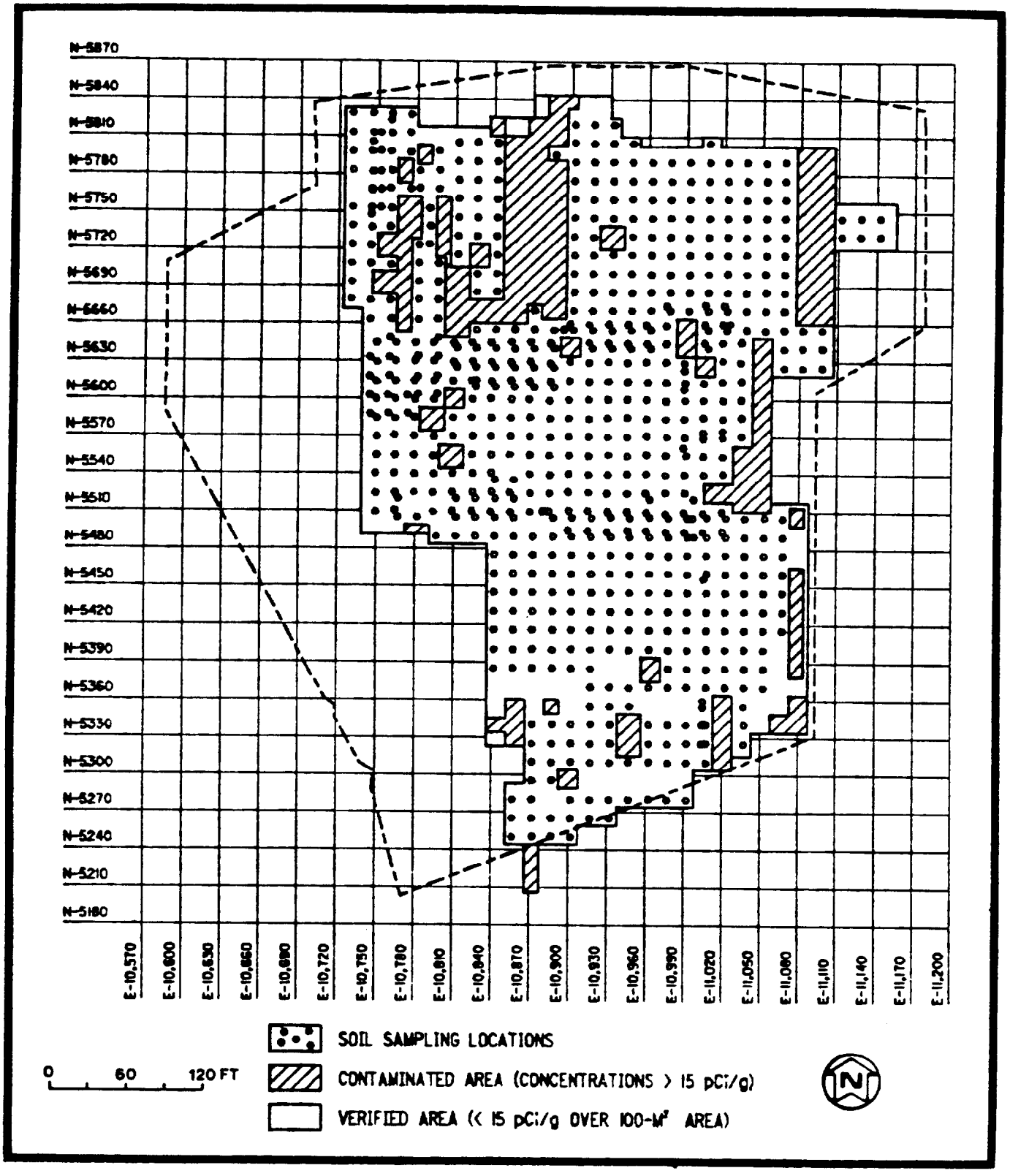

FIGURE 4 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 1

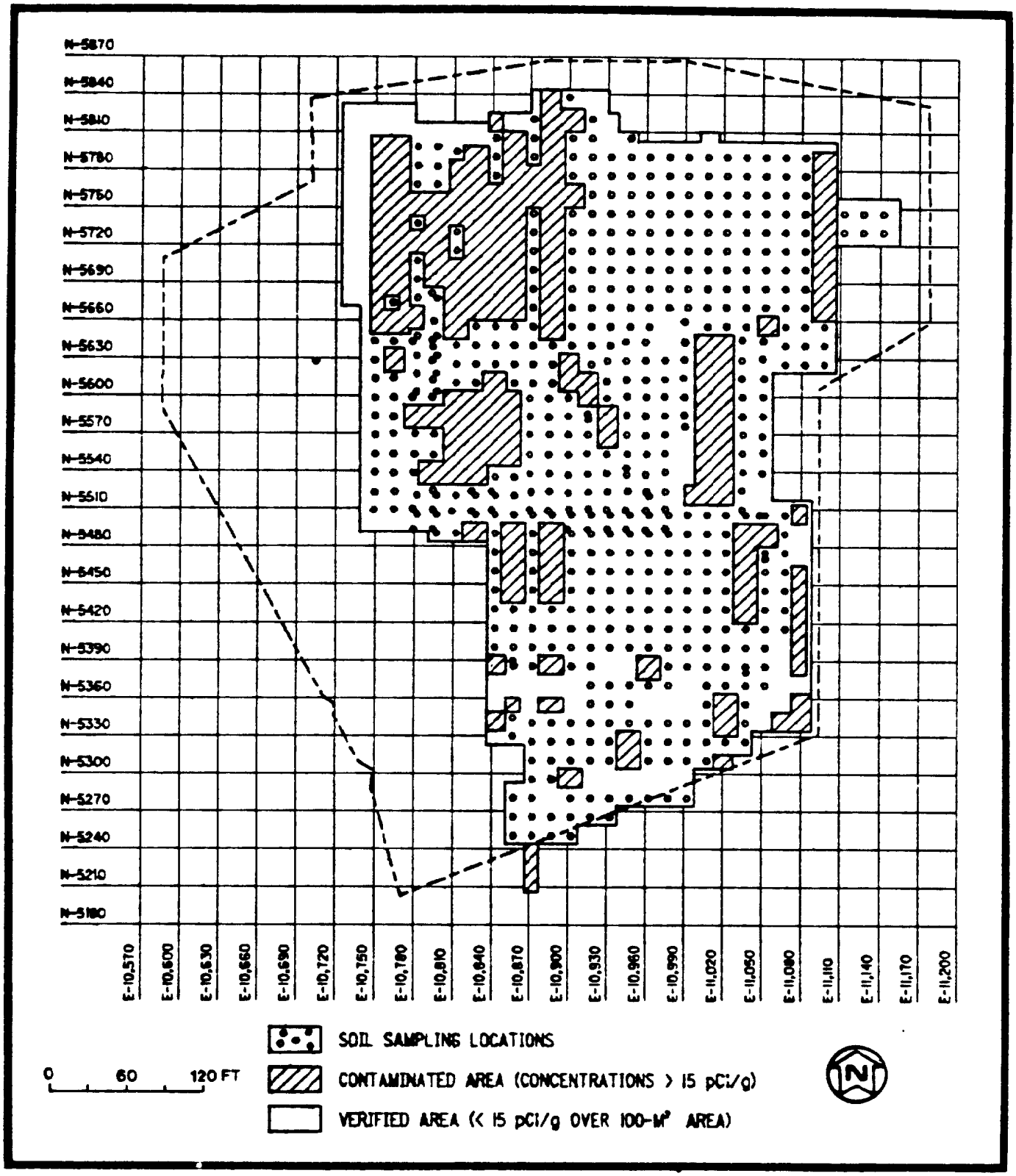

FIGURE 5 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 2

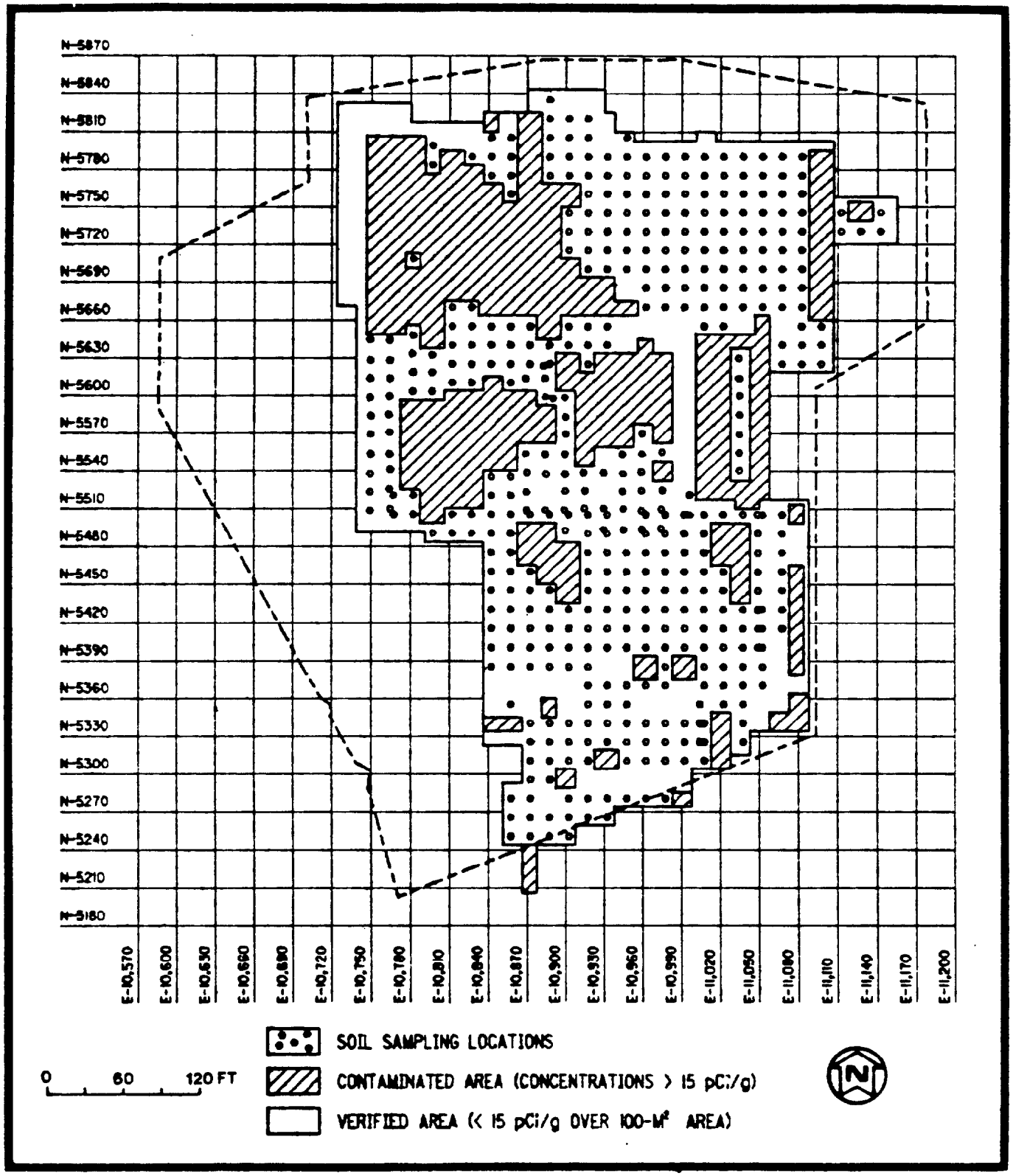

FIGURE 6 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 3

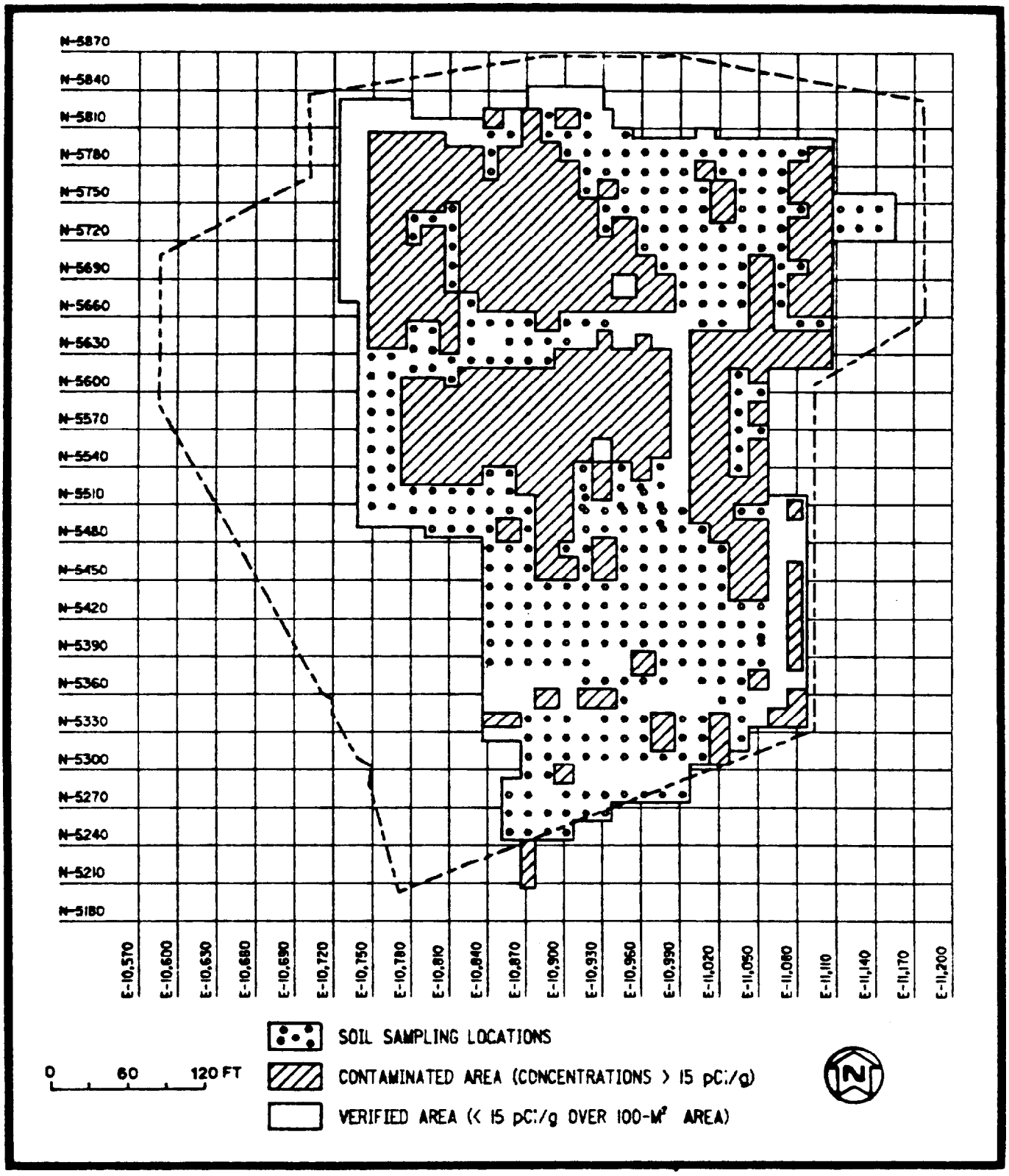

FIGURE 7 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 4

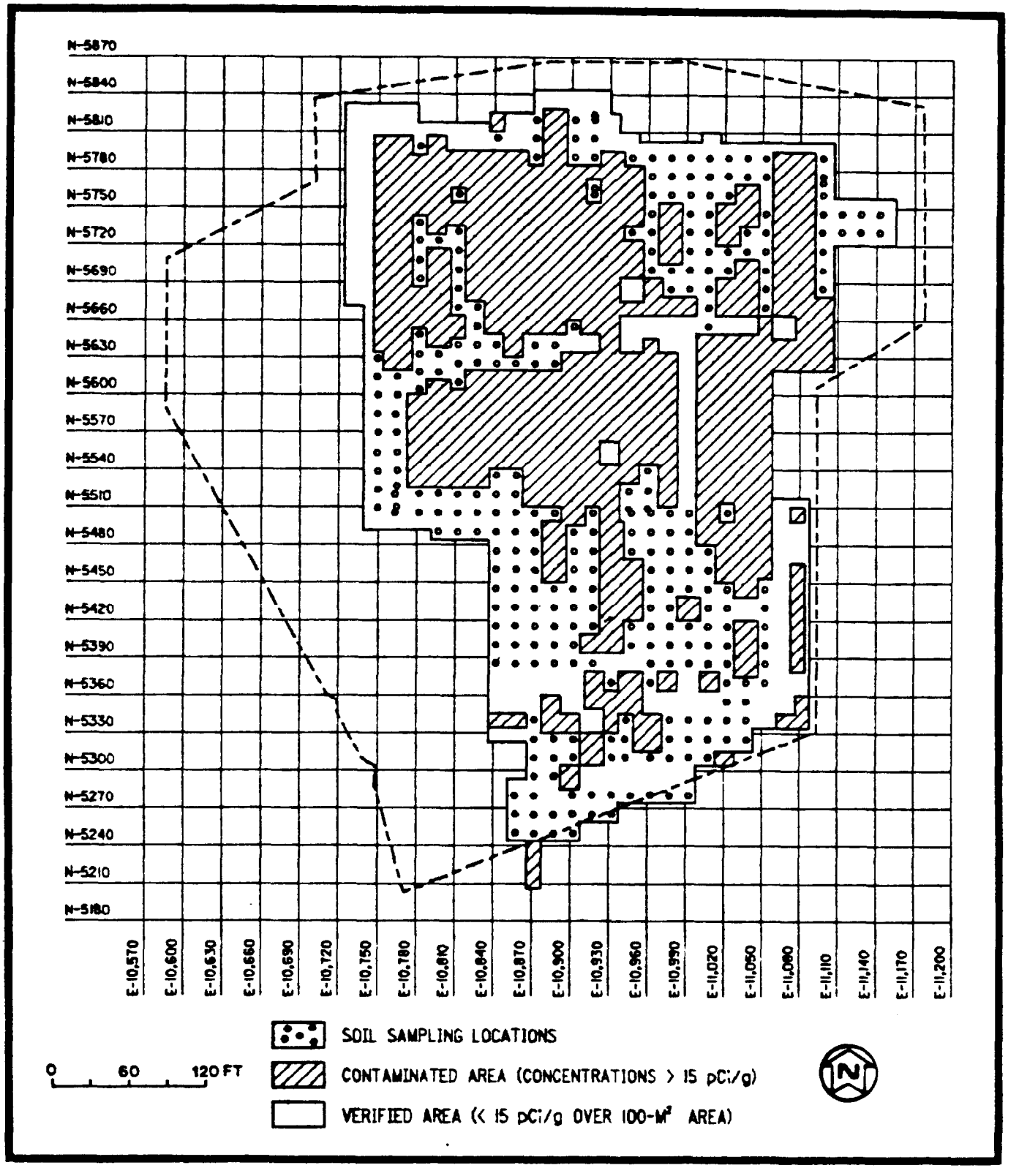

FIGURE 8 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 5

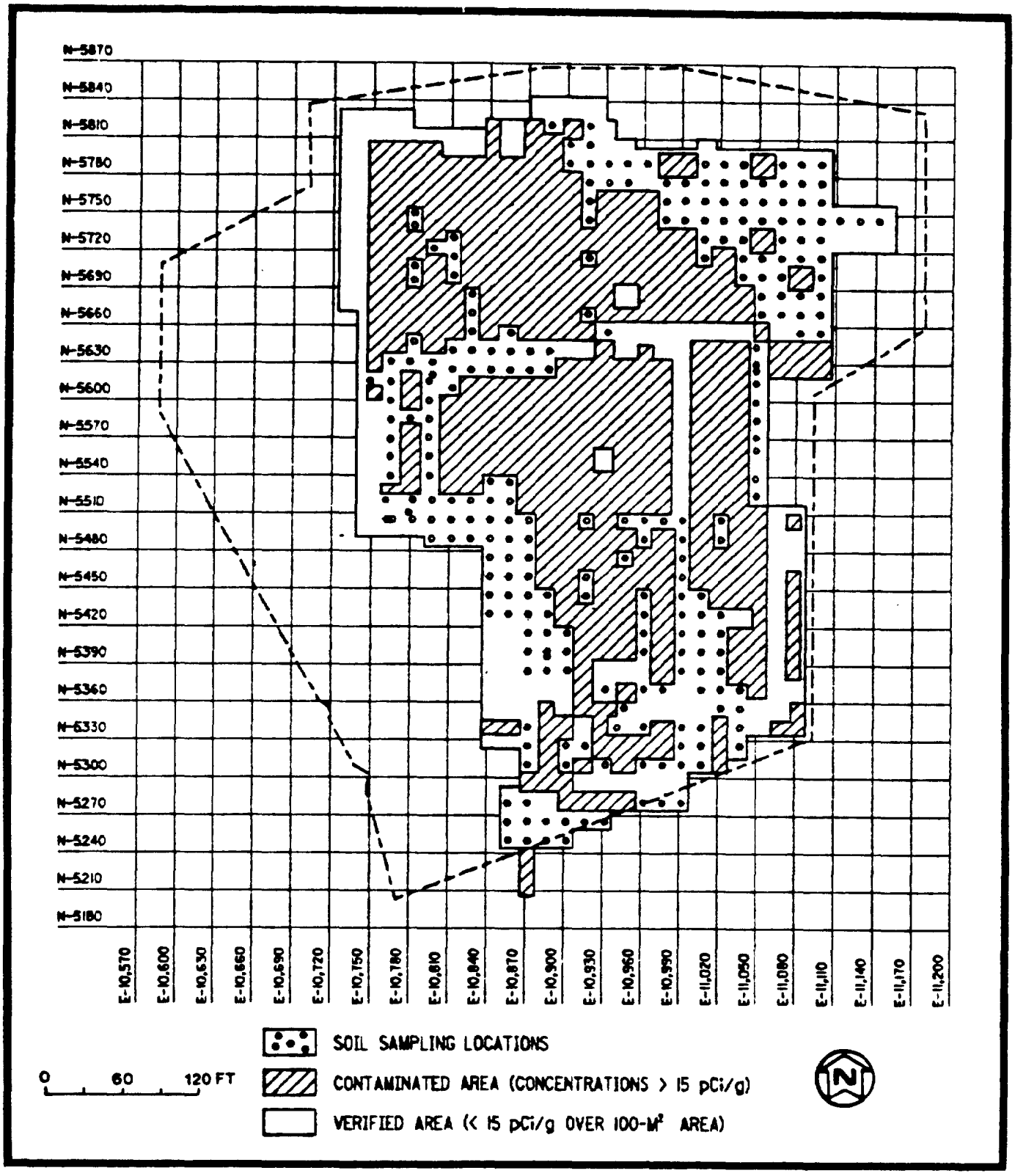

FIGURE 9 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 6

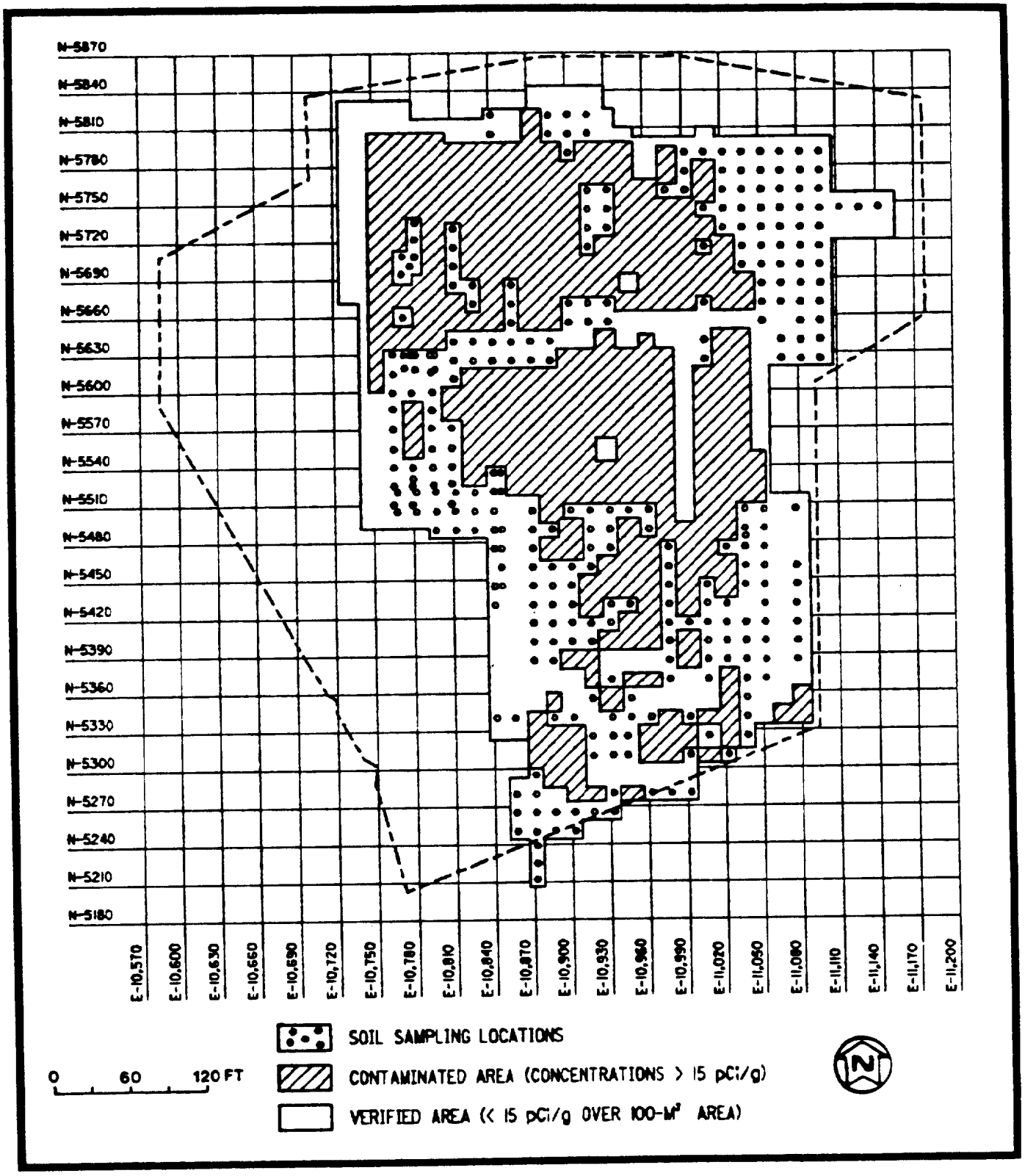

FIGURE 10 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 7

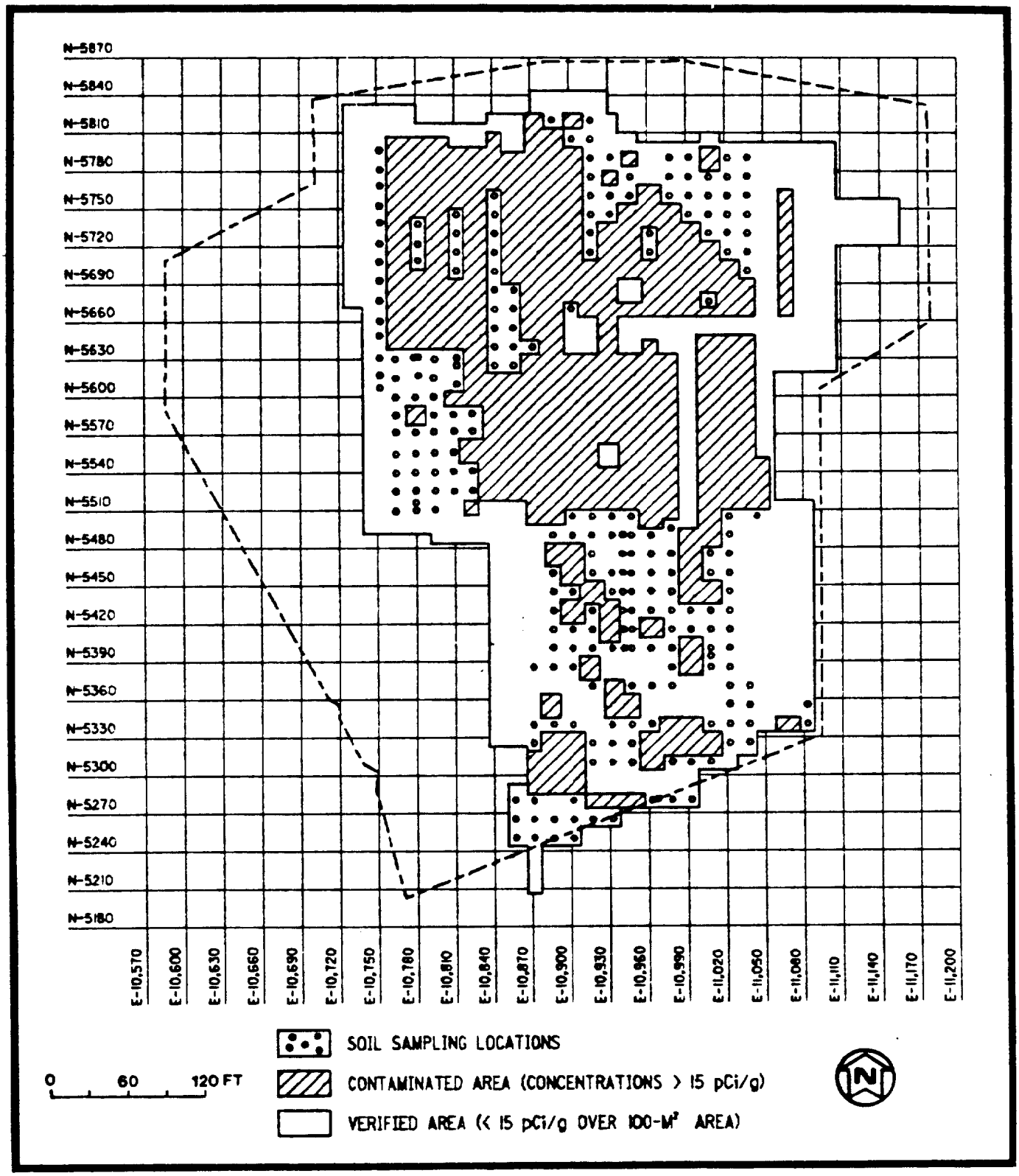

FIGURE 11 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 8

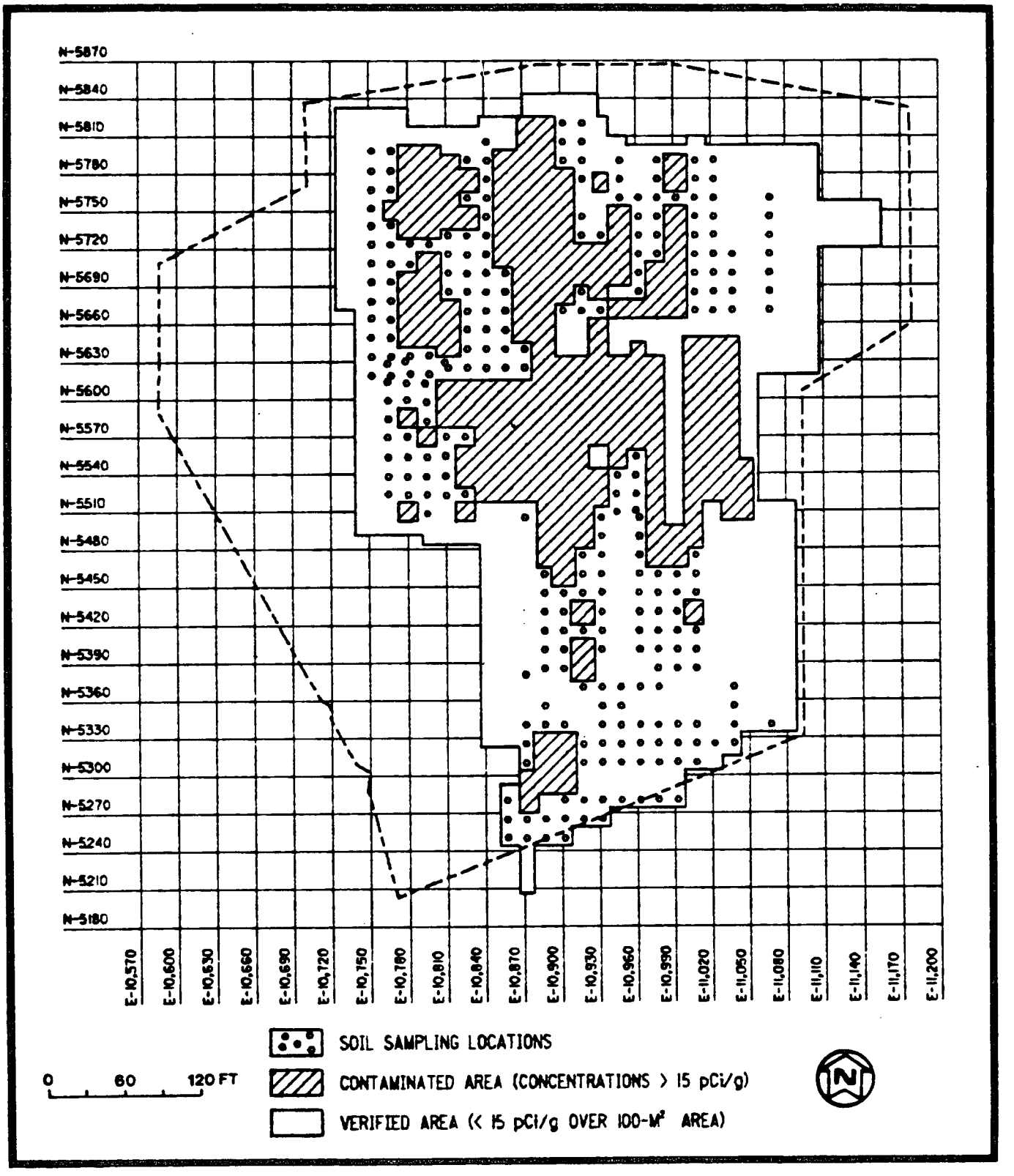

FIGURE 12 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 9

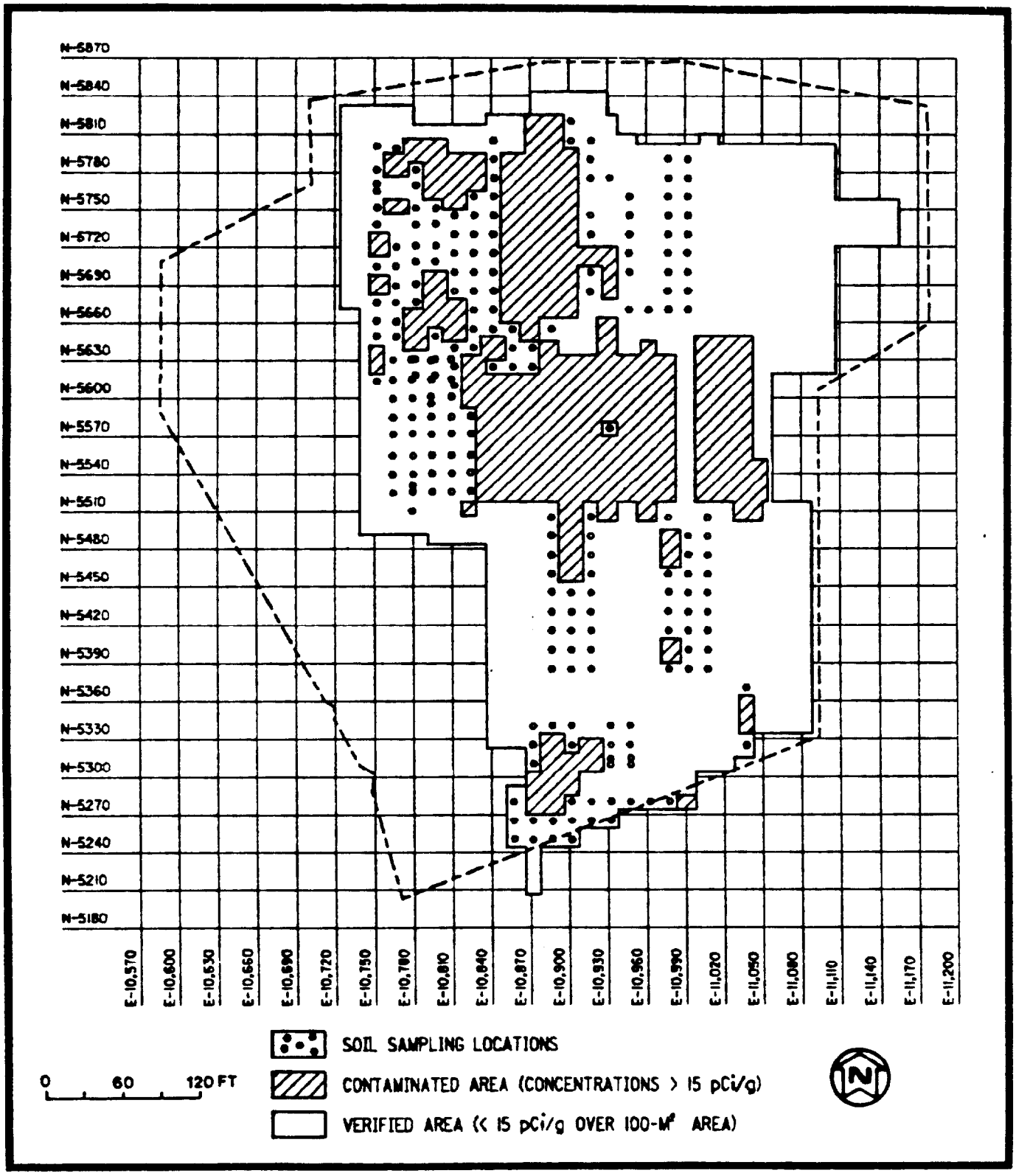

FIGURE 13 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 10

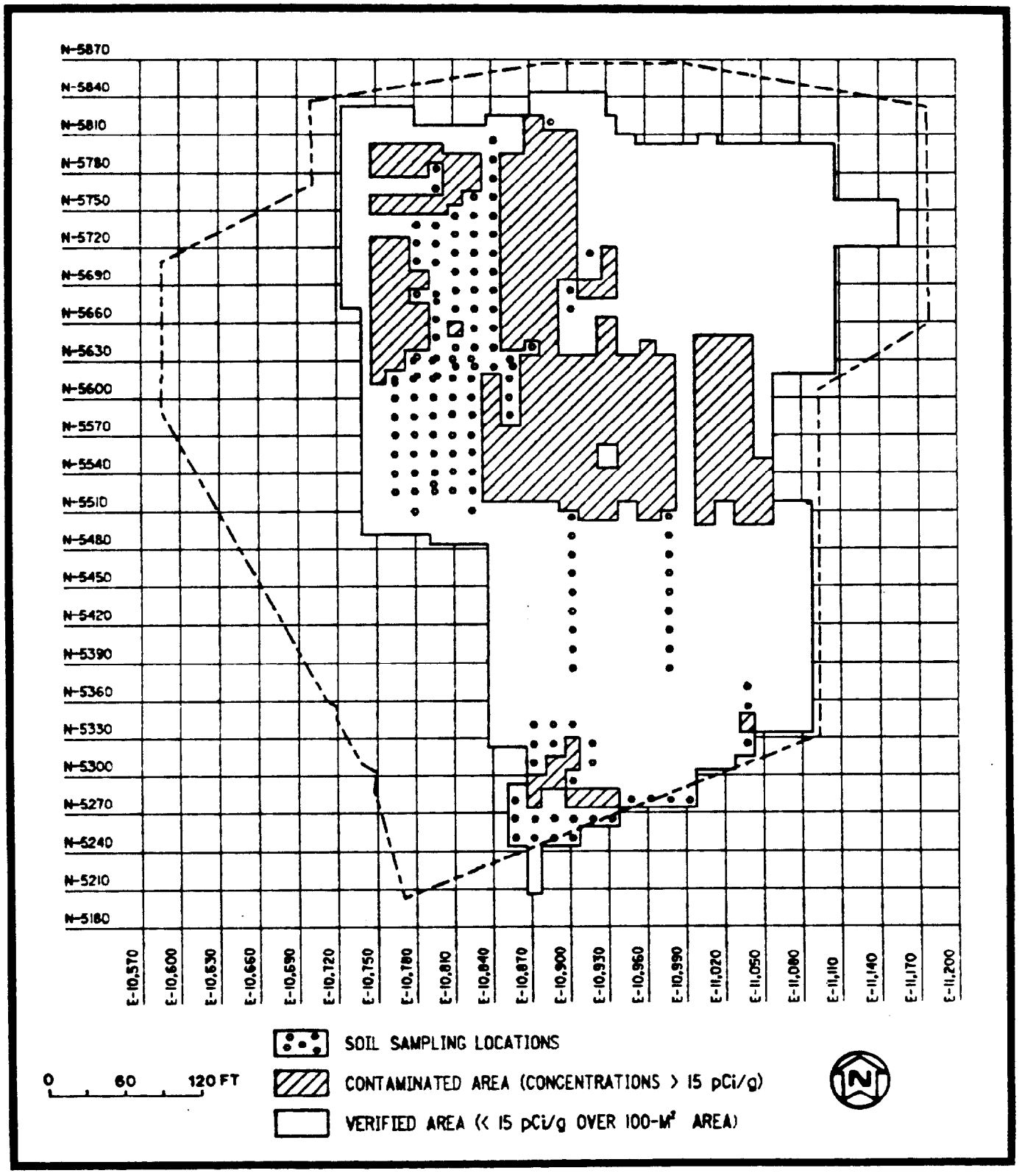

FIGURE 14 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 11

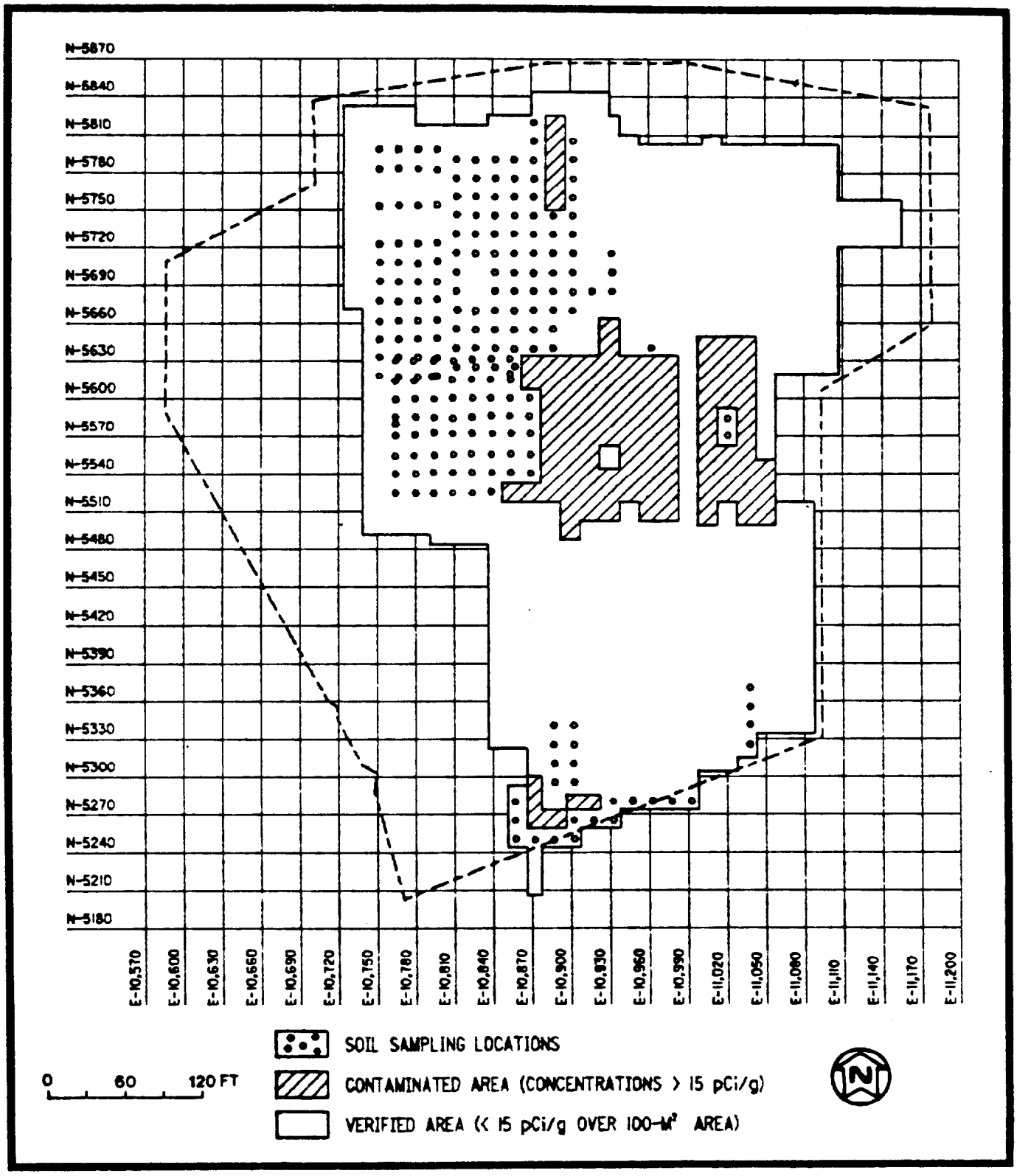

FIGURE 15 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 12

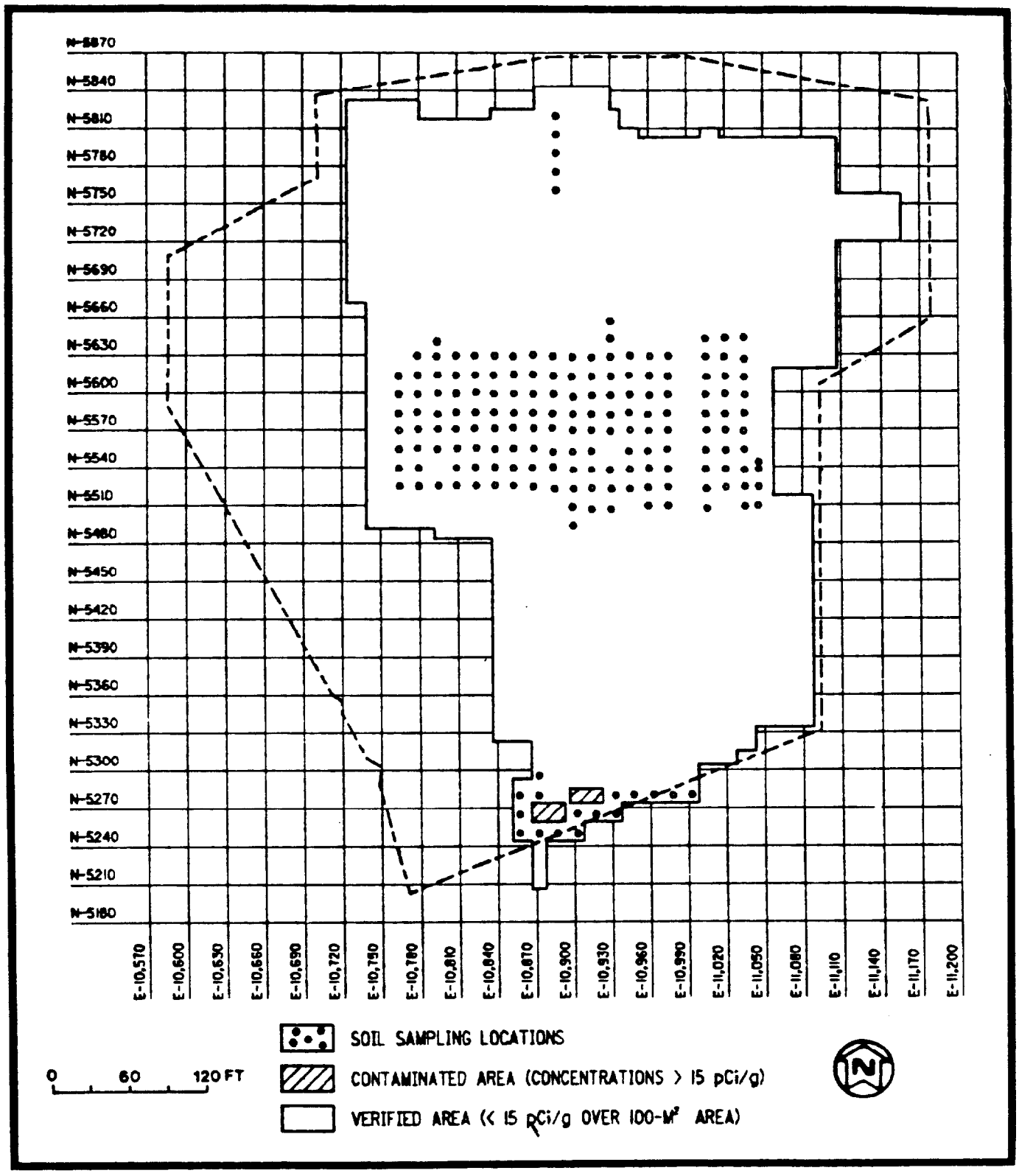

FIGURE 16 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 13

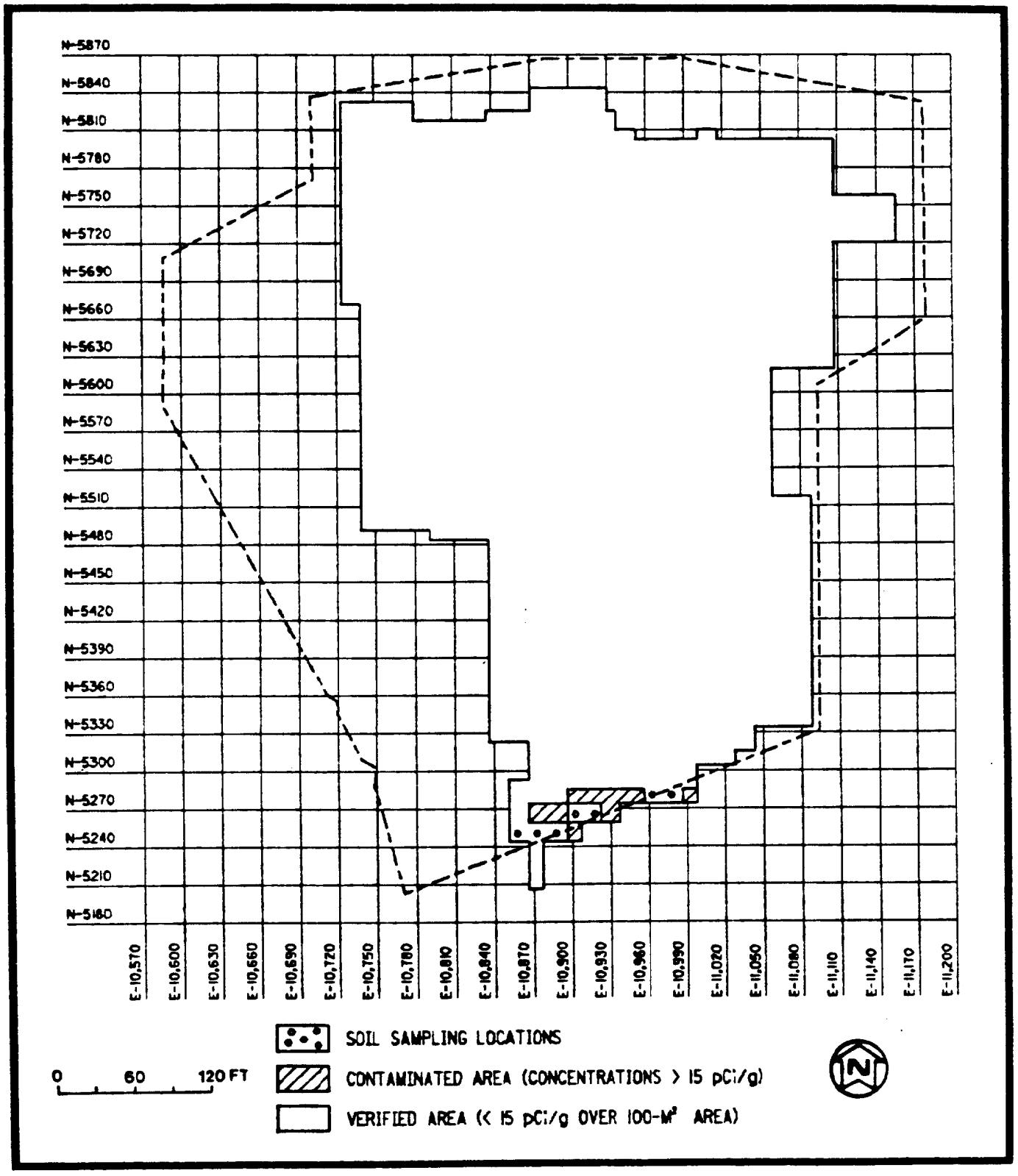

FIGURE 17 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 14

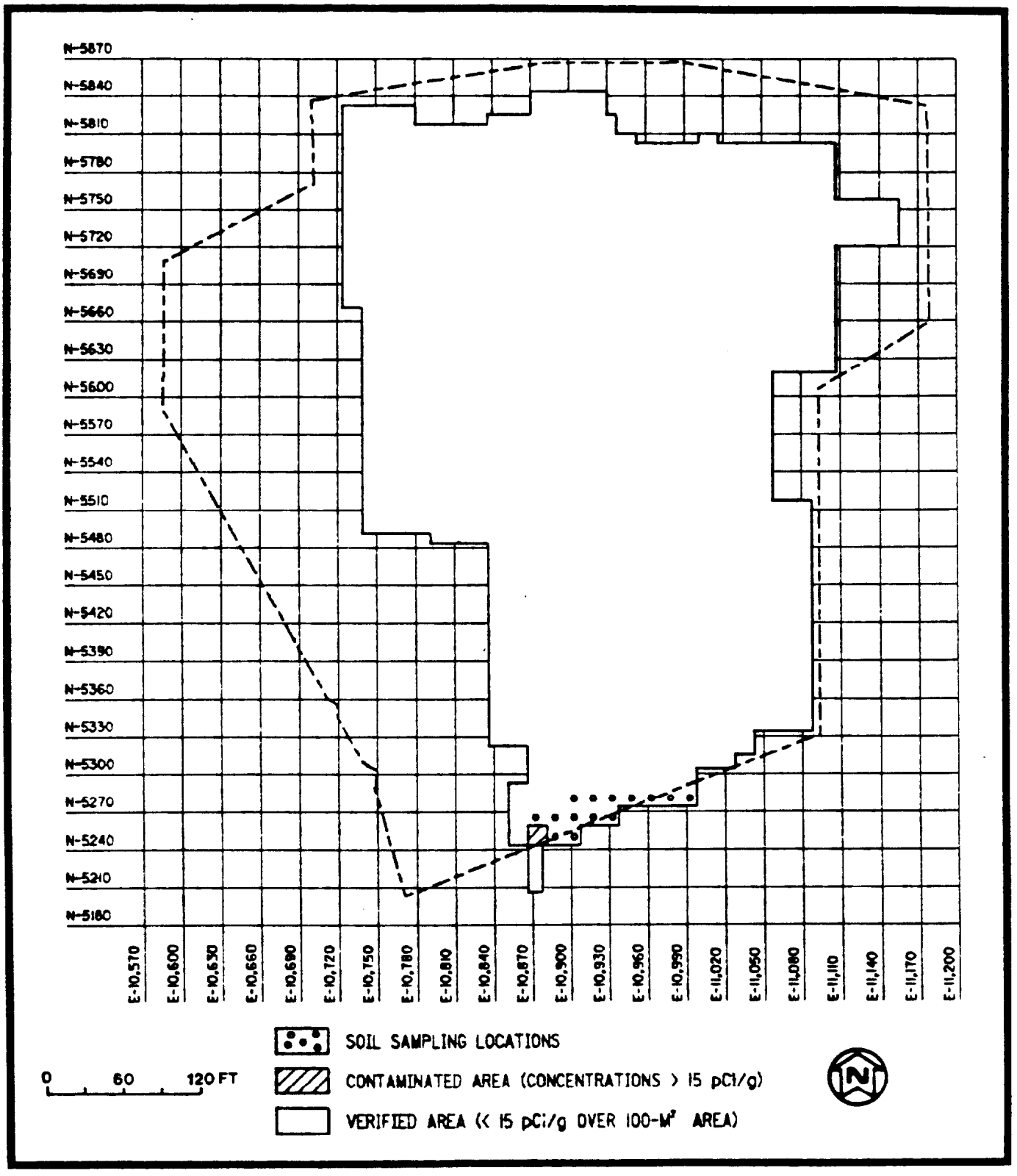

FIGURE 18 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 15

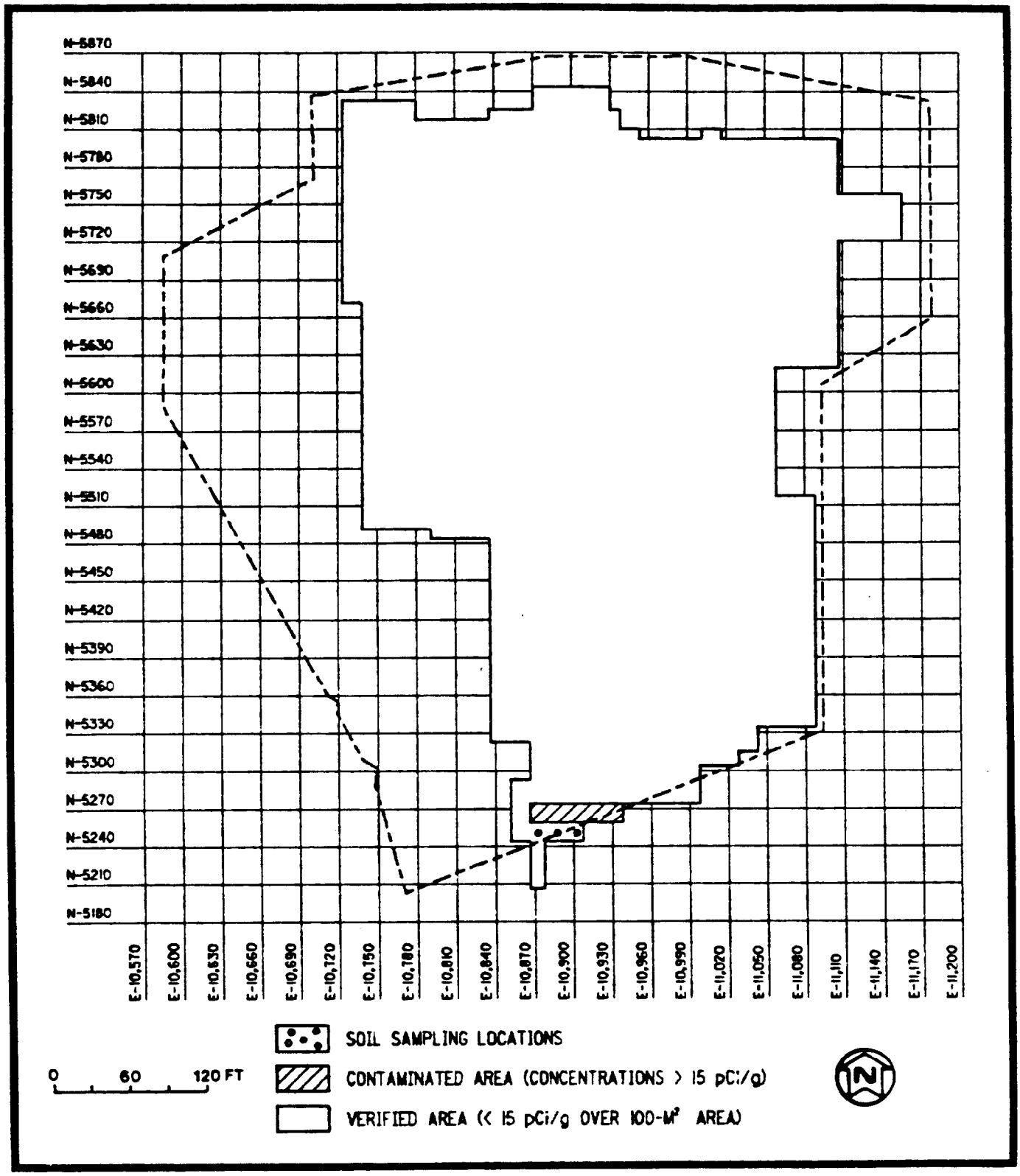

FIGURE 19 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 16

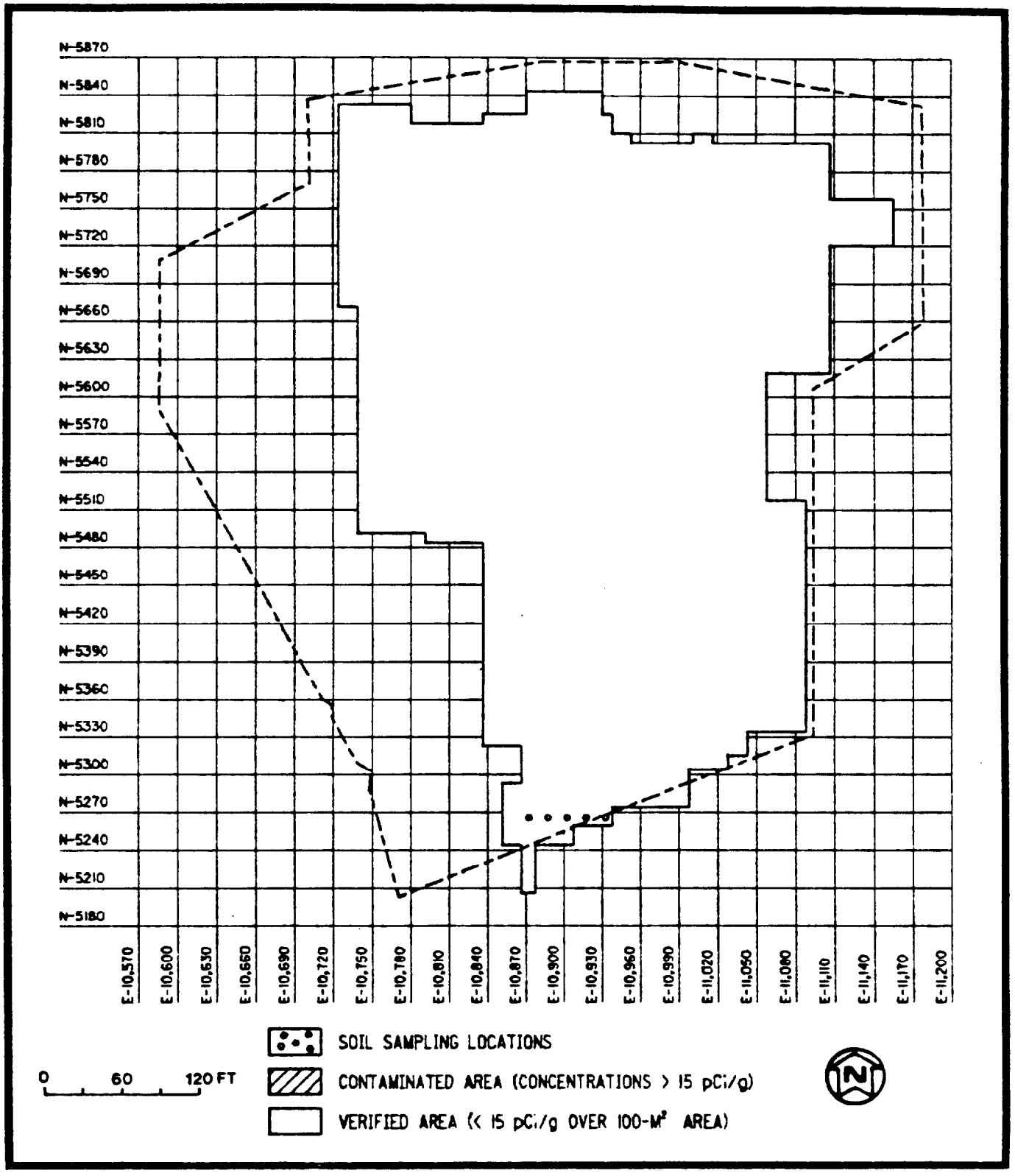

FIGURE 20 CONTAMINATION BOUNDARIES AND POST-REMEDIAL ACTION SAMPLING LOCATIONS: LIFT 17

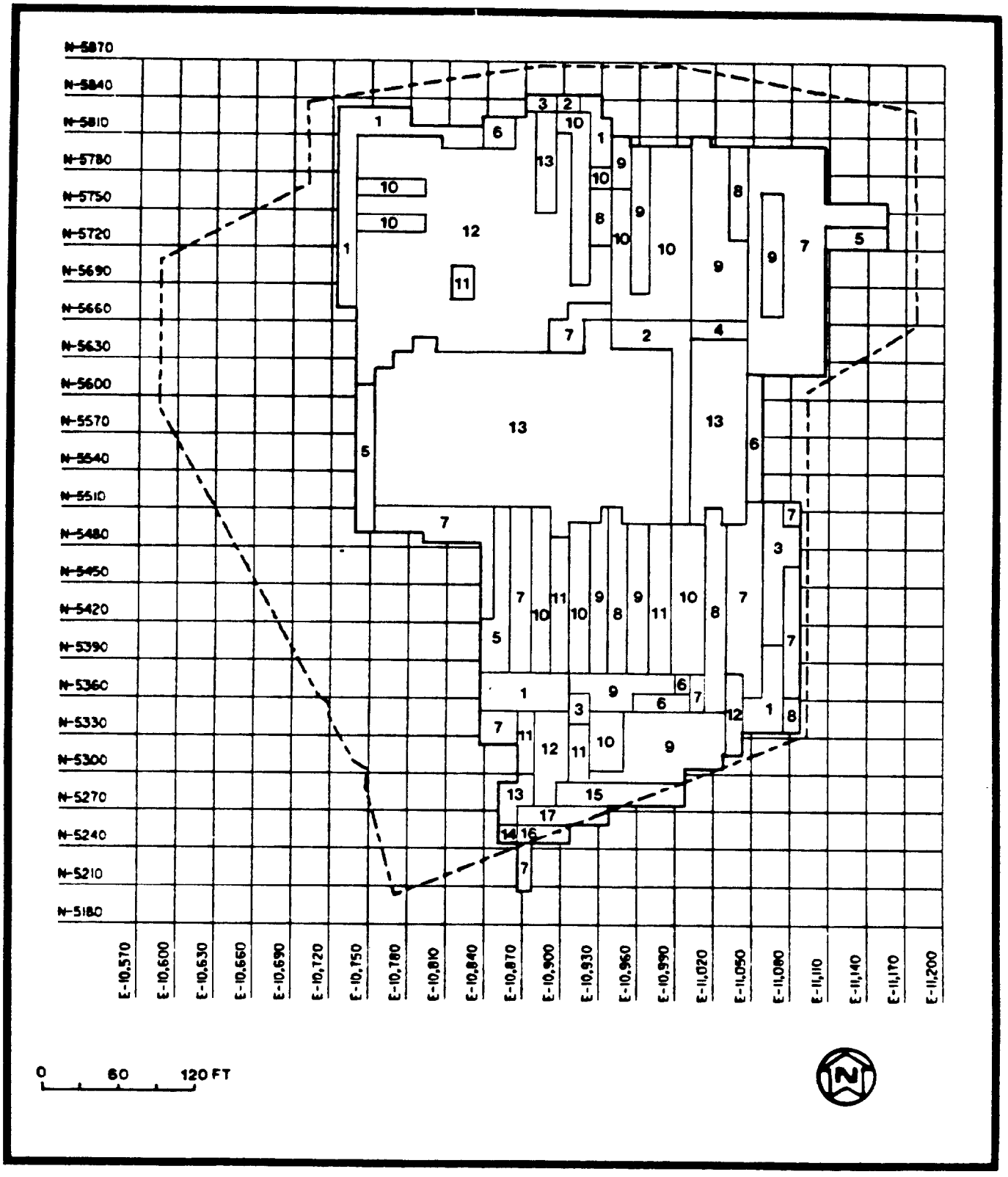

FIGURE 21 APPROXIMATE EXCAVATION DEPTHS (FT)

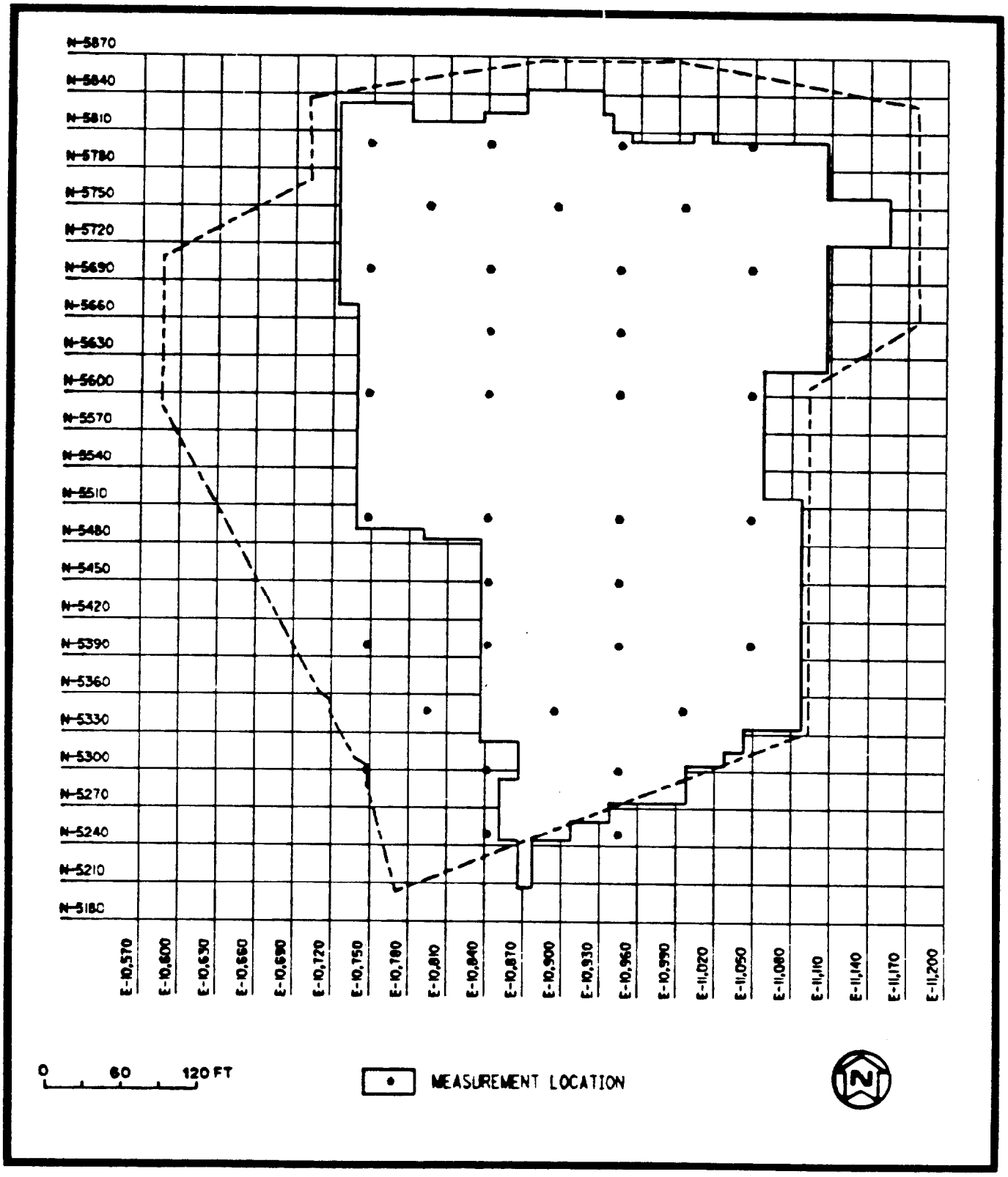

FIGURE 22 POST-REMEDIAL ACTION GAMMA RADIATION EXPOSURE RATE MEASUREMENT LOCATIONS

NOTE: The guidelines contained herein have been superseded by those contained in Appendix A to Exhibit I of the certification docket.

TABLE I

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES

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 FOR UNRESTRICTED USE)

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.
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

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 are intended for unrestricted 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.[d] 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 to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200

TABLE I

(continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 $\beta-\gamma$	15,000 $\beta-\gamma$	1,000 $\beta-\gamma$

[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]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.

[e]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.

[f]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.

[g]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.

[h]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.

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

[j]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.

TABLE 2

GAMMA RADIATION EXPOSURE RATE MEASUREMENTS

AT MIDDLESEX MUNICIPAL LANDFILL*

Number of Measurements	Exposure Rate (mrem/yr)**		DOE Radiation Protection Standard (mrem/yr)***
	Average	Range	
35	80	60-94	100

*Measurements were taken 1 m above the backfilled excavation.

**Converted to 100 mrem/yr from exposure rate measurements. Assumes continuous occupancy at point of measurement, and includes contribution from natural background.

***Above background.

REFERENCES

1. U.S. Department of Energy. Description of the Formerly Utilized Sites Remedial Action Program, ORO-777, Oak Ridge, TN, September 1980 (as modified by DOE, October 1983).

2. U.S. Atomic Energy Commission. U.S. Atomic Energy Commission Radiation Survey Report of the Middlesex Landfill Site, March 25-April 4, 1974, Germantown, MD, June 1974.

3. Oak Ridge National Laboratory. Radiological Survey of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, DOE/EV-005/20, Oak Ridge, TN, April 1980.

4. Ford, Bacon and Davis Utah, Inc. Engineering Evaluation of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, FBDC 230-004, July 1979.

5. Ford, Bacon and Davis Utah, Inc. Environmental Analysis of the Middlesex Municipal Landfill Site, Middlesex, New Jersey, FBDU 230-008, July 1979.

6. Letter, John E. Baublitz, Jr. to E. L. Keller. "Guidelines for Residual Radioactivity at FUSRAP and Remote SFMP Sites" (Attachment: U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Rev. 1, July 1985), July 22, 1985.

7. U.S. Code of Federal Regulations. 40 CFR 192, "Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings," Washington, DC, July 1984.

8. U.S. Department of Energy. Remedial Action Work Plan for the Middlesex Municipal Landfill Site, ORO-846, Rev. 2, Oak Ridge, TN, February 1986.

9. Letter, J. R. Kannard, Bechtel National, Inc., to J. D. Berger, Oak Ridge Associated Universities. "Middlesex Landfill Post-Remedial Action Data," CCN 043207, February 13, 1987.

GLOSSARY

Background Radiation - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., New Jersey typically receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, and thorium.

Contamination - Contamination means a concentration of radioactive materials in the soil exceeding that permitted by DOE guidelines.

Counts per minute - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material.

Disintegrations per minute - Disintegrations per minute is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of picocurie for more information.

Exposure rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (μR) and the exposure rate is typically given as μR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual were exposed to gamma radiation at a rate of 20 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

Gamma Radiation - See radiation.

Gram - A gram is a metric unit for weight. It takes 454 grams to make 1 pound; 1 ounce equals 28 grams.

Meter - A meter is a metric unit of measurement for length; 1 meter is equal to approximately 39 inches.

Microroentgen - A microroentgen (uR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

Millirem - The millirem is the unit used to measure radiation doses to man. The DOE limit is 100 mrem above background radiation levels for members of the general public in any one year. For comparison, a typical chest x-ray is about 40 mrem. Naturally occurring radioactive substances in the ground result in a yearly exposure to everyone of about 100 mrem. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

Microrem - The microrem is also a unit used to measure radiation doses to man. It is equal to one-thousandth of a millirem.

Picocurie - A picocurie is the unit of measure for radioactivity just as an ounce is a unit to measure weight. One picocurie means that one radioactive particle is released on the average of every 27 seconds.

Pitchblende - A black-to-brown ore mineral that is the chief source of uranium.

Radium-226 - Radium-226 is a naturally occurring, radioactive material that spontaneously emits alpha radiation.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

Radionuclide - A radionuclide is a specific radioactive element. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Remedial Action - Remedial action is a general term used to mean "cleanup of contamination." It refers to any action required so that a property can be released for unrestricted use as uncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc.

Thorium - Thorium is a naturally occurring element that is recovered from monazite for commercial purposes. Monazite contains from 3 to 9 percent thorium oxide. The principal use of thorium to date has been in the preparation of gas lantern mantles because thorium oxide burns with a brilliant white light. Thorium oxide is also commonly found in high quality glasses and camera lenses because of its good optical characteristics.

Unrestricted Use - Unrestricted use means that a property can be used for any purpose without regard to the radioactivity that used to be on the property. These uses could include anything -- farming, a residence, a playground, etc.

Uranium - Uranium is a naturally occurring, radioactive element. The principal use of uranium -- when refined -- is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

Working level - Working level is a unit of measurement for the energy expended in air by radon or its radioactive decay products. The term was derived for use with uranium mine workers and has become the accepted unit for environmental measurements.

Exhibit II (7) - Interim Verification Letters to Property Owners and Verification Statements and Reports

The verification statement for the subject properties is listed below and included in this section. The verification report is also included in this section.

	Page
Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy Headquarters. "Verification of Remedial Actions at the MML," March 16, 1987.	II-273
Oak Ridge Associated Universities. Verification of Remedial Action, Middlesex Municipal Landfill, Middlesex, New Jersey, Oak Ridge, Tennessee, September 1987.	II-275