ORISE
OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

December 20, 1995

Mr. David Fauver
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U.S. Nuclear Regulatory Commission
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SUBJECT: FINAL REPORT - CONFIRMATORY SURVEY FOR THE SOUTH URANIUM YARD REMEDIATION, KERR-McGEE CORPORATION, CIMARRON FACILITY, CRESCENT, OKLAHOMA (DOCKET NO. 79-925)

Dear Mr. Fauver:

The Environmental Survey and Site Assessment Program (ESSAP) of ORISE conducted a confirmatory survey of the south uranium yard remediation at Kerr-McGee's Cimarron Facility in Crescent, Oklahoma on April 24 and 25, 1995. Confirmatory survey activities included surface scans, exposure rate measurements, soil sampling, and confirmatory analyses of licensee's soil samples.

Enclosed are 5 copies of the subject document. The draft report was revised as requested. If you have any questions, please direct them to me at (423) 576-3740 or W. L. (Jack) Beck at (423) 576-5031.

Sincerely,

Eric W. Abelquist

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CONFIRMATORY SURVEY FOR THE SOUTH URANIUM YARD REMEDIATION KERR-McGEE CORPORATION, CIMARRON FACILITY CRESCENT, OKLAHOMA

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

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CONFIRMATORY SURVEY FOR THE SOUTH URANIUM YARD REMEDIATION KERR-McGEE CORPORATION, CIMARRON FACILITY CRESCENT, OKLAHOMA

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ABBREVIATIONS AND ACRONYMS

μR/h	microroentgens per hour
μrem/h	microrem per hour
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
D&D	Decontamination and Decommissioning
DAP	Designated Area Pile
DOE	Department of Energy
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
ft^3	cubic feet
km	kilometer
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
SFC	Sequoyah Fuels Corporation
UF_6	uranium hexafluoride

CONFIRMATORY SURVEY
FOR THE SOUTH URANIUM YARD REMEDIATION
KERR-McGEE CORPORATION, CIMARRON FACILITY
CRESCENT, OKLAHOMA

INTRODUCTION AND SITE HISTORY

The Kerr-McGee Corporation operated the Cimarron facility in Crescent, Oklahoma to produce slightly enriched (approximately 3% U-235) uranium fuel and mixed oxide (uranium plus plutonium) fuel between 1965 and 1975. These activities were conducted under License SNM-928 with the Atomic Energy Commission (AEC), predecessor to the Nuclear Regulatory Commission (NRC). In 1983, Sequoyah Fuels Corporation (SFC) became the owner of the Cimarron Facility, when Kerr-McGee Nuclear Corporation was divided into SFC and Quivira Mining Corporation. Subsequently, Cimarron Corporation, a subsidiary of the Kerr-McGee Nuclear Corporation, became responsible for the Cimarron Facility.

Cimarron Corporation has discontinued fuel production activities and is in the process of performing the decontamination to terminate the NRC licensing restrictions. The decontamination and decommissioning (D&D) project was divided into several phases, which involved the Mixed Oxide Plant, the Uranium Plant, the On-site Burial Ground, and the Sanitary Lagoons.

As part of the overall D&D effort, remediation of contaminated soil at the Cimarron Facility began as early as 1976. This soil is contaminated, primarily, with low-enrichment uranium; however, areas of thorium-contaminated soil, presumed to have been brought to the Cimarron Facility from the Kerr-McGee site at Cushing, have been identified (Cimarron 1994a). Plutonium contamination was confined, primarily, to the interior surfaces of the Mixed Oxide Plant as well as isolated locations in the soil areas immediately adjacent to the building. There were no elevated levels of plutonium identified in the survey of the Sanitary Lagoons (ORISE 1991a,b); therefore, plutonium is not considered as a likely contaminant in this area.

The restricted area south of the Uranium Plant (Building 1), referred to as the South Uranium Yard, contained the Tank Storage Facility (Building 2), the Solvent Extraction Facility

(Building 3), the UF_6 (uranium hexafluoride) Receiving Area (Vaporizer Room in Building 1), and adjacent yard areas. Site operations resulted in a number of spills and overflows that caused contamination of soil beneath the flooring in these structures and the adjacent yard areas.

Remediation of the South Uranium Yard area was initiated with the removal of Buildings 2 and 3 in 1989 and 1990. The concrete floor of the Vaporizer Room was removed in 1992 and soil characterization was performed from May to June 1992. The South Uranium Yard areas were characterized in 1993 (Cimarron 1994b).

The contaminated soil at this facility was characterized and sorted into Option 1, Option 2, and Option 4 categories, according to the NRC Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations" (U.S. NRC 1981). The Option 1 soil was left in place. Option 2 soil has been stockpiled, in anticipation of being permanently relocated to the on-site disposal cells. Option 4 soil has been removed and shipped off-site for disposal.

On May 4 and 5, 1994, the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed a confirmatory survey of two Option 2 soil piles, adjacent to the Uranium Plant (ORISE 1994). Since the time of that survey, further soil excavation at the site has resulted in the establishment of one additional Option 2 soil pile, referred to as Designated Area Pile 3 (DAP-3).

At the request of the NRC's Division of Waste Management, Office of Nuclear Material Safety and Safeguards (NMSS), ESSAP performed an independent confirmatory survey of the South Uranium Yard area and the new Option 2 soil pile (DAP-3) at the Kerr-McGee Cimarron Facility, in Crescent, Oklahoma on April 24 and 25, 1995.

SITE DESCRIPTION

The Kerr-McGee Corporation, Cimarron Facility is located on a site of approximately 450 hectares (1,100 acres) in Logan County, Oklahoma, about 8 kilometers (km [5 miles]) south of Crescent (Figure 1). The main facilities at this site were the Uranium Plant and the Mixed Oxide Plant (Figure 2). Directly south of the Uranium Plant, the South Uranium Yard remediation includes the soil area beneath the previous Vaporizer Room, the excavated soil beneath the former Building 2 location, and adjacent yard areas. Additionally, the Option 2 soil pile (DAP-3), created since the time of the last ESSAP survey, is located on-site (Figure 4).

OBJECTIVES

The objectives of the confirmatory process are 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 April 24 and 25, 1995, ESSAP performed a confirmatory survey of the South Uranium Yard area and the DAP-3 soil pile at the Kerr-McGee Cimarron Facility, in Crescent, Oklahoma. The survey was conducted in accordance with a survey plan dated April 19, 1995, 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.

SURVEY PROCEDURES

Reference Grid

ESSAP used the reference grid system (10 m x 10 m) established by the licensee for referencing survey data. 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% area coverage scan of the South Uranium Yard and the DAP-3 soil pile was performed. 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 at twenty-eight surface and subsurface locations and at nine locations in the DAP-3 soil pile using a microrem meter. Background exposure rate measurements were performed at six locations within a 0.5 to 10 km radius of the site. Measurement locations are shown on Figures 3 through 5.

Soil Sampling

A total of 25 surface soil samples (0 to 15 cm), in addition to ten subsurface soil samples from three boreholes, was collected at randomly selected locations from soil excavations beneath the Vaporizer Room, the former Building 2 location, and adjacent yard areas. Sample locations are shown on Figure 3. Sampling depths for the three boreholes are indicated in Table 1.

Nine soil samples were collected from the DAP-3 soil pile. Measurement locations are shown on Figure 4.

Background soil samples were collected from each background exposure rate measurement location (Figure 5).

Confirmatory Analyses

Six soil samples were selected from the licensee's sample archive for confirmatory analysis. The basis for selection of these samples was to provide a range of activities, from approximately 100 to 800 pCi/g of total uranium. Analytical results for 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. All six background soil samples were analyzed by both alpha and gamma spectrometry. 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

SURVEY RESULTS

Surface Scans

Surface scans for gamma activity within the South Uranium Yard soil area resulted in the identification of one area of elevated direct radiation originating at the middle of the Uranium Plant (at approximately the 115E line) and extending to the south fenceline. A whitish material, to a depth of 0.5 m, was noted within this area. Samples #6 and #21 from the South Uranium Yard were collected from this material (Figure 3).

Surface scans for gamma activity within the DAP-3 soil pile did not identify any locations of elevated direct radiation.

Exposure Rates

Background exposure rates at 1 m above the surface ranged from 6 to 8 μR/h, with an average of 7 μR/h. Exposure rates at the twenty-five surface soil locations and the three borehole locations in the South Uranium Yard ranged from 6 to 13 μR/h and 7 to 8 μR/h, respectively. Exposure rates at the nine locations in the DAP-3 soil pile ranged from 8 to 9 μR/h.

Radionuclide Concentrations in Soil Samples

Radionuclide concentrations in background soil samples are summarized in Tables 1 and 2, for gamma and alpha spectrometry analyses, respectively. The total uranium concentrations in background soil samples determined by gamma spectrometry ranged from 0.8 to 2.3 pCi/g (with an average of 1.6 pCi/g), and alpha spectrometry ranged from 0.80 to 1.86 pCi/g.

For this survey, five samples from the South Uranium Yard and DAP-3 soil pile were analyzed by alpha spectrometry for isotopic uranium. The uranium concentrations for these samples are summarized in Table 2. This analysis indicated an average U-234 to U-235 ratio of approximately 20. This same U-234 to U-235 ratio was used by ESSAP to calculate the total uranium concentrations in soil samples that were analyzed by gamma spectrometry.

Concentrations of radionuclides in soil samples from the South Uranium Yard and DAP-3 soil pile are summarized in Table 1. Concentrations of radionuclides in surface soil samples ranged from <0.1 to 1.2 pCi/g for U-235, 0.9 to 5.6 pCi/g for U-238, and 2.7 to 29.6 pCi/g for total uranium. The average total uranium concentration for surface soil samples was 11 pCi/g. Concentrations of radionuclides in subsurface soil samples ranged from <0.1 to 1.5 pCi/g for U-235, 0.3 to 6.9 pCi/g for U-238, and 1.2 to 38.4 pCi/g for total uranium, with an average total uranium concentration of 9.5 pCi/g. Concentrations of radionuclides in the DAP-3 soil pile ranged from 0.7 to 1.8 pCi/g for U-235, 3.5 to 6.5 pCi/g for U-238, and 18.7 to 41.8 pCi/g for total uranium, with an average total uranium concentration of 29 pCi/g.

Confirmatory Analyses

The results of the confirmatory analyses of soil samples, which were selected by ESSAP and provided by the licensee, are also presented in Table 1. Previously, a disagreement between ESSAP and the licensee for samples with total uranium concentrations greater than 100 pCi/g was identified (ORISE 1994). Thus, the confirmatory samples were selected to provide a range of activities between 100 and 800 pCi/g, total uranium. Consequently, the radionuclide concentration values in these samples are not normally distributed. Therefore, in order to compare ESSAP and the licensee's analytical results, the nonparametric Wilcoxon Signed Ranks test was performed. The null hypothesis was that there were no differences between the licensee's and ESSAP's analytical results. The results of the Wilcoxon Signed Ranks test indicated, as a whole, ESSAP's and the licensee's analytical results are statistically identical ($p>0.6$).

COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminant of concern for this site is enriched uranium. 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 guideline for enriched uranium is 30 pCi/g, and the Option 2 average soil guideline is 100 pCi/g.

With the exception of the soil sample (0-15 cm) collected from borehole #1 (38.4 pCi/g total uranium), all soil samples collected from the South Uranium Yard were within the average soil guideline for enriched uranium. This sample was averaged with the results of the twenty-five surface soil samples (12 pCi/g total uranium) to demonstrate that compliance had been achieved. The soil samples collected from the DAP-3 soil pile were all within the Option 2 average soil guideline.

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

SUMMARY

On April 24 and 25, 1995, the Environmental Survey and Site Assessment Program of ORISE performed a confirmatory survey of the South Uranium Yard area and the new Option 2 soil pile (DAP-3) at the Kerr-McGee Cimarron Facility, in Crescent, 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 South Uranium Yard satisfies NRC guidelines for release to unrestricted use. In addition, the soil contained in DAP-3 meets the Option 2 soil guideline for disposal in on-site cells.

Results of confirmatory analyses performed on six of the licensee's soil samples indicates that there is no longer a disagreement between ESSAP and the licensee for samples with total uranium concentrations in excess of 100 pCi/g.

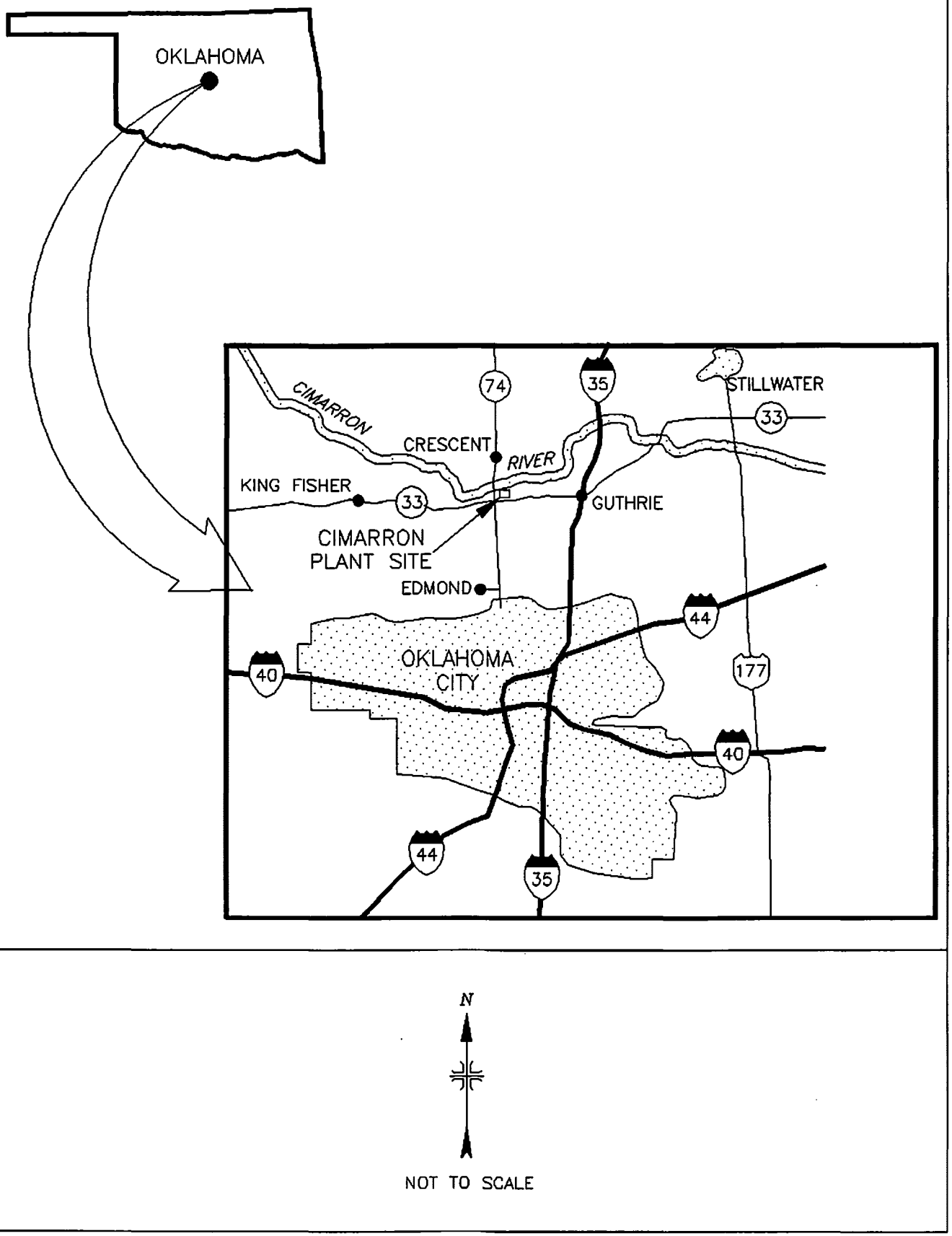


FIGURE 1: Location of the Cimarron Facility, Crescent, Oklahoma

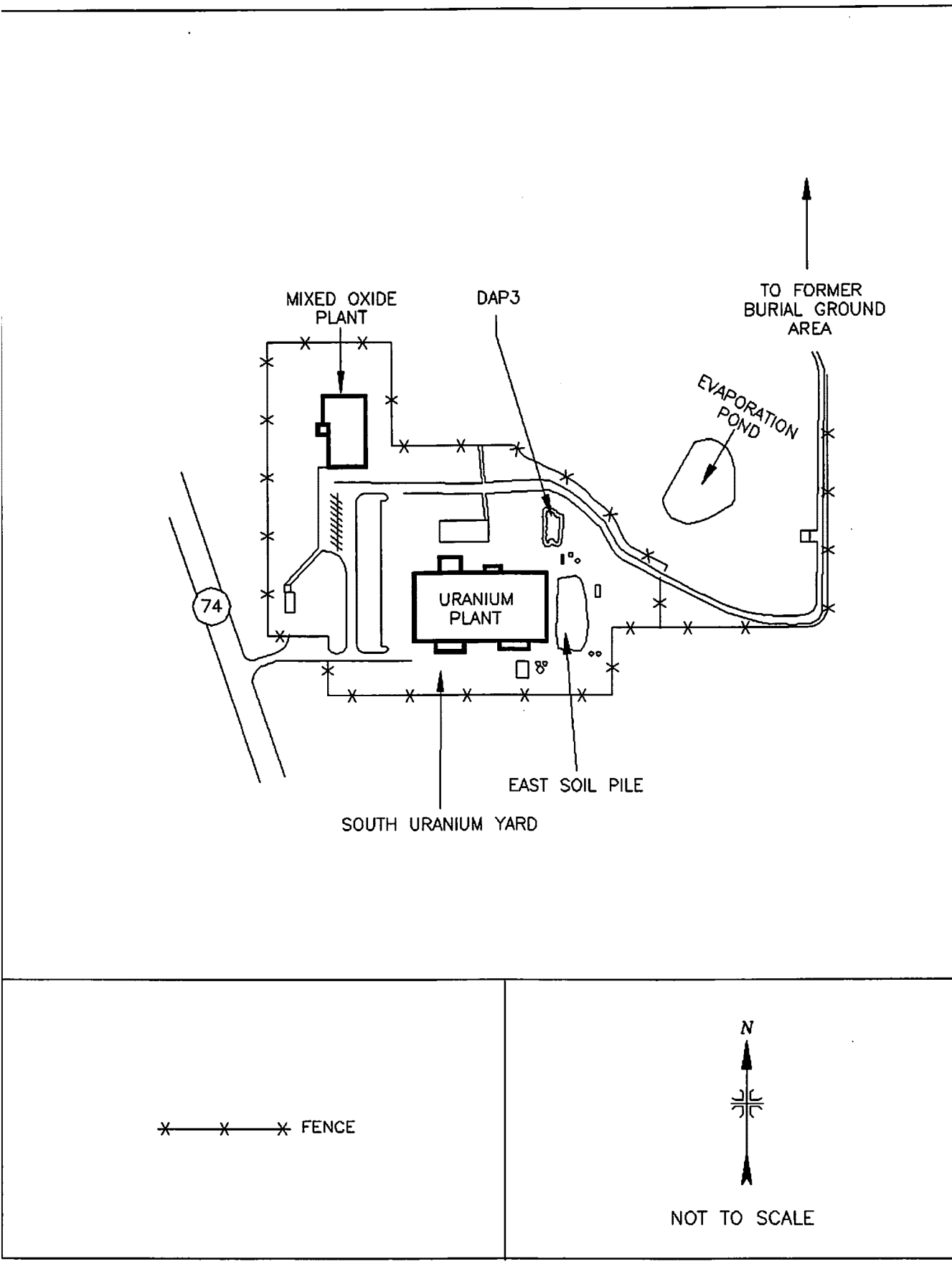
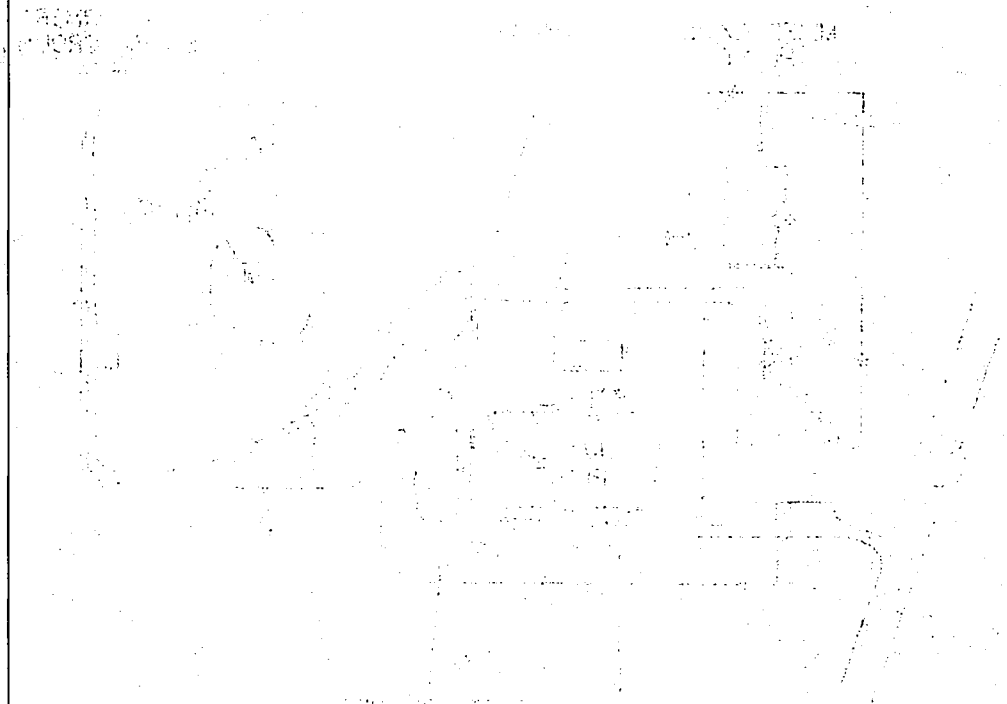


FIGURE 2: The Cimarron Facility – Plot Plan



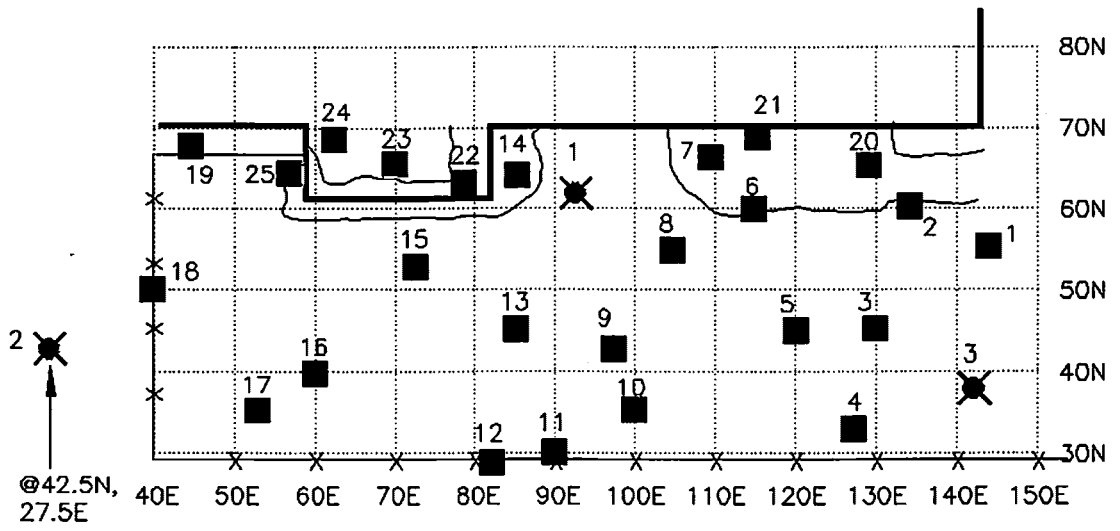


FIGURE 3: South Uranium Yard – Measurement and Sampling Locations

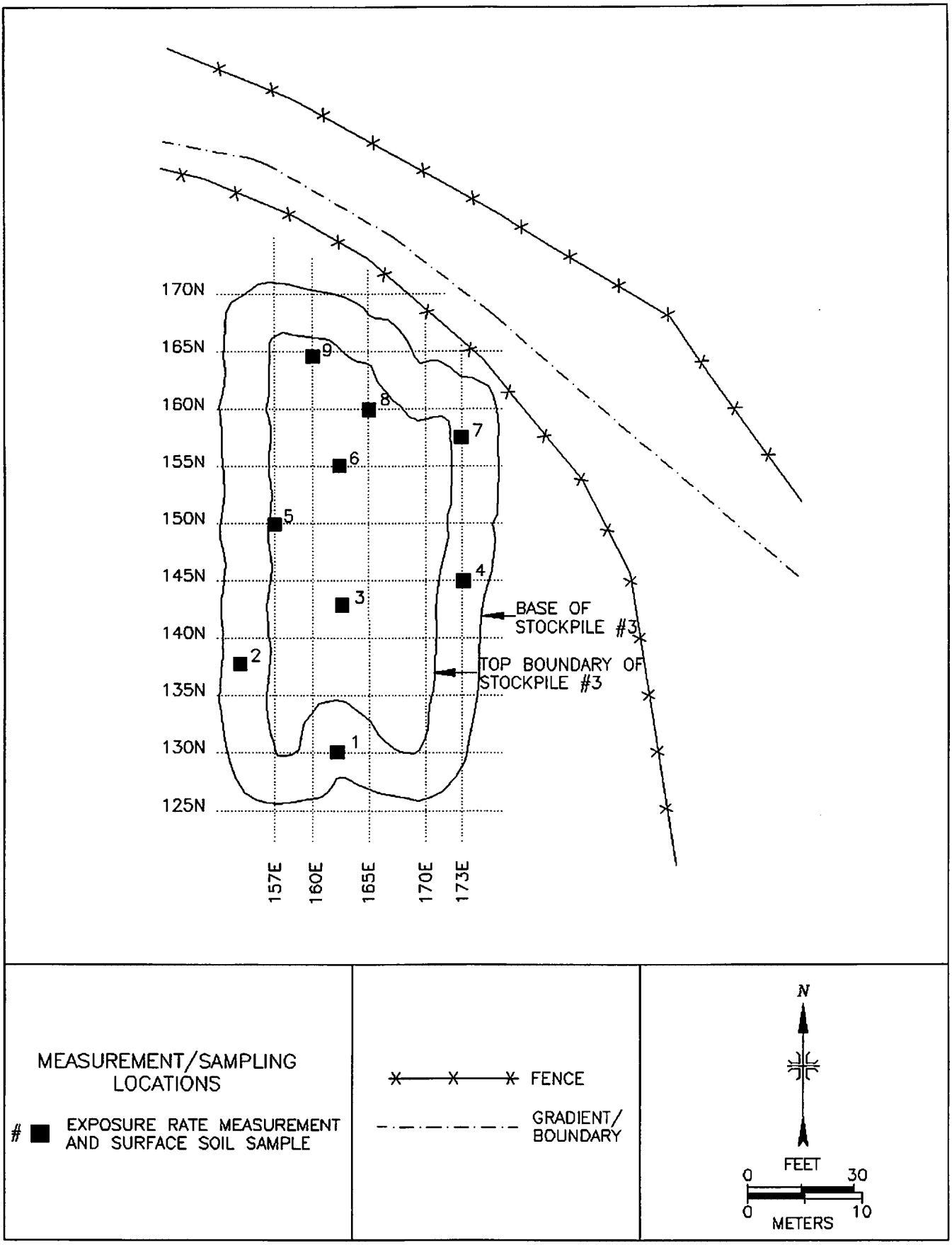
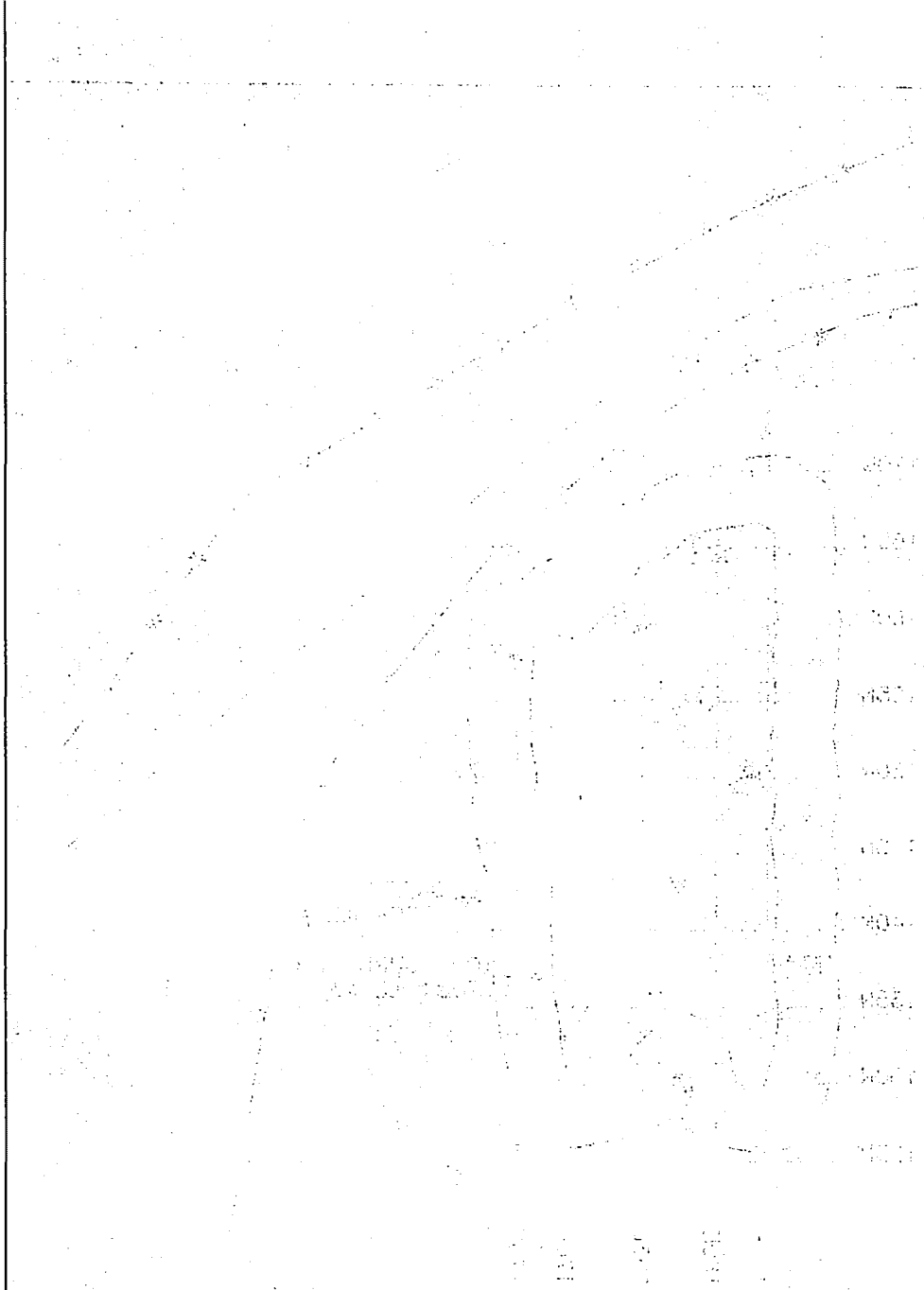


FIGURE 4: Designated Area Pile #3 – Measurement and Sampling Locations



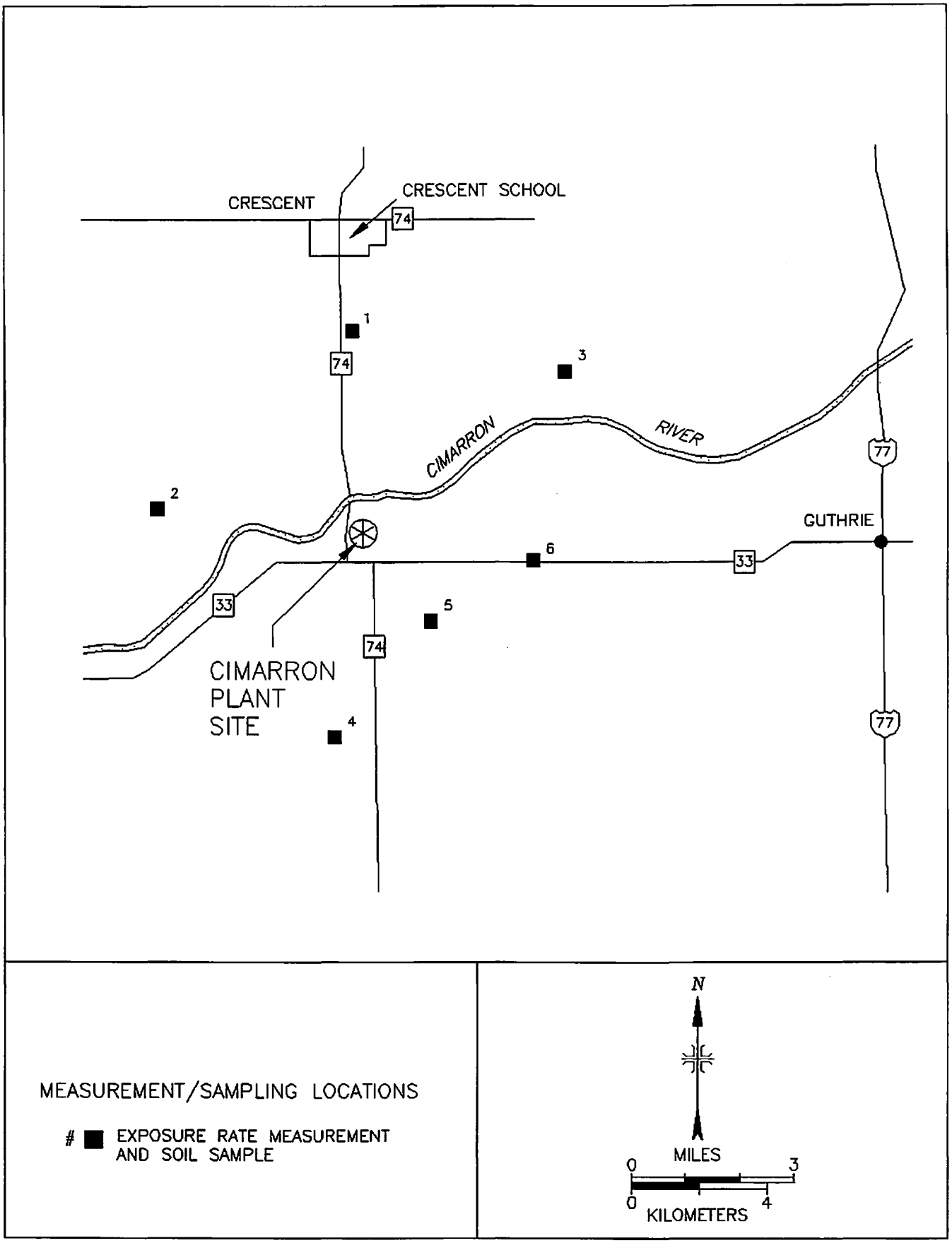


FIGURE 5: Cimarron Site – Background Measurement and Sampling Locations

TABLE 1

URANIUM CONCENTRATIONS IN SOIL SAMPLES (USING GAMMA SPECTROMETRY) KERR-McGEE CORPORATION,CIMARRON FACILITY CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)		
	U-238	U-235	Total Uranium[a]
South Uranium Yard - Surface Soil[b]			
1	3.8 ± 0.9[c]	0.9 ± 0.1	22.3
2	3.3 ± 0.8	0.5 ± 0.1	14.2
3	3.1 ± 0.8	0.7 ± 0.1	16.4
4	4.3 ± 0.9	0.7 ± 0.1	18.2
5	1.5 ± 0.9	0.2 ± 0.1	6.5
6	5.6 ± 1.1	1.2 ± 0.1	29.6
7	1.1 ± 0.9	<0.1	3.2
8	3.2 ± 1.2	0.7 ± 0.1	17.6
9	3.5 ± 1.1	0.7 ± 0.1	18.0
10	0.9 ± 0.7	<0.1	2.9
11	1.9 ± 1.0	<0.1	3.4
12	1.2 ± 0.7	<0.1	2.7
13	1.9 ± 0.7	0.3 ± 0.1	8.4
14	1.4 ± 0.8	<0.1	2.9

TABLE 1 (Continued)

URANIUM CONCENTRATIONS IN SOIL SAMPLES
(USING GAMMA SPECTROMETRY)
KERR-MCGEE CORPORATION, CIMARRON FACILITY
CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)		
	U-238	U-235	Total Uranium[a]
15	1.9 ± 0.8	<0.1	3.5
16	3.4 ± 1.2	0.4 ± 0.1	12.3
17	1.5 ± 0.7	0.3 ± 0.1	6.9
18	2.9 ± 1.0	0.6 ± 0.1	15.6
19	2.1 ± 0.9	<0.1	3.8
20	4.4 ± 1.1	0.7 ± 0.1	19.2
21	2.6 ± 1.1	<0.1	4.6
22	3.0 ± 1.0	0.5 ± 0.1	12.3
23	4.5 ± 1.0	0.6 ± 0.1	17.1
24	1.9 ± 0.9	0.4 ± 0.1	9.6
25	1.5 ± 1.3	<0.1	3.4
Average for South Uranium Yard-Surface Soil			11
South Uranium Yard - Subsurface Soil[b]			
#1 (0 - 15 cm)	6.9 ± 1.1	1.5 ± 0.1	38.4
#1 (35 - 50 cm)	2.6 ± 1.2	<0.1	4.0

TABLE 1 (Continued)

URANIUM CONCENTRATIONS IN SOIL SAMPLES
(USING GAMMA SPECTROMETRY)
KERR-MCGEE CORPORATION, CIMARRON FACILITY
CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)		
	U-238	U-235	Total Uranium[a]
#1 (85 -100 cm)	1.6 ± 0.9	<0.1	3.5
#1 (135 - 150 cm)	1.3 ± 1.0	<0.1	2.8
#2 (0 - 15 cm)	3.9 ± 1.2	0.7 ± 0.1	18.2
#2 (35 - 50 cm)	0.8 ± 0.9	<0.1	2.2
#2 (85 - 100 cm)	0.3 ± 0.6	<0.1	1.2
#3 (0 - 15 cm)	3.8 ± 0.9	0.7 ± 0.1	18.8
#3 (35 - 50 cm)	1.0 ± 0.5	0.2 ± 0.1	4.2
#3 (85 - 100 cm)	0.7 ± 0.6	<0.1	2.2
Average for South Uranium Yard-Subsurface Soil			9.5
DAP-3 Soil Pile[d]			
1	5.1 ± 1.3	1.2 ± 0.1	29.7
2	5.4 ± 1.4	1.8 ± 0.1	41.8
3	3.8 ± 1.1	0.7 ± 0.1	19.1
4	3.5 ± 1.0	0.9 ± 0.1	21.6
5	4.7 ± 1.2	1.2 ± 0.1	28.5

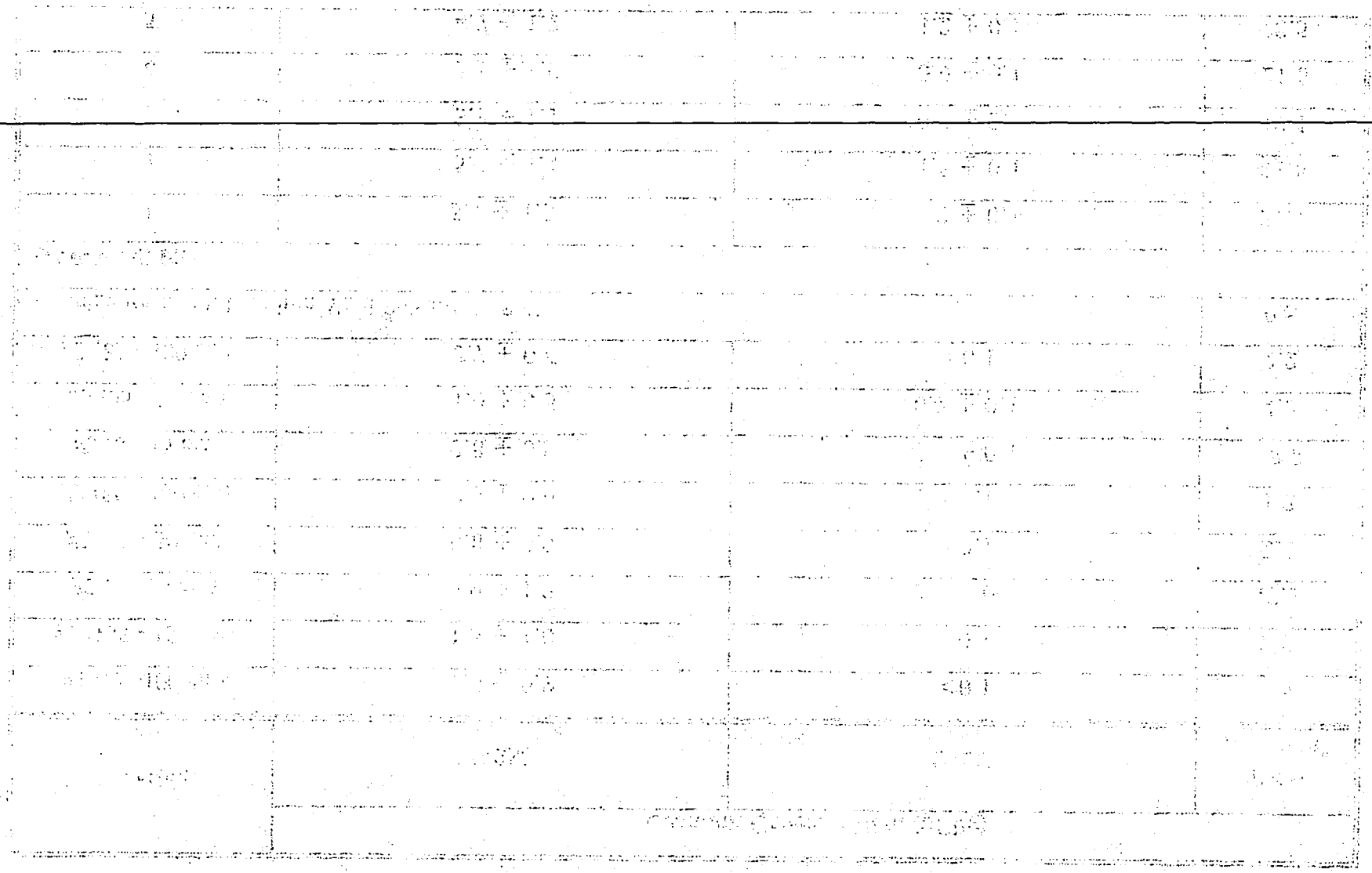


TABLE 1 (Continued)

URANIUM CONCENTRATIONS IN SOIL SAMPLES
(USING GAMMA SPECTROMETRY)
KERR-MCGEE CORPORATION, CIMARRON FACILITY
CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)		
	U-238	U-235	Total Uranium[a]
6	6.2 ± 1.2	1.3 ± 0.1	33.2
7	4.1 ± 1.1	1.2 ± 0.1	29.3
8	6.5 ± 1.0	1.5 ± 0.1	37.1
9	4.1 ± 1.0	0.7 ± 0.1	18.7
Average for DAP-3 Soil Pile			29
Background Soil Samples[e,f]			
1	0.4 ± 0.4	<0.1	0.8
2	0.4 ± 0.5	<0.1	0.9
3	0.5 ± 0.4	<0.1	1.0
4	1.1 ± 0.6	<0.1	2.2
5	1.1 ± 0.7	<0.1	2.3
6	1.1 ± 0.6	<0.1	2.2
Average for Background Soil Samples			1.6

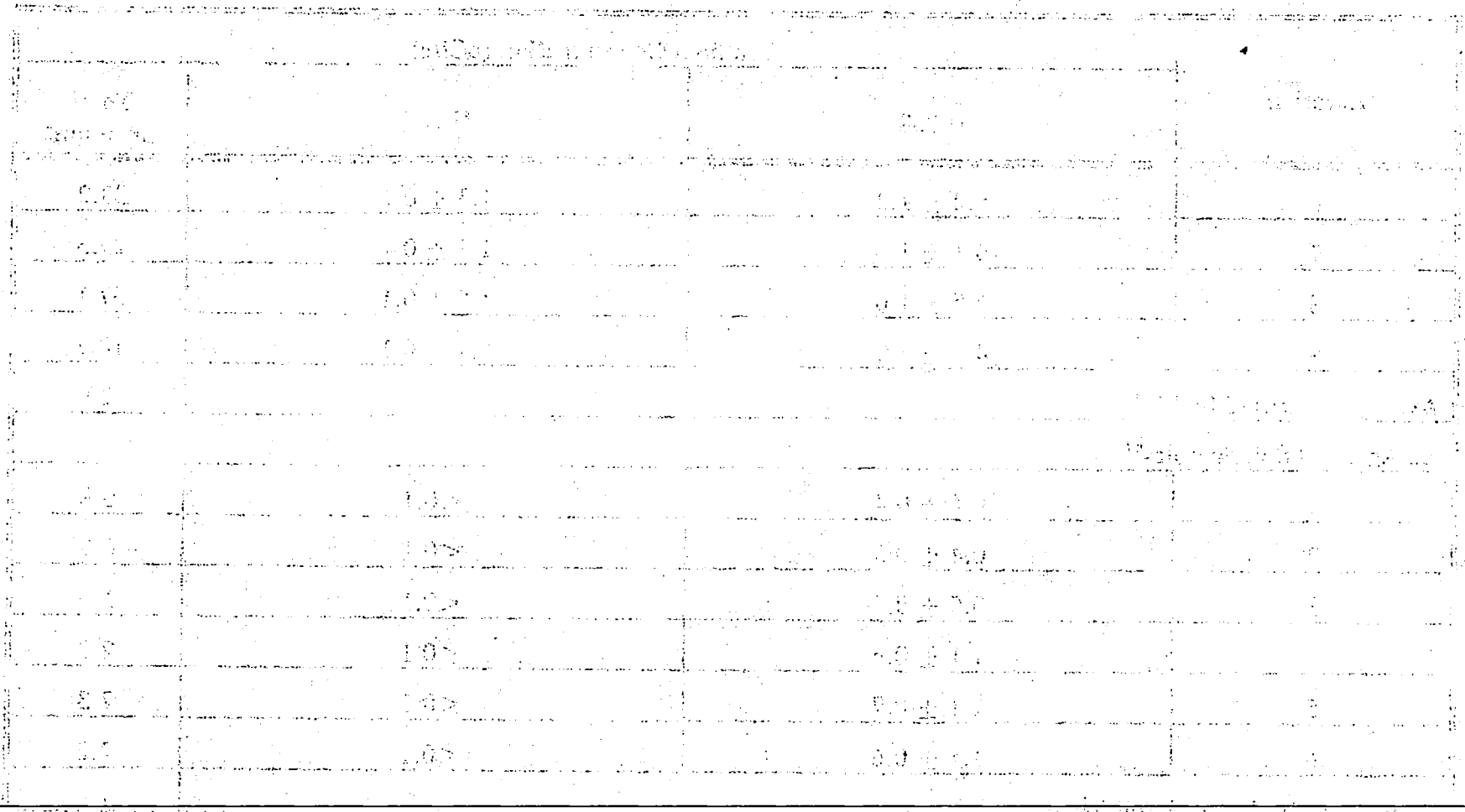


TABLE 1 (Continued)

URANIUM CONCENTRATIONS IN SOIL SAMPLES (USING GAMMA SPECTROMETRY) KERR-MCGEE CORPORATION, CIMARRON FACILITY CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)			
	U-238	U-235	Total Uranium[a]	
			ESSAP	Licensee
Confirmatory Analyses				
#212	35.87 ± 1.39	7.69 ± 0.12	195.1	215
#153	21.30 ± 0.98	3.58 ± 0.07	95.4	99
#147	162.90 ± 1.91	30.75 ± 0.20	799.4	786
#457	8.46 ± 1.03	10.85 ± 0.15	233.1	249
#453	16.67 ± 0.64	4.79 ± 0.08	115.8	135
#420	21.67 ± 0.91	11.39 ± 0.12	257.4	197

[a]Total uranium was calculated by the sum of U-238, U-235, and U-234, using an U-234:U-235 activity ratio of 20, based on alpha spectrometry results.
[b]Refer to Figure 3.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Refer to Figure 4.
[e]Refer to Figure 5.
[f]Total uranium concentrations for background samples are based on natural isotopic abundances.

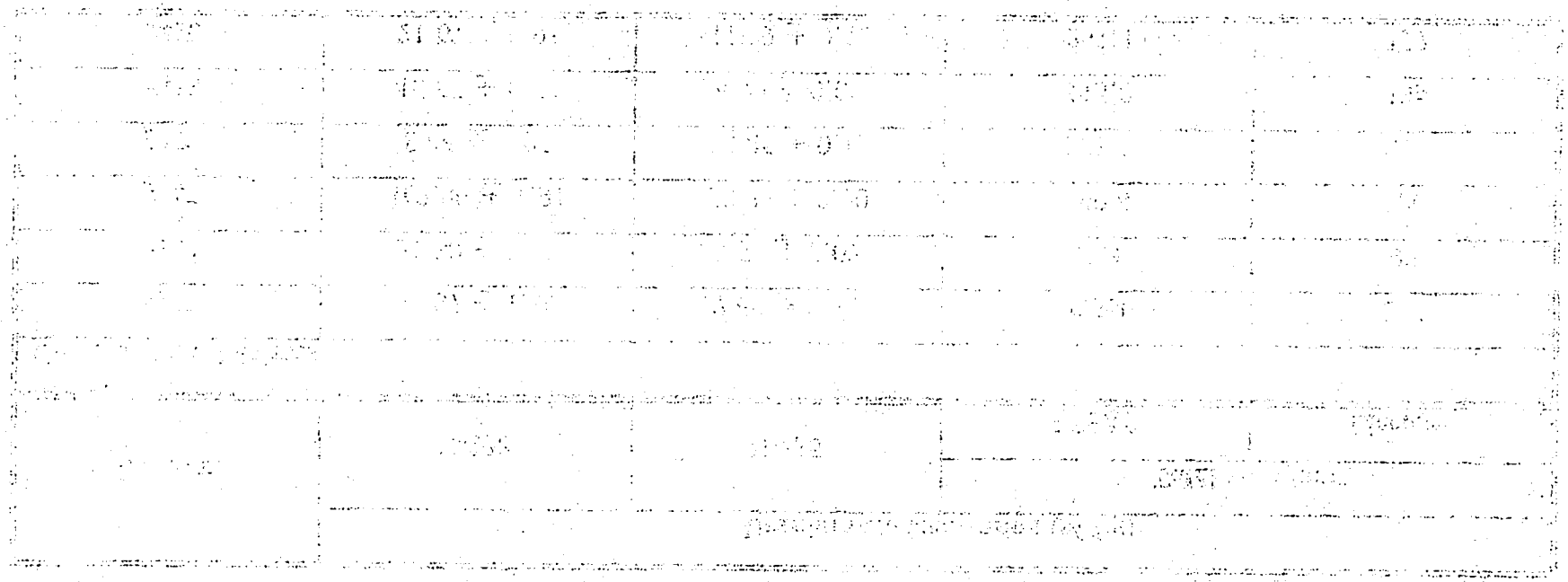
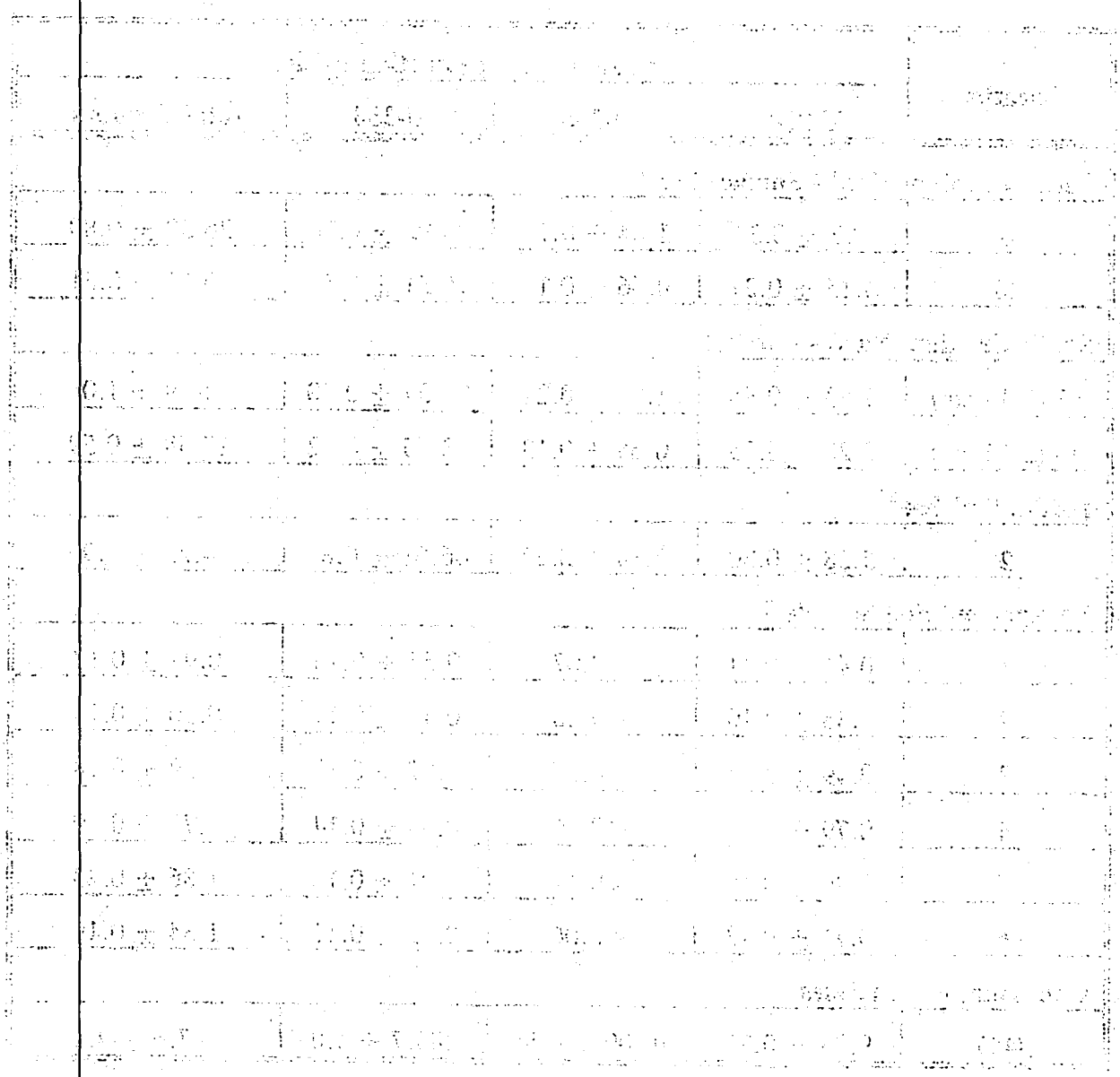


TABLE 2
ISOTOPIC URANIUM CONCENTRATIONS
IN SOIL SAMPLES
KERR-MCGEE CORPORATION, CIMARRON FACILITY
CRESCENT, OKLAHOMA

Location	Uranium Concentration (pCi/g)			
	U-238	U-235	U-234	Total Uranium[a]
South Uranium Yard - Surface Soil[b]				
6	4.57 ± 0.33[c]	1.04 ± 0.18	20.92 ± 0.70	26.52 ± 0.80
20	4.15 ± 0.27	0.66 ± 0.12	15.31 ± 0.53	20.12 ± 0.61
South Uranium Yard - Borehole[b]				
#1 (0-15 cm)	7.53 ± 0.44	1.81 ± 0.24	31.54 ± 0.90	40.9 ± 1.0
#3 (0-15 cm)	3.28 ± 0.25	0.65 ± 0.13	13.65 ± 0.52	17.58 ± 0.59
DAP-3 Soil Pile[d]				
2	5.28 ± 0.30	2.34 ± 0.22	46.61 ± 0.89	54.23 ± 0.96
Background Soil Samples[e]				
1	0.41 ± 0.11	<0.07	0.55 ± 0.13	0.97 ± 0.18
2	0.38 ± 0.10	<0.08	0.42 ± 0.11	0.80 ± 0.15
3	0.49 ± 0.11	<0.07	0.57 ± 0.13	1.09 ± 0.18
4	0.79 ± 0.13	<0.06	0.90 ± 0.14	1.72 ± 0.19
5	0.90 ± 0.15	<0.11	0.91 ± 0.16	1.86 ± 0.23
6	0.71 ± 0.13	<0.06	0.59 ± 0.12	1.34 ± 0.19
Confirmatory Analyses				
#457	9.93 ± 0.75	10.00 ± 0.86	283.7 ± 4.0	303.6 ± 4.2

[a]Total uranium calculated based on the sum of U-238, U-235, and U-234.
[b]Refer to Figure 3.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.
[d]Refer to Figure 4.
[e]Refer to Figure 5.



REFERENCES

Cimarron Corporation, "Report of Characterization of Option 2 Stockpiled Soil," prepared by Karen Morgan, May 4, 1994a.

Cimarron Corporation, "Report on the South Uranium Yard Remediation at the Cimarron Facility," November 1994b.

Oak Ridge Institute for Science and Education, "Confirmatory Survey of the Cimarron Corporation Mixed Oxide Fuel Fabrication Plant, Crescent, Oklahoma," January 1991a.

Oak Ridge Institute for Science and Education, "Confirmatory Radiological Survey of the Sanitary Lagoons at the Cimarron Corporation Facility, Crescent, Oklahoma," November 1991b.

Oak Ridge Institute for Science and Education, "Confirmatory Radiological Survey of Two Soil Piles Proposed for On-Site Storage, Kerr-McGee Corporation, Cimarron Facility, Crescent, Oklahoma," October 1994.

Oak Ridge Institute for Science and Education, "Confirmatory Survey Plan for the South Uranium Yard Remediation, Kerr-McGee Corporation, Cimarron Facility, Crescent, Oklahoma (Docket No. 79-925)," April 19, 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

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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

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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 probe and the surface was maintained at a minimum. The boreholes were also scanned for elevated direct radiation. 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. Samples from boreholes were collected from the surface (0-15 cm), the center (85-100 cm), and the bottom (185-200 cm) of each borehole. 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*

*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 participated with barium sulfate. Barium sulfate participate 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 activity (MDA), 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 MDA of the measurement procedure, the result was reported as less than MDA. 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 8 (December, 1993)
- 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

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 (pCi/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.