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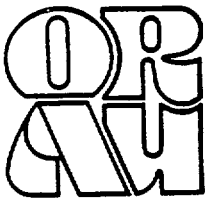

Prepared by
Oak Ridge Associated
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Industrial and
Medical Nuclear Safety

# RADIOLOGICAL SURVEY OF THE SHIELDALLOY CORPORATION NEWFIELD, NEW JERSEY

**J. D. BERGER AND A. D. LUCK**

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

FINAL REPORT
JULY 1988

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Final Report

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# RADIOLOGICAL SURVEY
# OF THE
# SHIELDALLOY CORPORATION
# NEWFIELD, NEW JERSEY

## INTRODUCTION

The Shieldalloy Corporation of Newfield, New Jersey, manufactures a variety of specialty ferro alloys using aluminathermic or thermal electric smelting processes. The raw material for one of the products, known as ferro-columbium (Fe-Cb), is pyrochlore ore, a sodium-calcium fluor columbite which also contains naturally occurring thorium and uranium of up to 2% and 0.4%, respectively, by weight. Because the thorium and uranium contents are greater than 0.05%, the operation is subject to licensing and regulation by the Nuclear Regulatory Commission (NRC), in accordance with 10 CFR 40.[1]

The thorium and uranium from the ores is not incorporated into the finished alloy product, but remains in the slag waste from the operation. This slag is segregated from other (nonradioactive material containing) slags, generated at the site, and is stored in two separate piles on the eastern end of the Shieldalloy property. One pile is for Fe-Cb "high ratio" slag and a second pile is for Fe-Cb "standard" slag. Because no acceptable use has been identified for this slag and the cost of disposal as radioactive waste is prohibitive, a large quantity of the material has been accumulated on the site, since operations began in 1955. Possible radionuclide contamination of shallow groundwater, subsurface soil, and surface drainage pathways, due to precipitation runoff, is of concern to Shieldalloy and federal and state regulatory agencies.

Processing activities also generate airborne dusts, containing low concentrations of radionuclides from the thorium and uranium decay series. Exhaust air from the processing area passes through 10,000 $m^3$/min baghouse dust collectors (two) before release to the environment. Discharges are estimated by Shieldalloy on the basis of mass balance calculations. Dusts collected in the baghouses are accumulated in several small piles onsite.

At the request of Region I of the NRC, the Radiological Site Assessment Program of Oak Ridge Associated Universities performed a radiological survey in the vicinity of the Shieldalloy site to evaluate the impact of the ferro columbium process and accumulated slag on the site environment.

## SITE DESCRIPTION

Shieldalloy is located on a 27 hectare site, on the south side of Newfield, New Jersey (Figure 1). Site access is controlled by a chain link fence. There are multiple buildings on the property; however, all ferro columbium smelting operations are conducted in a foundry, near the west central portion of the site (Figure 2). Pyrochlore ores are stored in a warehouse, southwest of the foundry building. Slag, bag house dust, and miscellaneous scrap and waste from all Shieldalloy activities are stored on the eastern portion of the site. Surface drainage in the vicinity of the plant site is to the west-southwest, into Hudson Branch. Groundwater in the area of the plant, in general, is unconfined and parallels surface drainage flow.

## PROCEDURES

Radiological monitoring of the Shieldalloy site was conducted by the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) during October 13-25 and December 15-16, 1987. This section describes the study objective and procedures.

### Objective

The objective of the ORAU study was to perform independent radiological measurements of the accumulated slag and various environmental media. The findings would be used to evaluate the radiological impacts of Shieldalloy activities on the environment of the site. The survey was in accordance with a monitoring plan, developed on the basis of information provided by the Shieldalloy Corporation, Nuclear Regulatory Commission, and New Jersey Department of Environmental Protection.

Survey Procedures

1. Twenty meter intervals were established around the perimeter fence (Figure 3). Walkover gamma scans were performed out to a distance of 5-10 m around the entire perimeter, using NaI(Tl) scintillation detectors and count rate survey meters. Locations of elevated direct radiation were marked for further investigation.

   Exposure rates at the surface and 1 m above the surface were performed at 20 m intervals around the perimeter fence and at locations identified by walkover scans. Measurements were performed using portable gamma NaI(Tl) scintillation survey meters. Conversion of these measurements to exposure rates in microentgens per hour ($\mu$R/h) was in accordance with cross calibration with a pressurized ionization chamber.

   Surface (0-15 cm) soil samples of approximately 1 kg each were collected at 20 m grid intervals, around the plant perimeter, and at locations identified by walkover scans.

2. A 10 m grid was established around the two ferro columbium slag piles, to facilitate measurements of pile size and reference sampling and radiation measurement locations (Figure 4). The aerial and vertical dimensions of the piles were measured to enable calculation of the total slag volume.

   Thirty samples of slag were obtained at random from locations throughout the piles for determination of average radioactive material content. Samples of soil were collected at approximately 10 m intervals around the slag piles and at locations which appeared to be surface runoff pathways (Figure 5).

3. Walkover gamma scans were performed throughout the remainder of the slag and waste storage areas on the western portion of the site, to identify locations of elevated direct radiation, which might indicate inappropriate segregation or inadequate control of radioactively contaminated materials.

4. Borehole drilling for subsurface investigations were conducted by Empire Soil Investigations, Inc. of Highland Park, New Jersey. Drilling was by 8.3 cm diameter hollow-stem augers. Drilling was at locations around the perimeter of the slag pile and at representative locations throughout the plant area. Twenty-six such boreholes were drilled (Figure 6). Drilling and sampling were to the depth of the water table, where possible.

   Soil samples were obtained from these boreholes at the surface and at approximately 1.5 m intervals between the surface and hole bottom. Subsurface sampling was performed using split-barrel samplers, driven ahead of the hollow-stem auger. Samples of ground water were obtained from boreholes, where available.

   Gamma scans of the boreholes were performed to identify elevated radiation levels, which would indicate subsurface residues. Radiation profiles in the boreholes were determined by measuring gamma radiation at 30 cm intervals between the surface and the hole bottom. A collimated gamma scintillation detector and portable scaler were used for these measurements.

5. Water samples were obtained from 11 wells in the plant and Newfield area (Figures 7 and 8). In addition, two, twenty-four hour composite water samples were collected from the plant outfall.

   Shieldalloy operates a system for removal of chrome contamination from groundwater beneath the southeast portion of the site, believed to have occurred in the mid-to-late 1960's. An on-site well is

pumped at approximately 3.9 x $10^2$ l/m; the pumped water is passed through cation and anion resin columns and then discharged into Hudson Branch. Samples of water were collected from the inlet and outlet of the ion-exchange columns.

6. Samples of sediment and water were collected from surface drainage pathways leading from the site; the pond (origin of Hudson Branch); and at locations along Hudson Branch, both upstream and downstream of the plant outfall (Figures 7 and 8). Samples were also collected from drainage pathways A and B at their entry point onto the site.

7. Samples of sediment were collected from two setting ponds, used to treat liquid wastes.

8. Four cm diameter access ports were drilled in the stacks of the new baghouse and in the inlet duct of the old baghouse. A pitot tube and Alnor Velometer were used to measure velocity distributions in the stacks and duct. Preliminary measurements were made to detect any significant air flow variations. Velocity measurements were then made at predetermined distances in each of the stacks, based on recommendations found in EPA Standard Method #1.[2]

   Sampling nozzle diameters were selected to achieve isokinetic sampling at nominal flow rates of 10 to 20 l/m. The nozzles were connected to probes, supported by metal plates, which were held in position on the stack by duct tape. Filter holders with 0.8 $\mu$m millipore filters were attached to the probes.

   Following installation of the probe assemblies and connection of the vacuum, control, and measurement equipment, the air flow in each probe was set at the calculated isokinetic sampling rate. Times and flow rates were recorded; periodic checks of the flow rate were made to assure that the desired sampling rate was being maintained. Samples were collected from both stacks on the new baghouse for three

days (samples were collected only during those times that pyrochlore ore processing was taking place and the baghouse exhaust was in operation). Three separate samples were obtained from the old baghouse duct at various times over two days.

9. A sample of dust was collected from the old baghouse, and four samples were collected from the lime pile, where dust from the old and new baghouses is stored.

Background and Baseline Measurements

Samples of soil were collected from 7 locations in the Newfield area, to provide baseline concentrations of radionuclides for comparison purposes (Figure 9). Direct background radiation levels were measured at locations where baseline soil samples were collected.

Sample Analysis and Interpretation of Results

Samples and direct measurement data were returned to Oak Ridge, Tennessee, for analysis and interpretation. Soil and sediment samples were analyzed by solid state gamma spectrometry. Radionuclides of primary interest were Th-232, Ra-226, and U-238; however, spectra were also reviewed for other identifiable radionuclides. Water samples were analyzed for gross alpha and gross beta levels using low-background proportional counters. Isotopic analyses were performed on samples exceeding 5 pCi/l gross alpha. Air samples were analyzed for thorium, radium, and uranium concentrations by combinations of wet chemistry separations and radiological counting.

Additional information concerning analytical equipment and procedures is contained in Appendices A and B. Results were compared with guidelines for radionuclides in the environment, developed by federal agencies.

## RESULTS

### Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil, determined for seven locations in the Newfield, New Jersey area are presented in Table 1. Exposure rates ranged from 6 to 8 $\mu$R/h. Concentrations of radionuclides in soil were: Th-232, 0.1 to 0.6 pCi/g; Ra-226, 0.2 to 0.9 pCi/g; and U-238, <0.3 to 1.3 pCi/g. These concentrations are typical of radionuclide levels normally encountered in surface soil.

### Perimeter Survey

Approximately 17 areas of elevated direct radiation were identified by the walkover scan of the plant perimeter fence. These areas, shown on Figure 10, ranged in size from small, isolated locations, associated with individual pieces of slag and contaminated soil, to an area along the north fence, about 400 m in length. This elevated region along the north fence was due to the two slag piles located nearby.

Exposure rates measured at 20 m intervals along the perimeter fence are presented in Table 2. Gamma levels ranged from 4 to 175 $\mu$R/h at 1 m above the surface and from 4 to 165 $\mu$R/h at surface contact. The highest exposure rates were primarily along the north fence line, between the 160 and 260 m distance indicators; levels in this area were up to 175 $\mu$R/h at 1 m above the surface. Exposure rates, associated with locations identified by perimeter walkover scans are presented in Table 3. At contact these levels ranged from 8 to 412 $\mu$R/h; the levels at 1 m above the surface ranged from 9 to 103 $\mu$R/h.

### Radionuclide Concentration in Soil

Table 4 presents the radionuclide concentrations in surface soil from 20 m grid intervals along the plant perimeter fence. Ranges of major radionuclides are: Th-232, 0.2 to 52.3 pCi/g; Ra-226, 0.2 to 29.3 pCi/g; and U-238, 0.3 to 13.4 pCi/g. The highest Th-232 concentration was in the sample from the 660 m distance marker; the highest Ra-226 concentration was from the 1840 m location, along the south perimeter fence.

Concentrations in samples from locations of elevated radiation around the perimeter are presented in Table 5. Surface Th-232 concentrations ranged from 0.9 to 68 pCi/g. At all locations the concentrations decreased at depths below the surface.

Slag Pile Measurements

Concentrations of radionuclides in samples from the ferro columbium slag piles are presented in Tables 6 and 7. Thorium 232 was the primary radionuclide in the samples; however, most samples also contained elevated concentrations of Ra-226 and U-238. Large differences were observed among individual samples from these piles. For example, samples from the "high-ratio" pile contained from <0.5 to 1460 pCi/g of Th-232 and samples from the "standard" pile ranged from 0.6 to 1500 pCi/g of Th-232. The average concentrations for the "high-ratio" pile were: Th-232, 366 pCi/g; Ra-226, 69 pCi/g; and U-238, 105 pCi/g. The "standard" pile had average concentrations of: Th-232, 516 pCi/g; Ra-226, 123 pCi/g; and U-238, 202 pCi/g. Several samples were also analyzed by neutron activation to confirm the Th-232 levels identified by gamma spectroscopy.

Radionuclide concentrations in surface soil samples from the vicinity of the slag piles are presented in Table 8. All samples contained concentrations of Th-232 above those in baseline samples; the highest level was 437 pCi/g. Concentrations of Ra-226 and U-238 were also generally higher than the levels in baseline soil. The highest concentration of Ra-226 was 128 pCi/g; the highest U-238 concentration was 160 pCi/g. These levels were in the same sample with the highest Th-232 concentration. Average concentrations in soil samples from the periphery of the slag piles were: Th-232, 28.6 pCi/g; Ra-226, 8.4 pCi/g; and U-238, 10.5 pCi/g.

General Scans of Other Plant Areas

Numerous locations of elevated gamma radiation were identified within the slag and waste storage area and near the ferro columbium foundry and warehouse. Figure 11 indicates these locations.

## Borehole Investigations

Table 9 summarizes data on the radionuclide concentrations in samples from boreholes. Six borehole locations had Th-232 concentrations above 10 pCi/g. The highest level was 689 pCi/g, from borehole 23, near the south perimeter fence. Concentrations of Ra-226 and U-238 in this sample were 283 pCi/g and 330 pCi/g, respectively. Four of the surface samples having greater than 10 pCi/g of Th-232 were from boreholes 10, 13, 14, and 17, in the vicinity of the slag piles. Most subsurface soil samples contained radionuclide concentrations in the range of baseline soil. Borehole 17 contained the highest subsurface levels, with 7.0 pCi/g of Th-232 and 27.2 pCi/g of Ra-226 at the 1.5 to 2.1 m depth.

Concentrations of gross alpha and gross beta activity in water samples from the boreholes are presented in Table 10. Gross alpha concentrations ranged from 0.7 to 143 pCi/l. The sample from Borehole 17, which contained a gross alpha concentration greater than 5 pCi/l, was analyzed for isotopic radionuclide contents; results presented in Table 11, indicate that, with exception of Th-228, all radionuclide concentrations were less than 1 pCi/l. The Th-228 concentration was 29.7 pCi/g. This level is not consistent with the gross and Ra-228 analyses; duplicate analyses provided similar results, and no explanation for this result could be determined.

Gamma direct monitoring of boreholes indicated elevated levels near the surface, in those boreholes in the vicinity of the slag piles. Levels decreased rapidly over the upper 1-2 m of depth, suggesting that the gamma levels are likely due to ambient radiation from the piles, rather than subsurface contamination. No evidence of elevated gamma radiation was noted below 2 m in any of the boreholes.

## Radioactivity Levels in Well Water and Plant Effluent

Levels of gross alpha and gross beta activity in surface and well water samples are presented in Table 12. Gross alpha concentrations in plant and area wells ranged from <0.4 to 4.0 pCi/l; gross beta concentrations ranged from 1.2 to 32.9 pCi/l. Except for Well W2, samples contained radioactivity levels,

typical of those usually found in baseline water. The two plant effluent samples contained gross alpha levels of 0.5 and 3.0 pCi/l and gross beta levels of 1.7 and 4.0 pCi/l. Neither the inlet nor outlet of the ion exchange column contained significant concentrations of radioactivity.

Samples from Drainage Pathways

Water samples from surface drainage pathways contained <0.4 to 2.4 pCi/l gross alpha, and <0.7 to 9.7 pCi/l, gross beta (Table 12). Table 13 presents concentrations in sediment samples from these drainage pathways. Thorium 232 concentrations ranged up to 33.6 pCi/g; this sample was from surface water Drain Exit B, at the south perimeter fence. Another drainage area, at the 1476 m distance on the south perimeter fence, contained 20.2 pCi/g of Th-232. The highest Ra-226 concentration was 24.8 pCi/g - from the 1476 perimeter fence location.

The East Settling Pond sediment contained 6.4 pCi/g of Th-232 and the West Settling Pond sediment had 2.3 pCi/g of Th-232. Uranium 238 concentrations in these two ponds were 5.1 and 10.1 pCi/g, respectively.

Stack Effluent Measurements

Stack sampling flow rates and volumes are presented in Table 14, and sampling results are summarized in Table 15. Because sampling in the old baghouse was in the inlet duct before the filtration section, concentrations in samples from the system were higher than those from the stacks, exiting the new baghouse. The highest concentrations measured in a sample from the old baghouse was $1.1 \times 10^{-11}$ $\mu$Ci/ml of Ra-226. Several other samples from this system contained Ra-226, Ra-228, U-234, and U-238 concentrations between $1 \times 10^{-12}$ and $5 \times 10^{-12}$ $\mu$Ci/ml; thorium concentrations were generally less than $10^{-14}$ $\mu$Ci/ml. These levels could be expected to be reduced by about a factor of 20 by the filtration of the baghouse, which has a typical removal efficiency of about 95%.

Concentrations in the effluent from the new baghouse were generally less than the measurement sensitivities of the analytical procedures. For the two samples collected from this baghouse, the highest concentrations were: Th-228, $9.6 \times 10^{-16}$ pCi/ml; Th-230, $<4.1 \times 10^{-16}$ $\mu$Ci/ml; Th-232, $<4.1 \times 10^{-16}$ $\mu$Ci/ml; U-234, $<2.3 \times 10^{-15}$ $\mu$Ci/ml; U-235 $<3.1 \times 10^{-15}$ $\mu$Ci/ml; and U-238, $<2.4 \times 10^{-15}$ $\mu$Ci/ml.

Samples of baghouse dust contained elevated levels of Th-232 and Ra-226 (Table 16). The highest levels were in the sample from the old baghouse. This sample contained 76.5 pCi/g of Th-232 and 27.5 pCi/g of Ra-226. Samples from the baghouse dust piles contained levels of Th-232 ranging from 15.7 to 71.0 pCi/g.

## DISCUSSION OF FINDINGS

Elevated gamma radiation levels and associated areas of thorium, radium, and uranium contamination, outside the perimeter fence, indicate loss of control through surface migration and inadvertent relocation. Although many of these areas appear to be individual pieces of slag, there is evidence of contaminated soil in several onsite drainage pathways. The pattern of contamination in the drainage pathways suggests that the mechanism of contamination is predominantly dispersal of fine particulates by surface runoff. The ratios of various radionuclides in the samples from these pathways and the predominant surface nature of the contamination is not consistent with the pattern which would be expected, if the radionuclides were being dissolved in the runoff. Samples of sediment from offsite drainage pathways did not contain radionuclide levels above typical baseline concentrations. Onsite scans also identified areas of elevated radiation, associated with stored materials and waste, which site personnel had previously believed to be free of contamination. It is apparent from these findings that there has not been adequate segregation and control of potentially radioactive materials at this site in the past.

The two piles of ferro-columbium slag produce elevated gamma exposure rates of up to 175 $\mu$R/h, outside the perimeter fence. Under conditions of continuous exposure, this would result in an external total body dose

equivalent of about 26 mrem in one week. Levels of radionuclides in some soil samples, outside the perimeter fence, exceed 10 pCi/g (above background) of total natural thorium and Ra-226 and 35 pCi/g of total uranium.

Samples from the two ferro columbium slag piles, vary widely in radioactive materials content; however average concentrations show that the major contaminant is thorium. The average concentrations of Th-232, in the two piles are: "high-ratio" pile, 366 pCi/g (0.34 weight %) and "standard" pile, 516 pCi/g (0.47 weight %). Concentrations for U-238 in the two piles are: "high-ratio" pile, 105 pCi/g (0.032 weight %), and "standard pile", 202 pCi/g (0.061 weight %). Estimates of total volume and activity in the pile were calculated, and results, presented in Table 17, indicate a "standard" slag volume of about 10,000 $m^3$ and a volume of "high-ratio" slag of approximately 3000 $m^3$. The total quantity (assuming 20% void space) in the "standard" pile is 13.2 Ci ($1.21 \times 10^5$ kg) of Th-232; 3.1 Ci (3.1 g) of Ra-226; and 5.2 Ci ($1.58 \times 10^4$ kg) of U-238. In the "high-ratio" pile, the estimated quantities are: Th-232, 2.5 Ci ($2.29 \times 10^4$ kg); Ra-226, 0.47 Ci (0.47 g); and U-238, 0.72 Ci ($2.16 \times 10^3$ kg). For higher void volumes, the total weights and activity levels decrease slightly.

Soil around the slag piles is contaminated on the surface, but the contaminants appear to be limited to the upper 30-60 cm of soil. At other locations little evidence of subsurface soil contamination was noted. Water samples from boreholes and wells, have contamination levels well below the NRC guidelines for water in unrestricted areas. With only a few exceptions, the concentrations are below the EPA screening levels of 15 pCi/l gross alpha and 50 pCi/l gross beta for community drinking water systems.[4] These low concentrations in subsurface soil and water are evidence that contamination from the site operations is not migrating into the soil and groundwater.

Sediments from area drainage pathways indicate some locations of contamination at the plant perimeter but no accumulation in area streams, ponds, or lakes. Water samples from these bodies of water are also typical of naturally occurring concentrations.

Concentrations in stack effluents from the new baghouse are generally below the detection sensitivities of the procedures. Levels for all radionuclides ranged from $<3.9 \times 10^{-16}$ to $<3.0 \times 10^{-14}$ $\mu$Ci/ml. Concentrations measured in the inlet duct to the old baghouse were typically several orders of magnitude higher than those in the new baghouse discharge. However, a reduction in the discharge from the old baghouse to about 5% (or less) of the inlet concentration would be anticipated. Dusts from the baghouses contain concentrations of Th-232, Ra-226, and U-238, which are above baseline soil levels.

## SUMMARY

During October and December 1987, the Radiological Site Assessment Program of Oak Ridge Associated Universities performed a radiological survey of the Shieldalloy Corporation site in Newfield, New Jersey. The survey included measurement of direct radiation levels and concentrations of radionuclides in soil, sediment, water, and airborne discharges. The total volume and activity content of slag was also estimated. Findings of the survey indicate evidence of inadequate past practices for segregation and control of some contaminated material. As a result, some plant areas contain concentrations of radionuclides in excess of those which could be released for unrestricted use. There was no evidence of migration of radionuclides into subsurface soil or groundwater. Some onsite surface drainage pathways are slightly contaminated, but contamination was not noted in sediments from offsite drainage pathways or offsite water samples.

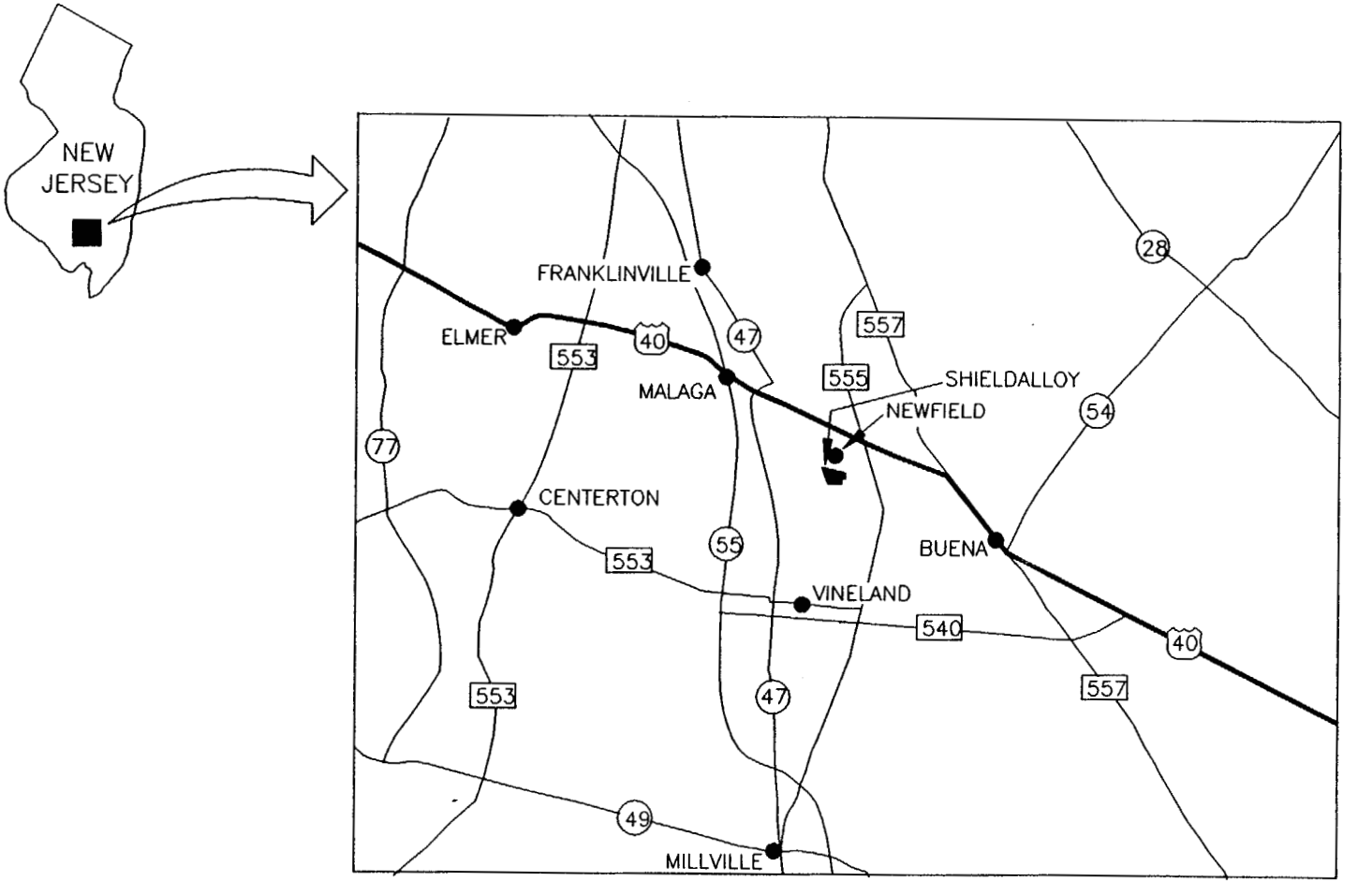


FIGURE 1: Newfield, New Jersey Area, Indicating the Location of the Shieldalloy Site

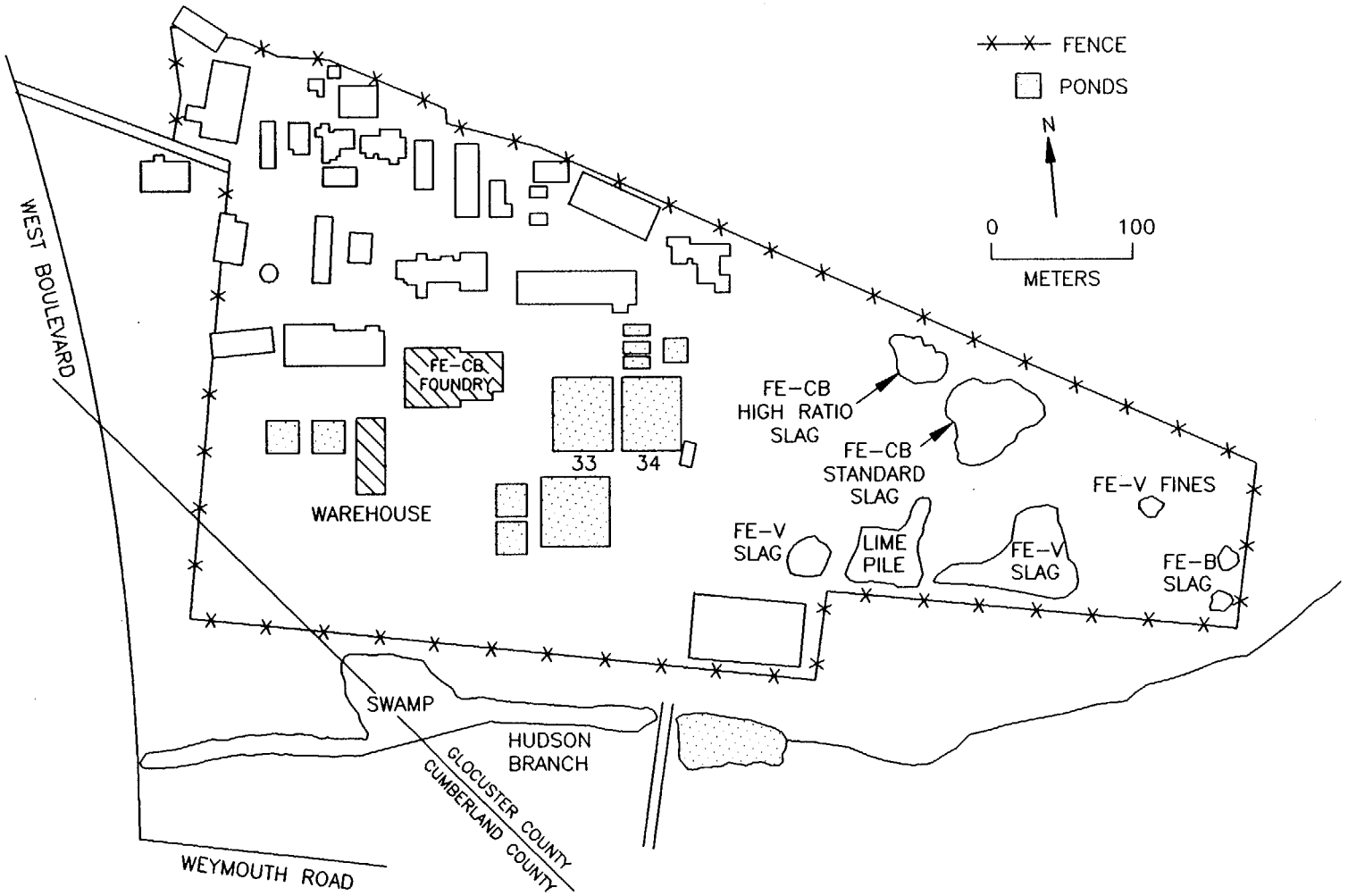


FIGURE 2: Layout of the Shieldalloy Plant in Newfield, New Jersey (Produced from older drawing; fenceline is not currently as represented on this figure.)

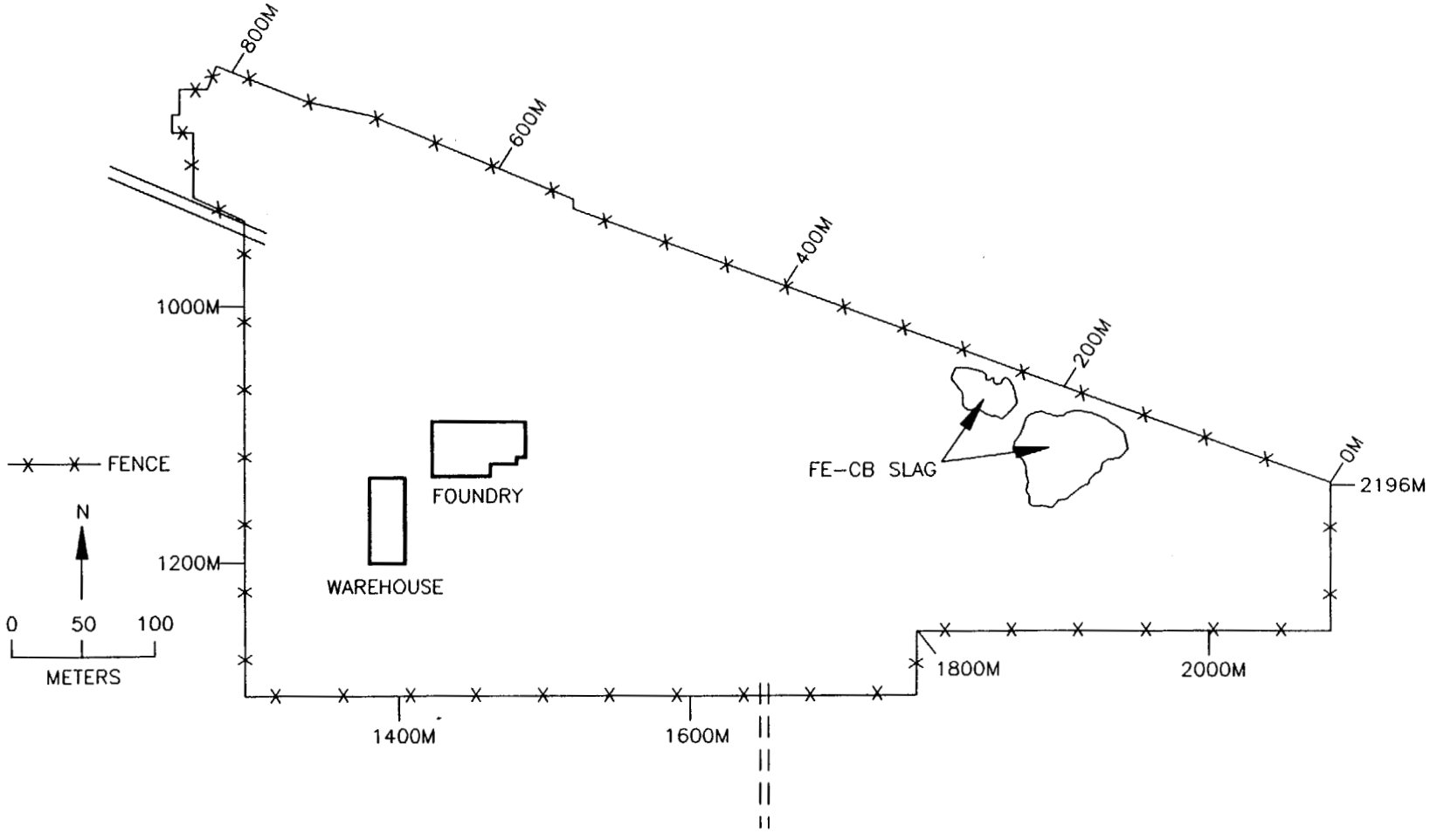


FIGURE 3: Reference Distances Around the Shieldalloy Perimeter Fence

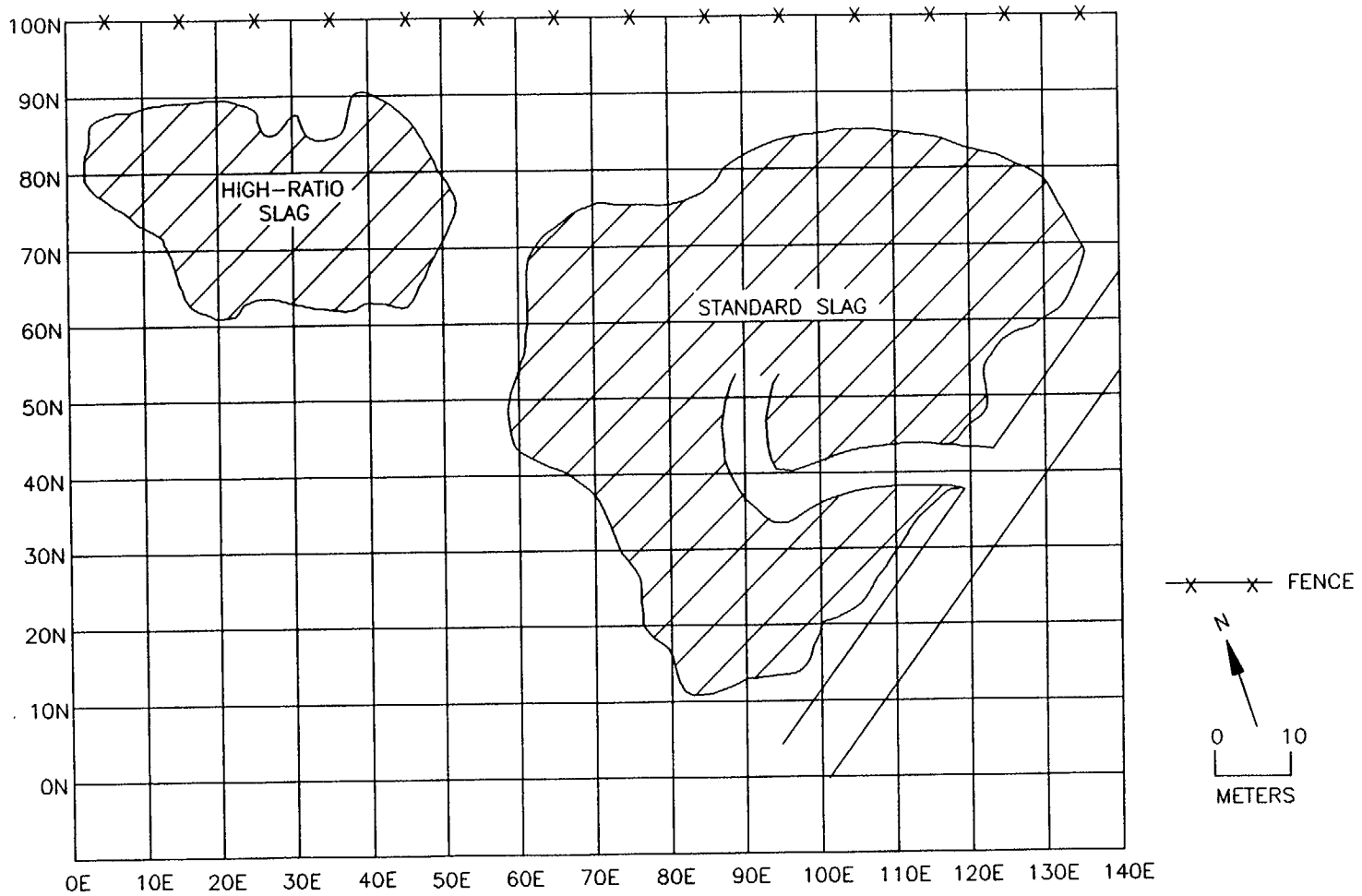


FIGURE 4: Grid System Established in the Vicinity of the Slag Piles

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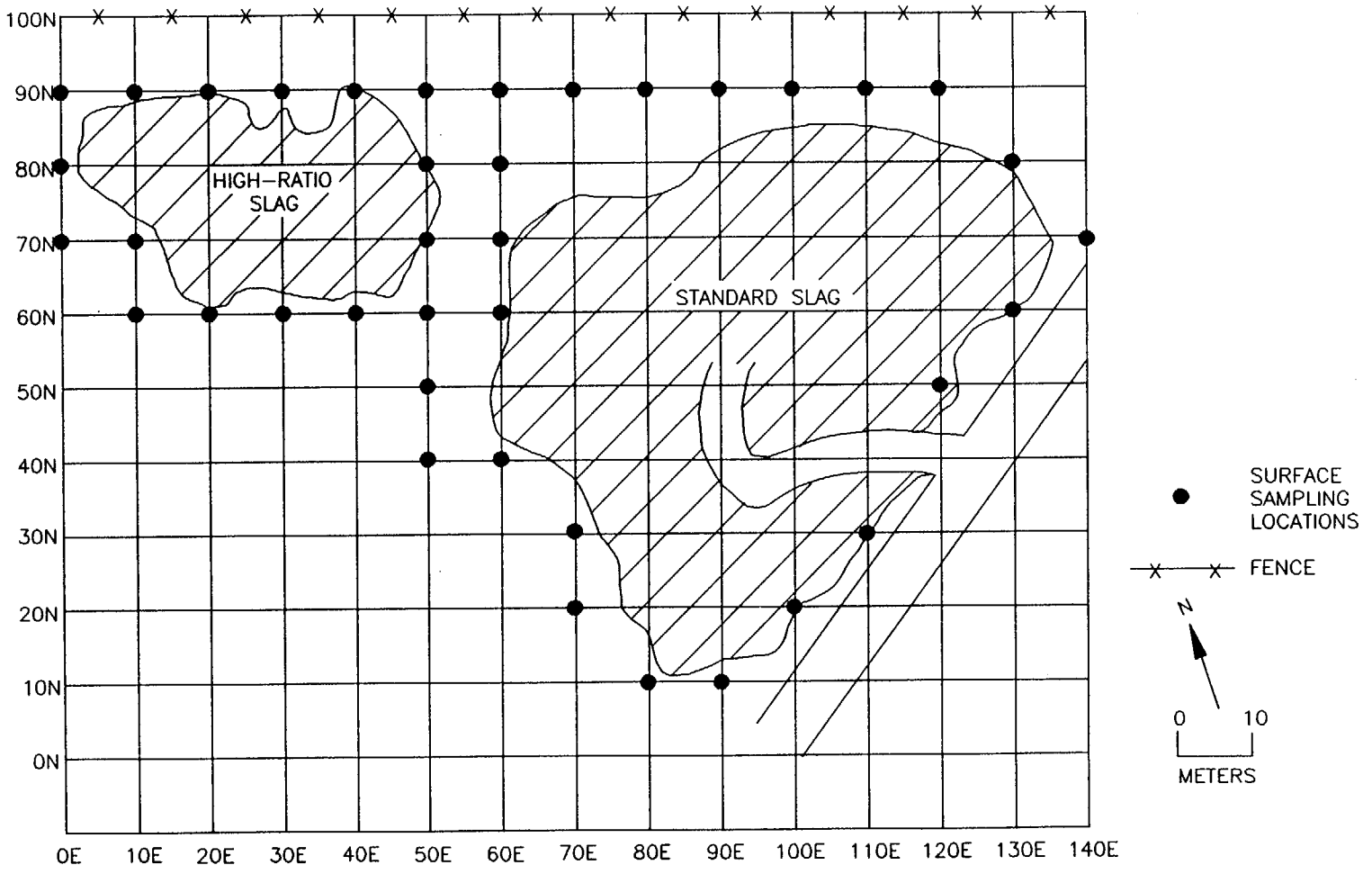


FIGURE 5: Locations of Soil Sampling on the Periphery of the Slag Piles

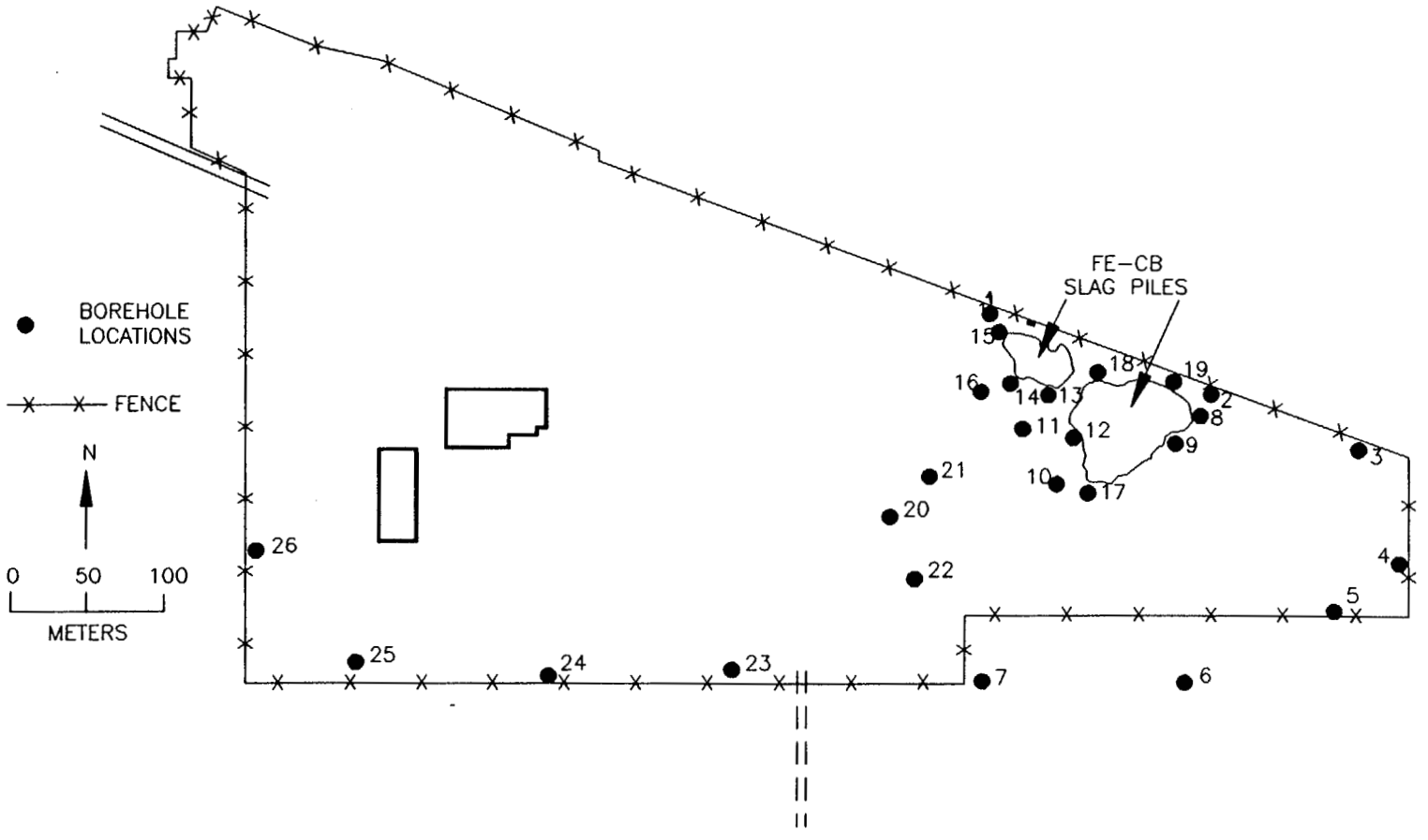


FIGURE 6: Locations of Boreholes for Subsurface Investigations

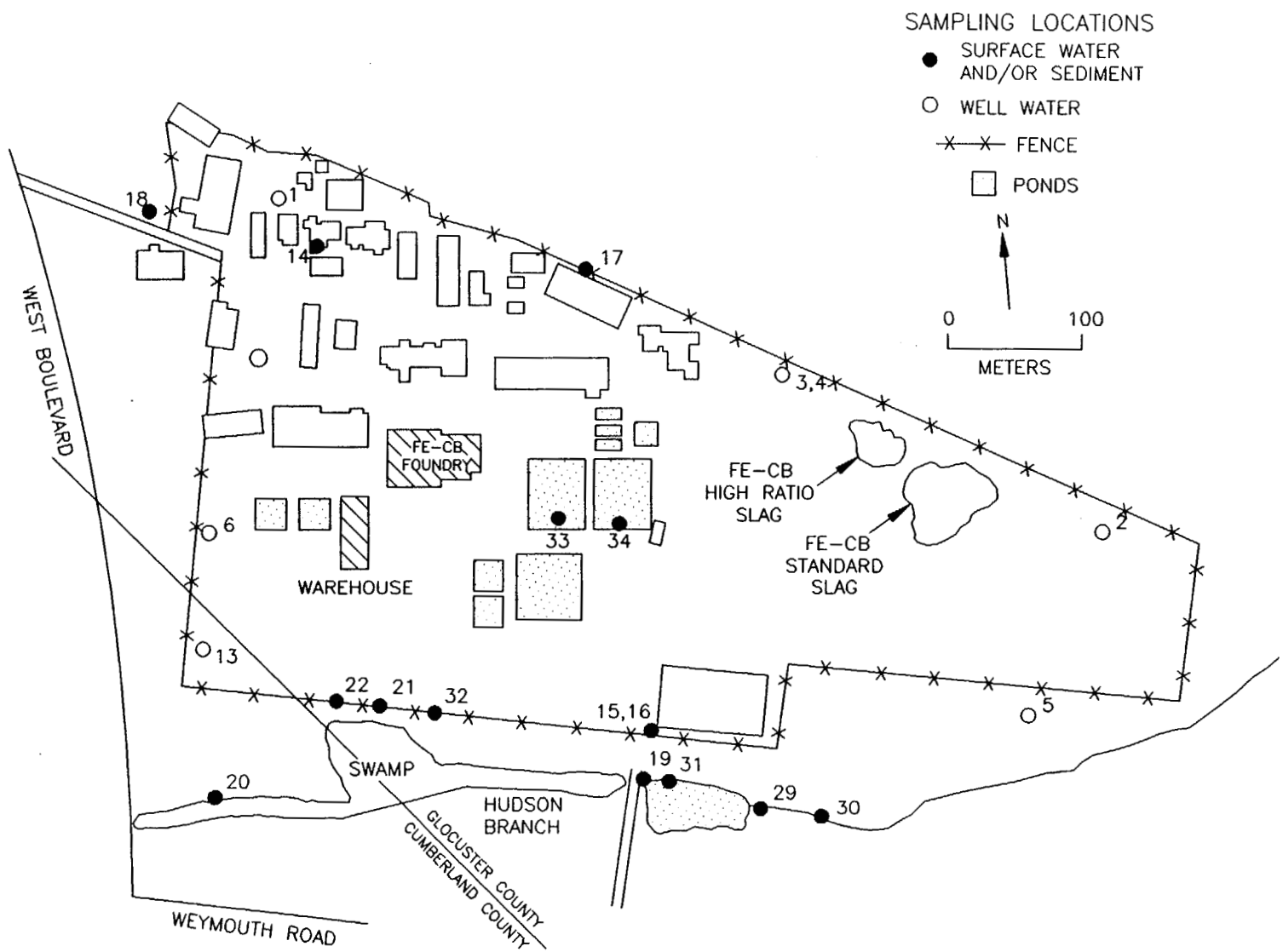


FIGURE 7: Locations of Plant Area Sediment and Water Samples

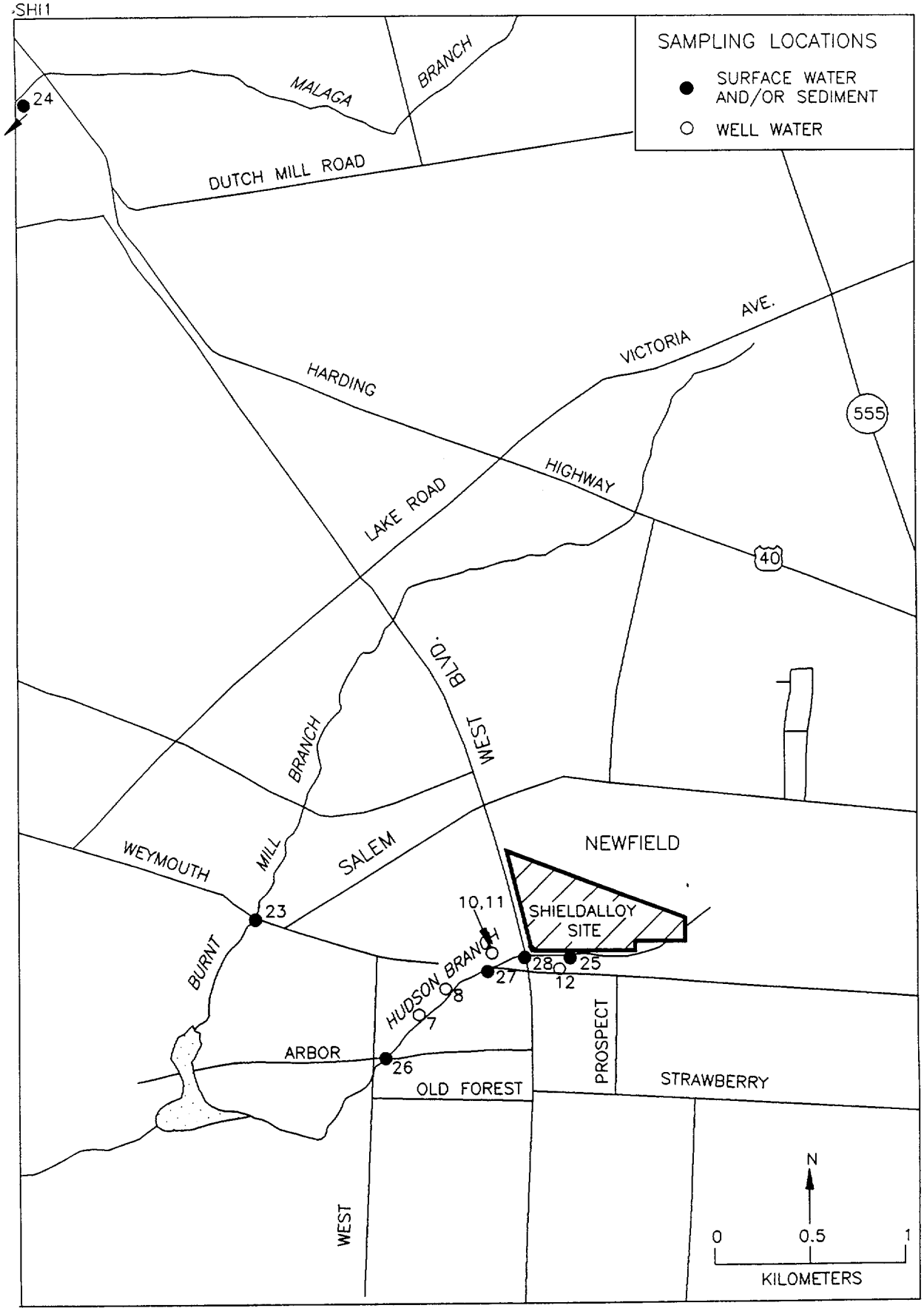


FIGURE 8: Locations of Sediment and Water Samples from Outside the Plant Site

SHI1a

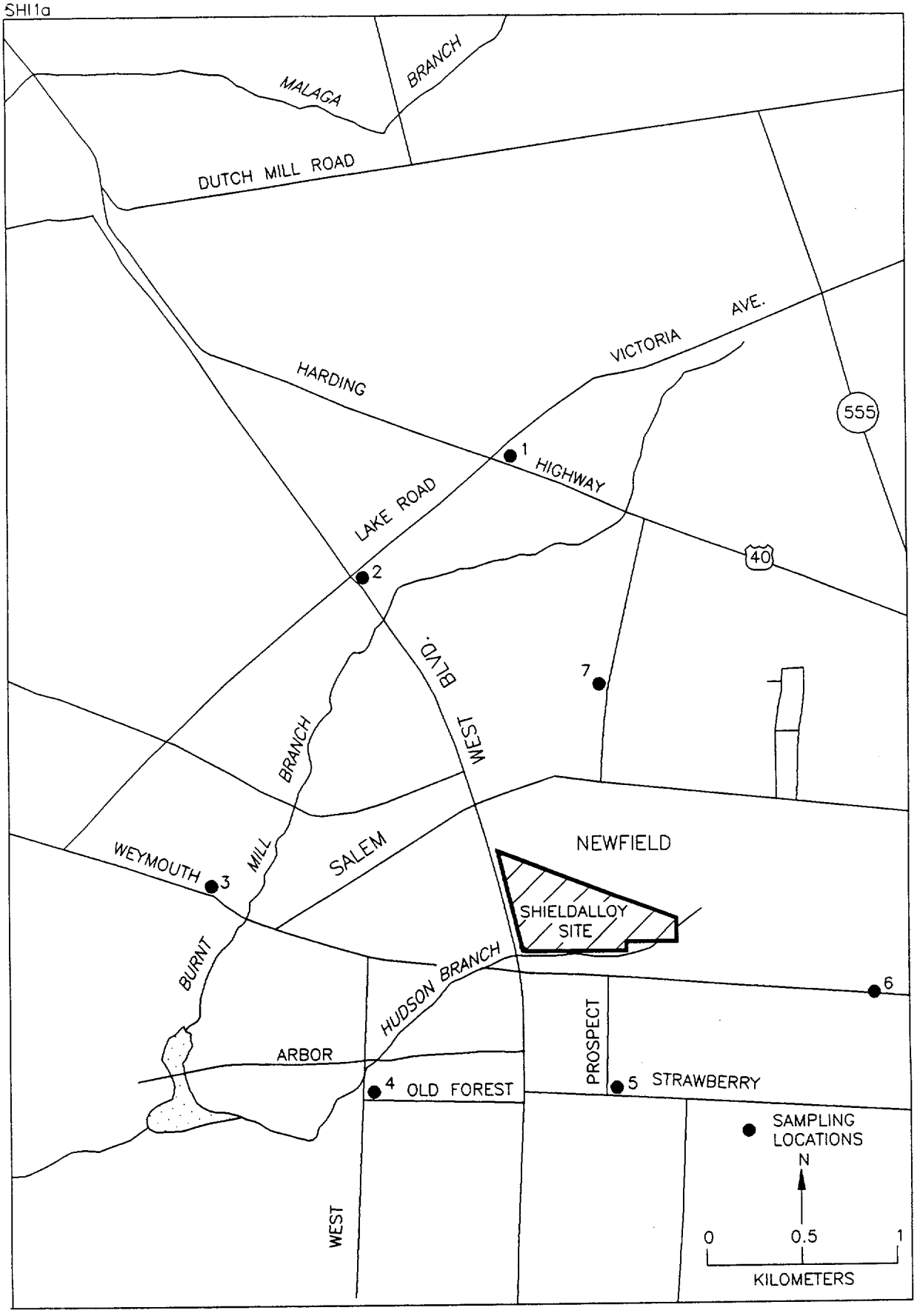


FIGURE 9: Location of Background Measurements and Baseline Samples

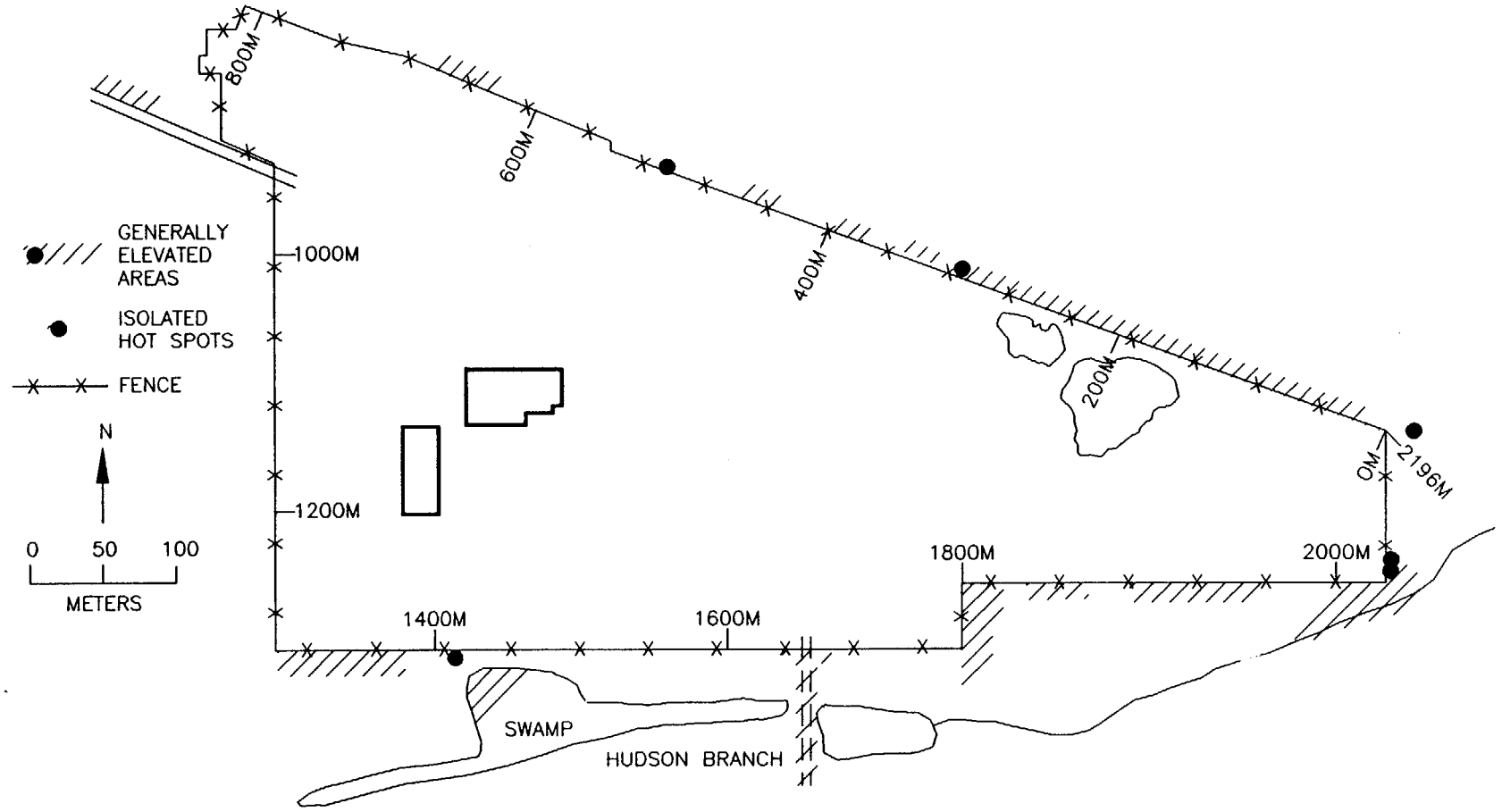


FIGURE 10: Locations of Elevated Radiation Identified by Perimeter Scans

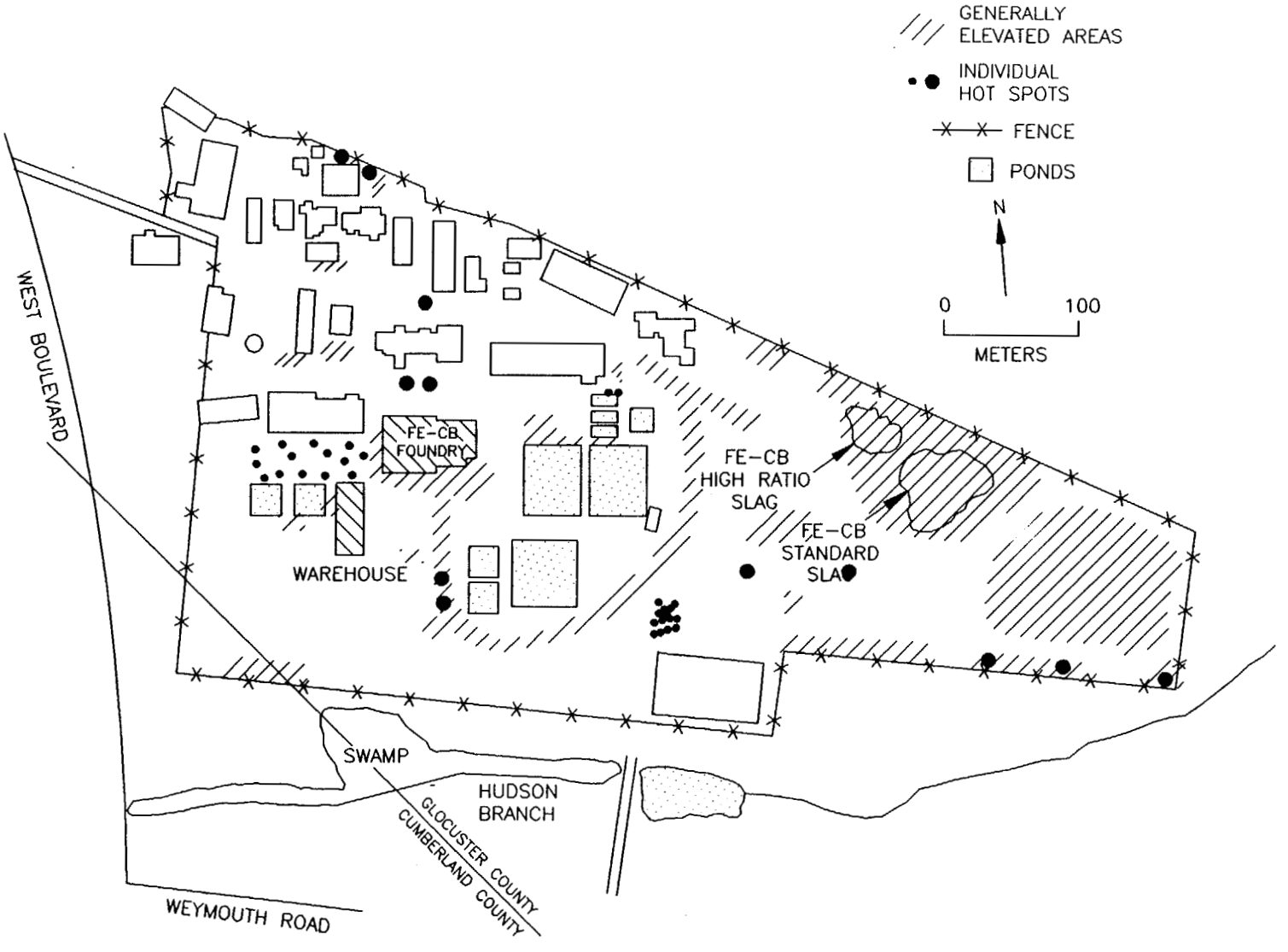


FIGURE 11: Locations of Elevated Radiation Identified Within the Plant Area

TABLE 1

BACKGROUND EXPOSURE RATES AND BASELINE
RADIONUCLIDE CONCENTRATIONS IN SOIL
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location[a] | Gamma Exposure Rate at 1 m Above the Surface (μR/h) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 1 | 7 | 0.3 ± 0.2[b] | 0.5 ± 0.3 | 1.3 ± 1.0 |
| 2 | 7 | 0.5 ± 0.2 | 0.4 ± 0.1 | <0.4 |
| 3 | 6 | 0.1 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.4 |
| 4 | 7 | 0.1 ± 0.1 | 0.2 ± 0.1 | <0.3 |
| 5 | 7 | 0.4 ± 0.3 | 0.7 ± 0.3 | <0.4 |
| 6 | 7 | 0.5 ± 0.5 | 0.9 ± 0.2 | 0.4 ± 0.8 |
| 7 | 8 | 0.6 ± 0.3 | 0.5 ± 0.3 | 0.8 ± 1.1 |

[a]Refer to Figure 10.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 2

DIRECT RADIATION LEVELS MEASURED AT 20 M GRID INTERVALS
ALONG THE PLANT PERIMETER FENCE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location[a] | Gamma Exposure Rate at 1 m Above the Surface (μR/h) | Gamma Exposure Rate at the Surface (μR/h) |
|---|---|---|
| 0 | 13 | 12 |
| 20 | 21 | 19 |
| 40 | 27 | 25 |
| 60 | 31 | 27 |
| 80 | 37 | 33 |
| 100 | 45 | 37 |
| 120 | 68 | 62 |
| 140 | 95 | 66 |
| 160 | 165 | 68 |
| 180 | 165 | 103 |
| 200 | 144 | 82 |
| 220 | 144 | 123 |
| 240 | 175 | 144 |
| 260 | 154 | 144 |
| 280 | 78 | 58 |
| 300 | 66 | 45 |
| 320 | 62 | 52 |
| 340 | 29 | 25 |
| 360 | 21 | 21 |
| 380 | 31 | 29 |
| 400 | 16 | 21 |
| 420 | 14 | 14 |
| 440 | 16 | 16 |
| 460 | 9 | 12 |
| 480 | 9 | 10 |
| 500 | 9 | 10 |
| 520 | 8 | 9 |
| 540 | 7 | 7 |
| 560 | 7 | 7 |
| 580 | 10 | 10 |
| 600 | 19 | 23 |
| 620 | 12 | 21 |
| 640 | 12 | 14 |
| 660 | 47 | 41 |
| 680 | 12 | 21 |
| 700 | 27 | 33 |
| 720 | 9 | 10 |
| 740 | 4 | 5 |
| 760 | 4 | 4 |

TABLE 2 (continued)

DIRECT RADIATION LEVELS MEASURED AT 20 M GRID INTERVALS
ALONG THE PLANT PERIMETER FENCE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location | Gamma Exposure Rate at 1 m Above the Surface (μR/h) | Gamma Exposure Rate at the Surface (μR/h) |
|---|---|---|
| 780 | 5 | 5 |
| 800 | 4 | 4 |
| 820 | 4 | 4 |
| 840 | 6 | 6 |
| 860 | 7 | 6 |
| 880 | 5 | 5 |
| 900 | 4 | 4 |
| 920 | 5 | 5 |
| 940 | 4 | 4 |
| 960 | 4 | 4 |
| 980 | 5 | 5 |
| 1000 | 5 | 5 |
| 1020 | 5 | 5 |
| 1040 | 5 | 5 |
| 1060 | 5 | 5 |
| 1080 | 6 | 6 |
| 1100 | 4 | 5 |
| 1120 | 5 | 6 |
| 1140 | 6 | 7 |
| 1160 | 6 | 6 |
| 1180 | 6 | 6 |
| 1200 | 6 | 6 |
| 1220 | 5 | 5 |
| 1240 | 6 | 6 |
| 1260 | 5 | 5 |
| 1280 | 5 | 5 |
| 1300 | 12 | 16 |
| 1320 | 29 | 39 |
| 1340 | 33 | 52 |
| 1360 | 33 | 19 |
| 1380 | 8 | 7 |
| 1400 | 9 | 8 |
| 1420 | 8 | 8 |
| 1440 | 7 | 6 |
| 1460 | 6 | 7 |
| 1480 | 7 | 7 |
| 1500 | 8 | 7 |
| 1520 | 8 | 8 |
| 1540 | 9 | 8 |

TABLE 2 (continued)

DIRECT RADIATION LEVELS MEASURED AT 20 M GRID INTERVALS
ALONG THE PLANT PERIMETER FENCE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location | Gamma Exposure Rate at 1 m Above the Surface (μR/h) | Gamma Exposure Rate at the Surface (μR/h) |
|---|---|---|
| 1560 | 9 | 8 |
| 1580 | 9 | 9 |
| 1600 | 10 | 10 |
| 1620 | 11 | 10 |
| 1640 | 11 | 10 |
| 1660 | 10 | 10 |
| 1680 | 11 | 10 |
| 1700 | 14 | 12 |
| 1720 | 14 | 12 |
| 1740 | 14 | 13 |
| 1760 | 19 | 19 |
| 1780 | 25 | 23 |
| 1800 | 87 | 62 |
| 1820 | 58 | 52 |
| 1840 | 58 | 165 |
| 1860 | 41 | 41 |
| 1880 | 45 | 49 |
| 1900 | 41 | 35 |
| 1920 | 49 | 41 |
| 1940 | 58 | 37 |
| 1960 | 37 | 25 |
| 1980 | 45 | 33 |
| 2000 | 33 | 25 |
| 2020 | 27 | 29 |
| 2040 | 23 | 16 |
| 2060 | 33 | 29 |
| 2080 | 41 | 21 |
| 2100 | 56 | 41 |
| 2120 | 103 | 113 |
| 2140 | 23 | 21 |
| 2160 | 21 | 19 |
| 2180 | 16 | 12 |

[a]Refer to Figure 3.

TABLE 3

RADIATION LEVELS AT LOCATIONS IDENTIFIED
BY THE PERIMETER FENCE WALKOVER SCAN
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location[a] | Gamma Exposure Rates at 1 m above the surface (μR/h) | Gamma Exposure Rates at the surface (μR/h) |
|---|---|---|
| 610 | 19 | 37 |
| 650 | 37 | 57 |
| 1363 | 78 | 330 |
| 1405 | 9 | 8 |
| 1810 | 43 | 47 |
| 1841 | 82 | 206 |
| 1888 | 103 | 123 |
| 1915 | 58 | 82 |
| 2023 | 29 | 95 |
| 2090 | 41 | 37 |
| 2095 | 66 | 103 |
| 2115 | 103 | 412 |

[a]Refer to Figure 10.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM THE PLANT PERIMETER
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location[a] | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|
| | Th-232 | Ra-226 | U-238 |
| 0 | 0.8 ± 0.3[b] | 0.7 ± 0.2 | <0.5 |
| 20 | 0.4 ± 0.4 | 0.7 ± 0.2 | 0.6 ± 0.6 |
| 40 | 1.4 ± 0.4 | 0.9 ± 0.2 | <0.6 |
| 60 | 2.7 ± 0.5 | 1.4 ± 0.3 | 1.2 ± 1.5 |
| 80 | 0.8 ± 0.4 | 0.5 ± 0.2 | 0.8 ± 1.1 |
| 100 | 1.2 ± 0.4 | 0.9 ± 0.2 | 2.2 ± 1.1 |
| 120 | 0.6 ± 0.2 | 0.6 ± 0.2 | 1.0 ± 1.0 |
| 140 | 1.4 ± 0.3 | 0.8 ± 0.2 | <0.6 |
| 160 | 2.2 ± 0.4 | 1.1 ± 0.2 | <0.8 |
| 180 | 10.6 ± 1.0 | 5.5 ± 0.6 | 5.4 ± 3.7 |
| 200 | 8.3 ± 1.1 | 4.5 ± 0.5 | 7.2 ± 2.6 |
| 220 | 2.7 ± 0.6 | 1.4 ± 0.2 | 1.2 ± 1.8 |
| 240 | 1.3 ± 0.4 | 1.1 ± 0.2 | 2.2 ± 0.6 |
| 260 | 1.1 ± 0.5 | 0.7 ± 0.2 | 1.0 ± 0.6 |
| 280 | 2.2 ± 0.5 | 1.5 ± 0.3 | 1.1 ± 1.4 |
| 300 | 1.4 ± 0.5 | 0.8 ± 0.2 | 1.2 ± 0.5 |
| 320 | 8.5 ± 1.0 | 5.7 ± 0.6 | 3.3 ± 1.5 |
| 340 | 1.0 ± 0.4 | 0.7 ± 0.2 | 0.6 ± 1.0 |
| 360 | 1.5 ± 0.4 | 1.2 ± 0.3 | 0.6 ± 1.0 |
| 380 | 2.0 ± 0.5 | 1.0 ± 0.3 | 1.6 ± 1.4 |
| 400 | 5.9 ± 0.6 | 1.6 ± 0.4 | 2.7 ± 1.1 |
| 420 | 2.8 ± 0.5 | 1.7 ± 0.3 | 1.6 ± 1.1 |
| 440 | 2.2 ± 0.5 | 1.3 ± 0.4 | 3.2 ± 0.9 |
| 460 | 1.8 ± 0.7 | 1.3 ± 0.2 | 1.4 ± 1.3 |
| 480 | 2.1 ± 0.4 | 1.8 ± 0.3 | 1.8 ± 0.6 |
| 500 | 1.2 ± 0.3 | 0.9 ± 0.2 | 0.9 ± 1.0 |
| 520 | 1.7 ± 0.3 | 1.7 ± 0.3 | <0.7 |
| 540 | 1.1 ± 0.3 | 0.7 ± 0.2 | <0.4 |
| 560 | 1.1 ± 0.3 | 1.0 ± 0.2 | 1.1 ± 1.2 |
| 580 | 1.2 ± 0.4 | 1.7 ± 0.3 | 1.4 ± 1.6 |
| 600 | 7.3 ± 0.7 | 2.6 ± 0.3 | 2.2 ± 2.4 |
| 620 | 10.4 ± 0.9 | 2.6 ± 0.4 | 5.4 ± 2.2 |
| 640 | 4.1 ± 0.6 | 6.2 ± 0.5 | 3.4 ± 2.1 |
| 660 | 52.3 ± 1.9 | 6.7 ± 0.7 | 13.4 ± 1.7 |
| 680 | 3.4 ± 0.5 | 6.1 ± 0.5 | 3.2 ± 1.9 |
| 700 | 14.6 ± 1.3 | 6.4 ± 0.6 | 5.3 ± 1.8 |
| 720 | 6.3 ± 0.7 | 3.0 ± 0.4 | 4.0 ± 0.8 |
| 740 | 0.8 ± 0.3 | 0.6 ± 0.2 | <0.5 |
| 760 | 0.5 ± 0.2 | 0.6 ± 0.1 | 0.3 ± 0.9 |
| 780 | 0.5 ± 0.2 | 0.8 ± 0.2 | 2.2 ± 0.7 |
| 800 | 0.5 ± 0.2 | 0.4 ± 0.5 | 2.1 ± 1.4 |

TABLE 4 (continued)

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM THE PLANT PERIMETER
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|
| | Th-232 | Ra-226 | U-238 |
| 820 | 0.3 ± 0.2 | 0.4 ± 0.1 | <0.4 |
| 840 | 0.9 ± 0.4 | 1.1 ± 0.3 | 0.6 ± 1.2 |
| 860 | 0.8 ± 0.4 | 0.6 ± 0.2 | <0.6 |
| 880 | 0.4 ± 0.2 | 0.7 ± 0.2 | 0.9 ± 1.1 |
| 900 | 0.4 ± 0.2 | 0.4 ± 0.1 | 0.2 ± 0.7 |
| 920 | 0.5 ± 0.3 | 0.7 ± 0.2 | 0.8 ± 0.8 |
| 940 | 0.6 ± 0.2 | 0.6 ± 0.2 | 0.5 ± 0.6 |
| 960 | 0.6 ± 0.2 | 0.7 ± 0.2 | 0.7 ± 0.4 |
| 980 | 0.7 ± 0.2 | 0.7 ± 0.2 | 0.6 ± 0.8 |
| 1000 | 0.6 ± 0.3 | 0.6 ± 0.1 | 0.4 ± 0.3 |
| 1020 | 0.6 ± 0.3 | 0.6 ± 0.2 | 0.8 ± 1.2 |
| 1040 | 0.5 ± 0.3 | 0.6 ± 0.1 | 0.4 ± 1.2 |
| 1060 | 0.5 ± 0.2 | 0.4 ± 0.2 | 0.5 ± 1.0 |
| 1080 | 0.4 ± 0.2 | 0.5 ± 0.1 | 0.4 ± 0.3 |
| 1100 | 0.6 ± 0.3 | 0.5 ± 0.2 | 0.6 ± 0.8 |
| 1120 | 0.5 ± 0.2 | 0.5 ± 0.2 | 0.8 ± 0.7 |
| 1140 | 0.4 ± 0.3 | 0.3 ± 0.2 | 0.6 ± 0.4 |
| 1160 | 0.2 ± 0.4 | 0.5 ± 0.2 | <0.6 |
| 1180 | 0.7 ± 0.3 | 0.5 ± 0.1 | <0.4 |
| 1200 | 0.4 ± 0.4 | 0.5 ± 0.2 | <0.4 |
| 1220 | 0.4 ± 0.4 | 0.5 ± 0.1 | 0.7 ± 0.3 |
| 1240 | 0.4 ± 0.2 | 0.5 ± 0.1 | 1.0 ± 0.9 |
| 1260 | 0.4 ± 0.4 | 0.5 ± 0.2 | <0.4 |
| 1280 | 0.5 ± 0.2 | 0.5 ± 0.1 | <0.5 |
| 1300 | 1.6 ± 0.4 | 1.9 ± 0.3 | 2.4 ± 0.9 |
| 1320 | 7.3 ± 0.7 | 5.9 ± 0.5 | 2.8 ± 1.3 |
| 1340 | 13.1 ± 0.9 | 2.6 ± 0.4 | 5.3 ± 1.7 |
| 1360 | 0.5 ± 0.2 | 0.5 ± 0.1 | 0.4 ± 0.9 |
| 1380 | 0.5 ± 0.2 | 0.6 ± 0.1 | <0.4 |
| 1400 | 0.7 ± 0.3 | 0.6 ± 0.1 | 0.6 ± 0.9 |
| 1420 | 0.2 ± 0.3 | 0.9 ± 0.2 | <0.5 |
| 1440 | 0.4 ± 0.2 | 0.5 ± 0.2 | 0.5 ± 1.0 |
| 1460 | 0.3 ± 0.2 | 0.6 ± 0.2 | <0.4 |
| 1480 | 0.5 ± 0.4 | 0.5 ± 0.2 | <0.6 |
| 1500 | 0.6 ± 0.2 | 0.8 ± 0.2 | 0.6 ± 0.4 |
| 1520 | 0.6 ± 0.3 | 0.6 ± 0.1 | 1.1 ± 0.9 |
| 1540 | 0.5 ± 0.3 | 0.7 ± 0.2 | 0.3 ± 0.7 |
| 1560 | 0.4 ± 0.2 | 0.8 ± 0.2 | 0.5 ± 1.4 |

TABLE 4 (continued)

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM THE PLANT PERIMETER
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|
| | Th-232 | Ra-226 | U-238 |
| 1580 | 0.3 ± 0.4 | 0.5 ± 0.1 | 1.0 ± 0.8 |
| 1600 | 0.7 ± 0.3 | 0.8 ± 0.2 | 0.4 ± 1.0 |
| 1620 | 0.5 ± 0.2 | 1.0 ± 0.2 | <0.4 |
| 1640 | 0.3 ± 0.3 | 0.4 ± 0.1 | 0.4 ± 0.7 |
| 1660 | 0.6 ± 0.2 | 0.5 ± 0.2 | <0.5 |
| 1680 | 0.3 ± 0.2 | 0.3 ± 0.2 | 0.3 ± 0.4 |
| 1700 | 0.6 ± 0.3 | 0.6 ± 0.2 | <0.6 |
| 1720 | 0.5 ± 0.2 | 0.6 ± 0.2 | 0.3 ± 1.1 |
| 1740 | 0.4 ± 0.2 | 0.2 ± 0.1 | 0.8 ± 0.5 |
| 1760 | 0.6 ± 0.2 | 0.6 ± 0.2 | 1.1 ± 0.5 |
| 1780 | 0.4 ± 0.2 | 0.6 ± 0.1 | 0.4 ± 0.9 |
| 1800 | 5.3 ± 0.7 | 1.7 ± 0.3 | 2.2 ± 2.1 |
| 1820 | 12.3 ± 1.1 | 4.2 ± 0.5 | 3.2 ± 3.4 |
| 1840 | 6.6 ± 1.0 | 29.3 ± 1.0 | 3.4 ± 2.9 |
| 1860 | 6.0 ± 0.8 | 2.4 ± 0.4 | 2.5 ± 1.2 |
| 1880 | 12.7 ± 0.9 | 5.6 ± 0.4 | 5.9 ± 3.6 |
| 1900 | 2.5 ± 0.4 | 0.9 ± 0.2 | 1.3 ± 0.7 |
| 1920 | 9.1 ± 0.8 | 2.4 ± 0.3 | 4.5 ± 2.2 |
| 1940 | 0.9 ± 0.3 | 0.5 ± 0.2 | 0.4 ± 0.4 |
| 1960 | 1.1 ± 0.4 | 0.6 ± 0.2 | 0.8 ± 1.4 |
| 1980 | 1.5 ± 0.4 | 0.7 ± 0.3 | 0.9 ± 1.2 |
| 2000 | 0.2 ± 0.2 | 0.3 ± 0.1 | <0.4 |
| 2020 | 4.5 ± 0.6 | 1.7 ± 0.3 | 4.9 ± 1.3 |
| 2040 | 1.0 ± 0.4 | 0.4 ± 0.2 | 0.4 ± 1.1 |
| 2060 | 0.6 ± 0.2 | 1.2 ± 0.2 | 4.3 ± 0.8 |
| 2080 | 0.6 ± 0.2 | 0.4 ± 0.1 | 0.5 ± 0.8 |
| 2100 | 2.7 ± 0.5 | 0.9 ± 0.2 | 1.0 ± 1.5 |
| 2120 | 1.0 ± 0.3 | 0.6 ± 0.2 | <0.4 |
| 2140 | 1.2 ± 0.4 | 0.7 ± 0.2 | 0.9 ± 0.9 |
| 2160 | 1.2 ± 0.3 | 0.6 ± 0.2 | 1.2 ± 1.3 |
| 2180 | 0.5 ± 0.3 | 0.3 ± 0.1 | 0.3 ± 0.5 |

[a]Refer to Figure 3.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PERIMETER LOCATIONS IDENTIFIED BY THE WALKOVER SCAN
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location[a] | Sampling Depth (cm) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 610 | 0-15 | 27.2 ± 1.6[b] | 5.1 ± 0.6 | 16.8 ± 2.8 |
| | 15-30 | 1.9 ± 0.4 | 0.6 ± 0.2 | 0.9 ± 1.4 |
| | 30-45 | 0.6 ± 0.3 | 0.4 ± 0.2 | <0.5 |
| 650 | 0-15 | 68.1 ± 2.2 | 13.7 ± 0.9 | 31.0 ± 4.3 |
| | 15-30 | 4.0 ± 0.7 | 1.1 ± 0.2 | 1.1 ± 1.8 |
| 1363 | 0-15 | 41.1 ± 3.4 | 192 ± 3 | 147 ± 9 |
| | 15-30 | 14.2 ± 1.2 | 42.9 ± 1.2 | 20.5 ± 6.0 |
| | 30-45 | 4.2 ± 0.8 | 19.7 ± 0.8 | 18.9 ± 2.4 |
| 1405 | 0-15 | 0.9 ± 0.4 | 0.6 ± 0.2 | 1.2 ± 0.9 |
| | 15-30 | 0.6 ± 0.2 | 0.4 ± 0.2 | 0.9 ± 0.8 |
| 1810 | 0-15 | 17.5 ± 1.6 | 3.4 ± 0.6 | 17.9 ± 2.9 |
| | 15-30 | 1.6 ± 0.4 | 0.8 ± 0.2 | 1.2 ± 1.0 |
| 1841 | 0-15 | 4.1 ± 0.9 | 61.9 ± 1.3 | <2.4 |
| | 15-30 | 0.6 ± 0.4 | 1.6 ± 0.2 | 0.7 ± 1.0 |
| 1888 | 0-15 | 9.3 ± 1.8 | 76.3 ± 1.5 | 63.5 ± 4.4 |
| | 15-30 | 1.9 ± 0.4 | 8.5 ± 0.5 | 7.8 ± 2.2 |
| 1915 | 0-15 | 18.1 ± 1.3 | 7.2 ± 0.8 | 11.0 ± 2.5 |
| | 15-30 | 2.7 ± 0.5 | 1.0 ± 0.2 | 0.9 ± 1.4 |

TABLE 5 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES
FROM PERIMETER LOCATIONS IDENTIFIED BY THE WALKOVER SCAN
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Perimeter Grid Location | Sampling Depth (cm) | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 2023 | 0-15 | 5.9 ± 1.4 | 5.0 ± 0.8 | 3.6 ± 2.8 |
| | 15-30 | 0.3 ± 0.3 | 0.4 ± 0.2 | <0.5 |
| 2090 | 0-15 | 2.6 ± 0.5 | 1.0 ± 0.2 | 0.9 ± 1.4 |
| | 15-30 | 0.7 ± 0.3 | 0.5 ± 0.2 | 0.4 ± 1.0 |
| 2095 | 0-15 | 1.6 ± 0.4 | 0.8 ± 0.2 | 0.7 ± 1.7 |
| 2115 | 0-15 | 1.1 ± 0.3 | 0.6 ± 0.2 | 0.7 ± 0.8 |
| | 15-30 | 0.4 ± 0.2 | 0.3 ± 0.1 | <0.4 |

[a]Refer to Figure 10.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN SAMPLES
FROM THE FE-CB HIGH-RATIO SLAG PILE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location[a] N | Location[a] E | Radionuclide Concentration (pCi/g) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|
| 71 | 48 | 1.8 ± 0.9[b] | 0.7 ± 0.7 | < 1.8 |
| 70 | 44 | 1460 ± 20 | 110 ± 7 | <98 |
| 64 | 39 | 3.9 ± 1.1 | 4.3 ± 0.6 | <2.0 |
| 70 | 30 | 542 ± 10 | 114 ± 5 | <58 |
| 67 | 15 | 263 ± 6 | 96.1 ± 3.6 | 119 ± 80 |
| 72 | 18 | 683 ± 17 | 243 ± 9 | 700 ± 260 |
| 85 | 16 | 181 ± 7 | 51.4 ± 3.7 | 66 ± 43 |
| 86 | 12 | 240 ± 7 | 86.1 ± 3.7 | 107 ± 81 |
| 88 | 30 | 263 ± 8 | 24.8 ± 3.1 | <49 |
| 89 | 30 | 0.5 ± 0.8 | 0.5 ± 0.8 | 1.5 ± 3.0 |
| 79 | 35 | 586 ± 6 | 79.9 ± 2.2 | 44 ± 65 |
| 85 | 47 | 173 ± 3 | 12.1 ± 1.0 | 11.2 ± 6.4 |
| AVERAGE | | 366 | 69 | 105 |

[a]Refer to Figure 4.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 7

RADIONUCLIDE CONCENTRATIONS IN SAMPLES
FROM THE FE-CB STANDARD SLAG PILE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location[a] N | Location[a] E | Radionuclide Concentration (pCi/g) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|
| 70 | 65 | 659 ± 11[b] | 267 ± 6 | 430 ± 170 |
| 50 | 68 | 706 ± 13 | 247 ± 7 | 280 ± 150 |
| 30 | 80 | 0.6 ± 0.3 | 0.5 ± 0.1 | 0.8 ± 1.3 |
| 18 | 90 | 1500 ± 20 | 105 ± 7 | 130 ± 160 |
| 20 | 98 | 1340 ± 22 | 185 ± 8 | 480 ± 160 |
| 30 | 110 | 10.9 ± 1.4 | 2.5 ± 0.6 | 1.9 ± 2.6 |
| 46 | 110 | 683 ± 14 | 270 ± 8 | 280 ± 190 |
| 61 | 131 | 137 ± 5 | 23.4 ± 1.5 | 24 ± 15 |
| 78 | 126 | 482 ± 11 | 187 ± 6 | 340 ± 160 |
| 80 | 100 | 393 ± 7 | 118 ± 4 | 159 ± 94 |
| 75 | 80 | 1500 ± 20 | 23.6 ± 5.1 | 520 ± 180 |
| 74 | 68 | 13.8 ± 2.1 | 2.9 ± 0.9 | 6.8 ± 3.7 |
| 45 | 100 | 472 ± 7 | 318 ± 5 | 310 ± 130 |
| 52 | 110 | 219 ± 7 | 85.6 ± 3.8 | 209 ± 92 |
| 64 | 110 | 93.7 ± 5.8 | 44.0 ± 3.1 | 70 ± 68 |
| 65 | 90 | 3.5 ± 0.9 | 2.5 ± 0.7 | <1.9 |
| 78 | 115 | 671 ± 10 | 198 ± 5 | 300 ± 120 |
| 35 | 87 | 412 ± 8 | 140 ± 4 | 94 ± 110 |
| AVERAGE | | 516 | 123 | 202 |

[a]Refer to Figure 4.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 8

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM THE VICINITY OF THE SLAG PILES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Grid Location[a] N | Grid Location[a] E | Radionuclide Concentration (pCi/g) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|
| 90 | 60 | 7.3 ± 0.7[b] | 3.9 ± 0.4 | 10.2 ± 1.8 |
| 80 | 60 | 15.7 ± 0.9 | 5.9 ± 0.4 | 2.8 ± 3.1 |
| 70 | 60 | 7.9 ± 0.7 | 2.5 ± 0.3 | 3.7 ± 1.6 |
| 60 | 60 | 33.0 ± 1.8 | 10.9 ± 0.8 | 16.9 ± 4.8 |
| 40 | 60 | 14.0 ± 1.0 | 2.7 ± 0.5 | 3.4 ± 2.9 |
| 40 | 50 | 62.5 ± 1.9 | 10.3 ± 0.7 | 8.9 ± 6.0 |
| 50 | 50 | 15.3 ± 0.9 | 3.6 ± 0.4 | 2.3 ± 5.8 |
| 60 | 50 | 10.4 ± 0.7 | 2.9 ± 0.3 | 4.8 ± 1.4 |
| 60 | 40 | 13.3 ± 0.8 | 3.2 ± 0.4 | 2.8 ± 3.0 |
| 60 | 30 | 48.9 ± 1.6 | 10.1 ± 0.7 | <10 |
| 60 | 20 | 22.2 ± 1.1 | 6.4 ± 0.5 | 6 ± 12 |
| 60 | 10 | 13.9 ± 0.8 | 4.0 ± 0.4 | 10.3 ± 2.1 |
| 70 | 10 | 24.3 ± 1.2 | 12.6 ± 0.7 | 11 ± 13 |
| 70 | 0 | 22.1 ± 1.2 | 4.1 ± 0.5 | <7.0 |
| 80 | 0 | 61.4 ± 3.6 | 29.6 ± 1.8 | 20.8 ± 7.3 |
| 90 | 0 | 9.4 ± 2.1 | 4.8 ± 0.9 | 5.2 ± 2.4 |
| 90 | 10 | 6.5 ± 0.8 | 6.0 ± 0.5 | 3.4 ± 1.5 |
| 90 | 20 | 3.8 ± 0.6 | 1.7 ± 0.3 | 4.2 ± 1.1 |
| 90 | 30 | 437 ± 8.0 | 128 ± 4 | 160 ± 81 |
| 90 | 40 | 5.5 ± 0.7 | 1.7 ± 0.3 | 2.1 ± 1.1 |
| 90 | 50 | 3.6 ± 1.0 | 1.9 ± 0.5 | 3.7 ± 2.1 |
| 80 | 50 | 50.9 ± 1.8 | 6.4 ± 0.7 | 3.4 ± 3.3 |
| 70 | 50 | 4.5 ± 0.7 | 1.7 ± 0.3 | 2.3 ± 2.4 |
| 90 | 70 | 3.2 ± 0.5 | 1.6 ± 0.3 | 1.6 ± 1.0 |
| 90 | 80 | 11.8 ± 1.2 | 5.4 ± 0.5 | 7.9 ± 2.8 |
| 90 | 90 | 2.1 ± 0.6 | 3.1 ± 0.3 | 1.8 ± 0.7 |

TABLE 8 (continued)

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
FROM THE VICINITY OF SLAG PILES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Grid Location | | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|---|
| N | E | Th-232 | Ra-226 | U-238 |
| 90 | 100 | 16.9 ± 1.6 | 5.3 ± 0.7 | 13.2 ± 3.3 |
| 90 | 110 | 10.6 ± 1.1 | 4.5 ± 0.5 | 5.2 ± 3.0 |
| 90 | 120 | 10.0 ± 1.1 | 4.2 ± 0.5 | 2.1 ± 4.3 |
| 80 | 130 | 3.6 ± 0.5 | 1.9 ± 0.2 | 1.7 ± 0.7 |
| 70 | 140 | 17.0 ± 1.0 | 3.9 ± 0.4 | 15.5 ± 2.2 |
| 60 | 130 | 7.7 ± 0.9 | 2.0 ± 0.3 | 3.7 ± 1.3 |
| 50 | 120 | 20.5 ± 1.3 | 4.4 ± 0.5 | 11.4 ± 1.4 |
| 30 | 110 | 53.5 ± 2.4 | 6.6 ± 1.0 | <14 |
| 20 | 100 | 10.0 ± 1.1 | 6.7 ± 0.8 | 5.1 ± 4.9 |
| 10 | 90 | 15.6 ± 1.5 | 5.7 ± 0.8 | 6.6 ± 2.9 |
| 10 | 80 | 14.0 ± 1.1 | 3.1 ± 0.5 | <7.1 |
| 20 | 70 | 16.2 ± 1.1 | 3.7 ± 0.6 | 8.0 ± 1.9 |
| 30 | 70 | 11.2 ± 1.0 | 3.1 ± 0.4 | 3.7 ± 2.1 |

[a]Refer to Figure 4.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 9

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM BOREHOLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location[a] | Sampling Depth (m) | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 1 | Surface | 4.7 ± 0.6[b] | 1.8 ± 0.3 | 5.4 ± 0.8 |
| | 1.5 - 2.1 | 0.2 ± 0.3 | 0.2 ± 0.1 | 0.2 ± 0.3 |
| | 3.0 - 3.6 | 0.2 ± 0.1 | 0.2 ± 0.1 | <0.2 |
| | 4.5 - 5.1 | 0.2 ± 0.1 | 0.3 ± 0.1 | 0.2 ± 0.5 |
| 2 | Surface | 0.6 ± 0.3 | 0.6 ± 0.2 | 0.5 ± 1.0 |
| | 1.5 - 2.1 | 0.3 ± 0.2 | 0.3 ± 0.1 | 0.1 ± 0.6 |
| | 3.0 - 3.6 | 0.2 ± 0.2 | 0.2 ± 0.1 | <0.3 |
| | 4.5 - 5.1 | 0.2 ± 0.2 | 0.2 ± 0.2 | <0.5 |
| 3 | Surface | 0.8 ± 0.3 | 0.4 ± 0.1 | 0.8 ± 0.7 |
| | 1.5 - 2.1 | 0.4 ± 0.1 | 0.2 ± 0.1 | 0.7 ± 0.4 |
| | 3.0 - 3.6 | 0.3 ± 0.3 | 0.3 ± 0.2 | <0.4 |
| | 4.5 - 5.1 | 0.3 ± 0.2 | 0.2 ± 0.1 | 0.2 ± 0.3 |
| 4 | Surface | 5.2 ± 0.6 | 1.3 ± 0.3 | 1.7 ± 2.1 |
| | 1.5 - 2.1 | 0.4 ± 0.2 | 0.3 ± 0.1 | 0.3 ± 0.5 |
| | 3.0 - 3.6 | 0.4 ± 0.5 | 0.2 ± 0.1 | 0.4 ± 0.6 |
| 5 | Surface | 12.7 ± 2.3 | 2.9 ± 0.9 | 7.8 ± 3.4 |
| | 1.5 - 2.1 | 0.9 ± 0.4 | 0.1 ± 0.3 | <0.9 |
| | 3.0 - 3.6 | 0.2 ± 0.2 | 0.3 ± 0.1 | 0.4 ± 0.8 |
| 6 | Surface | <0.2 | <0.2 | <0.6 |
| | 1.5 - 2.1 | 0.4 ± 0.6 | 0.2 ± 0.3 | 0.4 ± 0.6 |

TABLE 9 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM BOREHOLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location | Sampling Depth (m) | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 7 | Surface | 0.2 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.7 |
| | 1.5 - 2.1 | 0.2 ± 0.2 | 0.3 ± 0.1 | 0.5 ± 0.5 |
| 8 | Surface | 7.1 ± 0.8 | 1.6 ± 0.3 | 3.3 ± 1.8 |
| | 1.5 - 2.1 | 1.0 ± 0.3 | 0.3 ± 0.1 | 0.6 ± 0.7 |
| | 3.0 - 3.1 | 1.6 ± 0.3 | 0.4 ± 0.2 | <0.6 |
| | 4.5 - 5.1 | 0.6 ± 0.2 | 0.3 ± 0.1 | 0.8 ± 0.4 |
| | 6.0 - 6.6 | 0.4 ± 0.3 | 0.2 ± 0.3 | <0.8 |
| 9 | Surface | 1.8 ± 0.6 | 0.8 ± 0.2 | 1.2 ± 1.2 |
| | 1.5 - 2.1 | 4.0 ± 0.5 | 0.5 ± 0.2 | 2.6 ± 0.6 |
| | 3.0 - 3.6 | 0.2 ± 0.2 | 0.2 ± 0.1 | 0.9 ± 0.4 |
| | 4.5 - 5.1 | 0.2 ± 0.3 | 0.2 ± 0.2 | <0.4 |
| 10 | Surface | 10.7 ± 0.9 | 4.1 ± 0.4 | 3.8 ± 1.7 |
| | 1.5 - 2.1 | 2.5 ± 0.4 | 0.4 ± 0.2 | 1.0 ± 3.0 |
| | 3.0 - 3.6 | 0.4 ± 0.2 | 0.4 ± 0.1 | 0.8 ± 0.9 |
| 11 | Surface | 0.7 ± 0.5 | 2.4 ± 0.3 | 2.6 ± 1.1 |
| | 1.5 - 2.1 | 0.4 ± 0.2 | 0.3 ± 0.1 | <0.4 |
| | 3.0 - 3.6 | 0.1 ± 0.2 | 0.2 ± 0.1 | <0.3 |
| 12 | Surface | 2.8 ± 0.5 | 0.9 ± 0.3 | 3.3 ± 0.7 |
| | 1.5 - 2.1 | 0.5 ± 0.2 | 0.3 ± 0.1 | 0.8 ± 0.8 |
| | 3.0 - 3.6 | 0.3 ± 0.2 | 0.3 ± 0.1 | <0.3 |

TABLE 9 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM BOREHOLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location | Sampling Depth (m) | Radionuclide Concentrations (pCi/g) | | |
|---|---|---|---|---|
| | | Th-232 | Ra-226 | U-238 |
| 13 | Surface | 17.8 ± 1.3 | 2.7 ± 0.5 | 8.3 ± 1.4 |
| | 1.5 - 2.1 | 5.0 ± 0.7 | 1.0 ± 0.2 | 0.7 ± 1.8 |
| | 3.0 - 3.6 | 0.7 ± 0.3 | | <0.4 |
| 14 | Surface | 13.6 ± 1.0 | 6.3 ± 0.5 | 15.5 ± 1.4 |
| | 1.5 - 2.1 | 0.8 ± 0.3 | 0.4 ± 0.2 | <0.6 |
| | 3.0 - 3.6 | 0.3 ± 0.2 | 0.3 ± 0.1 | 0.4 ± 0.3 |
| | 4.5 - 5.1 | 0.1 ± 0.1 | 0.1 ± 0.1 | <0.3 |
| 15 | Surface | 2.5 ± 0.5 | 1.8 ± 0.2 | 1.8 ± 1.4 |
| | 1.5 - 2.1 | 0.3 ± 0.2 | 0.3 ± 0.1 | 0.3 ± 0.5 |
| | 3.0 - 3.6 | 0.2 ± 0.1 | 0.1 ± 0.1 | <0.3 |
| | 4.5 - 5.1 | 0.1 ± 0.2 | 0.2 ± 0.1 | <0.3 |
| 16 | Surface | 5.8 ± 1.0 | 6.1 ± 2.2 | 4.2 ± 1.0 |
| | 1.5 - 2.1 | 1.1 ± 0.5 | 2.7 ± 0.6 | <1.3 |
| | 3.0 - 3.6 | 0.2 ± 0.3 | 0.5 ± 0.1 | 0.5 ± 0.6 |
| | 4.5 - 5.1 | 0.2 ± 0.1 | 0.3 ± 0.1 | 0.3 ± 0.3 |
| 17 | Surface | 11.6 ± 1.6 | 35.0 ± 1.9 | 5.6 ± 6.8 |
| | 1.5 - 2.1 | 7.0 ± 0.3 | 27.2 ± 2.4 | 7.3 ± 4.6 |
| | 3.0 - 3.6 | 0.1 ± 0.3 | 0.8 ± 0.2 | <0.5 |
| 18 | Surface | 7.0 ± 0.8 | 6.7 ± 0.5 | 5.3 ± 1.4 |
| | 1.5 - 2.1 | 0.8 ± 0.3 | 0.5 ± 0.2 | <0.4 |
| | 3.0 - 3.6 | 0.2 ± 0.2 | 0.2 ± 0.1 | 0.5 ± 0.6 |

TABLE 9 (continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM BOREHOLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location | Sampling Depth (m) | Radionuclide Concentrations (pCi/g) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|
| 19 | Surface | 1.3 ± 0.3 | 1.0 ± 0.2 | 0.8 ± 0.5 |
| | 1.5 - 2.1 | 0.2 ± 0.1 | 0.3 ± 0.1 | <0.3 |
| | 3.0 - 3.6 | 0.1 ± 0.2 | 0.2 ± 0.1 | 0.5 ± 0.6 |
| 20 | Surface | 0.7 ± 0.3 | 2.7 ± 0.3 | <0.5 |
| | 1.5 - 2.1 | 0.6 ± 0.3 | 1.5 ± 0.3 | <0.6 |
| | 3.0 - 3.6 | 0.2 ± 0.3 | 0.2 ± 0.1 | 0.8 ± 0.6 |
| 21 | Surface | 2.4 ± 0.5 | 2.5 ± 0.3 | <0.7 |
| | 1.5 - 2.1 | 0.4 ± 0.4 | 0.3 ± 0.1 | 0.4 ± 0.9 |
| | 3.0 - 3.6 | 0.4 ± 0.2 | 1.2 ± 0.2 | 0.5 ± 0.3 |
| 22 | Surface | 2.4 ± 0.5 | 7.2 ± 0.5 | 2.5 ± 1.4 |
| | 1.5 - 2.1 | 0.4 ± 0.3 | 0.3 ± 0.2 | 0.3 ± 1.1 |
| 23 | Surface | 689 ± 16 | 283 ± 9 | 148 ± 54 |
| | 1.5 - 2.1 | 0.2 ± 0.2 | 0.3 ± 0.1 | 0.8 ± 0.5 |
| 24 | Surface | 0.6 ± 0.2 | 0.5 ± 0.2 | <0.4 |
| | 1.5 - 2.1 | 0.7 ± 0.3 | 0.6 ± 0.1 | <0.5 |
| 25 | Surface | 0.5 ± 0.2 | 0.4 ± 0.2 | 0.5 ± 0.3 |
| | 1.5 - 2.1 | 0.7 ± 0.3 | 0.4 ± 0.2 | 0.2 ± 1.0 |
| 26 | Surface | 0.6 ± 0.6 | 0.5 ± 0.3 | 1.3 ± 1.9 |
| | 1.5 - 2.1 | <0.2 | 0.1 ± 0.2 | <0.6 |

[a]Refer to Figure 6.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 10

RADIONUCLIDE CONCENTRATIONS IN WATER FROM BOREHOLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location[a] | Water Depth (m) | Radionuclide Concentration (pCi/l) | |
|---|---|---|---|
| | | Gross Alpha | Gross Beta |
| 1 | No recovery | ---- | ---- |
| 2 | 4.6 | 1.4 ± 1.5[b] | 26.1 ± 2.7 |
| 3 | No recovery | ---- | ---- |
| 4 | 3.0 | <0.7 | 6.4 ± 1.5 |
| 5 | 3.0 | <1.5 | 13.3 ± 3.2 |
| 6 | 1.5 | 0.5 ± 0.6 | 3.7 ± 1.0 |
| 7 | 1.5 | <0.9 | 12.1 ± 1.9 |
| 8 | 6.1 | <1.0 | 7.5 ± 2.2 |
| 9 | 3.5 | 1.9 ± 1.8 | 9.2 ± 2.4 |
| 10 | 2.7 | <3.0 | 124 ± 9 |
| 11 | 3.0 | <3.1 | 33.4 ± 6.4 |
| 12 | 3.0 | <1.3 | 40.0 ± 3.5 |
| 13 | 3.7 | <3.6 | 27.1 ± 7.5 |
| 14 | 4.3 | <0.8 | 5.6 ± 1.5 |
| 15 | 4.3 | <0.5 | 0.7 ± 1.0 |
| 16 | 4.6 | 1.2 ± 1.1 | 18.7 ± 1.9 |
| 17 | 3.0 | 5.6 ± 5.0 | 143 ± 10 |
| 18 | 3.4 | 3.1 ± 0.9 | 12.8 ± 1.4 |
| 19 | 3.4 | 1.1 ± 0.9 | 6.5 ± 1.2 |
| 20 | 2.4 | 2.2 ± 1.0 | 3.6 ± 1.1 |
| 21 | 3.4 | 4.5 ± 2.7 | 50.2 ± 4.5 |
| 22 | 1.8 | <0.5 | 3.6 ± 1.2 |
| 23 | 1.5 | 2.0 ± 2.0 | 36.2 ± 3.3 |
| 24 | 1.5 | 1.0 ± 0.9 | 28.4 ± 1.8 |
| 25 | 1.5 | <0.6 | 13.2 ± 1.5 |
| 26 | 1.8 | <0.6 | 2.5 ± 1.1 |

[a]Refer to Figure 6.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 11

ISOTOPIC ANALYSES ON WATER SAMPLES FROM BOREHOLE
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Borehole Location[a] | Radionuclide Concentration (pCi/l) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Th-228 | Th-230 | Th-232 | Ra-226 | Ra-228 | U-234 | U-235 | U-238 |
| 17 | 29.7 ± 2.1[b] | 0.1 ± 0.2 | 0.2 ± 0.2 | 0.1 ± 0.1 | 0.4 ± 1.5 | 0.7 ± 0.4 | 0.1 ± 0.1 | 0.8 ± 0.3 |

[a]Refer to Figure 6.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 12

RADIONUCLIDE CONCENTRATIONS IN WELL
AND SURFACE WATER SAMPLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location[a] | Source | Radionuclide Concentration (pCi/1) Gross Alpha | Gross Beta |
|---|---|---|---|
| 1 | Well H | <0.7 | 6.4 ± 1.3[b] |
| 2 | Well DW4 | 4.0 ± 0.8 | 9.2 ± 1.2 |
| 3 | Well W3(S) | 2.9 ± 0.8 | 4.9 ± 1.1 |
| 4 | Well W3(D) | 1.4 ± 0.6 | 3.3 ± 1.0 |
| 5 | Well W2 | 1.4 ± 1.1 | 32.9 ± 2.1 |
| 6 | Well W4 | 1.0 ± 0.7 | 2.6 ± 1.0 |
| 7 | Well SC3(D) | 0.6 ± 0.6 | 3.8 ± 1.0 |
| 8 | Well IW2 | <1.3 | <1.4 |
| 9 | Water Plant | 2.3 ± 0.7 | 4.3 ± 1.0 |
| 10 | Well SC6(S) | <3.6 | 7.6 ± 5.7 |
| 11 | Well SC6(D) | <1.6 | 2.3 ± 2.5 |
| 12 | Mohan Well | <0.4 | 1.2 ± 0.9 |
| 13 | Ion Exchange Inlet (Well 9) | <0.9 | 2.8 ± 1.5 |
| 14 | Ion Exchange Outlet | <0.4 | 1.8 ± 0.9 |
| 15 | Plant Outfall | <0.5 | 1.7 ± 1.1 |
| 16 | Plant Outfall | 3.0 ± 0.8 | 4.0 ± 1.0 |
| 17 | Drain Entrance A | 1.8 ± 0.7 | 6.9 ± 1.2 |
| 18 | Drain Entrance B | 2.0 ± 0.7 | 4.0 ± 1.1 |
| 19 | Drain Exit A | 2.4 ± 0.8 | 4.7 ± 1.1 |
| 20 | Drain Exit B | 0.5 ± 0.6 | 2.0 ± 1.0 |
| 21 | Drain Exit C | 1.8 ± 0.7 | 6.4 ± 1.2 |
| 22 | Drain Exit D | 2.0 ± 0.7 | 4.1 ± 1.1 |
| 23 | Burnt Mill Branch | 1.6 ± 0.7 | 4.7 ± 1.1 |
| 24 | Malaga Lake | <0.4 | <0.7 |
| 25 | Hudson Branch at Pond | 1.0 ± 0.7 | 9.7 ± 1.3 |
| 26 | Hudson Branch Near Arbor | 1.6 ± 0.7 | 9.3 ± 1.3 |
| 27 | Hudson Branch at Weymouth | <0.4 | 4.1 ± 1.0 |
| 28 | Hudson Branch at West | <0.4 | 2.7 ± 1.0 |

[a]Refer to Figures 7 and 8.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 13

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location[a] | Source | Radionuclide Concentration (pCi/g) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|
| 17 | Drain Entrance A | 0.3 ± 0.2[b] | 0.2 ± 0.1 | 0.5 ± 1.4 |
| 18 | Drain Entrance B | 1.8 ± 0.5 | 1.2 ± 0.3 | 2.2 ± 1.3 |
| 19 | Drain Exit A | 4.5 ± 2.2 | 2.5 ± 2.1 | 12.5 ± 6.7 |
| 20 | Drain Exit B | 33.6 ± 46.0 | 15.5 ± 2.7 | 20 ± 16 |
| 21 | Drain Exit C | 14.1 ± 1.6 | 5.4 ± 0.7 | 7.3 ± 2.4 |
| 22 | Drain Exit D | 4.9 ± 0.6 | 1.5 ± 0.3 | 4.3 ± 1.1 |
| 23 | Burnt Mill Branch at Weymouth | 0.4 ± 1.2 | 0.8 ± 0.4 | <1.2 |
| 24 | Malaga Lake | 0.2 ± 0.2 | 0.2 ± 0.1 | <0.3 |
| 27 | Hudson Branch at Weymouth | 0.6 ± 0.2 | 0.3 ± 0.2 | 0.6 ± 1.0 |
| 28 | Hudson Branch at West | 0.5 ± 0.4 | 0.6 ± 0.2 | <0.8 |
| 29 | Hudson Branch - 10 m E Pond | 1.4 ± 1.0 | 1.0 ± 0.6 | 1.8 ± 3.8 |
| 30 | Hudson Branch - 50 m E Pond | 0.7 ± 0.4 | 0.8 ± 0.2 | 0.4 ± 0.6 |
| 31 | Pond - 1680 m | 2.6 ± 1.5[b] | 1.4 ± 0.7 | 4.8 ± 2.0 |
| 32 | Perimeter Fence - 1476 m | 20.2 ± 5.2 | 24.8 ± 3.5 | <6.6 |
| 33 | West Settling Pond | 2.3 ± 5.0 | 0.3 ± 1.4 | 10.1 ± 5.9 |
| 34 | East Settling Pond | 6.4 ± 2.3 | 1.5 ± 1.1 | 5.1 ± 4.3 |

[a]Refer to Figures 7 and 8.
[b]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 14

STACK SAMPLING FLOW RATES AND VOLUMES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Stack Sample | Sampling Dates | Sampling Point and Location (cm from duct wall) | Velocity at Sampling Point (m/min) | Sampling Rate (l/min) | Sampling Time (min) | Sample Volume (l) |
|---|---|---|---|---|---|---|
| Old Baghouse 1 | 10/14/87 | 50.0 | 457.2 | 14.7 | 110 | 1616 |
| Old Baghouse 2 | 10/14/87 | 50.0 | 457.2 | 16.6 | 163 | 12708 |
| Old Baghouse 3 | 10/14-15/87 | 50.0 | 457.2 | 20.5 | 1506 | 30886 |
| New Baghouse E | 10/13-15/87 | 70.8 | 990.6 | 16.7 | 1774 | 29626 |
| New Baghouse W | 10/13-15/87 | 55.0 | 579.1 | 17.9 | 1867 | 33419 |

TABLE 15

RESULTS OF STACK EFFLUENT SAMPLING
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Stack Sample | Radionuclide Concentration (μCi/ml) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Th-228 | Th-230 | Th-232 | Ra-226 | Ra-228 | U-234 | U-235 | U-238 |
| Old Baghouse 1 | 2.8 ± 2.4 E-14[a] | <8.0 E-15 | <8.0 E-15 | 1.1 ± 0.1 E-11 | 1.7 ± 0.7 E-12 | 1.5 ± 0.2 E-12 | 6.2 ± 0.4 E-13 | 1.7 ± 0.2 E-12 |
| Old Baghouse 2 | 0.9 ± 1.1 E-14 | <4.8 E-15 | <4.8 E-15 | 4.8 ± 0.2 E-12 | <2.5 E-13 | 1.3 ± 0.1 E-12 | 3.7 ± 2.4 E-14 | 1.4 ± 0.1 E-12 |
| Old Baghouse 3 | <4.2 E-16 | <4.2 E-16 | <4.2 E-16 | 7.1 ± 0.6 E-14 | 6.8 ± 3.5 E-14 | 1.6 ± 0.2 E-13 | 4.3 ± 3.8 E-15 | 1.4 ± 0.2 E-13 |
| New Baghouse E | <4.1 E-16 | <4.1 E-16 | <4.1 E-16 | 6.0 ± 2.4 E-15 | <3.0 E-14 | <2.4 E-15 | <3.1 E-15 | <2.4 E-15 |
| New Baghouse W | 9.6 ± 9.9 E-16 | <3.9 E-16 | <3.9 E-16 | 8.1 ± 2.4 E-15 | <2.0 E-14 | <1.7 E-15 | <1.5 E-15 | <1.7 E-15 |
| NRC Guideline for unrestricted areas[b] | 2 E-13 | 3 E-13 | 1 E-12 | 2 E-12 | 1 E-12 | 4 E-12 | 4 E-12 | 5 E-12 |

[a]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[b]10 CFR 20 (Reference 3).

TABLE 16

RADIONUCLIDE CONCENTRATIONS IN BAGHOUSE DUST SAMPLES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Location | Radionuclide Concentration (pCi/g) | | |
|---|---|---|---|
| | Th-232 | Ra-226 | U-238 |
| Dust-Old Baghouse | 76.5 ± 3.2[a] | 27.5 ± 1.6 | 20 ± 11 |
| Dust-Lime Pile 1 (East) | 15.7 ± 2.1 | 5.3 ± 0.8 | 13.1 ± 3.4 |
| Dust-Lime Pile 2 | 43.8 ± 2.4 | 15.0 ± 1.2 | 10.0 ± 7.2 |
| Dust-Lime Pile 3 | 41.8 ± 2.5 | 12.2 ± 1.2 | 27 ± 20 |
| Dust-Lime Pile 4 (West) | 71.0 ± 3.2 | 19.1 ± 1.6 | 13.5 ± 6.2 |

[a]Uncertainties represent the 95% confidence levels, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 17

ESTIMATED VOLUME AND RADIOACTIVITY CONTENT OF SLAG PILES
SHIELDALLOY SITE
NEWFIELD, NEW JERSEY

| Slag Pile | Volume[a] ($m^3$) | Density[b] ($g/cm^2$) | Void Est.[c] (%) | Radionuclide Activity (Curies) Th-232 | Ra-226 | U-238 |
|---|---|---|---|---|---|---|
| Standard | 1.0 E4 | 3.2 | 20.0 | 13.2 | 3.1 | 5.2 |
| | | | 22.5 | 12.8 | 3.0 | 5.0 |
| | | | 25.0 | 12.4 | 2.9 | 4.8 |
| High Ratio | 3.0 E3 | 2.9 | 20.0 | 2.5 | 0.47 | 0.72 |
| | | | 22.5 | 2.4 | 0.45 | 0.69 |
| | | | 25.0 | 2.3 | 0.43 | 0.66 |

[a]Factors taken into account for volume calculation included areal extent, slope, and height.
[b]Density was determined using a known volume - weight of sample corrected for void with a known volume of water.
[c]Void estimates for the slag pile are based on geologic experience with similar materials and densities.

## REFERENCES


1. Title 10, Code of Federal Regulations, Part 40, Domestic Licensing of Source Material, 1985.

2. Title 40, Code of Federal Regulations, Part 60, Standards of Performance for New Stationary Sources, 1977.

3. Title 10, Code of Federal Regulations, Part 20, Standards for Protection Against Radiation, 1985.

4. Title 40, Code of Federal Regulations, Part 141, Interim Primary Drinking Water Regulations, 1976.

# APPENDIX A

## MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

## APPENDIX A

## MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

The display or description of a specific product is not to be construed as an endorsement of that product or its manufacturer by the authors or their employer.

A. Direct Radiation Measurements

Victoreen NaI Scintillation Detector
Model 489-55
(Victoreen, Cleveland, OH)

Eberline PRM-6
Portable Ratemeter
(Victoreen, Inc., Cleveland, OH)

Ludlum Scaler
Model 2200
(Ludlum, Sweetwater, TX)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

B. Air Sampling

Aluminum In-Line Filter Holders
47 mm
Cat. #996209
(Research Appliance Co., Cambridge, MD)

Stack Sampling Nozzles
(NuTech Corp., Durham, NC)

Rotameters
Model RMB
(Dwyer Instruments, Inc., Miligan City, IN)

Membrane Particulate Filters
Metrical, 47 mm diam., 0.8 μm pore size
(Gelman Sciences, Inc., Ann Arbor, MI)

Gast Vacuum Pumps
115v/60Hz
Cat. #P8400
(American Scientific Products, Stone Mountain, GA)

Velometer - all purpose set
Type 6000 a.p.
(Alnor Instrument Co., Niles, NJ)

"Precision" Wet Test Meter
Used to calibrate rotameters
(Precision Scientific Co., Chicago, IL)

Additional supplies
Plastic tubing, miscellaneous connectors

C. Laboratory Analysis

Automatic low-background Alpha-Beta Counter
Model LB5110-2080
(Tennelec, Inc., Oak Ridge, TN)

High-Purity Germanium Detector
Model GMX-23195-S, 23% efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, G-16
(Gamma Products Inc., Palos Hills, IL)

High Purity Germanium Coaxial Well Detector
Model GWL-1102010-PWS-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield Model G-16
(Applied Physical Technology, Atlanta, GA)

Multichannel Analyzer
ND-66/ND-680 System
(Nuclear Data Inc., Schaumburg, IL)

Alpha Spectroscopy System
Tennelec Electronics
(Tennelec, Oak Ridge, TN)

Surface Barrier Detectors
(EG&G ORTEC, Oak Ridge, TN)

Multichannel Analyzer
Model ND-66
(Nuclear Data, Schaumburg, IL)

# APPENDIX B

# MEASUREMENT AND ANALYTICAL PROCEDURES

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### Gamma Surface Scans

Walkover surface scans were performed at approximately 1-2 m intervals using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Relative count rates were monitored using earphones and rates above the ambient background levels were noted.

### Exposure Rate Measurements

Measurements of gamma exposure rates were performed using an Eberline PRM-6 portable ratemeter with a Victoreen Model 489-55 gamma scintillation probe containing a 3.2 cm x 3.8 cm NaI(Tl) scintillation crystal. Count rates were converted to exposure rates ($\mu$R/h) by cross-calibrating with a Reuter Stokes model RSS-111 pressurized ionization chamber.

### Borehole Logging

Borehole gamma radiation measurements were performed using a Victoreen Model 489-55 gamma scintillation probe, shielded by a 1.25 cm thick lead shield, with four 2.5 x 7 mm holes evenly spaced around the region of the scintillation detector. The probe was lowered into each hole using a tripod holder with a small winch. Gross gamma measurements were performed at 30 cm intervals between the surface and the bottom of the hole and recorded using a Ludlum Model 2200 portable scaler. At locations where the borehole had a tendency to cave in, the probe was lowered through the inside of the hollow stem auger.

## Soil and Sediment Sample Analysis

### Gamma Spectrometry

Soil and sediment samples were dried, mixed, and a portion placed in a 0.5 l Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 600 to 1000 g of sample. Net weights were determined and the samples counted using intrinsic germanium detectors coupled to a Nuclear Data Model ND-680 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:

Th-232 - 0.911 MeV from Ac-228*

Ra-226 - 0.609 MeV from Bi-214*

U-238 - 0.094 MeV from Th-234 or
1.001 MeV from Pa-234m*

*Secular equilibrium was assumed.

### Neutron Activation Analysis

Aliquots of samples were placed in "rabbits" and exposed to thermal neutrons in a facility containing a Californium 252 source of approximately 40 mg. Following a timed irradiation and decay period, Th-233 activity levels were determined and results used to calculate the Th-232 concentrations.

## Water Sample Analysis

Water samples were rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45 $\mu$m membrane filters and the filtrate was acidified by addition of 10 ml of concentrated nitric acid.

Gross Alpha and Gross Beta Analysis

Aliquots were evaporated to dryness and counted on a Tennelec Model LB5100 low background proportional counter.

Isotopic Thorium and Uranium

Aliquots of water were acidified and evaporated to dryness. The residues were then dissolved by pyrosulphate fusion and precipitated with barium sulfate. The barium sulfate precipitates were redissolved. Thorium and uranium were separated by liquid - liquid extraction, precipitated with a cerium fluoride carrier, and counted using surface barrier detectors (ORTEC), alpha spectrometers, (Tennelec), and an ND-66 Multichannel Analyzer (Nuclear Data).

Radium 226/228

Aliquots of water were treated with barium sulfate to coprecipitate radium; the precipitate was purified by dissolving in EDTA. After 36 hours the Ra-228 daughter, Ac-228, was removed by yttrium oxalate, purified, and counted on a low background proportional counter. The radium-containing solution was then transferred to a bubbler, sealed, and Rn-222 allowed to ingrow for a known time period. After ingrowth, the Rn-222 gas was purged into a Lucas scintillation cell and the short-lived radon daughter products allowed to reach equilibrium with the parent. Gross alpha counting was used to determine the activity in the scintillation cell, which was then related to the total radium-226 activity

Stack Sample Analysis

Isotopic Uranium and Thorium

Portions of filter papers were dissolved by pyrosulphate fusion and precipitated with barium sulfate. Precipitates were then processed as described above for water samples.

Radium 226/228

Portions of filter papers were fused and residues dissolved in hydrochloric acid. Radium was coprecipitated with barium sulfate. Precipitates were analyzed for Ra-226/228 as described above for water samples.

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report, represent the 95% confidence levels for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. When the net sample count was less than the 95% statistical deviation of the background count, the sample concentration was reported as less than the detectable limits of the procedures. Because of variations in background levels and Compton contributions from other radionuclides in samples, the detection limits differ from sample to sample. Additional uncertainties of caused by other $\pm$ 6 to 10%, associated with sampling and laboratory procedures, have not propagated into the data presented in this report.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in manuals developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program.

With the exception of the measurements conducted with portable gamma scintillation survey meters, instruments were calibrated with NBS-traceable standards. The calibration procedures for the portable gamma instruments are performed by comparison with an NBS calibrated pressurized ionization chamber.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA and FML Quality Assurance Program.