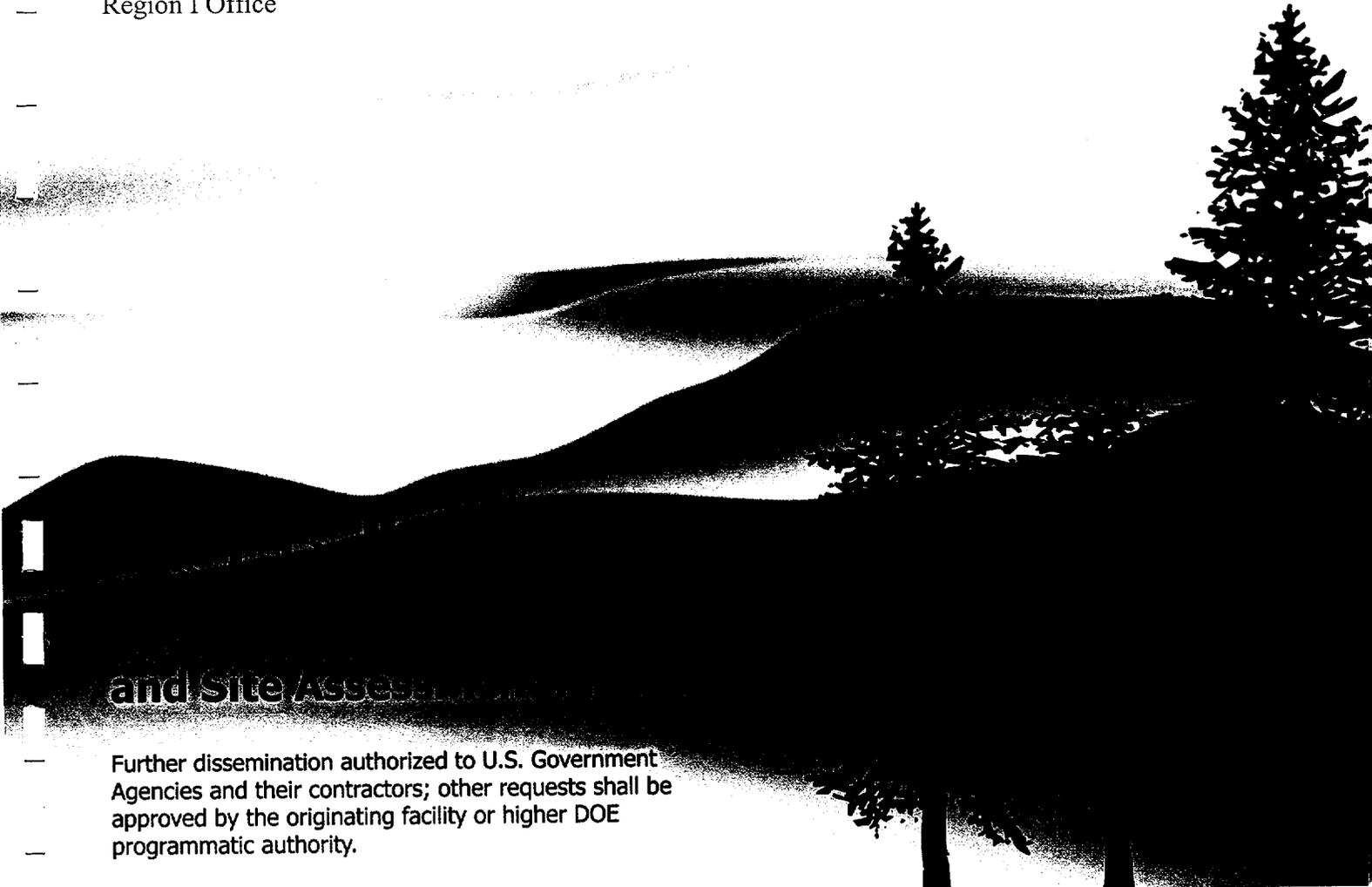


**CONFIRMATORY SURVEY
OF PORTIONS OF THE
HERITAGE MINERALS, INC., FACILITY
LAKEHURST, NEW JERSEY
PHASE 2**

J. R. MORTON AND W. C. ADAMS

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



and Site Assessment

Further dissemination authorized to U.S. Government
Agencies and their contractors; other requests shall be
approved by the originating facility or higher DOE
programmatic authority.

**CONFIRMATORY SURVEY
OF PORTIONS OF THE
HERITAGE MINERALS, INC., FACILITY
LAKEHURST, NEW JERSEY
PHASE 2**

Prepared by

J. R. Morton and W. C. Adams

Environmental Survey and Site Assessment Program
Radiological Safety, Assessments and Training
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

Prepared for the

U.S. Nuclear Regulatory Commission
Division of Waste Management
Region I Office

FINAL REPORT

DECEMBER 2003

This report is based on work performed under an Interagency Agreement (NRC Fin. No. J-5403) 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-AC05-00OR22750 with the U.S. Department of Energy.

**CONFIRMATORY SURVEY
OF PORTIONS OF THE
HERITAGE MINERALS, INC., FACILITY
LAKEHURST, NEW JERSEY
PHASE 2**

Prepared by: Wade C. Adams Date: 12/1/2003
W. C. Adams, Project Leader
Environmental Survey and Site Assessment Program

Prepared by: J. R. Morton Date: 12/1/03
J. R. Morton, Field Survey Team Leader
Environmental Survey and Site Assessment Program

Reviewed by: T. J. Vitkus Date: 12/1/2003
T. J. Vitkus, Survey Projects Manager
Environmental Survey and Site Assessment Program

Reviewed by: R. D. Condra Date: 12/2/03
R. D. Condra, Laboratory Manager
Environmental Survey and Site Assessment Program

Reviewed by: A. T. Payne Date: 12/4/03
A. T. Payne, Quality Manager
Environmental Survey and Site Assessment Program

Reviewed by: E. W. Abelquist Date: 12/2/03
E. W. Abelquist, Program Director
Environmental Survey and Site Assessment Program

ACKNOWLEDGMENTS

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

FIELD STAFF

T. L. Brown

LABORATORY STAFF

E. M. Ball
R. D. Condra
J. S. Cox
W. P. Ivey

CLERICAL STAFF

D. K. Herrera
K. L. Pond
A. Ramsey

ILLUSTRATOR

T. L. Brown
T. D. Herrera

TABLE OF CONTENTS

	<u>PAGE</u>
List of Figures	ii
List of Tables	iii
Abbreviations and Acronyms.....	iv
Introduction and Site History	1
Site Description.....	3
Objectives	3
Document Review.....	4
Procedures.....	4
Sample Analysis and Data Interpretation.....	5
Findings and Results	6
Comparison of Results with Guidelines	7
Summary	8
Figures.....	10
Tables.....	18
References.....	23
Appendices:	
Appendix A: Major Instrumentation	
Appendix B: Survey and Analytical Procedures	
Appendix C: Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material	
and	
Guidelines for Residual Concentrations of Thorium and Uranium Wastes in Soil	

LIST OF FIGURES

	<u>PAGE</u>
FIGURE 1: Location of the Heritage Minerals Site—Lakehurst, New Jersey	11
FIGURE 2: Heritage Minerals Site, Lakehurst, New Jersey	12
FIGURE 3: Heritage Minerals Site—Surveyed Area.....	13
FIGURE 4: Dry Mill Pad—Measurement and Sampling Locations	14
FIGURE 5: Wet Mill Pad—Measurement and Sampling Locations.....	15
FIGURE 6: Land Area Surveys—Measurement and Sampling Locations.....	16
FIGURE 7: Background Measurement and Sampling Locations.....	17

LIST OF TABLES

	<u>PAGE</u>
TABLE 1: Summary of Surface Activity Levels	19
TABLE 2: Exposure Rates and Radionuclide Concentrations in Soil Samples	20

ABBREVIATIONS AND ACRONYMS

ϵ_i	instrument efficiency
ϵ_s	surface efficiency
ϵ_{total}	total efficiency
b_i	background counts in the observation interval
$\mu R/h$	microrentgen per hour
$\mu rem/h$	microrem per hour
BKG	background
cm	centimeter
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurements Laboratory
ENERCON	ENERCON Services, Inc.
ESSAP	Environmental Survey and Site Assessment Program
FSS	final status survey
ha	hectare
HMI	Heritage Minerals, Inc.
ISO	International Standards Organization
ITP	Intercomparison Testing Program
JHA	job hazard analysis
keV	kiloelectron volts
kg	kilogram
km	kilometer
m	meter
MAPEP	Mixed Analyte Performance Evaluation Program
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electron volts
min	minute
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NORM	naturally occurring radioactive material
NRC	Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
RA	remedial action
RSI	Radiation Sciences, Inc.
s	second

**CONFIRMATORY SURVEY
OF PORTIONS OF THE
HERITAGE MINERALS, INC., FACILITY
LAKEHURST, NEW JERSEY
PHASE 2**

INTRODUCTION AND SITE HISTORY

From 1973 to 1982, the Heritage Minerals, Inc. site was operated by ASARCO, Incorporated. ASARCO's operations consisted of hydraulic mining (dredging) of sand deposits and processing these sands to extract the titanium mineral, ilmenite. ASARCO's process involved bringing in raw materials and pumping the materials to a land-based processing plant where the heavy metals were concentrated using spiral separators. The Wet Mill Tailings were pumped back to a dredge pond as backfill. The heavy metals which followed a different path, were dewatered and then fed onto a conveyor belt and heated until completely dried. The heated material was then conveyed to the Dry Mill where the ilmenite was removed and placed in storage bins for shipping to customers. The non-conductor minerals, referred to as the Dry Mill Tailings, containing virtually all of the monazite material, were then mixed with water and pumped to a storage area east of the mill. ASARCO discontinued all operations at the site in 1982 and the property was sold to Heritage Minerals, Inc. (HMI) in 1986 (RSI 1997).

When HMI began operations, the Dry Mill Tailings, containing the monazite, were reprocessed through the mill to produce market-grade zircon with some monazite impurities. The remaining product, containing the majority of the monazite, was then combined with the other tailings to make up the plant tailings which were then pumped to a storage area (RSI 1997).

In March 1990, HMI decided that sufficient zircon and titanium products remained in the plant tailings to warrant a second round of processing known as Phase II of the operation. This phase involved the isolation of the monazite-rich tailings which were then stored in an area southeast of the Dry Mill known as the Monazite Pile. In August 1990, after about 200,000 tons of tailings were processed through the plant, HMI decided to terminate all operations due to the economic turnaround which resulted in a reduced demand for plant products (RSI 1997).

The reprocessing of the 200,000 tons of plant tailings resulted in producing about 150,000 tons of tailings that were relatively monazite free. These tailings were stored separately from the

Monazite Pile. As a result, approximately 1,400 tons of monazite-rich product were generated and were stored in the Monazite Pile. The Monazite Pile and the plant buildings were under control of the U.S. Nuclear Regulatory Commission (NRC) according to terms of License No. SMB-1541 because of the thorium and uranium concentrations within the monazite.

After the plant shutdown in August 1990 a gamma survey was performed within both mills and on selected pieces of equipment which were known to have been in contact with the monazite-containing product. Direct measurements were also performed on selected pieces of equipment (wet tables, dryer, and dry magnets). These survey activities were performed in January 1991 (RSI 1997).

Radiation Sciences, Inc. (RSI), the previous decommissioning contractor to HMI, performed a survey of the natural background levels of uranium and thorium within the soils and measured background exposure rates in 1996 (RSI 1996). This information was used to correct final survey soil sample and exposure rate data. RSI then performed decommissioning of the Wet and Dry Mills and the Monazite Pile and provided the results of their final status surveys (FSS) to the NRC in December 2001 (RSI 2001).

At the request of the NRC, the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed confirmatory survey activities at the site in December 2001. The results of those activities indicated the surface activity levels in the Wet and Dry Mills and soil radionuclide concentrations in the Monazite Pile and other soil areas were in excess of the guideline levels (ORISE 2002). As a result, the NRC determined that further decommissioning activities were warranted.

HMI committed to the removal of all licensable quantities of source material prior to license termination and calculated a soil concentration for licensable material at 116 pCi/g of total thorium. "Fugitive" licensable material was then defined as any licensable material found outside of the Monazite Pile area; hence, the trench area was considered a fugitive materials area.

The new site decommissioning contractor, ENERCON Services, Inc. (ENERCON), performed further remediation activities in the Monazite Pile area and a trench area that was identified during the previous ESSAP confirmatory survey activities. The Monazite Pile and the trench

areas were remediated to less than 10 pCi/g for total thorium and 10 pCi/g for total uranium. Approximately 300 additional tons of contaminated soils were removed from the site, the excavated areas were backfilled with clean sand, and ENERCON issued a report on their field activities documenting their decommissioning efforts for the soil contamination (ENERCON 2003). Final surveys of materials located outside these areas indicated that all licensable material was removed (ENERCON 2003).

ENERCON also remediated and dismantled the Wet and Dry Mills and disposed of the buildings' construction components so that only the slabs remained. Some support buildings, however, are still being used for equipment storage and office space.

The NRC's Division of Waste Management and Region I requested that the ESSAP of ORISE perform radiological confirmatory survey activities on various land areas and the remaining Wet and Dry Mill slabs of the HMI facility in Lakehurst, New Jersey.

SITE DESCRIPTION

HMI is located in Lakehurst, New Jersey and is approximately 50 kilometers [km (30 miles)] southeast of downtown Trenton, New Jersey (Figures 1 and 2). The HMI facility once consisted of two large milling buildings known as the Wet and Dry Mills and other support and laboratory buildings occupying approximately 2,800 hectares [ha (7,000 acres)]. With the dismantling of the mills, the two concrete pads still remain (Figure 3). The remaining buildings on the property are the Maintenance, Warehouse, Main Office, and Change House buildings. The site is bounded on the north and west by Route 70, the east by Route 37 and to the south by two residential areas and Pinewald Keswick Road.

OBJECTIVES

The objectives of the radiological confirmatory survey were to provide independent contractor field data reviews and radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's field activities relative to established guidelines. Information was gathered and survey data were collected to evaluate the facility's current radiological status as reported by the licensee.

DOCUMENT REVIEW

ESSAP reviewed the final survey data and used the information gathered from that review to plan the confirmatory survey activities (ENERCON 2003).

PROCEDURES

ESSAP personnel visited the HMI facility during the period of September 8 through 10, 2003 and performed visual inspections and independent measurements and sampling of portions of the site. Survey activities were conducted in accordance with a site-specific survey plan and the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 2003a, b and c). Survey activities included alpha plus beta and gamma surface scans, direct measurements, soil sampling, and exposure rate measurements.

REFERENCE SYSTEM

Measurements and sampling locations were referenced on ESSAP maps generated from the previous survey activities (ORISE 2002).

SURFACE SCANS

Surface scans for alpha plus beta and gamma radiation were performed on 20% of the concrete pads where the mills once stood. Particular attention was given to openings, cracks, and joints in the pads where material may have accumulated. Gamma scans were conducted over 100% of accessible soil surfaces within and in the immediate vicinity of the Monazite Pile and trench areas, including the re-excavated locations within the trench and Monazite Pile where ENERCON had already backfilled their final depth sampling locations. Gamma scans were also performed over approximately 50% of the soil areas surrounding the former mill facilities. Scans were performed using gas proportional and NaI scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation detected by surface scans were marked for further investigation—to include additional surface scans, as deemed necessary to delineate contamination boundaries and for possible soil sampling.

SURFACE ACTIVITY MEASUREMENTS

Construction material specific backgrounds were collected and used to correct gross surface activity measurements. Direct measurements of alpha and beta surface activity were performed at a total of ten locations on each concrete pad (Figures 4 and 5). All of the direct measurements were performed using gas proportional detectors coupled to ratemeter-scalers.

SOIL SAMPLING

Thirty-eight soil samples were collected from the entire NRC-licensed materials area including the Monazite Pile and trench excavations and from existing penetrations in the Wet Mill Pad and from ENERCON-bored locations in the Dry Mill Pad (Figures 4 through 6). Surface (0 to 15 cm) soil samples were collected at the locations of maximum elevated direct radiation identified by surface scans around the remainder of the site. Subsurface soil samples were collected if elevated radiation was suspected to be present below the initial 15 centimeters of exposed soils. Three additional samples were collected from the waste soil pile located south of the former Dry Mill (Figure 6). The waste pile consisted of the recovered wash water and sand from the Wet Mill Pad which was used as the staging area during the remediation of the Wet and Dry Mill building structures and process equipment components. Background soil samples were collected from six locations within a 0.5 to 10 km radius of the site during the previous ESSAP survey activities (Figure 7).

EXPOSURE RATE MEASUREMENTS

Site exposure rates were measured at each soil sample location at one meter above the surface using a micro-rem meter. Background exposure rate measurements were collected from the six previous background soil sampling locations (Figure 7).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 2003d). Soil samples were analyzed by gamma spectroscopy and results reported in units of picocuries per gram (pCi/g). The

radionuclides of interest were uranium and thorium; however, spectra were reviewed for other identifiable photopeaks. Direct measurement data were converted to units of disintegrations per minute per one hundred square centimeters (dpm/100 cm²). Exposure rates were reported in microroentgens per hour (μ R/h). Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B.

FINDINGS AND RESULTS

SURFACE SCANS

Gamma scans conducted over the concrete pads and soil areas identified multiple locations of elevated gamma radiation. Seven locations of elevated alpha plus beta activity were detected during scans of the Dry and Wet Mill pads.

SURFACE ACTIVITY MEASUREMENTS

Results of total alpha and total beta surface activity levels for the concrete pads are summarized in Table 1. Initial total activity levels for the Wet Mill ranged from -9 to 640 dpm/100 cm² for alpha and from -94 to 6,700 dpm/100 cm² for beta. Initial total activity levels for the Dry Mill ranged from -9 to 130 dpm/100 cm² for alpha and from -53 to 2,400 dpm/100 cm² for beta. ENERCON was notified of the elevated beta readings and chose to perform additional remedial actions (RA) while ESSAP was still on-site. After post-RA activities, beta activity levels ranged from -94 to 3,400 dpm/100 cm² and -53 to 1,100 dpm/100 cm² for the Wet and Dry Mills, respectively.

EXPOSURE RATE MEASUREMENTS

Site and background exposure rates are summarized in Table 2. Site exposure rates ranged from 8 to 130 μ R/h. Background exposure rates ranged from 3 to 7 μ R/h and averaged 4 μ R/h (ORISE 2002).

RADIONUCLIDE CONCENTRATIONS IN SOIL

Radionuclide concentrations in soil samples are also summarized in Table 2. The radionuclide concentrations for individual samples ranged as follows: -1.5 to 190 pCi/g for total uranium and

0.65 to 775 pCi/g for total thorium. Radionuclide concentrations in background samples ranged as follows: 0.5 to 2.3 pCi/g for total uranium and 0.3 to 1.0 pCi/g for total thorium.

COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminants at this site are thorium and uranium. The applicable NRC guidelines at HMI for natural thorium and natural uranium total surface activity levels are (NRC 1987):

Natural Uranium

5,000 α dpm/100 cm², averaged over a 1 m² area

15,000 α dpm/100 cm², total, maximum in a 100 cm² area

Natural Thorium

1,000 dpm/100 cm², averaged over a 1 m² area

3,000 dpm/100 cm², total, maximum in a 100 cm² area

ESSAP used the more restrictive guidelines for thorium contamination. Natural thorium emits both alpha and beta radiations, therefore, either alpha or beta radiation may be measured for determining the residual activity of the thorium contaminant. As interpreted by the NRC, the average 1,000 dpm/100 cm² and maximum 3,000 dpm/100 cm² guideline should apply independently to both alpha and beta measurements for surface contamination involving natural thorium (NRC 1992). ESSAP's experience has shown that beta measurements typically provide a more accurate evaluation of thorium contamination on structural surfaces due to problems inherent in measuring alpha contamination on rough, porous, and/or dirty surfaces. For the thorium series in secular equilibrium, the activity level providing 1,000 alpha dpm/100 cm² would result in about 670 beta dpm/100 cm². Therefore, a beta activity measurement that is greater than 670 dpm/100 cm² was considered to have exceeded the average alpha activity guideline for thorium while a beta activity measurement of 2,000 dpm/100 cm² corresponded to the maximum alpha guideline for thorium. Of the 20 initial direct measurements that were performed for beta activity, seven locations exceeded the maximum activity (>2,000 dpm/100 cm² for beta) and two locations exceeded the average activity (>670 dpm/100 cm² for beta). These locations were reported to ENERCON. Prior to the end of the confirmatory survey, further decontamination activities performed by ENERCON lowered the radioactivity levels to where

only one measurement location exceeded the maximum and two exceeded the average guideline. Due to time constraints, these areas were not remediated immediately, but were pointed out to ENERCON and remediated appropriately at a later date.

The exterior exposure rate guideline is 10 μ R/h above background with the average site background being 4 μ R/h (NRC 1991). Thirty-three of the 41 on-site exposure rates exceeded this guideline.

The soil remediation guidelines are as follows (NRC 1981 and 1983):

<u>Radionuclide</u>	<u>Soil Concentration Above Background (pCi/g)</u>
Total uranium in excavated areas	10
Total thorium in excavated areas	10

For areas where fugitive thorium source material was found, HMI committed to removal of material above the licensable concentration of 116 pCi/g.

Of the 41 surface and subsurface soil samples that were collected from the Heritage site, 34 exceeded the guideline of 10 pCi/g for total uranium. There were 17 soil samples collected from the Monazite Pile and trench areas of which 15 exceeded the total thorium guideline of 10 pCi/g. The three samples collected from the waste pile each had total uranium and thorium concentrations greater than 10 pCi/g. Twenty-one soil samples were collected from the "fugitive" areas (surrounding land areas and beneath the Wet and Dry Mill pads) of which six exceeded the licensable quantity concentration of 116 pCi/g for total thorium.

SUMMARY

The Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education performed confirmatory survey activities on portions of the HMI site in Lakehurst, N.J. during the period of September 8 through 10, 2003. Areas included in the scope of the survey were the Wet and Dry Mill concrete pads and the soil areas surrounding the mill operations, including the former Monazite Pile and the trench of licensable material that was discovered during previous ESSAP confirmatory surveys (ORISE 2002). Survey activities included a review of the final survey report and performance of independent gamma and alpha

plus beta scans, direct surface activity measurements, exposure rate measurements, and soil sampling.

The results of the confirmatory activities indicated that some surface activity levels on the concrete pads still exceeded the applicable NRC guidelines. However, the decommissioning contractor, ENERCON, demonstrated the ability to further remediate those areas to levels within the guidelines, as the residual contamination appeared to be easily removable. However, ESSAP is concerned that the surrounding soils are easily redistributed and may recontaminate the pads.

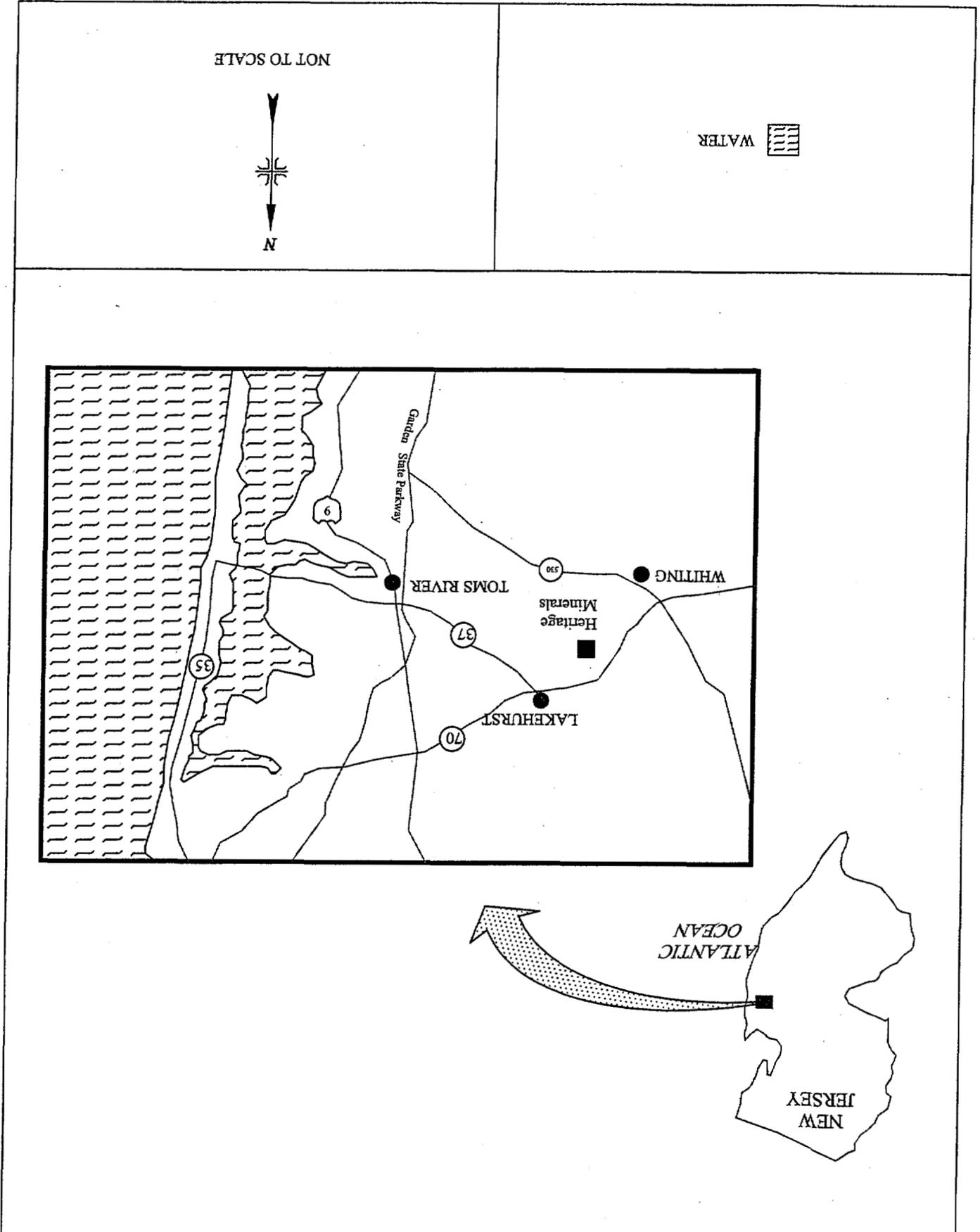
The exterior exposure rate guideline is 10 $\mu\text{R/h}$ above background with the average site background being 4 $\mu\text{R/h}$ (NRC 1991). Thirty-three of the 41 on-site exposure rates exceeded this guideline.

The soil sample results for the Monazite Pile and the trench areas indicated that residual contamination remained well above the applicable NRC unrestricted release guideline level for both total uranium and total thorium at 10 pCi/g each. The soil data also indicated that elevated concentrations were present at various subsurface depths (greater than 15 cm).

The soil sample results for the areas surrounding the Monazite Pile and trench areas (the "fugitive" materials area) indicated that residual contamination remained well above the NRC criteria and licensee's commitments for this area. Of particular concern is that the licensee has claimed that the area surrounding the former mill buildings contains naturally occurring radioactive materials (NORM) at high concentrations; therefore, the background concentrations of uranium and thorium are elevated above typical backgrounds. However, this does not appear to be the case as soil samples collected from beneath the previously unbroken Dry Mill Pad indicated radionuclide concentrations that were equivalent to the off-site background soil concentrations determined during the previous ESSAP survey activities (ORISE 2002). In contrast, the samples collected from the Wet Mill Pad were from previously exposed soil areas in the pad where processing equipment had been located.

FIGURES

FIGURE 1: Location of the Heritage Minerals Site - Lakehurst, New Jersey



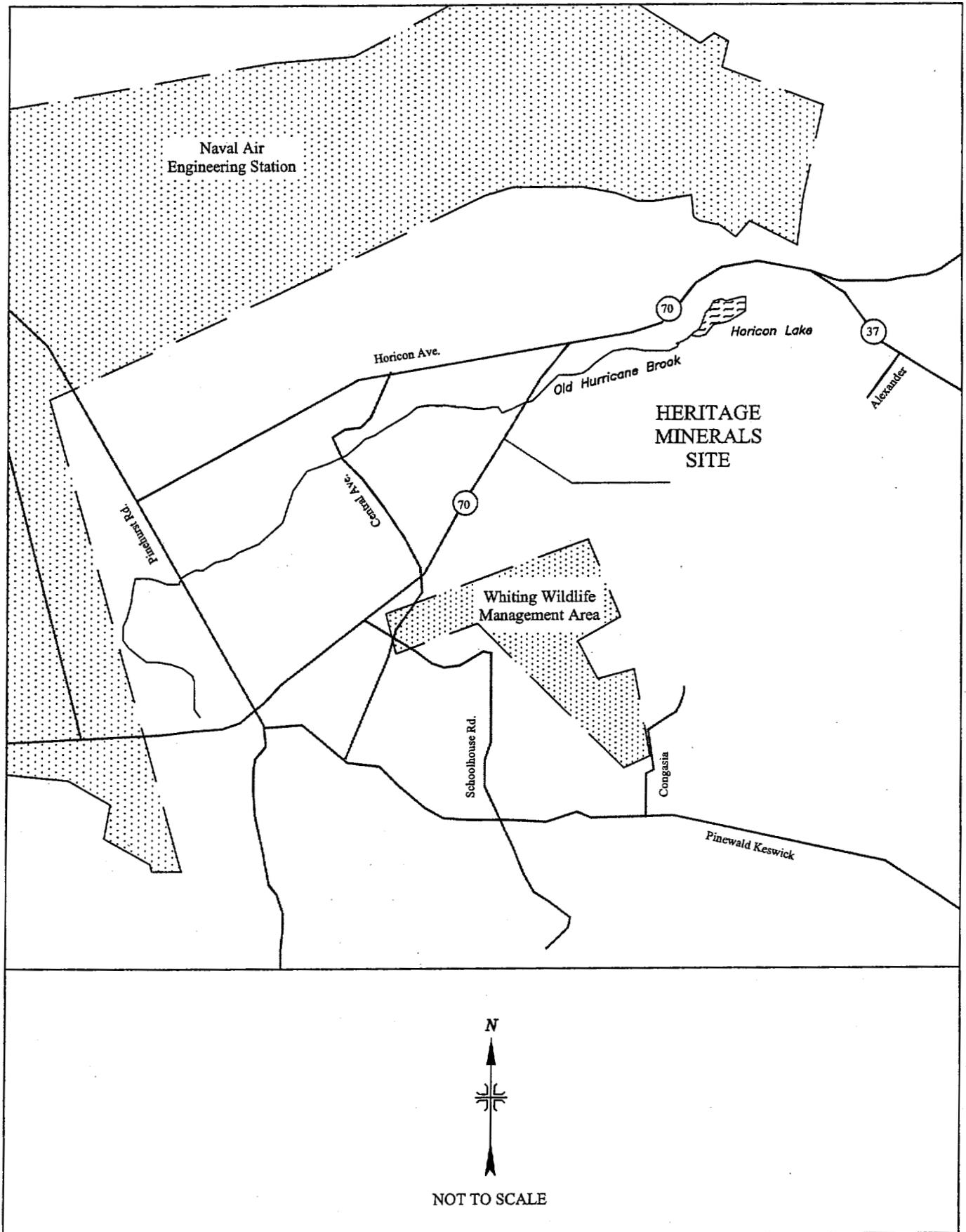


FIGURE 2: Heritage Minerals Site, Lakehurst, New Jersey

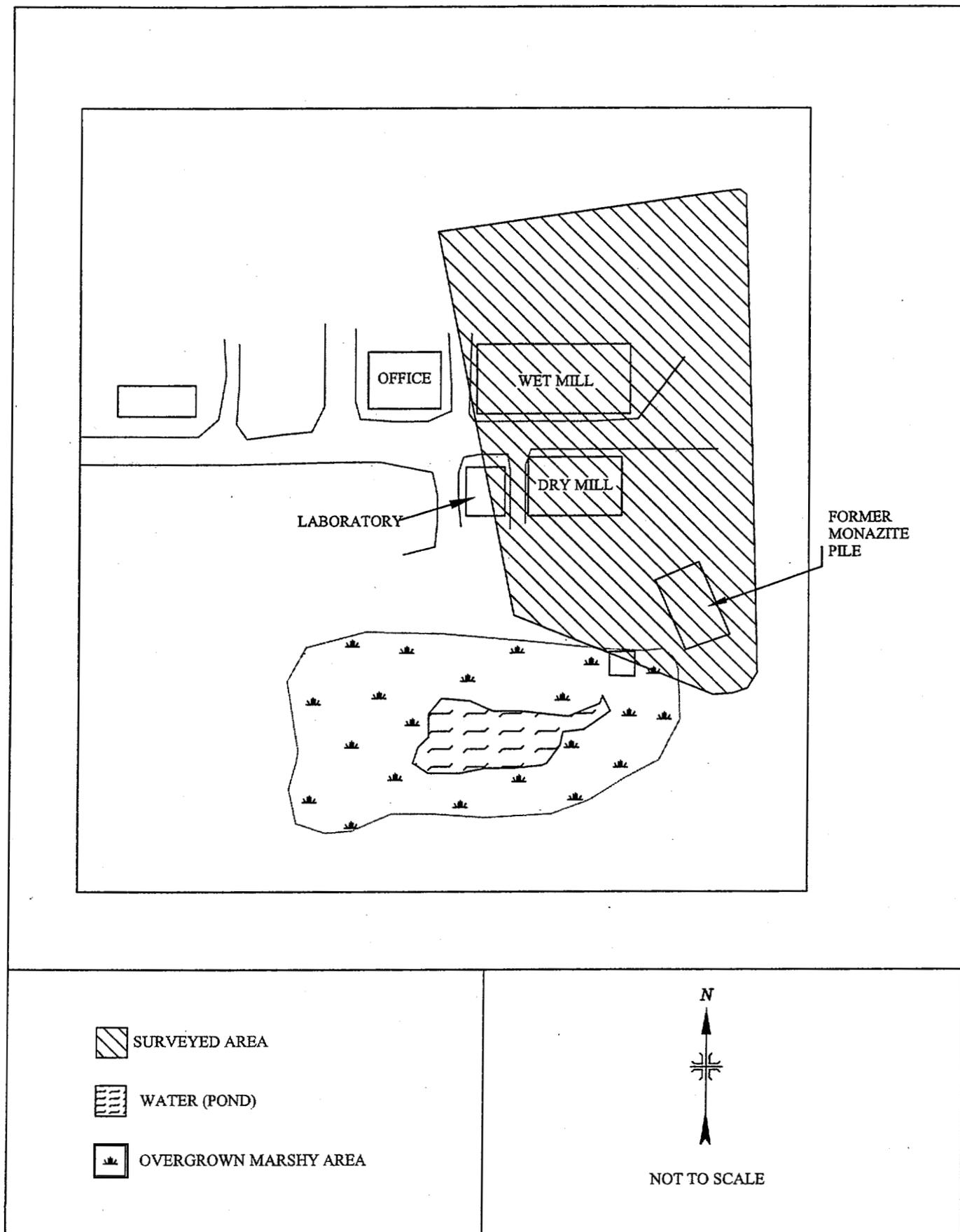


FIGURE 3: Heritage Minerals Site - Surveyed Area

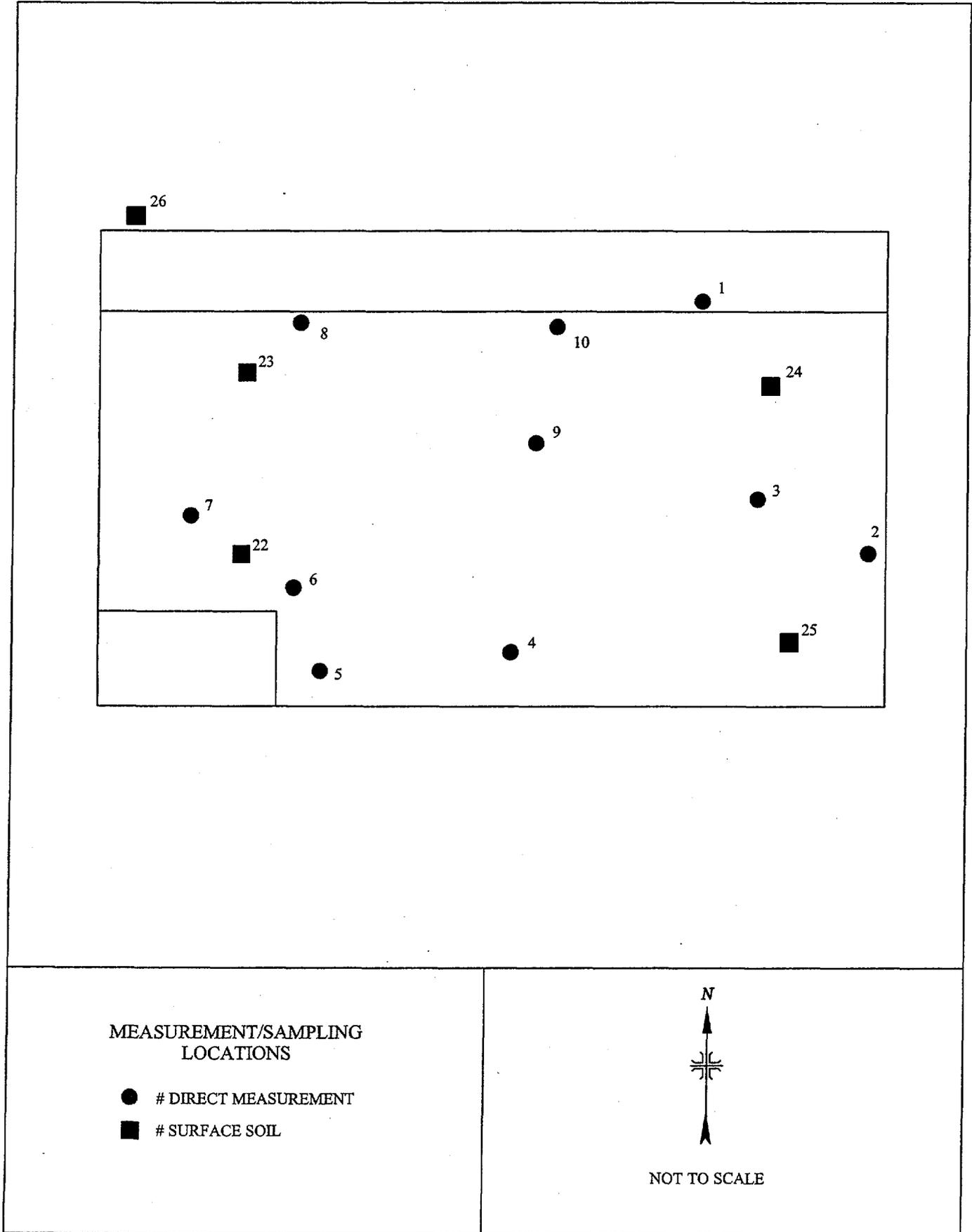


FIGURE 4: Dry Mill Pad - Measurement and Sampling Locations

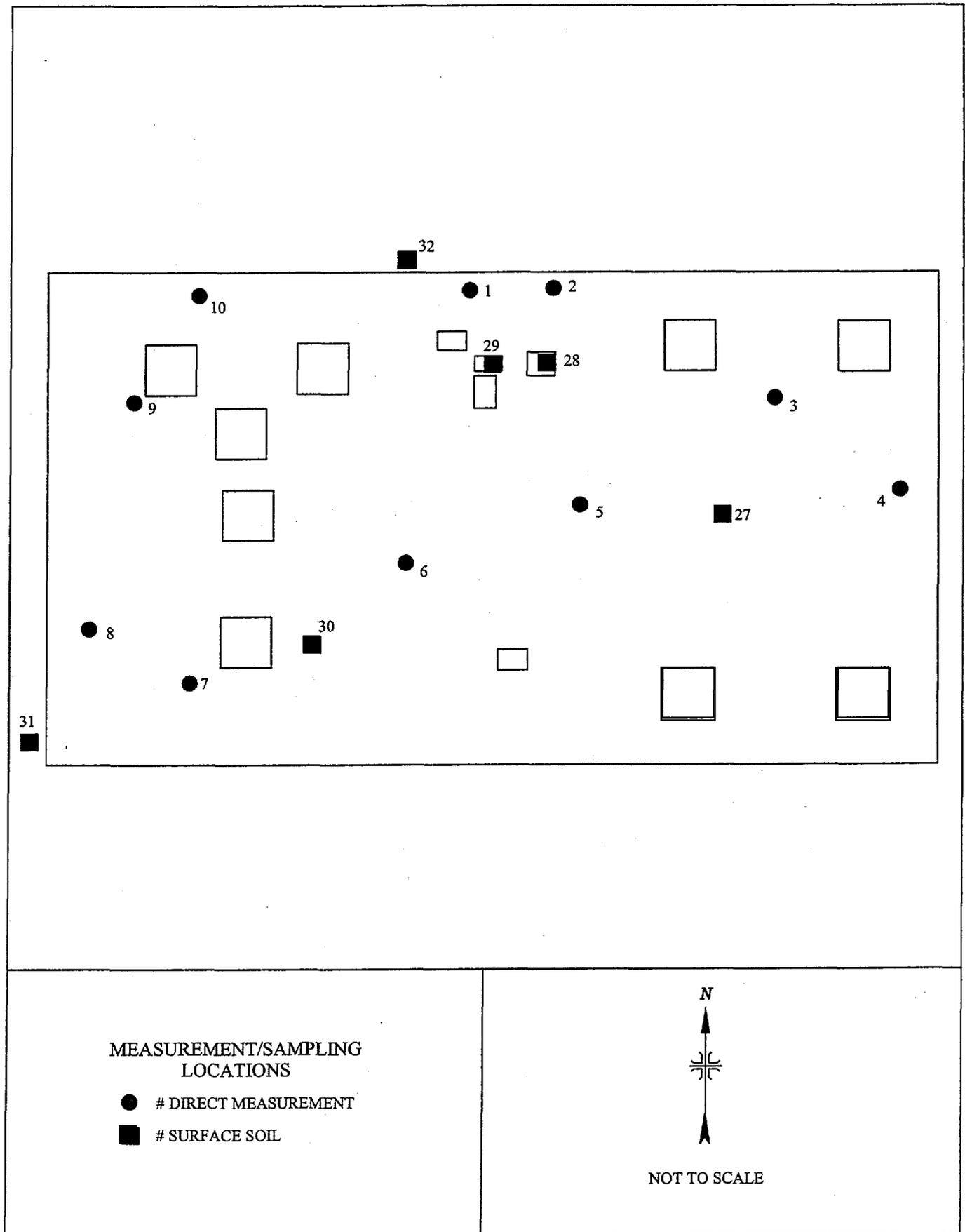


FIGURE 5: Wet Mill Pad - Measurement and Sampling Locations

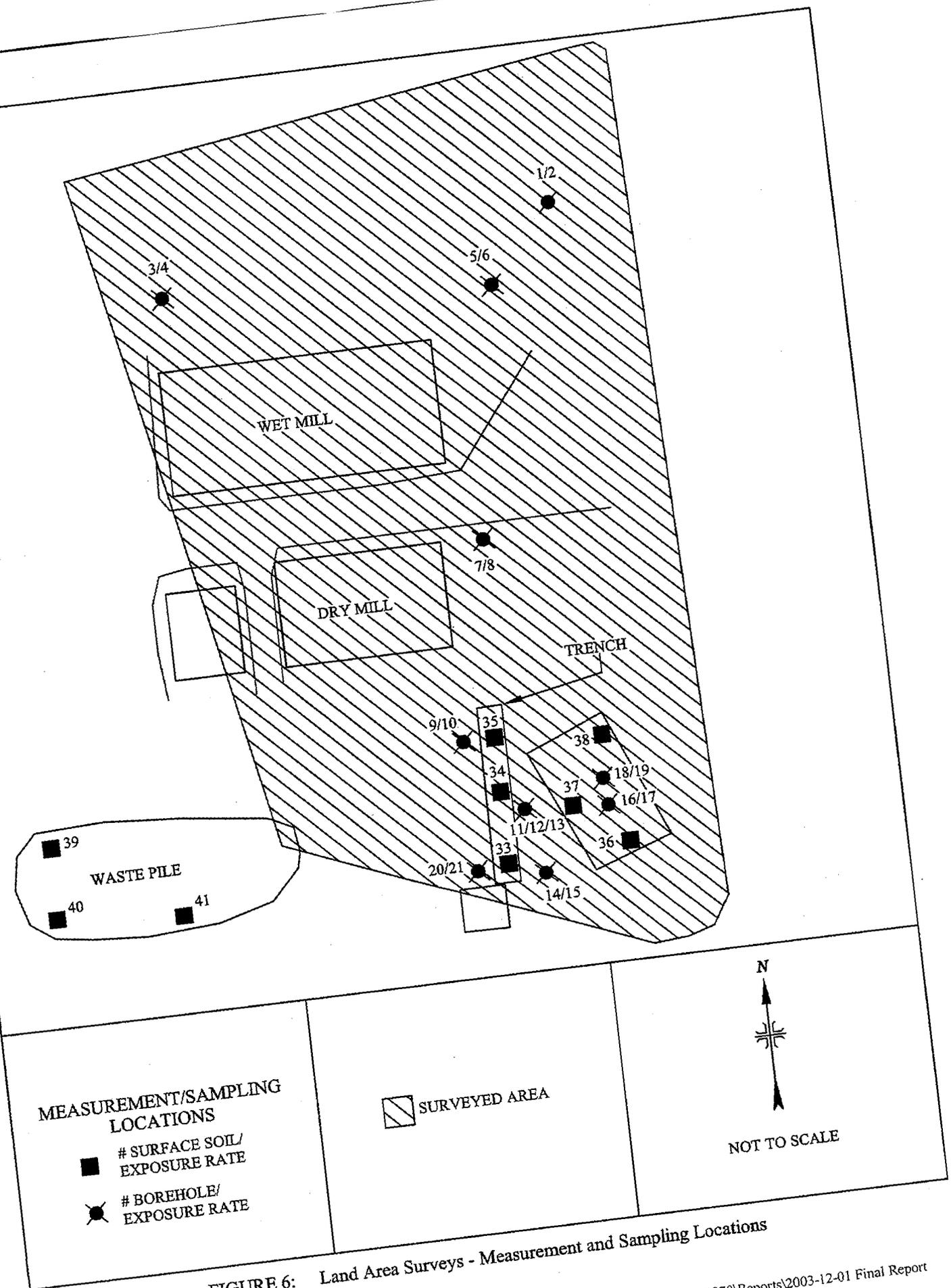


FIGURE 6: Land Area Surveys - Measurement and Sampling Locations

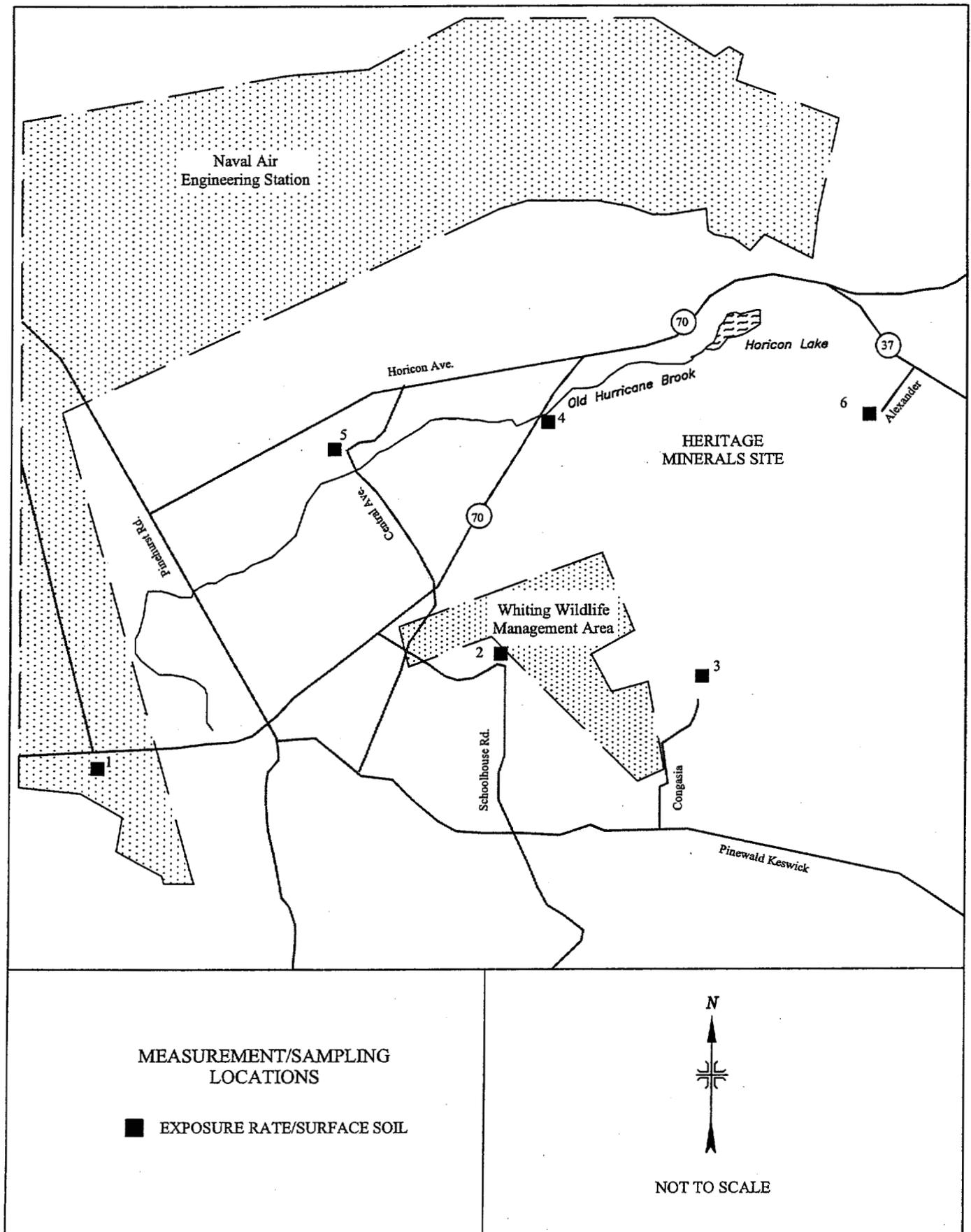


FIGURE 7: Background Measurement and Sampling Locations

TABLES

TABLE 1

SUMMARY OF SURFACE ACTIVITY LEVELS
 HERITAGE MINERALS, INC.
 LAKEHURST, NEW JERSEY

Location ^a	Total Activity (dpm/100 cm ²)	
	Alpha	Beta
Wet Mill		
Location 1	410	4,000
Post RA, Location 1	150	380
Location 2	640	6,700
Post RA, Location 2	110	-42
Location 3	360	3,400
Location 4	-9	3,400
Post RA, Location 4	NA	310
Location 5	-9	560
Location 6	-9	-94
Location 7	130	11
Location 8	79	15
Location 9	-9	-49
Location 10	-9	960
Dry Mill		
Location 1	-9	2,400
Post RA, Location 1	-9	-11
Location 2	130	2,200
Post RA, Location 2	26	-30
Location 3	-9	2,100
Post RA, Location 3	-9	380
Location 4	-9	11
Location 5	-9	-53
Location 6	-9	38
Location 7	88	1,100
Location 8	110	160
Location 9	71	120
Location 10	44	220

^aRefer to Figures 4 and 5.

TABLE 2

**EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
HERITAGE MINERALS, INC.
LAKEHURST, NEW JERSEY**

Sample ID ^a	Depth (cm)	Exposure Rate @ 1m (μR/h)	Radionuclide Concentrations (pCi/g)					
			U-238	U-235	Total U ^b	Th-228	Th-232	Total Th ^c
Samples from the Monazite Pile Area								
16	15	22	19 ± 14 ^d	0.11 ± 0.78	38 ± 20	71.5 ± 4.7	70.4 ± 5.7	141.9 ± 7.4
17	30	22	26 ± 19	-0.38 ± 0.87	51 ± 26	77.5 ± 4.9	77.6 ± 6.4	155.1 ± 8.1
18	15	23	31 ± 11	1.21 ± 0.63	63 ± 16	77.1 ± 4.9	76.8 ± 6.2	153.9 ± 7.9
19	30	23	10.1 ± 7.0	0.21 ± 0.49	20 ± 10	26.6 ± 1.8	25.5 ± 2.2	52.1 ± 2.8
36	100	17	-0.6 ± 1.2	0.02 ± 0.07	-1.3 ± 1.8	0.50 ± 0.05	0.49 ± 0.10	0.98 ± 0.11
37	100	18	0.8 ± 1.2	0.04 ± 0.07	1.7 ± 1.7	1.04 ± 0.08	1.08 ± 0.14	2.12 ± 0.16
38	100	19	2.8 ± 3.8	0.21 ± 0.24	5.9 ± 5.4	5.47 ± 0.39	5.21 ± 0.60	10.67 ± 0.71
Samples from the Trench Area								
9	15	33	38 ± 10	1.65 ± 0.64	78 ± 14	34.7 ± 2.2	35.4 ± 2.9	70.1 ± 3.7
10	30	33	36 ± 14	2.11 ± 0.89	74 ± 20	41.5 ± 2.7	42.8 ± 3.5	84.3 ± 4.5
11	15	54	25 ± 12	1.63 ± 0.91	52 ± 16	57.4 ± 3.7	58.7 ± 4.9	116.1 ± 6.1
12	30	54	42 ± 13	1.66 ± 0.60	85 ± 19	61.2 ± 3.9	61.3 ± 5.0	122.5 ± 6.3
13	45	54	35 ± 13	1.43 ± 0.81	71 ± 18	33.0 ± 2.2	33.3 ± 2.8	66.3 ± 3.6
14	15	26	28 ± 24	1.28 ± 0.89	58 ± 34	80.0 ± 5.1	79.6 ± 6.5	159.6 ± 8.3
15	30	26	36 ± 12	0.96 ± 0.74	73 ± 18	77.9 ± 4.9	77.1 ± 6.2	155.0 ± 7.9
33	15	22	16.8 ± 6.1	0.26 ± 0.28	33.8 ± 8.7	16.4 ± 1.1	15.9 ± 1.4	32.4 ± 1.7
34	15	18	18 ± 10	0.41 ± 0.50	37 ± 14	19.0 ± 1.2	19.3 ± 1.7	38.3 ± 2.1
35	15	33	28 ± 11	1.73 ± 0.63	58 ± 16	32.4 ± 2.1	34.6 ± 2.8	67.0 ± 3.5
Samples from the Waste Pile^e								
39	15	40	9.7 ± 7.9	0.67 ± 0.42	20 ± 11	13.78 ± 0.92	13.5 ± 1.3	27.3 ± 1.6
40	15	37	6.1 ± 4.9	0.44 ± 0.32	12.7 ± 6.9	10.26 ± 0.68	9.75 ± 0.90	20.0 ± 1.1
41	15	25	15.9 ± 7.1	0.69 ± 0.50	32 ± 10	13.27 ± 0.91	12.9 ± 1.2	26.1 ± 1.5

TABLE 2 (continued)

**EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
HERITAGE MINERALS, INC.
LAKEHURST, NEW JERSEY**

Sample ID ^a	Depth (cm)	Exposure Rate @ 1m (μR/h)	Radionuclide Concentrations (pCi/g)					
			U-238	U-235	Total U ^b	Th-228	Th-232	Total Th ^c
Samples from Other Areas								
1	15	92	67 ± 24	1.2 ± 1.3	136 ± 34	175 ± 11	175 ± 14	350 ± 18
2	30	92	34 ± 11	1.10 ± 0.89	69 ± 16	48.2 ± 3.2	48.8 ± 4.0	97.0 ± 5.1
3	15	40	40 ± 15	1.44 ± 0.83	81 ± 22	89.5 ± 5.7	90.9 ± 7.3	180.3 ± 9.3
4	30	40	45 ± 21	1.8 ± 1.0	93 ± 30	109.5 ± 7.2	109.7 ± 8.8	219 ± 11
5	15	47	52 ± 22	2.07 ± 0.93	107 ± 30	44.0 ± 2.8	45.2 ± 3.8	89.2 ± 4.7
6	30	47	11.5 ± 8.0	0.69 ± 0.51	24 ± 11	15.8 ± 1.0	15.9 ± 1.4	31.8 ± 1.7
7	15	45	16 ± 13	1.06 ± 0.70	34 ± 18	49.7 ± 3.3	50.0 ± 4.1	99.7 ± 5.3
8	30	45	82 ± 32	3.0 ± 1.8	166 ± 45	381 ± 24	395 ± 32	775 ± 40
20	15	130	94 ± 24	2.22 ± 0.82	190 ± 34	83.8 ± 5.3	93.6 ± 7.6	177.4 ± 9.3
21	30	130	75 ± 14	3.44 ± 0.78	154 ± 20	56.7 ± 3.6	61.3 ± 5.0	118.1 ± 6.1
Samples from Underneath and Immediately Adjacent to the Dry Mill Pad								
22	15	11	1.0 ± 1.0	0.05 ± 0.05	2.0 ± 1.4	0.29 ± 0.04	0.37 ± 0.09	0.66 ± 0.10
23	15	8	-0.8 ± 1.0	0.04 ± 0.06	-1.5 ± 1.4	0.29 ± 0.04	0.36 ± 0.08	0.65 ± 0.09
24	15	13	0.6 ± 1.2	-0.03 ± 0.06	1.2 ± 1.7	0.53 ± 0.05	0.46 ± 0.09	0.98 ± 0.10
25	15	13	0.7 ± 1.4	-0.02 ± 0.07	1.4 ± 1.9	0.47 ± 0.05	0.53 ± 0.10	1.00 ± 0.11
26	15	26	15.0 ± 8.0	1.07 ± 0.59	32 ± 12	13.38 ± 0.89	13.1 ± 1.3	26.5 ± 1.5
Samples from Underneath and Immediately Adjacent to the Wet Mill Pad								
27	15	11	28 ± 10	1.24 ± 0.56	58 ± 14	17.2 ± 1.1	17.7 ± 1.5	34.9 ± 1.9
28	15	11	7.4 ± 4.8	0.19 ± 0.27	15.0 ± 6.8	6.56 ± 0.45	5.77 ± 0.63	12.32 ± 0.77
29	15	11	32 ± 13	1.25 ± 0.77	65 ± 19	22.0 ± 1.4	21.5 ± 2.0	43.5 ± 2.5
30	15	9	25.5 ± 9.2	0.48 ± 0.40	52 ± 13	14.37 ± 0.94	14.8 ± 1.3	29.2 ± 1.6
31	15	15	35 ± 12	2.04 ± 0.67	72 ± 17	37.1 ± 2.4	39.1 ± 3.2	76.2 ± 4.0
32	15	23	27 ± 13	2.26 ± 0.81	57 ± 18	32.0 ± 2.1	32.8 ± 2.8	64.8 ± 3.5

TABLE 2 (continued)

EXPOSURE RATES AND RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
HERITAGE MINERALS, INC.
LAKEHURST, NEW JERSEY

Sample ID ^a	Depth (cm)	Exposure Rate @ 1m (μR/h)	Radionuclide Concentrations (pCi/g)					
			U-238	U-235	Total U ^b	Th-228	Th-232	Total Th ^c
Background Samples								
1	15	3	0.2 ± 0.2	0.1 ± 0.0	0.5	0.3 ± 0.0	0.3 ± 0.1	0.6
2	15	3	0.3 ± 0.2	0.0 ± 0.0	0.6	0.1 ± 0.0	0.2 ± 0.1	0.3
3	15	5	0.5 ± 0.3	0.0 ± 0.0	1.0	0.3 ± 0.0	0.3 ± 0.1	0.6
4	15	4	0.3 ± 0.4	0.0 ± 0.1	0.6	0.3 ± 0.0	0.3 ± 0.1	0.6
5	15	7	0.4 ± 0.4	0.0 ± 0.1	0.8	0.3 ± 0.0	0.3 ± 0.1	0.6
6	15	4	1.1 ± 0.4	0.1 ± 0.1	2.3	0.5 ± 0.0	0.5 ± 0.1	1.0

^aRefer to Figures 4 through 7.

^bTotal uranium concentrations were calculated by multiplying the U-238 concentration result by two and adding the U-235 concentration.

^cTotal thorium concentrations were calculated by adding the Th-228 and Th-232 concentrations.

^dUncertainties represent the 95% confidence level based on total propagated uncertainties.

^eThe waste pile consisted of the recovered sand and wash water from the remediation activities on the building structure construction materials and process equipment that was performed on the Wet Mill Pad.

REFERENCES

ENERCON Services, Inc. (ENERCON). Removal of Fugitive Licensable Soil, Heritage Minerals, Inc., Lakehurst, New Jersey. Murrysville, PA; June 26, 2003.

Oak Ridge Institute for Science and Education (ORISE). Confirmatory Survey of Portions of the Heritage Minerals Incorporated Facility, Lakehurst, New Jersey. Oak Ridge, TN; March 22, 2002.

Oak Ridge Institute for Science and Education. Final Confirmatory Survey Plan for Portions of the Heritage Minerals, Incorporated Facility in Lakehurst, New Jersey, Phase 2 (Docket No. 040-08980; RFTA No. 03-017). Oak Ridge, TN; September 3, 2003a.

Oak Ridge Institute for Science and Education. Survey Procedures Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; February 28, 2003b.

Oak Ridge Institute for Science and Education. Quality Assurance Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; April 1, 2003c.

Oak Ridge Institute for Science and Education. Laboratory Procedures Manual for the Environmental Survey and Site Assessment Program. Oak Ridge, TN; February 25, 2003d.

Radiation Sciences, Inc. (RSI). Background Determination at Heritage Minerals. Cranbury, NJ; July 1996.

Radiation Sciences, Inc. Final Status Survey Plan for License Termination of Heritage Minerals NRC License # SMB-1541. Cranbury, NJ; November 1997.

Radiation Sciences, Inc. Final Status Survey Report for License Termination of Heritage Minerals NRC License # SMB-1541. Cranbury, NJ; December 2001.

U.S. Nuclear Regulatory Commission (NRC). "Disposal or Onsite Storage of Thorium and Uranium Waste from Past Operations", 46 CFR 52061, Washington, DC; October 23, 1981.

U.S. Nuclear Regulatory Commission. Policy and Guideline Directive FC83-23, Termination of Byproduct, Source, and Special Nuclear Material Licenses. R.E. Cunningham to Regional Administrators, Branch Chiefs and Division of Fuel Cycle and Materials Safety. Washington, D.C.; November 4, 1983.

U.S. Nuclear Regulatory Commission. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproducts, Source, or Special Nuclear Material. Washington, DC; August 1987.

U.S. Nuclear Regulatory Commission. Policy and Guideline Directive FC91-2, Standard Review Plan: Evaluating Decommissioning Plans for Licensees Under 10 CFR Parts 30, 40, and 70. Washington, D.C.; August 1991.

REFERENCES (Continued)

U.S. Nuclear Regulatory Commission. Memorandum from J. Hickey (USNRC-HQ) to D. Collins (USNRC, Region II), RE: "Interpretation of Thorium Surface Contamination Limits" February 20, 1992.

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.

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Alpha Plus Beta

Ludlum Ratemeter-Scaler Model 2221

coupled to

Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm²
(Ludlum Measurements, Inc., Sweetwater, TX)

Gamma

Eberline Pulse Ratemeter Model PRM-6

(Eberline, Santa Fe, NM)

coupled to

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

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Alpha

Ludlum Ratemeter-Scaler Model 2221

coupled to

Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm²
(Ludlum Measurements, Inc., Sweetwater, TX)

Beta

Ludlum Ratemeter-Scaler Model 2221

coupled to

Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm²
(Ludlum Measurements, Inc., Sweetwater, TX)

Gamma (Exposure Rate)

Bicron Micro-Rem Meter

(Bicron Corporation, Newburg, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

High Purity Extended Range Intrinsic Detector

Model No. GMX-45200-5

(EG&G ORTEC, Oak Ridge, TN)

used in conjunction with:

Lead Shield Model SPG-16-K8

(Nuclear Data)

Multichannel Analyzer

DEC ALPHA Workstation

(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detectors

Tennelec Model No: ERVDS30-25195

(Canberra, Meriden, CT)

Used in conjunction with:

Lead Shield Model G-11

(Nuclear Lead, Oak Ridge, TN) and

Multichannel Analyzer

DEC ALPHA Workstation

(Canberra, Meriden, CT)

APPENDIX B
SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

The proposed survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current job hazard analyses (JHAs). All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures.

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 documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, (February 2003)
- Laboratory Procedures Manual, (February 2003)
- Quality Assurance Manual, (April 2003)

The procedures contained in these manuals were developed to meet the requirements of Department of Energy (DOE) Order 414.1A and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* 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 MAPEP, NRIP, ITP, and EML Laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.

Detectors used for assessing surface activity were calibrated in accordance with ISO-7503¹ recommendations. The total beta efficiency (ϵ_{total}) was determined for each instrument/detector combination and consisted of the product of the 2π instrument efficiency (ϵ_i) and surface efficiency (ϵ_s): $\epsilon_{\text{total}} = \epsilon_i \times \epsilon_s$.

The alpha calibration ϵ_i was 0.36 for the gas proportional detectors calibrated to Th-230 and the beta calibration ϵ_i was 0.42 for the gas proportional detectors calibrated to Tl-204. The beta calibration source was selected based on the beta energy distribution of the radionuclide. ISO-7503¹ recommends an ϵ_s of 0.25 for alpha emitters and beta emitters with a maximum energy of less than 0.4 MeV (400 keV) and an ϵ_s of 0.5 for maximum beta energies greater than 0.4 MeV. Since the maximum beta energy for the HMI radionuclides of concern was greater than 0.4 MeV, an ϵ_s of 0.5 was used to calculate ϵ_{total} . The total alpha and beta efficiencies for the gas proportional detectors were 0.09 and 0.21, respectively.

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. A NaI scintillation detector was used to scan for elevated gamma radiation on the concrete pad and soil surfaces. The concrete pad surface was also scanned using small area (126 cm²) hand-held gas proportional detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument.

Scan minimum detectable concentrations (MDCs) were estimated using the calculational approach described in NUREG-1507.² The scan MDC is a function of many variables, including the background level. Typical beta background levels on concrete surfaces range from 250 to 450 cpm for the hand-held gas proportional detectors. Additional parameters selected for the calculation of scan MDCs included a three-second observation interval for the gas proportional

¹International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

²NUREG-1507. Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. US Nuclear Regulatory Commission. Washington, DC; June 1998.

detectors, a specified level of performance at the first scanning stage of 95% true positive rate and 25% false positive rate, which yields a d' value of 2.32 (NUREG-1507, Table 6.1), and a surveyor efficiency of 0.5. The instrument efficiency (ϵ_i) for the hand-held gas proportional detector calibrated to TI-204 was 0.42. To illustrate an example for the hand-held gas proportional detector, the minimum detectable count rate (MDCR) and scan MDC for beta activity can be calculated as follows:

$$\begin{aligned}b_i &= (250 \text{ cpm})(3 \text{ s})(1 \text{ min}/60 \text{ s}) = 12.5 \text{ counts,} \\ \text{MDCR} &= (2.32)(12.5 \text{ counts})^{1/2} [(60 \text{ s}/\text{min})/(3 \text{ s})] = 164 \text{ cpm,} \\ \text{MDCR}_{\text{surveyor}} &= 164/(0.5)^{1/2} = 232 \text{ cpm}\end{aligned}$$

The scan MDC is calculated assuming a source efficiency (ϵ_s) of 0.5 (for TI-204):

$$\text{ScanMDC} = \frac{\text{MDCR}_{\text{surveyor}}}{(\epsilon_s)(\epsilon_i)} \text{ dpm} / 100 \text{ cm}^2$$

For the given background range, the estimated scan MDC ranged 1,100 to 1,430 dpm/100 cm² for the hand-held gas proportional detectors.

The scan MDC for the NaI scintillation detector for uranium and thorium were obtained directly from NUREG-1507. The scan MDCs were 115 and 28.3 pCi/g, respectively, for total uranium and total thorium (includes sum of all radionuclides in the uranium and thorium decay series).

Surface Activity Measurements

Measurements of total alpha and total beta surface activity levels were performed using hand-held gas proportional detectors with portable ratemeter-scalers. Count rates (cpm), which were integrated over one minute with the detector held in a static position, were converted to activity levels (dpm/100 cm²) by dividing the net count rate by the total static efficiency ($\epsilon_i \times \epsilon_s$) and correcting for the physical area of the detector.

Surface activity measurements were performed on unpainted concrete. The background count rate for the gas proportional detector was 1 cpm for alpha activity. To distinguish between the beta background that naturally occurs in concrete and the high ambient gamma background that was present on the site during the beta activity measurements, unshielded and shielded beta

activity measurements were performed at each background direct measurement location on concrete surfaces having no known radiological history. A Plexiglas™ shield of enough thickness to block the beta particles from the natural uranium and natural thorium series was used to determine the gamma count rate associated with the unshielded count rates. The background count rate for concrete surfaces was 303 cpm unshielded and 221 cpm shielded. These material-specific background count rates represented the net beta activity difference between unshielded and shielded beta direct measurements performed in the background reference area for the HMI site. The material-specific background beta count rate difference (reference material count rate) of 82 cpm was then subtracted from the net count rate determined from the concrete pad unshielded and shielded direct measurements to provide a true beta-only direct measurement on the concrete pad surfaces.

The following equation was used to determine the net beta count rate when correcting for ambient gamma background differences:

$$N = (R_{u, su} - R_{s, su}) - R_{rm}$$

where:

- N = net beta count rate
- $R_{u, su}$ = unshielded survey unit count rate
- $R_{s, su}$ = shielded survey unit count rate
- R_{rm} = reference material gross count rate

The background material unshielded gross count rates were used to calculate beta surface activity when shielded measurements were not performed in the survey area.

The static beta MDC—calculated using the background material unshielded average count rate—was 320 dpm/100 cm² using the gas proportional detectors calibrated to Tl-204. The physical surface area assessed by the gas proportional detector used was 126 cm²

The static alpha MDC was 67 dpm/100 cm² using the gas proportional detectors calibrated to Th-230. The physical surface area assessed by the gas proportional detector used was 126 cm².

Exposure Rate Measurements

Measurements of dose equivalent rates ($\mu\text{rem/h}$) were performed at 1 m above the surface using a Bicon microrem meter. Although the instrument displays data in $\mu\text{rem/h}$, the $\mu\text{rem/h}$ to $\mu\text{R/h}$ conversion is essentially unity.

Soil Sampling

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

RADIOLOGICAL ANALYSIS

Gamma Spectroscopy

Samples of soil and residues were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 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. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Photopeaks used for determining the activities of radionuclides of concern and the typical associated MDCs for a one-hour count time were:

Radionuclide	Photopeak	MDC soil (pCi/g)
Th-228	0.583 MeV from Tl-208*	0.05
	(or 0.239 MeV from Pb-212*)	0.02
Th-232	0.911 MeV from Ac-228*	0.05
U-235	0.143 MeV (or 0.186 MeV)	0.06
U-238	1.001 MeV from Pa-234 m*	1.74

*Secular equilibrium assumed. The Pa-234m photopeak was used in lieu of the Th-234

(63 keV) photopeak due to the attenuation of the low-energy gammas due to the high Z material associated with the samples.

Spectra were also reviewed for other identifiable photopeaks.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the total propagated uncertainties for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65\sqrt{\text{BKG}})]$. 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.

APPENDIX C

**GUIDELINES FOR DECONTAMINATION OF FACILITIES AND
EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR
TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE OR
SPECIAL NUCLEAR MATERIAL**

AND

**GUIDELINES FOR RESIDUAL CONCENTRATIONS
OF THORIUM AND URANIUM WASTES IN SOIL**

APPENDIX C

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE OR SPECIAL NUCLEAR MATERIAL

The instructions in this guide, in conjunction with Table 1, specify the radionuclides and radiation exposure rate limits which should be used in decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control is considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.
2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to the application of the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.
3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces or premises, equipment, or scrap which are likely to be contaminated, but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement, shall be presumed to be contaminated in excess of the limits.
4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to special circumstances such as razing of buildings, transfer from premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term

storage or standby status. Such requests must:

- a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.
 - b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.
5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of the survey report shall be filed with the Division of Fuel Cycle, Medical, Academic, and Commercial Use Safety, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:
- a. Identify the premises.
 - b. Show that reasonable effort has been made to eliminate residual contamination.
 - c. Describe the scope of the survey and general procedures followed.
 - d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1
ACCEPTABLE SURFACE CONTAMINATION LEVELS

Nuclides ^a	Average ^{b,c,f}	Maximum ^{b,d,f}	Removable ^{b,e,f}
U-nat, U-235, U-238, and associated decay products	5,000 dpm α /100 cm ²	15,000 dpm α /100 cm ²	1,000 dpm α /100 cm ²
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm ²	300 dpm/100 cm ²	20 dpm/100 cm ²
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm ²	3,000 dpm/100 cm ²	200 dpm/100 cm ²
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$ /100 cm ²	15,000 dpm $\beta\gamma$ /100 cm ²	1,000 dpm $\beta\gamma$ /100 cm ²

^aWhere surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

^bAs 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.

^cMeasurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

^dThe maximum contamination level applies to an area of not more than 100 cm².

^eThe amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

^fThe average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

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 establishes 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) above background 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

^aBased 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 μ R/h above background from direct external exposure.

^bBased on limiting individual dose to 170 mrem/yr.

^cBased on limiting equivalent exposure to 0.02 working level or less.

^dBased on limiting individual dose to 500 mrem/yr and in case of natural uranium, limiting exposure to 0.02 working level or less.