PHASE I WORK PLAN FOR A SCOPING SURVEY OF VICINITY PROPERTIES CAMBRIDGE, OHIO

Prepared for
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Kings Mountain, North Carolina

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TABLE OF CONTENTS

Section		Page
1.0	INTRODUCTION	1
1.1	SITE DESCRIPTION AND BACKGROUND	1
1.2	FINDINGS OF NRC INVESTIGATIONS OF OFF-SITE PROPERTIES	3
1.3	ASSESSMENT OF CURRENT HEALTH RISKS POSED BY DIRECT RADIATION FROM THE SLAG	4
1.4	RATIONALE AND OBJECTIVES FOR THE PHASE I INVESTIGATION	5
2.0	SCOPE OF PHASE I INVESTIGATION	7
2.1	SCOPE OF WORK	7
2.2	RADIONUCLIDES OF INTEREST	8
2.3	EVALUATION OF THE ORIGIN OF SLAG WITH UNSUPPORTED URANIUM AND ACTINIUM SERIES DECAY PRODUCTS	8
2.4	LITERATURE REVIEW OF HYDROLOGIC AND METEOROLOGIC DATA	9
2.5	FIELD INVESTIGATION	9
2.5.1	Radiological Surveys	9
2.5.2	Evaluation of the Areal Extent and Thickness of Slag and Cover Material	9
2.5.3	Biased Sampling of Slag Fill Material	9
2.5.4	Composite Sampling of Slag Fill Material	10
2.5.5	Collection of Subsoil Samples	10
2.5.6	Collection of Slag Samples for Fate-and-Transport Properties	11
2.5.7	Sampling Protocol, Collection Utensils, and Equipment Decontamination	11
2.5.8	Health and Safety and Management of Investigation Wastes	11
2.6	LABORATORY TESTING OF SLAG SAMPLES	12
2.7	QUALITY ASSURANCE/QUALITY CONTROL	12
2.7.1	Field Instrumentation	12
2.7.2	Field Measurements	12

TABLE OF CONTENTS

Section **Page**

2.7.3 Sample and Document Custody Procedures 13
2.7.4 Laboratory Quality Control 13

2.8 RESRAD EVALUATION OF RADIONUCLIDE DOSE FACTORS 13

3.0 REPORTING AND SCHEDULING 14

3.1 KEY DELIVERABLES 14
3.2 SCHEDULE OF ACTIVITIES 14

4.0 REFERENCES 15

LIST OF TABLES

TABLE 1 ORISE RADIONUCLIDE ANALYTICAL RESULTS FOR PROPERTIES 13, 19, 24, AND 47

TABLE 1 RADIONUCLIDE TESTING PARAMETERS, ANALYTICAL METHODS, AND DETECTION LIMITS

LIST OF FIGURES

FIGURE 1 SITE LOCATION MAP

FIGURE 2 LOCATION OF PROPERTIES TO BE INVESTIGATED

FIGURE 3 SITE PLAN, PROPERTY 13

FIGURE 4 SITE PLAN, PROPERTY 19

FIGURE 5 SITE PLAN, PROPERTY 24

FIGURE 6 SITE PLAN, PROPERTY 47

FIGURE 7 SCHEDULE OF ACTIVITIES

LIST OF APPENDIXES

APPENDIX A HEALTH & SAFETY PLAN

1.0
INTRODUCTION

1.1 SITE DESCRIPTION AND BACKGROUND

The Shieldalloy Metallurgical Corporation (SMC) plant in Cambridge, Ohio ("Cambridge plant") (Figure 1) is a ferroalloy production facility. The plant was previously owned and operated by Foote Mineral Company (FMC) until its sale to SMC in 1987. Cyprus Minerals Company purchased FMC from FMC's parent company, Newmont Mining Corporation, in 1988, after FMC had sold the Cambridge plant to SMC, and changed FMC's name to Cyprus Foote Mineral Company ("Cyprus Foote"). Cyprus Foote never operated the Cambridge plant.

The Cambridge plant currently manufactures ferrovanadium alloys and vanadium chemicals. In the past, the plant also produced other varieties of ferroalloys, including ferrotitanium and ferrocolumbium alloys, and Grainal, a ferroalloy of zirconium and titanium.

As is common practice in the metallurgical industry, many of the feed materials used in alloy production contain naturally occurring radionuclides. The production of ferrocolumbium alloy used feed materials that met the Atomic Energy Commission (AEC) definition of "source material," i.e., greater than 0.05 weight percent combined uranium and thorium content. Accordingly, during the period of ferrocolumbium alloy production, FMC held a source material license from the AEC and its successor, the US Nuclear Regulatory Commission (NRC). Information reviewed to date indicates that the feed materials used to produce the other types of alloy did not contain licensable quantities of radionuclides.

All of the alloy production processes resulted in the production of slag. The radionuclides present in the feed materials generally became incorporated into the slag, which was stored in several large piles at the plant. No source material has been processed at the Cambridge plant since the production of ferrocolumbium alloy ended in 1972. However, SMC possesses an NRC license for possession of source material in the on-site slag piles. SMC is in the process of terminating its NRC license, which includes decontamination of the plant and decommissioning of the slag piles.

Some of the slag from the Cambridge plant was sold for off-site use as fill material. In late 1993 and early 1994, NRC conducted scoping surveys at some off-site properties with slag that reportedly came from the Cambridge plant. Prior to the completion of all the surveys, NRC expressed concern that slag from the licensed operation may have been sold or given away for use as off-site fill material (NRC, 1994a,b).

Interviews of former plant employees by NRC (1994a) and Cyprus Foote indicate that the slag from the licensed operation was produced in massive, 5-6 ton buttons that were stored on-site in the slag piles and were not amenable for off-site use. There is no documentation that slag from the licensed operation (ferrocolumbium alloy) was sold or given away for off-site uses.[1] It is important to note that a preliminary review of historical production information indicates that the volume of ferrocolumbium slag generated by the licensed operation was <1% of the total volume of slag generated during the history of the Cambridge plant.

Moreover, it is clear that the overwhelming majority of slag that left the Cambridge plant was not produced until after the license operation ended. NRC's interviews with off-site recipients of the slag indicate that approximately 90% of the properties received the slag after the licensed operation ended. The practice of selling or giving away slag for off-site uses apparently continued for several years after the 1987 purchase of the plant by SMC. NRC's interviews with off-site recipients indicate that approximately 30% of the properties received slag in 1987 or later (NRC, 1994c).

Therefore, based on the available information, the probability that slag from the licensed operation exists at off-site locations is extremely low.

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[1] A limited amount of slag from the licensed operation apparently was removed from the plant by a local contractor, the Messerschmidt Construction Company, in connection with a pilot project to crush slag buttons (NRC, 1994b). The pilot test was unsuccessful because the slag buttons were too hard to crush. The existence of source material slag on the property of the Messerschmidt Construction Company is believed to be an anomaly. There is no documentation that slag from the licensed operation was sold for off-site use as fill material.

1.2 FINDINGS OF NRC INVESTIGATIONS OF OFF-SITE PROPERTIES

NRC has issued three inspection reports (NRC, 1994a,b,d) that present the results of surveys of 59 off-site properties with slag fill material that allegedly came from the Cambridge plant. With the exception documented in Footnote 1, the NRC did not find any slag with licensable quantities of radionuclides on any of the off-site properties. The findings in the NRC inspection reports are summarized below.[2]

An April 22, 1994 NRC inspection report (NRC, 1994a) indicated the presence of slag with low, but slightly elevated, levels of radionuclides on an off-site residential property. However, NRC performed a dose assessment using the RESRAD computer program and concluded that the slag does not pose a significant or immediate health and safety concern and that the estimated dose from the slag is below the 100 millirem (mrem) per year stated in 10 CFR 20.1301(a)(1) as the dose limit to an individual member of the public.

A May 19, 1994 NRC inspection report (NRC, 1994b) indicated the presence of slag with licensable quantities of thorium on the property of a contractor who performed a pilot slag button crushing test. However, as explained in Footnote 1, the existence of source material slag on this contractor's property is believed to be an anomaly. The NRC concluded that the presence of the slag material at this location does not present an immediate health and safety concern. As part of this inspection, NRC visited three additional properties with slag fill material. The measured radiation levels at these additional properties did not exceed ambient background.

A September 22, 1994 NRC inspection report (NRC, 1994d) presented the results of a scoping survey of 54 off-site properties by an NRC contractor, Oak Ridge Institute for Science and Education (ORISE) (NRC, 1994e). The results in the NRC inspection report indicated the following:

- None of the 54 properties contain slag that is source material.

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[2] This document is necessarily based on the information available to Cyprus Foote. Additional documents provided by NRC in response to Cyprus Foote's FOIA request could affect the analysis presented herein.

- There are no elevated levels of radon associated with the slag.
- Groundwater does not appear to be impacted by the slag.
- Several of the properties surveyed contained slag with elevated levels of radionuclides, including Thorium-230.
- One of the properties surveyed contained slag with elevated levels of actinium decay series radionuclides.

Based on the physical nature of the slag, the specific areas where the slag is located, and the types of radiation emitted, NRC concluded that the slag does not pose an immediate health risk to residents and does not result in exposures in excess of the 100 mrem/year allowed for members of the public by NRC regulation 10 CFR 20.1301(a)(1).

1.3 ASSESSMENT OF CURRENT HEALTH RISKS POSED BY DIRECT RADIATION FROM THE SLAG

NRC regulations in 10 CFR 20 establish radiation protection standards for members of the general public at levels not to exceed 100 mrem/year above background. Because 100 mrem/year above background was used by the NRC in its inspection reports to determine whether a significant and imminent risk is posed by the slag, this report evaluates significant and imminent risk using this level. Use of this radiation exposure level is very conservative, because this level is at the low end of the possible range of values that may be used to establish such criteria. Natural background radiation results in over 100 mrem/year to all members of the population throughout their lifetimes, and there is no empirical evidence that such exposures have resulted in any harmful effects. In addition, the occupational radiation protection limit for workers at NRC-licensed facilities is 5,000 mrem/year, and, as is the case for exposures to background radiation, there is no empirical evidence that workers at NRC-licensed facilities have experienced any adverse health effects as a result of prolonged occupational exposures within these radiation protection limits.

Environmental radiation exposure is measured in units of microRoentgens per hour (μR/hour). One μR/hour corresponds to 0.001 mrem/hour or 8.76 mrem/year. The exposure rates measured by NRC at the off-site properties in the Cambridge, Ohio area are expressed in units of μR/hour and include variable background radiation levels with an average of about 10 μR/hour. In order to result in exposures clearly exceeding 100 mrem/year above background, the exposure rates at occupied or occupiable locations would have to be well in excess of 20 μR/hour. Such exposures do not exist at the properties surveyed by NRC. Therefore, the direct radiation from the slag does not appear to pose any immediate health risks in excess of the 100 mrem/year above background dose limit for members of the general public.

1.4 RATIONALE AND OBJECTIVES FOR THE PHASE I INVESTIGATION

The Phase I investigation is intended to be a scoping study that will provide information regarding dose factors, release limits, and the development of a focused protocol for the investigation of additional vicinity properties. The investigation protocol is particularly important given the reported presence of elevated levels of alpha-emitting radionuclides (e.g., thorium-230) which cannot be readily detected by radiological surface scans or exposure readings.

The objectives of the Phase I investigation are as follows.

- Confirm the results of NRC's scoping survey, including surface scans, exposure rate measurements, and radionuclide concentrations.
- Further evaluate the origin of slag with unsupported uranium and actinium series decay products.
- Collect data in support of the evaluation of dose factors, including:
  - thickness and areal extent of slag on each property;
  - extent of contamination, if any, in the subsoil beneath the slag;
  - thickness of clean cover above the slag at each property;
  - average radionuclide concentrations;
  - distribution coefficients for the radionuclides of interest in the slag;
  - radon emanation coefficients for slag containing elevated levels of radium-226;

  - concentrations of the radionuclides of interest in the grain size fraction relevant to the inhalation exposure pathway (<10 micron); and

  - hydrologic and meteorologic data specific to the Cambridge, Ohio area (depth to groundwater, precipitation and infiltration rates, airborne dust levels, etc.)

- Evaluate dose factors appropriate for the characteristics of the slag and the conditions in the Cambridge, Ohio area.

2.0
SCOPE OF PHASE 1 INVESTIGATION

2.1 SCOPE OF WORK

In order to meet the investigation objectives identified in Section 1.4, the Phase I scope of work will include the following activities:

- Interviews with former employees and review of historical information to evaluate the origin of slag with unsupported uranium and actinium series decay products;
- A literature review to collect hydrologic and meteorologic data specific to the Cambridge, Ohio area;
- Radiological surveys;
- Surficial soil sampling, subsurface sampling with hand augers, and the performance of small, shallow, hand-dug test pits;
- Collection and analysis of discrete slag samples;
- Collection and analysis of composite slag samples;
- Collection of surficial and subsurface soil samples and radionuclide analysis of the <10 micron size fraction;
- Collection and analysis of subsoil samples;
- Collection of slag samples to determine distribution coefficient and radon emanation coefficient; and
- RESRAD evaluation of dose factors.

The Phase I field activities will be focused on a subset of four properties of the fifty-four properties previously investigated by NRC's contractor, ORISE. These four properties are identified by ORISE as the properties numbered 13, 19, 24, and 47 (Figures 2 through 6). These four properties were selected from the ORISE group of fifty-four because they are reported to contain slightly elevated direct radiation and some of the highest levels of the radionuclides. The study of these four properties will provide a basis for making informed judgements about the remaining properties. The ORISE analytical results for properties 13, 19, 24, and 47 are presented in Table 1. Properties 13, 19, and 24 were selected because of the reported range of concentrations of unsupported thorium-230. Property 47 was selected because of the reported presence of unsupported protactinium-231 and actinium-227. In addition, properties 19 and 47 were selected because of the presence of elevated radium-226 levels and the opportunity to collect slag samples for the determination of radon emanation coefficients.

2.2 RADIONUCLIDES OF INTEREST

The radionuclides of interest for the Phase I investigation are identified below. The selection is based on historical production process information and the results of NRC's scoping surveys (NRC, 1994a,b,d,e).

Decay Series	Radionuclide
Uranium (Uranium-238)	Uranium-238
	Thorium-230
	Radium-226
Thorium (Thorium-232)	Thorium-232
	Thorium-228
Actinium (Uranium-235)	Protactinium-231
	Actinium-227

2.3 EVALUATION OF THE ORIGIN OF SLAG CONTAINING UNSUPPORTED URANIUM AND ACTINIUM SERIES DECAY PRODUCTS

The Phase I investigation will include an evaluation of the origin of slag containing unsupported uranium and actinium series decay products (i.e., Th-230, Pa-231, Ac-227). As indicated by NRC (NRC, 1994e), these characteristics appear to indicate that the alloy feed materials were byproducts of the extraction of uranium, radium, or other materials. Interviews with former employee will be conducted and available historical records will be reviewed to evaluate the origin and uses of the feed materials and to identify the feed material suppliers.

2.4 LITERATURE REVIEW OF HYDROLOGIC AND METEOROLOGIC DATA

A literature review will be performed to collect data on hydrologic and meteorologic parameters that are important for the evaluation of dose factors. These data include, but are not limited to parameters such as aquifer porosity, hydraulic conductivity, depth to groundwater, precipitation rate, infiltration rate, and airborne dust levels. The hydrologic and meteorologic data will be specific to the Cambridge, Ohio area.

2.5 FIELD INVESTIGATION

2.5.1 Radiological Surveys

Surface scans and exposure rate measurements will be performed to confirm the results of the ORISE scoping survey and to identify areas of elevated direct radiation measurement from which biased samples may be collected. The surface scans will be performed by passing a NaI detector (Ludlum Model 19 microR meter or equivalent) slowly over the surface at a minimum distance. The exposure rate measurements will be performed at 1 meter above the surface using a micro-R meter or pressurized ionization chamber (PIC).

2.5.2 Evaluation of the Areal Extent and Thickness of Slag and Cover Material

The areal extent and thickness of slag and any clean cover material that may exist will be evaluated at each property by visual observation. The evaluation of thickness will be based on shallow, hand-dug test pits or shallow hand auger borings.

2.5.3 Biased Sampling of Slag Fill Material

Biased samples of slag fill material will be collected from areas of elevated direct radiation readings at each of the four properties. The approximate sample locations, based on the scoping surveys by ORISE, are shown on Figures 3 through 6. A total of approximately five discrete samples will be collected, including one each from properties 13, 24, and 47, and two from property 19. To evaluate the radionuclide content in both the coarse fraction and the clay/silt fraction relevant to the inhalation exposure pathway, the samples will be shipped to a commercial laboratory and size separated into the >10 micron and <10 micron size fractions. Testing for the radionuclides of interest will be performed on the coarse (>10 micron) size fraction. The <10 micron size fraction also will be tested for the radionuclides of interest provided sufficient sample mass exists in this size fraction.

2.5.4 Composite Sampling of Slag Fill Material

Composite samples of slag/soil will be collected from each of the four properties to be surveyed during the Phase I investigation. The approximate locations for the collection of aliquots for the composite samples are shown on Figures 3 through 6. A total of approximately six composite slag samples will be collected, including one each from properties 13 and 24, and two each from properties 19 and 47. Each aliquot will consist of approximately equal amounts of slag. The aliquots will be placed together in a sample bag, resulting in a composite sample consisting of approximately 1 kg of slag.

2.5.5 Collection of Subsoil Samples

Subsoil samples will be collected from areas of elevated direct radiation readings in the driveway areas of properties 19 and 47. The subsoil samples will be collected from the following relative depth intervals beneath the base of the slag layer: 0-6 inches, 6-12 inches, and 12-24 inches. The samples will be barren of visible slag.

To evaluate the radionuclide content in both the coarse fraction and the clay/silt fraction relevant to the inhalation exposure pathway, the 0-6 inch samples will be size separated at the laboratory into the >10 micron and <10 micron size fractions. The two size fractions from the uppermost samples (0-6 inches below slag layer) will be tested for the radionuclides of interest. The lower samples will be held for potential size separation and laboratory analysis pending the outcome of testing on the uppermost samples.

2.5.6 Collection of Slag Samples for Fate-and-Transport Properties

Samples to be tested to determine radon emanation coefficients will be collected from properties 19 and 47 due to the reported elevated concentrations of radium-226. Samples to be tested for distribution coefficient will be collected from properties 19 and 47 due to the reported elevated concentrations of thorium-230 and actinium-series radionuclides, respectively. The evaluation of distribution coefficients will be based on ASTM methods.

2.5.7 Sampling Protocol, Collection Utensils, and Equipment Decontamination

Approximately 1 kg (2.2 pounds) of sample will be collected for each type of sample to be shipped for laboratory analytical testing. The collected samples will be placed in a plastic bag, sealed, and appropriately labeled. The samples will be shipped to the analytical laboratory under chain of custody.

Sample collection utensils may include stainless steel shovels, hand augers, bowls, and spoons, or equivalent. To avoid cross-contamination, disposable sampling equipment will be employed or sampling equipment will be decontaminated between each sample location.

Decontamination of sampling utensils will be performed in three stages. The first step will employ dry cleaning methods. Friable soil will be scraped or brushed from the equipment back into the hole from which the sample was collected. In the second step, the equipment will be held over the sample hole and rinsed with a light stream of distilled water from a spray bottle. The equipment will then be wiped with a damp paper towel until any remaining visible soil is removed. In the final step, the equipment will again be held over the sample hole and will receive a final rinse from the spray bottle. Following decontamination, clean equipment will be stored in plastic bags or covered with plastic sheeting if not immediately reused.

2.5.8 Health and Safety and Management of Investigation Wastes

A Health and Safety Plan for the Phase I Investigation is contained in Appendix A. Investigation wastes (disposable sampling utensils, gloves, booties, coveralls, equipment decontamination wipes, etc.) will be containerized and disposed of in an appropriate manner.

2.6 LABORATORY TESTING OF SAMPLES

Samples of slag fill material and subsoil to be tested for the radionuclides of interest will be shipped to a commercial laboratory. The radionuclide testing parameters, analytical methods, and detection limits are shown in Table 2. Each sample will be analyzed by gamma spectroscopy. In addition, each sample will be tested for isotopic thorium (Th-232, Th-230, Th-228) using alpha spectroscopy.

Samples of slag to be tested for distribution coefficient and radon emanation coefficient will be shipped to a commercial laboratory. The evaluation of distribution coefficients will be based on ASTM methods.

Laboratory turnaround time for testing results is expected to be four weeks.

2.7 QUALITY ASSURANCE/QUALITY CONTROL

2.7.1 Field Instrumentation

All field instrumentation will be calibrated against NIST traceable sources prior to use during this investigation. Certificates will be issued and maintained for all equipment. Background and response checks will be performed on field instrumentation at the beginning and end of each day in the field, or at the beginning and end of surveying on each property. Response checks must agree within +/- 20% of the calibrated efficiency. If response checks fall outside of this range, the instrument will be tagged out-of-service and replaced with a new one. Check sources used in the field are NIST traceable, and certificates will be maintained for the check sources. Documentation will be maintained for all background and response checks.

2.7.2 Field Measurements

Duplicate radiation survey measurements will be taken on 1 in 20 measurements performed for gamma and alpha/beta/gamma readings. Measurements will be recorded and marked as "D" or "Dup" on the appropriate form.. Field data sheets and calculations will undergo an independent peer review.

2.7.3. Sample and Document Custody Procedures

Sample custody will be initiated at the time of sample collection. The field sampling team leader will ensure that field samples will be identified by sample labels with the following information: unique sample identification number, date and time of sampling, sampling location, analysis, and any additional relevant comments. Field chain-of-custody forms containing the same information will be completed for each set of samples and will be signed by the field team sampling leader or sampling technician. The original chain-of-custody form is to be shipped to the laboratory with the samples. Personnel at the laboratory will acknowledge receipt of the sample by adding their signature and by entering the date and time the samples were received.

2.7.4 Laboratory Quality Control

All analyses from commercial laboratories will be performed under a fully implemented quality assurance program that addresses all aspects of the analytical process. Laboratory QA/QC samples will include spikes, blanks, and duplicates. QA/QC samples will be analyzed at a rate of 10% of the total number of samples or one per analytical batch.

2.8 RESRAD EVALUATION OF RADIONUCLIDE DOSE FACTORS

Cyprus Foote desires to develop dose factors that are based on realistic input parameters appropriate for the slag and the conditions in the Cambridge area. The RESRAD code (Version 5.19) will be used to develop dose factors (units of mrem/year TEDE/pCi/gram) for the radionuclides of interest, employing the methodology described by Yu et. al. (1993).

3.0
REPORTING AND SCHEDULING

3.1 KEY DELIVERABLES

A Scoping Report/Phase II Work Plan will be prepared within two weeks of receipt of the Phase I laboratory data. The following information will be included in the Scoping Report/Phase II Work Plan:

- A summary of the Phase I laboratory analytical results;
- An evaluation of the origin of the slag material with unsupported uranium and actinium series decay products;
- Dose factors appropriate for the characteristics of the slag and the hydrologic and meteorologic conditions in the Cambridge, Ohio area;
- A plan for the identification and characterization of additional properties containing slag fill material from the Cambridge plant;
- A proposed method for the development of release limits that will be used to evaluate potential response actions.

3.2 SCHEDULE OF ACTIVITIES

Figure 7 provides a schedule for completion of the activities presented in this Phase I Work Plan. It is estimated that field activities will be initiated within one week after NRC's receipt of the Work Plan, assuming NRC has no comments requiring major Work Plan revisions. Pre-field activities will include securing access agreements from property owners, contracting and scheduling laboratories, and completing mobilization tasks. Although we do not anticipate difficulties, meeting the schedule shown on Figure 7 is contingent upon timely review of the Work Plan by NRC, receipt of signed access agreements from the property owners, and timely turnaround of testing results by the analytical laboratories.

4.0
REFERENCES CITED

NRC, 1994a, NRC Inspection Report No. 999-90003/94032 (DRSS), April 22, 1994.

NRC, 1994b, NRC Inspection Report No. 999-9003/94038 (DRSS), May 19, 1994.

NRC, 1994c, NRC/ORISE June 1994 field sampling notes.

NRC, 1994d, NRC Inspection Report No. 999-90003/94044 (DRSS), September 22, 1994.

NRC, 1994e, "Radiological Scoping Survey for Foote Mineral Offsite Locations, Guernsey County, Ohio, Final Report"; August 19, 1994 (prepared by Oak Ridge Institute for Science and Education).

Yu, C., et al. (1993), Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.0, Prepared by Argonne National Laboratory for the U.S. Department of Energy, September 1993.

TABLES

Table 1. ORISE Radionuclide Analytical Results For Properties 13, 19, 24, and 47[1]

Property Designation	Sample Location Number	Radionuclide Concentration (pCi/gram)							
		Ra-226	Th-232	Th-228	U-238	Th-230	Pa-231	Th-227	Ra-223
13	1	2.8 ± 0.3	2.9 ± 0.4	2.4 ± 0.3	1.8 ± 1.8	79 ± 19	<1.1	<0.9	1.5 ± 0.4
	2	1.3 ± 0.3	1.8 ± 0.4	1.5 ± 0.3	2.1 ± 1.6	<20	<1.3	<0.7	0.3 ± 0.4
19	1	9.1 ± 0.4	1.2 ± 0.5	0.6 ± 0.3	4.0 ± 1.7	1796 ± 51	<1.7	1.3 ± 0.5	1.1 ± 0.4
	2	6.9 ± 0.4	0.6 ± 0.5	0.3 ± 0.3	1.3 ± 2.1	1312 ± 50	<2.0	<1.2	<0.8
	3	30.2 ± 0.7	1.1 ± 0.5	0.6 ± 0.3	3.2 ± 3.1	4864 ± 70	3.4 ± 1.4	3.0 ± 0.9	3.1 ± 0.8
24	1	3.1 ± 0.3	3.1 ± 0.5	3.3 ± 0.6	4.4 ± 2.4	24 ± 16	<1.4	<0.7	1.5 ± 0.5
	2	2.2 ± 0.3	2.0 ± 0.4	1.8 ± 0.3	3.9 ± 2.3	18 ± 12	<1.5	<0.7	0.4 ± 0.2
47	1	13.2 ± 0.5	0.4 ± 0.3	0.6 ± 0.3	5.3 ± 1.4	<75	48.2 ± 5.5	33.8 ± 1.4	57.9 ± 1.7
	2	7.4 ± 0.4	0.6 ± 0.2	0.6 ± 0.3	2.0 ± 1.1	<38	24.7 ± 2.9	18.3 ± 0.9	30.8 ± 1.2
	3	0.9 ± 0.2	0.6 ± 0.2	0.3 ± 0.3	2.1 ± 1.2	<10	<0.6	<0.4	<0.3

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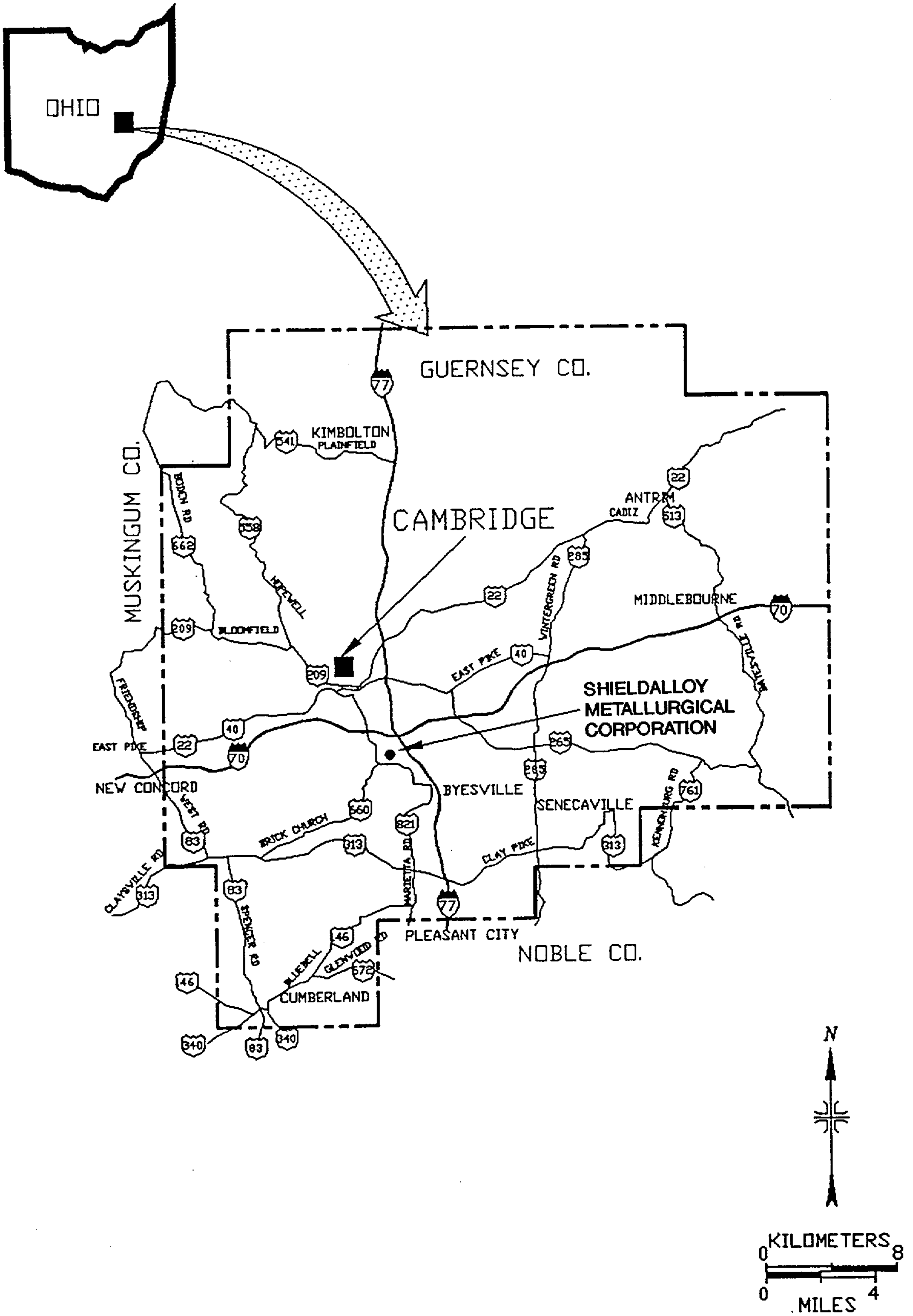
[1] Radionuclide data from August 19, 1994 ORISE Survey Report (NRC, 1994e).

Table 2. Radionuclide Testing Parameters, Analytical Methods, and Detection Limits

Parameter	Analytical Method	Detection Limit
Isotopic Thorium (Th-228, Th-230, Th-232)	Alpha Spectrometry, NAS NS 3004	0.1 pCi/gram
Uranium-238	Gamma Spectrometry, HASL 300 4.4.2.5	1 pCi/gram
Radium-226	Gamma Spectrometry, HASL 300 4.4.2.5	1 pCi/gram
Protactinium-231	Gamma Spectrometry, HASL 300 4.4.2.5	1 pCi/gram
Thorium-227	Gamma Spectrometry, HASL 300 4.4.2.5	1 pCi/gram
Actinium-227	Gamma Spectrometry, HASL 300 4.4.2.5	1 pCi/gram

FIGURES



Source: modified from August 19, 1994
ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

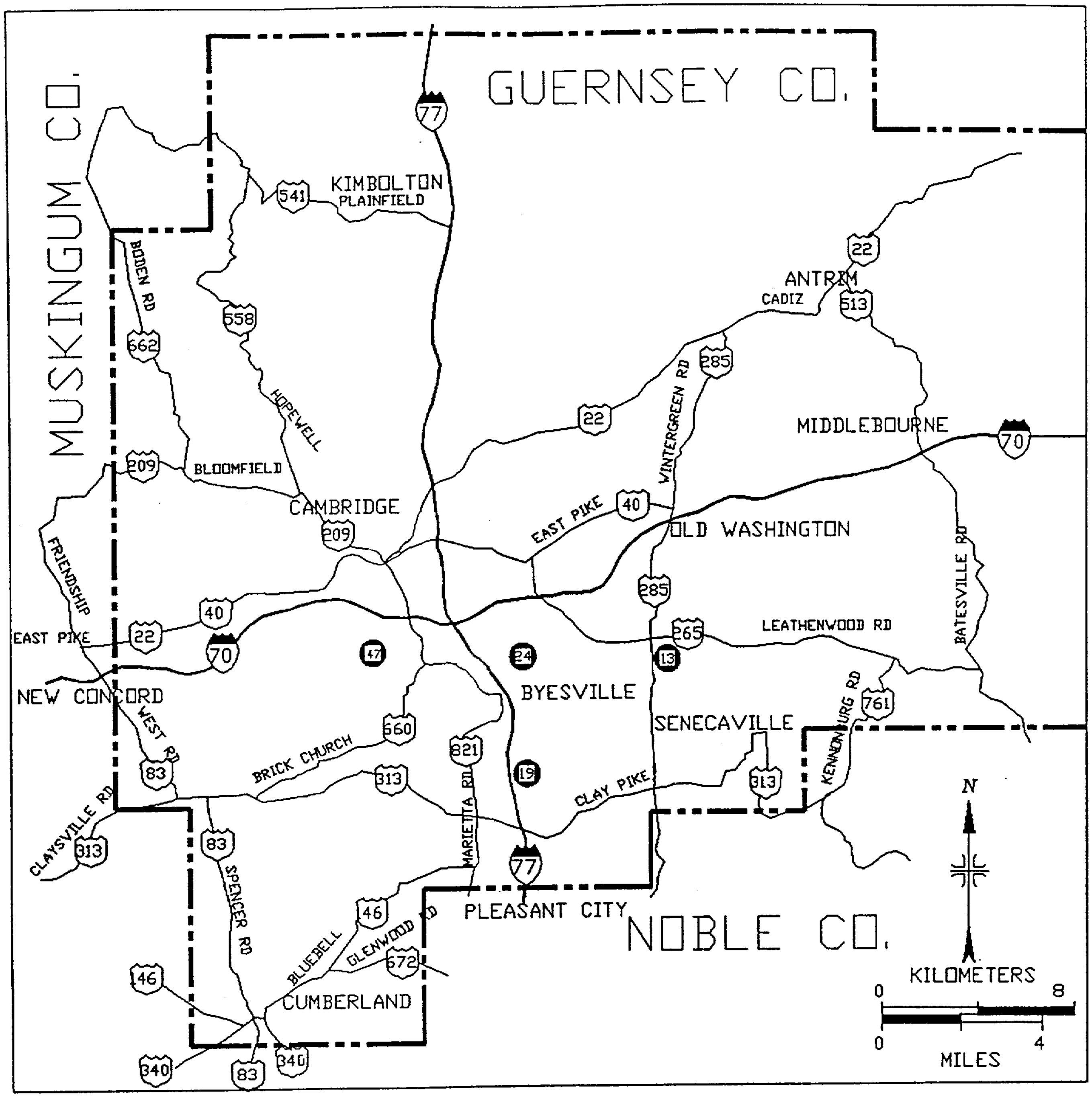
PROJECT NO.
4E08103

Woodward·Clyde Consultants
CONSULTING ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DRN. BY: RET
CHKD. BY: CFP

SITE LOCATION MAP

FIG. NO.
1



● Property Designation Number

Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

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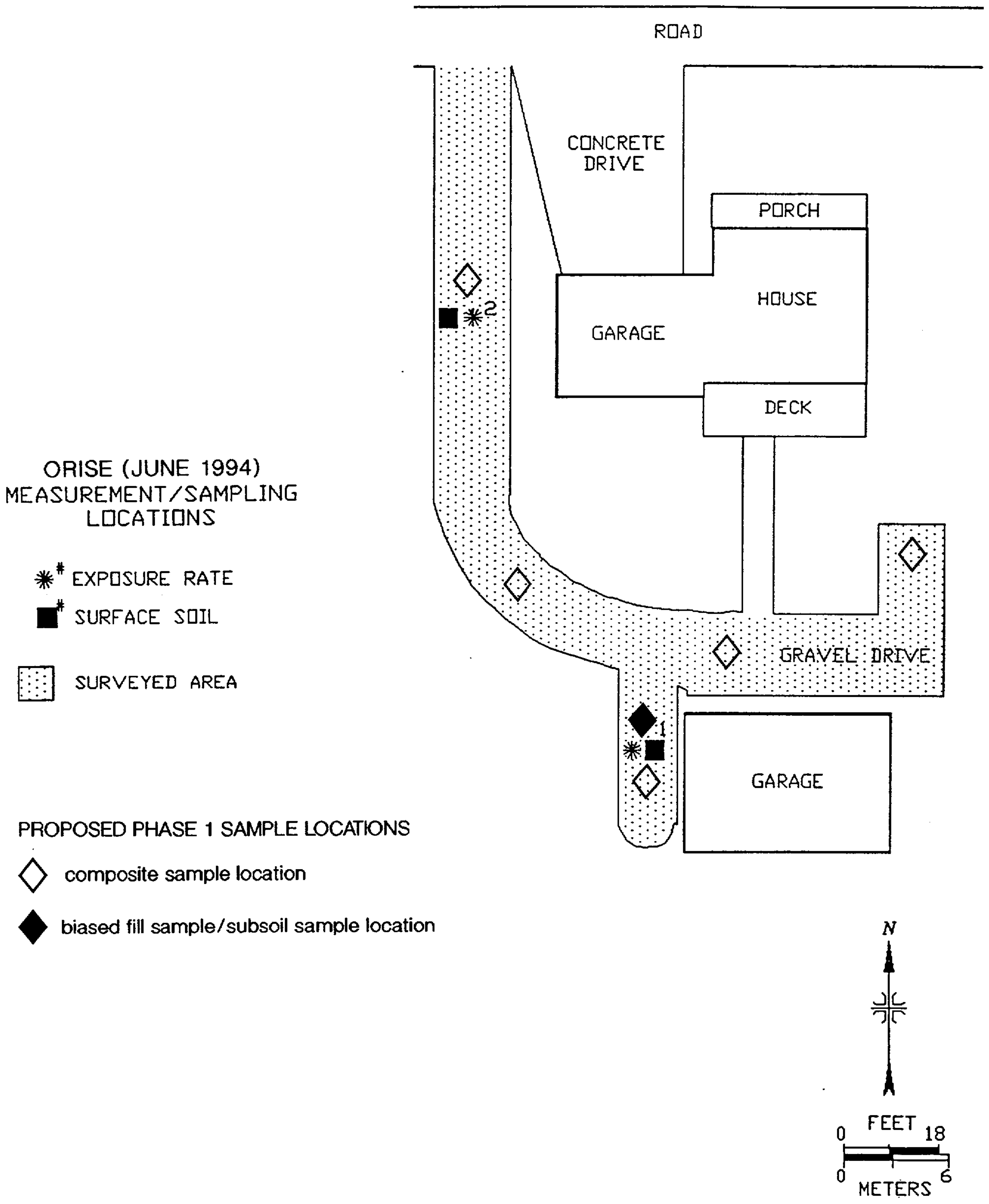
DRN. BY: RET
CHKD. BY: CFP

LOCATION OF PROPERTIES
TO BE INVESTIGATED

FIG. NO.
2



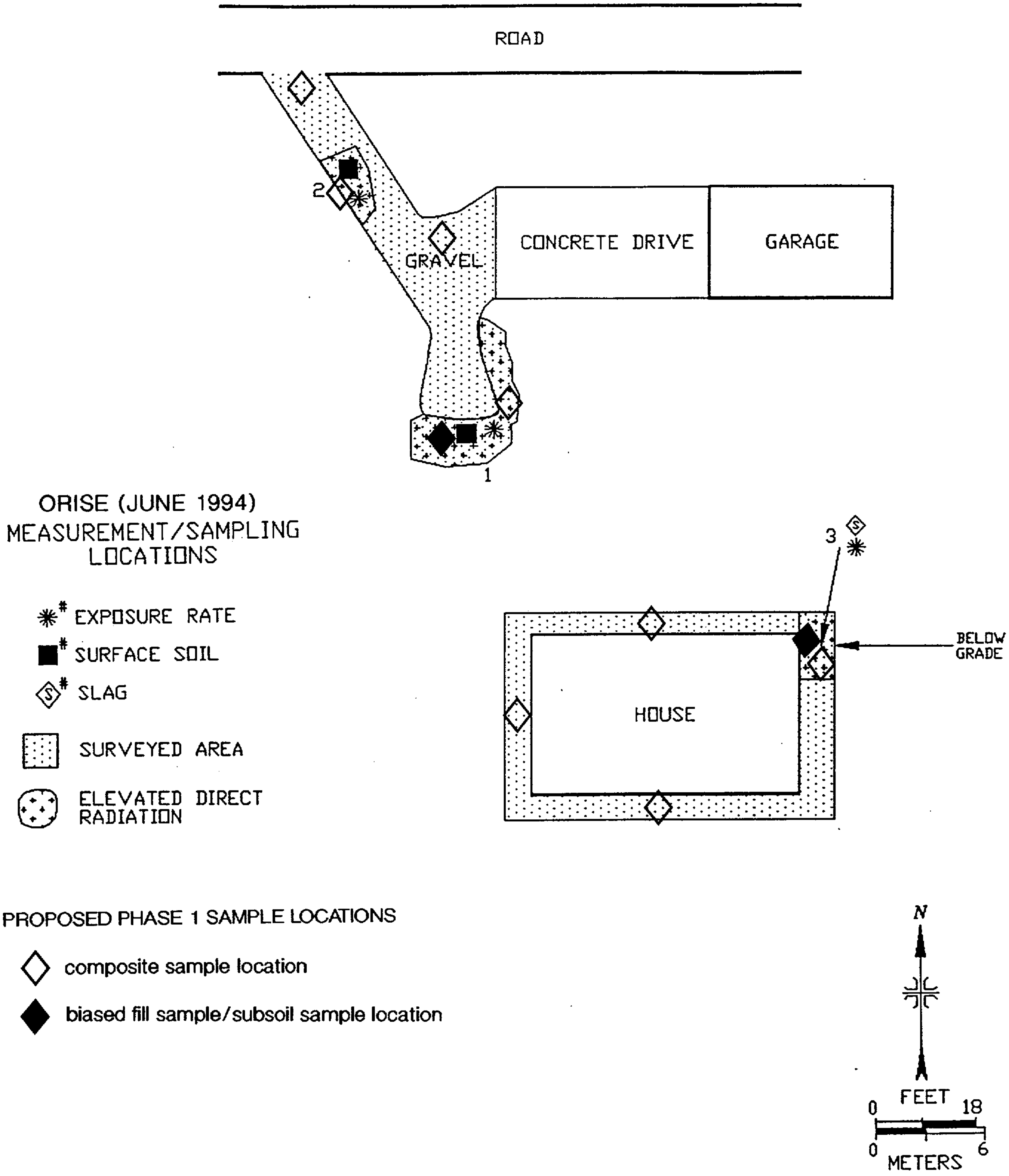
Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY CAMBRIDGE, OHIO	PROJECT NO. 4E08103

Woodward·Clyde Consultants

CONSULTING ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DRN. BY: RET CHKD. BY: CFP	SITE PLAN, PROPERTY 13	FIG. NO. 3



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

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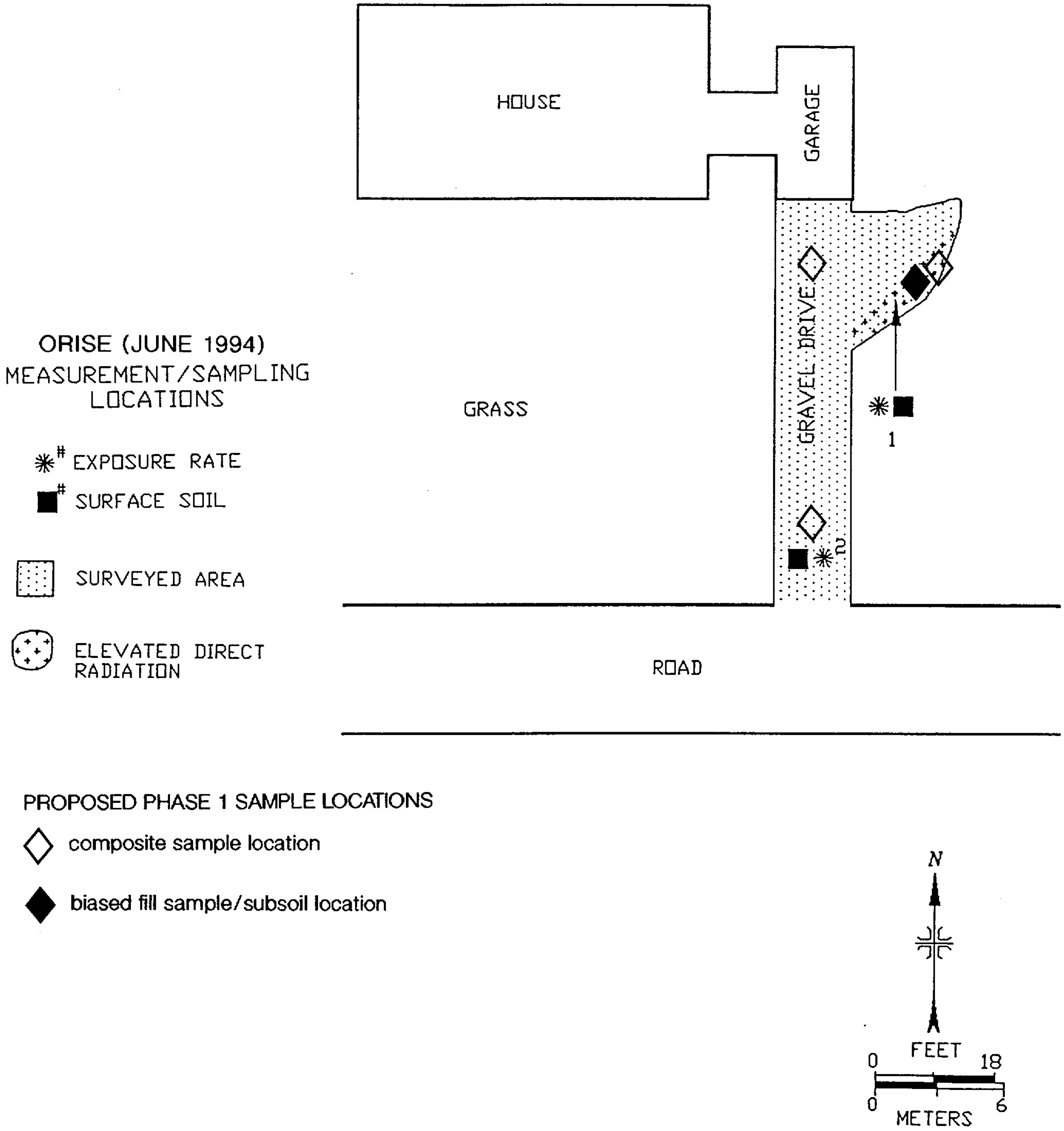
DRN. BY: RET CHKD. BY: CFP	SITE PLAN, PROPERTY 19	FIG. NO. 4



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

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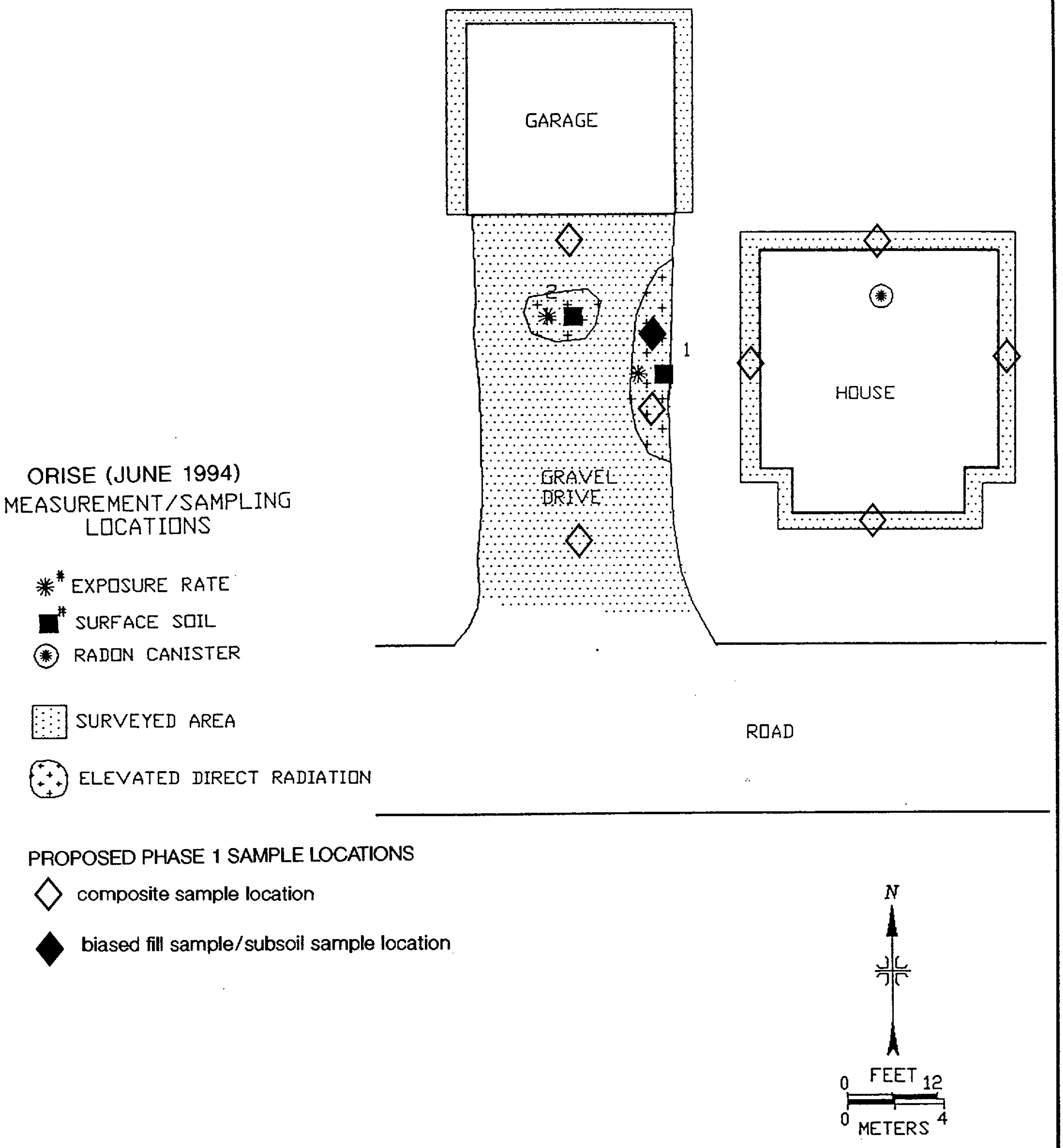
DRN. BY: RET CHKD. BY: CFP	SITE PLAN, PROPERTY 24	FIG. NO. 5



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

PROJECT NO.
4E08103

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CONSULTING ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

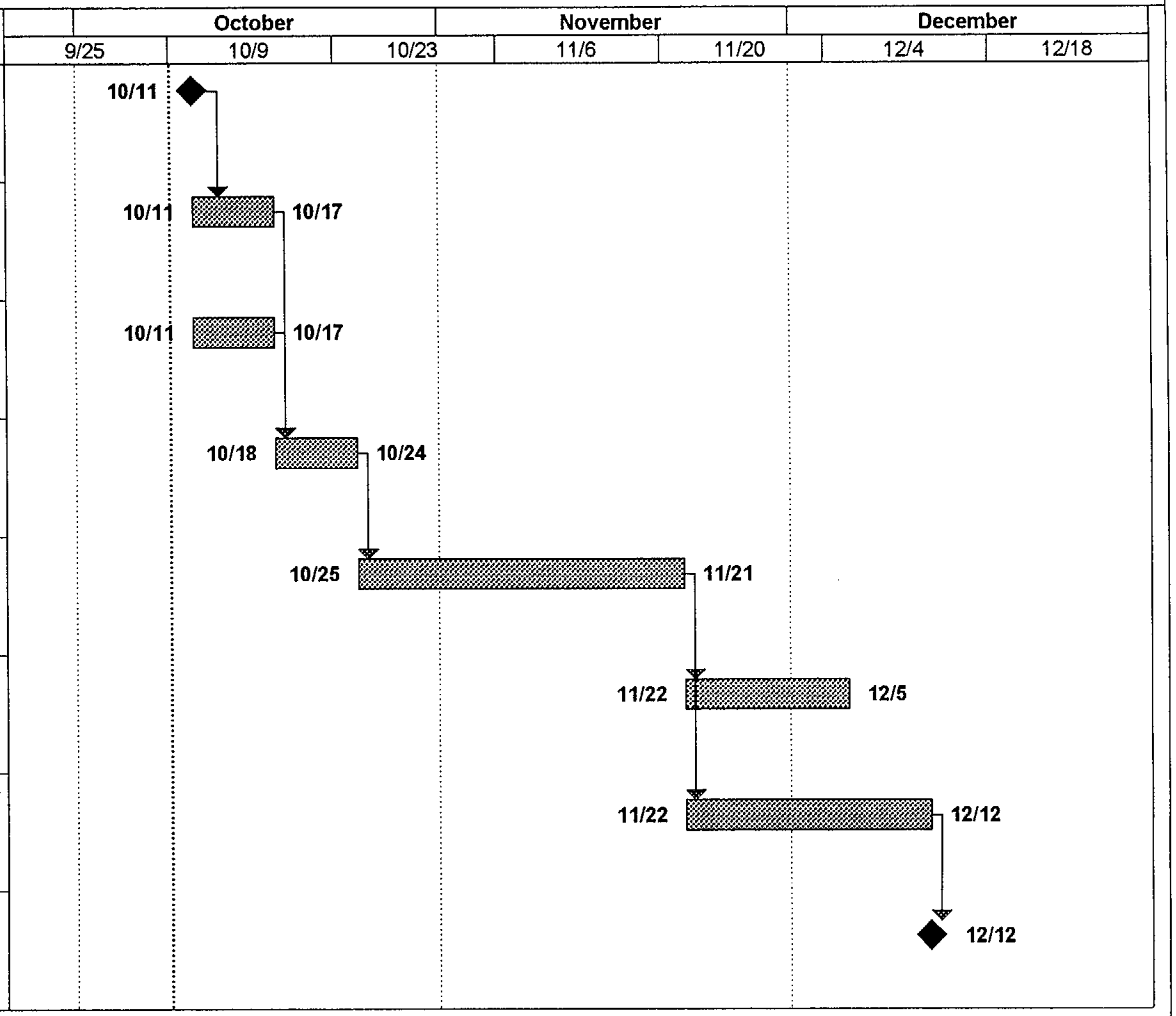
DRN. BY: RET
CHKD. BY: CFP

SITE PLAN, PROPERTY 47

FIG. NO.
6

FIGURE 7
SCHEDULE OF ACTIVITIES

ID	Task Name	Duration
1	**Submit Phase I Work Plan to NRC**	**0d**
2	**NRC Review and Approval**	**1w**
3	**Pre-Mobilization Activities**	**1w**
4	**Field Activities**	**1w**
5	**Laboratory Analysis**	**4w**
6	**Data Evaluation**	**2w**
7	**Prepare Scoping Report/ Phase II Work Plan**	**3w**
8	**Submit Scoping Report/ Phase II Work Plan to NRC**	**0d**



Project: Cyprus Foote
Date: 10/9/94

Task	▨	Summary	▬	Rolled Up Progress	▬
Progress	▬	Rolled Up Task	▨		
Milestone	◆	Rolled Up Milestone	◇		

APPENDIX A

HEALTH & SAFETY PLAN

HEALTH AND SAFETY PLAN FOR A SCOPING SURVEY OF VICINITY PROPERTIES CAMBRIDGE, OHIO

October 11, 1994

WOODWARD-CLYDE CONSULTANTS
2318 MILLPARK DRIVE
MARYLAND HEIGHTS, MISSOURI 63043

WCC PROJECT 4E08103

TABLE OF CONTENTS

Section Page

APPROVALS 0

1.0 INTRODUCTION 1

2.0 PROJECT SAFETY ORGANIZATION 3

3.0 FIELD ACTIVITIES 5

  3.1 SITE INFORMATION 5
  3.2 OBJECTIVES 5
  3.3 RADIOLOGICAL SURVEYS 6
  3.4 HAND DUG TEST PITS AND HAND AUGER BORINGS 6
  3.5 SOIL AND SLAG SAMPLING 6

4.0 HAZARD ASSESSMENT 7

  4.1 RADIOLOGICAL HAZARDS 7
  4.2 CHEMICAL HAZARDS 8
  4.3 PHYSICAL HAZARDS 8

5.0 RISK EVALUATION 10

  5.1 NON-INTRUSIVE ACTIVITIES 10
  5.2 INTRUSIVE ACTIVITIES 10
  5.3 DETECTABILITY 11

6.0 GENERAL HEALTH AND SAFETY REQUIREMENTS 12

  6.1 HEALTH AND SAFETY CLEARANCE 12
  6.2 SAFETY BRIEFING 12
  6.3 DISTRIBUTION OF HASP 13
  6.4 DOCUMENTATION 13
  6.5 INCIDENT REPORTING 13
  6.6 PROHIBITED ACTIVITIES 14

TABLE OF CONTENTS

Section Page

7.0 SITE SPECIFIC HEALTH AND SAFETY REQUIREMENTS 15

7.1 SPECIAL MEDICAL TESTS 15
7.2 SPECIAL TRAINING REQUIREMENTS 15
7.3 SITE CONTROL 15
7.4 WORK ZONES 15
7.5 DUST MINIMIZATION MEASURES 16
7.6 PERSONAL PROTECTIVE EQUIPMENT 16
7.7 OTHER EQUIPMENT 17
7.8 EXPOSURE MONITORING GUIDELINES 17

7.8.1 Instrumentation 17
7.8.2 Dosimetry 17
7.8.3 Dust Monitoring Guideline 18
7.8.4 Level of Protection/Action Guidelines 18

7.9 DECONTAMINATION PROCEDURES 19

7.9.1 General 19
7.9.2 Equipment Decontamination 19
7.9.3 Personnel Decontamination 19

7.10 CONTROL OF FIELD-WORK GENERATED WASTE MATERIALS 21

8.0 EMERGENCY RESPONSE 22

8.1 RESPONSE PROCEDURES 22
8.2 DIRECTIONS TO NEAREST HOSPITAL 22

9.0 REFERENCES CITED 24

LIST OF TABLES

TABLE 1 ORISE RADIONUCLIDE ANALYTICAL RESULTS FOR PROPERTIES 13, 19, 24, AND 47
TABLE 2 METALS IN SLAG AND CHEMICAL HAZARD DATA
TABLE 3 RADIATION SURVEY INSTRUMENTATION AND OPERATIONAL RANGES
TABLE 4 EMERGENCY CONTACTS

LIST OF FIGURES

FIGURE 1 LOCATION OF PROPERTIES TO BE INVESTIGATED
FIGURE 2 SITE PLAN, PROPERTY 13
FIGURE 3 SITE PLAN, PROPERTY 19
FIGURE 4 SITE PLAN, PROPERTY 24
FIGURE 5 SITE PLAN, PROPERTY 47
FIGURE 6 ROUTE TO HOSPITAL

LIST OF ATTACHMENTS

ATTACHMENT 1 COMPLIANCE AGREEMENT

ATTACHMENT 2 WCC OPERATING PROCEDURES

HS-102 Incident Reports
HS-201 Heat Stress
HS-202 Cold Stress

1.0
INTRODUCTION

This Health and Safety Plan (HASP) has been prepared for the field investigation of slag allegedly containing low levels of radioactivity on four residential properties in Guernsey County, Ohio (Figure 1). This HASP was developed in accordance with applicable sections of 29 CFR 1910 and 29 CFR 1926, and was prepared for exclusive use by employees of Woodward-Clyde Consultants (WCC) and its subcontractor, Sanford Cohen & Associates (SC&A). This HASP shall not be used for work other than that described in Section 4.0, nor shall it be modified or used after the expiration date without written approval of the WCC Project Manager (PM), Health and Safety Officer (HSO), and Corporate Health and Safety Officer (CHSO). All Employees of WCC and SC&A involved in this project are required to abide by the provisions of this plan. All WCC and SC&A personnel involved in the field activities are required to read this plan and sign the attached Compliance Agreement.

The HASP guidelines and requirements presented are based on a review of available information and evaluation of potential hazards. This plan outlines the health and safety procedures and equipment required for activities at off-site, vicinity properties (private residences) to minimize the potential of exposure of field personnel.

This plan will be implemented by the Site Safety Officer (SSO), and compliance is required of all participants in the project.

It is not possible to foresee, discover, evaluate and provide protection for all possible hazards which may be encountered at a particular site. Strict adherence to the health and safety guidelines set forth herein will reduce the potential for injury at a site.

The application of this HASP is restricted to environmental radiation monitoring and sample collection activities at off-site residential properties and should not be applied to any activities within the boundary of an industrial site or where industrial type hazards are likely to exist. The sample collection activities will not involve the use of drilling rigs, backhoes, or any heavy machinery. By restricting this plan to apply only to activities at off-site residential properties the following health and safety requirements apply:

- monitoring for internal (bio-assay) radiation exposure should not be necessary; and
- personnel protective clothing higher than modified Level D should not be required.

2.0
PROJECT SAFETY ORGANIZATION

The PM has overall responsibility for implementing this HASP. The SSO reports to the PM, directs day-to-day health and safety activities in the field and must be present whenever work is being conducted in the field by WCC or SC&A employees. The CHSO, HSO and HSC are responsible for advising the PM and SSO on health and safety matters and monitoring compliance. The PM, SSO, HSC, HSO and CHSO have the authority to suspend work when the health or safety of field personnel or the public is threatened and to remove individuals from the site for engaging in activities that jeopardize the health and safety of themselves or others.

The responsibilities of the SSO include the following:

- ensuring that the provisions of this HASP are adequate for that site and are implemented in the field;
- ensuring that all health and safety documentation is complete and accurate;
- ensuring that all team participants are properly trained;
- observing routine field practices in order to ensure the effectiveness of this plan;
- ensuring that all team members are informed of any special work precautions; and
- coordinating any deviations to previously approved operations that may affect the health and safety of personnel.

For those occasions when more than one monitoring and/or sampling team are operating simultaneously in the field, a qualified person on each team will be designated by the SSO to act as the "Team SSO".

Proposed revisions to this plan must be reviewed and signed approval obtained from the WCC PM and HSO.

It is the responsibility of each monitoring/sampling team member to know and understand the contents of this HASP and to strive at all times to perform in a safe and sane manner.

3.0
FIELD ACTIVITIES

3.1 SITE INFORMATION

The field activities will be performed at four off-site residential properties located in Guernsey County, Ohio (Figures 1 through 5). The property addresses and their numerical designations based on a previous survey by the Oak Ridge Institute for Science and Education (ORISE) (NRC, 1994), are:

- property 13: 136 East Street, Lore City, Ohio
- property 19: 58815 Grisak Road, Byesville, Ohio
- property 24: 11275 Ideal Street, Byesville, Ohio
- property 47: 10215 Sycamore Street., Byesville, Ohio

Slag is reported to have been used at these properties as fill material.

3.2 OBJECTIVES

The field activities may include:

- Radiological surveys;
- Hand-dug test pits;
- Hand auger borings;
- Soil and slag sampling; and
- Other activities as required.

The objective of the field activities is to delineate the areal extent and thickness of the slag fill material and the fate-and-transport parameters of the slag and soil.

3.3 RADIOLOGICAL SURVEYS

Surface scans and exposure rate measurements will be performed to confirm the results of the ORISE scoping survey and to identify areas of elevated direct radiation measurement from which biased samples may be collected. The surface scans will be performed by passing a NaI detector slowly over the surface at a minimum distance. The exposure rate measurements will be performed at 1 meter above the surface using a micro-R meter or pressurized ionization chamber (PIC). A list of all survey instruments to be used for this project is provided **Table 3**.

3.4 HAND DUG TEST PITS AND HAND AUGER BORINGS

The thickness of slag and any clean cover material that may exist will be evaluated at each property by visual observation in the field. The thicknesses of the layers will be evaluated on the basis of shallow hand dug test pits or hand auger borings and will be recorded on field data sheets. The hand dug test pits will be approximately one square foot in area and 1 foot deep. Hand auger borings may penetrate to a total depth of two feet below the base of the slag layer.

3.5 SOIL AND SLAG SAMPLING

Samples of slag, slag/soil mixtures, and subsoils will be collected during the Phase I investigation. The sampling effort will include the collection of both discrete and composite types of samples. Each sample will consist of approximately 1 kg (2.2 pounds) of material. Sample collection utensils may include stainless steel shovels, bowls, and spoons, or equivalent. The sample collection utensils will be disposed of and replaced with clean utensils or, alternatively, will be decontaminated between sample locations. The collected samples will be placed in a plastic bag, sealed, appropriately labeled, and shipped to a commercial laboratory for analysis. Specific details of the soil and slag sampling are presented in the Phase I Work Plan.

4.0
HAZARD ASSESSMENT

4.1 RADIOLOGICAL HAZARDS

Based on the physical nature of the slag, the specific areas where the slag is located, and the types of radiation emitted (alpha particle and a low energy, low abundance gamma), the U.S. Nuclear Regulatory Commission (NRC) has concluded that the slag does not pose an immediate health risk to residents and does not result in exposures in excess of the 100 millirem (mrem)/year total effective dose equivalent (TEDE) allowed for members of the public under NRC Standards for Protection Against Radiation, 10 CFR 20, 1301(a)(1) (NRC, 1994a).

The radionuclides of concern in the slag are identified below. The selection is based on historical production process information and the results of previous surveys of off-site properties by ORISE, including properties 13, 19, 24, and 47.

Decay Series	Radionuclide
Uranium (Uranium-238)	Uranium-238
	Thorium-230
	Radium-226
Thorium (Thorium-232)	Thorium-232
	Thorium-228
Actinium (Uranium-235)	Protactinium-231
	Actinium-227

The levels of these radionuclides identified by previous analyses of the slag and soil at properties 13, 19, 24, and 47 are presented in **Table 1**. The previous analyses indicate a lack of secular equilibrium among the radionuclides, with unsupported thorium-230 ranging up to 4,864 picoCuries per gram (pCi/g), and unsupported protactinium-231 ranging up to 48 pCi/g.

Exposure rates measured at 1 meter at the four properties to be investigated ranged from 9 to 13 μR/hour as compared to background exposure rates in Guernsey County of approximately 9 to 11 μR/hour. The elevated levels of thorium-230 cannot be readily detected in the field by radiological survey instruments because thorium-230 is primarily an alpha-emitting isotope.

The slag was formed at high temperatures as a byproduct of ferroalloy production. It is extremely hard and dense and is reported to occur in gravel to cobble size pieces. Where the slag has been used as a base for driveways or as foundation fill material, it is generally covered by a clean layer of limestone gravel, asphalt, concrete, or topsoil. Therefore, the slag is not expected to be friable or susceptible to suspension as airborne particulates.

4.2 CHEMICAL HAZARDS

Previous investigations indicate that the slag may contain heavy metals, including chromium, vanadium, nickel, titanium, and zirconium. **Table 2** lists the metals that may exist in the slag, their TLV and IDLH values, and the symptoms or effects of exposure.

4.3 PHYSICAL HAZARDS

The activities to be performed under the provisions of this plan involve the potential use of shovels, hand augers, and other hand tools. Personnel should be aware that the protective equipment worn may limit manual dexterity and may increase the difficulty of performing some tasks.

All personnel should be cognizant of the physical condition of fellow workers during adverse weather conditions. Cold weather can present conditions that require special planning when conducting site activities. In addition, the use of personnel protective equipment in warm or hot weather can place an additional strain on the wearer when performing work that requires strenuous activity. Heat exhaustion or heat stroke are possible. Operating procedures to identify and prevent heat stress and cold stress are provided in HS-201 and HS-202, respectively (**Attachment 2**).

Special precaution must be taken when digging (i.e., hand dug test pits and hand augering) in the vicinity of underground utility lines. Property owners and utility companies will be consulted regarding the locations of underground utility lines (i.e., electricity, gas, water, cable). Contact with an electrical utility line can shock, burn and result in death.

5.0
RISK EVALUATION

5.1 NON-INTRUSIVE ACTIVITIES

Non-intrusive activities that may be performed at the site consist of the following:

- Field mobilization/demobilization
- Radiological surveys
- Decontamination
- General support activities carried on outside of the sampling area

The mobilization/demobilization, radiological surveys, and general support activities are considered to be low hazard. These activities will be performed in the open. It is unlikely that direct contact by site personnel with hazardous substances will occur during the performance of these activities. In general, the inhalation pathway is indicated for metals and radionuclides. However, since these constituents are not volatile and generally are covered by clean material (e.g. gravel or topsoil), they should not present a significant inhalation hazard. As indicated in Section 5.1, the slag is expected to occur as gravel to cobble size pieces and is not expected to be friable or otherwise susceptible to suspension as airborne particulate matter.

The decontamination activities are considered to be a low to medium hazard. Direct contact with hazardous substances by field personnel is possible during the decontamination of personnel and equipment. Exposure could occur by contact with decontamination fluids, spent Personal Protective Equipment (PPE) and through the handling of equipment. Inhalation, ingestion, and dermal contact exposure routes are indicated.

5.2 INTRUSIVE ACTIVITIES

Intrusive activities that may be performed at the site consist of the following:

- Manual digging of test pits and hand augering

- Collecting soil and slag samples

Excavating and sampling of the test pits, and soil and slag sampling are considered to be a medium hazard. Direct contact by site personnel with hazardous substances may occur. Exposure could occur by contact with contaminated equipment, or by the unprotected handling of contaminated samples. For the metals and radionuclides, inhalation, ingestion and dermal contact exposure routes are indicated. Since these constituents are not volatile, they should not present a significant inhalation hazard unless sampling activities or wind generate dust. As indicated in Section 4.1, the slag is expected to occur as gravel to cobble size pieces and is not expected to be friable or otherwise susceptible to suspension as airborne particulate matter. However, to provide additional assurance, half face respirators will be used for those situations identified as having a greater potential for inhalation of these agents.

5.3 DETECTABILITY

Visual observations and the appropriate radiation meter will be used to assess whether metal- and radionuclide-contaminated slag or soil have been encountered (or potentially encountered) during the performance of the work. Visual observation will be used to assess whether dust levels encountered during the performance of the work require stopping work and evacuating the area.

6.0
GENERAL HEALTH AND SAFETY REQUIREMENTS

6.1 HEALTH AND SAFETY CLEARANCE

WCC and SC&A employees must obtain health and safety clearances before beginning field work on this project. To obtain clearance, an employee must have (1) been certified within the past 12 months by an approved physician as being physically fit to wear respiratory protective devices and to work with hazardous chemical substances, (2) successfully completed a 40-hour basic health and safety training course (Level C), which fulfills the requirements of 29 CFR 1910.120 and (3) passed a respirator fit test with isoamyl acetate and/or irritant smoke as indicators. The field sampling team leader must have successfully completed an 8-hour site manager's health and safety course and First Aid/CPR in addition to all other clearance requirements.

Physical examination protocols and basic training requirements which meet the requirements of 29 CFR 1910.120 are described in Sections HS-501 and HS-502, respectively, of WCC's Hazardous Waste Management Practice Health and Safety Manual, dated November 1993.

SC&A employees must also have similar medical, training and respirator fit clearances and will be required to provide proof of clearance before beginning work.

The names of all WCC and SC&A employees that perform field work must be recorded daily and the record maintained in the health and safety file.

6.2 SAFETY BRIEFING

Before the field activities commence, all WCC and SC&A employees participating in the field activities must be briefed by the SSO, HSC or a HSO on their work assignments and the site-specific health and safety requirements contained in this plan. The SSO/HSC/HSO giving the briefing should test the knowledge and understanding of the provisions of this HASP and shall not allow anyone who does not appear to understand the provisions to perform work in exclusion areas. The dates of briefing sessions and attendees must be recorded and the records maintained in the health and safety file.

6.3 DISTRIBUTION OF HASP

Before site work begins, a copy of this HASP must be provided to each WCC and SC&A employee participating in the field activities as well as to an authorized representative of SC&A. Individuals assigned to participate in the field activities must acknowledge receipt of the plan and agree to comply with its provisions by completing and signing the compliance agreement included with this HASP as **Attachment 1**. The SSO is responsible for ensuring that a copy of the plan is immediately available wherever and whenever work is in progress.

6.4 DOCUMENTATION

The SSO will document implementation of this HASP. The SSO will set up a file to receive health and safety related records and activity reports. This file should contain the following:

- Signed copies of the Compliance Agreement
- Copies of safety equipment operations manuals
- Records of usage and calibration of environmental monitoring equipment
- Employee injury/exposure incident reports
- Records of safety violations and remedial actions taken

A health and safety field logbook will be maintained on-site and should contain the following information: weather conditions, employees participating in the field activities, level of personal protection worn, monitoring instrumentation readings (average, peak and background), subjects discussed during site health and safety briefings, and safety violations.

6.5 INCIDENT REPORTING

Injuries, exposures, illnesses, safety infractions, and other incidents specified in Operating Procedure HS-102 included as a part of **Attachment 2** must be reported to the Business Unit HSO using Form HS-102 within 24 hours of occurrence.

6.6 PROHIBITED ACTIVITIES

The following activities are prohibited:

- Smoking, eating, drinking, applying cosmetics, chewing gum or tobacco, storing food or food containers while in the exclusion and contamination-reduction zones. Good personnel hygiene should be practiced by field personnel to avoid ingestion of contaminants or spread of contaminated materials.
- Use of drugs, alcohol, or controlled substances while on site.
- Wearing contact lenses while in the exclusion and contamination-reduction zones.

7.0
SITE SPECIFIC HEALTH AND SAFETY REQUIREMENTS

7.1 SPECIAL MEDICAL TESTS

Special medical tests will not be required for this project.

7.2 SPECIAL TRAINING REQUIREMENTS

Training requirements for this project include:

- the basic OSHA 40-hour health and safety course; and
- radiation health & safety training.

The field sampling team leader (SSO) must also have completed the 8-hour site supervisor's health and safety training course and be certified in first aid/CPR.

7.3 SITE CONTROL

The sites to be sampled are residential properties. Formal site control measures beyond those existing will not be required.

7.4 WORK ZONES

Due to the potential for encountering buried contamination, areas where trenches or test pits are dug will be considered restricted areas. These areas will be clearly defined using stakes and yellow rope, and will cover approximately 8 ft x 8 ft. A sheet of plastic approximately 4 ft x 4 ft will be placed on the ground inside of each sample location prior to the beginning of sampling activities, and will be used for the placement of sampling equipment while sampling in process. All personnel working in such an area will wear the appropriate protective clothing, defined as cloth coveralls, disposable shoe covers and disposable surgical-type gloves under work gloves. Upon leaving a restricted area, all personnel will frisk themselves for contamination using the appropriate survey meter. All personnel must certify they are clean prior to resuming work outside of the restricted area.

As described in Section 8.9, decontamination of sampling equipment will be performed at each sample location prior to personnel decontamination. A temporary decontamination area for personnel will be established within each restricted area.

7.5 DUST MINIMIZATION MEASURES

Dust minimization measures for soil and slag sampling will consist of wetting the soil/slag if visible dust conditions are present. The water will be sprayed on the ground at the sample location with a fine mist to encourage wetting of the top layers while not producing any runoff. The hand dug test pits or hand auger borings will be immediately backfilled upon completion to reduce the potential for creating dusty conditions. In addition, the field personnel will endeavor to position themselves upwind while conducting intrusive activities. It is recognized that it will not always be possible to achieve the desired orientation due to physical restraints of the site.

7.6 PERSONAL PROTECTIVE EQUIPMENT

Due to the radiological nature of these sites, we do not anticipate the need to provide dosimetry for personnel on this project. However, to provide additional assurance, personnel will wear thermoluminescent dosimeters (TLDs) for all work at the four sites described in Section 3.1. The TLDs will be provided to personnel for this project only and will be returned upon completion of site survey/sample collection activities.

It is recommended that field activities generally be performed at EPA Level "D" or modified Level "D". Level D personnel protective equipment consists of the following protective ensemble:

- Tyvek or cotton (disposable) coveralls
- Hard hat (when working around heavy equipment only)
- Safety glasses with side shields or goggles

- Work gloves, surgical-type disposal gloves worn under cotton or canvas work gloves
- Safety shoes or boots (Steel toed and shanked when working around heavy equipment)

Modified Level D protective equipment consists of the items listed above and a half-face respirator with particulate dust/radionuclide cartridge.

Additionally, disposable shoe covers/booties will be worn to minimize the need to decontaminate safety shoes or boots. These covers are intended as single use items. A new pair will be donned at each sample test pit/slag sample collection location, and will be discarded upon termination of activities at that location. Disposable gloves are also single use items and will be discarded after each use.

In consideration of the potential hazards described in Section 4.0 and the residential setting of the sites to be sampled, the hard hat and safety glasses are optional.

7.7 OTHER EQUIPMENT

A general purpose first aid kit, including eye wash, will be within easy access of the sampling team.

7.8 EXPOSURE MONITORING GUIDELINES

7.8.1 Instrumentation

External radiation exposure rates during field activities will be monitored using a NaI detector (Ludlum Model 19 microR meter or equivalent).

7.8.2 Dosimetry

All Woodward-Clyde and SC&A personnel will wear TLDs when conducting survey and/or sample collection activities at the four sites described in Section 3.1. The TLDs will be provided through for use on this project only and will be returned for processing upon termination of this project.

7.8.3 Dust Monitoring

No historical site air quality information is available for this site. Dust monitoring will be based on observation of visible dust. The dust minimization measures described in Section 7.5 will be implemented as needed.

7.8.4 Level of Protection / Action Guidelines

Due to the importance of the inhalation pathway for alpha emitting radionuclides, any areas where slag is or may become exposed poses a potential exposure hazard. Modified Level "D" Protection is required at all properties when digging or excavating test pits and hand augering, or collecting soil or slag samples from test pits when the following conditions apply:

- the external exposure is three times normal background as indicated by the appropriate survey instrument; or
- previous radionuclide testing indicates slag with concentrations of thorium-230 exceeding 1,000 pCi/gram.

Radiological surveys, routine equipment/personnel decontamination and other site activities excluding those listed above will be conducted at Level "D' Protection as described in Section 7.6.

Intrusive sampling activities shall be stopped and the area evacuated when visible dust is generated. Dust monitoring will be based on visual observation of dust. Dust minimization measures such as wetting of material will be used to control dusty conditions. If visible dust is identified, operations shall cease until the material has been wetted as identified in Section 8.5 Dust Minimization Measures. If dust minimization measures do not control visible dust emissions, all operations shall cease and the SSO shall direct the field personnel retreat from the sampling area. The PM and the HSO will be contacted and health and safety procedures will be reassessed before work may resume.

7.9 DECONTAMINATION PROCEDURES

7.9.1 General

Decontamination of equipment and personnel will be performed to limit the migration of contaminants off-site and between work zones at each property. Equipment decontamination should be performed prior to personnel decontamination. Personnel shall be monitored for radioactive contamination on skin and clothing between sample locations and prior to leaving each property. Sampling equipment will be cleaned prior to the onset of sampling activities at each property. The SSO will inspect all sampling equipment prior to use.

7.9.2 Equipment Decontamination

Disposable sampling utensils will be employed, or sampling equipment will be decontaminated between each sampling location. Decontamination of sampling utensils will be performed in three stages. The first step will employ dry cleaning methods. Friable soil will be scraped or brushed from the equipment back into the hole from which the sample was collected. In the second step, the equipment will be held over the sample hole and rinsed with a light stream of distilled water from a spray bottle. The equipment will then be wiped with a damp paper towel until any remaining visible soil is removed. In the final step, the equipment will again be held over the sample hole and will receive a final rinse from the spray bottle and a thorough drying. Following decontamination, clean equipment will be stored in plastic bags or covered with plastic sheeting if not immediately reused.

At the conclusion of sampling at each property, the SSO will inspect all equipment for adequacy of decontamination. This inspection will include the use of the appropriate survey equipment and the certification that all equipment is clean prior to its release from the site.

7.9.3 Personnel Decontamination

At the conclusion of equipment decontamination at each sampling location, personnel decontamination will be conducted at a temporary decontamination area established within each restricted area. The general decontamination sequence will be as follows:

1. Remove and dispose of shoe covers/booties.
2. Remove and dispose of outer gloves.
3. Frisk hands, shoes/boots, and coveralls, and face with appropriate survey meter.
4. Remove coveralls and dispose as waste if contaminated.
5. Remove and dispose of inner gloves.

Attention must be paid to limiting the spread of contamination when conducting decontamination. Gloves, booties, and coveralls should be removed by turning inside out. Booties, gloves, and coveralls will be placed into plastic trash bags for containerization and appropriate disposal. Potable water and soap will be available for washing of hands, face, and arms after personnel protective equipment has been removed.

Decontamination equipment and supplies consist of the following:

- Potable water
- Washtubs
- Soap
- Brushes, hand sprayers
- Plastic sheeting
- 5-gallon buckets with lids
- Garbage bags
- Sponges or paper towels
- Double deionized or distilled water

7.10 CONTROL OF FIELD-WORK GENERATED WASTE MATERIALS

Investigation wastes (e.g., gloves, booties, coveralls, plastic sheeting, and equipment decontamination wipes) will be containerized and disposed of in an appropriate manner.

8.0
EMERGENCY RESPONSE

8.1 RESPONSE PROCEDURES

In the event that an emergency situation arises such as an injury or illness, the appropriate immediate response must be taken by the first person to recognize the situation. Emergency contacts are provided in **Table 4**. The Site Manager, with assistance from the SSO, has responsibility and authority for coordinating all emergency response activities until proper authorities arrive and assume control.

In case of injuries to personnel, first aid (first aid kits meet the requirements of 29 CFR 1926.50) treatment will be initiated immediately by trained personnel. In case of serious injuries, the victim will be transported to a medical center as soon as possible. Minor injuries may be treated on site, but all injuries will be examined by trained medical personnel. Victims of serious bites or stings will be taken to a medical center. In the event an injured person is contaminated with chemicals or radionuclides, the person shall be taken to a medical center as soon as possible. Decontamination shall be performed to prevent further exposure only if it will not aggravate the injury. Treatment of life-threatening or serious injuries will always be considered first.

8.2 DIRECTIONS TO NEAREST HOSPITAL

All field personnel should be familiar with the most direct route to Guernsey County Memorial Hospital. A hospital route map is included as **Figure 6**.

HOSPITAL: Guernsey County Memorial Hospital
1341 Clark Street
Cambridge, Ohio

ROUTE TO HOSPITAL: Access Ohio 209 or Interstate 70 from the off-site residential properties, Take Ohio 209 or Interstate 70 to the Cambridge Exit, exit Ohio 209 or Interstate 70 to Southgate Parkway, take Southgate Parkway north to Wheeling Avenue, turn right on

Wheeling Avenue and continue to Clark Street, turn left on Clark street and continue north for approximately one mile, turn left to hospital emergency entrance.

DISTANCE TO HOSPITAL: Variable, approximately 4 to 10 miles.

9.0

REFERENCES CITED

NRC, 1994a, NRC Inspection Report No. 999-90003/94044 (DRSS), September 22, 1994.

NRC, 1994b, "Radiological Scoping Survey for Foote Mineral Offsite Locations, Guernsey County, Ohio, Final Report"; August 19, 1994 (prepared by Oak Ridge Institute for Science and Education).

TABLES

Table 1. ORISE Radionuclide Analytical Results For Properties 13, 19, 24, and 47[1]

Property Designation	Sample Location Number	Radionuclide Concentration (pCi/gram)							
		Ra-226	Th-232	Th-228	U-238	Th-230	Pa-231	Th-227	Ra-223
13	1	2.8 ± 0.3	2.9 ± 0.4	2.4 ± 0.3	1.8 ± 1.8	79 ± 19	<1.1	<0.9	1.5 ± 0.4
	2	1.3 ± 0.3	1.8 ± 0.4	1.5 ± 0.3	2.1 ± 1.6	<20	<1.3	<0.7	0.3 ± 0.4
19	1	9.1 ± 0.4	1.2 ± 0.5	0.6 ± 0.3	4.0 ± 1.7	1796 ± 51	<1.7	1.3 ± 0.5	1.1 ± 0.4
	2	6.9 ± 0.4	0.6 ± 0.5	0.3 ± 0.3	1.3 ± 2.1	1312 ± 50	<2.0	<1.2	<0.8
	3	30.2 ± 0.7	1.1 ± 0.5	0.6 ± 0.3	3.2 ± 3.1	4864 ± 70	3.4 ± 1.4	3.0 ± 0.9	3.1 ± 0.8
24	1	3.1 ± 0.3	3.1 ± 0.5	3.3 ± 0.6	4.4 ± 2.4	24 ± 16	<1.4	<0.7	1.5 ± 0.5
	2	2.2 ± 0.3	2.0 ± 0.4	1.8 ± 0.3	3.9 ± 2.3	18 ± 12	<1.5	<0.7	0.4 ± 0.2
47	1	13.2 ± 0.5	0.4 ± 0.3	0.6 ± 0.3	5.3 ± 1.4	<75	48.2 ± 5.5	33.8 ± 1.4	57.9 ± 1.7
	2	7.4 ± 0.4	0.6 ± 0.2	0.6 ± 0.3	2.0 ± 1.1	<38	24.7 ± 2.9	18.3 ± 0.9	30.8 ± 1.2
	3	0.9 ± 0.2	0.6 ± 0.2	0.3 ± 0.3	2.1 ± 1.2	<10	<0.6	<0.4	<0.3

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[1] Radionuclide data from August 19, 1994 ORISE Survey Report (NRC, 1994b).

TABLE 2. METALS IN SLAG AND CHEMICALS HAZARD DATA

K E Y			
K	Abs = Skin Absorption	T = Tailings	Ing = Ingestion
E	NA = Not Available	S = Soil	U = Unknown
Y	NE = None Established	A = Air	Inh = Inhilation

CONTAMINANT	PEL/TLV ppm or mg/m3 (specify)	IDLH ppm or mg/m3 (specify)	WARNING CONCENTRATIONS ppm or mg/m3 (specify)	EXPOSURE ROUTE	SYMPTOMS/EFFECTS OF EXPOSURE	TOXI–COLOGY
Chromium metals & insoluable salts (as Cr)	TLV 0.5 mg/m3 PEL 1 mg/m3	NE	odorless	Inh	Histologic fibrosis of lungs.	Carcinogen
Chromium: (soluable Chromic& Chromous Salts)	TLV 0.5 mg/m3	NE	odorless	Ing	Dermal sensitization.	Suspected Carcinogen
Nickel	TLV 1.0 mg/m3	NE	odorless	Inh Ing Con	Headache, vertigo, nausea, vomiting, epigastric pain, substernal pain; cough, hypernea; cyanosis; weakness; leukocytosis, pneumonitis; delerium, convulsions.	Carcinogen
Titanium	PEL 10.0 mg/m3	NE	odorless	Inh Ing Con Abs	Nausea, diarrhia, abdominal pain, ptosis, optic axis vomiting, failure, peripheral neuritis tremor, leg paralysis; chest pain behind sternum pulmonary edema, seizure; chorea psychialopecia, strabismus.	Carcinogen
Vanadium (dust)	TLV 0.05 mg/m3	70 mg/m3	0.5 – 2.2 mg/m3	Inh Ing Con	Irritation of the eyes, green tongue, metal taste, throat irritaion, cough, bubbling sounds in bronchi during breathing, wheezing, bronchitis, difficult breathing, eczema.	NE
Zirconium (Zirconium compounds as Zr)	PEL 5.0 mg/m3	500 mg/m3	odorless	Inh Con	Skin granulomas in animals: X–ray evidence of retention in lungs; irritated skin and mucuous membrane	NE

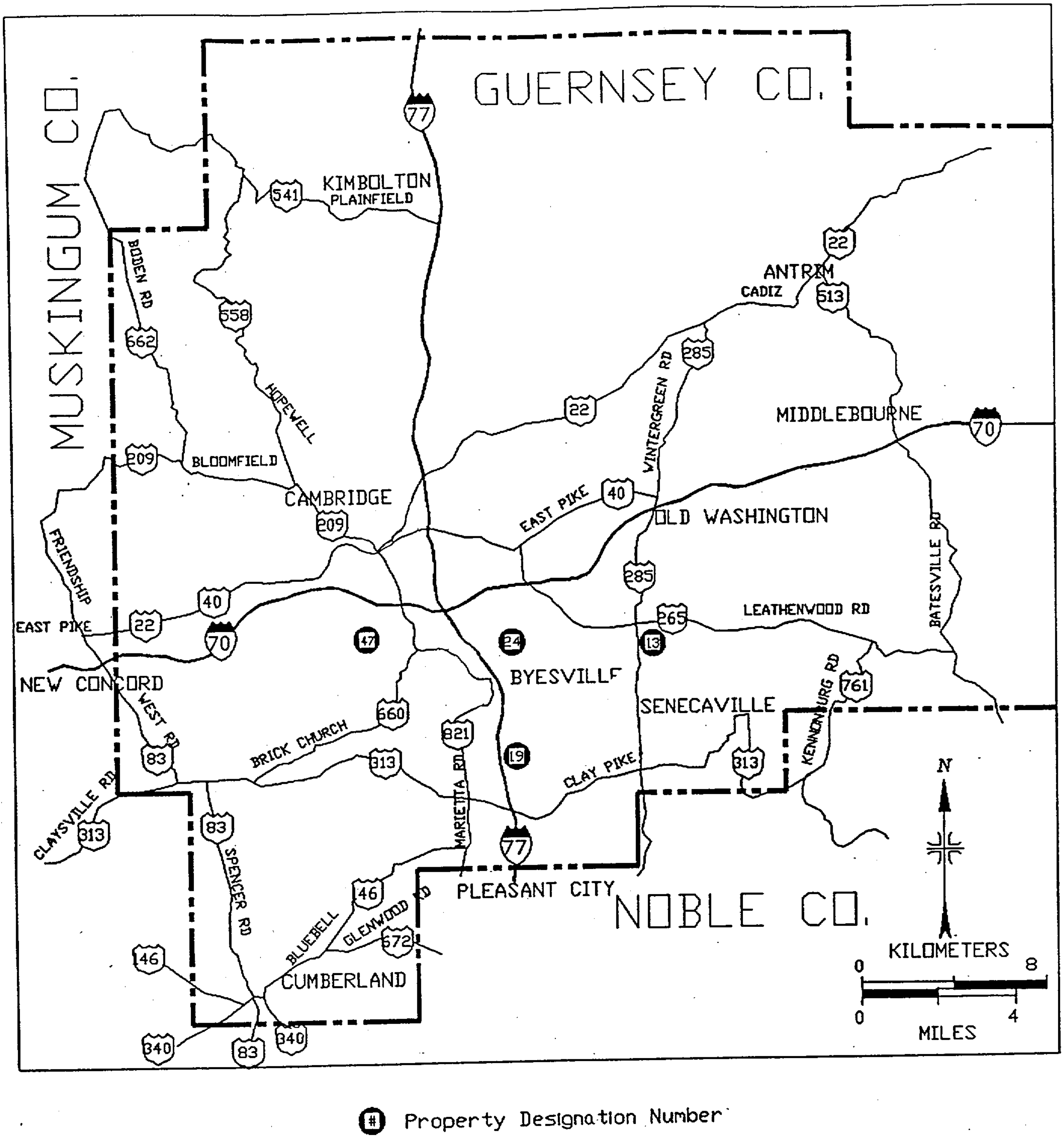
Table 3. Radiation Survey Instrumentation and Operational Ranges

Instrument Type/Model	Radiation Detected	Operational Range
Ludlum No.19 Micro R Meter, NaI Detector	gamma	0 - 5000 μR/hr
Ludlum Ratemeter & No. 44-9 GM Probe	alpha, beta & gamma	0 - 100,000 cpm
Ludlum Ratemeter & No. 43-2 Alpha Scintillation Probe	alpha	0 - 100,000 cpm

TABLE 4
EMERGENCY CONTACTS

Name	Telephone Number
Guernsey County Memorial Hospital	614/439-3561
Ambulance (United Ambulance Service)	614/439-7787
Cambridge	
Police Department	614/439-4431
Fire Department and Rescue Squad	614/432-6000
State Police, Ohio Highway Patrol	614/439-1388
Poison Control Center	800/686-4221
24-Hour Hotline for Toxic Exposure Treatment	513/421-3063
WCC CHSA, Phil Jones (WCC-Plymouth Meeting)	215/825-3000
WCC Consulting Physician, Peter Greany	714/535-8221
WCC Health Physicist, Nancy Daugherty (WCC-Denver)	303/694-2770
WCC - HSO, Greg Horton (WCC-Solon)	216/349-2708
WCC St. Louis Office HSC, Franziska-Y. D. Malsy	314/429-0100
WCC St. Louis Office Manager, William Durbin	314/429-0100
WCC Project Manager, Rudy Torrini, Jr.	314/429-0100

FIGURES



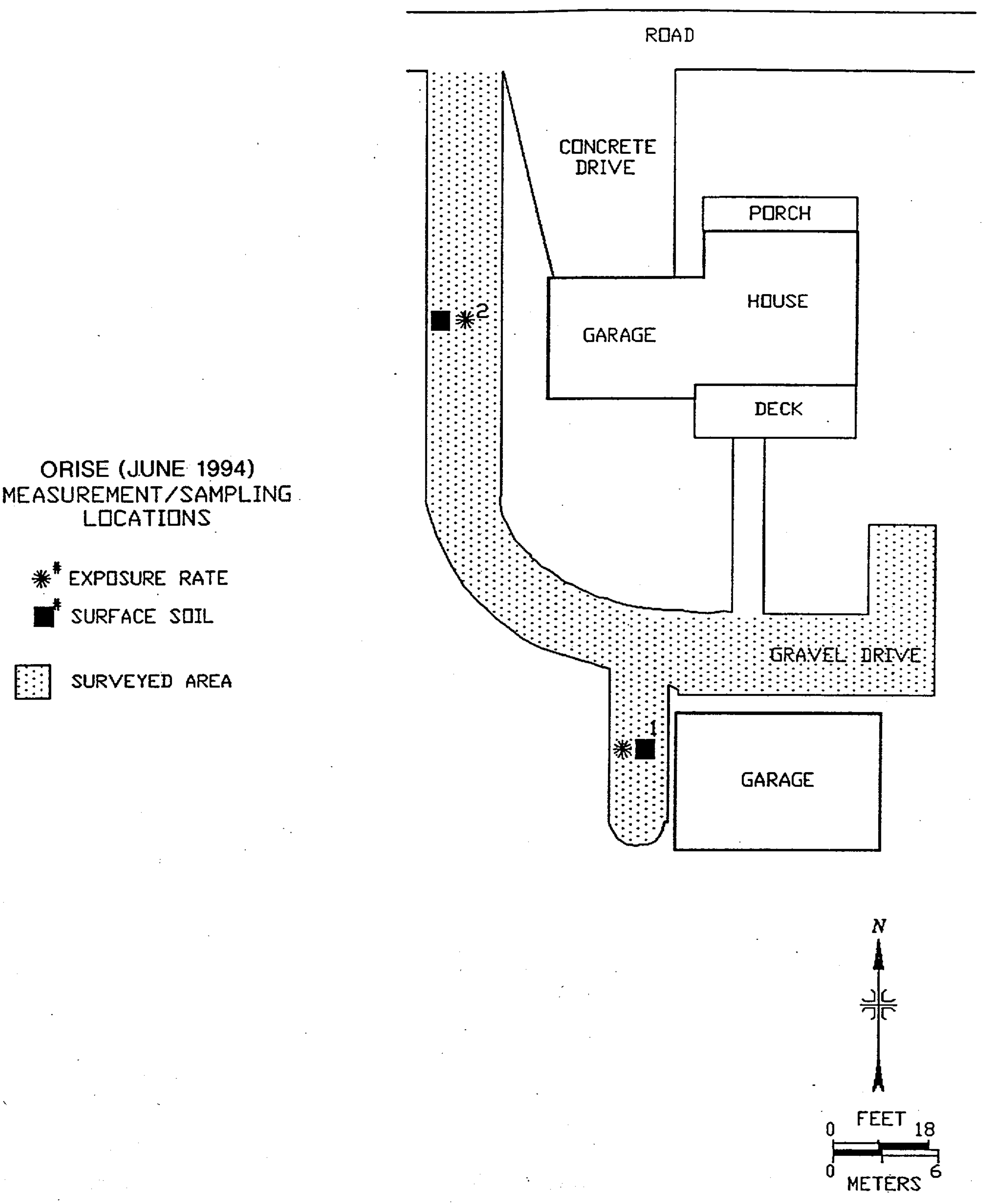
Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY CAMBRIDGE, OHIO	PROJECT NO. 4E08103

Woodward·Clyde Consultants

CONSULTING ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DRN. BY: RET CHKD. BY: CFP	LOCATION OF PROPERTIES TO BE INVESTIGATED	FIG. NO. 1



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

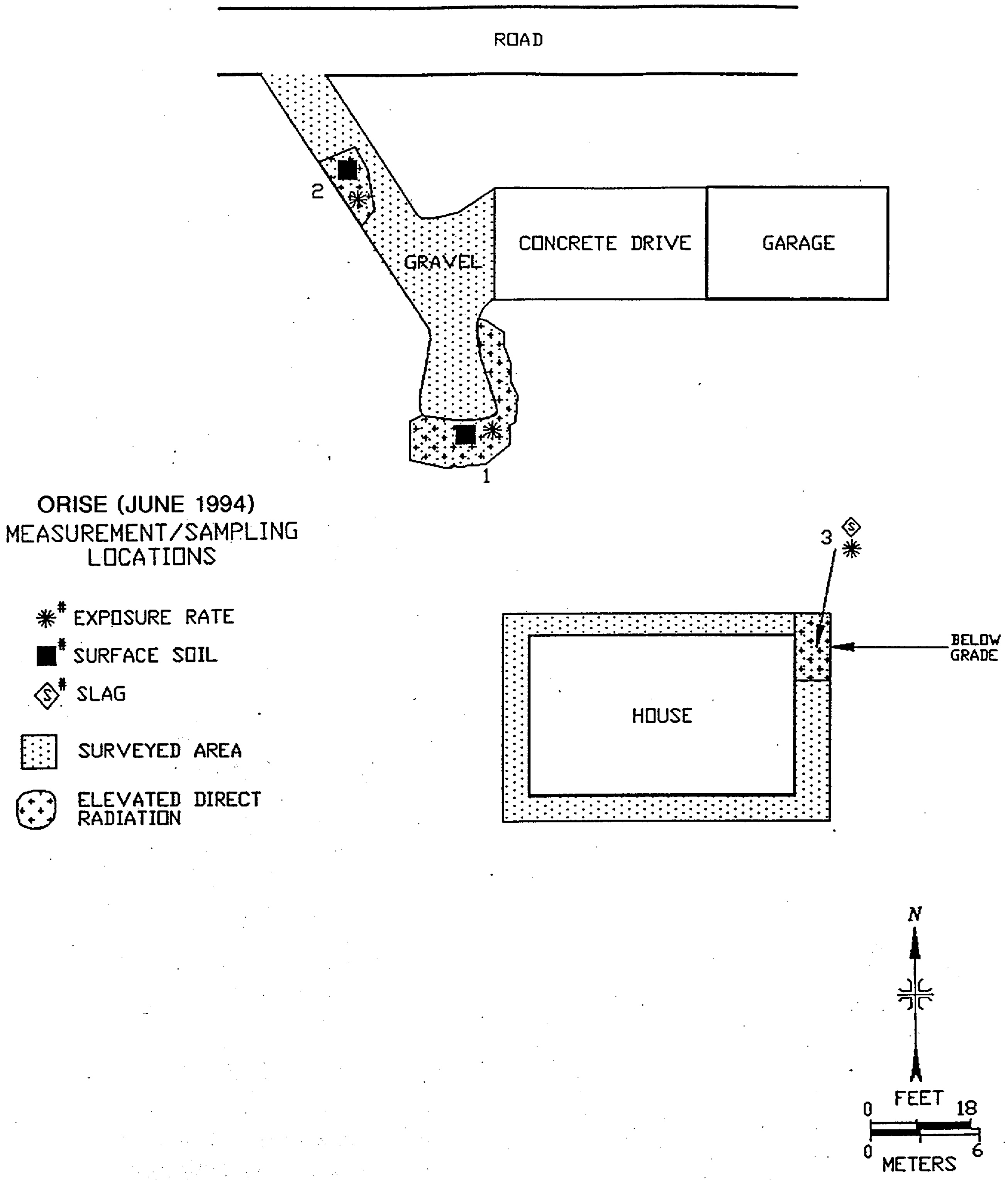
PROJECT NO.
4E08103

Woodward·Clyde Consultants
CONSULTING ENGINEERS, GEOLOGISTS, AND ENVIRONMENTAL SCIENTISTS

DRN. BY: RET
CHKD. BY: CFP

SITE PLAN, PROPERTY 13

FIG. NO.
2



ORISE (JUNE 1994)
MEASUREMENT/SAMPLING
LOCATIONS

Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

PROJECT NO.
4E08103

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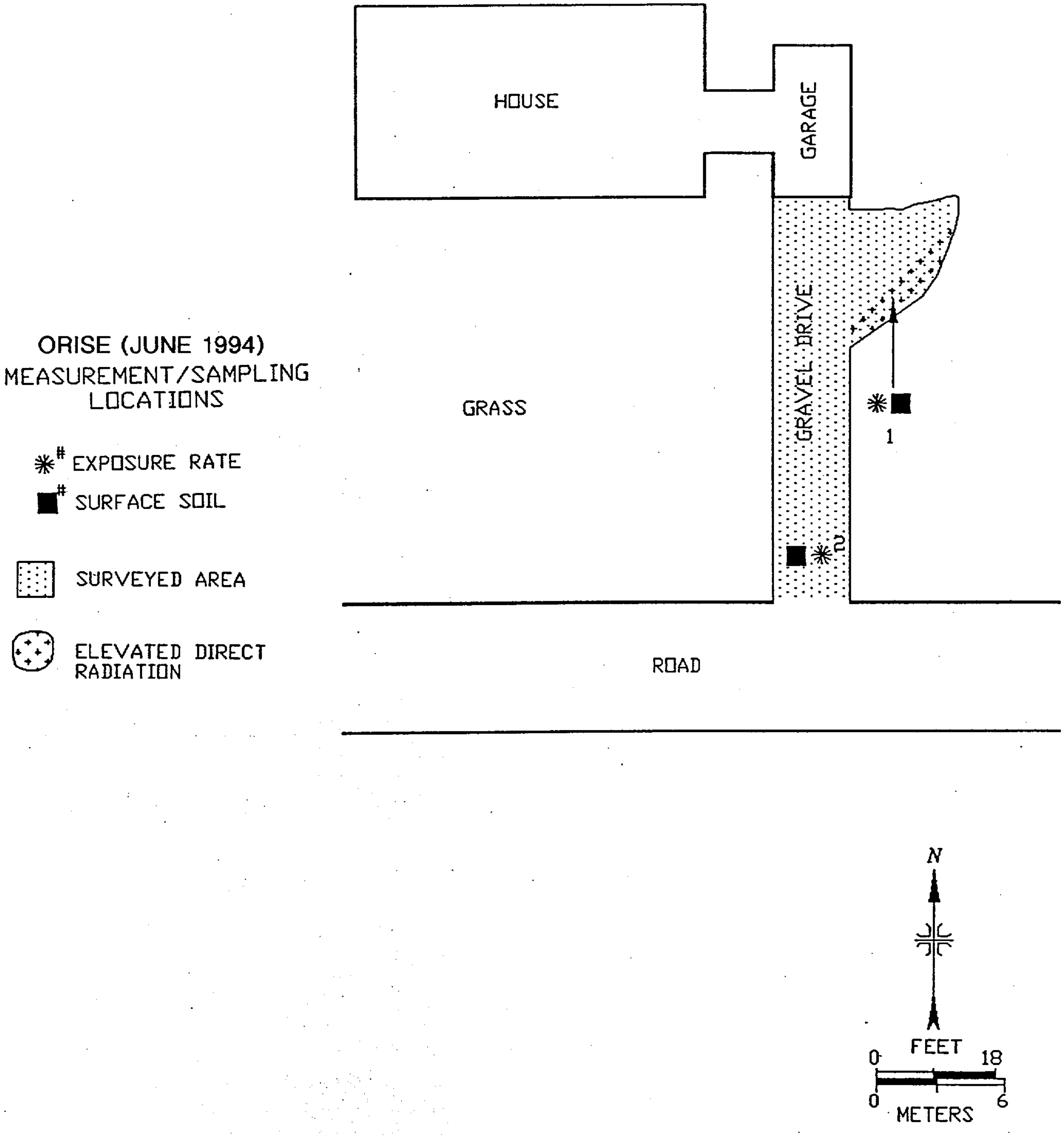
DRN. BY: RET
CHKD. BY: CFP

SITE PLAN, PROPERTY 19

FIG. NO.
3



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

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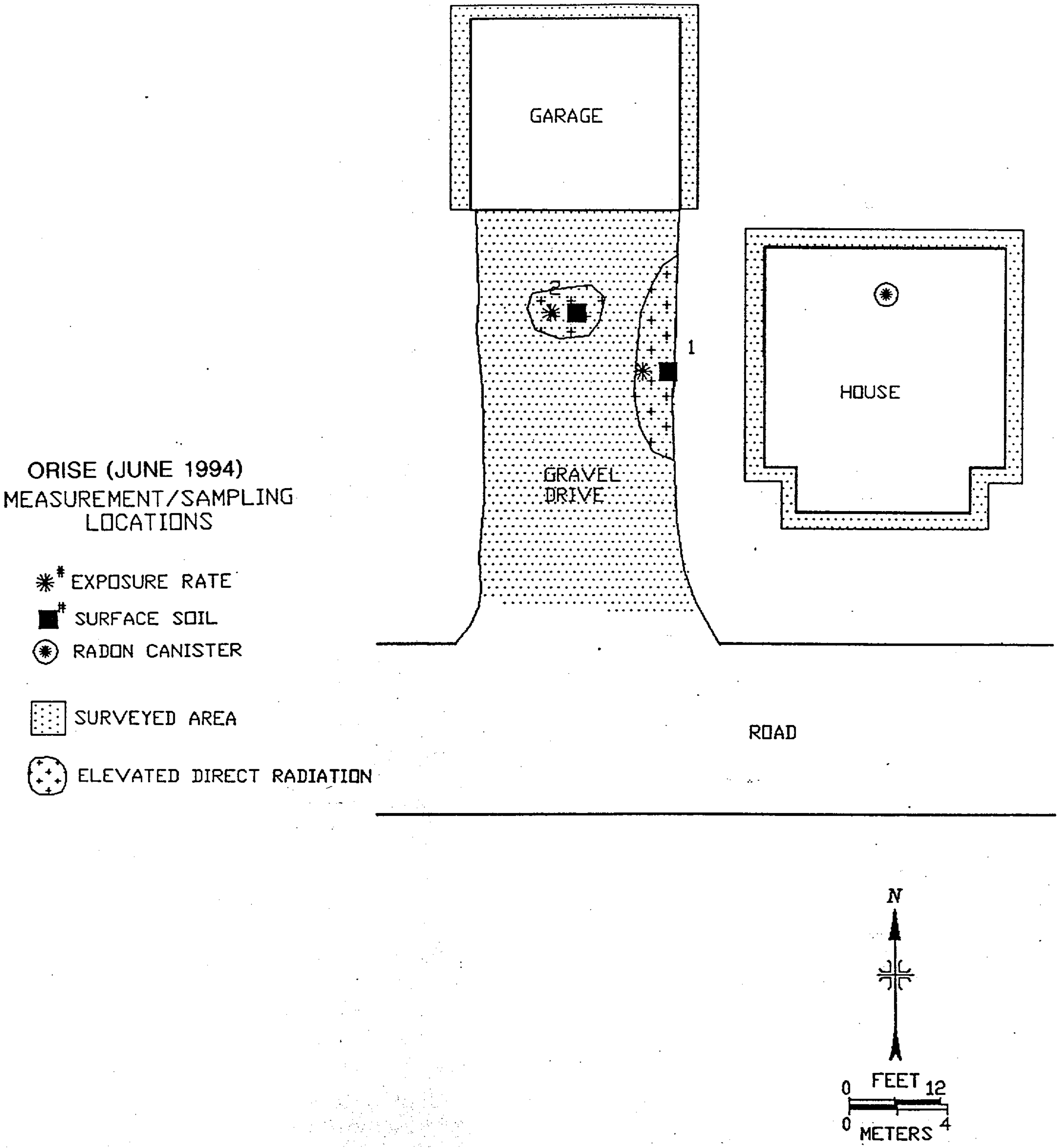
DRN. BY: RET
CHKD. BY: CFP

SITE PLAN, PROPERTY 24

FIG. NO.
4



Source: modified from August 19, 1994 ORISE Survey Report (NRC, 1994d)

CYPRUS FOOTE MINERAL COMPANY CAMBRIDGE, OHIO	PROJECT NO. 4E08103

Woodward·Clyde Consultants

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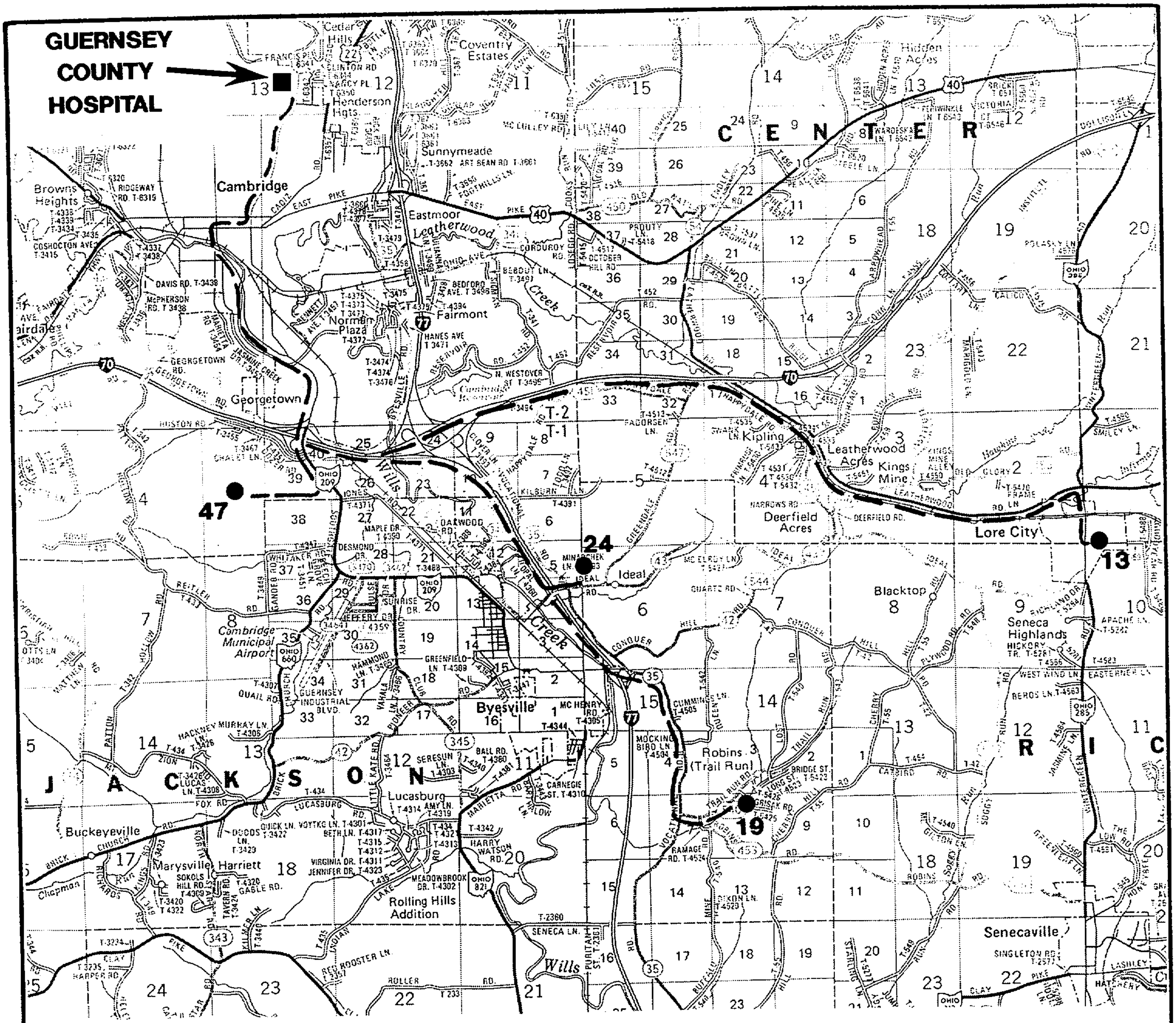
DRN. BY: RET CHKD. BY: CFP	SITE PLAN, PROPERTY 47	FIG. NO. 5



CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

PROJECT NO.
4E08103

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DRN. BY: RET
CHKD. BY: CFP

ROUTE TO HOSPITAL

FIG. NO.
6

ATTACHMENT 1

Compliance Agreement

ATTACHMENT 1

CYPRUS FOOTE MINERAL COMPANY
CAMBRIDGE, OHIO

HEALTH AND SAFETY PLAN COMPLIANCE AGREEMENT

I, ________________________________, have read this Health and Safety Plan and hereby agree to abide by its provisions and to aid the Site Safety Officer in its implementation. I understand that it is in my best interest to see that site operations are conducted in the safest manner possible; therefore, I will be alert to site health and safety conditions at all times.

____ ________________

Signature Date

WCC NO. 4E08103

HASP EFFECTIVE DATE: OCTOBER 10, 1994

HASP EXPIRATION DATE: DECEMBER 31, 1994

ATTACHMENT 2

WCC OPERATING PROCEDURES

HS-102 Incident Reports
HS-201 Heat Stress
HS-202 Cold Stress

OPERATING PROCEDURE NO. HS-102

102.0 INCIDENT REPORTS

102.1 PURPOSE

All health and safety incidents shall be reported to Woodward-Clyde (W-C) management and health and safety staff. The prompt investigation and reporting of incidents will reduce the risk of future incidents, better protect W-C employees, and reduce W-C liability.

102.2 DEFINITIONS

A health and safety incident is any event listed below:

- Illness resulting from chemical exposure or suspected chemical exposure.
- Physical injury, including both those that do and do not require medical attention to W-C employees or W-C subcontractors.
- Fire, explosions, and flashes resulting from activities performed by W-C and its subcontractors.
- Property damage resulting from activities performed by W-C and its subcontractors.
- Vehicular accidents occurring on-site, while travelling to and from client locations, or with any company-owned vehicle.
- Infractions of safety rules and requirements.
- Unexpected chemical exposures.
- Complaints from the public regarding W-C field operations.

102.3 REPORTING PROCEDURES

102.3.1 Reporting Format

Incident reports shall be prepared by completing Form HS-102. This form may be obtained from any W-C Health and Safety Officer (HSO) and is attached to this operating procedure.

102.3.2 Responsible Party

Reports of incidents occurring in the field shall be prepared by the Site Safety Officer or, in the absence of the site safety officer, the supervising field engineer, witness, or injured/exposed individual.

102.3.3 Filing

A report must be submitted to the Health and Safety Officer of the Operating Unit to which the Project Manager belongs within 24 hours of each incident involving medical treatment. In turn, the Health and Safety Officer must distribute copies of the report to the Corporate Health and Safety Manager and the Corporate Health and Safety Officer. When an injury or illness is reported, the Health and Safety Officer must deliver a copy of the report to the individual in charge of Human Resources so that a Worker's Compensation Insurance Report can be filed if necessary. Reports must be received by Human Resources within 48 hours of each qualifying incident.

102.3.4 Major Incidents

Incidents that include fatalities, hospitalization of employees or subcontractors, or involve injury/illness of the public shall be reported to the HSO and Project Manager as soon as possible. Any contact with the media should be referred to the Project Manager and Operating Unit Manager.

FORM HS-102

W-C HEALTH AND SAFETY INCIDENT REPORT

Project Name: ____________

Project Number: ____________

Date of Incident: ____________

Time of Incident: ____________

Location: ____________

____

TYPE OF INCIDENT (Check all applicable items)

☐ Illness

☐ Injury

☐ Property Damage

☐ Health & Safety Infraction

☐ Other (describe) ____________

☐ Fire, explosion, flash

☐ Unexpected exposure

☐ Vehicular Accident

DESCRIPTION OF INCIDENT (Describe what happened and possible cause. Identify individual involved, witnesses, and their affiliations; and describe emergency or corrective action taken. Attach additional sheets, drawings, or photographs as needed.)

Reporter: ____________ ____________ ____________

Print Name Signature Date

Reporter must deliver this report to the Operating Unit Health & Safety Officer within 24 hours of the reported incident for medical treatment cases and within five days for other incidents.

Reviewed by: ____________ ____________

Operating Unit Health & Safety Officer Date

Distribution by HSO:

- WCGI Corporate Health and Safety Manager
- Corporate Health and Safety Officer
- Project Manager
- Personnel Office (medical treatment cases only)

OPERATING PROCEDURES NO. HS-201

201.0 HEAT STRESS

201.1 PURPOSE

The purpose of this Operating Procedure is to provide general information on heat stress and the methods that can be utilized to prevent or minimize the occurrence of heat stress.

Adverse climatic conditions are important considerations in planning and conducting site operations. Ambient temperature effects can include physical discomfort, reduced efficiency, personal injury, and increased accident probability. Heat stress is of particular concern while wearing impermeable protective garments, since these garments inhibit evaporative body cooling.

201.2 TYPES OF HEAT STRESS

Heat stress is the combination of environmental and physical work factors that constitute the total heat load imposed on the body. The environmental factors of heat stress are the air temperature, radiant heat exchange, air movement, and water vapor pressure. Physical work contributes to the total heat stress of the job by producing metabolic heat in the body in proportion to the intensity of the work. The amount and type of clothing also affects heat stress.

Heat strain is the series of physiological responses to heat stress. When the strain is excessive for the exposed individual, a feeling of discomfort or distress may result, and, finally, a heat disorder may ensue. The severity of strain will depend not only on the magnitude of the prevailing stress, but also on the age, physical fitness, degree of acclimatization, and dehydration of the worker.

Heat disorder is a general term used to describe one or more of the heat-related disabilities or illnesses shown in Table 201-1.

201.3 METHODS OF CONTROLLING HEAT STRESS

As many of the following control measures, as appropriate, should be utilized to aid in controlling heat stress:

- Provide for adequate liquids to replace lost body fluids. Encourage personnel to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.

- Replace body fluids primarily with water, with commercial mixes such as Gatorade or Quick Kick used only as a portion of the replacement fluids. Avoid excessive use of caffeine drinks such as coffee, colas or tea.

- Establish a work regimen that will provide adequate rest periods for cooling down. The heat exposure Threshold Limit Values (TLV) may be used for guidelines.

- Provide shaded work areas, if possible.

- Wear cooling devices such as vortex tubes or cooling vests.

- Consider adjusting work hours to avoid the worst heat of the day.

- Take breaks in a cool rest area.

- Remove any impermeable protective garments during rest periods.

- Do not assign other tasks to personnel during rest periods.

- Inform personnel of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress.

201.6 MONITORING

201.6.1 Temperature

The environmental heat stress of an area can be monitored by the Wet Bulb Globe Temperature Index (WBGT) technique. When heat stress is a possibility, a heat stress monitoring device, such as the Wibget Heat Stress Monitor (Reuter Stokes) can be utilized.

The WBGT shall be compared to the TLV outlined by the American Conference of Governmental Industrial Hygienists (ACGIH) TLV guides, and a work-rest regiment can be established in accordance with the WBGT. Note that approximately 5°C must be subtracted from the TLVs listed for heat stress to compensate for the wearing of impermeable protective clothing.

201.6.2 Medical

In addition to the provisions of the Woodward-Clyde (W-C) medical surveillance program, on-site medical monitoring of personnel should be performed for projects where heat stress is a significant concern. Blood pressure, pulse, body temperature (oral), and body weight loss may be utilized.

Heart Rate: Count the radial pulse during a 30-second period as early as possible in the rest period. If the heart rate exceeds 110 beats per minute at the beginning of the rest period, shorten the next work cycle by one-third. If the heart rate still exceeds 110 beats per minute at the next rest cycle, shorten the following work cycle by one-third.

Oral Temperature: Use a clinical thermometer or similar device to measure the oral temperature at the end of the work period (before drinking liquids). If the oral temperature exceeds 99.6°F (37.6°C), shorten the next work cycle by one-third without changing the rest period. If the oral temperature still exceeds 99.6°F (37.6°C) at the beginning of the next rest period, shorten the following work cycle by one-third.

Do not permit a worker to wear a semipermeable or impermeable garment if his/her oral temperature exceeds 100.6°F (38.1°C).

Body Water Loss: Measure body weight on a scale accurate to ±0.25 pounds at the beginning and end of each work day (also at lunch break, if possible) to see if enough fluids are being taken to prevent dehydration. Weights should be taken while the employee wears similar clothing or, ideally, nude. The body water loss should not exceed 1.5 percent total body weight loss in a work day.

Physiological Monitoring: Initially, the frequency of physiological monitoring depends on the air temperature adjusted for solar radiation and the level of physical work. The length of the work cycle will be governed by the frequency of the required physiological monitoring.

201.7 REFERENCES

American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents, 1992-1993.

EPA, Standard Operating Safety Guides, 1992, Pages 91-93.

National Institute for occupational Safety and Health, Criteria for a Recommended Standard: Occupational Exposure to Hot Environments, 1986.

TABLE 201-1
Classification, Medical Aspects, and Prevention of Heat Illness

Category and Clinical Features	Predisposing Factors	Underlying Physiological Disturbances	Treatment	Prevention
Temperature Regulation Heatstroke				
Heatstroke: (1) Hot, dry skin; usually red, mottled, or cyanotic; (2) rectal temperature 40.5°C (104°F) and over; (3) confusion, loss of consciousness, convulsions, rectal temperature continues to rise; fatal if treatment is delayed	(1) Sustained exertion in heat by unacclimatized workers; (2) lack of physical fitness and obesity; (3) recent alcohol intake; (4) dehydration; (5) individual susceptibility; and (6) chronic cardiovascular disease	Failure of the central drive for sweating (cause unknown) leading to loss of evaporative cooling and an uncontrolled accelerating rise in t_{re}; there may be partial rather then complete failure of sweating	Immediate and rapid cooling by immersion in chilled water with massage or by wrapping in wet sheet with vigorous fanning with cool dry air; avoid overcooling; treat shock if present	Medical screening of workers, selection based on health and physical fitness; acclimatization for 5-7 days by graded work and heat exposure; monitoring workers during sustained work in severe heat
Circulatory Hypostasis Heat Syncope				
Fainting while standing erect and immobile in heat	Lack of acclimatization	Pooling of blood in dilated vessels of skin and lower parts of body	Remove to cooler area; rest in recumbent position; recovery prompt and complete	Acclimatization; intermittent activity to assist venous return to heat
Water and or Salt Depletion				
(a) Heat Exhaustion (1) Fatigue, nausea, headache, giddiness; (2) skin clammy and moist; complexion pale, muddy, or hectic flush; (3) may faint on standing with rapid thready pulse and low blood pressure; (4) oral temperature normal or low, but rectal temperature usually elevated (37.5-38.5°C or 99.5-101.3°F); water restriction type: urine volume small, highly concentrated; salt restriction type; urine less concentrated chlorides less than 3 g/L	(1) Sustained exertion in heat; (2) lack of acclimatization; and (3) failure to replace water lost in sweat	(1) Dehydration from deficiency of water; (2) depletion of circulating blood volume; (3) circulatory strain from competing demands for blood flow to skin and to active muscles	Remove to cooler environment; rest in recumbent position; administer fluids by mouth; keep at rest until urine volume indicates that water balances have been restored	Acclimatize workers using a breaking-in schedule for 5-7 days; supplement dietary salt only during acclimatization; ample drinking water to be available at all times and to be taken frequently during work day
(b) Heat Cramps Painful spasms of muscles used during work (arms, legs, or abdominal); onset during or after work hours	(1) Heavy sweating during hot work; (2) drinking large volumes of water without replacing salt loss	Loss of body salt in sweat, water intake dilutes electrolytes; water enters muscles, causing spasm	Salted liquids by mouth or more prompt relief by IV infusion	Adequate salt intake with meals; for unacclimatized workers, supplement salt intake at meals.

TABLE 201-1 (continued)
Classification, Medical Aspects, and Prevention of Heat Illness

Category and Clinical Features	Predisposing Factors	Underlying Physiological Disturbances	Treatment	Prevention
Skin Eruptions				
(a) Heat Rash (miliaria rubra, or "prickly heat") Profuse tiny raised red vesicles (blisterlike) on affected areas; prickling sensations during heat exposure	Unrelieved exposure to humid heat with skin continuously wet from unevaporated sweat	Plugging of sweat gland ducts with sweat retention and inflammatory reaction	Mild drying lotions; skin cleanliness to prevent infection	Cool sleeping quarters to allow skin to dry between heat exposures
(b) Anhidrotic Heat Exhaustion (miliaria profunda) Extensive areas of skin which do not sweat on heat exposure, but present gooseflesh appearance, which subsides with cool environments; associated with incapacitation in heat	Weeks or months of constant exposure to climatic heat with previous history of extensive heat rash and sunburn	Skin trauma (heat rash; sunburn) causes sweat retention deep in skin; reduced evaporative cooling causes heat intolerance	No effective treatment available for anhidrotic areas of skin; recovery of sweating occurs gradually on return to cooler climate	Treat heat rash and avoid further skin trauma by sunburn; provide periodic relief from sustained heat
Behavioral Disorders				
(a) Heat Fatigue - Transient Impaired performance of skilled sensorimotor, mental, or vigilance tasks, in heat	Performance decrement greater in unacclimatized and unskilled worker	Discomfort and physiologic strain	Not indicated unless accompanied by other heat illness	Acclimatization and training for work in the heat
(b) Heat Fatigue - Chronic Reduced performance capacity; lowering of self-imposed standards of social behavior (e.g., alcoholic over-indulgence); Inability to concentrate, etc.	Workers at risk come from temperature climates for long residence in tropical latitudes	Psychosocial stresses probably as important as heat stress; may involve hormonal imbalance but no positive evidence	Medical treatment for serious causes; speedy relief of symptoms on returning home	Orientation on life in hot regions (customs, climate, living conditions, etc.)

OPERATING PROCEDURE NO. HS-202

202.0 COLD STRESS

202.1 PURPOSE

The purpose of this Operating Procedure is to provide information on cold stress and the procedures for preventing and dealing with cold stress. Adverse climatic conditions are important considerations in planning and conducting site operations. Ambient temperature effects can include physical discomfort, reduced efficiency, personal injury, and increased accident probability.

202.2 TYPES OF COLD STRESS EFFECTS

202.2.1 Frostbite

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite can be categorized into:

- **Frost Nip or Initial Frostbite:** (1st degree frostbite) Characterized by blanching or whitening of skin.

- **Superficial Frostbite:** (2nd degree frostbite) Skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient. Blistering and peeling of the frozen skin will follow exposure.

- **Deep Frostbite:** (3rd degree frostbite) Tissues are cold, pale, and solid; extremely serious injury with possible amputation of affected area.

Frostbite can occur without hypothermia when the extremities do not receive sufficient heat. The toes, fingers, cheeks, and ears are the most commonly affected. Frostbite occurs when there is freezing of the fluids around the cells of the affected tissues. The first symptom of frostbite is an uncomfortable sensation of coldness, followed by numbness. There may be tingling, stinging, or cramping. Contact by the skin with tools or other metal objects below 20°F (-7°C) may result in contact frostbite.

The prevention of frostbite includes early recognition of problems, adequate protective clothing, recognizing the combination of wind and low temperature (see Table 202-1 Windchill Index), adequate fluids, work-rest regimens with heated rest areas, and use of controls such as wind-breaks and heaters.

The initial treatment for frostbite includes bringing the individual to a warm location, removal of clothing in the affected area, and placing the affected parts in warm (100-105°F) water. Do not massage or rub the frostbite area. After the initial treatment, wrap the affected area loosely in sterile gauze and seek medical attention.

202.2.2 Hypothermia

Hypothermia results when the body loses heat faster than it can be produced. When this situation first occurs, blood vessels in the skin constrict in an attempt to conserve vital internal heat. Hands and feet are first affected. If the body continues to lose heat, involuntary shivers begin. This is the body's way of attempting to produce more heat, and it is usually the first real warning sign of hypothermia. Further heat loss produces speech difficulty, confusion, loss of manual dexterity, collapse, and finally death. Wet clothes or immersion in cold water greatly increases the hypothermia risk. The progressive clinical presentation of hypothermia may be seen in Table 202-2.

Prevention of hypothermia includes planning for outside work in winter conditions, particularly work over water. Planning will include adequate layers of clothing, training employees in recognizing hypothermia in themselves and others, recognition of the combination of wind and temperature (see Windchill Index in Table 202-1), use of controls such as wind-breaks and heaters, a work-rest schedule, and adequate fluid intake.

Fatal exposure to cold among workers has usually resulted from immersion in low temperature water. Water transmits body heat over 200 times faster than air. Wetsuits or drysuits are recommended for work over water with water temperatures below 45°F. Individuals who fall into cold water without wetsuits or drysuits may not be able to swim due to the rapid onset of hypothermia.

Prompt treatment of hypothermia is essential. Once the body temperature drops below 95°F, the loss of temperature control occurs, and the body can no longer rewarm itself. Initial treatment includes reducing heat loss by moving the individual out of the wind and cold, removal of wet clothing, applying external heat (such as a pre-warmed sleeping bag, electric blanket, or body-heat from other workers) and follow-up medical attention.

202.4 EXPOSURE LIMITS

The American Conference of Governmental Industrial Hygienists (ACGIH) has adopted Threshold Limit Values (TLVs) for cold stress. These limits set maximum work periods based on a combination of wind and temperature.

202.5 REFERENCES

American Conference of Governmental Industrial Hygienists, Documentation of Threshold Limit Values, 1984

EPA, Standard Operating Safety Guides, 1992, pages 95-100.

TABLE 202-1

Windchill Index[1]

	ACTUAL THERMOMETER READING (°F)									
	50	40	30	20	10	0	-10	-20	-30	-40
Wind speed in mph	EQUIVALENT TEMPERATURE (F)									
calm	50	40	30	20	10	0	-10	-20	-30	-40
5	48	37	27	16	6	-5	-15	-26	-36	-47
10	40	28	16	4	-9	-21	-33	-46	-58	-70
15	36	22	9	-5	-18	-36	-45	-58	-72	-85
20	32	18	4	-10	-25	-39	-53	-67	-82	-96
25	30	16	0	-15	-29	-44	-59	-74	-88	-104
30	28	13	-2	-18	-33	-48	-63	-79	-94	-109
35	27	11	-4	-20	-35	-49	-67	-82	-98	-113
40	26	10	-6	-21	-37	-53	-69	-85	-100	-116
Over 40 mph	Little Danger				Increasing Danger			Great Danger		
(little added effect)	(for properly clothed person)				(Danger from freezing of exposed flesh)					

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[1] Source: Fundamentals of Industrial Hygiene, Third Edition. Plog, B.A., Benjamin, G.S., Kerwin, M.A., National Safety Council, 1988.

TABLE 202-2

Progressive Clinical Presentations of Hypothermia*

Core Temperature		
°C	°F	Clinical Signs
37.6	99.6	"Normal" rectal temperature
37	98.6	"Normal" oral temperature
36	96.8	Metabolic rate increases in an attempt to compensate for heat loss
35	95.0	Maximum shivering
34	93.2	Victim conscious and responsive, with normal blood pressure
33	91.4	Severe hypothermia below this temperature
32	89.6	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light; shivering ceases
31	87.8	
30	86.0	Progressive loss of consciousness; muscular rigidity increases; pulse and blood pressure difficult to obtain; respiratory rate decreases
29	84.2	
27	82.4	Ventricular fibrillation possible with myocardial irritability
27	80.6	Voluntary motion ceases; pupils nonreactive to light; deep tendon and superficial reflexes absent
26	78.8	Ventricular fibrillation may occur spontaneously
25	77.0	
24	75.2	Pulmonary edema
22	71.6	Maximum risk of ventricular fibrillation
21	69.8	
20	68.0	Cardiac standstill
18	64.4	Lowest accidental hypothermia victim to recover
17	62.6	Isolectric electroencephalogram
9	48.2	Lowest artificially cooled hypothermia patient to recover

* Presentations approximately related to core temperature. Reprinted from the January 1982 issue of American Family Physician, published by the American Academy of Family Physicians.