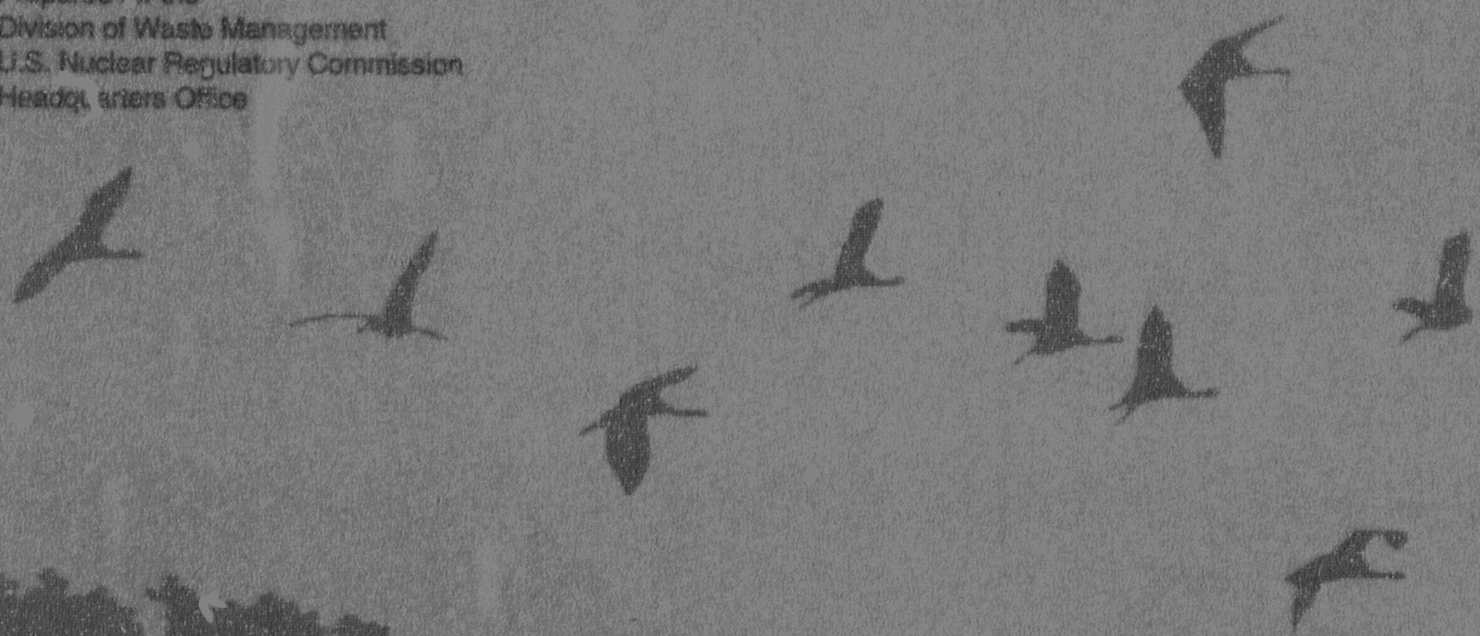
CONFIRMATORY SURVEY FOR THE FOUR UNAFFECTED AREAS OF THE CUSHING REFINERY SITE KERR-McGEE CORPORATION CUSHING, OKLAHOMA

[DOCKET 70-3073]

E.W. ABELQUIST

Prepared for the
Division of Waste Management
U.S. Nuclear Regulatory Commission
Headquarters Office



ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program
Environmental and Health Sciences Division

The Oak Ridge Institute for Science and Education (ORISE) was established by the U.S. Department of Energy to undertake national and international programs in science and engineering education, training and management systems, energy and environmental systems, and medical sciences. ORISE and its programs are operated by Oak Ridge Associated Universities (ORAU) through a management and operating contract with the U.S. Department of Energy. Established in 1946, ORAU is a consortium of 89 colleges and universities.

NOTICES

The opinions expressed herein do not necessarily reflect the opinions of the sponsoring institutions of Oak Ridge Associated Universities.

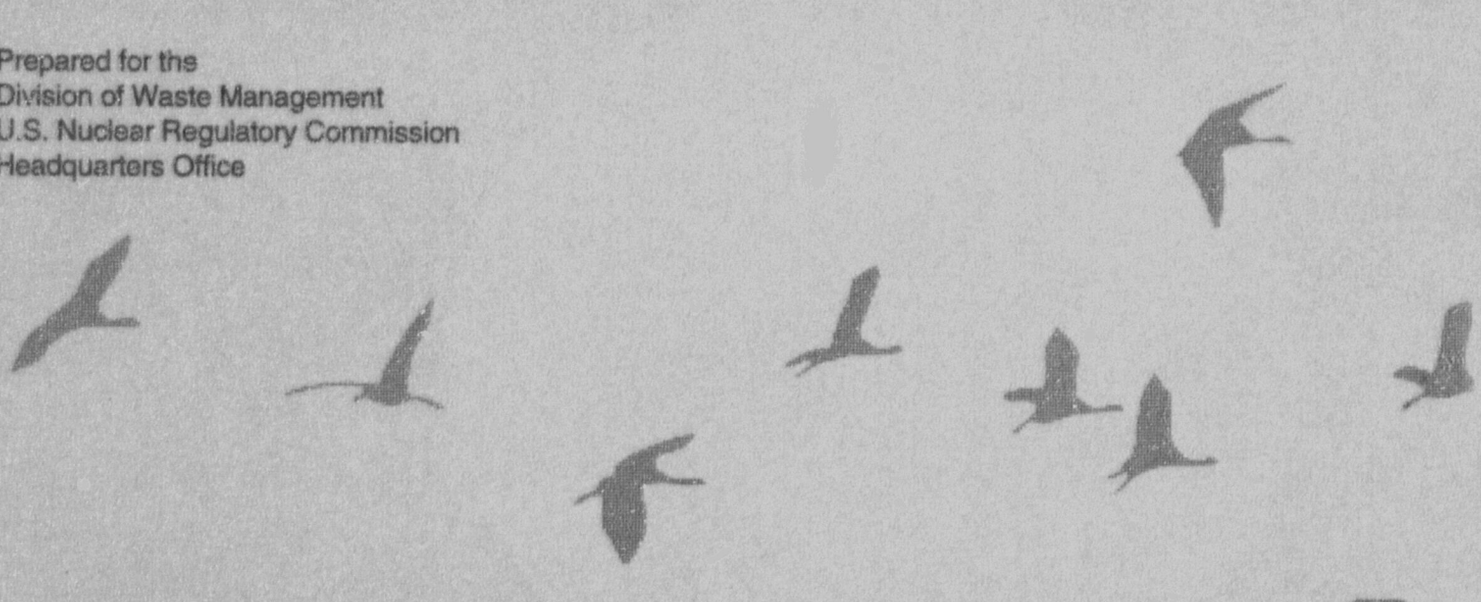
This report was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor the U.S. Department of Energy, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe on privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement or recommendation, or favor by the U.S. Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the U.S. Government or any agency thereof.

CONFIRMATORY SURVEY FOR THE FOUR UNAFFECTED AREAS OF THE CUSHING REFINERY SITE KERR-McGEE CORPORATION CUSHING, OKLAHOMA

[DOCKET 70-3073]

E.W. ABELQUIST

Prepared for the
Division of Waste Management
U.S. Nuclear Regulatory Commission
Headquarters Office



ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION
Environmental Survey and Site Assessment Program
Environmental and Health Sciences Division

The **Oak Ridge Institute for Science and Education** (ORISE) was established by the U.S. Department of Energy to undertake national and international programs in science and engineering education, training and management systems, energy and environment systems, and medical sciences. ORISE and its programs are operated by Oak Ridge Associated Universities (ORAU) through a management and operating contract with the U.S. Department of Energy. Established in 1946, ORAU is a consortium of 89 colleges and universities.

CONFIRMATORY SURVEY FOR THE FOUR UNAFFECTED AREAS OF THE CUSHING REFINERY SITE KERR-McGEE CORPORATION CUSHING, OKLAHOMA

Prepared by

E.W. Abelquist

Environmental Survey and Site Assessment Program
Environmental and Health Sciences Division
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

Prepared for the
Division of Waste Management
U.S. Nuclear Regulatory Commission

MAY 1996

FINAL REPORT

This report is based on work performed under an Interagency Agreement (NRC Fin. No. A-9076) between the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy. Oak Ridge Institute for Science and Education performs complementary work under contract number DE-AC05-76OR00033 with the U.S. Department of Energy.

CONFIRMATORY SURVEY
FOR THE FOUR UNAFFECTED AREAS
OF THE CUSHING REFINERY SITE
KERR-McGEE CORPORATION
CUSHING, OKLAHOMA

Prepared by: Eric W. Abelquist Date: 5/30/96
E.W. Abelquist, Assistant Program Director
Environmental Survey and Site Assessment Program

Reviewed by: Mark Laudeman Date: 5/31/96
M. J. Laudeman, Radiochemistry Laboratory Supervisor
Environmental Survey and Site Assessment Program

Reviewed by: Cinn T Payne Date: 5/30/96
A. T. Payne, Administrative Services Manager,
Quality Assurance/Health & Safety Manager
Environmental Survey and Site Assessment Program

Reviewed by: W S Beck Date: 5/30/96
W. L. Beck, Program Director
Environmental Survey and Site Assessment Program

ACKNOWLEDGMENTS

The author would like to acknowledge the significant contributions of the following staff members:

FIELD STAFF

J. S. Cox
A. L. Mashburn

LABORATORY STAFF

R. D. Condra
J. S. Cox
M. J. Laudeman
S. T. Shipley

CLERICAL STAFF

T. S. Fox
K. E. Waters

ILLUSTRATOR

T. D. Herrera

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

µR/h	microroentgens per hour
µrem/h	microrem per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BTP	Branch Technical Position
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
D&D	Decontamination and Decommissioning
DOE	Department of Energy
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
ft^3	cubic feet
kg	kilogram
km	kilometer
KMC	Kerr-McGee Corporation
m	meter
m^2	square meter
m^3	cubic meter
MDA	minimum detectable activity
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NMSS	Office of Nuclear Material Safety and Safeguards
NRC	Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
UF_6	uranium hexafluoride

CONFIRMATORY SURVEY
FOR THE FOUR UNAFFECTED AREAS
OF THE CUSHING REFINERY SITE
KERR-McGEE CORPORATION
CUSHING, OKLAHOMA

INTRODUCTION AND SITE HISTORY

The Cushing refinery site is located two miles [3 kilometers (km)] north of the City of Cushing in Payne County, Oklahoma and was operated from 1915 to 1972. Kerr-McGee Corporation (KMC) purchased the Cushing site from General American Oil Company of Texas in 1956 and operated an oil refinery there from 1956 to 1972. From 1962 to 1966, KMC used part of the Cushing refinery site to process natural thorium and natural, depleted, and enriched uranium under two Atomic Energy Commission (AEC) licenses, SMB-664 and SNM-695.

AEC License SMB-664 was issued to KMC on November 7, 1962 and authorized unlimited quantities in a variety of chemical forms of uranium and thorium. The bulk of uranium material received was UF_6 (uranium hexafluoride). Typical products were oxides, carbides, fluorides, nitrates, metal, etc. Thorium material was received in the form of concentrates. Typical products were oxides or carbides or combinations of uranium and thorium compounds at various ratios of thorium to uranium (KMC 1995).

AEC license SNM-695 was issued to KMC on April 23, 1963 and authorized possession of any enrichment of uranium in any form, except metal, including scrap recovery, not to exceed 1000 kilograms (kg) of uranium-235. The uranium was received in the form of UF_6 and other chemical compounds and was converted to other compounds of uranium suitable for nuclear fuels. AEC license SNM-695 was amended to permit reduction of high enriched UF_4 (green salt) to uranium metal buttons (KMC 1995).

Enriched uranium was processed at Cushing from early 1963 until September 1965 and thorium processing was performed from December 1964 until February 1966. In April 1966 KMC reported to the AEC that as of April 26, 1966, all special nuclear material had been transferred from the Cushing site to KMC's new Cimarron facility in Crescent, Oklahoma and that all Cushing buildings

in which licensed activities had been performed were cleaned and decontaminated. The AEC conducted a termination survey of the Cushing facility on July 6, 1966. On the basis of this survey, and in response to KMC's request for authorization to release the facility for unrestricted use, licenses SMB-664 and SNM-695 were terminated on July 25, 1966 (KMC 1995).

During cleanup activities, some radioactively contaminated materials were placed in burial trenches, old petroleum storage tanks dike areas, and part of a hydrocarbon waste impoundment (Pit 4) on the site. Materials placed in trenches and waste impoundment were covered with native soil. An October 1989 radiological survey conducted by the Oak Ridge Associated Universities confirmed the presence of general low-level radioactive material in the northeast corner of the site and around and in Pit 4.

The remediation and restoration of the former refinery site by KMC has identified localized areas of contamination from former processing and waste management activities. About 5600 cubic meters (m^3) of soil and other materials contaminated with licensed uranium or thorium at limits specified in Nuclear Regulatory Commission (NRC) Branch Technical Position (BTP) Option 2 or 4 are estimated to remain on site. About 1375 m^3 of material averaging Option 1 concentration is buried in trenches on-site. On April 6, 1993, the NRC (formerly AEC) issued license SNM-1999 to KMC allowing for decommissioning the site for release for unrestricted use.

The site contains four large areas that were used for oil refining and storage during the years nuclear processing and disposal took place. KMC has no evidence suggesting that radioactive materials were disposed of in any of these areas during subsequent decommissioning activities. These areas are considered unaffected by licensed radioactive material. It is KMC's intent to use portions of these unaffected areas in the future for disposition of soil meeting the specifications of NRC's BTP Option 1 and Option 2 for disposal of thorium and uranium waste from past operations in an engineered containment cell.

At the request of the NRC's Division of Waste Management, Office of Nuclear Material Safety and Safeguards (NMSS), the Environmental Survey and Site Assessment Program (ESSAP) performed independent confirmatory survey activities at the four unaffected areas located at Kerr-McGee's Cushing Refinery Site in Cushing, Oklahoma on September 11 through 13, 1995.

SITE DESCRIPTION

The KMC Cushing site is located in Payne County, Oklahoma, two miles (3 km) north of the City of Cushing (Figure 1). Cushing, Oklahoma lies about midway between Tulsa and Oklahoma City. The Cushing Refinery Site is located on Deep Rock Road, with terrain characterized by rolling, oil-producing pasture land (Figure 2). Several oil fields were developed in the immediate area. Skull Creek flows east to west at the southern portion of the site. The elevation of the refinery site ranges from 250 to 280 meters above sea level. The total size of the four unaffected areas is approximately 76 hectares (Figure 3). The respective land areas for unaffected areas 1, 2, 3, and 4 are 20, 12, 40, and 4 hectares (Figures 4 through 7). Unaffected areas 1 and 2 contain sizeable portions that are covered by acid sludge pits that limited the survey coverage in these areas. The entire Cushing site encompasses approximately 178 hectares.

OBJECTIVES

The objectives of the confirmatory process were to provide independent document reviews and radiological data, for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and final status survey results.

DOCUMENT REVIEW

As part of the confirmatory activities, ESSAP reviewed the licensee's analytical procedures and methods for adequacy and appropriateness. Licensee's data were reviewed for accuracy, completeness, and compliance with applicable NRC guidelines.

PROCEDURES

On September 11 through 13, 1995, ESSAP performed independent confirmatory survey activities of the four unaffected areas located at Kerr-McGee's Cushing Refinery Site in Cushing, Oklahoma. The survey was conducted in accordance with a survey plan dated August 31, 1995, which was

submitted to and approved by the NRC's Division of Waste Management, NMSS (ORISE 1995). This report summarizes the procedures and results of the survey.

Reference Grid

ESSAP used the 100 meter (m) x 100 m reference grid system established by the licensee for referencing survey data in the unaffected areas. Measurement and sampling locations on ungridded surfaces were referenced to either prominent site features or the existing grid.

Surface Scans

Exterior soil surfaces were scanned for gamma radiation using NaI scintillation detectors. A 50% to 100% area coverage scan was performed over seven of the 100 m x 100 m exterior grid blocks (Figures 8 through 14). All detectors were coupled to ratemeters with audible indicators. Locations of elevated direct radiation detected by scans were marked for further investigation.

Exposure Rate Measurements

Exposure rates were measured at 1 m above the surface using a microrem meter. Exposure rate measurements were performed at five locations from each of the four unaffected areas, for a total of twenty exposure rate measurements (Figures 8 through 14). Background exposure rate measurements were performed at five locations within a 0.5 to 10 km radius of the site (Figure 2).

SOIL SAMPLING

Surface soil samples [0 to 15 centimeters (cm)] were collected from each exposure rate measurement location. The twenty soil sample locations are shown on Figures 8 through 14.

Background soil samples were collected from each background exposure rate measurement location (Figure 2).

CONFIRMATORY ANALYSES

KMC collected split-samples from each of the twenty soil sampling locations within the four unaffected areas sampled by ESSAP. KMC provided ESSAP with the results of their uranium analyses for data comparison. Analytical results for each of these samples were compared to those reported by the licensee.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Soil samples were analyzed by gamma spectrometry and alpha spectrometry. Spectra were reviewed for U-235 and U-238, and any other identifiable photopeaks. Selected soil samples were also analyzed by alpha spectrometry for uranium. Soil sample results were reported in units of picocuries per gram (pCi/g). Exposure rate measurements were reported in units of microroentgens per hour (μR/h). Results were compared with the licensee's documentation and NRC guidelines established for release to unrestricted use.

FINDINGS AND RESULTS

SURFACE SCANS

Surface scans for gamma activity within the unaffected areas resulted in the identification of two areas of elevated direct radiation. One location, within unaffected area #2, grid #129 (Figure 10) had been identified and marked as an affected area by the licensee prior to the confirmatory survey, due to identification of licensable material above release criteria. The second location of elevated direct radiation was identified in unaffected area #3, grid #135, at sample location #18 (Figure 13). As noted in subsequent discussions of analytical results, the elevated direct radiation was due to increased levels of Ra-226 activity in soil sample #18. Surface scans for gamma activity within the remaining surveyed areas did not identify any locations of elevated direct radiation.

EXPOSURE RATES

Site exposure rates are summarized in Table 1. Exposure rates at the twenty measurement locations within the unaffected areas ranged from 4 to 12 μR/h. Background exposure rates at 1 m above the surface ranged from 4 to 8 μR/h (Table 2).

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

Radionuclide concentrations in background soil samples are summarized in Table 3 and were less than 0.1 pCi/g for U-235, 1.0 to 1.6 pCi/g for U-238, 0.6 to 0.9 pCi/g for Th-232, 0.5 to 1.0 pCi/g for Th-228, and 0.6 to 0.9 pCi/g for Ra-226.

Four soil samples from the unaffected areas and one background soil sample were analyzed by alpha spectrometry for isotopic uranium. The uranium concentrations for these samples are summarized in Table 4. This analysis indicated natural isotopic abundances of uranium for all of the samples

except for sample #8 in grid #129. This sample was collected from the affected area within unaffected area #2, and contains a U-234 to U-238 ratio of 2.5 (as compared to a ratio of 1 for natural uranium).

Concentrations of radionuclides in soil samples from the unaffected areas are summarized in Table 5. Uranium concentration ranges are as follows: less than the minimum detectable concentration (MDC) of the procedure for U-235, which ranged from less than 0.1 to less than 0.5 pCi/g, and 0.3 to 3.0 pCi/g for U-238, with five samples less than the MDC for U-238, which ranged from less than 1.3 to less than 4.7. Radionuclide concentrations for Th-232, Th-228, and Ra-226 were as follows: <0.8 to 10.0 pCi/g for Th-232, 0.6 to 9.0 pCi/g for Th-228, and 0.5 to 29.4 pCi/g for Ra-226.

CONFIRMATORY ANALYSES

The licensee's results for U-238 analyses on the twenty soil samples collected from the four unaffected areas are provided in Table 6. As discussed above, the U-238 results obtained by ESSAP for each of these samples were consistent with background levels of uranium radioactivity. The nonparametric Mann-Whitney test (Conover 1980), also referred to as the Wilcoxon Signed Ranks test, was performed to compare ESSAP and the licensee's analytical results for U-238. The null hypothesis was that ESSAP's analytical results were less than or equal to the KMC analytical results. The results of the Mann-Whitney test indicated, as a whole, ESSAP's analytical results are less than or equal to the licensee's analytical results for U-238 ($p>0.1$).

COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminants of concern for this site are enriched uranium and thorium. However, because the scope of the confirmatory survey was limited to unaffected areas, it was expected that no areas of residual activity above background would be identified. The generic guidelines for residual concentrations of uranium in soil are provided in the NRC Branch Technical Position on

"Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations" (NRC 1981). Specifically, the Option 1 average soil guidelines for enriched uranium and thorium are 30 pCi/g and 10 pCi/g, respectively.

The soil sample collected from unaffected area #2, grid #129 (sample #8, Table 5) exhibited thorium concentrations in excess of the NRC guidelines. This area had been identified and marked as an affected area by the licensee prior to the confirmatory survey. Another sample collected from unaffected area #3, grid #135 exhibited elevated levels of Ra-226, likely the result of past oil refinery operations which often concentrate naturally occurring radium in the pipe scale. With the exceptions noted above, all soil samples collected from the four unaffected areas were within the average soil guideline for enriched uranium (Table 5). In fact, radionuclide concentrations in these soil samples were consistent with background levels (Table 3).

Review of the confirmatory analyses indicate that both data sets for U-238 concentrations in soil are consistent with background levels. Results of the Mann-Whitney test indicated that ESSAP's analytical results are less than or equal to the licensee's analytical results for U-238 ($p>0.1$).

The exposure rate guideline, measured at 1 m from the surface, is 10 μR/h above background. Exposure rates measured in the four unaffected areas were all within this guideline.

SUMMARY

On September 11 through 13, 1995, the Environmental Survey and Site Assessment Program of ORISE performed confirmatory survey activities at the four unaffected areas located at Kerr-McGee's Cushing Refinery Site in Cushing, Oklahoma. Survey activities included surface scans, exposure rate measurements, and soil sampling.

The ESSAP confirmatory measurements support the licensee's conclusion that residual radioactivity within the four unaffected areas at the Cushing Refinery Site satisfies NRC guidelines for release to unrestricted use. One notable exception is the presence of a small affected area of thorium, in excess of the guidelines, in unaffected area #2.

Results of confirmatory analyses performed on the twenty soil samples indicated that ESSAP's analytical results are less than or equal to the licensee's analytical results for U-238.

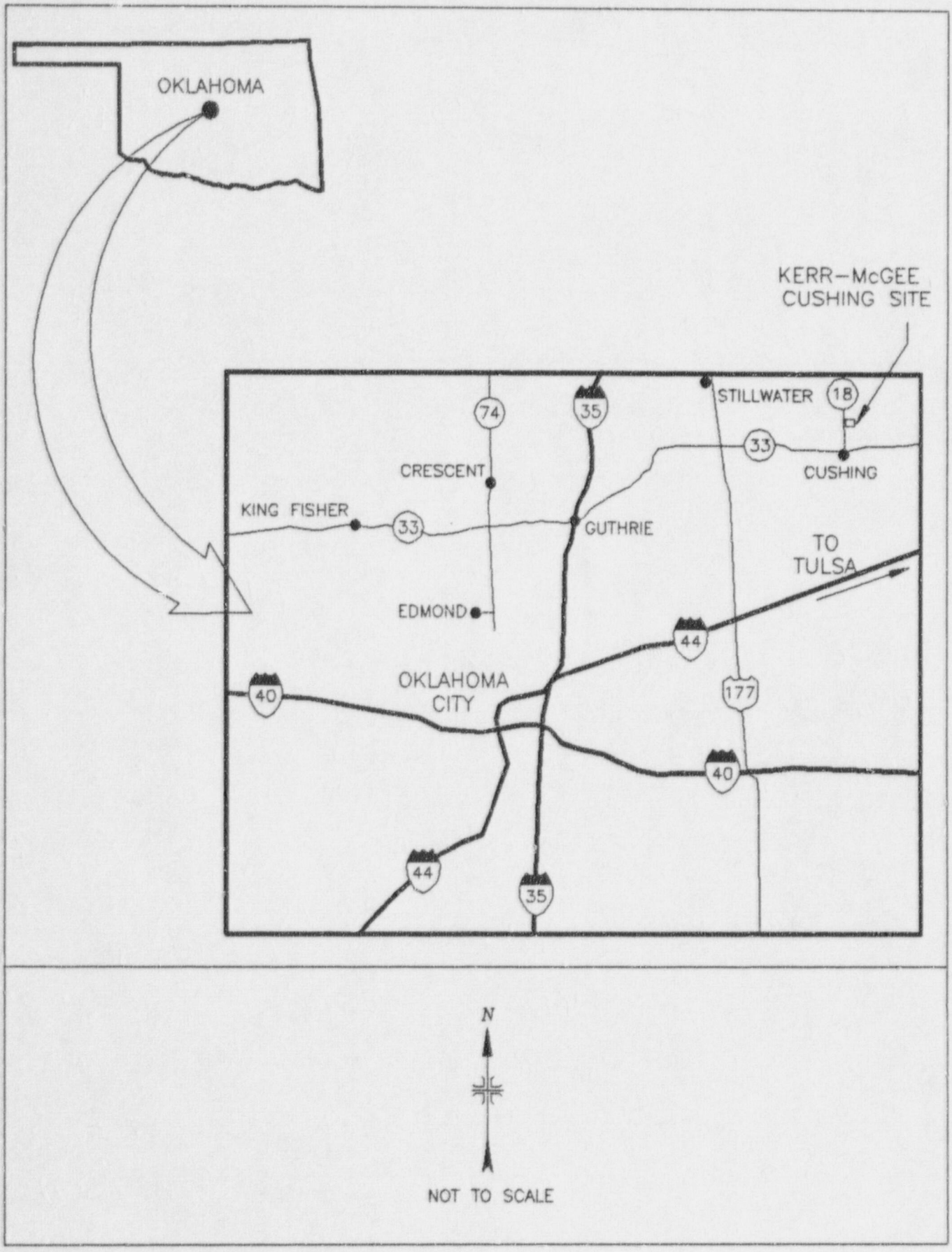


FIGURE 1: Location of the Kerr-McGee Corporation Site, Cushing, Oklahoma

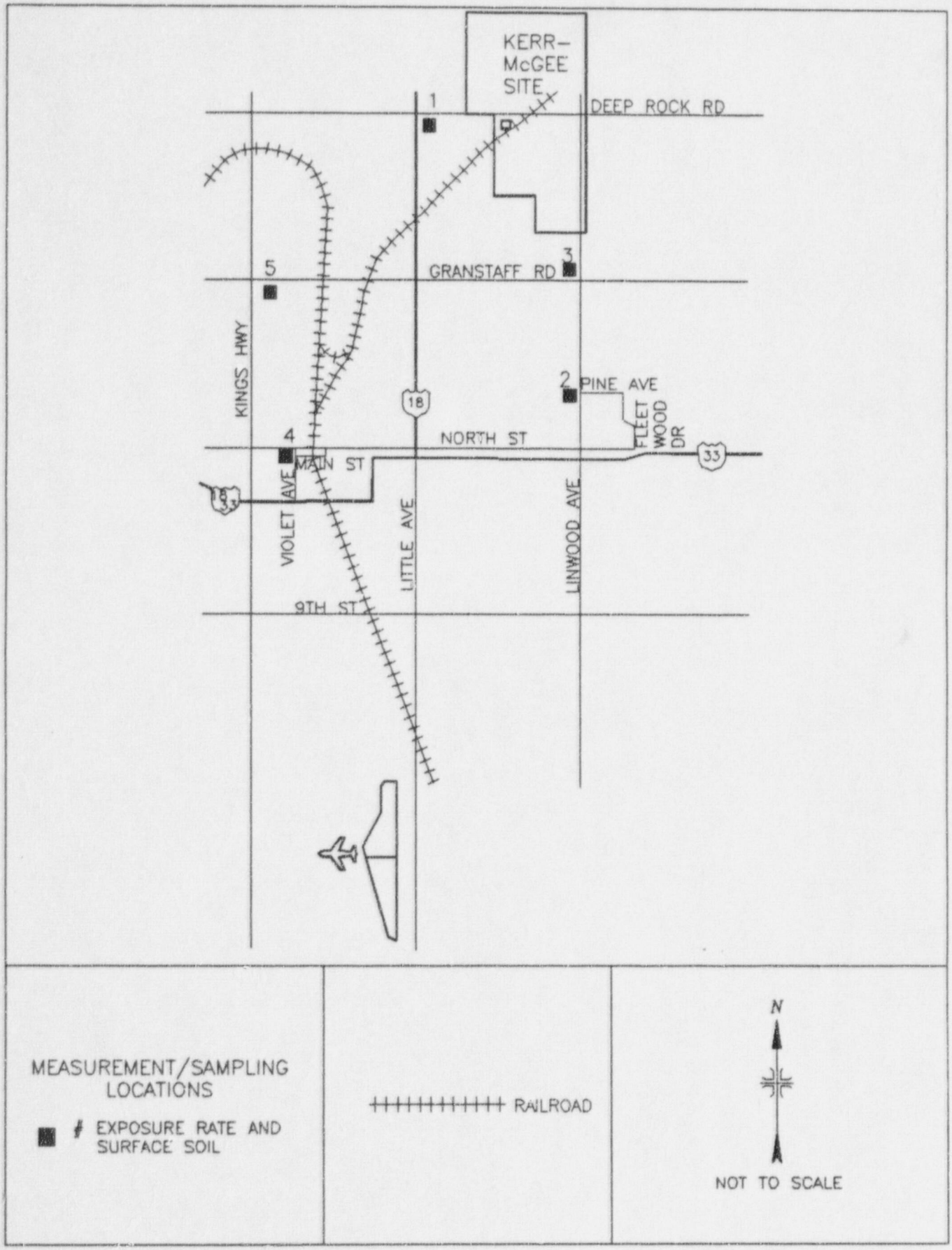


FIGURE 2: Cushing Refinery Site, Kerr-McGee Corporation - Background Exposure Rate Measurement and Soil Sampling Locations

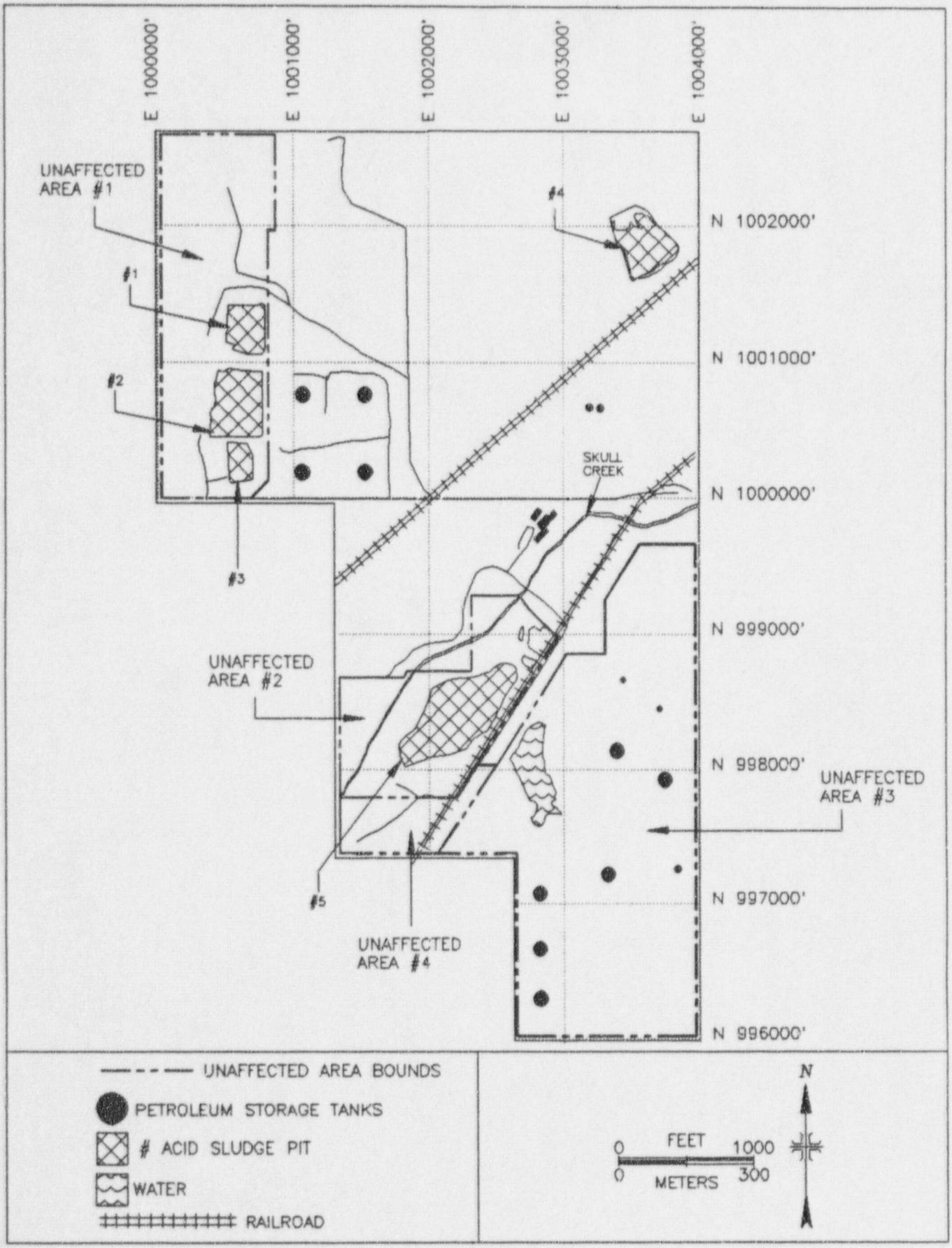


FIGURE 3: Kerr–McGee Corporation, Cushing, Oklahoma – Cushing Site Unaffected Areas

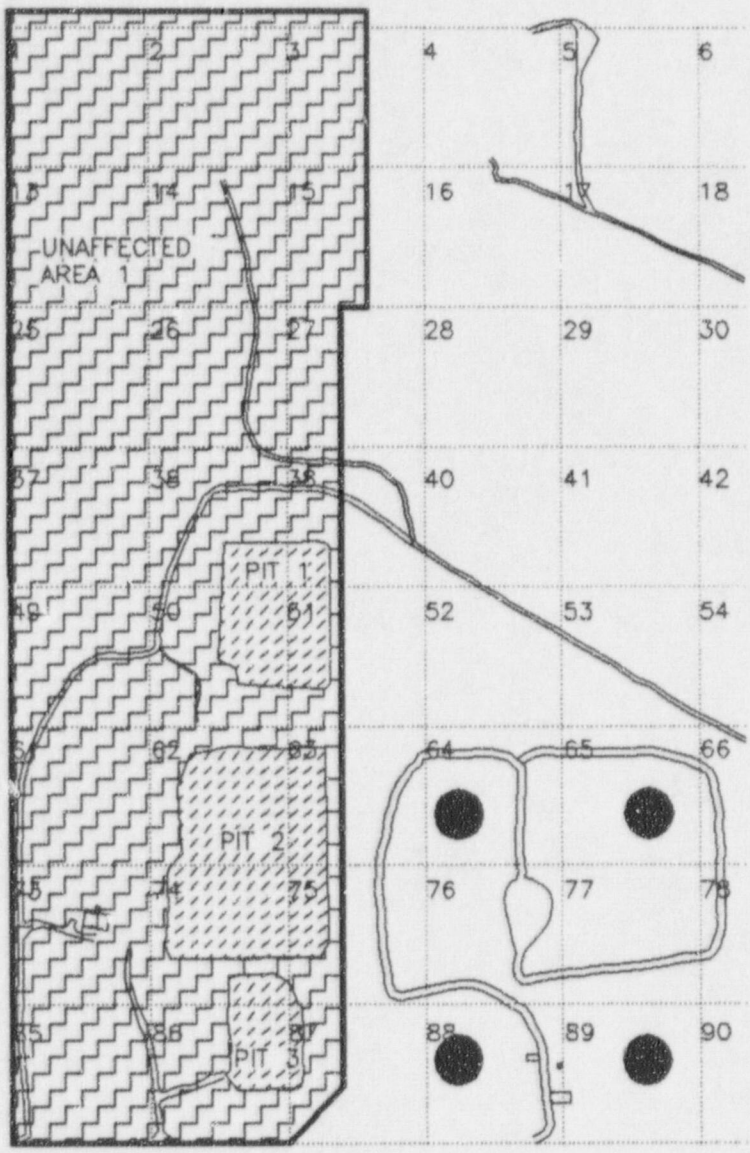


FIGURE 4: Kerr-McGee Corporation, Cushing, Oklahoma - Unaffected Area 1

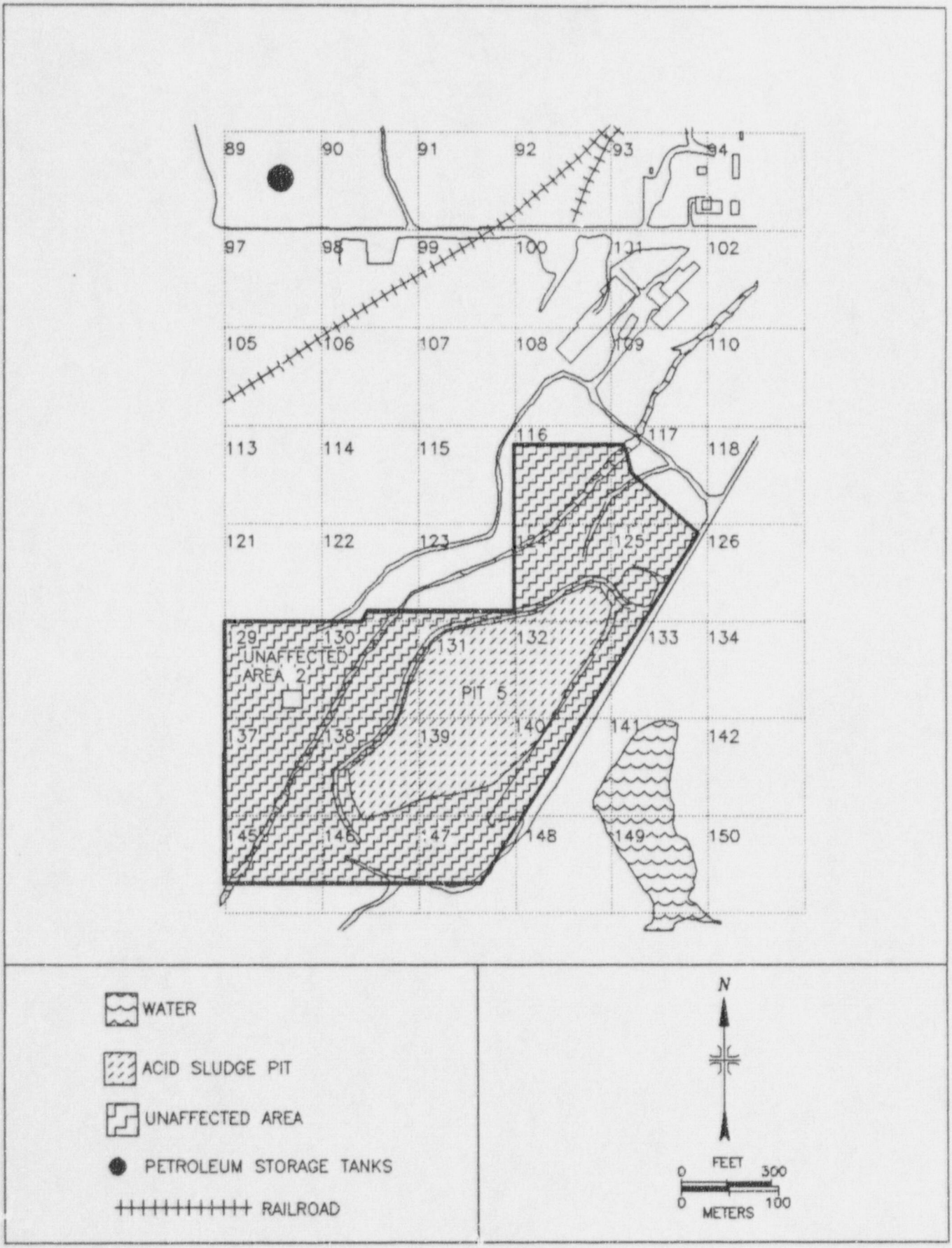
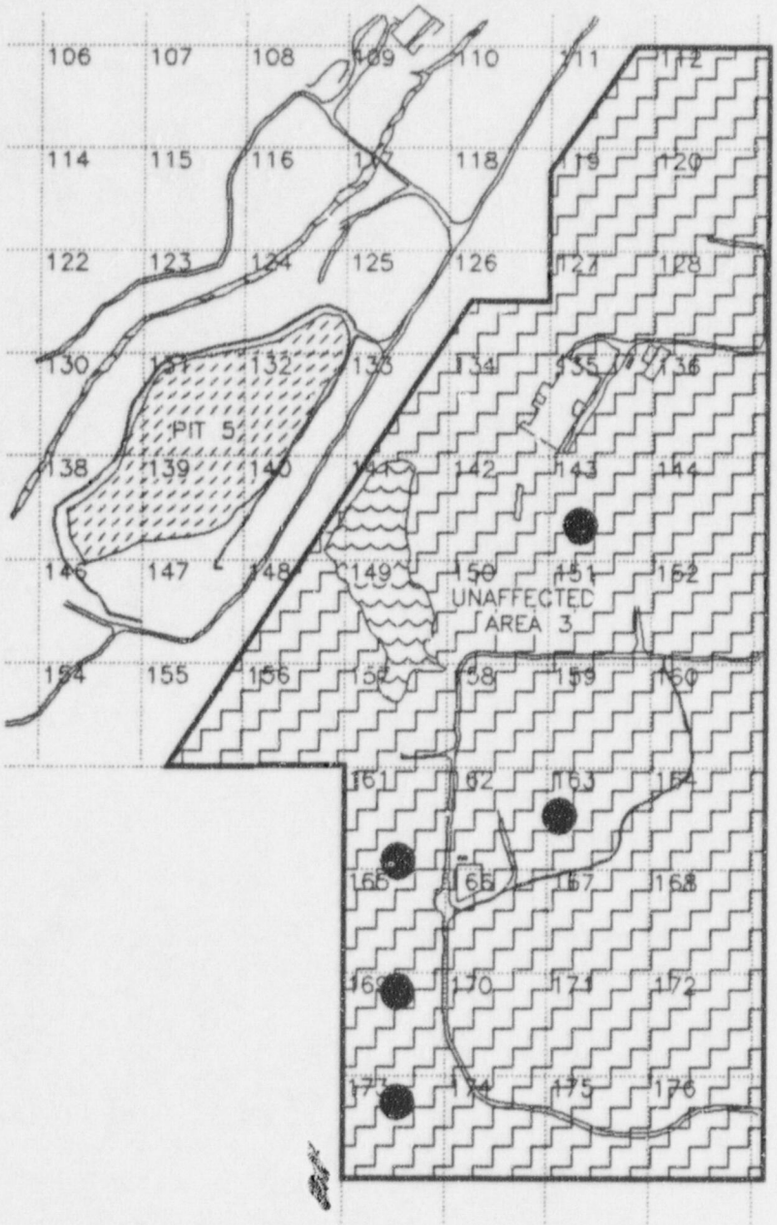


FIGURE 5: Kerr-McGee Corporation Site, Cushing, Oklahoma – Unaffected Area 2



WATER

ACID SLUDGE PIT

UNAFFECTED AREA

PETROLEUM STORAGE TANKS

N

FEET 0 300

METERS 0 100

FIGURE 6: Kerr-McGee Corporation Site, Cushing, Oklahoma -- Unaffected Area 3

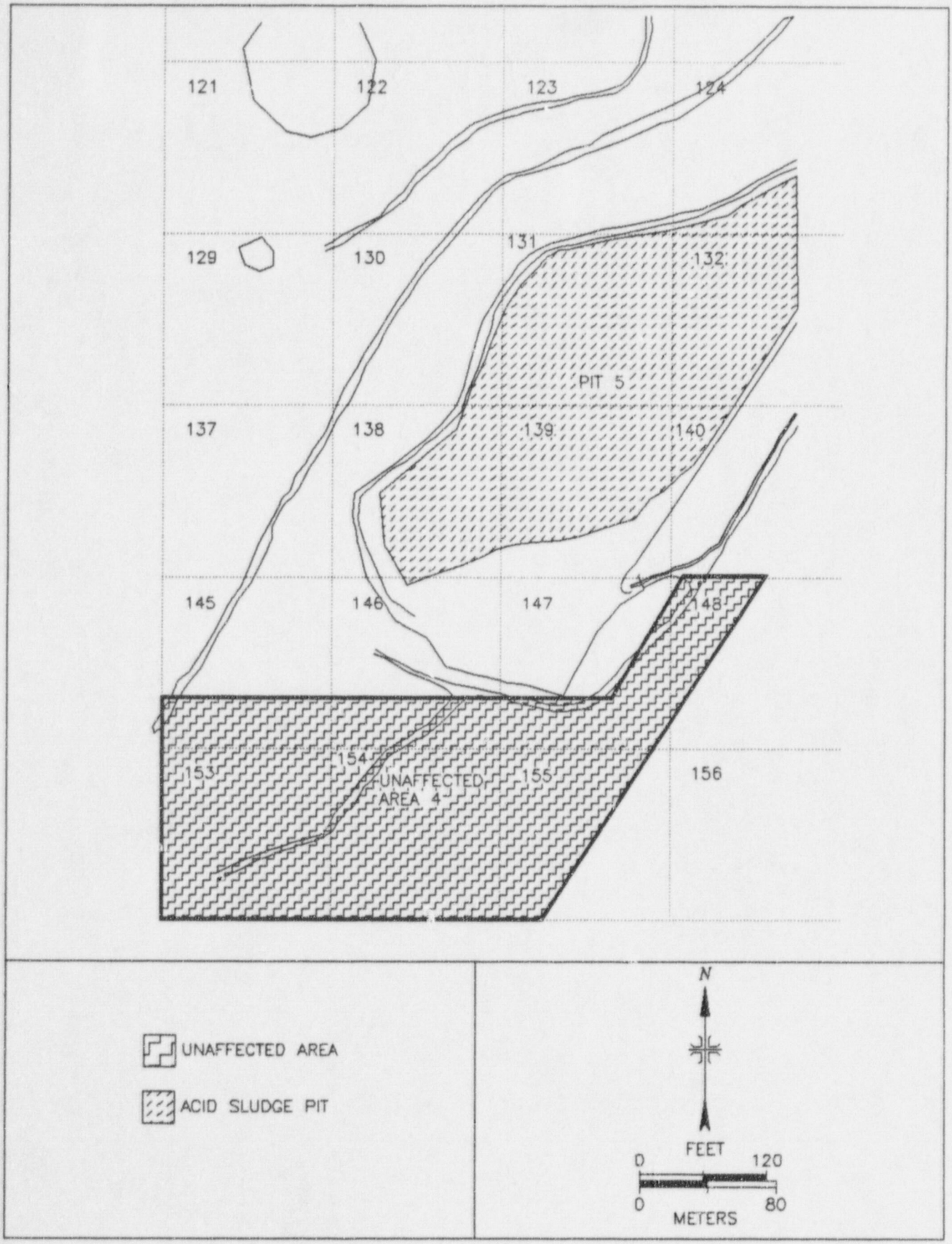


FIGURE 7: Kerr-McGee Corporation Site, Cushing, Oklahoma - Unaffected Area 4

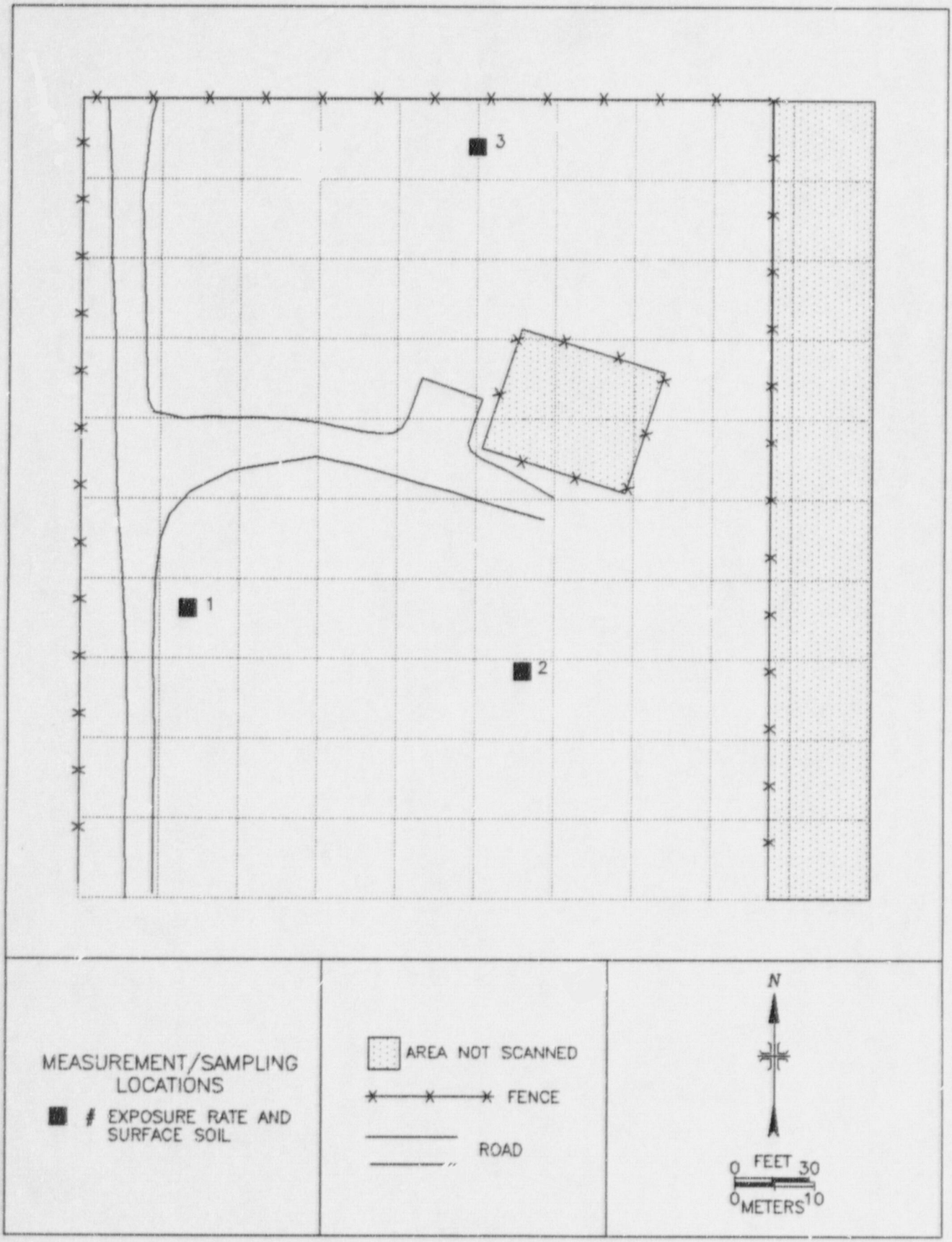
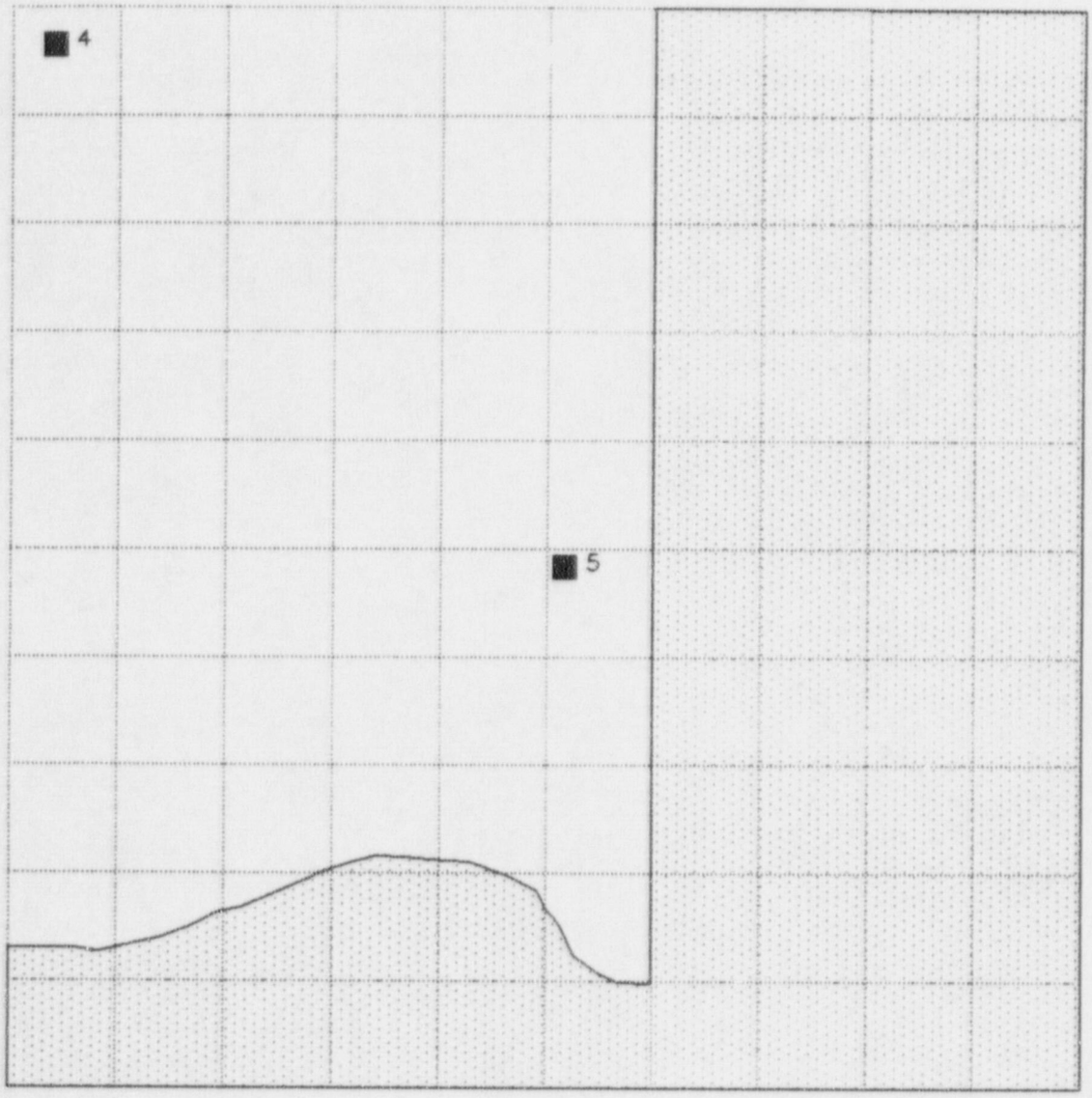


FIGURE 8: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #1, Grid #73 - Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

■ # EXPOSURE RATE AND SURFACE SOIL

AREA NOT SCANNED

N

0 FEET 30

0 METERS 10

FIGURE 9: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #1, Grid #3 – Measurement and Sampling Locations

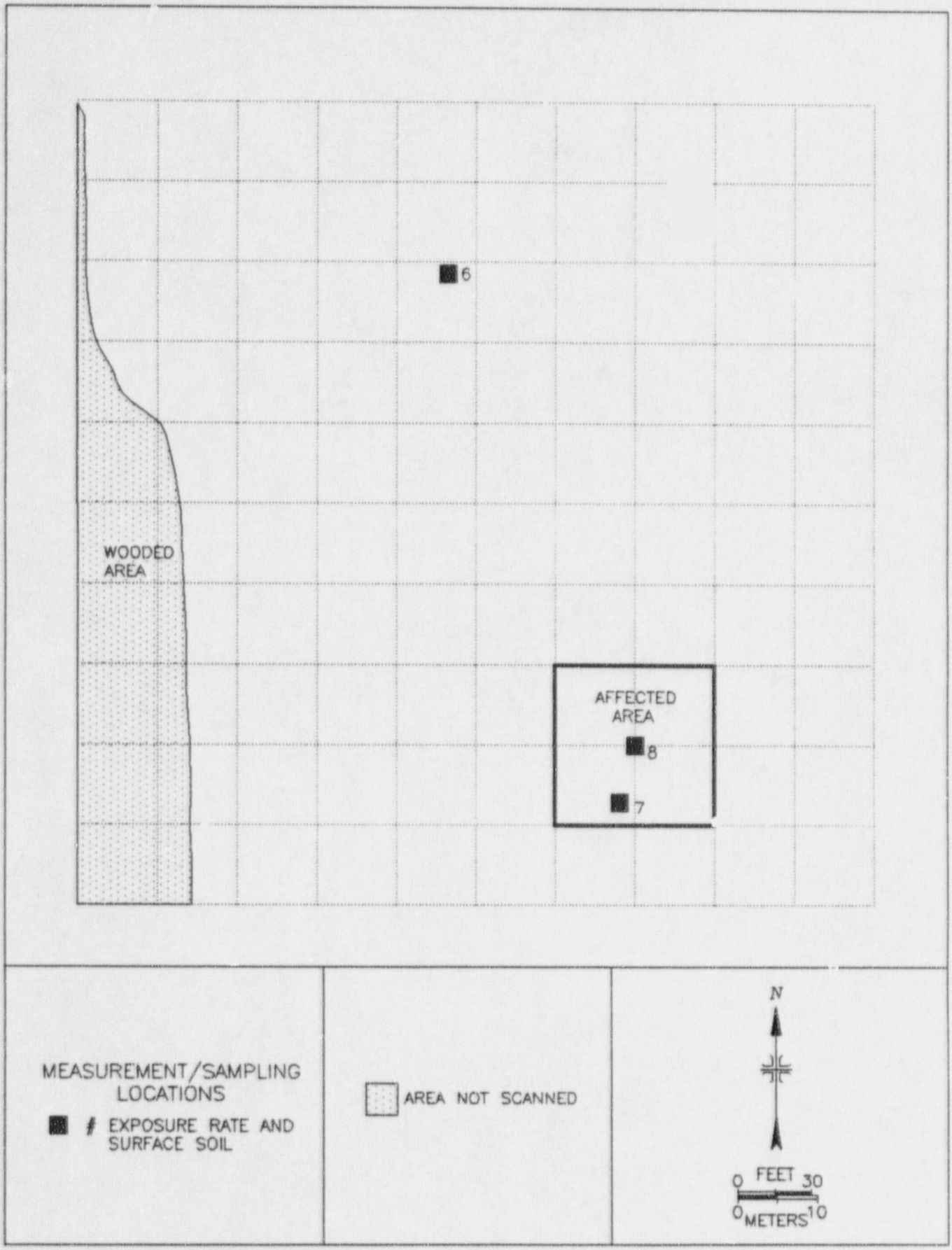


FIGURE 10: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #2, Grid #129 – Measurement and Sampling Locations

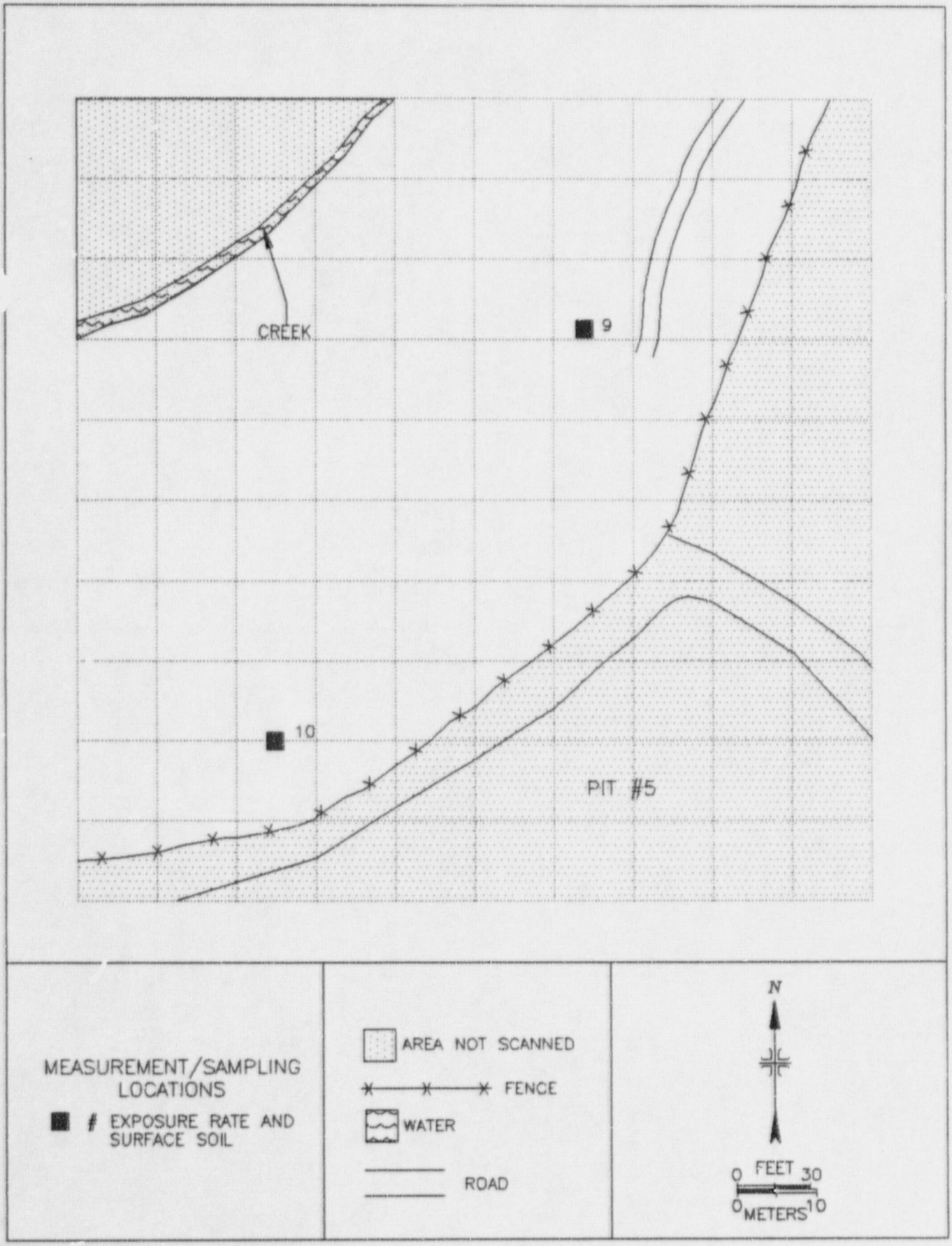


FIGURE 11: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #2, Grid #124 - Measurement and Sampling Locations

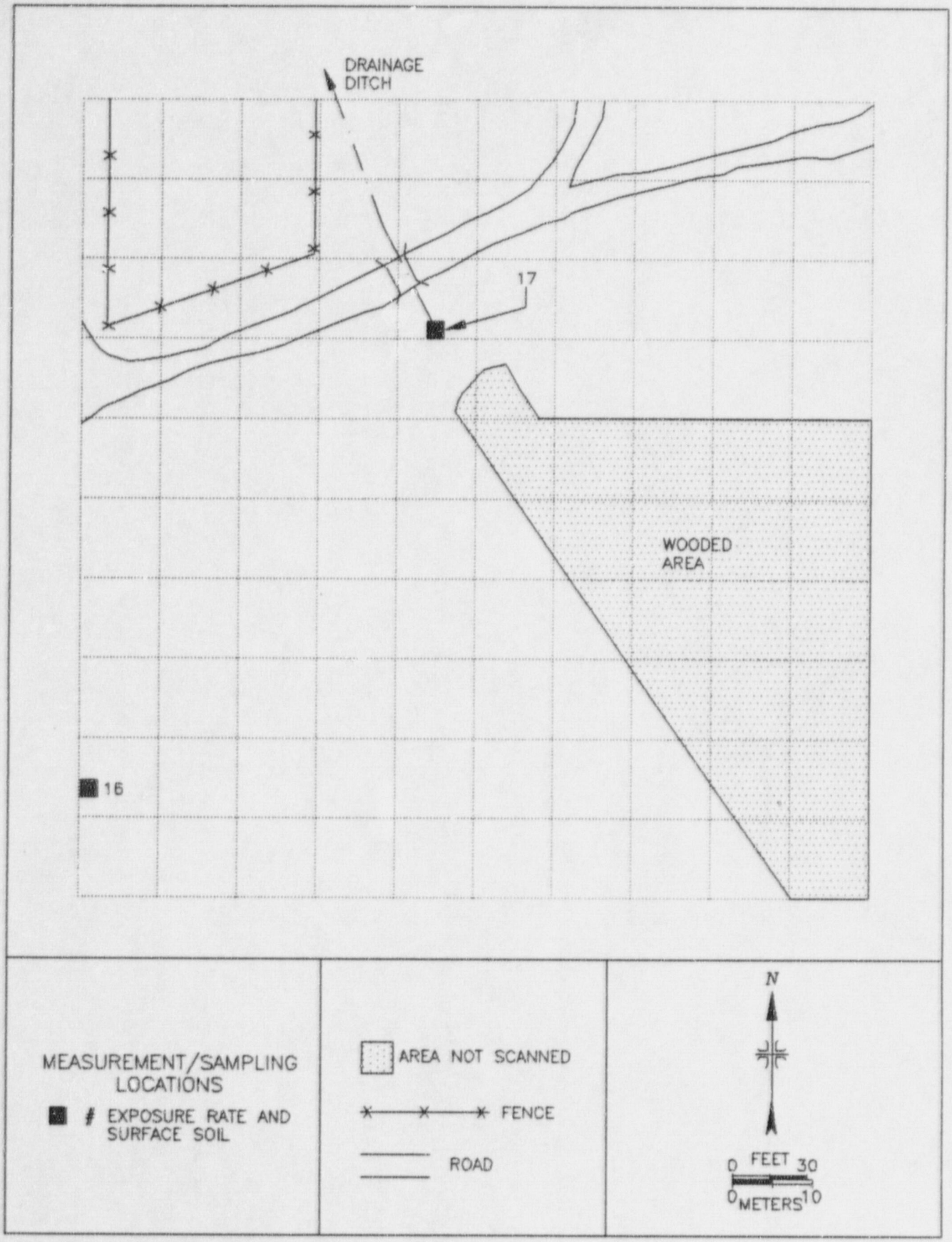


FIGURE 12: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #3, Grid #166 – Measurement and Sampling Locations

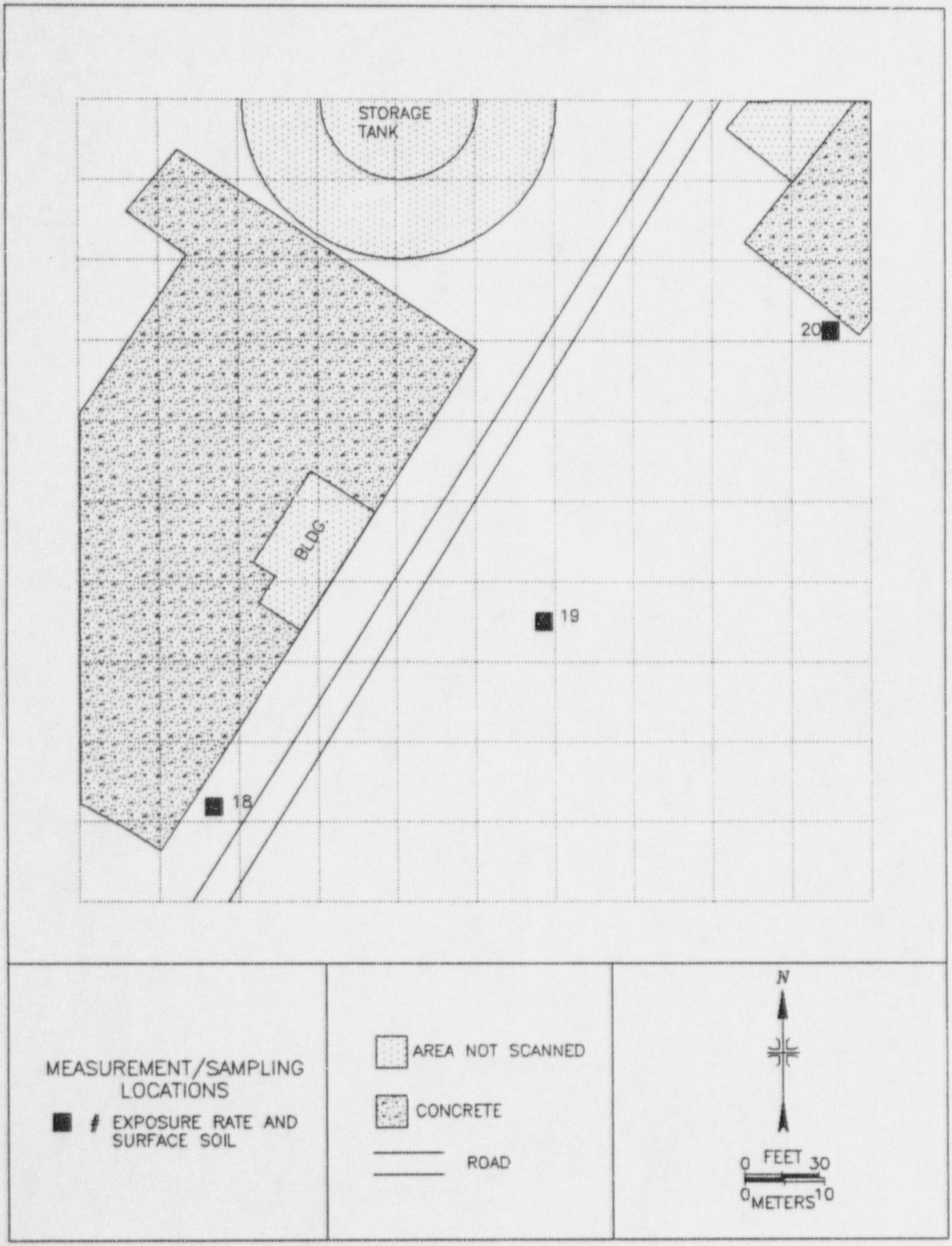


FIGURE 13: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #3, Grid #135 - Measurement and Sampling Locations

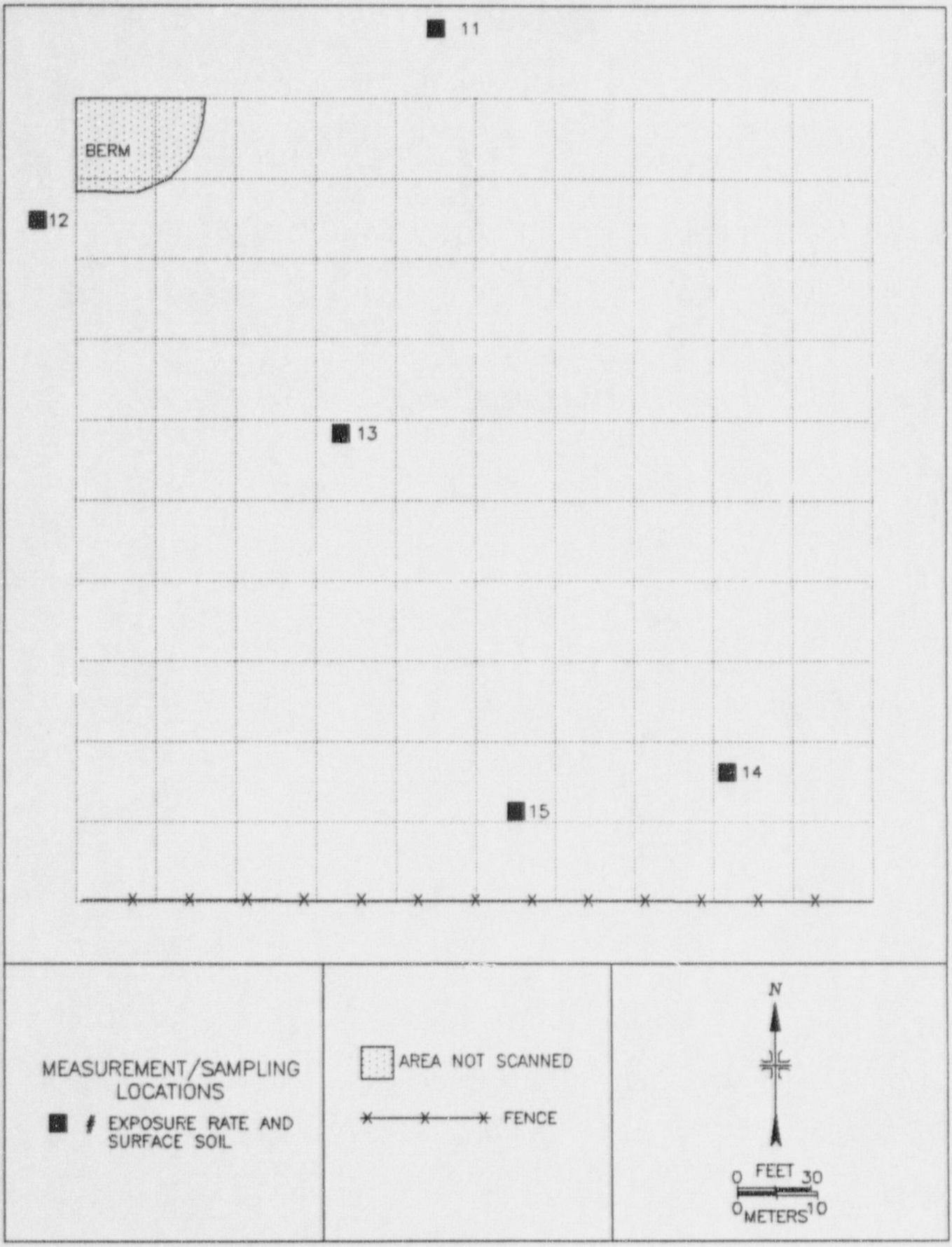


FIGURE 14: Cushing Refinery Site, Kerr-McGee Corporation Site, Unaffected Area #4, Grid #154 - Measurement and Sampling Locations

TABLE 1

EXPOSURE RATES IN UNAFFECTED AREAS
CUSHING REFINERY SITE, KERR-McGEE CORPORATION
CUSHING, OKLAHOMA

Location		Exposure Rate (μR/h) at 1 m Above Surface
UNAFFECTED AREA 1		
Grid 73[a]	1	7
	2	6
	3	10
Grid 3[b]	4	7
	5	5
UNAFFECTED AREA 2		
Grid 29[c]	6	9
	7	11
	8	12
Grid 124[d]	9	8
	10	6
UNAFFECTED AREA 3		
Grid 166[e]	16	4
	17	6
Grid 135[f]	18	11
	19	6
	20	6
UNAFFECTED AREA 4		
Grid 154[g]	11	10
	12	10
	13	8
	14	10
	15	8

[a]Refer to Figure 8.
[b]Refer to Figure 9.
[c]Refer to Figure 10.
[d]Refer to Figure 11.
[e]Refer to Figure 12.
[f]Refer to Figure 13.
[g]Refer to Figure 14.

TABLE 2

BACKGROUND EXPOSURE RATES
CUSHING REFINERY SITE, KERR-McGEE CORPORATION
CUSHING, OKLAHOMA

Location[a]	Exposure Rate (μR/h) at 1 m Above Surface
1	7
2	8
3	5
4	6
5	4

[a]Refer to Figure 2.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN BACKGROUND SOIL SAMPLES CUSHING REFINERY SITE, KERR-McGEE CORPORATION CUSHING, OKLAHOMA

Location[a]	Radionuclide Concentration (pCi/g)				
	U-235	U-238	Th-232	Th-228	Ra-226
1	<0.1	1.0 ± 0.9[b]	0.6 ± 0.3	0.7 ± 0.1	0.6 ± 0.2
2	<0.1	1.1 ± 1.1	0.9 ± 0.3	1.0 ± 0.1	0.9 ± 0.2
3	<0.1	1.6 ± 1.0	0.9 ± 0.3	0.9 ± 0.1	0.7 ± 0.1
4	<0.1	1.1 ± 0.9	0.8 ± 0.3	0.8 ± 0.1	0.6 ± 0.1
5	<0.1	1.2 ± 0.8	0.8 ± 0.2	0.5 ± 0.1	0.7 ± 0.2

[a]Refer to Figure 2.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 4

ISOTOPIC URANIUM CONCENTRATIONS IN SOIL SAMPLES CUSHING REFINERY SITE, KERR-McGEE CORPORATION CUSHING, OKLAHOMA

Location	Uranium Concentration (pCi/g)		
	U-234	U-235	U-238
Background, #4[a]	0.73± 0.18[f]	<0.14	0.70 ± 0.17
Grid 73, #3[b]	0.90 ± 0.16	<0.06	0.80 ± 0.15
Grid 129, #8[c]	2.00 ± 0.26	0.15 ± 0.07	0.80 ± 0.15
Grid 154, #12[d]	1.84 ± 0.27	<0.08	2.17 ± 0.29
Grid 135, #18[e]	0.86 ± 0.18	0.03 ± 0.03	0.90 ± 0.17

[a]Refer to Figure 2.
[b]Refer to Figure 8.
[c]Refer to Figure 10.
[d]Refer to Figure 14.
[e]Refer to Figure 13.
[f]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN
SOIL SAMPLES FROM UNAFFECTED AREAS
CUSHING REFINERY SITE, KERR-McGEE CORPORATION
CUSHING, OKLAHOMA

Location		Radionuclide Concentration (pCi/g)				
		U-235	U-238	Th-232	Th-228	Ra-226
UNAFFECTED AREA 1						
Grid 73[a]	1	< 0.1	1.9 ± 1.3[h]	1.3 ± 0.4	1.2 ± 0.1	0.9 ± 0.2
	2	< 0.1	1.9 ± 1.2	1.1 ± 0.2	1.1 ± 0.1	0.9 ± 0.2
	3	< 0.2	0.8 ± 1.5	1.4 ± 0.5	1.2 ± 0.2	4.2 ± 0.4
Grid 3[b]	4	< 0.1	0.9 ± 0.9	0.7 ± 0.2	0.8 ± 0.1	0.7 ± 0.1
	5	< 0.1	< 1.9	1.3 ± 0.4	1.3 ± 0.2	0.6 ± 0.2
UNAFFECTED AREA 2						
Grid 129[c]	6	< 0.1	0.3 ± 0.9	0.9 ± 0.3	0.9 ± 0.1	0.6 ± 0.1
	7	< 0.1	1.5 ± 1.0	1.1 ± 0.3	1.0 ± 0.1	0.7 ± 0.1
	8	< 0.2	< 3.6	10.0 ± 0.9	9.0 ± 0.4	0.7 ± 0.3
Grid 124[d]	9	< 0.1	< 1.3	1.0 ± 0.4	1.0 ± 0.1	0.8 ± 0.1
	10	< 0.1	1.5 ± 0.8	1.0 ± 0.3	1.1 ± 0.1	0.8 ± 0.1
UNAFFECTED AREA 3						
Grid 166[e]	16	< 0.1	1.5 ± 0.9	0.7 ± 0.2	0.6 ± 0.1	0.5 ± 0.1
	17	< 0.1	1.6 ± 0.9	1.0 ± 0.3	0.9 ± 0.1	0.7 ± 0.1
Grid 135[f]	18	< 0.5	< 4.7	3.0 ± 0.9	3.8 ± 0.3	29.4 ± 0.9
	19	< 0.1	0.6 ± 1.0	< 0.8	1.0 ± 0.1	0.6 ± 0.2
	20	< 0.1	0.8 ± 0.7	1.0 ± 0.3	0.8 ± 0.1	0.7 ± 0.1
UNAFFECTED AREA 4						
Grid 154[g]	11	< 0.1	< 1.8	1.4 ± 0.3	1.2 ± 0.1	1.0 ± 0.2
	12	< 0.1	3.0 ± 1.8	2.0 ± 0.4	1.5 ± 0.2	1.3 ± 0.2
	13	< 0.1	0.5 ± 0.9	1.2 ± 0.4	1.1 ± 0.1	0.7 ± 0.1
	14	< 0.1	1.2 ± 1.1	< 0.8	1.1 ± 0.1	0.7 ± 0.2
	15	< 0.1	1.1 ± 1.1	1.1 ± 0.3	1.2 ± 0.1	0.9 ± 0.2

[a]Refer to Figure 8.
[b]Refer to Figure 9.
[c]Refer to Figure 10.
[d]Refer to Figure 11.
[e]Refer to Figure 12.
[f]Refer to Figure 13.
[g]Refer to Figure 14.
[h]Uncertainties represent the 95% confidence level, based only on counting statistics.

TABLE 6

U-238 CONCENTRATIONS IN SOIL SAMPLES - CONFIRMATORY ANALYSES CUSHING REFINERY SITE, KERR-McGEE CORPORATION CUSHING, OKLAHOMA

U-238 Concentration (pCi/g)	
ESSAP	**KMC**
1.9 ± 1.3[a]	2.16 ± 1.24
1.9 ± 1.2	1.78 ± 2.02
0.8 ± 1.5	2.07 ± 2.41
0.9 ± 0.9	1.84 ± 1.67
< 1.9	3.01 ± 1.56
0.3 ± 0.9	2.36 ± 1.66
1.5 ± 1.0	2.02 ± 1.41
< 3.6	3.45 ± 2.86
< 1.3	2.37 ± 1.87
1.5 ± 0.8	2.78 ± 1.82
1.5 ± 0.9	4.20 ± 2.78
1.6 ± 0.9	2.41 ± 2.77
< 4.7	0.34 ± 1.67
0.6 ± 1.0	0.52 ± 1.46
0.8 ± 0.7	3.43 ± 2.41
< 1.8	1.51 ± 1.62
3.0 ± 1.8	3.14 ± 0.79
0.5 ± 0.9	0.00 ± 1.11
1.2 ± 1.1	1.35 ± 1.75
1.1 ± 1.1	1.04 ± 1.30

[a]ESSAP uncertainties represent the 95% confidence level, based only on counting statistics.

REFERENCES

Conover, W.J. Practical Nonparametric Statistics, second edition, John Wiley & Sons, New York, 1980.

Kerr-McGee Corporation, "Final Radiation Survey of Four Unaffected Areas of the Cushing Refinery Site," April 1995.

Oak Ridge Institute for Science and Education (ORISE), "Confirmatory Survey Plan for the Four Unaffected Areas of the Cushing Refinery Site, Kerr-McGee Corporation, Cushing, Oklahoma (Docket No. 70-3073)," August 31, 1995.

U.S. Nuclear Regulatory Commission, "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations," 46 FR 52061, Washington, D.C., October 23, 1981.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or his employer.

DIRECT RADIATION MEASUREMENT

Instruments

Bicron Micro-Rem Meter
(Bicron Corporation, Newbury, OH)

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Ludlum Ratemeter-Scaler
Model 12
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)
High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:

Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans for gamma activity were performed by passing the probes slowly over the surface; the distance between the detector and the surface was maintained at a minimum. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detector and instruments used for scans were:

Gamma - NaI scintillation detector with ratemeter.

Exposure Rate Measurements

Measurements of gamma exposure rates were performed using a microrem meter. The microrem meter was positioned one meter above the surface and allowed to stabilize. Although the microrem meter displays data in μrem/h, the μrem/h to μR/h conversion factor is essentially unity.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Surface soil samples were collected at 0-15 cm depth. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gamma Spectrometry

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

U-235	0.186 MeV
U-238	0.063 MeV from Th-234*
Th-228	0.239 MeV from Pb-212*
Th-232	0.911 MeV from Ac-228*
Ra-226	0.352 MeV from Pb-214*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

Alpha Spectrometry

Soil samples were crushed, homogenized and analyzed for isotopic uranium. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. Barium sulfate precipitate was redissolved and the specific elements of interest were individually separated by liquid-liquid extraction and re-precipitated with a cerium fluoride carrier. The precipitate was then counted using surface barrier and ion implanted detectors (ORTEC), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Nuclear Data).

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data based only on counting statistics. Additional uncertainties associated with sampling and measurement procedures have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 2.71 plus 4.65 times the standard deviation of the background count. When the activity was determined to be less than the MDC of the measurement procedure, the result was reported as less than MDC. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

Calibration and Quality Assurance

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry recognized organization were used.

Analytical and field survey activities were conducted in accordance with procedures from the following ESSAP documents:

- Survey Procedures Manual, Revision 9 (April, 1995)
- Laboratory Procedures Manual, Revision 9 (January, 1995)
- Quality Assurance Manual, Revision 7 (January, 1995)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.
- Participation in EPA and EML laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

APPENDIX C

GUIDELINES FOR RESIDUAL CONCENTRATIONS OF THORIUM AND URANIUM WASTES IN SOIL

APPENDIX C

GUIDELINES FOR RESIDUAL CONCENTRATIONS OF THORIUM AND URANIUM WASTES IN SOIL

On October 23, 1981, the Nuclear Regulatory Commission published in the Federal register a notice of Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." This document established guidelines for concentrations of uranium and thorium in soil, that will limit maximum radiation received by the public under various conditions of future land usage. These concentrations are as follows:

Material	Maximum Concentrations (ρCi/g) for various options			
	1[a]	2[b]	3[c]	4[d]
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10	50	--	500
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10	--	40	200
Depleted Uranium:				
Soluble	35	100	--	1,000
Insoluble	35	300	--	3,000
Enriched Uranium:				
Soluble	30	100	--	1,000
Insoluble	30	250	--	2,500

[a]Based on EPA cleanup standards which limit radiation to 1 mrad/yr to lung and 3 mrad/yr to bone from ingestion and inhalation and 10 μR/h above background from direct external exposure.
[b]Based on limiting individual dose to 170 mrem/yr.
[c]Based on limiting equivalent exposure to 0.02 working level or less.
[d]Based on limiting individual dose to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.

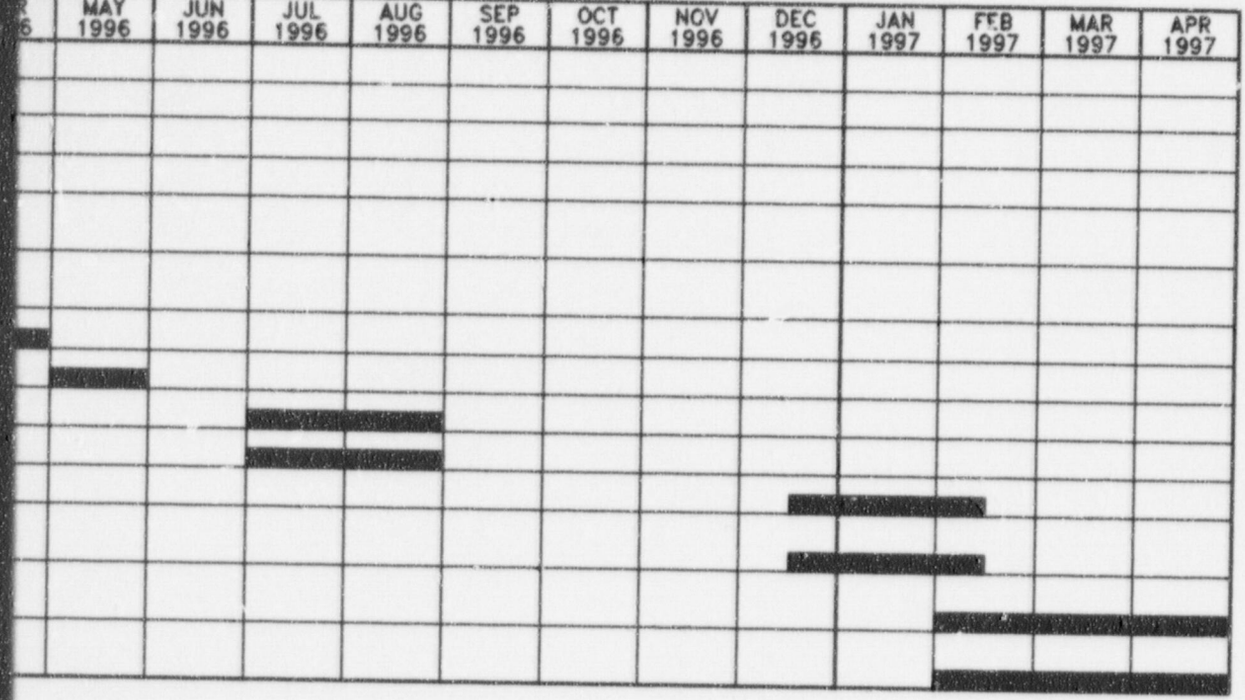
NRC Required Approvals

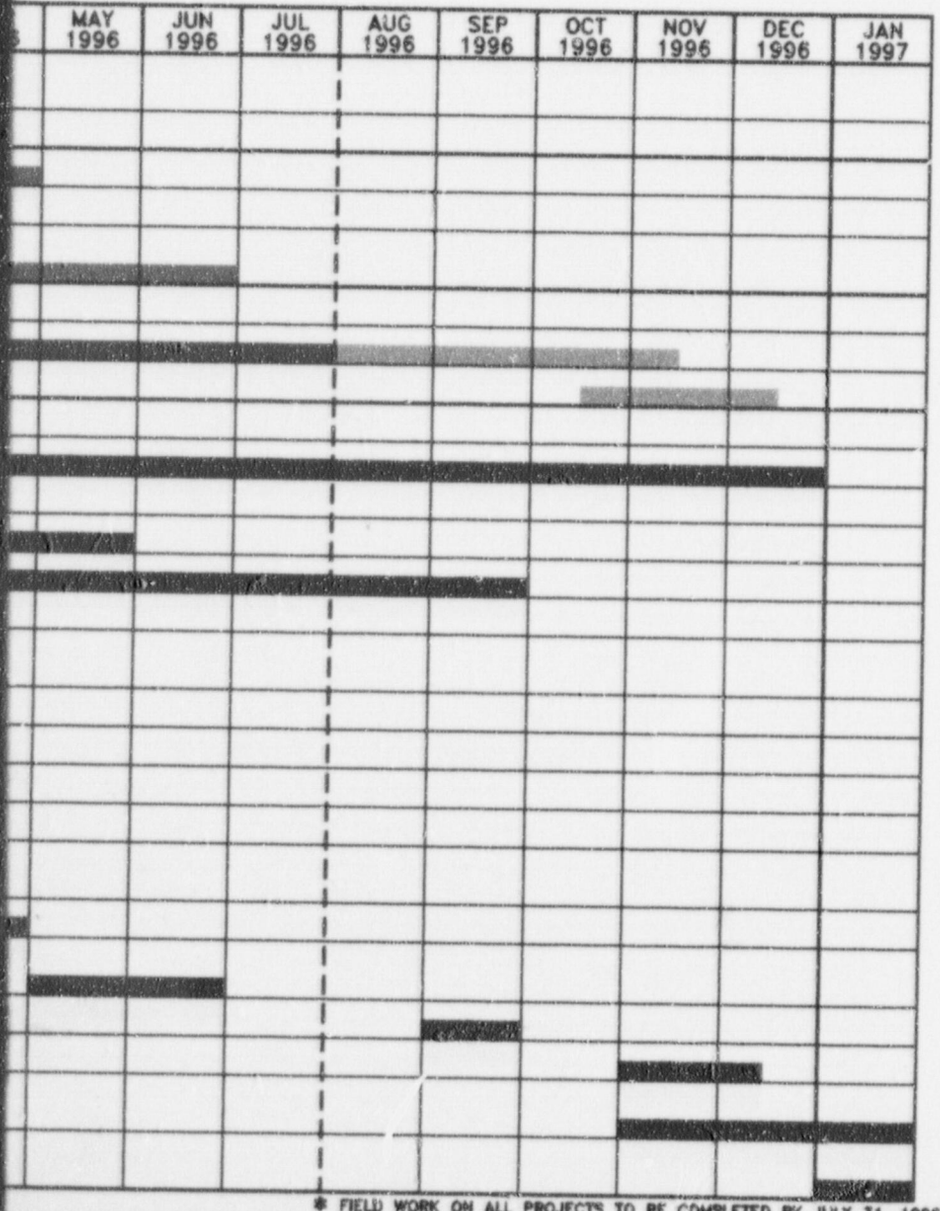
NOTE	JUN 1995	JUL 1995	AUG 1995	SEP 1995	OCT 1995	NOV 1995	DEC 1995	JAN 1996	FEB 1996	MAR 1996
NRC Review and Approval to Backfill South U-Yard										
NRC Review and Approval of Phase II Final Survey Plan										
NRC Review and Approval of Phase I Final Survey Report										
NRC Review and Approval of Cimarron Decommissioning Plan										
NRC Review and Approval of Cimarron Radiological Characterization Report										
NRC Review and Approval of Additional Stockpile Characterization Report										
NRC Review and Approval of Phase III Final Survey Plan										
NRC License Amendment for extending License Expiration Date										
NRC Review and Approval of Phase II Final Survey Report										
NRC Review and Approval of Backfill East U-Plant Yard Area										
NRC Review and Approval of Phase III Final Survey Report										
NRC Review and Approval of On-Site Disposal Cell Closure Report										
NRC Review and Approval of License SNM-928 Termination Request										
NRC Review and Approval of License 35-12636-02 Termination Request										

Cimarron Decommissioning Tasks

NOTE	JUN 1995	JUL 1995	AUG 1995	SEP 1995	OCT 1995	NOV 1995	DEC 1995	JAN 1996	FEB 1996	MAR 1996
Submit Phase I Final Report to NRC with License Amendment Request										
Unaffected Areas A-E (Phase I)										
Unaffected/Affected Areas F-J (Phase II)										
Submit Phase II Final Survey Plan to NRC										
Prepare and Submit Phase II Final Report to NRC with License Amendment Request										
Prepare and Submit Phase III Final Survey Plan to NRC										
Affected Areas (Phase III)										
Prepare and Submit Phase III Final Report to NRC										
Burial Area #2										
Routine Operational Activities										
Sanitary Lagoon Removal										
U-Plant Area Soil Removal										
Uranium Plant Interior										
Backfill U-Plant South Yard										
Submit Characterization Report(s) to NRC on Additional Stockpiles of Option #2 Materials.										
Exterior Building Roof & Walls										
Remediate Waste Pond #2 and Placement of Cap										
Area East of Substation										
Waste Line to Waste Pond #1										
Prepare and Submit Characterization Report on Concrete in Drainage Ways to NRC										
Submit License Amendment Request to Revise Expiration Date										
Prepare and Submit Final Report on East U-Plant Yard Area to NRC										
Backfill East U-Plant Yard Area										
Prepare and Submit On-Site Disposal Cell Final Report to NRC										
Prepare and Submit License Amendment Request to Terminate License SNM-928										
Prepare and Submit License Amendment Request to Terminate License 35-12636-02										

CILITY





9903080126-1

* FIELD WORK ON ALL PROJECTS TO BE COMPLETED BY JULY 31, 1996