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SOIL WASHING TREATABILITY STUDY WORK PLAN FOR OPERABLE UNIT 5 NOVEMBER 1991

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SOIL WASHING TREATABILITY STUDY WORK PLAN FOR OPERABLE UNIT 5

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION and FEASIBILITY STUDY

November 1991

U.S. DEPARTMENT OF ENERGY
FERNALD OFFICE

PUBLIC ENVIRONMENTAL INFORMATION CENTER
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LIST OF ACRONYMS

AA	atomic absorption
ACGIH	American Conference of Governmental Industrial Hygienists
ARAR	applicable or relevant and appropriate requirement
ASI	Advanced Sciences, Inc.
ASTM	American Society for Testing and Materials
CEC	cation exchange capacity
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CHP	Chemical Hygiene Plan
CLP	Contract Laboratory Program
CSF	cancer slope factor
DOE	U.S. Department of Energy
DQO	data quality objective
EDTA	ethylenediaminetetraacetic acid
EPA	U.S. Environmental Protection Agency
ETDC	Environmental Technology Development Center
FEMP	Fernald Environmental Management Project
FFCA	Federal Facilities Compliance Agreement
FMPC	Feed Materials Production Center
FS	feasibility study
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
HEAST	Health Effects Assessment Summary Tables
HSL	Hazardous Substance List
HSP	Health and Safety Plan
IC	ion chromatography
ICP	inductively coupled plasma
ID	Integrated Demonstration
IT	International Technology Corp.
MCL	maximum contaminant level
MSDS	material safety data sheets
MTCLP	modified toxicity characteristics leaching procedure
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission

LIST OF ACRONYMS
(Continued)

OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PRG	preliminary remediation goal
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QCC	Quality Control Coordinator
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RG	remediation goal
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RPD	relative percent difference
SAP	Sampling and Analysis Plan
STEL	short-term exposure limit
TCLP	toxicity characteristics leaching procedure
TCL	target compound list
TLD	thermoluminescent dosimeters
TLV	threshold limit values
TOC	total organic carbon
TWA	time-weighted average
VOC	volatile organic compounds
WEMCO	Westinghouse Environmental Management Company of Ohio
XRF	x-ray diffraction

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1.0 PROJECT DESCRIPTION

1.1 INTRODUCTION

The Feed Materials Production Center (FMPC), renamed on August 23, 1991 and hereinafter called the Fernald Environmental Management Project (FEMP), is a contractor-operated federal facility for the production of purified uranium metal located on 1050 acres in a rural area approximately 18 miles northwest of downtown Cincinnati, Ohio. Owned by the U.S. Department of Energy (DOE), production operations at the FEMP were suspended in July 1989 and the facility was formally closed in June 1991. On July 18, 1986, a Federal Facilities Compliance Agreement (FFCA) was jointly signed by the U.S. Environmental Protection Agency (EPA) and DOE to ensure that human health and environmental impacts associated with past activities at the FEMP are thoroughly investigated so that appropriate remedial actions can be assessed and implemented. In response to the FFCA, a remedial investigation/feasibility study (RI/FS) has been initiated to develop these remedial actions.

The 1986 FFCA was amended by a Consent Agreement under Section 120 and 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Consent Agreement was signed on April 9, 1990 and became effective on June 29, 1990. In 1991, a renegotiation of the Consent Agreement was initiated to establish a revised schedule for cleanup of the FEMP. This Amended Consent Agreement was signed in September 1991.

The technical strategy adopted under the RI/FS was to divide the site into five operable units to facilitate remedial actions (Figure 1-1). As a result of the renegotiations of the 1990 Consent Agreement, the scope of Operable Unit 5, which is the focus of this work plan, has been modified. The broad definition of Operable Unit 5 remains unchanged and still includes those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FEMP contaminants. However, soil and perched groundwater previously identified as components of Operable Unit 3 are now included within the scope of Operable Unit 5. The soils within Operable Unit 5 have been identified as an area of concern requiring remediation and are the focus of this treatability study. Radionuclides, other inorganics, and organics are present in these soils. A summary of the extent of this soil contamination is presented in Section 1.2.2.

1.1.1 Soil Washing Process Option

Several viable treatment technology process options have been identified for the remediation of soils during the initial screening of technologies. These include soil washing, vitrification, vapor extraction, plasma arc incineration, hydrocyclonic separation, and cement stabilization. A literature review has been completed for the soil washing process. This review revealed that water washing with extractive agents is applicable for cleaning nonvolatile hydrophilic and hydrophobic organics and heavy metals

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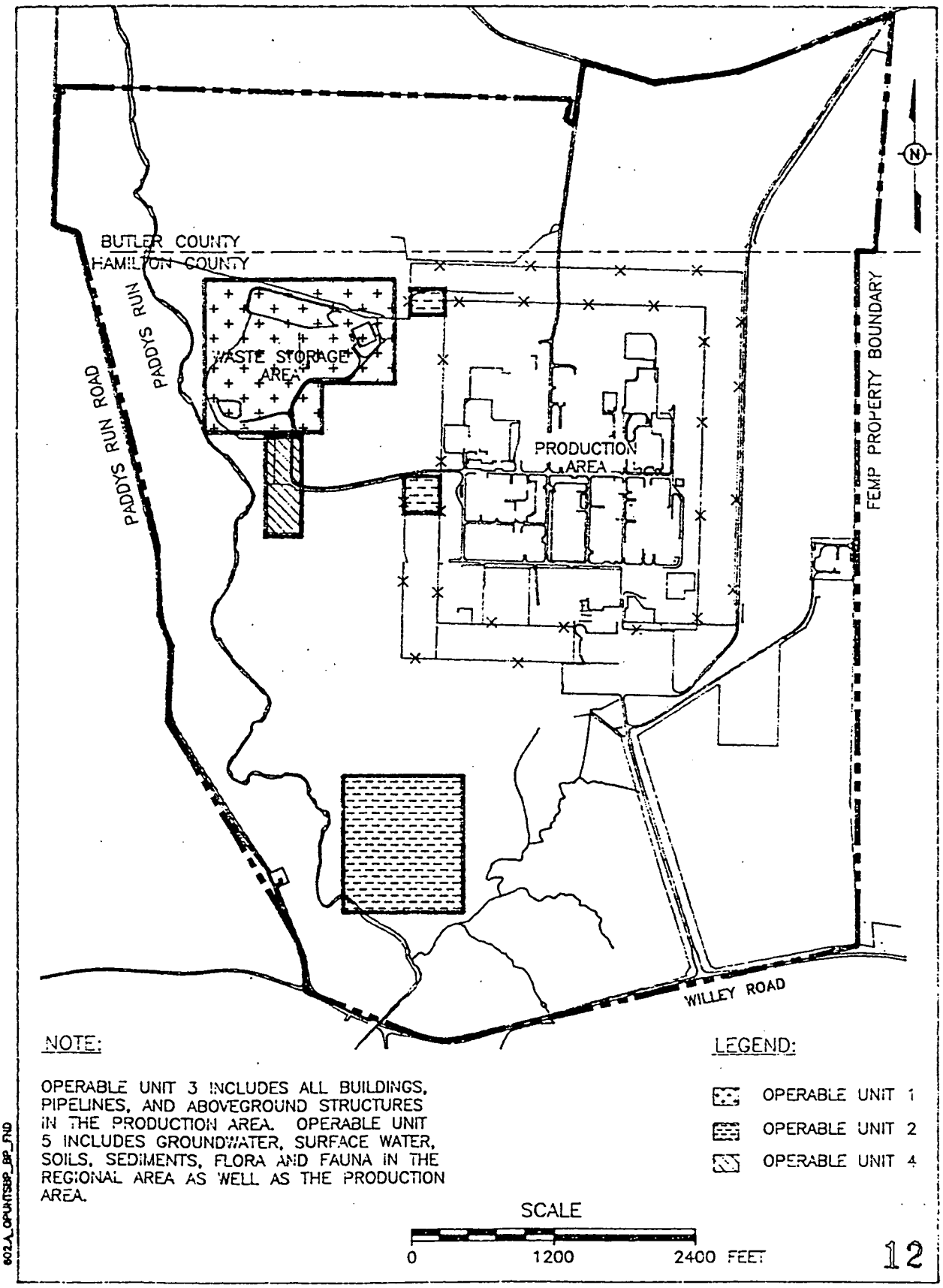

FIGURE 1-1. SOURCE OPERABLE UNITS

from soils (EPA 1989a) and has been successfully used on soil contaminated with radionuclides. Information was not found on its application to soils containing the radionuclides, inorganics and organics that characterize the Operable Unit 5 soils. Therefore, due to the lack of information available to adequately address the overall effectiveness of this process, as well as the other EPA remedy evaluation criteria necessary during the detailed analysis of alternatives, a decision was made to proceed with treatability testing of the soil washing process.

Literature reviews are currently underway for the other technologies identified as potentially applicable for Operable Unit 5. If this review provides sufficient data for evaluation of these processes within the detailed analysis, no other treatability studies will be conducted. Currently, no other treatability work plans are being prepared.

1.1.2 Organization of the Work Plan

This treatability study work plan is being prepared in accordance with EPA's "Guide for Conducting Treatability Studies Under CERCLA" (EPA 1989b) and the Fernald RI/FS Quality Assurance Project Plan (QAPP) (DOE 1988). In addition to the 14 sections suggested by the Treatability Guidance document, this work plan includes five appendices. Appendix A provides additional information on the nature and extent of contamination in Operable Unit 5 soils. Appendix B contains standard operating procedures for laboratory procedures. Appendix C is the health and safety plan (HASP) for field sampling and Appendix D is the HASP for the remedial screening and remedy selection phases of the treatability study. Appendix E contains the Integrated Demonstration's (ID) soil sampling project information. The ID project is a parallel program, being conducted outside the FEMP RI/FS, for evaluating alternative technologies for treatment of FEMP soils.

The work plan outlines the objectives and procedures for conducting treatability testing for soil washing. The data resulting from these studies will be used to support the FS by establishing or identifying the following:

- Confirmation of technology applicability to Operable Unit 5 soils
- Compliance of technology with applicable or relevant and appropriate requirements (ARARs)
- Fate and transport modeling input parameters
- Data for residual risk calculations that support the effectiveness criteria evaluation for the detailed analysis of alternatives
- Refinement of process requirements for cost estimation purposes

- Initial database for use in potential subsequent studies in support of remedial design

1.2 SITE DESCRIPTION

1.2.1 Site History

A variety of chemical and metallurgical processes were utilized at the FEMP for the manufacture of uranium products. These manufacturing processes occurred largely within the Production Area, which covers approximately 136 acres near the center of the FEMP and consists of several processing plants and waste storage areas. The Pilot Plant was completed in 1951 and was the first operational facility at the FEMP. The Pilot Plant was utilized to house many different processes including thorium metal production, uranium metal production, and uranium hexafluoride reduction. Following the completion of the Pilot Plant the metals fabrication plant, Plant 6, began operations in 1952. The metal production plant, Plant 5; the green salt plant, Plant 4; the recovery plant, Plant 8; the sampling plant, Plant 1; and the refinery (Plant 2/3) began operating in 1953. A uranium hexafluoride reduction plant, Plant 7, and the special products plant, Plant 9, were operational in 1954.

Production peaked in 1960 at approximately 10,000 metric tons of uranium (mtu) per year. A production decline began in 1964, to a low of about 1230 mtu in 1975. During the 1970s, consideration was given to closing the FEMP; therefore, capital improvements and staffing were minimized. In 1981 the FEMP began to accommodate increased production requirements. Production levels significantly increased and there was a rapid staff buildup for several years; implementation of a major facilities restoration program followed. Then production ceased in the summer of 1989 to focus plant resources on the environmental restoration program. The FEMP was officially closed in June 1991.

1.2.2 Nature and Extent of Soil Contamination

Surface soil has become contaminated from a variety of sources. Overall, the site has received a dusting of airborne uranium from the stacks in the Production Area. Additional airborne material has been released in the Waste Storage Area by dust blown from the disposal pits and tracking of contamination by vehicles. The incinerator in the Sewage Treatment Plant area was also a source of airborne contamination. Additionally, leaks and spills from processing activities within the Production Area have resulted in soil contamination.

In general, concentrations of total uranium in soil samples from outside the Production Area and the Waste Storage Area are below 35 pCi/g. The exceptions to this are in suspect areas, such as the Fire Training Area, the Sewage Treatment Plant area, and the rubble mound west of the K-65 silos. Each of these areas has surface contamination in excess of 35 pCi/g of total uranium.

As shown in Figure 1-2, large portions of the Production Area have total uranium concentrations in soil from 0.0 to 1.5 feet at greater than 50 µg/g, which is roughly equivalent to 35 pCi/g. Figure 1-3, which shows the total uranium concentrations for samples collected in the 1.5 to 3.0-foot interval, illustrates that in large part the uranium contamination is a surface contamination problem. A comparison of the 50 µg/g contours in Figures 1-2 and 1-3 indicates that below 1.5 feet total uranium values greater than 50 µg/g are restricted to the northern end of Plant 6, scattered points around the garage and heavy equipment building, the Plant 2/3 area, the southwest corner of the Pilot Plant, the northwest corner of the Maintenance Building, and the southeast corner of Plant 9.

Within the Production Area leaks and spills from process equipment have resulted in deeper migration of contamination at higher concentrations than is due to airborne deposition. Although uranium is the indicator parameter for contamination at the FEMP, many samples have been analyzed for other radionuclides. To better focus the investigation of this complex production network into a manageable technical framework, the Production Area was separated into four distinct quadrants. Table 1-1 summarizes, by quadrant, the maximum concentrations for radionuclides in soil samples from the Production Area. The maximum total uranium value was found just below the concrete floor of the Plant 6 waste water treatment area. More detailed information as to the extent and level of contamination, including summaries of other inorganics and organics, is given in Appendix A.

1.2.3 Summary

Uranium is the indicator parameter for contamination at the FEMP. Elevated levels of other radionuclides or chemicals may also be present where elevated levels of uranium occur. There have not been any samples that have shown high levels of other contaminants without uranium being present. The level of contamination in surface soil is generally less than the level of contamination of soil under or near certain process buildings. The highest levels of uranium have been detected near Plant 6 and Plant 2/3. Acids were used to digest or pickle material in these locations.

Organic contamination occurs near plants where chemicals were used for process development or in conjunction with machining and maintenance operations. The exceptions to this are the graphite furnace and oil burner and the coal pile.

1.3 Operable Unit 5 Soil Washing Treatability Study

1.3.1 EPA Treatability Guidance

The EPA's "Guide for Conducting Treatability Studies Under CERCLA" (1989b) outlines a three-tiered approach to conducting treatability studies for a Superfund site. The original interpretation of

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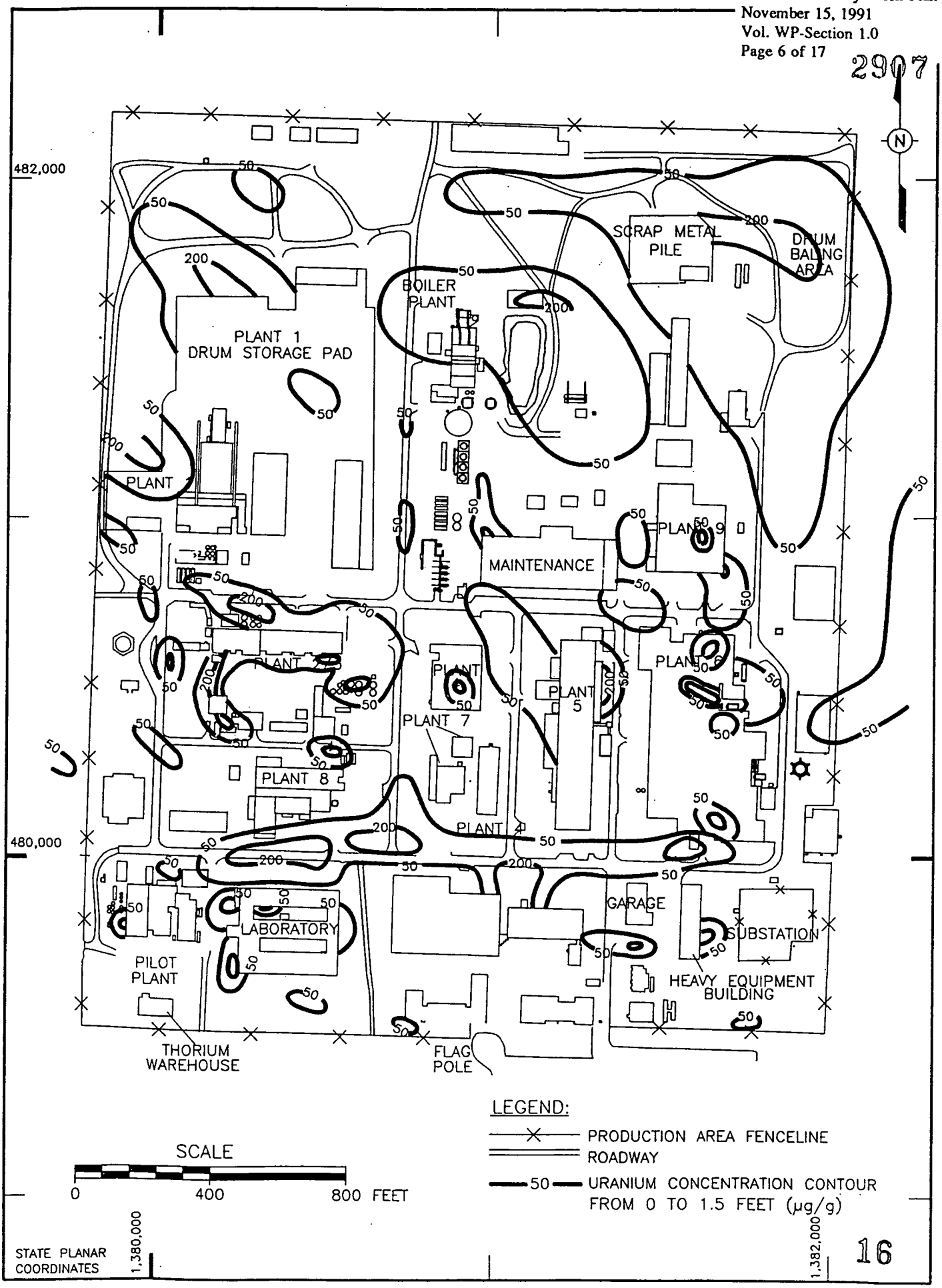

FIGURE 1–2. URANIUM CONCENTRATION CONTOURS IN SOIL – 0.0 TO 1.5 FEET

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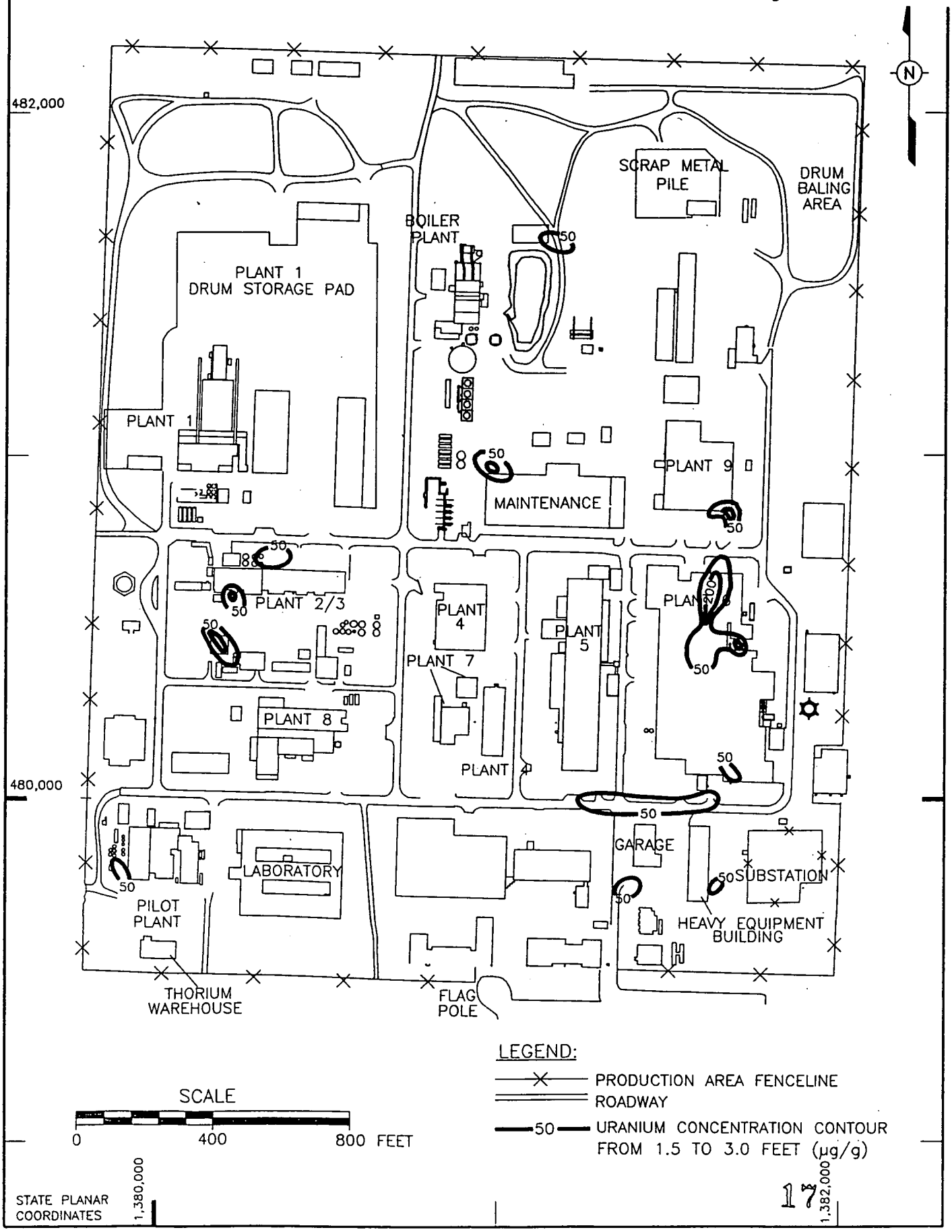


FIGURE 1–3. URANIUM CONCENTRATION CONTOURS IN SOIL – 1.5 TO 3.0 FEET

TABLE 1-1
MAXIMUM CONCENTRATIONS OF RADIONUCLIDES IN SOIL
FROM THE FEMP PRODUCTION AREA
Results are in pCi/g

Element	Northwest Quadrant	Northeast Quadrant	Southwest Quadrant	Southeast Quadrant	Fire Training Area	Incinerator/ Sewage Treatment Plant
Total uranium[a]	457	467	7450	90,350	67.9	4210
Total thorium	NA[b]	NA	NA	NA	NA	NA
Uranium-234	3857	7075	13,262	970[c]	361	10,977
Uranium-235/236	204	69.9	950	41.6[c]	0.7	1730
Uranium-238	4108	7.2	7944	986[c]	10.0	25,670
Thorium-228	31.2	39.2	315	7.5[c]	0.9	24.8
Thorium-230	2729	7901	288	40.3[c]	1.6	806
Thorium-232	31.4	194	283	9.1[c]	0.8	61.9
Radium-226	2720	2950	27.2	2.98[c]	1.2	57.4
Radium-228	65.2	558	546	5.4[c]	1.2	18.0
Cesium-137	--	1.0	2.9	14.4[c]	0.7	1.1
Technetium-99	1.4	8.1	3.0	2.0[c]	--	228
Strontium-90	3.1	2.7	26.3	3.6[c]	5.0	1.9
Neptunium-237	--	--	2.6	--	--	--
Plutonium-238	--	--	6.1	--	--	--
Plutonium-239/240	--	1.5	0.9	--	--	--

[a]Results in µg/g.
[b]NA - Not analyzed.
[c]Soil removed during construction program.

the approach can be seen in Figure 1-4. Since publication, the terminology of this approach has been revised as follows (dePercin et al. 1991), as shown in Figure 1-5:

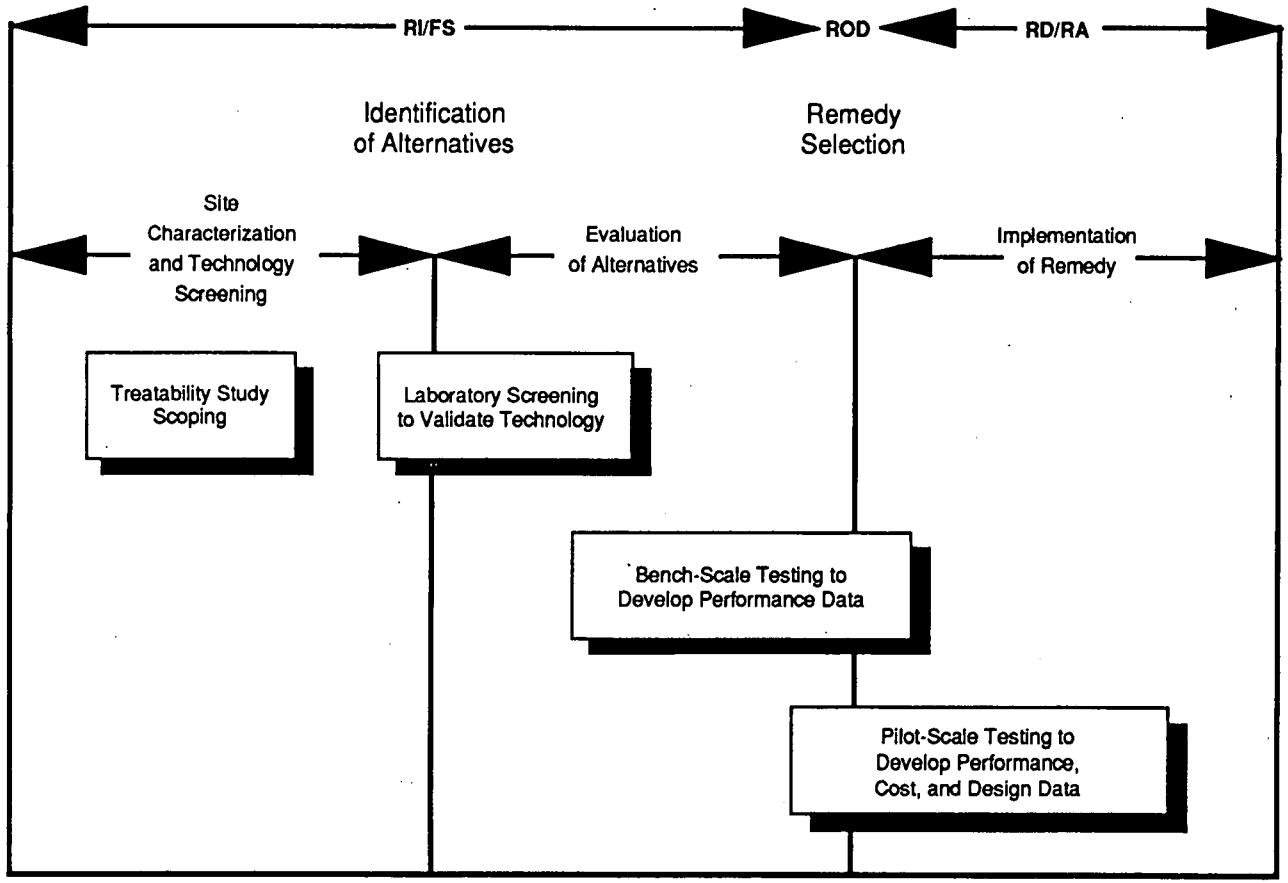
- Remedy screening
- Remedy selection
- Remedy design

The three tiers of treatability testing are divided into pre-record of decision (ROD) and post-ROD studies. The remedy screening and remedy selection testing are generally pre-ROD studies, and the remedy design studies are generally post-ROD. However, the appropriateness and levels of treatability testing required are flexible, and remedy design studies, on a site-specific basis, may be conducted prior to issuance of the ROD.

The remedy screening and remedy selection treatability studies provide the performance and cost data needed to (1) evaluate all potentially applicable treatment alternatives and (2) select an alternative for remedial action based on the nine RI/FS evaluation criteria. The detailed analysis of alternatives phase of the RI/FS follows the development and screening of alternatives and precedes the actual selection of a remedy in the ROD. During the detailed analysis, all remedial alternatives are evaluated based on nine RI/FS evaluation criteria. These criteria are as follows:

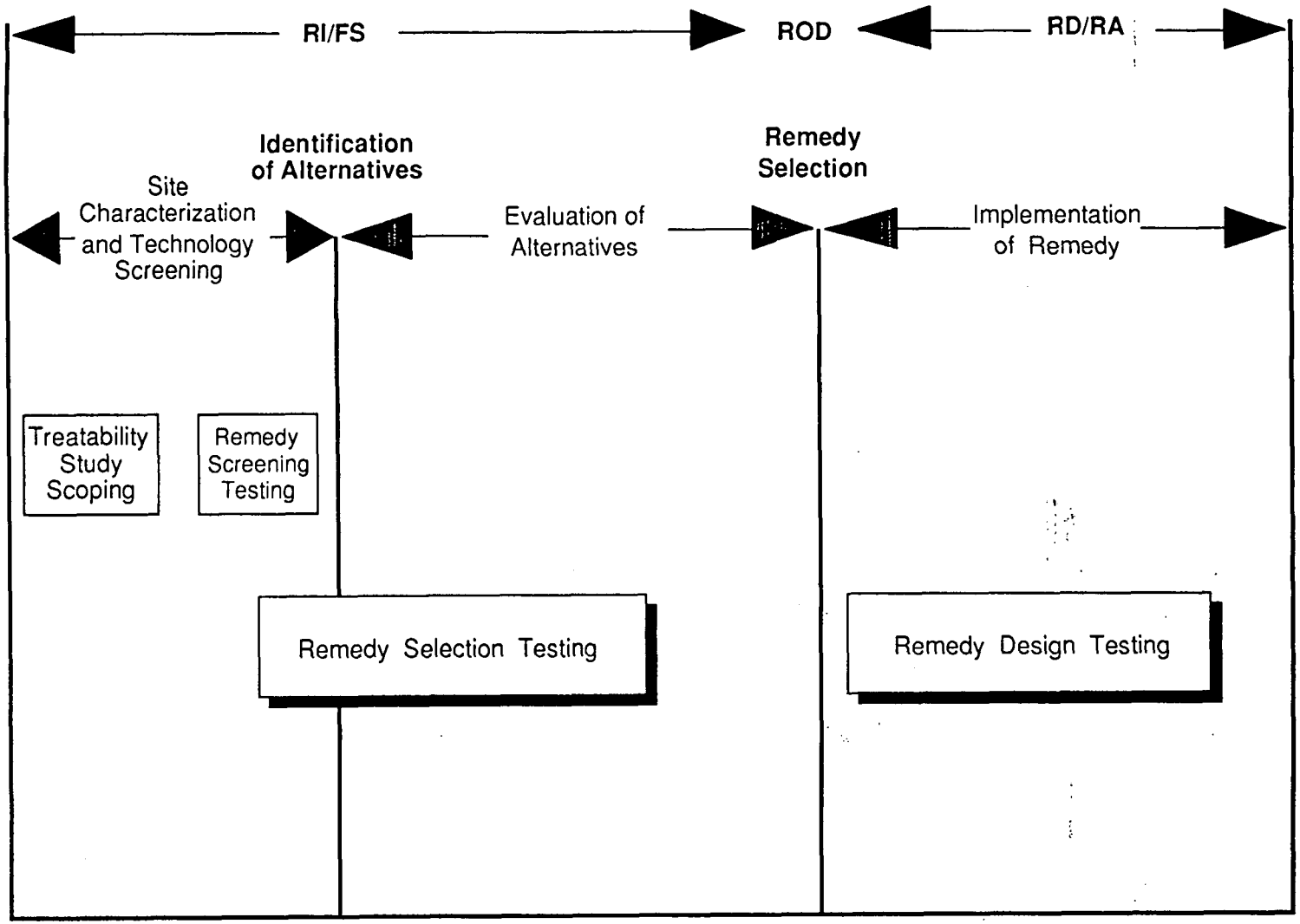
- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- State acceptance
- Community acceptance

These criteria are described in detail in "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA 1988).



Source: Guide to Conducting Treatability Studies Under CERCLA. December 1989.

FIGURE 1-4. THE ROLE OF TREATABILITY STUDIES IN THE RI/FS AND RD/RA PROCESS



Source: dePercin et al., 1991, "Designing Treatability Studies for CERCLA Sites," J. of the Air and Waste Management Assn., Vol. 41, No. 45.

FIGURE 1-5. RELATIONSHIP OF THE OPERABLE UNIT 5 TREATABILITY STUDIES TO THE RI/FS PROCESS

Remedy screening is the first step in the tiered approach. Its purpose is to determine the feasibility of a treatment alternative for the contaminants/matrix of interest. These tests are typically conducted under conditions that are favorable to the technology. These small scale studies are designed to provide a qualitative evaluation of the technology and are conducted with minimal levels of quality assurance/quality control (QA/QC). Tests conducted under this tier are generic in nature (not vendor specific). If the feasibility of the treatment cannot be demonstrated, the alternative should generally be screened out at this time.

The purpose of the remedy selection tier is to generate the performance and cost data necessary for remedy evaluation in the detailed analysis of alternatives phases of the FS. The cost data developed in this tier should support cost estimates of +50 percent to -30 percent accuracy. The performance data will be used to determine whether this technology will meet remedial action objectives. Remedy selection studies are typically small-scale, incorporating generic tests using bench- or pilot-scale equipment in either the laboratory or the field. The study costs are higher than those encountered in the remedy screening tier and the tests require longer durations to complete. The levels of QA/QC are moderate to high, because the data from these studies will be used to support the ROD.

In the remedy design tier, detailed scale-up design, performance, and cost data are generated to implement and optimize the selected remedy (Figure 1-5). Remedy design studies are usually performed as part of remedy implementation on full-scale or near full-scale equipment. These studies should focus on optimizing process parameters, which are not a part of this treatability study. The levels of QA/QC are moderate to high and are typically vendor specific.

1.3.2 Operable Unit 5 Soil Washing Treatability Approach

The proposed approach for these Operable Unit 5 studies is consistent with EPA's tiered system for conducting treatability studies, which can be seen in Figure 1-6, and consists of the following:

- Remedy Screening - Stage I, Stage II
- Remedy Selection

Two-tiered treatability approach is planned for evaluation of the soil washing process on Operable Unit 5 and will incorporate the ID treatability program as part of the total scope of work. A general description of the soil washing technology is presented in Section 2.0.

Soil washing is a physical/chemical treatment process that initially involves the separation of a soil into different particle size fractions. Reagent formulations in the washing solutions are used in the

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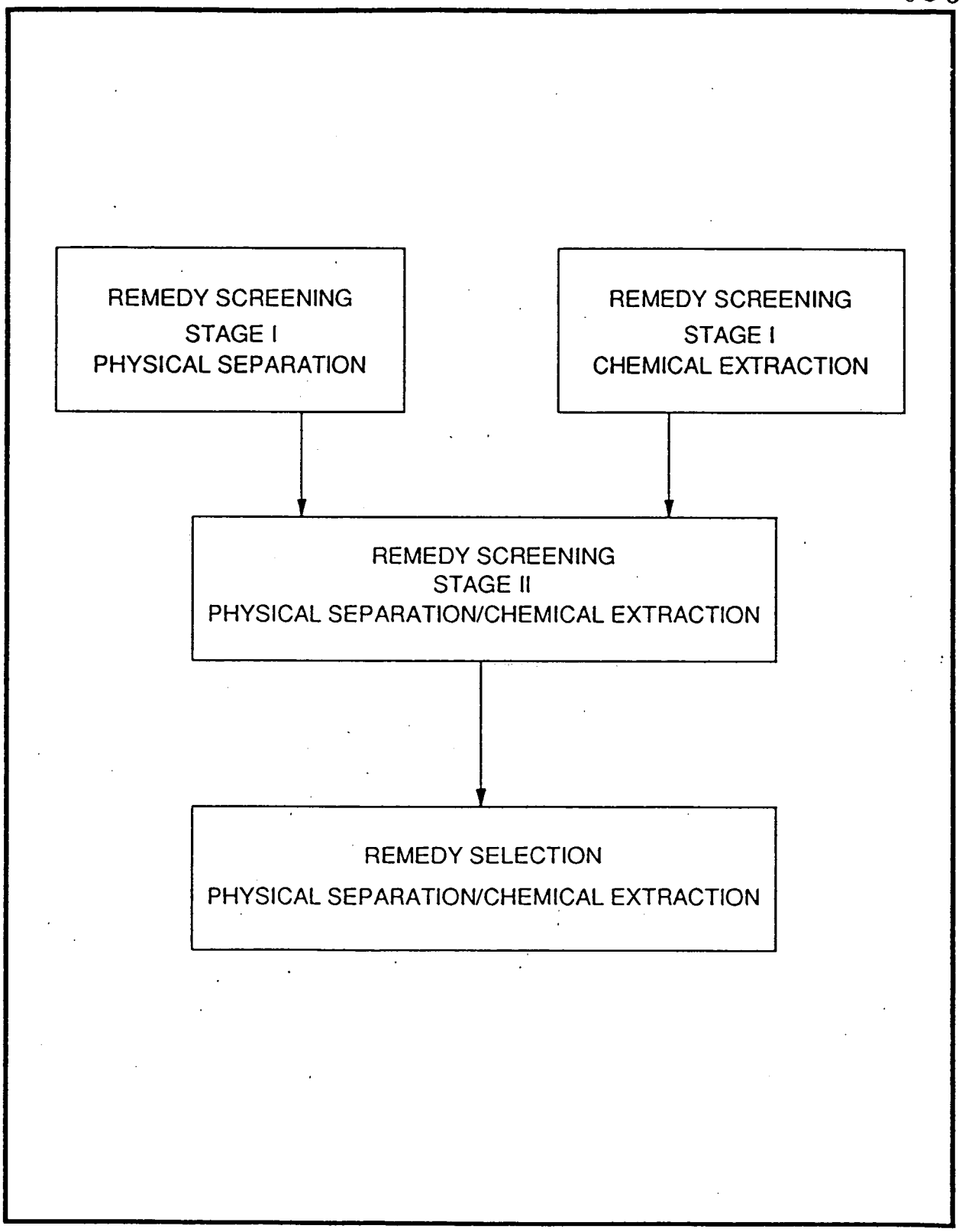


FIGURE 1-6.
SOIL WASHING EXPERIMENTAL DESIGN

extraction of radionuclides, organic and inorganic compounds from these different size fractions. The contaminants may be separated from the wash stream into a concentrated residue for further treatment (e.g., stabilization or vitrification).

A dual remedy screening phase is incorporated in Stage I and includes physical separation and chemical extraction tests. The physical separation tests will identify the soil size fractions with which each of the types of contamination (i.e., radionuclides, organics, metals) are associated. The chemical extraction tests will be performed on samples that have not been separated into specific size fractions. Extractants are screened to identify those most promising for separating the contaminants from the soil. Stage II will incorporate the use of selected individual soil size fractions and the most effective washing solutions as determined in Stage I testing. The remedy selection phase incorporates the results of the Stage II testing into a scaled version of the soil washing treatment system.

1.3.2.1 Remedy Screening

The physical separation component of Stage I remedy screening is designed to elucidate the association of contaminants with specific soil size fractions. This is accomplished by first mechanically separating soil samples received from the field into specific soil size fractions using a wet sieving technique. The water used in the dispersing and washing processes is then collected and analyzed for selected contaminants, as detailed in Section 3.0. Subsequently, each soil size fraction is extracted and also analyzed for selected contaminants.

The chemical extraction Stage I testing is conducted on a parallel track with the physical separation testing. Multiple extractants will be tested on the soil samples received from the field. The most effective extractants will be determined by evaluating the extraction temperature and weight of extractant to soil ratio.

Within Stage II of the remedy screening, the results of Stage I are combined. Those soil size fractions that are shown to retain the greatest levels of contaminants will be selected for use in a series of chemical extraction tests. Again, the extractants found to be most effective as a result of Stage I testing will be used in Stage II. If soil contamination is shown to be easily removed from the sand-size fraction by the wet sieving process conducted in Stage I, then chemical extractants will be tested only on the clay and fine silt fractions within Stage II. If, however, significant contamination is found in the sand fraction as well as the fine silt and clay fraction, the separate extraction experiments will be conducted on both fractions within Stage II.

1.3.2.2 Remedy Selection

The remedy selection component of the treatability program incorporates specific equipment (e.g., multigravity separators, centrifugal jigs, and centrifuges) in the soil washing system. Only the most

successful chemical extracting solutions are incorporated into this system. It is expected that a combination of chemical extractants will be necessary to remove the metals and organic compounds from the soil.

1.3.3 Relationship of Treatability Data to FS Evaluation Criteria

The following information will be obtained or can be calculated as a result of the treatability study testing:

- Volume of soils requiring disposal relative to the initial volume of untreated waste
- Amount of contaminant removed from soils, extractants, and washwater
- Cost of implementing the technology

This information will be used to evaluate the soil washing technology and compare it to other soil technologies during the detailed analysis of alternatives phase of the RI/FS.

The alternatives are evaluated in regard to each of the nine RI/FS evaluation criteria as previously discussed in Section 1.3.1. The relationship between the data generated during the remedy screening and remedy selection soil washing treatability studies and these evaluation criteria is presented in Table 1-2.

The ability of soil washing to provide protection of human health and the environment will be determined by considering such factors as the results of toxicity characteristics leaching procedure (TCLP) of the leachate, which establishes cross-media impacts, and the percent removal of soil contamination, which establishes the potential risk reduction. In addition, the overall assessment of human health and environmental protection will incorporate the assessment of long-term effectiveness, short-term effectiveness, and compliance with ARARs. Compliance with chemical-specific ARARs will be determined by whether the leachate meets or exceeds established or proposed discharge standards, and whether the treated soil meets or exceeds established cleanup levels.

Treatability testing parameters that will be evaluated to assess the ability of soil washing to provide long-term effectiveness and permanence to include the effectiveness of the process to permanently reduce radionuclide, organic, and inorganic contaminant concentrations in soil. These parameters will permit the assessment of residual risk remaining from untreated waste or treatment residuals at the

TABLE 1-2

RELATIONSHIP OF SOIL WASHING TREATABILITY DATA TO FEASIBILITY STUDY EVALUATION CRITERIA

	Soil Washing Treatability Data				
FS Evaluation Criteria	Leachate Analyses	Volume Reduction (%)	Radionuclide Removal (%)	Organic Removal (%)	Inorganic Removal (%)
Overall protection of human health and the environment	X		X	X	X
Compliance with ARARs	X		X	X	X
Long-term effectiveness and permanence	X		X	X	X
Reduction of toxicity, mobility, or volume through treatment	X	X	X	X	X
Implementability		X	X	X	X
Short-term effectiveness		X			
Cost		X			
State acceptance	X	X	X	X	X
Community acceptance	X	X	X	X	X

conclusion of remedial activities. The effectiveness of soil washing will also be evaluated via TCLP testing as to the leachability of contaminants from the treated soil.

The ability of soil washing to reduce the toxicity, mobility, or volume of contaminated waste will be measured by parameters such as TCLP leachate analysis, which will determine toxicity and mobility reduction, percent volume reduction, and percent contaminant removal in the treated soils, which will assess the reduction of toxicity.

Short-term effectiveness is impacted primarily by volume reduction, which indicates the amount of waste that must be treated and the amount of treated waste that must be handled and disposed of. The volume of soil that requires handling and treatment will impact the operation and maintenance requirements during implementation of the technology.

The implementability of soil washing is influenced primarily by the volume of waste to be handled. As with implementability, cost is also impacted by the volume of waste to be treated.

The final two evaluation criteria, state and community acceptance, are influenced by the results of all the data and by the other seven criteria as well.

The information required from the soil washing treatability study for use in the detailed analysis will be generated utilizing various analytical methods and various tiers of treatability testing. Various media (i.e., initial soil, treated soil, and washing solution) will be tested for radionuclide, organic, and other inorganic parameters within both the remedy screening and remedy selection stages of the treatability study.

2.0 REMEDIAL TECHNOLOGY DESCRIPTION

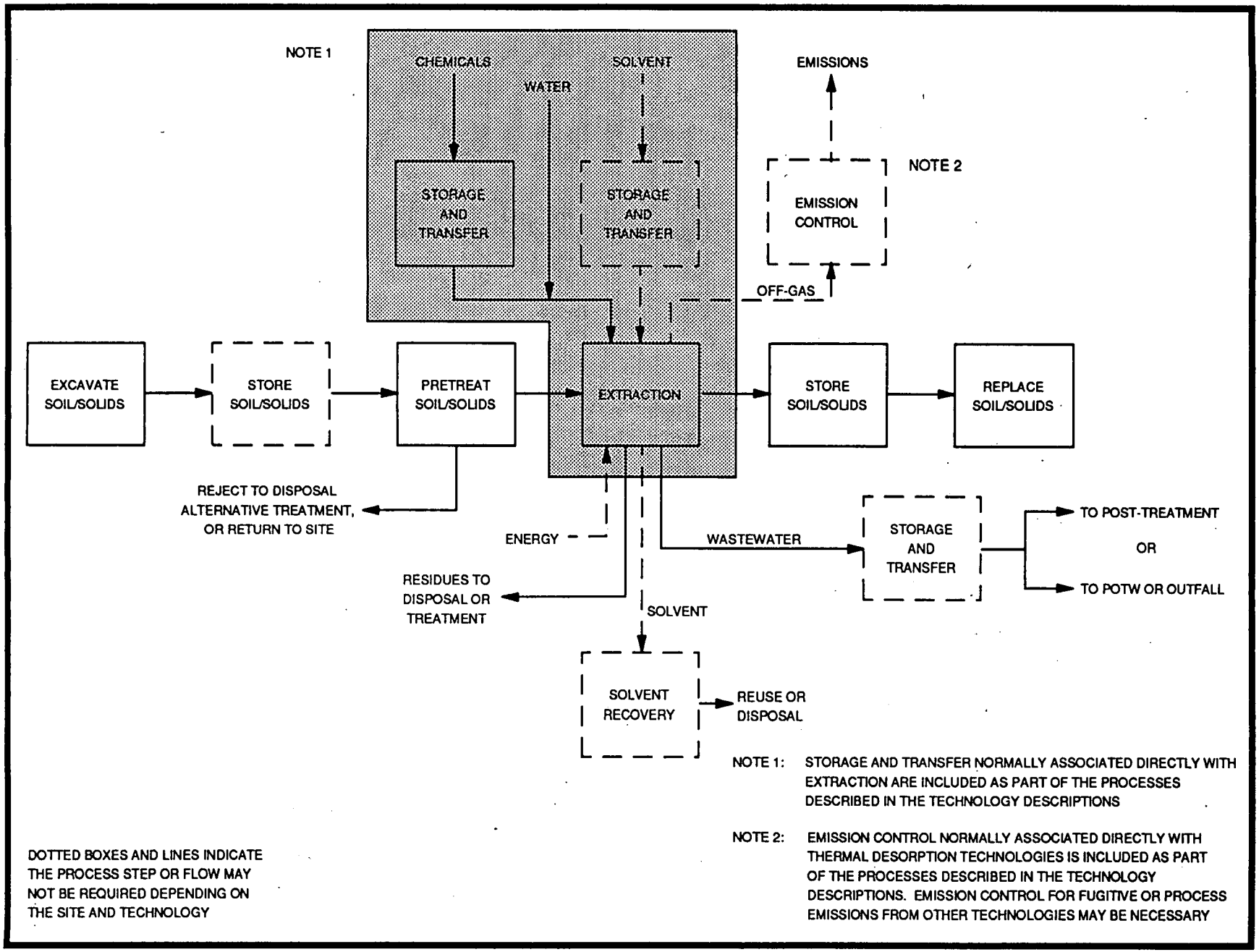
2.1 TECHNOLOGY JUSTIFICATION

The technology being evaluated within this treatability study is soil washing. A general soil-washing extraction system is illustrated in Figure 2-1. Soil washing was selected as one of the primary remediation alternatives due to the need to develop a simple, safe, economical, on-site treatment process that would produce a significant volume of remediated soil to remain on site. The soil washing treatment technology, if successful, will significantly reduce the final volume of material requiring selective handling by returning a significant volume of decontaminated soil to the site from which it was excavated. The success of the technology must also be assessed based on the final volume of washing solutions requiring selective storage and/or disposal practices. In essence, the sum of the final soil and washing solution (leachate) volumes must be significantly less than the initial volume of contaminated soil.

A review of soil washing technologies and their applicability to Superfund sites (EPA 1989a) reported that water washing with extractant reagents is applicable for cleaning nonvolatile hydrophilic and hydrophobic organics and heavy metals from soils. The report concluded that although extraction of organics and toxic metal contaminants from excavated sandy/silty soil that is low in clay and humus content has been successfully demonstrated at several pilot-plant test facilities, extraction from clay and humus soil fractions is more complicated.

Kunze and Gee (1989) demonstrated greater than 90 percent removal of a large number of contaminants from a CERCLA-site soil using various surfactant, organic solvent and acid washing solutions. They determined that both aqueous surfactant and aqueous citrate-based solutions are effective for high removals of all classes of the organic compounds tested. Their bench-scale soil washing study also showed that with high levels of contamination at a site, several washings may be required and used solutions would have to be treated prior to reuse.

Soil washing is not a new technology, but its application to a mixed waste (organics, inorganics and radionuclides) contamination problem such as exists at the FEMP site extends the application of such a technology to a relatively new dimension. Soil washing has been successfully used on soil contaminated with radionuclides. Richardson et al. (1989) conducted soil washing studies on the removal of radium-226 and thorium-230 from two soils. The results of their wet-sieving and water-



FL/303317.25.05.01/4-1

FIGURE 2-1. GENERAL SOIL EXTRACTION SYSTEM

washing studies indicated that the combination of the two processes can significantly reduce the radionuclide levels in soils.

2.2 PHYSICAL SEPARATION

Soil washing is a physical/chemical treatment process that initially involves the separation of a soil into different particle size fractions. Those size fractions that actually constitute soil particles include clays (< 2 μm), silts (2-50 μm), and sands (50 μm to 2 mm). Other constituents of the soil may include cobbles and stones (2 mm to 50 mm) and rocks, debris and trash (> 50 mm [2 inches]). All constituents of the soil may be contaminated with organics, metals and radionuclides. However, it is the soil particles (< 2 mm) that are of primary concern, and in particular those particle size fractions that include the silts and clays (< 50 μm). It is within this size fraction that contaminants are bound to soil particles by specific mechanisms such as ionic, covalent and hydrogen bonding, responsible for the absorption of metals and radionuclides (ionic species) and Van der Waals forces and nonspecific bonding, responsible for the affinity of organic molecules.

Soil washing techniques that employ the use of extraction reagents (such as proposed in this treatability plan) consist of soil excavation, aboveground treatment, isolation and removal or destruction of the contaminant, and redeposit of the cleaned soil. Techniques like those used in solution mining and mineral extraction have been proposed for use in this soil washing operation for the removal of contaminants from soil. This process is accomplished through a combination of particle separation by size and/or density. The proposed process utilizes conventional equipment (e.g., hydroclones, hydrogravimetric separators, scalping screens, trommels, mineral jigs, and centrifuges) for scrubbing, size reduction, washing, and dewatering of soils. Large objects (e.g., rocks and debris) are removed by screening and then cleaned separately. The soil is mixed thoroughly with water and extraction agents to remove the contaminants from the soil. This is followed by solid/liquid separation where the coarse fraction of the soil is separated. The extraction agent with contaminant and smaller soil particles (clay and fine silt) undergoes further solid/liquid separation where fine soil fractions are separated as much as possible. The extraction agent is cleaned and recycled. The separated soil fraction undergoes posttreatment where it is cleaned of any residual extraction fluid.

2.3 CHEMICAL EXTRACTION

Water and/or reagent formulations are used as the washing or leaching solutions in the extraction of organic compounds and inorganics and radionuclides from different soil size fractions. Water washing with extractive agents includes basic aqueous solutions (caustic, lime, slaked lime, or industrial alkali-based washing compounds); acidic aqueous solutions (sulfuric, hydrochloric, nitric, phosphoric, or carbonic acids); or solutions with surfactant or chelating agents. Hydrogen peroxide, sodium hypochlorite, and other strong oxidizing agents can chemically change the contaminants and enhance their removal from soil. The removal of organics from soil can be enhanced by strong basic or

surfactant solutions, while the extraction of metals is best facilitated by chelating agents or strongly acid solutions.

The treatment technique basically mobilizes the contaminants physically by mass action, or chemically by complexing, chelating, reducing, oxidizing, or ion exchange mechanisms. The washing solution, which now contains the disassociated contaminants, is then separated from the soil/water slurry. The soil is monitored for the presence of residual contaminants and either returned to the site as decontaminated soil or washed further using additional reagent solutions. The washing solution or leachate, which now contains the contaminants, is processed through a series of chemical extraction steps (e.g., complexing, chelating, reducing, oxidizing and/or exchange resins) to concentrate the contaminants into a finite volume of solution or onto a resin bed for ultimate disposal off site. The remaining solution is monitored to determine if the contaminants have been removed, and are then either released to the site treatment works or further processed to remove residual contaminants.

3.0 TEST AND DATA QUALITY OBJECTIVES

The purpose of this treatability study is to assess the performance of the soil washing technology on Operable Unit 5 soils in support of the RI/FS. Soil washing treatability testing will be conducted to elucidate the various levels of contaminant removal that can be achieved with increasing cleaning levels or numbers of washing processes (e.g., washing or chemical extraction steps) associated with the soil washing operation. Information obtained from this study will be used to support the detailed analysis of alternatives within the FS process.

This section establishes the performance objectives and the data desired from the soil washing tests. This section also establishes the data quality objectives (DQOs) for this program.

Performance objectives, and therefore DQOs for the remedy selection phase of the treatability testing, are driven by the remediation goals (RGs) established for the site. RGs are based on chemical-media-specific numerical concentration limits that should address all contaminants and all pathways found to be of concern during the baseline risk assessment process. The baseline risk assessment for Operable Unit 5 has not been completed, but site-wide preliminary remediation goals (PRGs) have been developed using results of the RI/FS investigation presently available. These PRGs are based on a 10^{-6} risk level (as a point of departure) and are presented in Tables 3-1 and 3-2 for chemical and radiological constituents. Although these cleanup levels are used to provide preliminary goals for determining the effectiveness of soil washing, they are not intended to provide final action levels for removing contaminants from soil. These levels are used as targets for evaluating the effectiveness of the soil washing technology. However, if the technology does not achieve individually specified levels, it should not be judged ineffective. The technology may eventually be determined to be the best available technology for remediation of soils on the FEMP site. Additionally, background concentrations and instrument contract required detection limits are provided for comparison purposes only.

3.1 PERFORMANCE OBJECTIVES

Test objectives have been established so that the performance of soil washing techniques can be evaluated on the basis of volume reduction, contaminant removal from individual soil fractions, and contaminant removal from the wash solutions. These performance objectives will be used to determine if a particular series of physical/chemical processes will effectively and efficiently remove contaminants from soil to a targeted cleanup level (Tables 3-1 and 3-2). Only the constituents found during the initial soil characterization in this study (Section 6.0) will be targeted and followed through the treatability study.

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TABLE 3-1
CHEMICALS IN SOILS
PRELIMINARY REMEDIATION GOALS

Preliminary Constituents of Concern	Basis for Preliminary Remediation Goal[a]	Soil Concentration for Meeting Criteria for PRG[b] (mg/kg)	Contract Required Detection Limit (mg/kg)	Background Concentration (mg/kg)[c]
Inorganics				
Aluminum	[d]	[e]	40	57,000
Antimony	0.0004 mg/kg/d RfD	32.	12	
Arsenic	1.75 $(mg/kg/d)^{-1}$ CSF	0.4	2	7.4
Barium	0.07 mg/kg/d RfD	5600	40	420
Beryllium	4.3 $(mg/kg/d)^{-1}$ CSF	0.16	1	0.85
Cadmium	0.0005 mg/kg/d RfD	4.	1	1.7
Chromium (total)	0.005 mg/kg/d RfD	400.	2	52
Cobalt	[d]	[e]	10	9.2
Copper	0.037 mg/kg/d RfD[f]	2960.	5	22
Lead	0.00069 mg/kg/d RfD[g]	55.	0.6	17
Manganese	0.14 mg/kg/d RfD	12,000.	3	640
Mercury	0.003 mg/kg/d RfD	24.	0.04	0.12
Nickel	0.02 mg/kg/d RfD	1600.	8	18
Silver	0.005 mg/kg/d RfD	400.	2	3
Thallium	0.00007 mg/kg/d RfD	5.6	2	8.6
Vanadium	0.003 mg/kg/d RfD	240.	10	66
Zinc	0.2 mg/kg/d RfD	16,000.	4	52

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TABLE 3-1
(Continued)

Preliminary Constituents of Concern	Basis for Preliminary Remediation Goal[a]	Soil Concentration for Meeting Criteria for PRG[b] (mg/kg)	Contract Required Detection Limit (mg/kg)	Background Concentration (mg/kg)[c]
Organics				
Acenaphthene	0.06 mg/kg/d RfD	4800.	0.33	NA
Acetone	0.1 mg/kg/d RfD	8000.	0.01	NA
Anthracene	0.3 mg/kg/d RfD	24,000	0.33	NA
PCBs	7.7 $(mg/kg/d)^{-1}$ CSF	0.09[h]		NA
Benzene	0.029 $(mg/kg/d)^{-1}$ CSF	24	.005	NA
Bis (2-ethylhexyl) - phthalate	0.014 $(mg/kg/d)^{-1}$ CSF	50	0.33	NA
Benzo (a) anthracene[i]	1.67 $(mg/kg/d)^{-1}$ CSF	0.42	0.33	NA
Benzo (a) pyrene	11.5 $(mg/kg/d)^{-1}$	0.06	0.33	NA
Benzo (b) fluoranthene[i]	1.61 $(mg/kg/d)^{-1}$ CSF	0.44	0.33	NA
Benzo (g,h,i) perylene[j]	0.03 mg/kg/d RfD	2400	0.33	NA
Benzo (k) fluoranthene[i]	0.759 $(mg/kg/d)^{-1}$ CSF	0.92	0.33	NA
Benzoic acid	4 mg/kg/d RfD	320,000	1.6	NA
Benzyl alcohol	0.3 mg/kg/d RfD	24,000	0.33	NA
Butyl benzyl phthalate	0.2 mg/kg/d RfD	16,000	0.33	NA
2-Butanone	0.05 $(mg/kd/d)^{-1}$ RfD	4000	0.01	NA
Carbon tetrachloride	0.13 $(mg/kg/d)^{-1}$ CSF	5.4	0.005	NA
Carbon disulfide	0.1 mg/kg/d RfD	8000	0.005	NA
Chlorobenzene	0.02 mg/kg/d RfD	1600	0.005	NA
Chloroethane	[e]	[f]	0.01	NA

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TABLE 3-1
(Continued)

Preliminary Constituents of Concern	Basis for Preliminary Remediation Goal[a]	Soil Concentration for Meeting Criteria for PRG[b] (mg/kg)	Contract Required Detection Limit (mg/kg)	Background Concentration (mg/kg)[c]
Chloroform	0.0061 $(mg/kg/d)^{-1}$ CSF	115	0.005	NA
Chrysene[i]	0.0506 $(mg/kg/d)^{-1}$ CSF	13.8	0.33	NA
1,1-Dichloroethane	0.1 mg/kg/d RfD	8000	0.005	NA
1,1-Dichloroethene	0.6 $(mg/kg/d)^{-1}$ CSF	11.7	0.005	NA
1,2-Dichloroethane	0.091 $(mg/kg/d)^{-1}$	7.7	0.005	NA
cis 1,2-Dichloroethene	0.01 mg/kg/d RfD	800	0.005	NA
trans 1,2-Dichloroethene	0.02 mg/kg/d RfD	1600	0.005	NA
2,4-Dimethylphenol	0.02 mg/kg/d RfD	1600	0.33	NA
Di-n-butylphthalate	0.1 mg/kg/d RfD	8000	0.33	NA
Dibenzo (a,h)-anthracene[h]	12.77 $(mg/kg/d)^{-1}$ CSF	0.05	0.33	NA
Dibenzofuran	[d]	[e]	0.33	NA
Diethylphthalate	0.8 mg/kg/d RfD	64,000	0.33	NA
Dimethylphthalate	1.0 mg/kg/d RfD	80,000	0.33	NA
Ethylbenzene	0.1 mg/kg/d RfD	8000	0.005	NA
Fluoranthene	0.04 mg/kg/d RfD	3200	0.33	NA
Fluorene	0.04 mg/kg/d RfD	3200	0.33	NA
2-Hexanone	0.05 mg/kg/d RfD	4,000	0.01	NA
Isophorone	0.004 $(mg/kg/d)^{-1}$ CSF	1710	0.33	NA

TABLE 3-1
(Continued)

Preliminary Constituents of Concern	Basis for Preliminary Remediation Goal[a]	Soil Concentration for Meeting Criteria for PRG[b] (mg/kg)	Contract Required Detection Limit (mg/kg)	Background Concentration (mg/kg)[c]
Indeno (1,2,3-c,d) pyrene[i]	2.668 $(mg/kg/d)^{-1}$ CSF	0.26	0.33	NA
2-Methylnaph-thalene[k]	0.004 mg/kg/d RfD	320	0.33	NA
Methylene chloride	0.0075 $(mg/kg/d)^{-1}$ CSF	93.3	0.005	NA
Naphthalene	0.004 mg/kg/d RfD	320	0.33	NA
3-Nitroaniline	[d]	[e]	1.6	NA
4-Nitrophenol	0.008 mg/kg/d RfD	640	1.6	NA
Pentachloro-phenol	0.12 $(mg/kg/d)^{-1}$ CSF	5.83	1.6	NA
Phenol	0.6 mg/kg/d RfD	48,000	0.33	NA
Penanthrene	0.03 mg/kg/d RfD	2400	0.33	NA
Pyrene	0.03 mg/kg/d RfD	2400	0.33	NA
1,1,2,2-Tetrachloro-ethane	0.2 $(mg/kg/d)^{-1}$ CSF	35	0.005	NA
Tetrachloro-ethene	0.051 $(mg/kg/d)^{-1}$ CSF	13.7	0.005	NA
Trichloroethene	0.011 $(mg/kg/d)^{-1}$	63.6	0.005	NA
1,1,1-Trichloro-ethane	0.035 mg/kg/d RfD	2800	0.005	NA
Toluene	0.2 mg/kg/d RfD	16,000	0.005	NA
Vinyl chloride	1.9 $mg/kg/d^{-1}$ CSF	0.37	0.01	NA
Total xylenes	2 mg/kg/d RfD	160,000	0.005	NA

[a] Reference Doses (RfDs) and Cancer Slope Factors (CSFs) from Health Effects Assessment Summary Tables (HEAST), EPA, 1991, and Drinking Water Regulations and Health Advisories, Office of Water, EPA, Washington, DC, October 1991.

TABLE 3-1
(Continued)

[b] EPA, 1990, Corrective Action for Solid Waste Management Units at Hazardous Waste Management Facilities; Proposed Rule 40CFR Parts 264, 265, 270, and 271.

[c] Sources: Shacklette, J. T. and J. G. Boerngen, 1984, Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Survey Professional Paper 1270, U.S. Dept. of the Interior.

Kabato-Pendias, A. and H. Pendias, 1984, Trace Elements in Soils and Plants, CRC Press, Inc., Boca Raton, Florida, p. 34. Background concentrations for organics are not available (NA).

[d] No MCL, PMCL< RfD or CSF value has been developed by EPA.

[e] No available appropriate criterion.

[f] Conversion of drinking water standard given in HEAST into reference dose.

[g] Marcus, W.L., 1986, "Lead Health Effects in Drinking Water," Toxicology and Industrial Health, Vol. 2, No.4, pp. 363-407. RfD for lead calculated from a fetal blood lead level.

[h] Values are araclor specific.

[i] Calculated CSF value based on Benzo(a)pyrene relative potency equivalent level as recommended in "Comparative Potency Approach for Estimating the Cancer Risk Associated with Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons," Interim Final Report, Clement Associates, 1988.

[j] Value for pyrene used as surrogate based on analogy.

[k] Value for naphthalene used as surrogate based on analogy.

TABLE 3-2
RADIONUCLIDES IN SURFACE SOILS (INHALATION PATHWAY ONLY) PRELIMINARY REMEDIATION GOALS

Constituents of Concern Radionuclides	Level of Concern Risk-Based (10^{-6}) Cleanup Level[a] (pCi/g)	Contract Required Detection Limits (pCi/g)	Natural Background Concentration (pCi/g)
Strontium-90	175.	0.5	~ 0[b]
Technetium-99	1200.	0.9	~ 0[b]
Ruthenium-106	22.	1	~ 0[b]
Cesium-137	515.	0.2	~ 0[b]
Lead-210	5.8	2	~ 1.5[c]
Polonium-210	3.6	2	~ 1.5[c]
Radium-224	8.2	2	1.0[c]
Radium-226	3.3	0.3	1.5[d]
Radium-228	15.	0.5	1.0[c]
Actinium-227	0.12	0.3	~ 0.06[c]
Protactinium-231	0.24	0.5	~ 0.06[c]
Thorium-228	0.13	0.6	1.0[c]
Thorium-230	0.32	0.6	1.4[c]
Thorium-232	0.32	0.6	1.0[d]
Uranium-234	0.36	0.6	1.4[c]
Uranium-235	0.39	0.4[f]	0.06[c]
Uranium-238	0.41	0.6	1.4[d]
Neptunium-237	0.28	0.2[f]	~ 0[b]
Plutonium-238	0.23	0.2[f]	~ 0[b]
Plutonium-239	0.24	0.2[f]	~ 0[b]

[a] Assuming a lifetime risk of cancer incidence of 1×10^{-6}, a dust loading of 0.0002 g/m^3 and an inhalation rate of 20 m^3/day for 70 years, using slope factors from HEAST (EPA 1991). The values represent the incremental risk above background radionuclide concentrations.

[b] Not naturally occurring; background is assumed to be zero.

[c] Equilibrium is assumed with activity of parent.

Table 3-2
(Continued)

[d] Myrick, T.E. et al, (1983), "Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S.," Health Physics, Vol. 45, No. 3, pp. 631-642.

[e] Derived assuming natural isotopic ratios of uranium.

[f] An extended counting time and larger sample size will be used to obtain this detection limit.

The specific objectives of the soil washing treatability study are as follows:

- To determine the levels of targeted contaminants associated with various soil size fractions
- To determine the amount of radionuclides and Hazardous Substance List (HSL) constituents removed from the soil during washing
- To determine the leachability of all radionuclides and HSL constituents from the treated (washed) soils
- To evaluate reagents and their effect on the removal of contaminants from soil and washing solutions
- To determine the volume of soil from which contaminants are removed to a targeted cleanup level (Tables 3-1 and 3-2)
- To determine the volume of waste produced as a result of individual soil washing processes
- To develop the following preliminary process data for use in potential future remedy design treatability studies:
  - Chemical and physical characterization of waste streams before and after particle size separation and reagent addition (chemical extraction)
  - System design description identifying the number and kinds of treatment steps in the soil washing operation
- To provide preliminary cost and design data for the RI/FS

3.2 DATA QUALITY OBJECTIVES

The establishment of DQOs is the part of the process that defines the data quality needs of the project. The implementation of an appropriate QA/QC program is required to ensure that data of known and documented quality are generated. The DQOs will define the level of QA/QC for the treatability testing and analysis. The DQOs for this remedy screening are quantitative in nature because the final soil washing products must meet specific performance criteria, namely toxicity characteristic leaching procedure (TCLP) and contaminant and radionuclide concentration criteria.

DQO analytical levels are defined in EPA's "Guide for Conducting Treatability Studies Under CERCLA" (EPA 1989b). This guide states that the requisite analytical levels are dictated by the types and magnitudes of decisions to be made based on the data and the objectives of the screening. A description of the analytical levels is presented in Table 3-3, an excerpt from EPA's guide. A discussion of the DQOs for each stage of the remedy screening for soil washing follows.

To assure that the level of detail and data quality needed for evaluating the soil-washing technology as a viable alternative for treating soils is achieved, DQO tables were prepared based on guidance given in "Data Quality Objectives for Remedial Response Activities (Development Process)" (EPA 1987).

TABLE 3-3
SUMMARY OF ANALYTICAL LEVELS

Level I	
Type of analysis	Field screening or analysis with portable instruments.
Limitations	Usually not compound-specific, but results are available in real time. Not quantifiable.
Data quality	Can provide an indication of contamination presence. Few QA/QC requirements.
Level II	
Type of analysis	Field analyses with more sophisticated portable instruments or mobile laboratory. Organics by GC; inorganics by AA, ICP, or XRF.
Limitations	Detection limits vary from low parts per million to low parts per billion. Tentative identification of compounds. Techniques/instruments limited mostly to volatile organics and metals.
Data quality	Depends on QA/QC steps employed. Data typically reported in concentration ranges.
Level III	
Type of analysis	Organics/inorganics performed in an off-site analytical laboratory. May or may not use CLP procedures. Laboratory may or may not be a CLP laboratory.
Limitations	Tentative identification of compounds in some cases.
Data quality	Detection limits similar to CLP. Rigorous QA/QC.
Level IV	
Type of analysis	Hazardous Substances List (HSL) organics/inorganics by GC/MS, AA, ICP. Low parts-per-billion detection limits.
Limitations	Tentative identification of non-HSL parameters. Validation of laboratory results may take several weeks.
Data quality	Goal is data of known quality. Rigorous QA/QC.
Level V	
Type of analysis	Analysis by nonstandard methods.
Limitations	May require method development or modification. Method-specific detection limits. Will probably require special lead time.
Data quality	Method-specific.

SOURCE: EPA, "Guide for Conducting Treatability Studies under CERCLA," December 1989.

The soil washing DQO tables appear as Tables 3-4 through 3-9 and summarize the following for each area of technical focus or activity:

- Soil washing activity objectives
- Prioritized data use(s)
- Appropriate analytical levels
- Constituents of concern
- Level of concern
- Required detection limits
- Critical samples

These tables are organized to provide DQO criteria based on the various phases of remedy screening and remedy selection.

A list of analyses for each phase of the treatability study is included as part of these series of DQO tables.

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TABLE 3-4
DATA QUALITY OBJECTIVES (DQOs) FOR THE SOIL WASHING TREATABILITY ALTERNATIVE - REMEDY SCREENING-STAGE I

Activity	Purpose/Criteria	
Objectives	Physical Separation:	To determine the concentration of targeted contaminants that are associated with various soil size fractions.
	Chemical Extraction:	To determine effective reagents in removing contaminants from soils.
Prioritized Data Use(s)	Physical Separation:	The level of targeted contaminants associated with specific soil size fractions will be determined to allow for additional soil washing and chemical extraction steps to focus on those size fractions retaining much of the contaminants.
	Chemical Extraction:	Initial screening of extraction reagents will select out only those chemicals that significantly effect removal of targeted contaminants from soil.
Appropriate Analytical Level	II, III and V - See Table 3-3	
Constituents of Concern	See Table 3-5	
Level of Concern	Specific targeted levels will not be set at this stage. Physical separation test will only characterize soil particle/contaminant relationships. Chemical extraction effectiveness will be statistically determined.	
Required Detection Limits	Specified in QAPP, Section 4.0	
Critical Samples	No specific sample has been determined to be a critical sample. However, the specified samples (Section 6.0) are required as part of an overall program in this stage of testing for remedy screening.	

TABLE 3-5
CONSTITUENTS OF CONCERN FOR REMEDY SCREENING - STAGE I

Analyses for Initial Soils		Analyses for Fractioned and Extraction Soils		Analyses for Soil Washing Solutions	
4 Target Organics[a]	Inorganics	4 Target Organics[a]	Inorganics	4 Target Organics	Inorganics
Semivolatiles	Radionuclides	Semivolatiles	Radionuclides	Semivolatiles	Radionuclides
Benzo(a)pyrene	Uranium by IC[b]	Benzo(a)pyrene	Uranium by IC[b]	Benzo(a)pyrene	Uranium by IC[b]
Benzo(g,h,i)perylene	Gross alpha	Benzo(g,h,i)perylene	Gross alpha	Benzo(g,h,i)perylene	Gross alpha
Fluorene	Gross beta	Fluorene	Gross beta	Fluorene	Gross beta
Naphthalene		Naphthalene		Naphthalene	
	Alkalinity				

[a]If the initial characterization does not show specific organic compound to be present, a replacement organic compound will be chosen as appropriate.
[b]IC is ion chromatography using a phosphorescence detector.

TABLE 3-6
DATA QUALITY OBJECTIVES (DQOs) FOR THE SOIL WASHING TREATABILITY ALTERNATIVE - REMEDY SCREENING-STAGE II

Activity	Purpose/Criteria
Objectives	1) To use most effective extraction reagents from Stage I on those soil size fractions determined to retain significant amounts of contaminants. 2) To determine the level of targeted contaminant removal from specific soil size fractions based on the use of various extraction reagents and their sequence of use required to effectively remove contaminants. 3) To determine the level of contaminants associated with each washing solution (leachate) and to elucidate those reagents effective in removal of targeted contaminants from those solutions.
Prioritized Data Use(s)	1) Data will provide preliminary estimates on volume reduction of contaminated soil with initial soil washing treatment processes. 2) Results from these tests will determine the process design most effective in removing contaminants from both soils and wash solutions. Process design will illustrate the number and sequence of washing (extracting) steps (for soils and wash solutions), and the extraction reagents in the soil washing operation.
Appropriate Analytical Level	II, III, V - See Table 3-3
Constituents of Concern	See Table 3-7
Level of Concern	Specific targeted levels will not be set at this stage; however, levels of targeted contaminants will be referenced to RAOs and evaluated as to the effectiveness of various soil washing and chemical extracting processes. Soil washing with chemical extraction effectiveness will be statistically evaluated to select the most effective reagents and process steps.
Required Detection Limits	Specified in QAPP, Section 4.0
Critical Samples	No specific sample has been determined to be a critical sample. However, the specified samples (Section 6.0) are required as part of an overall program in this stage of testing, for remedy screening.

TABLE 3-7
CONSTITUENTS OF CONCERN FOR REMEDY SCREENING - STAGE II

Analyses for Initial, Fractioned, and Extracted Soils		Analyses for Soil Washing Solutions		MTCLP[b] List for Extracted Soil	
8 Target Organics[a]	Inorganics	4 Target Organics[a]	Inorganics	Metals	Inorganics
Volatiles	Radionuclides	Semivolatiles	Radionuclides	Metals by ICP	Radionuclides
Benzene	Uranium by IC[c]	Benzo(a)pyrene	Uranium by IC[c]	Arsenic	Uranium by IC[c]
Toluene	Gross alpha	Benzo(g,h,i)perylene	Gross alpha	Barium	Gross alpha
Total xylenes	Gross beta	Fluorene	Gross beta	Cadmium	Gross beta
Trichloroethene		Naphthalene		Chromium	
	Metals by ICP[d]		Metals by ICP	Lead	
Semivolatiles	Arsenic		Arsenic	Selenium	
Benzo(a)pyrene	Barium		Barium	Silver	
Benzo(g,h,i)perylene	Cadmium		Cadmium		
Fluorene	Chromium		Chromium	Mercury by cold vapor	
Naphthalene	Lead		Lead		
	Selenium		Selenium		
	Silver		Silver		
	Mercury by cold vapor		Mercury by cold vapor		

[a]If the initial characterization does not show a specific organic compound to be present, a replacement organic compound will be chosen as appropriate.
[b]The Modified TCLP (MTCLP) differs from the standard TCLP as follows: the MTCLP uses only 2.5 grams of material rather than 100 grams; the MTCLP generates only 50 milliliters of leachate rather 2 liters; and the leachate from the MTCLP is analyzed for metals only rather than metals and organics.
[c]IC is ion chromatography using a phosphorescence detector.
[d]ICP is inductively coupled plasma.

TABLE 3-8
DATA QUALITY OBJECTIVES (DQOs) FOR THE SOIL WASHING TREATABILITY ALTERNATIVE - REMEDY SELECTION

Activity	Purpose/Criteria
Objectives	1) To incorporate the use of specific soil washing equipment (e.g., gravity separators, trommels, centrifugal jigs, centrifuges, etc.,) into a mini-pilot plant system that will simulate actual field system operations. 2) To incorporate the series of washing steps and respective reagents determined to be most effective in removal of targeted contaminants from both soils and wash solutions. 3) To determine soil washing reagent formulation so that the washed soil meets TCLP criteria.
Prioritized Data Use(s)	This data will be used to determine the volume of soil that can be cleaned to targeted cleanup levels and returned to the site as decontaminated soil. Data will include volume of soil cleaned during initial soil washing step. Remedy selection testing data will be used to determine that applicability of soil washing is an efficient and effective treatability alternative for FEMP soils.
Appropriate Analytical Level	III - Table 3-3
Constituents of Concern	See Table 3-9
Level of Concern	See Tables 3-1 and 3-2
Required Detection Limits	Specified in QAPP, Section 4.0
Critical Samples	No specific sample has been determined to be a critical sample. However, the specified samples (Section 6.0) are required as part of an overall program in this stage of testing, in remedy selection.

TABLE 3-9
CONSTITUENTS OF CONCERN FOR REMEDY SELECTION TESTING

Initial, Fractioned, and Extracted Soils, and Soil Washing Solutions			
	Inorganic List		
Organic List	TCLP and HSL Metals		Radionuclides
TCLP Volatiles	Aluminum (Al)	Magnesium (Mg)	Cs-137
TCLP Semivolatiles	Antimony (Sb)	Manganese (Mn)	Np-237
TCLP Pesticides/PCBs	Arsenic (As)	Mercury (Hg)	Pu-total
	Barium (Ba)	Molybdenum (Mo)	Ra-226
HSL Volatiles	Beryllium (Be)	Potassium (K)	Ra-228
HSL Semivolatiles	Boron (B)	Nickel (Ni)	Ru-106
HSL Pesticides/PCBs	Calcium (Ca)	Selenium (Se)	Sr-90
	Cadmium (Cd)	Silicon (Si)	Tc-99
	Chromium (Cr)	Silver (Ag)	Th-total
	Cobalt (Co)	Sodium (Na)	U-total
	Copper (Cu)	Thallium (Tl)	Gross alpha
	Cyanide (CN)	Vanadium (V)	Gross beta
	Lead (Pb)	Zinc (Zn)	

4.0 EXPERIMENTAL DESIGN AND PROCEDURES

Washing of radiological and mixed waste-contaminated soils has been selected as a technology to be considered for the remediation of Operable Unit 5 soils. The collection and characterization of soil samples for soil washing treatability studies is an important function within the experimental design. Therefore, initial study requirements will include the collection and characterization of soils used for treatability testing. Part of the experimental design is to integrate this soil washing treatability study with the ID treatability program being conducted onsite under the guidance of DOE.

Soils chosen for soil washing will be selected from four locations that are considered to be representative of the contamination problem at the FEMP. The basic criteria for the type of soil selected, described in Section 6.0, focuses on soils with moderate to high uranium contamination. Two of these locations will be common to the ID program while the other two locations will be unique to this treatability study. The two ID soils selected will represent a radiological contamination problem, uranium in particular. The two soils unique to this study will be selected as "mixed waste" soils, containing a range in HSL inorganics and organics as well as radionuclides. The locations of the soils selected will be based on the results of the initial soil sampling and characterization program described in Section 6.0, Sampling and Analysis. A complete physical and chemical characterization of the four soils from these locations will be conducted in accordance with guidelines established in Section 3.0, Test and Data Quality Objectives, and Section 6.0.

This section describes the soil washing experimental design for treatability testing of site soils following their collection and characterization. Soil washing (previously illustrated in Figure 2-1) involves dislodging contaminants bound to soil particles and then separating the dislodged contaminants and additional contaminated soil particles from the remaining soil matrix by an aqueous washing stream. The contaminants may be separated from this aqueous wash stream into a concentrated residue for further treatment (e.g., stabilization or vitrification).

4.1 SOIL WASHING EXPERIMENTAL DESIGN

Figure 4-1 shows the series of treatment stages that comprise the experimental design. This design for soil washing incorporates a tiered approach in determining the binding association of contaminants within the soil matrix and the physical separation and chemical extraction processes necessary for soil washing and wash solution (leachate) recovery. This design basically incorporates dual phases as part of Stage I, which involve performing initial screening tests that allow for refinement of the selected approach for soil washing. Physical separation tests and chemical extraction tests will be run independently. The physical separation tests will identify the soil-size fractions with which each of the types of contamination (e.g., radionuclides, organics, metals) are associated. Selective screens will

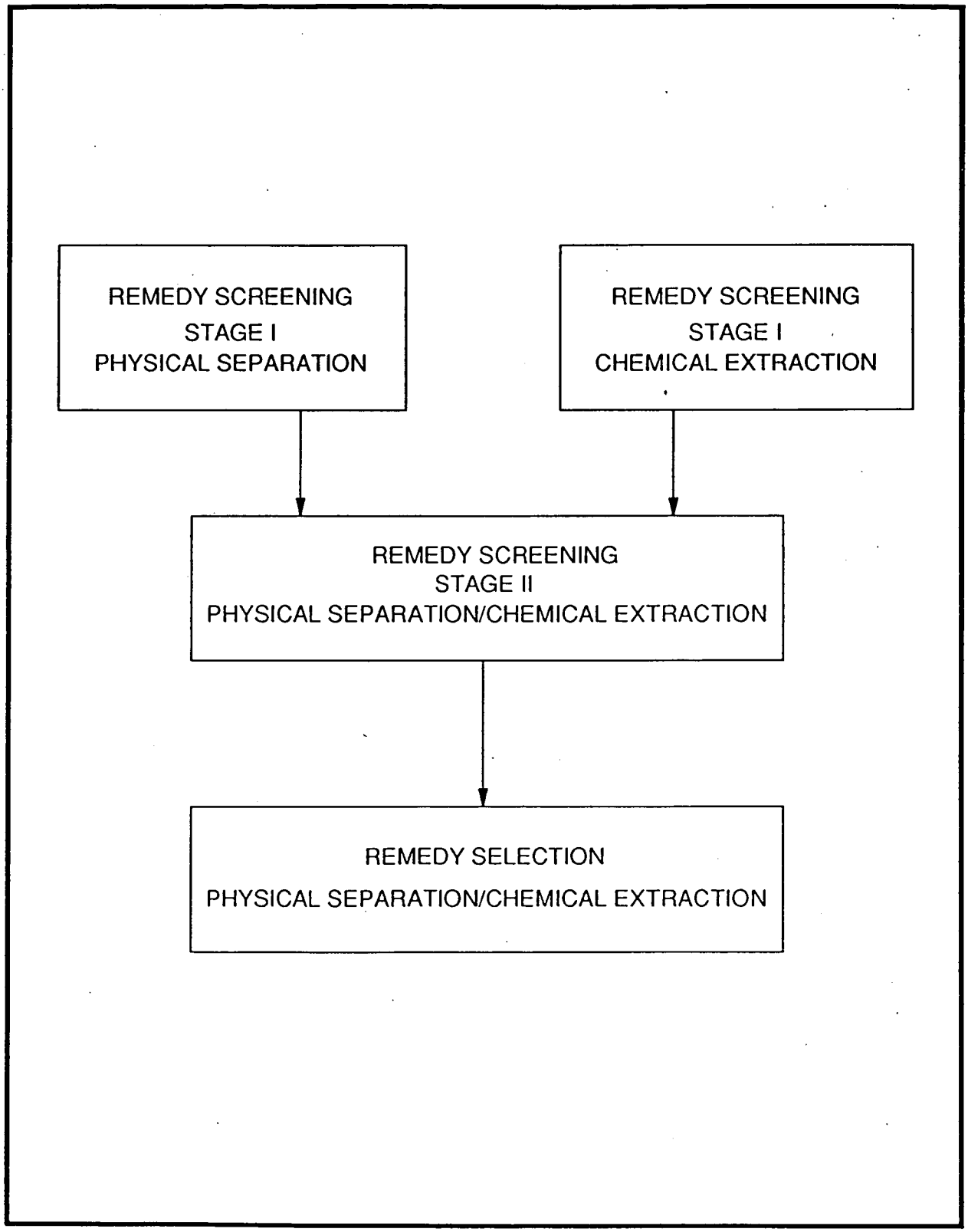

FIGURE 4-1. TREATMENT PHASES
SOIL WASHING EXPERIMENTAL DESIGN

separate soils into six individual soil size fractions (>50 mm, 50 mm - 9.5 mm, 9.5 mm - 2 mm, 2 mm - 50 μm, 50 μm - 2 μm, < 2 μm). The Stage I chemical extraction tests will be run on samples that have not been separated into specific-size fractions and will screen the extractants to identify those most promising for separating the contaminants from the soil.

Stage II remedy screening will incorporate in the test matrix the use of those selected individual soil-size fractions noted above. The most effective washing solutions, as determined in Stage I chemical extraction testing, will be used for washing those soil-size fractions determined in Stage I testing to have significant levels of contaminants associated with them. The remedy selection testing phase will, in turn, incorporate results from the remedy screening - Stage II tests into a laboratory-scaled version of the soil washing treatment system.

4.2 REMEDY SCREENING - STAGE I

4.2.1 Stage I - Initial Sample Preparation and Analysis

Before conducting chemical extraction and particle size separation experiments, analyses of the "as received" sample will be performed to determine baseline concentrations of constituents (contaminants) of concern, previously listed in Table 3-5. Approximately 5 to 10 kg of "as received" field soil samples will be homogenized in a rotating jar mixer. Loss of volatiles are expected during this homogenizing process. These are losses that normally occur during the handling of soil in the washing process. In support of the remedial design efforts, a qualitative evaluation of the dust production during handling and mixing of the soil, relative to the moisture content of the "as received" material, will be recorded as part of the laboratory notes.

The average activity of the homogenized soil will be determined by analyzing six 400-mg aliquots for gross alpha and gross beta. Uranium concentrations will be determined by ion chromatography (IC). The average activity and concentrations will be used as baseline values to determine the relative efficiency of radioactive compound extraction from the soil during Stage I. The gross alpha and beta results will also be used to determine the homogeneity of the sample.

Alkalinity is initially determined in soils to aid in determining the quantity of certain extraction reagents necessary to overcome buffering effects and effectively remove contaminants. The average alkalinity of four 3-gram aliquots of the homogenized soil will be determined by titration with 1 N hydrochloric acid (HCl). The test will be conducted at ambient temperature. The proposed weights of the soil and extraction fluid in initial chemical extraction tests will be reevaluated after analysis of the average gross alpha and beta and alkalinity of the soil.

The average concentration of eight selected target organic compounds in three samples will be determined. These concentrations will serve as baseline values for monitoring the efficiency of

organic compound extraction. The eight organic compounds will consist of four volatile and four semivolatile organic compounds. Initial volatile and semivolatile compounds have been chosen because of their reported presence in site soils and their distinct separation peaks in chromatographic analysis. Alternative compounds will be selected if the initial characterization shows that the compounds initially selected are not present at significant levels within the soil to be treated.

The volatile organic compounds (VOCs) initially targeted for monitoring are benzene, toluene, total xylene, and trichloroethene. The samples will either be analyzed by purge and trap gas chromatography (GC) analysis or a combination of sample extraction with a solvent (e.g., methanol) combined with purge and trap GC analysis. The analytical system used will depend on the concentration of VOCs in the sample. Approximately 5 to 10 grams of sample will be needed for the analysis.

The semivolatile organic compounds initially targeted for monitoring are benzo(a)pyrene, benzo(g,h,i)perylene, fluorene, and naphthalene. The samples will be extracted with a solvent (e.g., methylene chloride). The extraction medium will then be analyzed for the target semivolatile organic compounds. Approximately 5 to 10 grams of sample will be needed for the analysis.

4.2.2 Stage I - Physical Separation

Preliminary screening of soils from four locations will entail primarily size-fraction separation and characterization of the contaminants associated with each particle size. In the proposed bench-scale wet-sieving scheme for soils (Figure 4-2), a 250-gram sample of soil will be mixed with 1000 mℓ of the wash solution (tap water) in a 1.5-liter glass jar. A washing solution is an aqueous solution, possibly containing one of a wide variety of extraction reagents, that is used to wash or remove contaminants from a soil matrix. A dispersing chemical reagent (e.g., sodium hexametaphosphate, N-Brand sodium silicate, sodium tripolyphosphate, sodium hydroxide, or sodium carbonate) added to deflocculate any soil aggregates, may be part of the washing solution. This 4:1 solution-to-soil (weight:volume) ratio will then be shaken for 30 minutes on a reciprocating laboratory shaker. The washed soil will be segregated into six sized fractions by passing the soil through a series of sieves consisting of 50 mm, 9.5 mm, 2 mm, 50 μm, and 2 μm sizes.

The washing (dispersing) solution will be separated from the soil and collected at the end of the wet-sieving process. Uranium, gross alpha and beta, and targeted semivolatiles will be analyzed for in the wash solution and in each particle-size fraction of the washed soil. This characterization of the soils will determine the type and amount of contaminants associated with each of the particle-size fractions isolated from each soil sample for the four locations. Contaminants found in the solutions will be considered readily removable contaminants and therefore loosely or freely associated with the soil matrix. Those contaminants still present in selected particle-size fractions following washing and

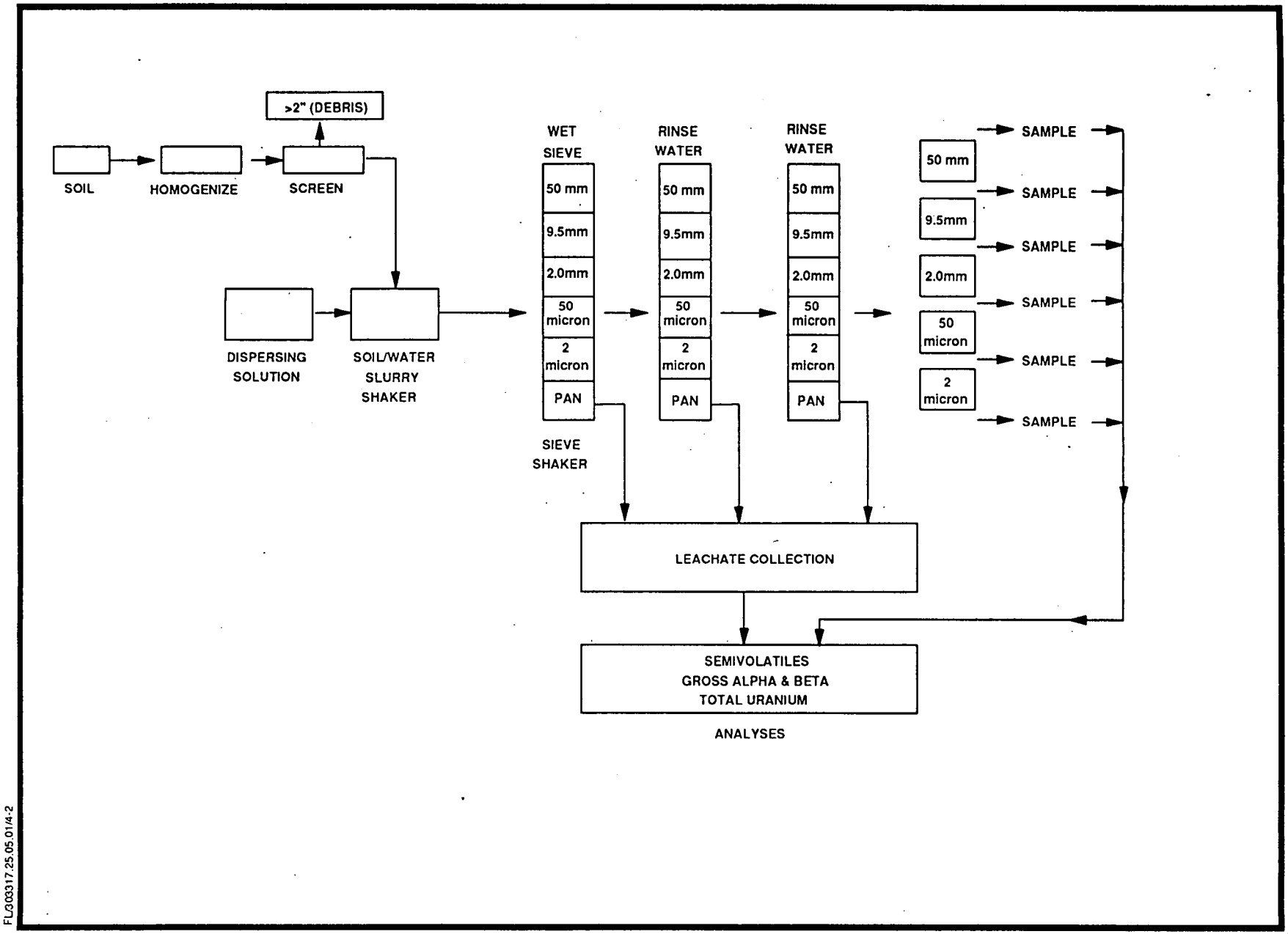

FIGURE 4-2. PROPOSED SOIL PARTICLE SIZE SEPARATION PROCEDURE
REMEDY SCREENING - STAGE I

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sieving will be considered strongly bound contaminants and will be the primary focus in development of the chemical extraction processes.

4.2.3 Stage I - Chemical Extraction

The objective of the chemical extraction portions of the Stage I is to determine the effectiveness of various acids, bases, chelants, surfactants, and alcohol extractant solutions in removing radionuclides, Hazardous Substance List (HSL) metals and organic compounds from the soil. A flow diagram for chemical extraction - Stage I is illustrated in Figure 4-3. Results from Stage I testing will be used to refine the experimental approach used in Stage II.

"As received" soil from the four sampling locations described in Section 6.0 will be used in this stage of testing. Soil samples will first be sieved through a 9.5-mm (3/8-inch) screen to remove any rocks, pebbles and debris. That fraction of the soil larger than 9.5 mm will be monitored for radionuclides. If radionuclides are detected, this material will be cycled through the first step of the soil washing operation.

Each extractant will be tested on 30- to 50-gram aliquots of the homogenized soil (<9.5 mm), according to Table 4-1. The extractants are acidic or basic solutions and solutions that contain chelants, surfactants, chlorides, and/or alcohols. Soil and extractant mixtures will be stirred during chemical extraction. Soil will be extracted at 80°C for four hours.

If decomposition of extractants occurs due to the elevated extraction temperature, a lower temperature will be used and recorded. After cooling to room temperature, the samples will be filtered and slurry rinsed with a volume of deionized water equal to about one-tenth the original extractant volume. Slurry rinsing is a step in the extraction and filtration process in which a sufficient quantity of liquid is used to rinse the extraction vessel and when transferred to the filter serves as a flushing solution to the soil sample that was just extracted and filtered.

The ethylenediaminetetraacetic acid (EDTA) solution will be tested at three different pH values. The surfactants will be tested at three different concentrations. Additional extractants, not listed in Table 4-1, may be investigated. Other extractants may be tested at various pH values not noted in the table, provided that standard pH values being tested give unsatisfactory results.

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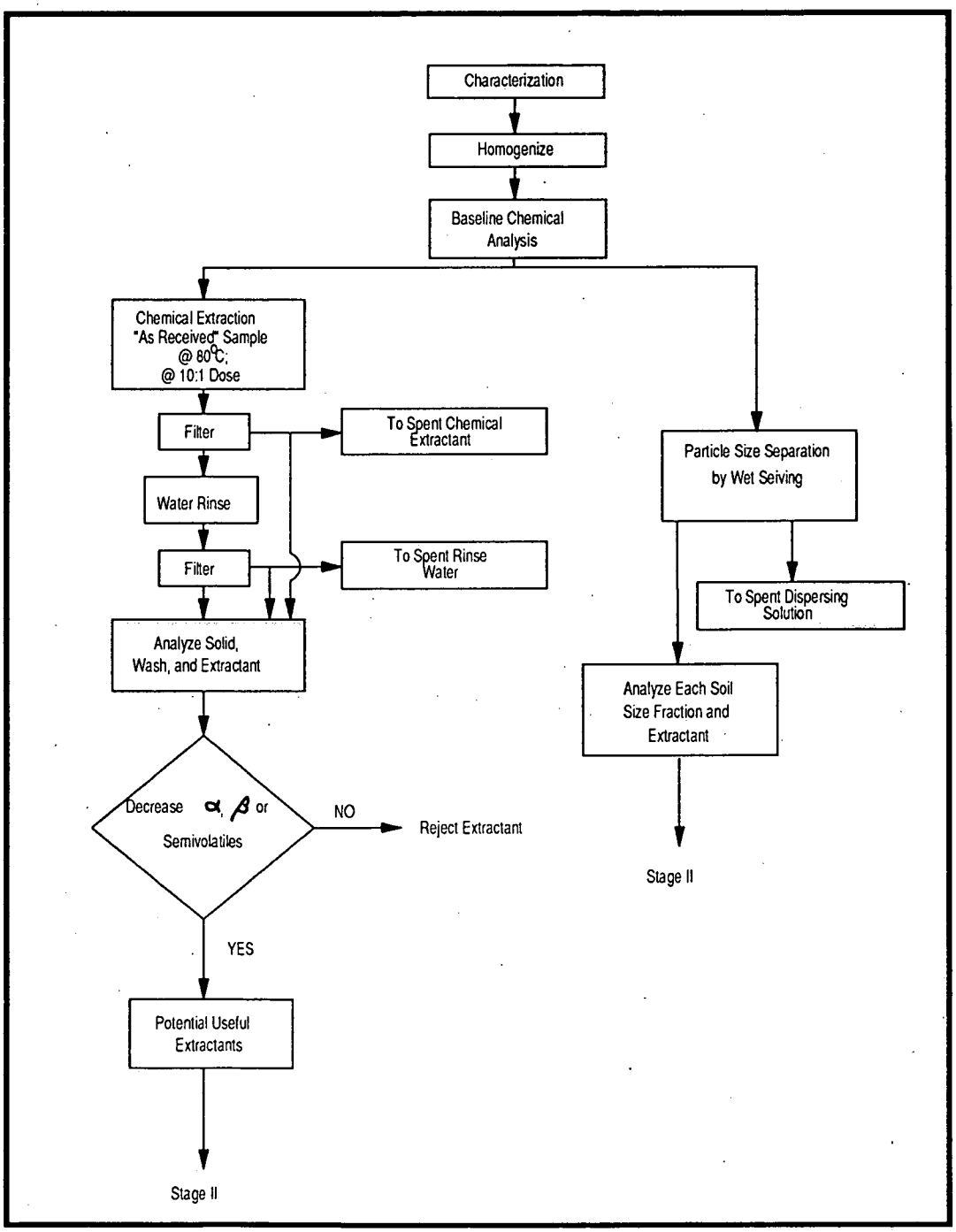

FIGURE 4-3. REMEDY SCREENING - STAGE I - CHEMICAL AND PHYSICAL EXTRACTION

TABLE 4-1
TEST PROGRAM FOR CHEMICAL EXTRACTANTS

Typical Extractants	Concentration	Dose (wt extractant/wt inital sample)
Acids/Bases/Salts		
H_2SO_4	1:1[a]	10:1
HCl	1:1[a]	10:1
HNO_3	1:1[a]	10:1
H_3PO_4	1:1[a]	10:1
$Na_2CO_3/NaHCO_3$	60/20 g/L[b]	10:1
NaOH	4N	10:1
$(NH_4)_2CO_3/NH_4HCO_3$	60/20 g/L[c]	10:1
NaCl	Various[d]	10:1
KCl	Various[d]	10:1
Chelants		
EDTA	30%	10:1
NSI	Commercial concentration	10:1
Citraklean	Commercial concentration	10:1
Surfactants		
Anionic	Various	10:1
Cationic	Various	10:1
Nonionic	Various	10:1
Octanol	Various	10:1

[a]Mixture of equal volumes of concentrated acid and water.
[b]60 g of Na_2CO_3 plus 20 g $NaHCO_3$ in each liter of solution.
[c]60 g of $(NH_4)_2CO_3$ plus 20 g of NH_4HCO_3 in each liter of solution.
[d]NaCl and KCl will be tested alone and in combination with other extractants.

The radiological activity of the extracted solid, extractant solution, and rinse water will be determined by performing uranium, gross alpha, and gross beta analyses. The concentrations of the four target semivolatile compounds in the extracted solid, extractant solutions, and rinse water will be determined by performing GC analyses as described in Section 4.2.1. The percent radiological and organic compound removal will be calculated.

4.2.4 Stage I - Contaminant Removal from Washing Solutions

A series of precipitation reagents will be investigated as illustrated in Figure 4-4. The reagents will be added in sequential order. A list of the tests for the precipitation of extraction solutions using sequential addition is in Table 4-2. These series of reagents have been investigated in earlier studies and have been determined to be effective under selective circumstances.

4.2.4.1 Stage I - Precipitation of Extractant Solutions

Precipitation reagents will be added to aliquots (3 to 5 cc) of the leachate solutions. The reagents to be investigated are the sodium or potassium salt solutions of hydroxide, sulfide, sulfate, carbonate, and phosphate. Alum, ferric sulfate, and aqueous sodium silicate ($Na_2O:SiO_2$) will also be investigated. Alum and ferric sulfate additions will be followed by the appropriate pH adjustments. Slurries of magnesium oxide (MgO) and calcium hydroxide ($Ca(OH)_2$) and dolomitic lime will also be tested. The solutions will be either syringe-filtered or filtered through a centrifugal microfilter using a 0.45-micron filter. A 0.45-micron filter is used to determine if a removable precipitate is formed. If larger particulates are needed to improve filtrations or settling, polymer addition and a filter aid may be used. The filtrate will be tested for uranium by IC fluorescence.

A series of reagents will also be added in a sequential order. The "first addition" reagent is added and allowed to react before the "second addition" reagent is added (Figure 4-4 and Table 4-2).

The most promising reagent formulations will be determined by use of professional judgment. The experimenter will note the appearance of turbidity and precipitation in the solution. Correlations between changes in pH and onset of turbidity and precipitation, and correlations of pH with volume or weight of titrant added will be noted. The experimenter will also note the rate of settling and which reagents lower the uranium concentration the most. The general procedure of this work plan is an iterative process where the results from matrices of experiments are used to determine the course of the next set of experiments.

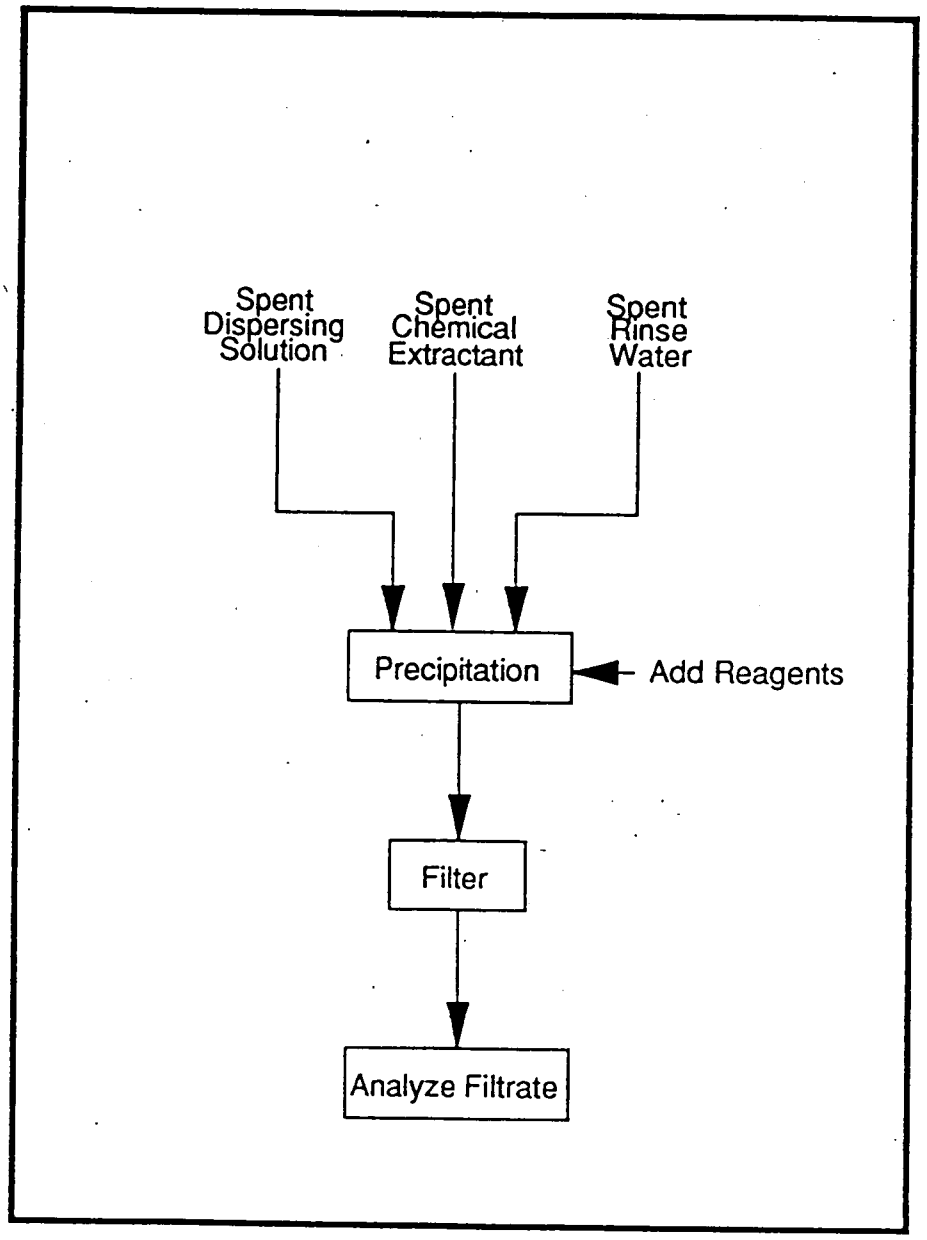

FIGURE 4-4. CONTAMINANT REMOVAL FROM WASH SOLUTIONS, STAGE I

TABLE 4-2
PRECIPITATION OF EXTRACTION SOLUTIONS

Solution	
First Addition	Second Addition
$Na_2O:SiO_2$	NaOH
$Na_2O:SiO_2$	Na_3PO_4
$Na_2O:SiO_2$	Na_2CO_3
$Na_2O:SiO_2$	Na_2S
$Na_2O:SiO_2$	MgO
$Na_2O:SiO_2$	$Ca(OH)_2$
MgO	Na_3PO_4
MgO	Na_2CO_3
MgO	Na_2S
NaOH	Na_3PO_4
NaOH	Na_2CO_3
NaOH	Na_2S
Na_3PO_4	NaOH
Na_3PO_4	MgO
Na_3PO_4	$Ca(OH)_2$

4.3 REMEDY SCREENING - STAGE II

4.3.1 Stage II - Initial Sample Preparation and Analysis

The soil samples for Stage II testing will be homogenized in the same manner as described in Section 4.2 for the Stage I samples. The following analyses will be performed before particle fractioning and chemical extraction (refer to Table 3-7):

- Gross alpha and beta
- Uranium by IC
- Semivolatiles
- Volatiles
- Eight HSL metals

4.3.2 Stage II - Physical Separation and Chemical Extraction

In Stage II, treatability testing incorporates the findings of Stage I testing, using an experimental design that will allow for the testing of the most effective extracting solutions on separate particle-size fractions. A flow diagram of Stage II is presented in Figure 4-5. The extractants that do not significantly decrease the gross alpha-beta, uranium, or semivolatiles in the soil in Stage I will not be used in Stage II.

The soil sample will first be sieved through a 9.5-mm screen to remove rocks and debris, then separated into specific particle-size fractions via wet sieving. Those size fractions determined during the Stage I testing to have strongly bound contaminants associated with the soil matrix will be used in this stage of testing. Each particle-size fraction will be analyzed for volatiles, semivolatiles, uranium, gross alpha and beta activity, arsenic, barium, cadmium, chromium, lead, selenium, silver, and mercury content. The soil fractions found to be contaminated will subsequently be subjected to chemical extraction.

The effects of temperature, extractant to soil ratios (dose rates), and the multiple extractants will be investigated according to Table 4-3. Two temperatures (ambient and 80°C) and two dose rates (2:1 and 4:1) will be tested. The soil will be extracted two times with virgin extractants. Fifty- to 100-gram aliquots of soil will be treated for four hours in each extraction. After each extraction cools to room temperature, the sample will be filtered. The sample will be slurry rinsed with deionized water after the second extraction.

The radiological activity of the extracted solid, extractant solution, and rinse water will be determined by gross alpha and gross beta analyses. The concentration of the eight volatile and semivolatile

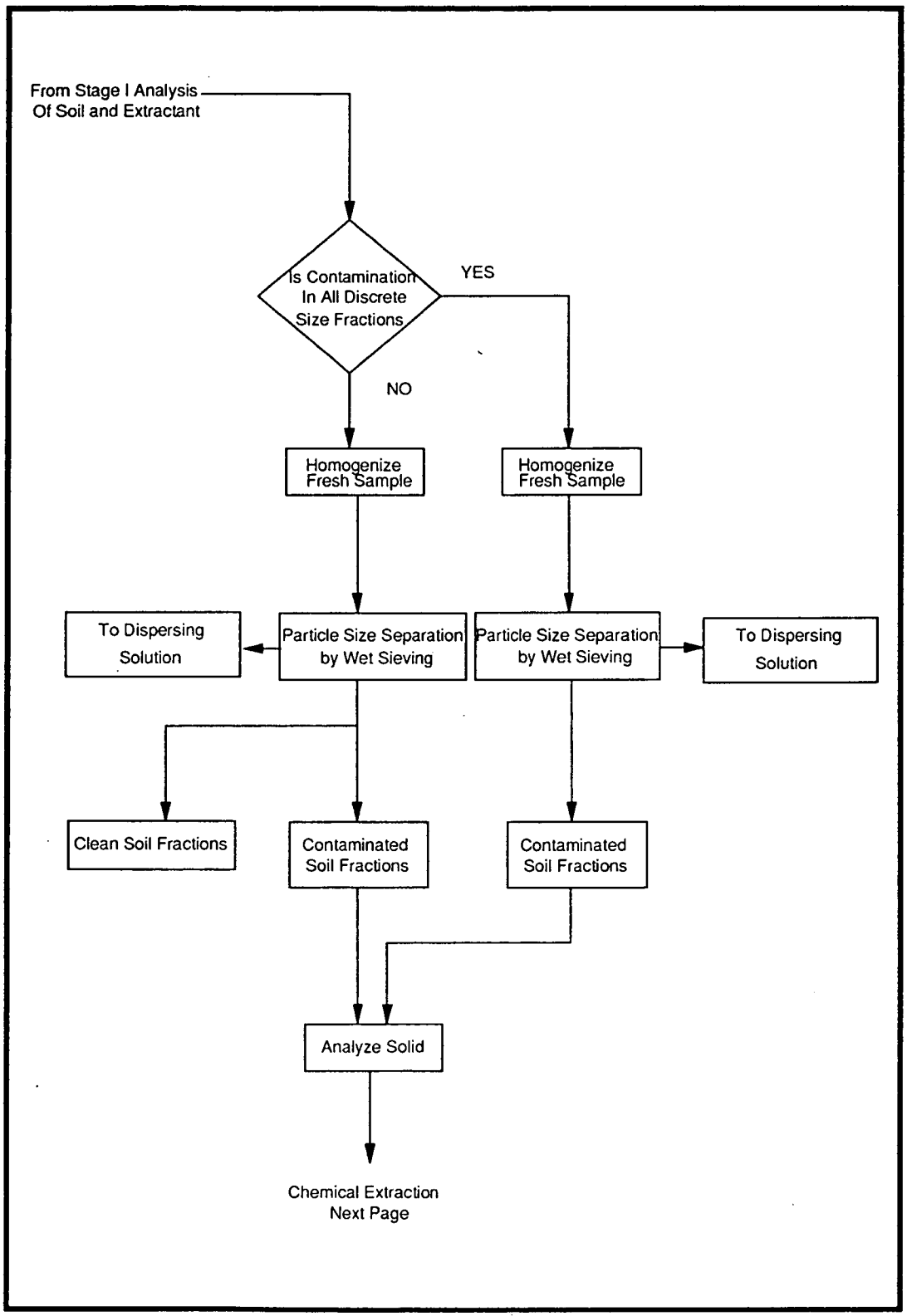

FIGURE 4-5. REMEDY SCREENING - STAGE II - PHYSICAL SEPARATION AND CHEMICAL EXTRACTION

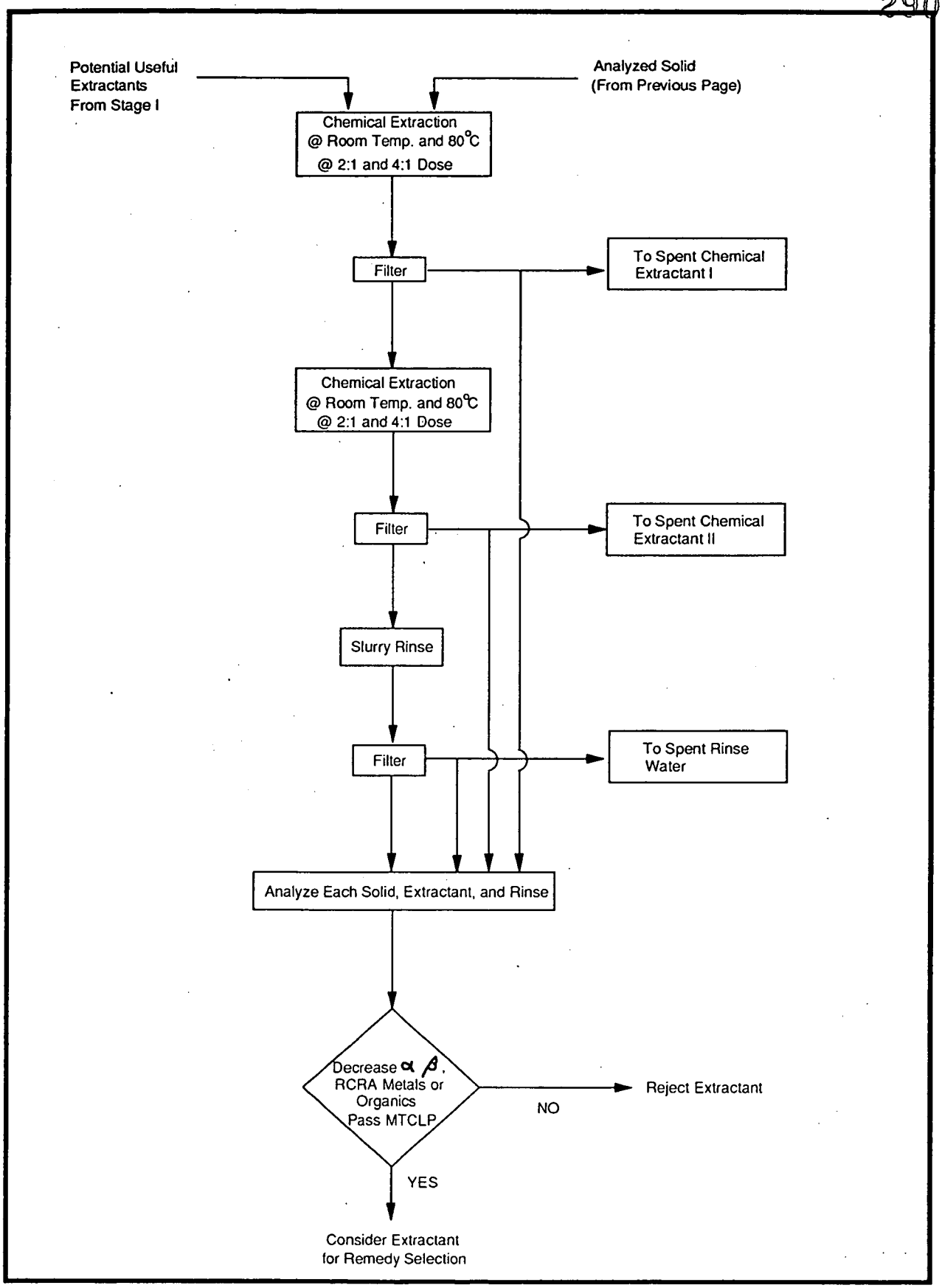

FIGURE 4-5. (CONTINUED)

TABLE 4-3

PROPOSED REMEDY SCREENING - STAGE II TESTS

Run Number	Dose Wt Extractant/Wt Initial Sample	Temperature (°C)	No. of Extractants
1	2:1	Ambient	1
2	2:1	Ambient	2
3	4:1	Ambient	1
4	4:1	Ambient	2
5	2:1	80	1
6	2:1	80	2
7	4:1	80	1
8	4:1	80	2

organic compounds in the extracted soil will be determined. The concentration of the semivolatile organic compounds in the extractant and wash water will also be determined. Uranium will be measured by IC and percent removal efficiencies will then be calculated. Modified TCLP (MTCLP), as described in Table 3-7, will also be performed on the extracted soil. Those extractants that decrease gross alpha and beta activity, metals, or organics by at least 80 percent will be considered for the remedy selection phase.

4.3.3 Stage II - Contaminant Removal from Washing Solutions

A series of precipitation reagents, resins, and precipitation aids will be investigated for contaminant removal from washing solutions. A flow diagram of contaminant removal from wash solutions for Stage II is illustrated in Figure 4-6.

4.3.3.1 Precipitation of Extractant Solutions

Larger aliquots (50 to 100 cc) of the washing solutions will be tested with the most promising precipitation reagents from Section 4.2.4.1 Settling rates will be determined. Aliquots of these mixtures will be filtered or centrifuged. Solutions from the latter two operations will be tested for uranium by IC fluorescence.

4.3.3.2 Settling/Polymers

If settling or filtration rates are very slow, then jar tests using inorganic coagulants (such as ferric sulfate) and/or organic polymers (such as Nalco #7768 anionic polymer) will be used. Preliminary range-finder tests will be performed with up to 10 different reagent combinations, incrementally adding the reagents until the appearance of floc. The most promising treatment, based on dosage versus sludge volume and effluent quality, will be tested at four different dosages to determine the most effective reagent dosage. A settling test will be run on the best treatment and dosage. The clear supernatant liquid will be sampled and analyzed for uranium by IC fluorescence.

4.3.3.3 Settling - Filter Aids

If the filtration rates are slow, these tests will be conducted. The feed solids concentration will be adjusted to pumpable solids concentration and the body feed concentrations to three different dosages of filter aid. Filter aid concentrations will be those recommended by the manufacturer. The treated samples will be filtered in a Buchner funnel. The optimum dose of reagents will be that producing the driest cake and the most filtrate in the shortest time. The filtrate will be analyzed to determine if the process successfully lowered the metal content. The filtrate will be tested for uranium by IC fluorescence.

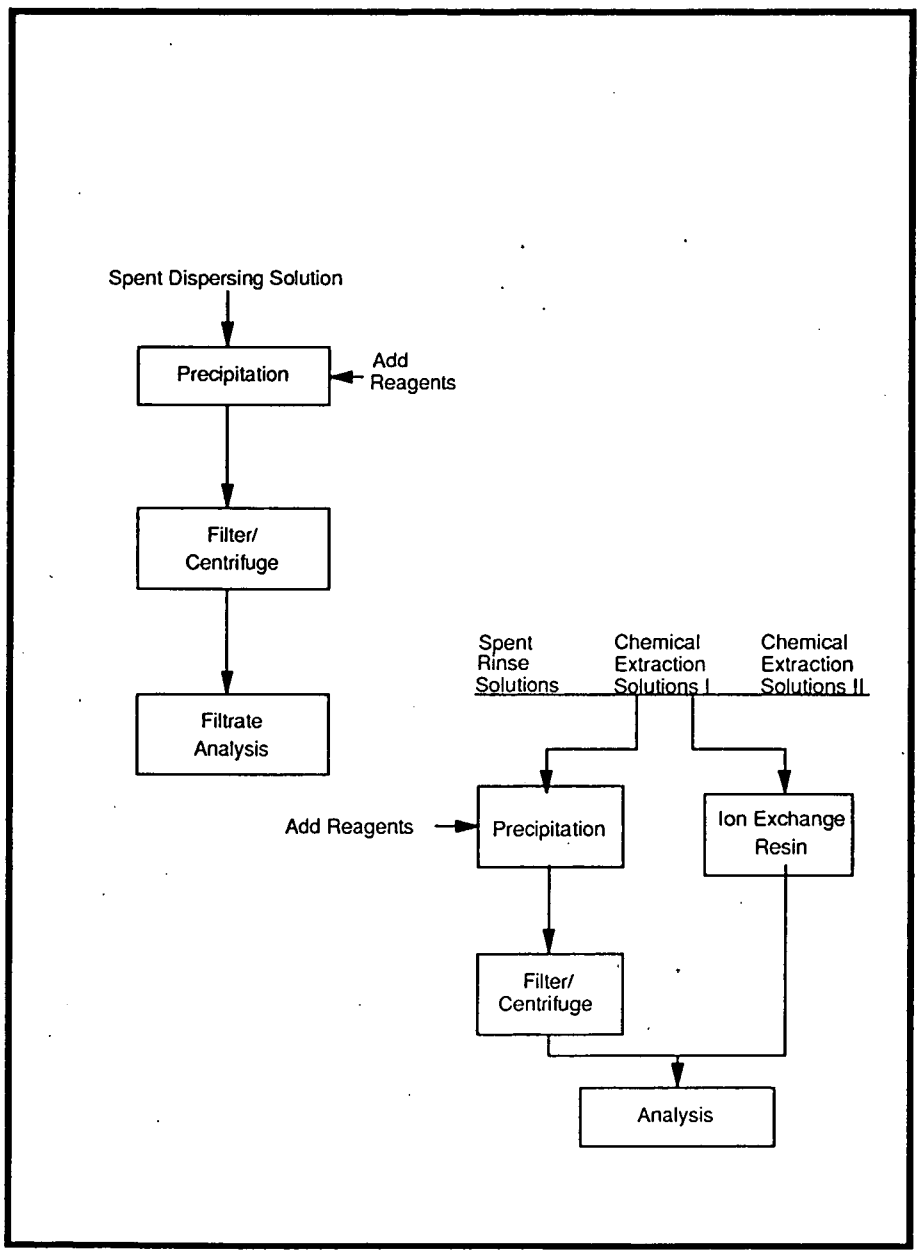

FIGURE 4-6. CONTAMINANT REMOVAL FROM WASH SOLUTION - STAGE II

4.3.3.4 Ion Exchange Resins

A series of isotherms with 11 resins, selected for their different bonding capacities, will be investigated in order to elucidate the most effective resin for removal of uranium. The uranium content will be determined by IC fluorescence after each hour of stirring for four hours and after stirring for 24 hours. Column experiments using the most promising resins will be conducted. At least 600 cc of liquid will be treated in these column experiments. The filtrate will be tested for uranium by IC fluorescence.

4.3.4 Stage II - Residual Organic and Surfactant Removal

If excessive organic residues remain in the soils, bioremediation technology will be investigated to remove these residual organic compounds and surfactants on the extracted solids. A slurry batch reactor would be used. Biological reagents would potentially have to be added to the slurry because the previous extraction procedure would probably sterilize the soil.

4.4 REMEDY SELECTION

The remedy selection testing will combine particle-size physical separation and chemical extraction into a single operation, incorporating the findings from Stages I and II into a laboratory/pilot-scaled version of the soil washing system (Figure 4-5).

4.4.1 Soil Size Physical Separation

The process flow sheet (Figure 4-7) for treating contaminated soils describes a proposed or tentative operation based on the information derived from the earlier soil sampling and analyses. For purposes of simplifying the explanation of the flow sheet, only uranium will be mentioned as the contaminant. The uranium contamination is also assumed to be present in several forms, including ionic, particulate, and as soil-particle coating. The size of the contaminated particles is assumed to be less than 75 microns. Before the soil is processed, it will be homogenized as described in Section 4.1.1, and analyzed for organics and inorganics in accordance with Table 3-1.

The contaminated soil will be fed to a two-inch scalping screen to remove coarse rock and large pieces of debris. The minus-two-inch material will be fed to a scrubbing trommel that is fitted with a 3/8-inch screen. The trommel's spray bar will wash the fines from the coarse particle. The tumbling and lifting action ensures that the fine material will be broken into clean discrete particles. The minus-2-inch by 3/8-inch material will be a clean pebble and debris product. The minus-3/8-inch fraction will be fed to a minus-14-mesh screen. This screening step is necessary to protect the fine screen, which makes a separation at 75 microns. The minus-3/8-inch by 14-mesh oversize will be a clean sand product. The minus-14-mesh undersize will be screened to achieve a 75 micron (200-mesh)

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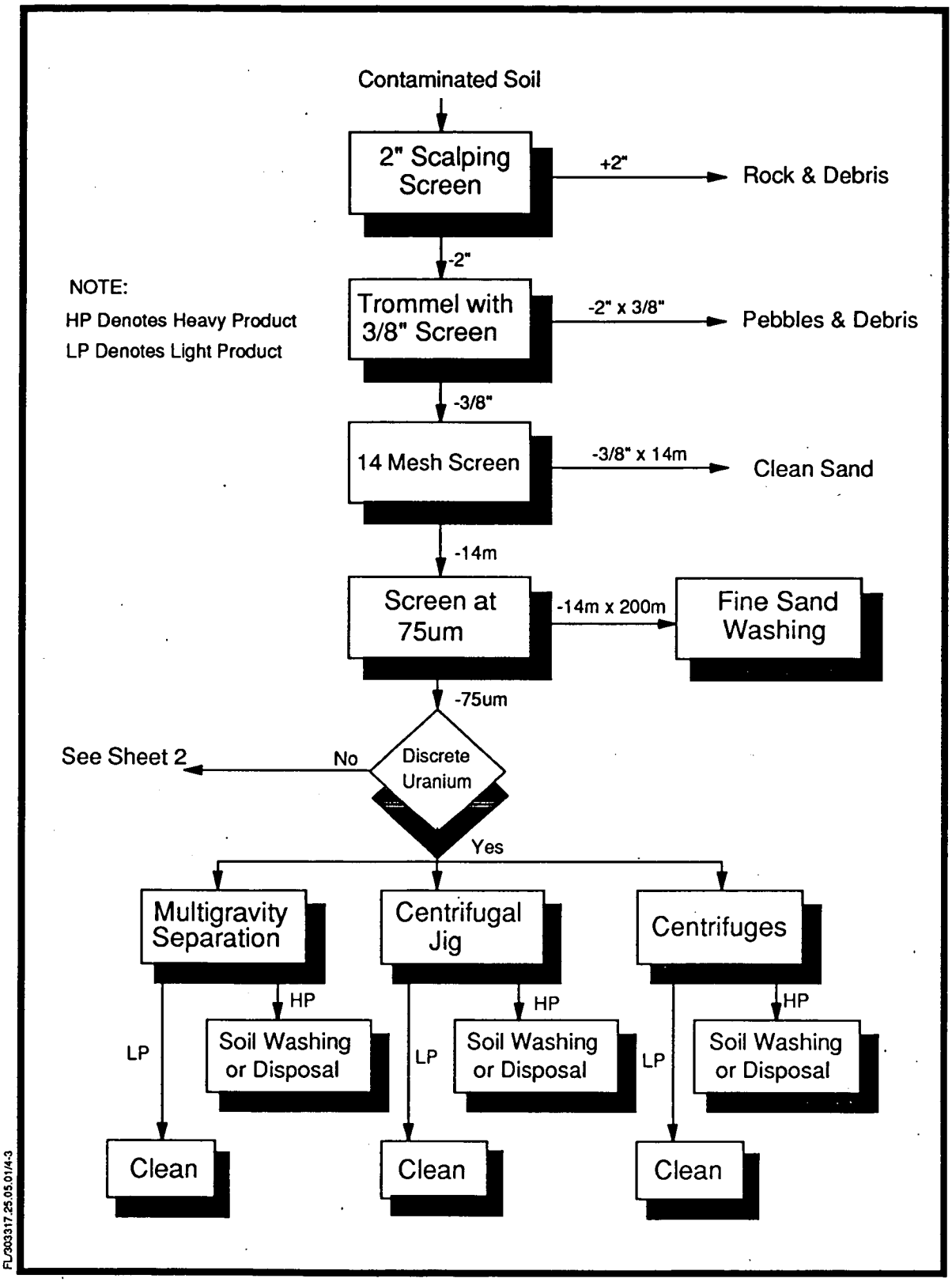

FIGURE 4-7. PROPOSED PROCESS FLOWSHEET FOR CONTAMINATED SOILS

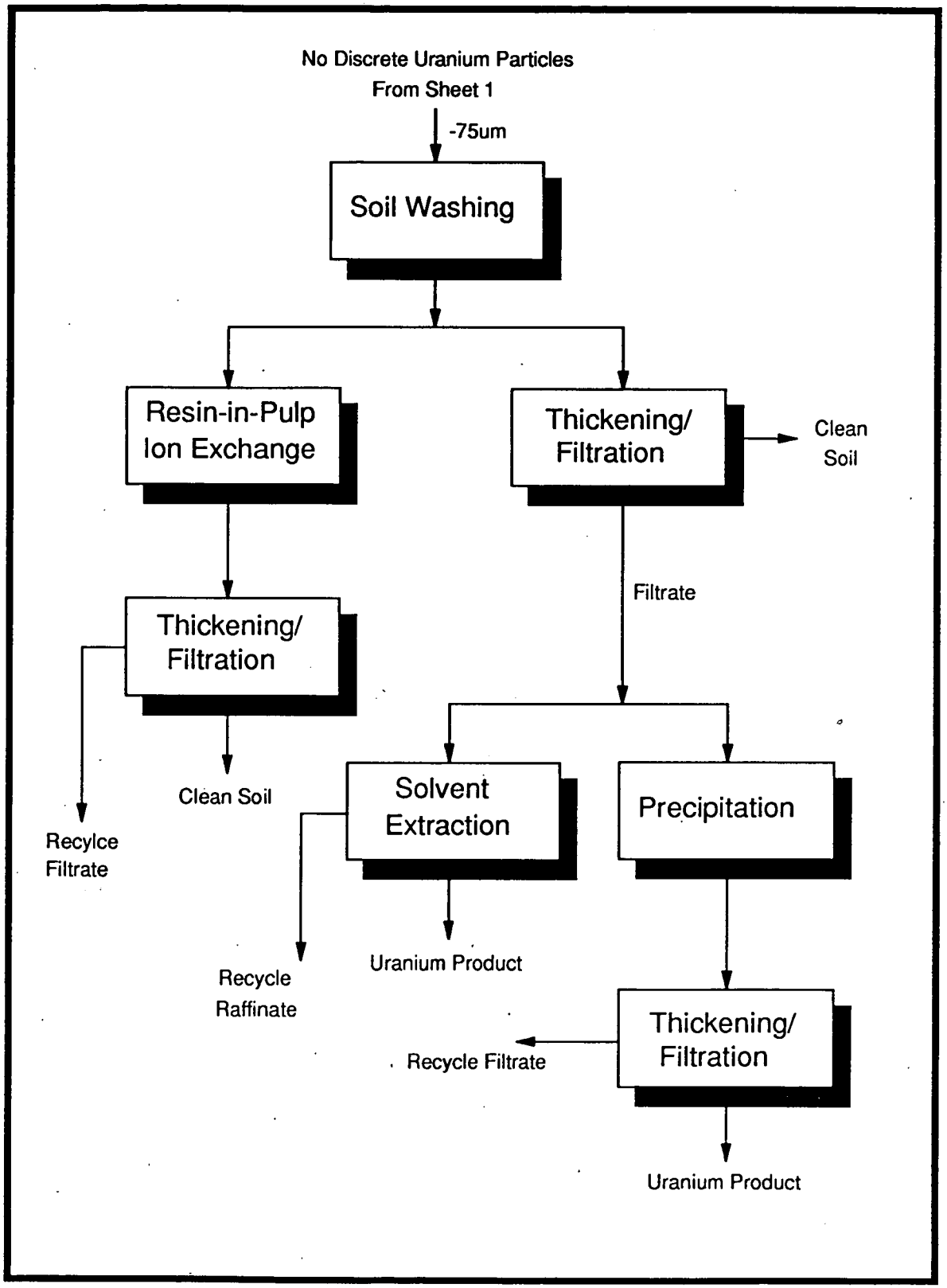

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FIGURE 4-7. PROPOSED PROCESS FLOWSHEET (CONTINUED)

separation. The minus-14-mesh by 200-mesh fraction may be clean product or may require soil washing.

A decision point has been inserted in the flow sheet, since it is uncertain whether or not the uranium contamination is present due to ion exchange with clay minerals, insoluble particulates, and/or physically bound coating of the particles. If discrete uranium particles are present, three optional multigravity separation processes are available. These processes are multigravity table separation, centrifugal jig, and centrifuges. These machines will produce a light-gravity and heavy-gravity product. The light-gravity product should be a clean soil, but may need a soil washing treatment. The heavy-gravity product can be disposed of or treated for uranium recovery, which will produce a clean product and a recyclable uranium product.

If the minus-75-micron (200-mesh) material contains no discrete uranium particles, the product will have to be processed by soil washing. One of the soil washing processes could incorporate resin-in-pulp ion exchange followed by thickening and filtration of the slurry. A clean soil and recycled filtrate are the products. The other alternatives for soil decontamination are extensions of the soil washing process. The soil washing slurry is thickened and filtered. This process yields a clean soil and a filtrate. The filtrate is decontaminated by solvent extraction or precipitation. If solvent extraction is used, a recycled raffinate and uranium product is formed. The precipitation route requires a thickening and filtration step to give a recycled filtrate and uranium product.

4.4.2 Chemical Extraction

The most effective chemical extractant solutions will be tested on soil samples from various locations. It is expected that a combination of chemical extractants and leachates will be necessary to remove the metals, organics, and radionuclides from the soil. As an example, the soil could first be extracted with a basic mixture containing surfactants (e.g., $(NH_4)_2CO_3$ combined with a nonionic surfactant) to remove organic compounds and some metals followed by an acid extraction enhanced with KCl (e.g., HCl, HNO_3, or H_2SO_4 combined with KCl) to remove metals and radionuclides. Depending on the results from the earlier phases, each extraction process may involve one or more stages. In this context, a stage consists of an extraction followed by a filtration.

The radioactive constituents will be analyzed in the extracted soils, extractant solutions, and wash water. In addition, a full TCLP with radionuclide constituents will be performed on the extracted solids. The concentration of the HSL metals and organic compounds in extractant and wash water will be determined by SW-846 methods. The percent removal efficiencies will be calculated.

4.5 DATA REQUIRED

The following data will be acquired during soil washing studies:

- Soil characterization data including moisture content, specific gravity, plasticity index, particle size distribution, total organic carbon (TOC), cation exchange capacity (CEC), and complete chemical characterization
- Percent by weight of the amount of soil within each particle-size fraction
- Concentration of target organic compounds associated with each particle-size fraction
- Concentration of target organic compounds in extracted soil, extractant, and rinse water during remedy screening
- Concentration of HSL metals from MTCLP during remedy screening
- Percent decrease in gross alpha and beta in soil
- Gross alpha and beta in the extractant, rinse, and in extracted soil during remedy screening
- Effectiveness of washing solution additives, expressed as amount of contaminant removed per amount of soil treated and volume of washing solution used
- Percent by weight of the amount of volume of soil reduced
- Full TCLP on extracted soils during remedy selection
- Radionuclide concentration in soil, extractants, and washwater during remedy selection
- Uranium in cleaned wash solution (by IC fluorescence)
- Organics in extractants and washwater during remedy selection
- Temperature of wash solution
- Resin type and effectiveness
- Types of filter aids

5.0 EQUIPMENT AND MATERIALS

A variety of equipment, materials, and reagents will be utilized in conducting the soil washing treatability studies and performing the associated analyses. This includes the equipment and materials necessary for leachate analyses, MTCLP analyses, and TCLP analyses. The reagents required are not listed here since they are described in detail within Chapter 4.0, Experimental Design and Procedures.

Table 5-1 lists the major equipment which will be used during the remedy screening and remedy selection soil washing testing.

TABLE 5-1
EQUIPMENT AND MATERIALS[a]

No. of Items	Item Description
Multiple	Plastic containers, 8 oz. and 5 oz.
Multiple	Spatulas
1	HACH digital pH meter
1	Soiltest Laboratory vibrating shaker
1	Thermometer, calibrated and traceable
1	Scale, calibrated
1	Drying oven
1	Multigravity separator
1	Kelsey centrifugal jig
1	Fulcan centrifuge
1	Knelson centrifuge
1	Scalping screen
1	Trommel screen
1	RO-TAP sieve shaker
1	Standard testing sieves 3" (stainless steel series)
1	Stainless steel soil sampler
1	High pressure cyclone
1	Sedimentation cylinders
1	Hydrometers
1	Mechanical stirring apparatus

[a]This equipment list does not include analytical instrumentation for leachate analyses, equipment for TCLP, or general laboratory equipment.

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6.0 SAMPLING AND ANALYSIS

The Sampling and Analysis Plan (SAP) for treatability studies on site soils is defined in this section of the Treatability Study Work Plan. It describes the incorporation of the ID soil sampling program with the SAP for the Soil Washing Treatability Study Work Plan for Operable Unit 5. The SAP ensures that samples obtained for characterization and testing are representative and that the quality of the analytical data generated is known and appropriate. This SAP addresses initial site selection, initial soil sampling and characterization, and the field sampling plan.

6.1 OVERVIEW

The collection of soil samples for soil washing treatability studies is a critical function within the experimental design. The rationale for selecting the location of soils and the number of samples to be collected is based on the objectives and constraints placed on the soil washing program. A primary consideration in this work study plan is to integrate the soil washing treatability technology being evaluated with other technology evaluations for on-site remediation of Operable Unit 5 soils. Part of this integration is to use soils common to the Uranium Soil Integrated Demonstration Treatability Sampling Plan (in revision). Therefore, this SAP for soils will incorporate the ID's sampling plan as part of the total scope of the Operable Unit 5 treatability study work plan (see Appendix E).

The sampling program's primary objective is to first select locations on site that contain soil that is representative of the contamination problem at the FEMP. These selected locations will then be sampled in a manner to retrieve a representative sample of soil for each location. A physical/chemical characterization of these soils will be conducted. Based on the results of these initial analyses, a final selection will be made as to the four locations to be used in the soil washing treatability study. A subsequent objective of this sampling program will then be to collect a sufficient quantity of soil from each of the four locations that will be homogenized (per location), and completely characterized (physically and chemically) for use in treatability testing.

The primary constraints within the soil sampling program will be sample size restrictions and personnel exposure limitations. Sample size restriction will be based on radiological limitations associated with the volume of soil proposed for collection and the level of radionuclides present in the soil. Personnel exposure limitations will also be governed by the level of radioactivity in soils used in treatability studies. Both of these constraints will be determined during the initial sample collection and characterization part of the sampling program.

This SAP identifies the procedures specific to the ID sampling program as well as the those procedures applicable to the Operable Unit 5 sampling program. The locations selected for initial soil sampling and characterization have been previously reported in initial site characterization data to contain a specific level and range of contaminants. Five soil locations were selected for the ID program based on the criteria for a soil with high levels of radionuclides and low levels of other inorganic and organic contaminants. Four additional locations have been selected in support of the Operable Unit 5 program for soils containing radionuclides and high levels of organic and inorganic contaminants, i.e., "mixed-waste" soils. This selection of nine Operable Unit 5 soils will provide a range in soils, contaminants and contamination levels that are considered to be representative of the soil contamination problem on the FEMP site.

Following the initial characterization of soils from each of the nine locations, soils from four locations will be selected for testing in the soil washing treatability study for Operable Unit 5; two of the four soils will be selected from locations designated by the ID program, and collected in accordance with the ID's Site Media Sampling Plan (see Appendix E). The additional two mixed-waste soils will be collected according to guidelines developed in this section of the work plan.

6.2 ID SAMPLING PLAN FOR SOILS

Five locations representing three characteristic waste forms (aqueous uranium waste, solid uranium product particulate, and airborne uranium waste particulate) were selected based on preliminary studies of site data. Four of the five following locations listed below are illustrated in Figure 6-1:

- Plant 2/3 Area
- Plant 1 Storage Pad Area
- Decontamination Pad/Drum Bailing Area
- Plant 6 Area
- Old Incinerator Area (not shown)

In June 1991, screening samples were obtained from these five locations in accordance with the RI/FS QAPP. The objective was to determine some specific physical/chemical data on the soil and uranium waste forms. Data tables from the "Characterization of Uranium Contaminated Soils from DOE Fernald Environmental Management Project Site: Results of Phase I Characterization," describing the results of this initial characterization, are contained in Appendix E. Based on the results of this report, two locations, the Plant 1 Storage Pad Area and the Old Incinerator Area, were selected for the collection of soils for ID treatability tests.

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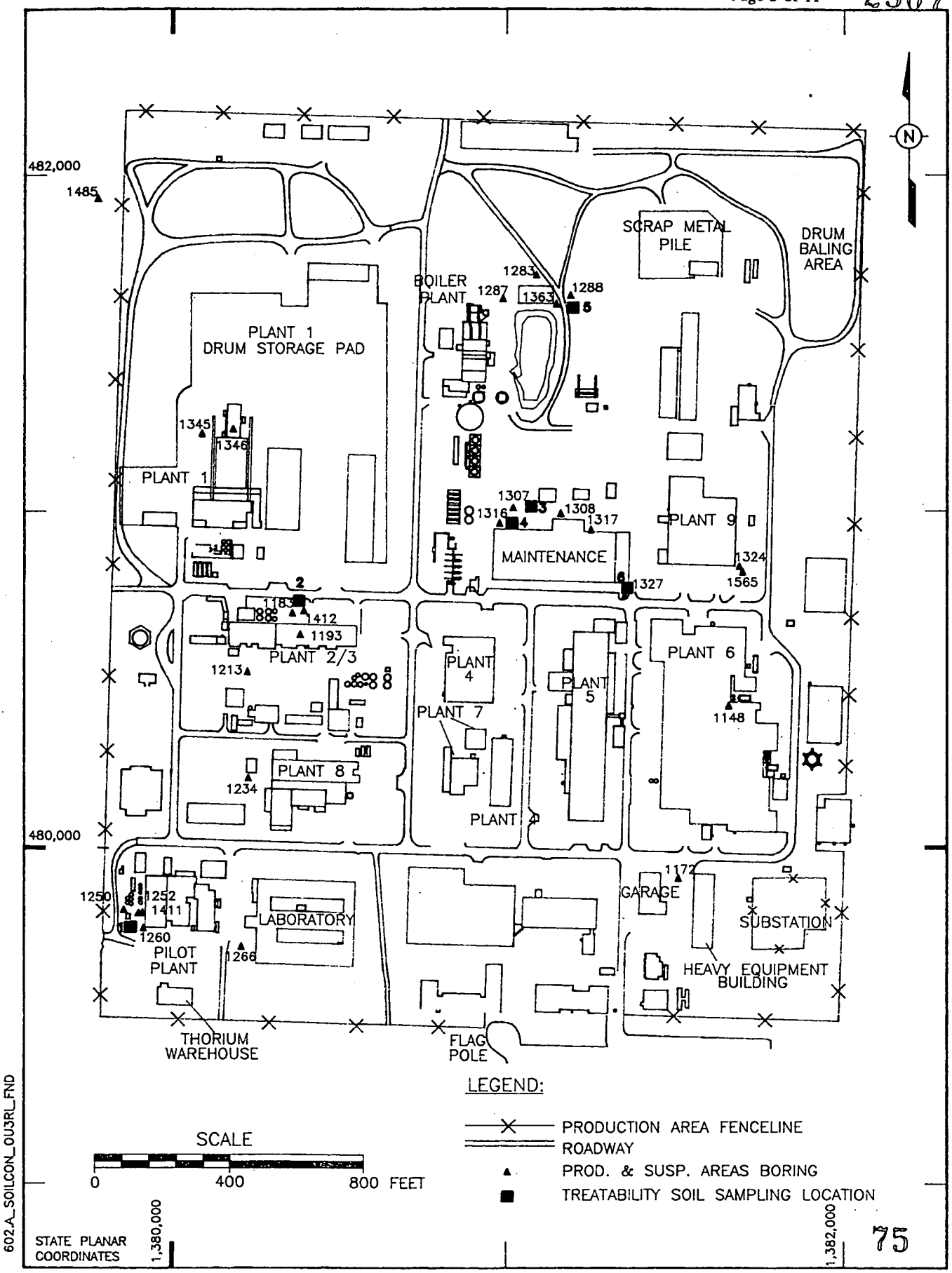

FIGURE 6–1. TREATABILITY SOIL SAMPLING LOCATIONS

Each location will be staked out to delineate the boundaries of the effective area. A grid of the area will be layed out so that volatile levels and radioactivity levels can be measured to determine homogeneity of surface soil within each location. Surface monitoring of soil within each location for volatiles will be done using a photoionizing detector while radiation levels will be measured using an alpha-beta frisker. Soil samples for volatile organic analyses will be collected first from each undisturbed location prior to excavation of the soil for treatability testing. Discrete point samples of soil for volatile analysis will be necessary in order to minimize volatile loss during sampling. These sampling points will be selected based on surface monitoring results in order to obtain representative soil from each location.

All vegetation will be removed prior to the excavation of the soil. The soil will be excavated to a depth of 15 to 20 centimeters by the use of a backhoe. A radiological survey utilizing sodium iodide detectors will be conducted in conjunction with soil removal to ensure that material being removed exceeds the action level of 35 pCi/g. The soil will then be screened through a 3/4-inch mesh. Material not passing the screen will be collected and stored for future analysis. Soil passing the screen will be collected and blended to obtain homogenous samples representing the location.

Blending of soil will be conducted using a redi-mix cement truck. After initial blending, a coring device will be used to collect representative aliquots of soil from each drum. A screening test will be conducted to determine homogeneity of the soil among the drums. This testing procedure is contained in Appendix E, Testing For Homogeneity. Soil homogeneity will be determined by first determining the distribution of soil particles into three diameter size classes (>2, 2-0.075, and <0.075 mm). Each size class will then have total uranium activity determined by a direct counting method. If it is determined that homogeneity of the soil among the drum does not exists, the soil will be removed from the drums and further blended. This will be followed again by testing for homogeneity.

Once homogenized, representative aliquots of the soil will be collected and completely analyzed to provide both a physical and chemical baseline of the material for future treatability testing. Table 6-1 lists all the analyses to be conducted on this soil. Only TCLP and HSL volatile organic analyses will not be conducted on this homogenized soil, since it was conducted on the soil prior to excavation.

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TABLE 6-1
CHEMICAL AND PHYSICAL ANALYSES FOR CHARACTERIZATION STUDY OF OPERABLE UNIT 5 SOILS

Organic List	Inorganic List		
	Chemical Analyses		Physical Analyses
Chemical Analyses	TCLP and HSL Metals	Radiological	
TCLP Volatiles	Aluminum	Cs-137	Moisture content
TCLP Semivolatiles	Antimony	Np-237	Specific gravity
TCLP Pesticides/PCBs	Arsenic	Pu-239	Atterberg limits
	Barium	Pu-240	Particle size
HSL Volatiles	Beryllium	Ra-226	Total organic carbon (TOC)
HSL Semivolatiles	Boron	Ra-228	Cation exchange capacity (CEC)
HSL Pesticides/PCBs	Calcium	Ru-106	Mineralogy
	Cadmium	Sr-90	
	Chromium	Tc-99	
	Cobalt	Th-230	
	Copper	Th-232	
	Cyanide	U-234	
	Lead	U-235	
	Magnesium	U-238	
	Manganese	Gross alpha	
	Mercury	Gross beta	
	Molybdenum		
	Potassium		
	Nickel		
	Selenium		
	Silicon		
	Silver		
	Sodium		
	Thallium		
	Vanadium		
	Zinc		

6.3 INITIAL LOCATION SELECTIONS FOR MIXED-WASTE SOILS

Four additional locations were selected for potential use in soil washing treatability studies, based on data generated during earlier soil sampling and characterization programs. These four locations, illustrated in Figure 6-1, are described in Table 6-2. Two previous soil sampling programs have been conducted as part of the RI/FS to characterize the extent and level of contamination in the soils within the Production Area. The first, a surface soil sampling program completed in the Spring of 1988, was conducted under the March 1988 RI/FS Work Plan. The second, a subsurface soil sampling program started in 1989, was conducted under the Production and Additional Suspect Areas Addendum to the RI/FS Work Plan. Appendix A contains the location of the borings and the supportive chemical analyses for the soils in the four locations selected for initial characterization. Results from these past sampling programs have provided the basis for the selection of representative sampling locations for soils to be used in the soil washing treatability testing.

Sampling bias in this SAP will be necessary to retrieve soil that has a designated range or level of contamination for each contaminant type, including radionuclides, organics, and inorganics. This type of sampling should provide the soil washing study with a "worst case" scenario: a mixed-waste soil with elevated levels of radionuclides (in particular, uranium concentrations greater than 200 μg/g) and elevated levels of organic and inorganic contaminants. This type of sampling should also provide a mixed-waste soil with elevated levels of organic and inorganic contaminants with uranium concentrations less than 50 μg/g. This range in the concentration of contaminants should enable the evaluation of soil washing efficiency on mixed-waste soils with both high and low levels of uranium contamination.

There are a number of potential sampling locations within the Production Area that would provide surface soils from the upper 30 centimeters (0 to 12 inches) of the soil profile that meet the above criteria. The four potential locations selected for consideration in the soil washing treatability studies are described below. These locations were selected based on the results of samples tested during the soil sampling program for the Production and Additional Suspect Areas Addendum to the RI/FS Work Plan.

6.4 INITIAL SOIL SAMPLING AND CHARACTERIZATION

The first objective of this SAP is to collect representative soil samples from the four targeted locations. Two of the four locations will be selected based on high levels of uranium (<200 μg/g) and elevated levels of organic and inorganic contaminants, and two locations will be selected based on soils containing low levels of uranium (<50 μg/g) but high levels of organic and inorganic contaminants. Sufficient soil will be collected to conduct a complete physical and chemical characterization of each location. Table 6-1 lists all physical parameters and chemical analytes to be

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TABLE 6-2
POTENTIAL SAMPLING LOCATIONS WITHIN THE PRODUCTION AREA

Location	Uranium	Volatiles	Semivolatiles	PCBs
North side of Plant 2/3 adjacent to the tributyl phosphate tanks and Boring 1183	3880 µg/g	Low levels	Low levels	Low levels
Northeast area of Maintenance Building near Boring 1307	330 µg/g	High levels	Medium levels	Low levels
North of Graphite Furnace Oil Burner near Boring 1283	467 µg/g	Medium levels	Medium levels	Low levels
Southeast corner of Maintenance Building near Boring 1327	133 µg/g	Low levels	High levels	Low levels

determined for the initial characterization of Operable Unit 5 soils. All the analytical methods and sampling criteria are listed in Table 6-3.

Each location will first be staked out, based on the findings of earlier sampling reports, to delineate the boundaries of the effective area. A grid of the area will be layed out so that volatile levels (photoionization detector) and radioactivity levels (beta-gamma frisker) can be measured to determine homogeneity of surface soil within each location. Six discrete soil samples within each location will be collected from the upper 30 cm (12 inches) of the soil using a stainless steel 4-inch bucket auger. The six samples from each location will be composited into a stainless steel five-gallon can (one can per location). The lid will be removed from the can only during the placement of the soil from the auger following sampling. Additional precautions will be taken to ensure that loss of volatiles will be minimized during this sampling phase. When all six samples have been collected for the location, the soil will be chilled to 4°C prior to sample shipment. Samples will be maintained at 4°C during shipment to the Environmental Technology Development Center (ETDC).

Once at the laboratory, the soil will be maintained in a refrigerator at 4°C during the mixing of the soil within each stainless steel can using a stainless steel spoon. The final mixture will be considered a homogeneous soil composite for that location. Representative aliquots (Table 6-3) from this homogeneous composite will be taken and maintained at 4°C until analyzed for complete physical and chemical characteristics. Standard analytical procedures from ASTM for physical analyses, and EPA Method SW-846 and CFR40 Part 136 for all chemical analyses will be used in the initial soil characterization. Specific references to individual methods are noted in Table 6-2.

6.5 SOIL SAMPLING FOR TREATABILITY STUDIES

The sampling or collection of soils that are representative of the contamination problem at the FEMP for use in treatability studies is a primary purpose of this sampling and analysis section of the Work Plan. The initial chemical and physical characterization of the four locations described previously will provide the fundamental information to select two primary locations where the soil is considered optimum for use in soil washing treatability studies. Based on these results, this part of the SAP describes the procedures to be followed to collect a sufficient volume of representative soil for use in the soil washing studies.

Before the collection of soils in the two primary designated locations, each will be monitored again to determine the "hot spot" within the delineated areas. A beta-gamma frisker will be used to monitor for radionuclides and a photoionization detector for volatile organics. An approximately

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TABLE 6-3
ANALYTICAL METHODS AND CRITERIA FOR OPERABLE UNIT 5 SOIL SAMPLING

Analysis	Volume	Container	Preservative	Holding Times	Method
RAD screen	1 - 15 g	VOA vial - 40 ml	None	None	
TCLP and HSL volatiles	2 - 85 g	VOA vial - 40 ml	Cool 4°C	14 days	624 CLP
TCLP and HSL semivolatiles (base neutral/acid)	1 - 100 g	Amber glass Teflon-lined cap	Cool 4°C	14 days until extraction 40 days after extraction	625 CLP
TCLP and HSL pesticides/PCBs	1 - 100 g	Amber glass Teflon-lined cap	Cool 4°C	14 days until extraction 40 days after extraction	608 CLP
TCLP and HSL metals	1 - 100 g	Amber glass	None	6 months	200 CLP
Cyanide	1 - 100 g	Amber glass	Cool 4°C	14 days	335.2 CLP
Total organic carbon	1 - 100 g	Glass	Cool 4°C	28 days	SW-846 9060
Radiological	1 - 100 g	Amber glass	None	6 months	
Physical parameters	1 kg	Clear glass	None	None	
Moisture content					ASTM D2216
Specific gravity					ASTM D854
Atterburg limits					ASTM 4318
Particle size					ASTM 422
Cation exchange capacity					SW-846 9081
Mineralogy					

20-foot- square area will be marked off as the area from which to collect the soil within each location. A rototiller will be used to loosen the surface soil and to provide a vertical mixing of the soil within the 20-square-foot sampling location prior to collection of the soil. All soil will be collected from within the 0 to 30-cm (0 to 12-inch) portion of the soil profile.

A stainless steel shovel will be used to transfer the soil from the ground to a 3/4-inch screen. The material not passing the screen will be collected and stored in 55-gallon drums for future analysis. Soils passing the screen will be further homogenized on site using a one-cubic-yard cement mixer. (Note: Use of a mixer may pose slight increases in certain metals; e.g., iron and nickel, or residual contaminants such as calcium: the level of increase in compounds bearing these elements is considered to be insignificant, relative to the need to provide a homogenous soil for use in treatability studies.) The soil will be transferred from the mixer onto a sheet of Herculite plastic. When sufficient soil to fill three 55-gallon drums has been collected on the plastic sheet, an additional mixing of the soil will be done using the stainless steel shovel. Based upon visual inspection of this material for homogeneity, the final soil composite for that location will then be transferred to the three 55-gallon drums and four 5-gallon buckets using the shovel. Volatile organic compounds may be lost from the soil during this process; these losses are considered standard with the normal preparation of soil within the soil washing process.

Prior to transferring the homogenized soil to drums, aliquots of the soil will be collected and sent to the laboratory for a complete physical and chemical characterization of the soil. Table 6-3 identifies the analytical method and criteria for soil sampling. In addition, four 5-gallon metal buckets of soil will be collected prior to the remaining soil being transferred to 55-gallon drums. These five-gallon buckets will be sealed and prepared for shipment to the soil washing treatability testing laboratory. Each 55-gallon drum and 5-gallon bucket will be secured and the drum properly labeled for storage and/or shipment. A chain-of-custody will be attached to each drum. A chain-of-custody and request for analysis will be completed for each set of four 5-gallon buckets to be sent for soil washing treatability testing. All drums and buckets will initially be stored on FEMP property until needed for soil washing studies.

6.6 QA/QC REQUIREMENTS FOR SAMPLING PROGRAMS

QA/QC protocols will follow the RI/FS QAPP, Revision 3, Volume 5 (DOE 1988) sampling requirements. These requirements include instrument calibrations, blind duplicates, trip blanks, and sampling equipment rinsates. All sampling equipment will follow chemical and radiological decontamination procedures as stipulated in the QAPP. Additional QA/QC guidelines for data management and analyses are described in Sections 7.0 and 8.0.

6.7 HEALTH AND SAFETY

Site-specific health and safety procedures for the SAP are described in Appendices C and D of this work plan. All soil sampling will be monitored by a health physics technician.

6.8 WASTE MANAGEMENT

Waste management, handling, and packaging requirements for the soil, residue and debris are part of the soil washing treatability study, and will be provided for by Westinghouse Environmental Management Company of Ohio (WEMCO) in accordance with their Procedure SOP-65-C-106. The generated waste will be handled as radioactive waste, packaged in appropriately labeled containers, and transferred to WEMCO for further handling and/or disposal. No liquid wastes, other than decontamination fluids, are expected to be generated during the sampling program. However, if any liquid waste is generated, it will be handled in accordance with WEMCO provisions and transferred to WEMCO for disposal after appropriate containment and packaging.

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7.0 DATA MANAGEMENT

Two types of laboratory notebooks will be used for this project. All laboratory notebooks are uniquely numbered and have sequentially numbered pages. The Technology Development Laboratory Standard Operating Procedure No. 1503 identifies the notebook criteria on data logging procedures (Appendix B).

Project-specific notebooks will be signed out by the facility quality control coordinator (QCC) to the individuals working on the project. All daily laboratory activities associated with the project will be recorded in the project-specific notebooks.

Separate nonproject-specific logbooks will be used to record the injection or introduction of samples into analytical instrumentation. These logbooks are also used to record maintenance or problems with the instruments (Appendix B).

At the completion of the project, the project-specific laboratory notebooks and logbooks will be returned to the facility QCC for retention. Instrument logbooks are returned to the facility QCC when the books are filled.

All data will be written in standard laboratory notebooks or on standard formatted data entry sheets. All records management and reporting will follow standard QA/QC protocol. Standard QA/QC protocol, as it applies to testing within the laboratory, will adhere to the following guidelines:

- One hundred percent verification on all numerical results - All raw data entries, transcriptions, and calculations are checked.
- Data validation through test reasonableness - Summaries of all test results for individual reports are reviewed to determine the overall reasonableness of data and to determine the presence of any data that may be considered outliers.
- Routine instrument calibration - Will be performed per the QAPP (DOE 1988).
- Use of trained personnel conducting tests - All technicians are trained in the application of standard laboratory procedures for analyses as well as in the QA measures implemented for internal QC checks.

8.0 DATA ANALYSIS AND INTERPRETATION

8.1 EFFECTIVENESS OF REAGENTS

The results of the leaching tests will be used to evaluate the effectiveness of the soil washing. The concentrations of radioactive and hazardous constituents in the leachate will be used as input into the geochemical models described in the draft RI/FS Work Plan Addendum on risk assessment methodology. These models will be used in conjunction with groundwater fate and transport models to generate data that will then be used to calculate concentrations of contaminants in the aquifer at the location of the reasonable maximum exposure. These concentrations will in turn be used to calculate the magnitude of that exposure, and the resulting risks to human health and the environment.

8.2 SOIL WASHING

For the remedy screening phase, Stages I and II, and remedy selection testing, the reagent formulation, inorganics, organics, and radionuclide concentrations will be presented in a tabular format for each test run. The results of the MTCLP and TCLP procedures will also be listed.

8.3 DATA PRECISION, ACCURACY, AND COMPLETENESS

The following procedures will be used to assess data precision, accuracy, and completeness. Calculations of precision, accuracy, and completeness will be used to assess data quality.

Example of calculations of precision:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2)/2}$$

where

RPD = relative percent difference

C_1 = larger of the two observed values

C_2 = smaller of the two observed values.

Example of calculation of accuracy:

$$\%R = \frac{100\% \times (S - U)}{C_{sa}}$$

where

%R = percent recovery

S = measured concentration in spiked aliquot

U = measured concentration in unspiked aliquot

C_{sa} = actual concentration of spike added.

Example of calculation of completeness:

$$\%C = 100\% \times \frac{V}{n}$$

where

%C = percent completeness

V = number of measurements judged valid

n = total number of measurements necessary to achieve a specified statistical level of confidence in decision making.

An example of the Technology Development Laboratory form used for reporting precision of duplicates and accuracy of spikes is given in Figure 8-1.

FIGURE 8-1

GENERAL QA/QC REPORT

Analyte:
Matrix:
Sample Number:

		Concentration (mg/L)
Precision of Duplicates Spike Value (b)= Spike Dup. Value (a)=		
Precision (RPD[a])	$\frac{\lvert a-b \rvert}{(a+b)/2} \times 100\% =$	
Accuracy of Spike Original Value (a)= Observed Spike Value (b)= Spike Level (c)=		
Accuracy=	$\frac{b-a}{c} \times 100\% =$	
Accuracy of Spike Dup. Original Value (a)= Observed Spike Dup. Value (b)= Spike Level (c) =		
Accuracy =	$\frac{b-a}{c} \times 100\% =$	

[a]RPD - Relative percent difference.

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9.0 HEALTH AND SAFETY

Appendix C contains the Health and Safety Plan for the Operable Unit 5 Treatability Field Sampling. These procedures will be implemented and followed by personnel involved in all field sampling activities related to the Operable Unit 5 treatability program.

Appendix D contains the Health and Safety Plan for the Operable Unit 5 Treatability Study Remedy Screening and Remedy Selection Phases, which describes the procedures. These will be implemented and followed by personnel involved in the soil washing treatability study.

These HSPs ensure that all activities are conducted so that the health and safety of all personnel involved are protected, and the hazards associated with field sampling, treatability studies and associated analyses are properly identified.

10.0 RESIDUALS MANAGEMENT

10.1 WASHED SOIL

These soil washing treatability studies will use approximately three 55-gallon drums of contaminated soil per sampling location. Ten to twelve 55-gallon drums of extractant and rinses and two to four 55-gallon drums of solid residue from the tests will be shipped to the Fernald site for disposal. All waste and residual shipments will comply with the provisions of the Federal Treatability Study Sample Exemption Rule (see Section 3.9 of "Guide for Conducting Treatability Studies Under CERCLA"). All disposal of materials at the Fernald site will be in accordance with requirements of CERCLA, RCRA, and the waste management requirements of the FEMP.

All treatability samples will be handled in accordance with Tennessee's Hazardous Waste Management Regulations for treatability study samples (Tennessee Rule Chapter 1200-1-11-.02-16) and samples undergoing treatability studies at laboratories and testing facilities (Tennessee Rule Chapter 1200-1-11-.02-19).

10.2 LEACHATE

As a result of the MTCLP and the TCLP procedures, approximately 60 liters of stabilized waste leachate, a RCRA waste, will be generated. This leachate will be sent to the IT Analytical Services Laboratory in Oak Ridge, Tennessee for analysis and then will be shipped to the Fernald site for disposal. All waste and residual shipments will comply with the provisions of the Federal Treatability Study Sample Exemption Rule (see Section 3.9 of "Guidance for Conducting Treatability Studies Under CERCLA").

All treatability samples will be handled in accordance with Tennessee's Hazardous Waste Management Regulations for treatability study samples (Tennessee Rule Chapter 1200-1-11-.02-16) and samples undergoing treatability studies at laboratories and testing facilities (Tennessee Rule Chapter 1200-1-11-.02-19).

11.0 COMMUNITY RELATIONS

Treatability studies and community information and involvement activities are required in the CERCLA process. Community relations activities will be conducted: 1) to support site-wide soil-washing treatability studies in Operable Unit 5 and to explain the role of treatability studies in the RI/FS and 2) to raise the public's confidence in cleanup alternatives and technologies identified in the alternatives screening/analysis process and in the preferred alternative for this operable unit. The treatability study community relations activities for Operable Unit 5 will comply with the "Community Relations Plan - Remedial Investigation/Feasibility Study and Removal Actions at the Department of Energy Feed Materials Production Center, Fernald, Ohio," August 1990. At a minimum, information appropriate to the Operable Unit 5 treatability studies will be transferred to the community via the following community relations activities:

- Community Meetings - Held a minimum of three times per year to provide status on cleanup issues, and to ensure that interested area residents have a routine public forum for receiving new information, expressing their views, and getting answers to their questions, the meetings will focus on operable unit updates, removal actions, major RI/FS documents, and other appropriate topics. During the July 1991 community meeting, an initial discussion made the community aware of treatability studies underway.

- Publications - RI/FS materials such as progress reports, fact sheets, a community newsletter *(Fernald Site Cleanup Report)*, and updates of CERCLA-related activities at the FEMP will include information on treatability study activities for this operable unit.

- Presentations to Community Groups - Information about treatability studies for this operable unit will be included in briefings to community groups in Ross, Crosby, and Morgan townships, and to Fernald Residents for Environment, Safety, and Health, as appropriate. Also, this information will be included in presentations to other organizations, as requested.

Key milestones in treatability studies will be identified and progress reported to the community in these presentations and publications. These milestones include:

- Submittal of work plan to EPA
- EPA approval of work plan
- Treatability testing
- Submittal of treatability testing report

Other activities identified in Section 4.0 of the Community Relations Plan may be utilized as appropriate to effectively communicate treatability information to the community. Such activities may include workshops and community roundtables.

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12.0 REPORTS

An interim draft report will be issued following the completion of the remedy screening phase of the treatability testing and will document the results of the physical separation and chemical extraction procedures. This report will identify those reagent combinations that yielded the best results for use in the remedy selection phase of testing. In addition, all raw data will be included and presented in a tabular format.

A final treatability study report will be prepared after the remedy selection of the study has been completed. The final report will incorporate information from the interim draft report. The following outline will be used as a guide when preparing this report.

SUGGESTED ORGANIZATION OF TREATABILITY STUDY REPORT

1.0 Introduction
- 1.1 Site description
  - 1.1.1 Site name and location
  - 1.1.2 History of operations
  - 1.1.3 Prior removal and remediation activities
- 1.2 Waste stream description
  - 1.2.1 Waste matrices
  - 1.2.2 Pollutants/chemicals
- 1.3 Remedial technology description
  - 1.3.1 Treatment process and scale
  - 1.3.2 Operating features
- 1.4 Previous treatability studies at the site

2.0 Conclusions and recommendations
- 2.1 Conclusions
- 2.2 Recommendations

3.0 Treatability Study Approach
- 3.1 Test objectives and rationale
- 3.2 Experimental design and procedures
- 3.3 Equipment and materials
- 3.4 Sampling and analysis
  - 3.4.1 Waste stream

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3.4.2 Treatment process
3.5 Data management
3.6 Deviations
4.0 Results and discussion
4.1 Data analysis and interpretation
4.1.1 Analysis of waste stream characteristics
4.1.2 Analysis of treatability study data
4.1.3 Comparison to test objectives
4.2 Quality assurance/quality control
4.3 Costs/schedule for performing the treatability study
4.4 Key contacts
References
Appendices
A. Data summaries
B. Standard operating procedures

13.0 SCHEDULE

The schedule to complete all soil washing treatability-related activities is shown in Figure 13-1. The activities and dates are based on the Operable Unit 5 Amended Consent Agreement schedule.

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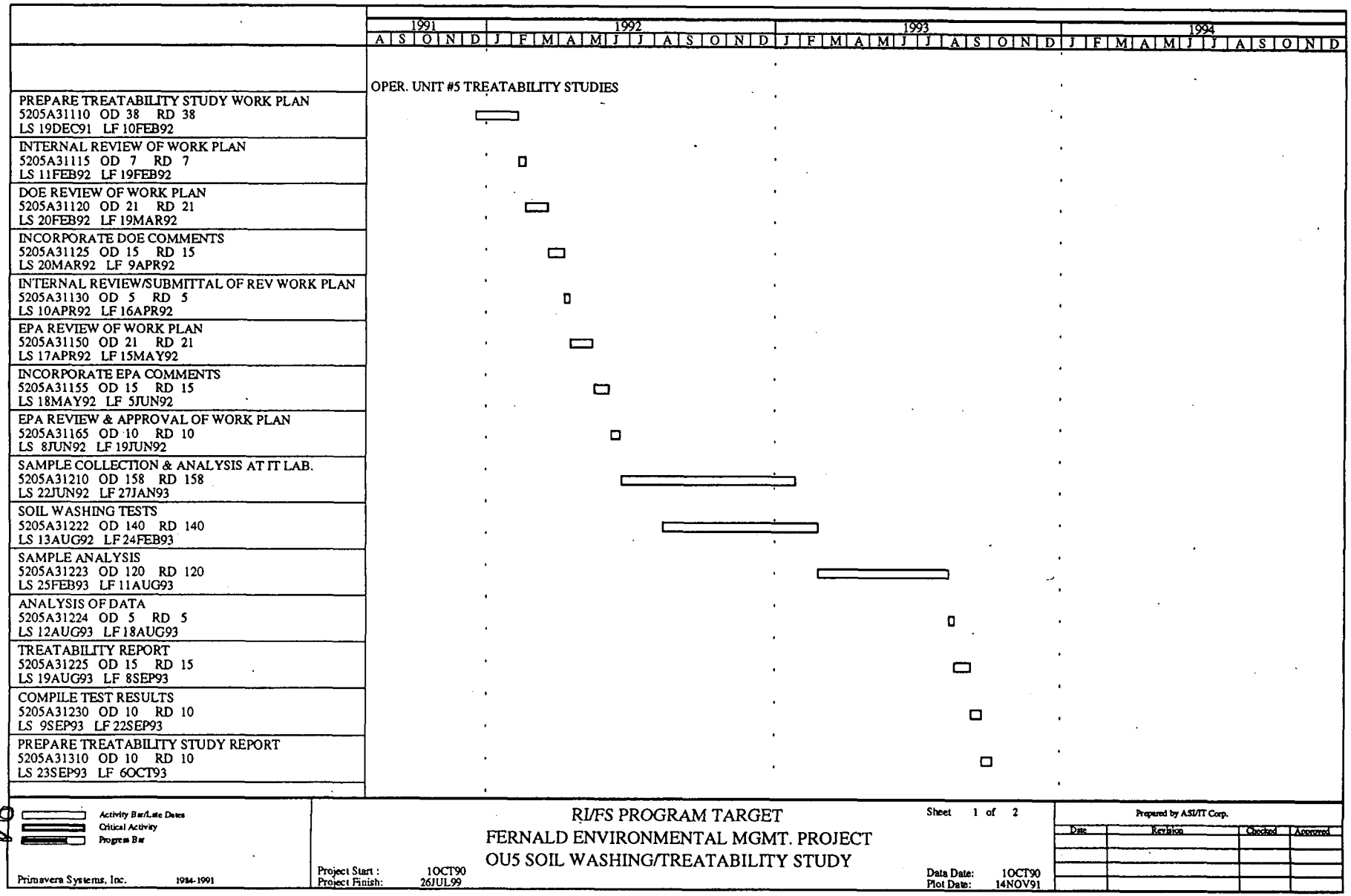

FIGURE 13-1. OPERABLE UNIT 5 TREATABILITY SCHEDULE

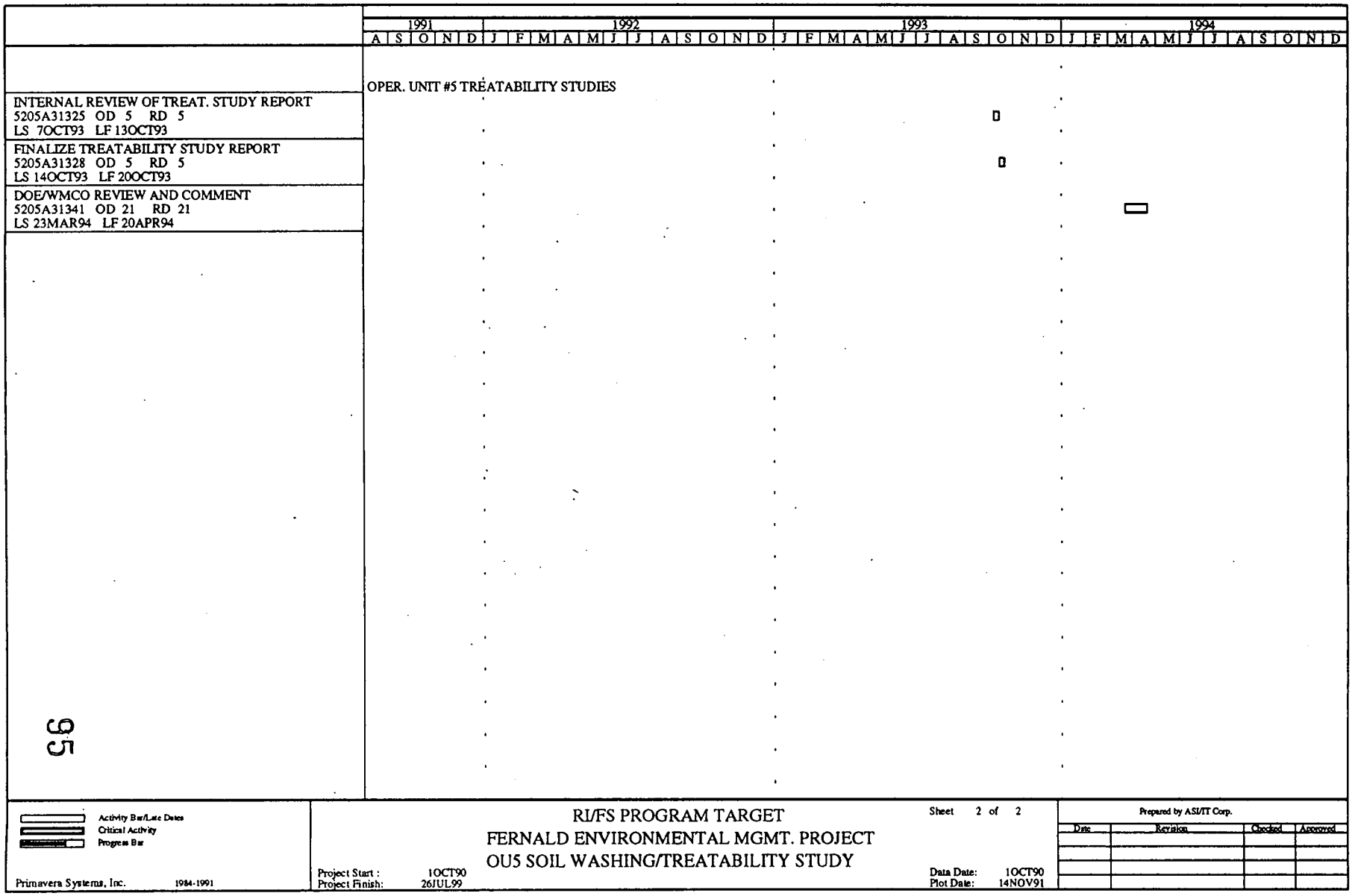

FIGURE 13-1.-CONTINUED

14.0 MANAGEMENT AND STAFFING

Personnel involved in the management of the entire RI/FS include: Jack Craig, DOE Project Director, who is responsible for the RI/FS; John Wood, ASI/IT's Project Director for the RI/FS consultant; and ASI/IT's John Razor, who serves as Deputy Project Director and is responsible for the technical content of the RI/FS consultant's documents. Sam Wolinsky serves as Treatability Coordinator for all operable unit treatability studies performed by the RI/FS consultant and serves as the focal point for RI/FS administrative communication with the laboratory.

Those personnel specifically involved in Operable Unit 5 include Carlos J. Fermaintt, DOE Operable Unit manager; Dave Brettschneider, WEMCO's (the integration contractor) Operable Unit 5 manager; and Brent Harvey, Operable Unit 5 manager for Parsons (the remedy design contractor). Robin Smith of ASI/IT serves as the RI/FS consultant's Operable Unit 5 manager and is the focal point for technical communication with the laboratory performing the treatability study.

The IT Technology Development Laboratory personnel will perform the actual treatability testing. Those personnel include Ed Alperin, Laboratory Manager, who is responsible for all of the treatability testing programs within the treatability laboratory. Darrell Drouhard, Project Manager/Engineer, coordinates all treatability laboratory work between the laboratory and the site. Ernie Stine, Operations Supervisor, and Michael Krstich, Environmental Scientist, are responsible for the technical aspects of the soil washing treatability program at the laboratory. Ken Sadler and Michael Krstich will perform most of the experiments. These personnel and their lines of communication are shown in Figure 14-1.

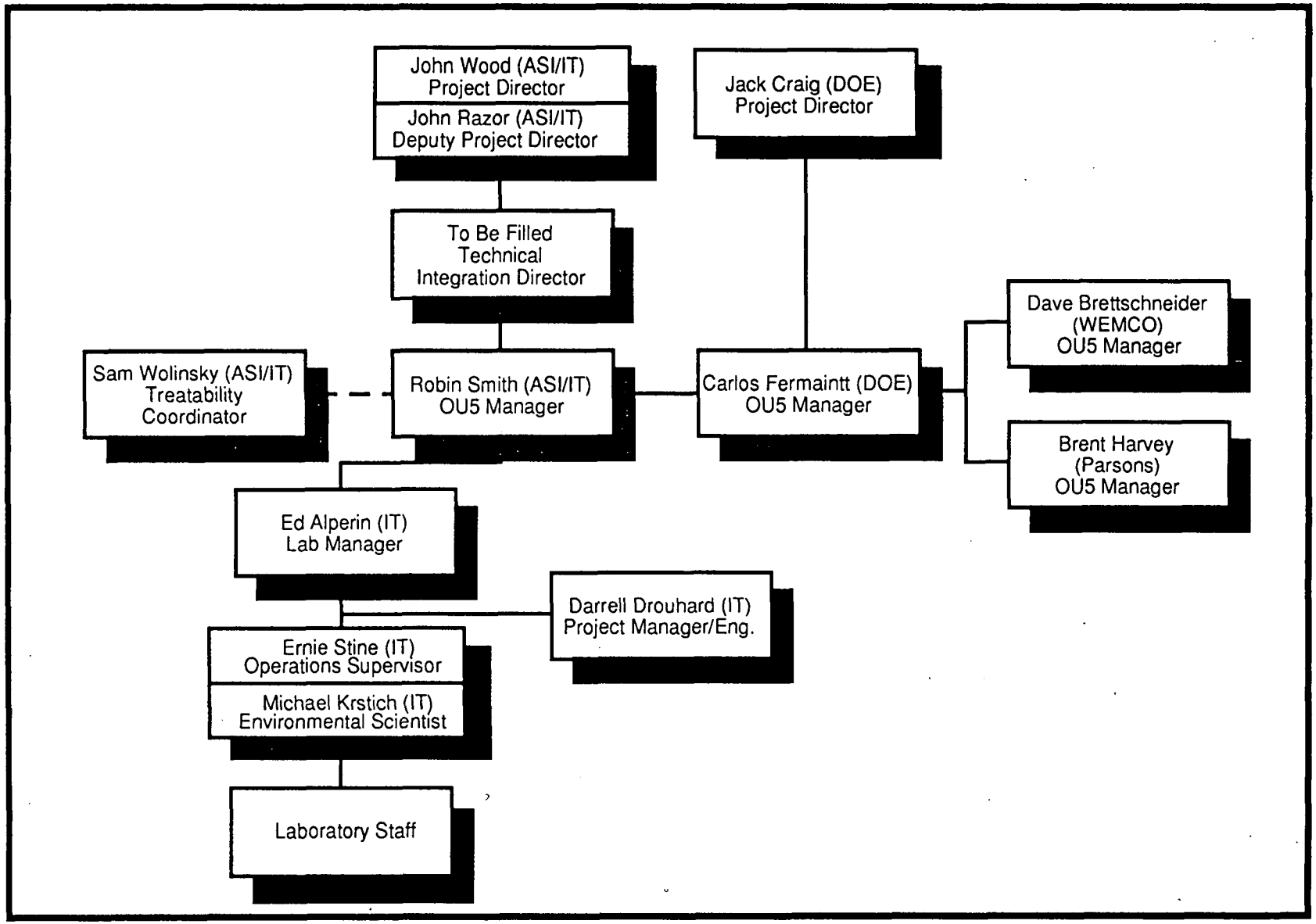

FIGURE 14-1. TREATABILITY STUDY MANAGEMENT AND STAFFING

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REFERENCES

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REFERENCES

dePercin, P., E. Bates and D. Smith, 1991, "Designing Treatability Studies for CERCLA Sites: Three Critical Issues," J. of the Air and Waste Management Assn., Vol. 41, No. 45.

Kabato-Pendias, A. and H. Pendias, 1984, Trace Elements in Soils and Plants, CRC Press, Inc., Boca Raton, FL.

Kunze, M.E. and J.R. Gee, 1989, "Bench- and Pilot- Scale Case Studies for Metals and Organics Removals from CERCLA Site Soils," in Superfund '89, Proceedings of the 10th National Conference, Hazardous Materials Control Research Institute, pp. 207-215.

Marcus, W.L., 1986, "Lead Health Effects in Drinking Water," Toxicology and Industrial Health, Vol. 2, No. 4, pp. 363-407.

Myrick, T.E., B.A. Berven and F.F. Haywood, 1983, "Determination of Concentrations of Selected Radionuclides in Surface Soil in the U.S.," Health Physics, Vol. 45, pp. 631-642.

Richardson, W.S., T.B. Hudson, J.G. Wood and C.R. Phillips, 1989, "Characterization and Washing Studies on Radionuclide Contaminated Soils," in Superfund '89, Proceedings of the 10th National Conference, Hazardous Materials Control Research Institute, pp. 198-201.

Shacklette, H.T. and J.A. Boerngen, 1984, "Elemental Concentrations in Soils and Other Surficial Materials of the Conterminous United States," U.S. Geological Survey Professional Paper 1270, U.S. Dept. of the Interior, Washington, DC.

U.S. Department of Energy, 1988, "Remedial Investigation and Feasibility Study, Feed Materials Production Center, Fernald, Ohio, Work Plan Requirements," Revision 3, Vol. V: Quality Assurance Project Plan, DOE, Oak Ridge Operations Office, Oak Ridge, TN.

U.S. Environmental Protection Agency, 1991, "Health Effects Assessment Summary Tables, FY - 1991," OERR 9200.6-303(91-1), EPA, Washington, DC.

U.S. Environmental Protection Agency, 1989a, "Summary of Treatment Technology Effectiveness for Contaminated Soil," EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1989b, "Guide for Conducting Treatability Studies under CERCLA," EPA/540/2-89-058, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1988, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA," EPA, 540-G-89/104, EPA, Office of Emergency and Remedial Response, Washington, DC.

U.S. Environmental Protection Agency, 1987, "Data Quality Objectives for Remedial Response Activities, Development Process," EPA/540/G-87/003, EPA, Office of Emergency and Remedial Response, Washington, DC.

APPENDIX A

ADDITIONAL INFORMATION ON THE NATURE AND EXTENT OF CONTAMINATION OF OPERABLE UNIT 5 SOILS

A.1.0 NATURE AND EXTENT OF CONTAMINATION

Figure A-1 shows the southeast quadrant of the Production Area. The total uranium values for samples from all borings in the quadrant are shown adjacent to the boring numbers. (This is the data that was used to generate the contours in Figure 1-2 in Section 1.0.). Figure A-1 illustrates the variability of uranium values over relatively short distances. Within the northern half of Plant 6 samples range from less than detection limits to several hundred µg/g over distances of 50 to 100 feet. Outside of buildings there is a similar variability, probably due to surface water transporting the airborne materials.

Also within the southeast quadrant, organic chemical contamination has been found in shallow soil in Piezometer 1148 in Plant 6, as illustrated in Figure A-2. The volatile organic compounds 1,2-dichloroethylene and trichloroethene were found at 55 and 200 µg/g respectively. Further sampling has been conducted; however, results are not available at this time.

Figure A-3 shows the total uranium contamination in surface soil for the upper part of the southwest quadrant of the Production Area. Surface soil contamination is highest in the vicinity of Plant 2/3. Figure A-4 shows the total uranium concentrations in surface soil in the lower half of the southwest quadrant. Total uranium concentrations are highest near the southwest corner of the Pilot Plant and along the west side of the laboratory.

Because organic chemicals were used in some of the facilities within the southwest quadrant, several soil samples were analyzed for hazardous substance list (HSL) parameters. Figure A-5 shows these sampling locations. Table A-1 lists chemical concentrations from surface soil samples in the Pilot Plant Area. Table A-2 lists chemical concentrations from soil samples in the Plant 2/3 area. These analyses indicate the range of contaminants that are found in these relatively small areas.

Figure A-6 shows the total uranium in surface soil in the northeast quadrant. Chemical contamination (Figure A-7) was detected in two areas within this quadrant: the graphite furnace and oil burner area near the northeast corner of the boiler plant and the area along the north side of the maintenance building. Tables A-3 and A-4 present the results of chemical analyses for samples in these respective areas. Between these two areas lie the coal pile and the runoff retention basin for the coal pile. Additional sampling for chemical contamination has been conducted between the graphite furnace and the maintenance building; however, the data are not currently available. It is quite possible that the

area bounded by the graphite furnace and the maintenance building is the largest contiguous area where chemical contamination exists on site.

Figure A-8 shows the concentration of total uranium in the surface soil in the northwest quadrant. Concentrations of total uranium in this area ranged from 7 μg/g to 211 μg/g. Additionally, radium and thorium were detected in the northwest quadrant. Limited chemical analysis has been conducted on the soils in this area as illustrated in Figure A-9.

The sewage treatment plant area contains the highest levels of total uranium contamination outside the Production Area or the Waste Storage Area. Figure A-10 shows the total uranium concentration in surface soil samples from this area.

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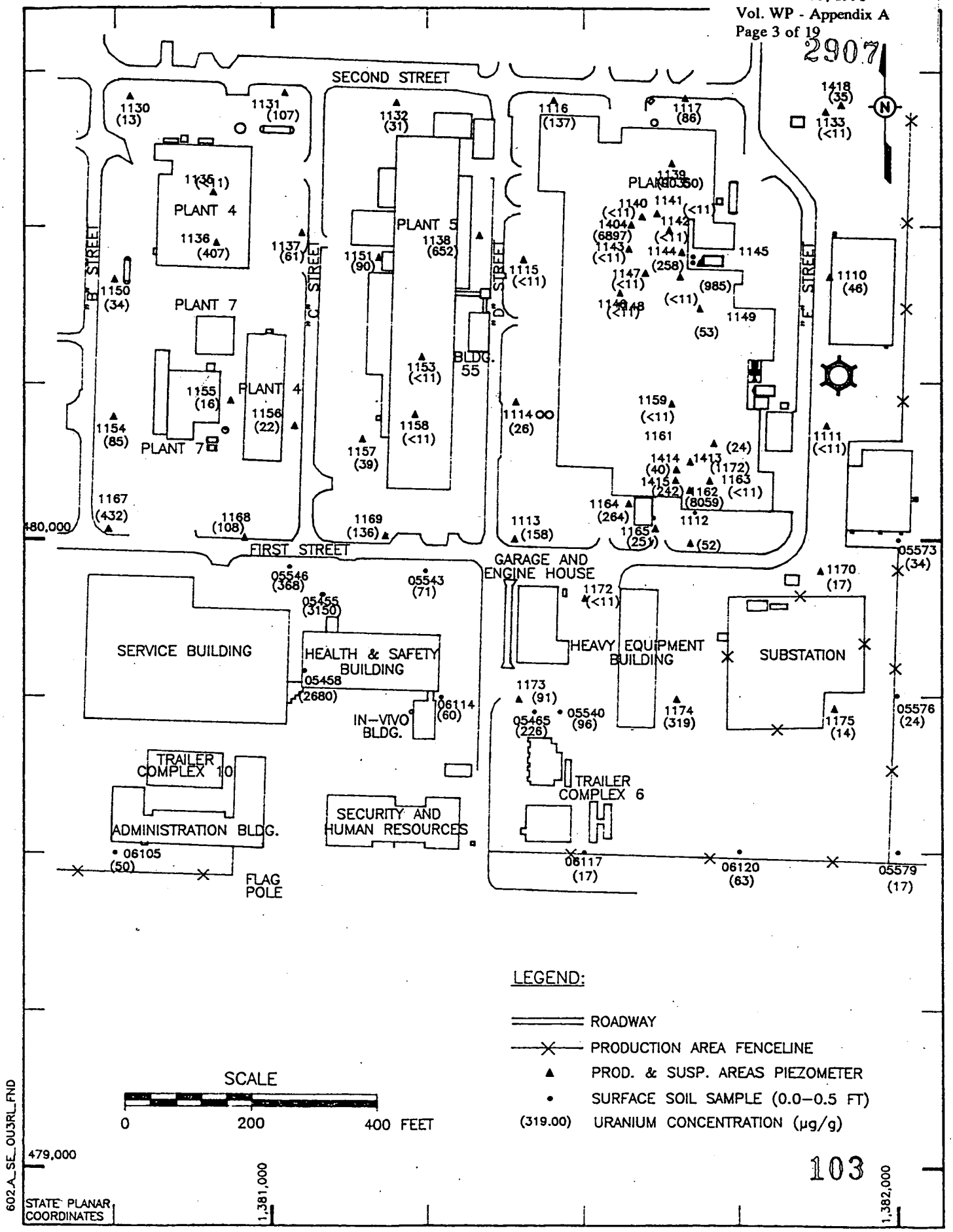

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FIGURE A–1. TOTAL URANIUM CONCENTRATIONS IN SOIL – SOUTHEAST QUADRANT

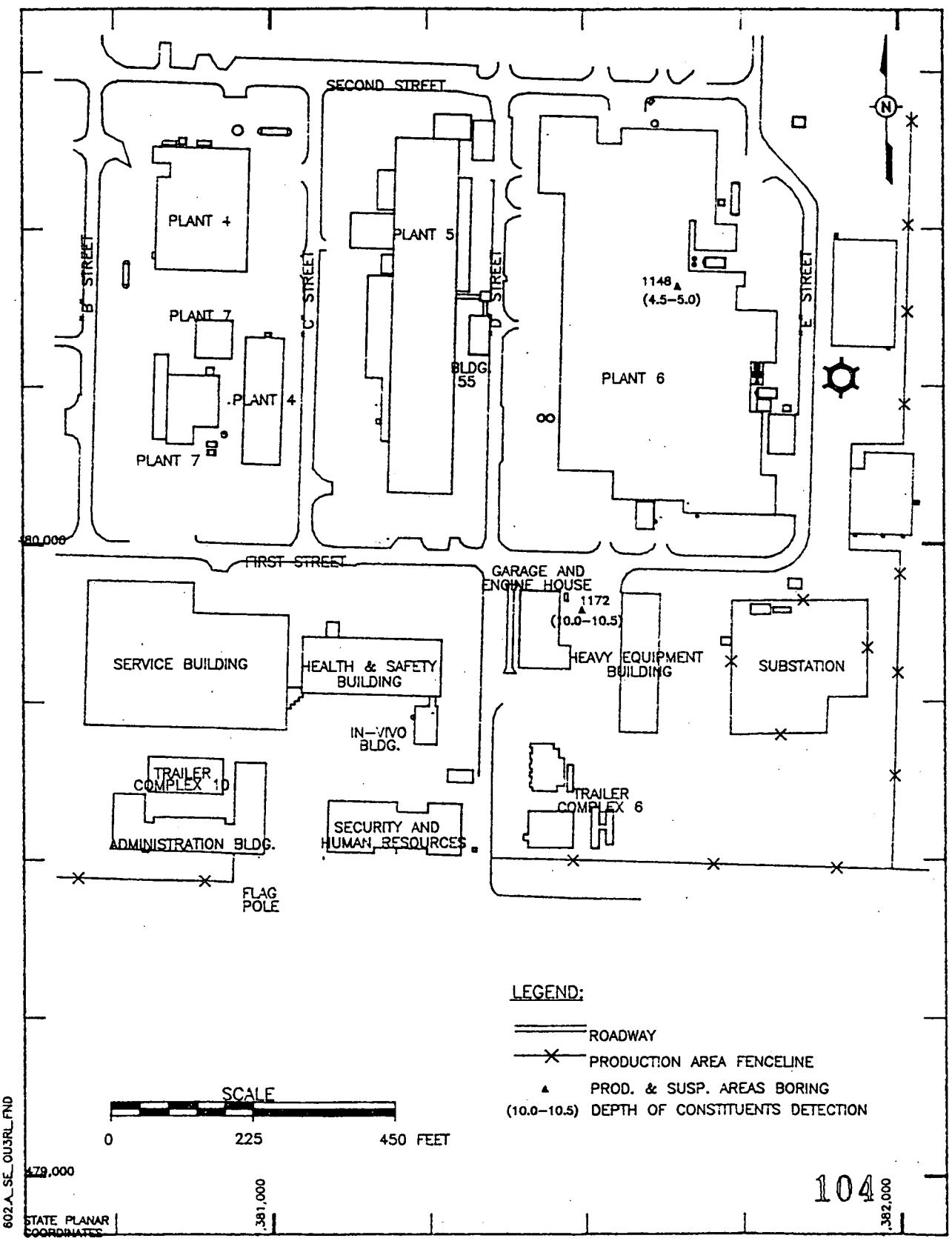

FIGURE A-2. CHEMICAL SAMPLING LOCATIONS IN THE SOUTHEAST QUADRANT

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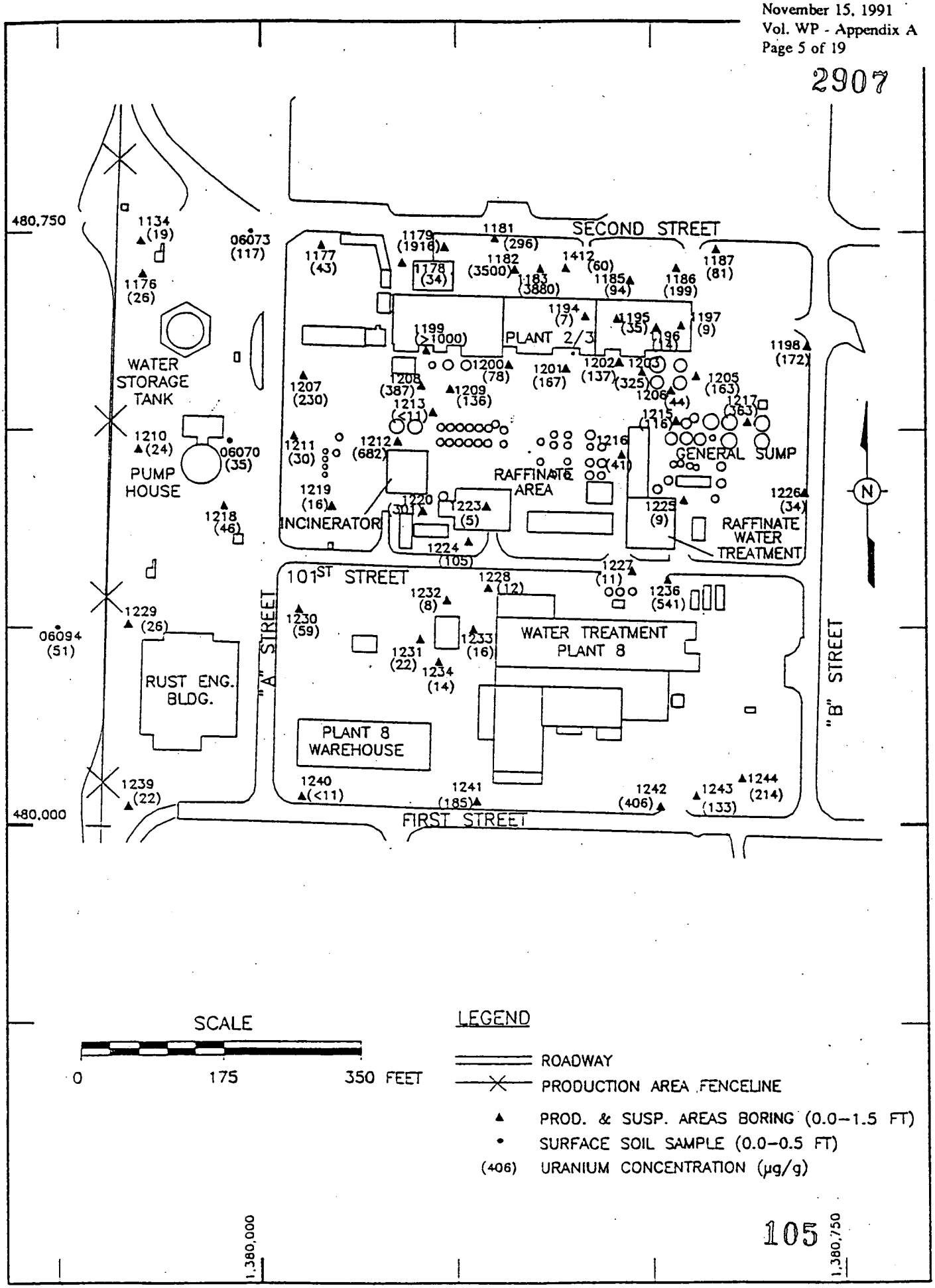

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FIGURE A-3. TOTAL URANIUM CONCENTRATIONS IN SOIL – UPPER SOUTHWEST QUADRANT

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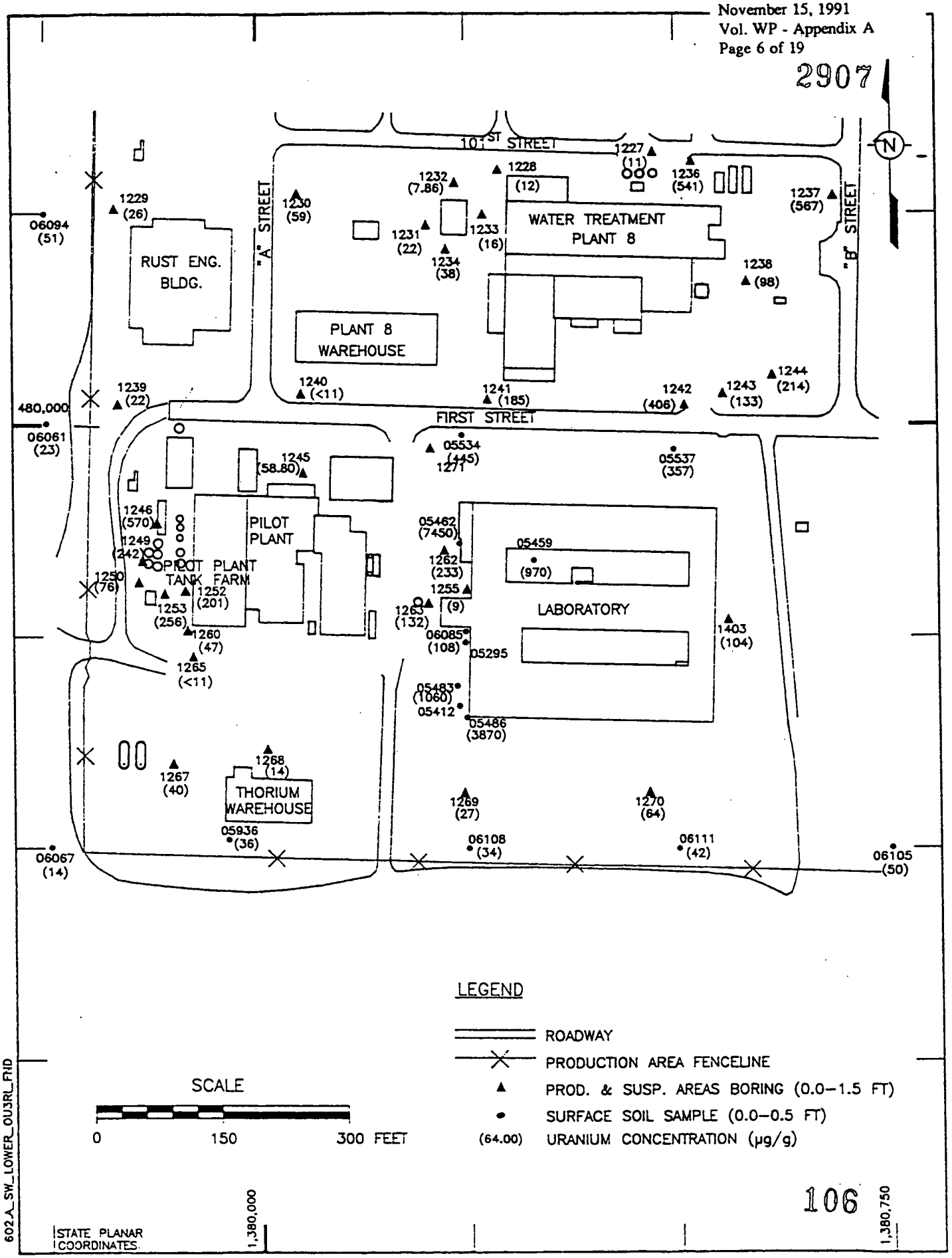

FIGURE A-4. TOTAL URANIUM CONCENTRATIONS IN SOIL - LOWER SOUTHWEST QUADRANT

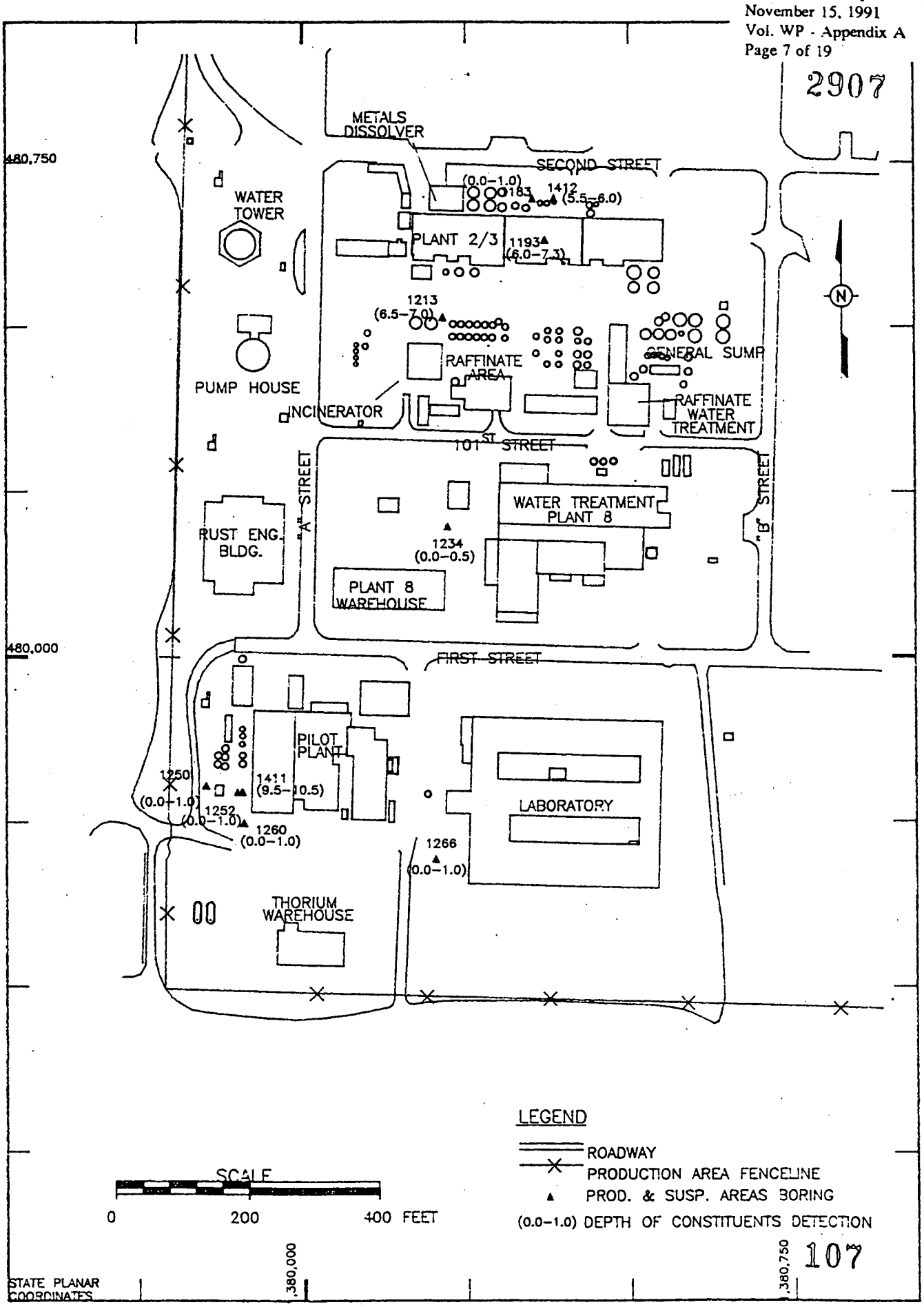

FIGURE A-5. CHEMICAL SAMPLING LOCATIONS IN THE SOUTHWEST QUADRANT

TABLE A-1

CHEMICAL CONCENTRATIONS IN SOILS FROM THE PILOT PLANT AREA IN THE SOUTHWEST QUADRANT

Constituents	Location Sample ID Depth (ft)	1250 18071 0.5-1.0	1250 18069 0.0-0.5	1252 52753 0.0-0.5	1252 52754 0.5-1.0	1260 18289 0.0-0.5	1260 18290 0.5-1.0	1411 54995 9.5-10.0	1411 54996 10.0-10.5
Inorganic Constituents (mg/kg)									
Arsenic		--	--	7.4	--	--	--	--	--
Barium		--	--	--	--	--	--	--	3610
Beryllium		1.7	1.5	1.2	0.94	1.2	0.82	0.93	0.99
Cadmium		4.5	3.4	4.7	3	5.4	3.4	4.5	4.2
Calcium		115,000	35,200	86,600	8440	181,000	103,000	77,100	89,400
Cobalt		16.5	13.8	13.9	14	13.3	--	9.9	10.4
Copper		22.3	27.1	--	25.3	28.9	--	--	--
Iron		--	--	--	--	27,300	--	--	--
Lead		--	30.3	--	26.7	117	--	--	--
Magnesium		26,000	9740	20,200	4680	11,400	20,700	26,600	20,000
Manganese		--	835	--	--	--	--	--	--
Nickel		41.9	39.8	40.5	34.7	35.1	29.2	27.4	25.9
Silver		--	--	--	--	--	3.1	--	--
Thallium		--	--	--	0.34	0.33	0.26	0.46	0.37
Zinc		--	60.8	219	242	207	210	209	213
Organic Constituents (µg/kg)									
Volatiles									
1,1-Dichloroethene		--	--	--	4	--	--	NA	--
1,1,2,2-Tetrachloroethane		--	--	--	--	--	--	NA	350
1,2-Dichloroethylene		2	--	--	--	--	--	NA	1600
2-Butanone		49	10	8	9	1	4	NA	2400
2-Propanone		--	9	--	12	6	6	NA	--
4-Methyl-2-pentanone		--	--	--	--	--	--	NA	330
Benzene		--	--	--	5	--	--	NA	--
Chlorobenzene		--	--	--	5	--	--	NA	--
Methylene chloride		10	7	20	20	20	19	NA	6700
Tetrachloroethene		--	-	1	--	2	--	NA	17,000
Toluene		1	--	--	5	--	--	NA	31,000
Trichloroethene		4	5	--	5	3	--	NA	2000

TABLE A-1
(Continued)

Constituents	Location Sample ID Depth (ft)	1250 18071 0.5-1.0	1250 18069 0.0-0.5	1252 52753 0.0-0.5	1252 52754 0.5-1.0	1260 18289 0.0-0.5	1260 18290 0.5-1.0	1411 54995 9.5-10.0	1411 54996 10.0-10.5
Semivolatiles									
Acenaphthene		--	--	1600	--	110	110	--	--
Anthracene		--	--	2800	60	170	290	--	--
Benzo(a)anthracene		--	--	5400	430	660	580	--	--
Benzo(a)pyrene		--	--	5100	320	470	520	--	--
Benzo(b)fluoranthene		--	--	4700	--	--	540	--	90
Benzo(g,h,i)perylene		--	--	3700	230	400	440	--	--
Benzo(k)fluoranthene		--	--	5000	550	730	510	--	--
bis(2-ethyl hexyl)phthalate		--	71	--	58	46	--	810	1100
Chrysene		--	--	7200	550	860	790	--	--
Dibenzofuran		--	--	640	--	55	72	--	--
Dibenzo(a,h)anthracene		--	--	1500	420	--	140	--	--
Di-n-butyl phthalate		--	--	--	--	--	46	1400	1400
Fluoranthene		--	43	10,000	940	1500	1600	94	190
Fluorene		--	--	1700	44	130	160	--	--
Indeno(1,2,3-cd)pyrene		--	--	2900	160	280	330	--	--
Phenanthrene		--	--	8800	480	950	1300	140	240
Phenol		69	--	--	--	--	--	--	--
Pyrene		--	--	10,000	860	1400	1300	83	150
Pesticides and PCBs (µg/kg)									
beta-BHC		--	--	220	--	--	46	--	--
PCB-1254		--	120	1000	170	200	--	--	--
PCB-1260		--	--	1000	270	340	--	830	1100

Note: Data presented by location, sample number, and sample depth
NA - Not analyzed
-- - Dash indicates concentrations below background for inorganic constituents
Dash indicates concentrations for organics, pesticides, and PCBs were below the contract-required detection limit

TABLE A-2

CHEMICAL CONCENTRATIONS IN SOILS FROM THE PLANT 2/3 AREA IN THE SOUTHWEST QUADRANT

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Data presented by location, sample number, and sample depth. NA indicates not available. For inorganic constituents, dashes indicate concentrations below background; for organic constituents, pesticides, and PCBs, dashes indicate no detection.

Constituents	Location Sample ID Depth (feet)	1183 16595 0.0-0.5	1183 16597 0.5-1.0	1213 17276 6.0-7.0	1193 51954 6.0-7.5	1412 55089 5.5-6.0
Inorganic constituents (mg/kg)						
Arsenic		8.4	--	NA	NA	26.5
Beryllium		2.4	1.7	NA	NA	1
Cadmium		6.9	5.2	NA	NA	4.1
Calcium		105,000	115,000	NA	NA	48,200
Chromium		75.5	--	NA	NA	--
Cobalt		17.4	14.3	NA	NA	12.8
Copper		38.5	--	NA	NA	--
Lead		334	440	NA	NA	161
Magnesium		38,600	21,400	NA	NA	17,500
Molybdenum		2.9	--	NA	NA	--
Nickel		50	42.3	NA	NA	38
Silver		17.2	5.9	NA	NA	3.9
Zinc		247	89	NA	NA	65.5
Organic constituents (µg/kg)						
Volatiles						
1,1-Dichloroethane		--	--	--	--	14
1,1,1-Trichloroethane		--	--	--	--	6
2-Butanone		4	4	--	10	110
2-Propanone		14	5	9	29	98
Methylene chloride		8	5	17	17	78
Toluene		2	2	--	2	--
Semivolatiles						
Benzoic acid		--	88	NA	NA	--
bis(2-Ethylhexyl)phthalate		180	--	NA	NA	--
Fluoranthene		--	--	NA	NA	81
N-Nitrosodiphenylamine		100	130	NA	NA	630
Phenanthrene		--	--	NA	NA	88
Pesticides and PCBs (mg/kg)						
PCB-1254		360	--	NA	NA	

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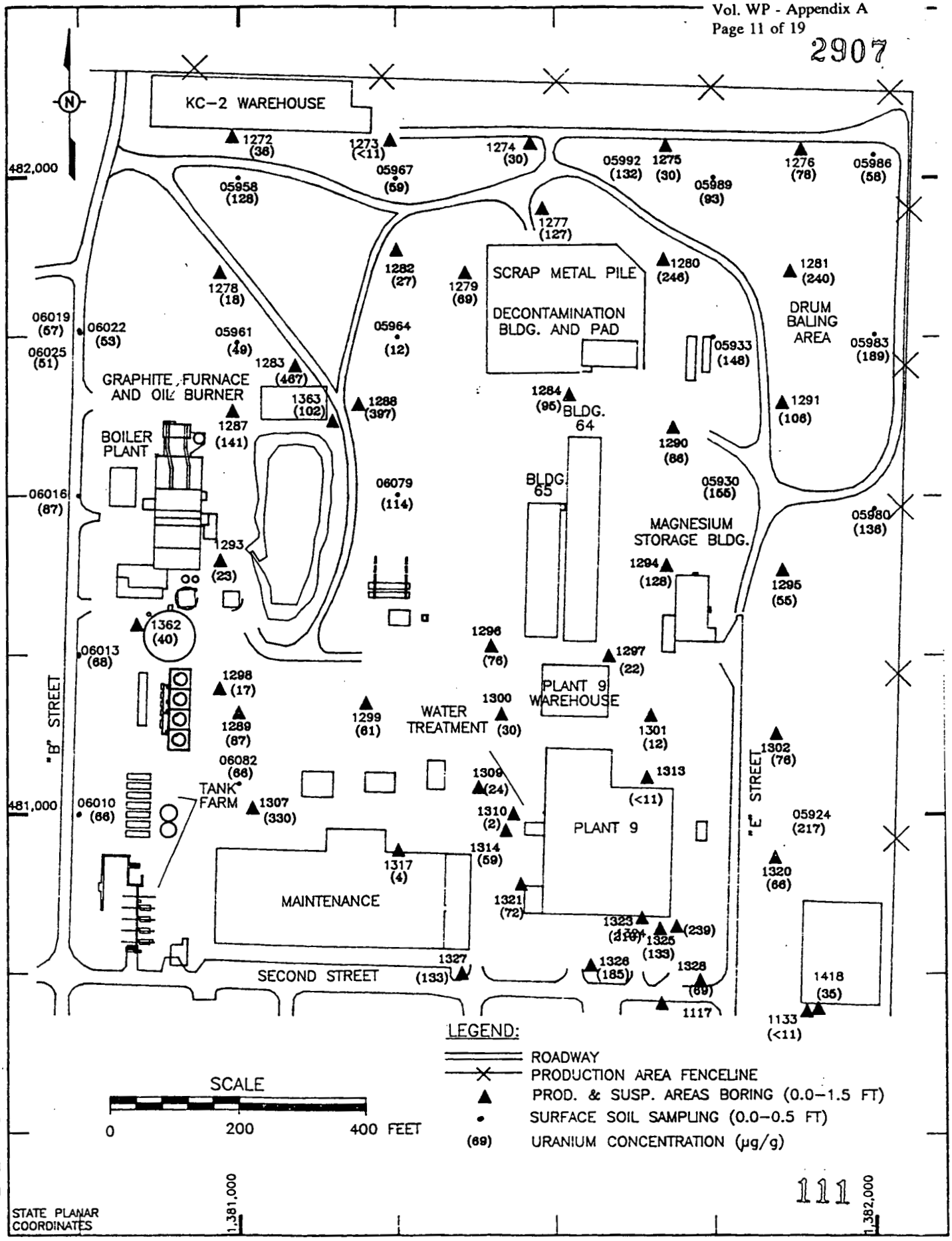

FIGURE A-6. **TOTAL URANIUM CONCENTRATIONS IN SOIL – NORTHEAST QUADRANT**

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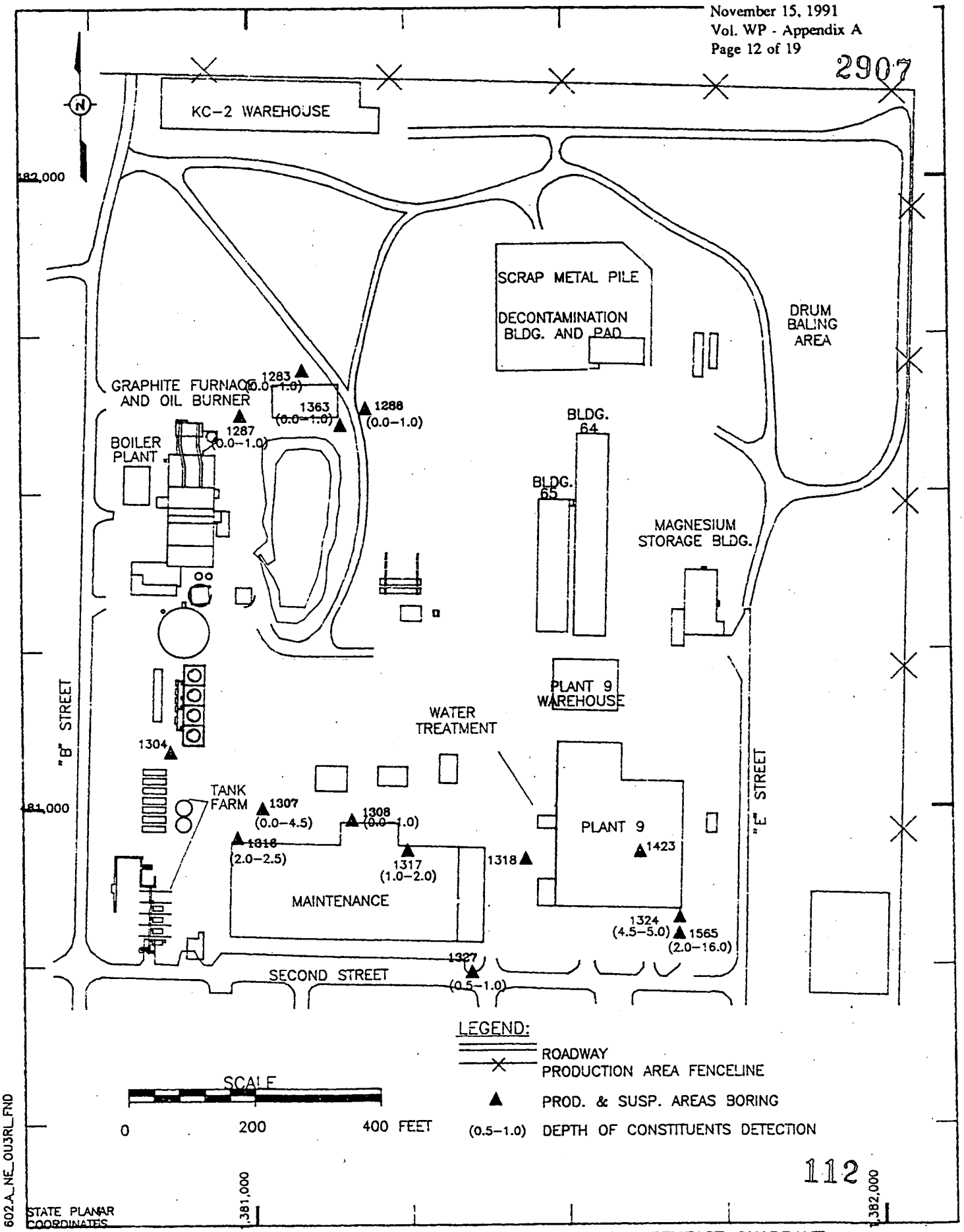

FIGURE A-7. CHEMICAL SAMPLING LOCATIONS IN THE NORTHEAST QUADRANT

TABLE A-3

CHEMICAL CONCENTRATIONS IN SOILS FROM THE GRAPHITE FURNACE AND OIL BURNER AREA IN THE NORTHEAST QUADRANT OF THE FEMP PRODUCTION AREA

Constituents	Location Sample ID Depth (ft)	1283 18795 0.0-0.5	1283 18796 0.5-1.00	1287 18883 0.0-0.5	1287 18884 0.5-1.0	1288 53473 0.0-0.5	1288 53474 0.5-1.0	1363 50554 0.0-0.5	1363 50555 0.5-1.0
Inorganic Constituents (mg/kg)									
Arsenic		7.5	17.2	22.6	12	8.7	--	7.6	--
Barium		--	--	--	523	512	456	--	--
Beryllium		1.8	1.2	--	1.3	1.2	1.2	0.98	0.87
Cadmium		6.2	3.9	3.5	2.9	4	4.4	4.7	4.9
Calcium		205,000	110,000	21,000	8000	44,200	42,700	88,100	162,000
Cobalt		11.8	11.4	15.7	12.6	13.4	16.1	12.6	10.4
Copper		--	--	24.9	--p	--	--	--	--
Iron		--	--	--	--	--	--	--	--
Lead		50.3	29.4	57.2	27	25.3	--	--	38.2
Magnesium		45,100	19,600	6710	--	13,200	15,000	20,800	29,300
Manganese		--	--	--	818	--	661	--	--
Mercury		0.16	0.16	0.22	--	0.28	0.32	--	--
Molybdenum		2.3	--	--	--	--	--	--	--
Nickel		30.5	32	40.7	44.8	37.5	44.3	35	28.2
Silver		--	2.3	--	--	4	2.9	--	--
Thallium		--	0.24	0.57	--	0.42	0.42	--	--
Zinc		194	203	248	285	270	232	233	145
Organic Constituents (µg/kg)									
Volatiles									
1,1,1-Trichloroethane		--	120	--	--	--	--	7	7
1,1-Dichloroethene		--	--	--	--	--	--	1	--
2-Butanone		--	67	2	6	12	1	3	--
2-Propanone		13	--	17	--	--	7	16	16
Chloroform		--	--	--	--	9	7	--	2
Ethyl benzene		--	140	--	--	--	--	--	--
Methylene chloride		22	640	24	13	24	27	28	27
Tetrachloroethene		12	140	10	12	--	--	5	7
Toluene		2	160	2	--	--	--	1	3
Total xylenes		--	120	--	--	--	--	--	--
Trichloroethene		12	52	5	2	--	--	1	2

TABLE A-3
(Continued)

Constituents	Location Sample ID Depth (ft)	1283 18795 0.0-0.5	1283 18796 0.5-1.00	1287 18883 0.0-0.5	1287 18884 0.5-1.0	1288 53473 0.0-0.5	1288 53474 0.5-1.0	1363 50554 0.0-0.5	1363 50555 0.5-1.0
Semivolatiles									
2-Methylphthalate		280	590	320	--	150	--	100	--
Benzo(a)anthracene		--	--	--	--	51	--	--	--
Benzo(b)fluoranthene		--	--	--	--	95	--	--	310
Benzo(k)fluoranthene		--	--	--	--	81	--	--	--
bis(2-ethyl hexyl)phthalate		--	--	--	--	--	--	--	--
Chrysene		--	--	--	--	83	--	--	--
Dibenzofuran		--	--	81	--	--	--	--	--
Di-n-butyl phthalate		240	--	--	--	--	--	--	--
Fluoranthene		--	--	81	--	150	--	--	--
Naphthalene		--	390	190	--	89	--	--	--
N-Nitrosodiphenylamine		530	370	--	--	--	--	120	--
Phenanthrene		310	330	190	--	180	--	79	--
Pyrene		--	--	--	--	140	--	--	--
Pesticides and PCBs (µg/kg)									
beta-BHC		--	--	--	--	--	--	100	--
PCB-1254		1200	370	1200	85	--	--	--	--
PCB-1260		560	150	2800	--	230	--	--	150

NA - Not analyzed
-- - Dash indicates concentrations below background for inorganic constituents
Dash indicates concentrations for organics, pesticides, and PCBs were below the contract-required detection limit

TABLE A-4

CHEMICAL CONCENTRATIONS IN SOILS FROM THE MAINTENANCE BUILDING AREA IN THE NORTHEAST QUADRANT OF THE FMPC PRODUCTION AREA

Constituents	Location Sample ID Depth (ft)	1307 19323 0.0-0.5	1307 19324 0.5-1.0	1307 53853 3.0-4.5	1307 53854 1.5-3.0	1308 19345 0.0-0.5	1308 19346 0.5-1.0	1316 19525 2.0-2.5	1317 54053 1.0-1.5	1317 54054 1.5-2.0	1327 19763 0.0-0.5	1327 19764 0.5-1.0
Inorganic Constituents (mg/kg)												
Arsenic		12.6	--	NA	NA	--	--	--	--	--	--	--
Barium		434	456	NA	NA	--	--	--	--	--	--	--
Beryllium		--	--	NA	NA	1.2	1.1	0.99	1.1	0.96	1.7	1.7
Cadmium		6.7	5.4	NA	NA	8	7.1	4	5.1	4.6	7.2	6.3
Calcium		91,900	132,000	NA	NA	157,000	180,000	139,000	126,000	111,000	178,000	189,000
Chromium		67.5	--	NA	NA	--	53	--	--	--	--	--
Cobalt		16.8	11.7	NA	NA	12.2	9.7	--	13.8	11.5	10.2	12.9
Copper		48.9	--	NA	NA	65.2	46.2	--	--	--	30.3	--
Iron		25,800	--	NA	NA	26,900	--	--	--	--	--	--
Lead		334	32.2	NA	NA	182	165	--	--	--	116	22.8
Magnesium		24,900	35,100	NA	NA	42,200	55,100	35,100	35,600	34,500	46,000	41,600
Manganese		0.65	0.46	NA	NA	0.53	0.18	--	--	--	0.37	--
Mercury		--	--	NA	NA	--	--	--	--	--	5.7	3.6
Molybdenum		72.2	36.7	NA	NA	67.8	70.5	20.6	49.3	33.6	63.3	38.1
Nickel		4.5	--	NA	NA	--	--	--	--	--	--	--
Silver		0.38	0.39	NA	NA	--	--	--	0.34	--	--	--
Thallium		767	292	NA	NA	431	324	--	--	--	119	--
Zinc												
Organic Constituents (µg/kg)												
Volatiles												
1,1-Dichloroethylene		--	--	310	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane		210	110	--	--	--	--	--	--	--	--	--
2-Butanone		1100	430	1200	1100	26	3	--	7	35	3	4
2-Propanone		2300	70	2700	2500	18	8	5	5	--	--	11
4-Methyl-2-pentanone		160	--	--	--	--	--	--	--	--	--	--
Chloroform		--	--	--	--	--	--	--	--	--	14	46
Methylene chloride		3000	1200	4200	4600	21	9	3	50	3	6	5
Tetrachloroethene		3300	2000	--	1600	--	--	--	--	--	--	--
Toluene		190	--	--	--	4	--	--	2	2	3	4
Trichloroethene		89,000	56,000	150,000	120,000	18	7	--	--	--	--	--

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TABLE A-4
(Continued)

Constituents	Location Sample ID Depth (ft)	1307 19323 0.0-0.5	1307 19324 0.5-1.0	1307 53853 3.0-4.5	1307 53854 1.5-3.0	1308 19345 0.0-0.5	1308 19346 0.5-1.0	1316 19525 2.0-2.5	1317 54053 1.0-1.5	1317 54054 1.5-2.0	1327 19763 0.0-0.5	1327 19764 0.5-1.0
Semivolatiles												
2-Methylnaphthalene		320	--	NA	NA	760	--	--	--	--	--	--
Acenaphthene		--	--	NA	NA	4800	570	--	--	--	--	--
Anthracene		--	--	NA	NA	6200	880	--	--	--	330	--
Benzo(a)anthracene		660	--	NA	NA	19,000	2900	--	--	--	2000	--
Benzo(a)pyrene		640	--	NA	NA	24,000	3700	--	--	--	2300	--
Benzo(b)fluoranthene		840	--	NA	NA	39,000	4200	--	--	--	2300	--
Benzo(g,h,i)perylene		--	--	NA	NA	12,000	1500	--	--	--	1900	--
Benzo(k)fluoranthene		790	--	NA	NA	--	3100	--	--	--	2600	--
bis(2-ethyl hexyl)phthalate		500	--	NA	NA	--	--	--	--	38	780	--
Chrysene		900	--	NA	NA	18,000	3000	--	--	--	1900	--
Dibenzofuran		--	--	NA	NA	2000	210	--	--	--	610	--
Dibenzo(a,h)anthracene		--	--	NA	NA	6900	690	--	--	--	--	--
Fluoranthene		1600	--	NA	NA	33,000	5900	--	--	--	4000	--
Fluorene		--	--	NA	NA	3300	380	--	--	--	--	--
Indeno(1,2,3-cd)pyrene		--	--	NA	NA	13,000	1500	--	--	--	1700	--
Naphthalene		--	--	NA	NA	1300	--	--	--	--	--	--
N-Nitrosodiphenylamine		580	130	NA	NA	--	--	--	--	--	200	99
Phenanthrene		1400	--	NA	NA	22,000	3700	--	--	--	1500	--
Phenol		--	--	NA	NA	--	200	--	--	--	--	--
Pyrene		1400	--	NA	NA	22,000	4300	--	--	--	4400	--
Pesticides and PCBs (µg/kg)												
PCB-1254		8600	1200	NA	NA	--	1700	200	--	--	460	--
PCB-1260		--	--	NA	NA	--	2100	--	--	--	--	--
Other (mg/kg)												
Cyanide		--	--	NA	NA	22.8	20.6	8.6	--	--	0.59	1.3

NA - Not analyzed
-- - Dash indicates concentrations below background for inorganic constituents
-- - Dash indicates concentrations for organics, pesticides, and PCBs were below the contract-required detection limit

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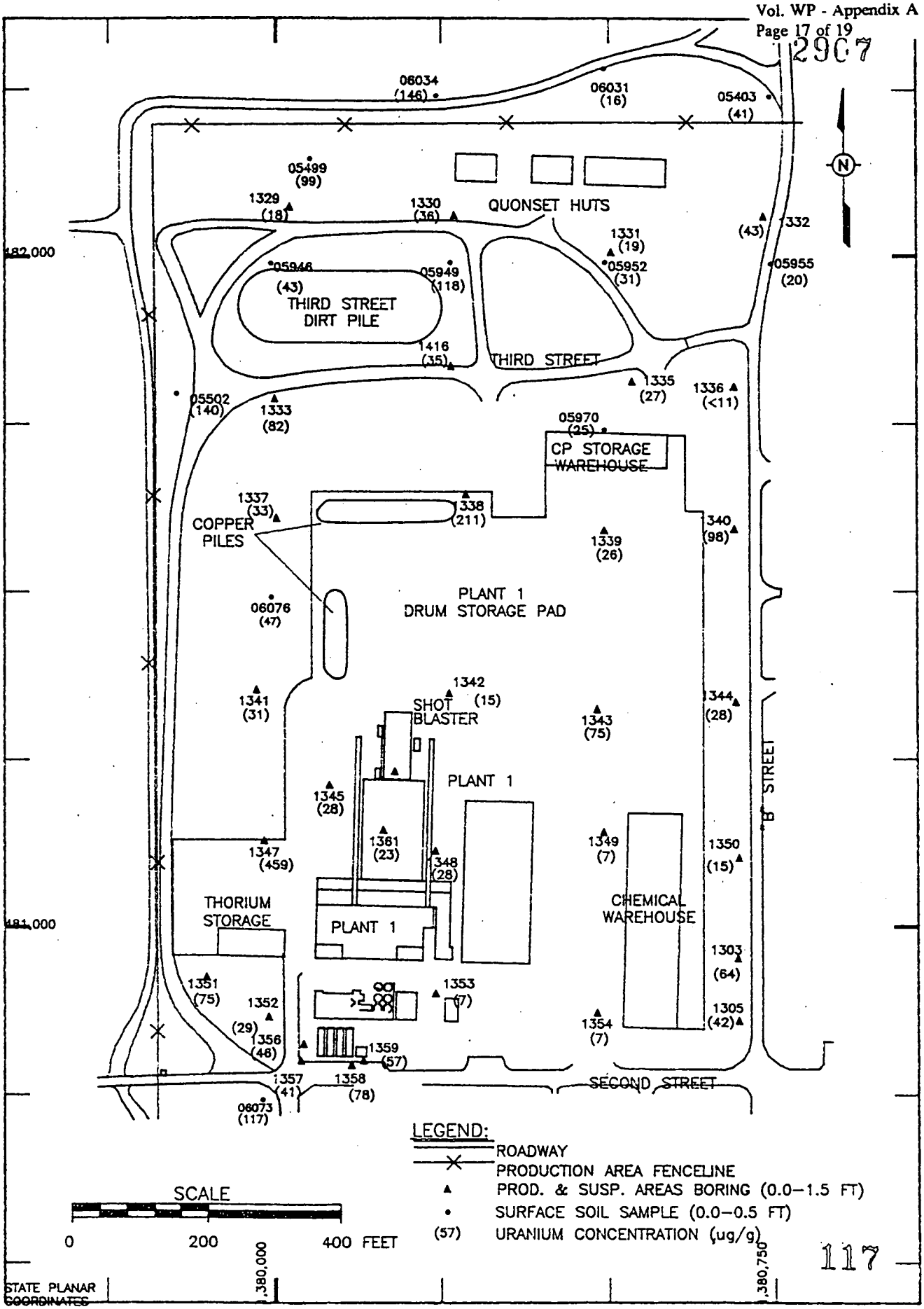

FIGURE A-8. TOTAL URANIUM CONCENTRATIONS IN SOIL – NORTHWEST QUADRANT

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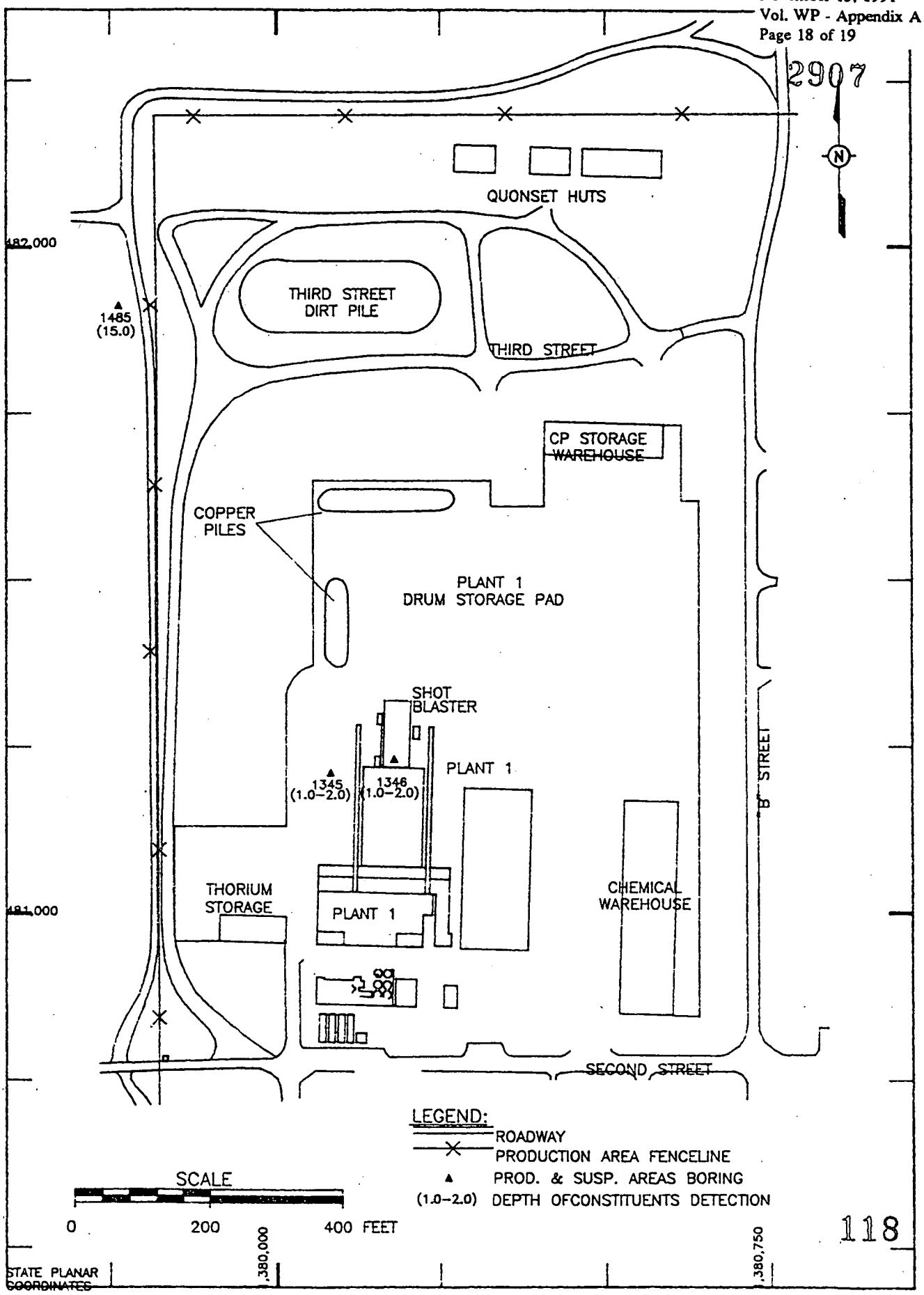

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FIGURE A-9. CHEMICAL SAMPLING LOCATIONS IN THE NORTHWEST QUADRANT

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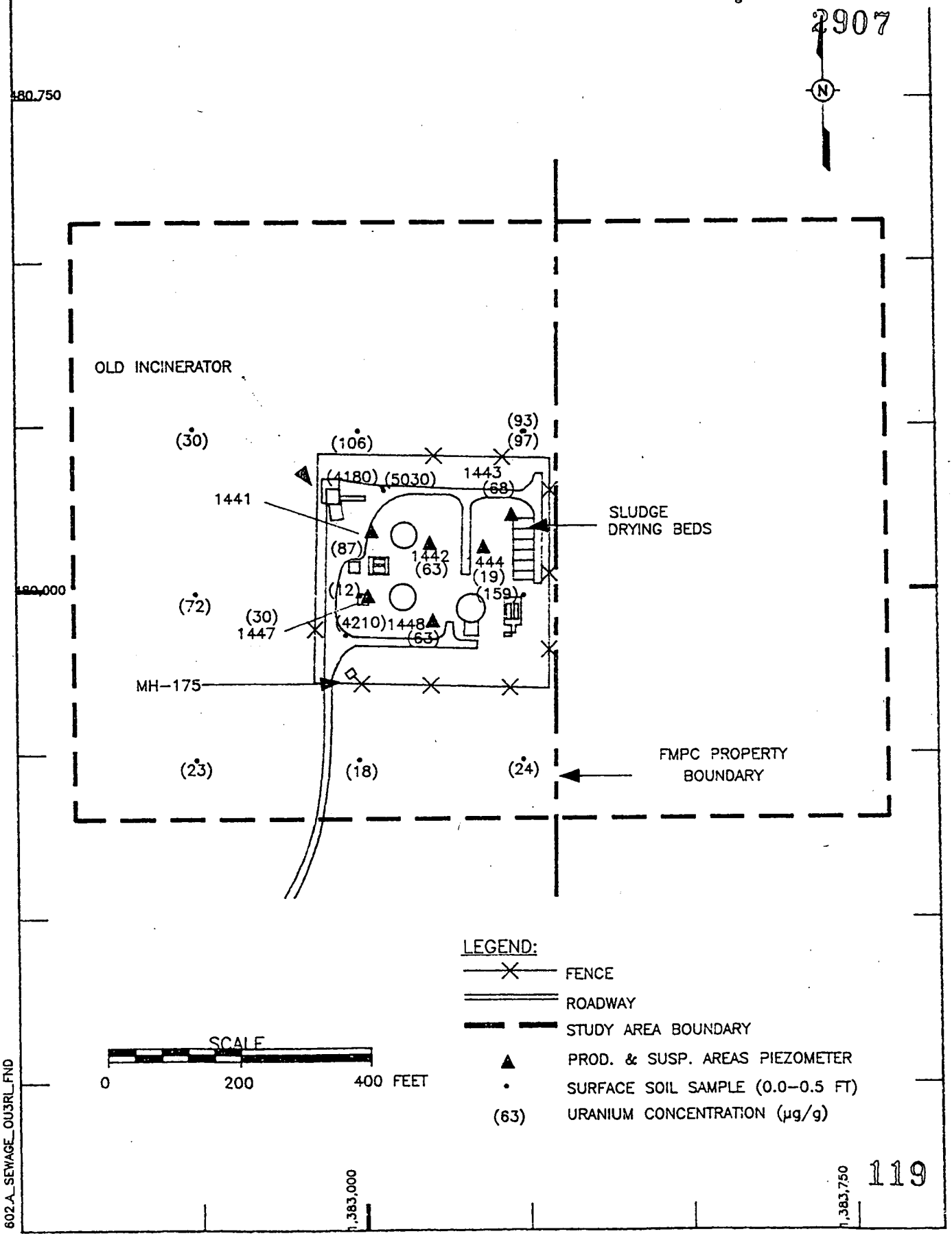

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FIGURE A-10. TOTAL URANIUM CONCENTRATIONS IN SOIL – SEWAGE TREATMENT PLANT

APPENDIX B

TECHNOLOGY DEVELOPMENT LABORATORY STANDARD OPERATING PROCEDURES

International Technology Corporation

IT Analytical Services

Technology Development Laboratory Standard Operating Procedure

Title: Laboratory Notebook Recording Procedures

Prepared by: Patti B. Carswell Date: 2/7/91

Reviewed by: Bruce F. Wagner Date: 2/7/91
Technical Specialist

Patti B. Carswell Date: 2/7/91
Quality Control Coordinator

Janet M. Jones Date: 3-26-91
Director, Quality and Compliance, ITAS

Approved by: R. Miller Date: 3/27/91
Laboratory Director

Controlled Copy No: Uncontrolled Copy

Key Words: NOTEBOOK

Revision #	0					
Date	1-21-91					121

Technology Development Laboratory
304 Directors Drive • Knoxville, Tennessee 37923 • (615) 690-3211 • FAX (615) 694-9573
IT Corporation is a wholly owned Subsidiary of International Technology Corporation.

1.0 Purpose and Application

1.1 The purpose of this method is to describe the required methods of data entry in Technology Development Laboratory notebooks.

1.2 This procedure applies to laboratory notebooks used for project-specific and non-project-specific documentation.

1.3 The purpose of each entry in your notebook is to provide a complete record of your work, one that would enable a co-worker to repeat, if necessary, exactly what you did and produce the same results, without having to ask any questions.

2.0 References

2.1 Writing the Laboratory Notebook, Howard M. Kanare, 1985.

3.0 Associated SOPs and Applicable Methods

3.1 ITAS SOP No. TDL1503, "Analytical Logbook Recording Procedures."

4.0 Definitions

4.1 None

5.0 Procedure

5.1 Safety

5.1.1 All applicable safety and compliance guidelines set forth by IT Corporation and by federal, state, and local regulations must be followed during performance of this procedure. All work must be stopped in the event of a known or potential compromise to the health or safety of any ITAS Associate, and must be reported immediately to a laboratory supervisor.

5.1.2 All laboratory notebooks must be kept free of chemical contamination while being used on benchtops, in field settings, etc.

5.2 Summary

5.2.1 All laboratory notebooks are the property of the International Technology Corporation (IT) Technology Development Laboratory (TDL). It is assigned to you so that you may keep a complete, careful, chronological record of your work. The work which you do and the data which you enter in the notebook are confidential; they must not be disclosed to unauthorized persons. The notebook's security and maintenance are your responsibility. In case of damage, loss, or disappearance, report the

5.0 Procedure (continued)

facts to your supervisor at once. When the notebook is filled or upon termination of your employment, it must be returned to the laboratory quality/operation files.

5.3 Procedure

5.3.1 All data is to be recorded directly into the notebook. Recording of original data on loose pieces of paper for later transcription into the logbook is to be avoided. Should loose paper be necessary for proper conduct of an experiment:

5.3.1.1 Write on the logbook page itself identification of what is affixed to that page.

5.3.1.2 Firmly affix the loose paper with clear tape

5.3.1.3 Initial and date over the edge of the tape.

5.3.2 All entries must be made in black ink. Red ink is reserved for Quality Control (QC) checking purposes only. Erasures, blacking out, or use of correction fluid is not permitted. If a mistake is made, draw a single line through the erroneous material and make a corrected entry, initial, and date the correction.

5.3.3 It is necessary to fill each page and keep the sequence of entries in chronological order. Several pages may be reserved for a particular experiment. However, if the continuity of pages for a particular experiment is broken for lack of reserved space, notations will be made on both sides of the break. The unused balance of a page will be cancelled by a diagonal line. Spaces intentionally left blank in tables or logs will contain horizontal lines.

5.3.4 Stock or standard solutions must reference:

5.3.4.1 Source
5.3.4.2 Lot number
5.3.4.3 Date received
5.3.4.4 Notebook and page numbers whenever available.

5.3.5 When reference is made to samples, the TDL sample number must be used. Additional sample identification may be offered, but not to the exclusion of the TDL sample number.

5.3.6 A co-worker performs a QC check on your calculations by recalculating 20 percent and verifying the formula used. Have him make a check in red ink beside each answer which was recalculated and sign and date

5.0 Procedure (continued)

calculations that lead to the generation of a result which is reported to the client either verbally or in writing. Any values which have not had a 20 percent QC check (one of every five calculations has been checked) are considered "preliminary" and will be marked as such on any material leaving the TDL lab. If an error is found during the 20 percent check, then a 100 percent QC check will be performed.

5.3.7 If one of your co-workers has witnessed an experiment you have conducted, to an extent that enables him to state of his own knowledge what you did and what results you secured, have him sign and date the notebook page(s) as "Witnessed and understood by." If the experiment seems to you to be of sufficient importance (i.e., is potentially patentable), arrange to have it witnessed for content and date of entry.

5.4 Project Documentation Requirements

5.4.1 Every page of the notebook will contain project name, project number, date, and initials of persons entering data. Each project will then be described by the following entries:

5.4.1.1 Objective - briefly describe the planned experiment and the expected or desired result.

5.4.1.2 Plan - give an overview of what you intend to do.

5.4.1.3 Calibrations and Standards - list frequency of calibration, acceptance limits, and concentrations.

5.4.1.4 Analytical Methods - state SOP, standard reference or give a brief description.

5.4.1.5 Experimental Set-ups - sketch and describe the set-up.

5.4.1.6 Data and Observations - provide tables including units and space for observations within or below.

5.4.1.7 Results - include formula and calculations which are necessary to produce results from raw data.

5.4.1.8 Conclusion - how objective was met and any interpretation of results.

6.0 Nonconformance and Corrective Action

6.1 A nonconformance is a deficiency in procedure sufficient to render the quality of an item unacceptable or indeterminate or any event which is beyond the limits documented and established for laboratory operation. A nonconformance may include data recording errors, transcription errors, and failure to document. A nonconformance memo associated with this procedure will be filed with the QC Coordinator.

7.0 Records Management

7.1 TDL Notebooks are the property of IT Corporation.

7.2 Document control of TDL Notebooks is handled by the QC Coordinator (QCC). The QCC will issue all notebooks. All completed notebooks will be returned to the QCC.

7.3 All returned Laboratory Notebooks are filed in TDL Central Files.

International Technology Corporation

IT Analytical Services

Technology Development Laboratory Standard Operating Procedure

Title: Analytical Logbook Recording Procedures

Prepared by: Patti B. Carswell Date: 2/7/91

Reviewed by: Bruce F. Wagner Date: 2/7/91
Technical Specialist

Patti B Carswell Date: 2/7/91
Quality Control Coordinator

Janet M. Jones Date: 3-26-91
Director, Quality and Compliance, ITAS

Approved by: R S Miller Date: 6/7/91
Laboratory Director

Controlled Copy No: Uncontrolled Copy

Key Words: Logbook, Notebook

Revision #	0					
Date	1-21-91					

Technology Development Laboratory
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IT Corporation is a wholly owned Subsidiary of International Technology Corporation

1.0 Purpose and Application

1.1 The purpose of this method is to describe the required methods of data entry in Technology Development Analytical Logbooks.

1.2 This procedure applies to analytical logbooks such as instrument injection logbooks, maintenance logbooks, and balance logs.

2.0 References

2.1 Writing the Laboratory Notebook, Howard M. Kanare, 1985.

3.0 Associated SOPs and Applicable Methods

3.1 ITAS SOP No. TDL1504, "Laboratory Notebook Recording Procedures."

4.0 Definitions

4.1 None

5.0 Procedure

5.1 Safety

5.1.1 All applicable safety and compliance guidelines set forth by IT Corporation and by federal, state, and local regulations must be followed during performance of this procedure. All work must be stopped in the event of a known or potential compromise to the health or safety of any ITAS Associate, and must be reported immediately to a laboratory supervisor.

5.1.2 All analytical logbooks must be kept free of chemical contamination while being used on benchtops, in field settings, etc.

5.2 Summary

5.2.1 All logbooks are the property of the International Technology Corporation (IT) Technology Development Laboratory (TDL). It is assigned to you so that you may keep a complete, careful, chronological record of your work. The work which you do and the data which you enter in this book are confidential; they must not be disclosed to unauthorized persons. The logbook's security and maintenance are your responsibility. In case of damage, loss

5.0 Procedure (continued)

disappearance, report the facts to your supervisor at once. When the logbook is filled, or upon termination of your employment, it must be returned to the laboratory quality/operation files.

5.3 Procedure

5.3.1 Briefly define in the front pages of the book what type of log is contained within. Definitions of column headings, references, and acceptance limits will be addressed on the first pages as well.

5.3.2 All entries are to be recorded directly into the logbook. Recording of original data on loose pieces of paper for later transcription into the logbook is to be avoided. Should loose paper be necessary for proper conduct of an experiment:

5.3.2.1 Write on the logbook page itself identification of what is affixed to that page

5.3.2.2 Firmly affix the loose paper with clear tape

5.3.2.3 Initial and date over the edge of the tape.

5.3.3 All entries must be made in black ink. Red ink is reserved for Quality Control (QC) checking purposes only. Erasures, blacking out, or use of correction fluid is not permitted. If a mistake is made, draw a single line through the erroneous material and make a corrected entry, initial, and date the correction.

5.3.4 It is necessary to fill each page and keep the sequence of entries in chronological order. Any unused section of a page will be cancelled with a diagonal line. Spaces intentionally left blank in tables or logs will contain horizontal lines.

5.3.5 When reference is made to samples, the TDL sample number will be used. Additional sample identification may be offered, but not to the exclusion of the TDL sample number.

5.3.6 Use a ruler to draw lines defining columns. Label columns including units when appropriate. Injection logs, balance logs, and other similar logs will include columns for the operators' initials and date.

5.3.7 Each entry in an analytical logbook is to be initialed and dated. The "Completed by" is signed by the last person to make entry on a given page and indicates that the page has been checked for completeness of entries.

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6.0 Nonconformance and Corrective Action

6.1 A nonconformance is a deficiency in procedure sufficient to render the quality of an item unacceptable or indeterminate or any event which is beyond the limits documented and established for laboratory operation. A nonconformance may include data recording errors, transcription errors, and failure to document. A nonconformance memo associated with this procedure will be filed with the QC Coordinator.

7.0 Records Management

7.1 TDL Analytical Logbooks are the property of IT Corporation.

7.2 Document control of TDL Logbooks is handled by the QC Coordinator (QCC). The QCC will issue all notebooks. All completed logbooks will be returned to the QCC.

7.3 All returned Laboratory Logbooks are filed in TDL Central Files.

INTERNATIONAL TECHNOLOGY CORPORATION

IT Analytical Services

2907

Technology Development Laboratory Standard Operating Procedure

Title: STANDARD LABORATORY SIEVES : SPECIFICATION, CALIBRATION, AND MAINTENANCE

Prepared by: Coy A. Lauer Date: March 5, 1991

Reviewed by: Tom Leist Date: 3/6/91
Technical Specialist

Patti B. Carswell Date: 3/13/91
Quality Control Coordinator

Janet M Jones Date: 6-24-91
Director, Quality and Compliance, ITAS

Approved by: John M Hall Date: 7/5/91
Laboratory Director

Controlled Copy No: Uncontrolled Copy

Key Words: Sieve, ASTM E 11-87, Geotechnical

Revision #	0					
Date	03/05/91					130

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LABORATORY SIEVES
SPECIFICATION, CALIBRATION, AND MAINTENANCE

1.0 Purpose and Application

1.1 This SOP defines the standards for standard laboratory sieves used in the Geotechnical Analysis Laboratory. It also describes calibration requirements and maintenance of the sieves.

2.0 References

2.1 ASTM E 11-87, Standard Specification For Wire Cloth Sieves For Testing Purposes.

3.0 Associated SOPs

3.1 None.

4.0 Definitions

4.1 None.

5.0 Procedure

5.1 All standard sieves will meet the specifications in ASTM E 11-87, Standard Specifications for Wire Cloth Sieves For Testing Purposes. Upon receipt, each sieve will be checked for a label which has the ASTM specification, sieve size, and a identification number or serial number. If the ASTM specification is not on the sieve, that sieve will be returned to the vendor and not used. If the sieve size or a serial number is not on the label, prepare a permanent label with the appropriate information and affix it to the side of the sieve. Due to the corrosive nature of some samples, brass sieves with stainless steel mesh are preferred.

5.2 Sieves put into use prior to this SOP do not require a serial number.

5.3 Calibration certificates should be provided by the manufacturer. If a calibration certificate did not come with the sieve, either return it, or get a certificate from the vendor. Calibration certificates will be kept in the Quality/Operations files maintained

by the lab QC Coordinator.

5.4 If a sieve calibration is suspect, it shall be either checked or replaced. Due to the amount of time involved in checking sieve calibration, replacement is usually the preferred alternative. AASHTO proficiency samples may also be used as an indication of sieve calibration. If the results from a proficiency sample are too far out of line (as determined by the lab supervisor), the suspect sieve shall be pulled for calibration or replacement.

5.5 Sieves with a mesh size of #200 or smaller will be replaced one year after initially being placed into service. Each sieve will be labeled with the replacement date at the time it is placed into service.

5.6 Prior to use, each sieve will be visually inspected for holes, broken mesh, or any other condition which may make the sieve unsuitable for use. Sieves which are clogged will be cleaned with a suitable brush. Caution shall be used when cleaning fine sieves with a wire bristle brush as this may damage the sieve. Any sieve deemed unsuitable for use will be immediately discarded.

5.7 Sieves used in washing samples or sieves used with corrosive samples will be cleaned with water and a brush after use. It may be useful to place the sieve in a drying oven (<120 °C) to dry. This will help to keep corrosion to a minimum.

5.8 Sieves will be stored in a clean, dry environment.

6.0 <u>Nonconformance and Corrective Action</u>

6.1 Sieves which do not meet the required specifications, are damaged, or otherwise unsuitable for use will be discarded or returned to the vendor if newly purchased. If a sieve is discovered nonuseable during use, the sample(s) will be retested and a nonconformance memo generated to describe the problem with the sieve and the fact that the sample(s) are being retested.

7.0 Records Management/Documentation

7.1 Sieve calibration records will be kept in the Quality/Operations files by the QA coordinator.

APPENDIX C

HEALTH AND SAFETY PLAN

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
OPERABLE UNIT 5 TREATABILITY FIELD SAMPLING

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SITE HEALTH AND SAFETY PLAN
ACKNOWLEDGMENT

I have read, understand, and agree to abide by the provisions as detailed in this Site-Specific Health and Safety Plan prepared by ASI/IT. Failure to comply with these provisions may lead to disciplinary action and/or my dismissal from the work site.

Printed Name	Employee Number	Signature	Date

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C.1.0 TASKS TO BE PERFORMED

This Health and Safety Plan (HSP) establishes the work practices necessary to help ensure protection of ASI/IT (ASI/IT) personnel during sampling at the six locations within Operable Unit 5.

The objective of this plan is to provide a mechanism for the establishment of safe working conditions at the site. The safety procedures have been established following an analysis of potential hazards at the site, and procedures have been developed to minimize the potential of accident or injury.

All site operations will be performed in accordance with applicable state, local, and ASI/IT regulations and procedures, Occupational Safety and Health Administration (OSHA) requirements, and any client requirements.

The work to be performed involves the retrieval of representative samples from six locations within Operable Unit 5 for use in treatability studies. Samples will be obtained from an area southwest of the pilot, north of Plant 2/3, southeast of graphite furnace, and from an area northeast, north, and southeast of the maintenance building. Samples will be obtained at depths of 0 to 1.5 feet at each sampling location. Samples will be obtained using a stainless steel drive tube sampler.

Based on screening of these six samples, four locations will be selected. Samples at these four locations will be obtained utilizing a shovel and will be placed into lined 55-gallon drums.

C.2.0 RESPONSIBILITIES

SITE HEALTH & SAFETY MANAGER: Steve Duce

The Site Health & Safety Manager is responsible for the technical development and coordination of the HSP. Inquiries regarding the HSP, ASI/IT health & safety procedures, and other technical or regulatory items shall be addressed to this individual.

SITE PROJECT SUPERVISOR: Michael Krstich

The site Project Supervisor shall be responsible for field implementation of the HSP. This shall include communication of site requirements to all field personnel, and interaction with client representatives and regulatory agencies. Additional communication may include consultation with the Site Health &Safety Manager regarding the execution of the project and the HSP.

TEAM MEMBERS:

All team members shall be responsible to understand and comply with all site health & safety requirements. Each team member shall be provided training on the requirements of this HSP before the beginning of the project.

Note: The Health & Safety Manager and any member of the team have the authority to stop work when imminent or serious safety hazards or conditions exist. Restart of work will be allowed only after the hazard or condition has been abated or reduced to an acceptable level.

C.3.0 SITE HISTORY

A variety of chemical and metallurgical processes were utilized at the Fernald Environmental Management Project (FEMP) for the manufacture of uranium products. During the manufacturing process, high quality uranium compounds are introduced into the FEMP processes at several points. Impure starting materials are dissolved in nitric acid, and the uranium is purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot.

Operable Unit 5 consists of those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FEMP contaminants. The media within Operable Unit 5 include groundwater, surface water, soils, sediments, flora and fauna. Operable Unit 5 specifically covers specifically the soils associated with the Production Area and nine suspect areas. The Production Area includes the buffer zones, the scrap piles, and the miscellaneous discarded materials and equipment overlying the former drum baling area. The nine suspect areas currently being addressed are:

- Clearwell
- Fire training area
- Main effluent line
- Rubble mound west of the K-65 silos
- South flagpole area
- Sewage treatment plant/incinerator area
- K-65 slurry line
- Suspected rubble mound south of the K-65 slurry line
- Rubble mound west of the northwest corner of the Production Area (north rubble mound)

C.4.0 TASK-SPECIFIC HAZARD ASSESSMENT

The following hazard assessment is based on historical information and defined task activities. Field personnel routinely reassess the hazards before starting work to ensure that conditions have not changed. All newly identified hazards will be addressed with the Health & Safety Officer to determine the degree of hazard and if any changes to the HSP are needed.

C.4.1 PHYSICAL HAZARDS

The potential physical hazards involved with Operable Unit 5 may include:

- Heat Stress
- Bending/Lifting hazards
- Slip/Trip/Fall

All ASI/IT employees shall be aware of these hazards, and shall utilize protective equipment and proper work procedures.

C.4.2 RADIOLOGICAL HAZARDS

The soil data from the areas to be sampled indicate areas where uranium is present due to surface deposition. Subsurface contamination appears to decrease significantly at depths greater than 1.5 to 2.0 feet.

The potential radiation hazards are from uranium (ranging from depleted to 2 percent enriched in uranium-235) and short-lived decay products. Uranium is the controlling radionuclide and was observed at concentrations up to 330 parts per million (ppm) at the maintenance building and 570 ppm west of the pilot plant. Gross activity levels will be referred to as uranium. Thorium was also found at concentrations up to 184 ppm at the pilot plant.

Uranium has an exposure route through inhalation or ingestion. The background level in ambient air is less than 2×10^{-12} microCuries/milliliter (μCi/mL). Action levels are described in Table C.3-2.

C.4.3 CHEMICAL HAZARDS

The potential chemical hazards involved at the Operable Unit 5 site are related to hydrocarbons. Preliminary soil sample analyses indicated concentrations of volatile hydrocarbons ranging from 0.005 parts per million (ppm) to 150 ppm. The contaminants in highest concentrations were methylene

chloride, xylene, trichloroethene and polynuclear aromatic hydrocarbons. Lower concentrations of polychlorinated biphenyls (PCB) were also found in soil samples.

Currently, exposure guidelines to pesticides and other chemical substances are regulated by the Federal OSHA. These exposures are based upon the time-weighted average (TWA) concentration for a normal 8-hour workday. Several chemical substances have short-term exposure limits or ceiling values which allow a maximum concentration to which workers can be exposed continuously for a short period of time without suffering from (1) irritation, (2) chronic or irreversible tissue damage, (3) narcosis of a sufficient degree to result in accidental injury, impair self rescue, or substantially reduce work efficiency.

Threshold limit values (TLVs) refer to airborne concentration of substances which represent conditions that nearly all employees may be repeatedly exposed to day after day without adverse effect. These threshold limits are prescribed by the American Conference of Governmental Industrial Hygienists (ACGIH). They are based upon the best available information from industrial experience and animal or human studies. Because of the wide variation in individual susceptibility, a small percentage of workers may experience discomfort from some substances at concentrations below the recommended values. It has been policy to use these guidelines for good hygienic practices; however, whenever applicable, stricter guidelines may be utilized.

The short-term exposure limit (STEL) is defined by the ACGIH and OSHA as a 15-minute TWA-exposure which should not be exceeded within a two-hour time period during a workday even if the 8-hour TWA is within applicable limits. OSHA requires that a 15 minute "ceiling" concentration never be exceeded for that chemical constituent. This notation appears as the letter "C" after the chemical name.

Under certain chemical substance listings, there may appear a "skin" notation. This refers to the potential contribution to the overall exposure by the cutaneous route, including mucous membranes and eye, either airborne or by direct contact. Little quantitative data are available describing absorption as a function of the concentration to which the skin is exposed. Biological monitoring may be considered to determine the relative contribution of dermal exposure to the total dose.

The ACGIH and OSHA have recognized that certain chemical substances may have the potential to be carcinogenic in humans from epidemiological studies, toxicology studies and, to a lesser extent, case histories. Because of the long latency period for many carcinogens, it is often impossible to base timely risk management decisions on the results of such information. Two categories of carcinogens are designated, based upon the most current literature and information. These include confirmed

human carcinogens and suspected human carcinogens. These chemical categories are based on either 1) limited epidemiologic evidence or 2) demonstration of carcinogens in one or more animal species by appropriate methods. The worker potentially exposed to a known human carcinogen must be properly equipped to insure virtually no contact with the chemical constituents. In the case of a suspected human carcinogen, worker exposure by all routes must be carefully controlled by the use of personal and respiratory protection, and administrative or engineering controls.

Table C.3-1 lists exposure standards for some contaminants which may be encountered.

C.5.0 MONITORING

C.5.1 GOALS

Air monitoring will be performed to ensure contaminant concentrations in the breathing zone do not exceed the concentrations specified by established exposure levels. The air monitoring program will consist of monitoring for long-lived radioactive particulates and for volatile organic vapors.

IT Corporation/Advanced Sciences, Inc. (IT/ASI) policy requires engineering controls, if feasible, or the use of personal protective equipment (PPE) to reduce on-site exposures to the action limit values. It is advisable to keep exposures to chemicals as low as possible because there are insufficient data to predict the combined effects of most chemical mixtures.

C.5.2 MONITORING METHODOLOGY (AIRBORNE CONTAMINANTS)

Long-lived airborne radioactivity will be monitored using a portable, battery-powered air pump (BZA) with a 37 millimeter (mm) membrane filter with an 8 mm pore size or with a high volume air sample pump. At a minimum, samples will be taken at the start of each workshift and hourly thereafter. Samples shall be taken in the breathing zone of the worker to obtain samples representative of the airborne concentrations to which the worker is exposed. Samples shall be collected and counted in accordance with Westinghouse Environmental Management Company of Ohio (WEMCO) procedure SP-P-35-026-Occupational Air Sampling.

Volatile organic vapors will be monitored using an HNu photoionization instrument. Both samples and excavated areas should be monitored to determine the presence of volatile organics. If organic vapors are detected, the concentrations will be compared to exposure limits or guidelines, the stricter of the two. Draeger tubes may also be used to determine levels of specific organic vapors. Breathing zone action levels are listed in Table C.3-1.

C.5.3 RADIATION/CONTAMINATION MONITORING

The Health and Safety Field Technician shall monitor each selected sample location for contamination and/or radiation before work begins to determine if protective clothing requirements are adequate. Radiation and contamination surveys will also be performed periodically during the performance of work to verify that levels have not changed significantly. All personnel involved in work on site are required to wear thermoluminescent dosimeters (TLD) to monitor for external radiation exposure. Equipment used for the sampling effort will be monitored for contamination at the completion of work and decontaminated or disposed of as required.

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C.5.4 HEAT/COLD STRESS

HEAT STRESS

Site project work conducted in summer months or in chemical protective clothing may cause heat related symptoms in some individuals. One or more of the following control measures can be used to help control heat related disorders:

- Provision of adequate liquids to replace lost body fluids. Employees must replace water and salt lost from sweating. Employees must be encouraged to drink more than the amount required to satisfy thirst. Thirst satisfaction is not an accurate indicator of adequate salt and fluid replacement.
- Replacement fluids can be a 0.1 percent salt water solution. Commercial mixes such as Gatorade are effective..
- Establishment of a work regimen that will provide adequate rest periods for cooling down. This may require additional shifts for workers.
- Cooling devices such as vortex tubes or cooling vests can be worn beneath protective garments.
- All breaks are to be taken in a cool rest area (77° F is best).
- All employees shall be informed of the importance of adequate rest, acclimation, and proper diet in the prevention of heat stress.

During periods of high temperature and/or humidity, project personnel should be alert for symptoms of heat stress, especially in areas where protective clothing is being worn. If the body's physiological process to maintain a normal body temperature fails, or is overburdened due to excessive heat exposure, a number of physical reactions can occur ranging from mild symptoms such as fatigue, irritability, anxiety, to decreases in mental concentration. Heat related problems are presented below:

Heat Rash - This is caused by continual exposure to heat and humid air, and aggravated by chaffing clothes. Heat rash decreases a person's ability to tolerate heat as well as becoming an irritating nuisance.

Heat Cramps - This is caused by profuse perspiration with inadequate water intake and chemical electrolyte imbalance. This results in muscle spasm and pain in the extremities and abdomen.

Heat Exhaustion - Stress on various organs to meet increasing demands to cool the body will result in signs and symptoms including shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and lassitude.

Heat Stroke - This is the most severe form of heat stress which must be treated immediately by cooling the body or death may result. Signs and symptoms include red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; and coma.

Supervisors will observe workers for signs and symptoms of heat/cold stress and adjust work schedules as required. Monitoring for heat (wet bulb globe temperature) and cold stress will be performed by the Health and Safety Field Technicians as needed to ensure compliance with the ACGIH limits established in the most recent edition of the TLV booklet.

COLD STRESS

Procedures for recognizing and avoiding cold stress must be implemented when the ambient temperature is below 40° F. Cold stress effects may range from frostbite to severe hypothermia. The following signs and symptoms in project personnel may indicate cold stress, and appropriate action should be taken if the signs are present:

Frostbite: Pain in the affected extremities, reddening of tissue, loss of dexterity; a tingling or lack of sensation in the affected area.

Hypothermia: Pain in the extremity, and loss of dexterity; severe or uncontrollable shivering; inability to maintain normal rate of activity; excessive fatigue, drowsiness or euphoria.

Severe Hypothermia: Clouded consciousness, low blood pressure, cessation of shivering, dilated pupils, unconsciousness.

If these symptoms are observed, remove the individual to a warm, dry place. Remove any wet clothing and replace with dry clothing. Keep patient warm, but warm gradually. If patient is conscious and alert, give warm liquids, but no caffeine. Warm affected extremities with moist, lukewarm compresses; gradually increase the temperature until normal circulation and temperature return. Seek medical attention for all but minor cold stress cases.

C.6.0 PERSONAL PROTECTIVE EQUIPMENT

Equipment for personnel protection will be determined based on the potential contact and/or airborne levels of any contaminant.

LEVELS OF PROTECTION

Specific levels of protection will be used to safeguard ASI/IT employees and subcontractors from potential hazards. Two distinct levels of protection may be required for this project. The final determination for ASI/IT personnel and subcontractors of any required level of protection will be based upon the hazards and current conditions of the work site. The situations requiring specific levels of protection are described in the following sections.

LEVEL C PROTECTION

Level C protection will be required when the airborne concentration of suspected contaminants are known to be one half the ACGIH TLV or the OSHA permissible exposure limit (PEL). This may occur during the excavation of heavily contaminated soil.

The following equipment will be used for Level C protection:

- Full-face, air-purifying respirators with organic vapor cartridge in combination with high efficiency particulate filter which are NIOSH/MSHA approved. Half-face respirators may be utilized if accompanied by chemical splash goggles.
- Hooded, chemical resistant suit such as polyethylene coated TYVEK.
- Gloves - (Outer) - chemical resistant Nitrile or Neoprene.
- Gloves - (Inner) - chemical resistant (latex).
- Boots - (Outer) - chemical resistant Neoprene with steel toes or double latex booties over steel toed shoes.
- Hard hat
- Hearing protection (if necessary)

LEVEL D PROTECTION

The minimal level of protection that will be required of ASI/IT personnel and subcontractors at the site will be Level D. The following equipment will be used for Level D protection:

- Coveralls or work clothing
- Boots/shoes - with steel toes, latex overboots if area is heavily contaminated.
- Safety glasses or goggles
- Hard hat
- Chemical resistant nitrile or PVC protective gloves with surgical latex undergloves.
- Hearing protection (if necessary)

RESPIRATORY PROTECTION

A comprehensive respiratory protection program has been established by ASI/IT. This program is required in all locations where use of such equipment could lessen the potential for adverse health affects to any employee.

As part of the respiratory training program, each employee is instructed in the following elements:

- Nature of the respiratory hazard on the work site and the appraisal of potential consequences if the respiratory protection is not utilized.
- Use and proper fitting of the respirator.
- Cleaning, disinfecting, inspection, maintenance, and storage of the respirator.
- Proper selection, capabilities, and their limitations.

Employees must demonstrate proper fit of the equipment in a test atmosphere.

Routinely used respiratory equipment will be inspected, cleaned, and disinfected daily to help assure proper hygienic practices. An inspection of these breathing devices will include the following:

- Examination of the head straps for breaks, loss of elasticity, broken or malfunctioning buckles, and other attachments.
- Examination of the facepiece for excessive dirt, cracks, tears, distortion, holes, or inflexibility.
- Examination of the exhalation and inhalation valves for any foreign material, cracks, tears, distortion, in the valve, and proper installation.

- Examination of air purifying elements for incorrect cartridge, expired shelf-life of the cartridge, cracks or dents in the cartridge or cartridge holder.

- Examination of proper insertion of the cartridges into the facepiece and a check of the gaskets inside the cartridge holder.

When Level C protection is required, respirator cartridges will be changed daily. All respirators will be inspected prior to each day's use. If broken or malfunctioning parts are found during the cleaning process, these parts will be replaced or new respiratory equipment will be issued to the user.

C.7.0 SITE CONTROL

A site control program has been developed to control worker exposure to radioactive and hazardous materials and to prevent the spread of contamination. The FEMP site access is controlled by WEMCO security. The Operable Unit 5 treatability sampling sites will have access restricted during operations by use of boundary rope. Only properly authorized and trained personnel will be allowed access.

For each sampling location, the work area will include three separate zones: an exclusion ("hot") zone, a contamination reduction zone, and a support zone.

The Exclusion Zone will consist of the entire area of suspected contamination during excavation. All employees will use proper personnel protective equipment when working in those areas. The exclusion zone will be a defined area where there is a possible respiratory and/or contact health hazard. In most instances this area will immediately adjacent to the sample excavation area. The location of the exclusion zone will be identified by cones, tape, or other appropriate means.

A Contamination Reduction Zone will be established and decontamination will be performed in this zone. All personnel entering or leaving the exclusion zone will pass through this area in order to prevent any cross-contamination and for the purpose of accountability. Tools and any equipment or machinery will be decontaminated in a specific location. The decontamination of all personnel will be performed on site adjacent to the exclusion zone. Personal protective outer garments and respiratory protection will be removed in the contamination reduction zone and properly labelled.

The Support Zone will consist of an area outside the contamination reduction zone. The support zone will be located to prevent employees from being exposed to any organic vapors or dust levels above regulatory limits. Eating, drinking, or smoking will be permitted in the support area only after washing face and hands.

Since this work will not involve any significant contamination of equipment or personnel except for the bailers, it will not be necessary to set up separate zones.

C.8.0 HAZARD CONTROL PROGRAM

The following procedures are mandatory for all ASI/IT and subcontractors' personnel. All site visitors entering exclusion zones must follow these procedures. Personnel not following procedures will be warned. If they refuse to follow these procedures, they will be escorted from the site.

C.8.1 GENERAL PRACTICES

All information regarding work to be performed, emergency procedures, and health and safety hazards will be reviewed before the work begins during a daily Tailgate Safety meeting. No work will be performed before this meeting has taken place. At least one copy of this plan shall be available at the job work site.

Only authorized personnel will be permitted in the work area. These authorized individuals must have successfully completed a medical exam and have been properly trained in the use of respiratory protective equipment and specific health and safety hazards. All visitors shall check in with the ASI/IT or client representative.

All personnel entering the site shall be thoroughly briefed on the hazards, equipment requirements, safety practices, emergency procedures, and communication methods.

Protective clothing and respiratory protective equipment will be used for various stages of the operation as needed. The level of protection will be specified in Section 5.2.5, and will depend upon the degree of hazard.

At least one person trained in a minimum of both American Red Cross first-aid techniques and cardiopulmonary resuscitation will be on site whenever remediation activities occur. As an alternative, this requirement is satisfied when a 911 emergency responder can respond within five (5) minutes to the site.

No food, beverages, tobacco products shall be present, consumed or used in contaminated areas or potentially contaminated areas. Taking medication, smoking or applying cosmetics are also prohibited. These activities are allowed only in the established clean room and clean areas.

Before eating, drinking, or smoking employees shall wash their hands and remove outer protective garments.

At the end of each work shift, before leaving the site, personnel who worked in contaminated zones shall thoroughly shower or wash themselves to remove any contaminants.

Containers shall be moved only with the proper equipment and shall be secured to prevent dropping or loss of control during transport.

Emergency equipment shall be located in readily accessible uncontaminated locations. A complete first-aid kit will be readily available on site. A fire extinguisher will be at the work site. In the event of an emergency, it will be readily available for the team's use. It shall be located not more than 25 feet from the work activity. At least one eyewash will be maintained in the contamination reduction zone (CRZ).

Employee entrance and exit routes shall be planned and emergency escape routes designated.

All operators of equipment used on site will be familiar with the requirements for inspection and operation of such equipment. Unfamiliar operations shall be discussed with affected employees before beginning work. The site supervisor will be responsible to check the proficiency of the operator. Perimeter barricades will be placed around the particular equipment used in a fixed location. Audio and/or visual backup alarms will be utilized on all heavy equipment on site.

Personnel will be prohibited from being transported by any other means than those prescribed for movement of personnel. When trucks or other heavy equipment enters or leaves the site, an individual shall direct the driver.

Any employee not willing to comply with this or any other health & safety procedure will be subject to disciplinary action.

No electrical equipment will be permitted in areas where a flammable atmosphere may exist. All static ignition sources will be identified and eliminated by the use of bonding and grounding techniques.

Material safety data sheets (MSDS) will be obtained for every chemical product used on site. This information will be made readily available to all employees upon request and stored in a central location. MSDS or applicable information will be available with regard to materials used in the soil collection. All containers of any chemical products will be properly labeled to comply with the OSHA Hazard Communication Standard (29CFR1910.1200).

C.8.1.1 Buddy System

All on-site personnel shall use the buddy system. Buddies shall maintain visual contact with each other. Personnel must observe each other for signs of heat stress or toxic exposure such as:

1. Changes in complexion and skin discoloration
2. Changes in coordination or demeanor
3. Excessive salivation and pupillary response
4. Changes in speech pattern

Personnel shall inform their supervisor of nonvisual effects of toxic exposure such as:

1. Headaches, dizziness, blurred vision
2. Nausea, cramps
3. Irritation of eyes, skin or respiratory tract

C.8.1.2 Fall Protection

The walking and working surfaces may become wet and slippery during these tasks. Use extra caution when working on these surfaces. In addition, visible barriers will be erected around any open excavations to prevent personnel from falling into these areas.

C.8.2 PROJECT SPECIFIC REQUIREMENTS

C.8.2.1 Bioassay Program

A bioassay program will be implemented to monitor employees for internal radiation exposure and to determine the amount and distribution of internally deposited radioactive material should an intake occur as a result of project operations. Sampling personnel will submit a monthly urinalysis sample to WEMCO to be analyzed for uranium. In addition to this routine bioassay program, any circumstances that could have resulted in any intake of radioactive materials by ingestion, inhalation, or skin absorption requires the affected employee to immediately report it to his/her supervisor and then to WEMCO Medical at the end of that shift in order to submit an incident-type urine sample and fill out an Incident Investigation Report. The involved employee will also submit another follow-up sample at the start of the next shift.

C.8.2.2 Medical Monitoring

In accordance with 29CFR1910.120 OSHA requirements, all ASI/IT and subcontractor personnel are required to participate in a medical monitoring program that includes:

- Baseline medical examination
- Annual medical examination

- Medical examinations may be required after potential exposures
- Respirator physical

C.8.2.3 Training Requirements

All ASI/IT and subcontractor personnel assigned to site tasks will be trained to meet OSHA and site-specific requirements including:

- 40-hour OSHA training
- 8-hour refresher training
- 8-hour supervisory training (supervisors)
- 24-hour supervised field experience
- Review of this HSP
- Site-specific training, required by WEMCO (radiation safety, etc.)

C.8.2.4 Sanitation

ASI/IT employees will keep the work and support areas neat and orderly and free of trash and debris.

An area will be established that is upwind from the sampling area and outside the contamination reduction zone where personnel can take a break. The area must be clearly marked and no contaminated personnel or equipment is permitted there. An adequate number of toilet facilities will be made available to employees.

If the facility does not have a water supply available then potable water will be carried to the site for use in decontamination and employee cleanup.

C.8.2.5 Illumination

Sampling activities will take place during daylight hours; therefore, the work areas will be illuminated to a minimum of 20 foot candles. Supplementary lighting may be necessary inside buildings, tanks, at night, or in other poorly lit areas.

C.8.2.6 Drum Handling

The following requirements will be adhered to when working with drums and containers:

- When practical, containers will be inspected and their integrity shall be evaluated before being moved.
- Containers whose contents are unknown will be considered to contain hazardous substances and handled accordingly until the contents are positively identified.
- Site operations will be organized to minimize the amount of drum or container movement.

- Before opening, transfer of contents, removal, or other operations that may involve employee contact (direct or airborne), all potentially exposed personnel shall be warned of the potential hazards associated with the contents of the container and the operation in which they are participating.

C.9.0 SITE ENTRY PROCEDURES

Site entry procedures will consist of the following:

- The site crew will radio CONTROL daily to establish radio contact, location, start time, and stop time.
- Procure radiation work permit for daily operations, if required,
  - Identifies degree of radiological hazard
  - Limits allowable work time
  - Specifies minimum PPE requirements
- All safety equipment is required to undergo a safety inspection by WEMCO Fire and Safety personnel upon initial entry to the FEMP.
- Perform tailgate meeting to familiarize team with site-specific hazards. Identify contamination zones and break area. Discuss alternate communications signals (if applicable).
- Calibrate instruments and log calibrations.
- Visually scan the site for signs of contamination.
- Perform respirator checkout and fit test before use.
- Enter potentially contaminated areas with monitoring.
- Monitor for radiation using radiation meters for alpha and beta/gamma.
- Use buddy system.
  - Teams of at least two people will be used for all activities within a Contamination Control Area. Team members will monitor each other for signs of heat stress or other distress and will render aid, if required.

Note: The ASI/IT Site Safety Officer and any member of the Field Team have the authority to stop work when imminent or serious safety hazards or conditions exist. Restart of work will be allowed only after the hazard or condition has been abated or reduced to a level deemed acceptable by the Site Safety Officer (or designee) and the Project Manager.

C.10.0 SITE EXITING PROCEDURE

10.1 CONTAMINATION DETECTION

All site personnel are required to decontaminate themselves and then confirm the effectiveness of the decontamination. The effectiveness will be determined by frisking with a hand-held radiation monitor. A Radiation Safety Technician (RST) shall monitor any visitors to the site.

Personnel monitoring will be performed using portable survey instruments equipped with either a GM Detector (beta/gamma) or a Zinc Sulfide Scintillation Detector (alpha). For beta/gamma monitoring, the detector will he held within 1/2 inch of the surface being frisked and surveyed at a rate of 2 to 3 inches per second. Background levels while frisking for beta/gamma contamination must be less than 300 counts per minute (cpm). In cases where background exceeds 300 cpm, monitoring will be performed using alpha scintillation detectors. For alpha contamination monitoring, the detector should be held as close as possible to the surface being frisked (not in contact) and surveyed at a rate of 1 to 2 inches per second. All personnel will perform a whole body frisk upon exit from a contamination area.

In the event that contamination cannot be removed to below the action level (100 cpm beta/gamma or detectable alpha above background), contact Health Physics personnel. Health Physics should be notified of any contamination incidents.

Vehicles and other equipment used on site must be monitored for contamination (and decontaminated if necessary) before moving them to noncontaminated areas. Health Physics Personnel will determine when the equipment is safe to move to clean areas.

10.2 DECONTAMINATION

Decontamination reduces contaminant concentrations to acceptable levels, but does not generally remove it totally. Try to avoid contamination where possible by making minimum contact with the contaminant.

Personnel: Remove disposable protective equipment, wash hands, face, and any other exposed skin. Detergent and water should be used to gently scrub skin surfaces that have contacted potentially contaminated wastes. The effectiveness of decontamination must be confirmed by frisking or the use of hand and foot monitors.

Heavy Equipment: Heavy equipment generally requires decontamination at the WEMCO Decontamination Pad. Frisking and/or wipe tests will be performed to confirm the effectiveness of decontamination.

C.11.0 SAMPLING-DERIVED WASTES

Sampling-derived wastes are those generated in the performance of on-site activities and will be handled in accordance with site procedures. These wastes include, but not limited to:

- Disposable PPE such as Tyvek coveralls, gloves, and booties
- Excess sample materials
- Used glovebags and decontamination materials

All potentially contaminated waste materials resulting from site activities will be collected and placed in drums or other containers specified by WEMCO. Protective clothing will be placed in plastic bags and disposed of as compactable, potentially contaminated waste through WEMCO. Wastes will be segregated as much as practical to aid in disposal.

Sampling derived wastes are the property of the client and are to be left on site.

C.12.0 CONFINED SPACE ENTRY

No confined space entry is permitted.

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C.13.0 CONTINGENCY PLANS

Emergency response procedures will be developed for extraordinary conditions that may occur at the work site; they will be covered during the Tailgate Safety Meeting.

Emergencies must be dealt with in a manner to minimize the health and safety risk to all project personnel. All ASI/IT personnel shall be aware of emergency procedures, evacuation routes, and "safe" areas.

ASI/IT team leaders have the following responsibilities in an emergency:

- Assess the emergency situation and notify appropriate response personnel (e.g. Fire Dept., Ambulance, Police)
- Determine the required response measures and inform the client representative.
- Determine and coordinate ASI/IT personnel actions for the particular emergency.
- Immediately complete the Supervisor Injury Report form upon occurrence of the accident or incident.

EMERGENCY TELEPHONE NUMBERS

			Radio
Ambulance:	Radio to Control	(513) 738-6511	CONTROL
Hospital:	Radio to Control	(513) 738-6511	CONTROL
Fire:	Radio to Control	(513) 738-6511	CONTROL

	Work	Home	Radio
John Wood: Project Director	(513) 738-3100	[redacted]	
Steve Duce, H.P.	(513) 738-3100		
Bill Kwoka, H&S (WMD)	(615) 483-1274		
Alvin Luttrell, V.P. (WMD)	(615) 483-1274		
Doug Harmel, Field Manager	(513) 738-3100		
Lee Vittitow, Sr. IH	(513) 738-3100		
William Hertel	(513) 738-3100		

Susan Birner, Personnel	(505) 883-0959			1
Greg McAnarney, H&S (Corp.)	(505) 883-0959			2
Mark Turner, H.P.	(513) 738-3100			3
Ron Gill, H&S	(513) 738-3100	[redacted]		4
Oba Vincent (DOE)	(513) 738-6937			5
EMERGENCY RESPONSE	**(513) 738-6511**	**or**	**CONTROL**	6
Leo Singleton (WEMCO)	(513) 738-8908			7
Dick Kasparek (WEMCO)	(513) 738-6899			8
Industrial Hygiene (WEMCO):	(513) 738-6207		357	9
Radiation Safety (WEMCO):	(513) 738-6889		355	10
Fire and Safety (WEMCO):	(513) 738-6235		303	11
Utility Engineer (WEMCO)	(513) 738-6295		202	12
PROJECT CONTACTS				13
ASI/IT Deputy Project Director - John Razor	(1) 738-3100	[redacted]		14
ASI/IT Ops. Supervisor - Doug Harmel	(1) 738-3100			15
WEMCO Health Physics Supervisor -	(513) 738-6672			16
Don Spahr	Beeper-844-5893			17

PUBLIC RESPONSE AGENCIES 18

Before the start of site work, the project supervisor will develop a list of response agencies which may 19
be contacted depending on the nature of the emergency. This list of contact agencies will include the 20
name, address, and telephone number of the following: 21

NATIONAL HOTLINES FOR EMERGENCY REPORTING AND INFORMATION 22

Center for Disease Control	404-633-5313	23
Chemtrec	800-424-9300	24
CMA Chemical Referral Center	800-262-8200	25
DOT Hazardous Materials Information	202-366-4488	26
Emergency Planning and Community Right-to-Know	800-535-0202	27
Federal Emergency Management Agency	817-898-9104	28
National Response Center Hotline	800-424-8802	29
Occupational Safety and Health Administration	800-582-1708	30
American Chemical Society Library -		31
Contact: Henry Saxe	(202) 872-4511	32
Substance Identification	(800) 848-6538	33
National Safety Council	(312) 527-4800	34

HOSPITALS

The nearest medical facility is the WEMCO medical department (Figure C.13-1). It is the primary choice for on-site injuries. First aid and ambulance service is available at the WEMCO medical department. Radio or call 6511 to contact CONTROL. WEMCO maintains an emergency response capability which includes an ambulance and trained emergency medical technicians. The WEMCO ambulance will transport the injured workers to the nearest hospital if necessary.

ACCIDENTS AND NONROUTINE EVENTS

The types of emergencies outlined below are not all inclusive and the corresponding response procedures will not be considered inflexible. Each accident presents a unique event that must be dealt with by key trained personnel. The objective is to provide the appropriate initial response to assist those in jeopardy without placing other personnel at unnecessary risk.

WORKER INJURY

If a person working in an area is physically injured, American Red Cross first-aid procedures will be followed. Depending upon the severity of the injury or illness, emergency medical response may be obtained accordingly. If the person can be moved, that person will be taken to a location from the work area where emergency first aid treatment an be administered. An ambulance should be summoned and the local emergency medical facility should be contacted.

The site supervisor will prepare a written report detailing the particular accident, its causes, and consequences within 24 hours of the accident.

If the injury to the worker is of chemical nature, the following first-aid procedures will be instituted as soon as possible:

- Eye Exposure - If contaminated material gets into the eyes, the eyes will be flushed immediately at the eyewash station using copious amounts of water while lifting up the lower and upper eyelids.

- Skin Exposure - If contaminated sludge or corrosive liquid material gets on the skin, the affected area will be washed with soap or mild detergent.

- Inhalation - If an individual inhales a volume of toxic or corrosive vapors, the employee will be removed to fresh air at once. If breathing has stopped, artificial respiration will be performed on the affected individual until medical attention can arrive on scene and transport the patient to the nearest medial facility.

- Ingestion - In the event a person ingests a toxic liquid or solid material, medical attention shall be obtained at once.

TABLE C.3-1

EXPOSURE GUIDELINES

	PEL		TLV	
Contaminant	OSHA TWA	OSHA STEL	ACGIH TWA	ACGIH STEL
Methylene chloride	500 ppm*	C1000 ppm*	50 ppm, A2	NE
Xylene	100 ppm	150 ppm	100 ppm	150 ppm
Trichloroethene	50 ppm	200 ppm	50 ppm	200 ppm
PCB	0.5 mg/m^3	NE	0.5 mg/m^3	NE

PEL - Permissible exposure limit, or maximum airborne exposure allowed by OSHA
NE - None established

Types of PELs include TWAs, STELs, and Ceilings.
TWA - Time weighted average, or average exposure allowed over an 8-hour shift.
STEL - Short-term exposure limit, or maximum average exposure during a 15-minute period
C - Ceiling, or maximum exposure allowed, even instantaneously.
* - In the process of 6(b) rulemaking.

TABLE C.3-2

ACTION LIMITS OF RADIOACTIVE CONTAMINANTS

Instrument/chem.	Need	Interval	Limit	Action
Alpha probe	Y	Pre-job and intermittent	20 cpm[a]	HP Review
Beta/gamma probe	Y	Pre-job and intermittent	500 cpm[a]	HP Review
External radiation	Y	Pre-job	>1 mrem/hour	HP Review
Thermoluminescent dosimetry (TLD) badge	Y	Continuous	N/A, no real time results	

[a]Above background.

TABLE C.3-3

SITE HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT

I have read, understand, and agree to abide by the provisions as detailed in this Site-Specific Health and Safety Plan prepared by ASI/IT. Failure to comply with these provisions may lead to disciplinary action and/or my dismissal from the work site.

Printed Name	Employee Number	Signature	Date

TABLE C.3-4
PERSONAL PROTECTION EQUIPMENT SELECTION MATRIX

Soil Sampling (Level D) • Coveralls or work clothing • Boots/shoes with steel toes, and latex overboots if the area is heavily contaminated • Safety glasses or goggles • Hard hat • Chemical-resistant nitrile or PVC protective gloves with surgical latex undergloves as necessary • Hearing protection, if necessary	
Action Levels	
Level D →→→ Level C	Required when the airborne concentration of suspected contaminants is known to be one-half the ACGIH TLV or the OSHA TLV or the OSHA PEL in Table 3-1.
Level C →→→ Level B	Required if airborne concentrations of toxic contaminants exceed the permissible exposure level in Table 3-1 as determined by personnel monitoring.
No one is permitted to downgrade levels of PPE without authorization of the Health and Safety Manager	

2907

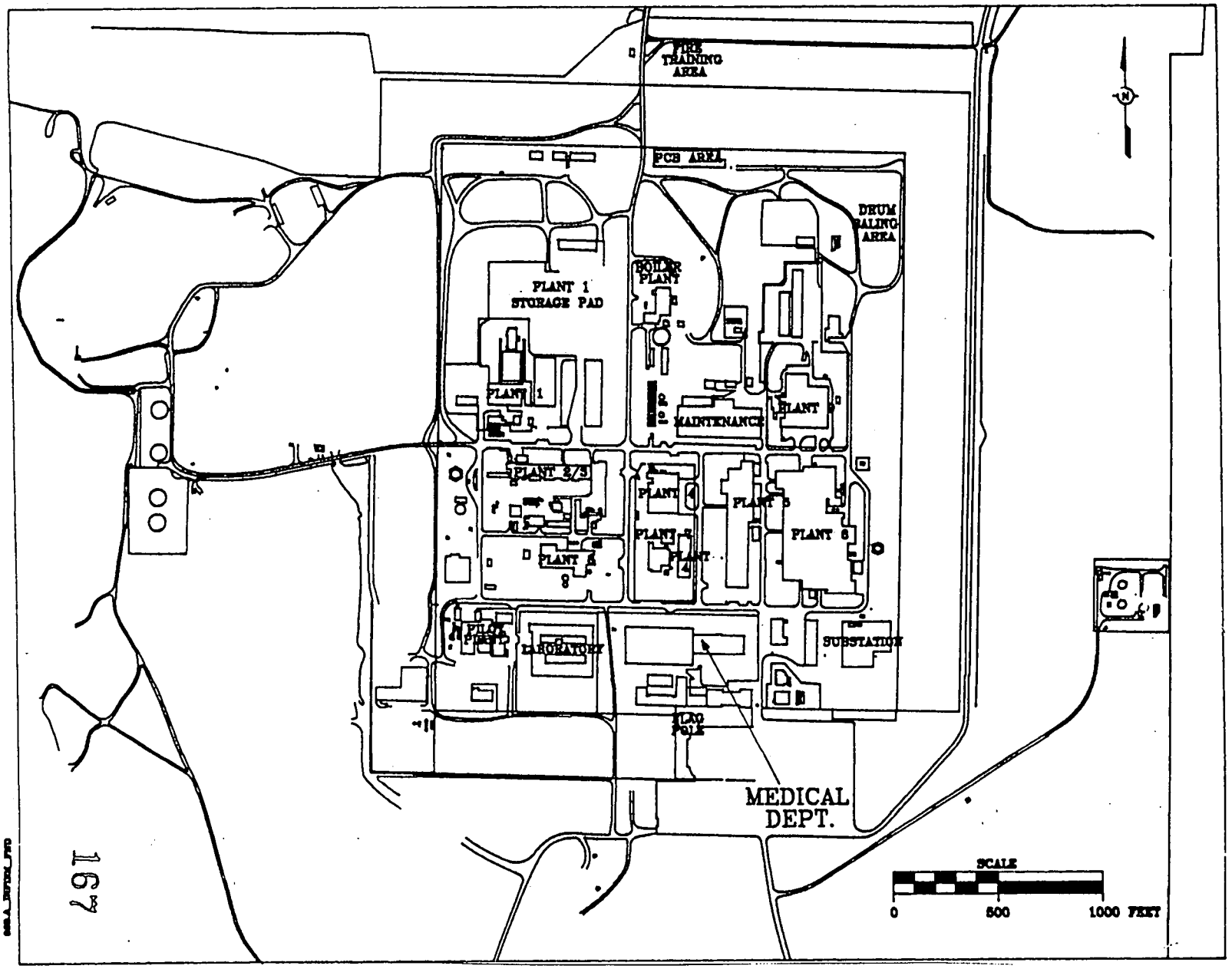

FIGURE C.13-1. LOCATION OF MEDICAL DEPARTMENT

APPENDIX D

HEALTH AND SAFETY PLAN
FOR THE
FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
OPERABLE UNIT 5 TREATABILITY STUDY
REMEDY SCREENING, REMEDY SELECTION PHASES

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D.1.0 INTRODUCTION

This Health and Safety Plan (HSP) in conjunction with the laboratory Chemical Hygiene Plan (CHP) establishes the work practices necessary to help ensure protection of personnel during the Operable Unit 5 laboratory screening to be performed at the Environmental Technology Development Center (ETDC) Laboratory in Oak Ridge, Tennessee.

The objective of this plan is to provide a mechanism for the establishment of safe and healthy working conditions at the laboratory. The safety procedures have been established following an analysis of potential hazards at the laboratory, and procedures have been developed to minimize the potential of accident or injury.

All laboratory operations will be performed in accordance with applicable state, local, and IT Corporate regulations and procedures and Occupational Safety and Health Administration (OSHA) requirements.

D.1.1 SCOPE OF WORK

This laboratory screening will involve washing the soil obtained from the Operable Unit 5 treatability Sampling and Analysis Plan (SAP) using two fundamental processes: froth flotation and hydro-gravimetric separation. The washing solutions will then be treated through a series of precipitation and ion exchange reaction steps for removal of contaminants. The soils will be analyzed for gross alpha and gross beta before to treatment. This will establish a baseline value for comparison against treated soils. The average alkalinity will also be determined before treatment. Samples will be analyzed for volatile and semivolatile organic compounds. All analyses will be run on the extracted solid, extractant, and water wash after treatment and will be compared against the original soil parameters. Two similar phases will follow this first phase with the addition of a modified TCLP analysis and a full toxicity characteristic leaching procedure (TCLP) being conducted on the extracted solids. Concentration of the Resource Conservation and Recovery Act (RCRA) hazardous metals and organic compounds in extractant and water wash will be determined by SW-846 methods.

D.1.1.1 Preliminary Characterization

The samples drawn under the Operable Unit 5 SAP will be composited at the Feed Materials Production Center in Ross, Ohio. These activities will be governed by the HSP for the SAP (Appendix C).

D.2.0 RESPONSIBILITIES

The following is a listing of those personnel responsible for various activities in the Health and Safety program and their responsibilities:

- ETDC Health & Safety Officer (Keith Hood) - responsible for the technical development and coordination of the HSP. Inquiries regarding the HSP, corporate health & safety procedures, and other technical or regulatory items shall be addressed to the Health and Safety Officer.

- Laboratory Project Supervisor (Ernie Stine) - responsible for implementation of the HSP. This shall include communication of requirements to all personnel and interaction with client representatives and regulatory agencies. Additional communication may include consultation with the Health & Safety Manager regarding the execution of the project and the HSP.

- Laboratory personnel - responsible for understanding and complying with all site health & safety requirements. Each team member shall be provided training on the requirements of this HSP before beginning the project.

- Emergency Coordinators (Tom Geisler, Rick Greene) - shall be responsible for and have the full authority to commit any personnel or equipment necessary for response and recovery operations during spills, disasters, or other emergencies.

D.3.0 SITE HISTORY

A variety of chemical and metallurgical processes were utilized at the FEMP for the manufacture of uranium products. During the manufacturing process, high quality uranium compounds are introduced into the FMPC processes at several points. Impure starting materials are dissolved in nitric acid, and the uranium is purified through solvent extraction to yield a solution of uranyl nitrate. Evaporation and heating convert the nitrate solution to uranium trioxide (UO_3) powder. This compound is reduced with hydrogen to uranium dioxide (UO_2) and then converted to uranium tetrafluoride (UF_4) by reaction with anhydrous hydrogen fluoride. Uranium metal is produced by reacting UF_4 and magnesium metal in a refractory-lined vessel. This primary uranium metal is then remelted with scrap uranium metal to yield a purified uranium ingot.

Operable Unit 5 consists of those environmental media that represent pathways and/or environmental receptors presently or potentially affected by FMPC contaminants. The media within Operable Unit 5 include groundwater, surface water, soils, sediments, flora, and fauna. Operable Unit 5 also specifically covers the soils associated with the Production Area and nine suspect areas. The Production Area includes the buffer zones, the scrap piles, and the miscellaneous discarded materials and equipment overlying the former drum baling area. The nine suspect areas currently being addressed are:

- Clearwell
- Fire training area
- Main effluent line
- Rubble mound west of the K-65 silos
- South flagpole area
- Sewage treatment plant/incinerator area
- K-65 slurry line
- Suspected rubble mound south of the K-65 slurry line
- Rubble mound west of the northwest corner of the production area (north rubble mound)

D.4.0 TASK SPECIFIC HAZARD ASSESSMENT

The following hazard assessment is based on historical information and defined task activities. The laboratory personnel routinely reassess the hazards before starting work to ensure that conditions have not changed. All newly identified hazards will be addressed with the Health and Safety Officer to determine the degree of hazard and if any changes to the HSP are needed.

D.4.1 PHYSICAL HAZARDS

- U-238

Contaminant	Derived Air Concentration	Action Limit .25DAC
Uranium-238	2×10^{-11} µCi/mL	5×10^{-12} µCi/mL

D.4.2 CHEMICAL HAZARDS

The following chemicals will be present, either in the samples or in the reagents, and will pose potential hazards. Other materials, such as ethylenediaminetetraacetic acid (EDTA), (NSI), and citraclean will be present but will pose no significant hazard due to their relatively low toxicity and use of small quantities.

Chemical	PEL		
Contaminants	**TWA**	**STEL**	
Methylene chloride	500 ppm*	C1000 ppm*	
Xylene		100 ppm	150 ppm
Trichloroethene	50 ppm	200 ppm	
PCB	0.5 mg/m3	NE	
Reagents	**TWA**	**STEL**	
Sulfuric acid	1 mg/m3	NE	
Hydrochloric acid, as HCl	NE	C5 ppm	
Nitric acid	2 ppm	4 ppm	
Phosphoric acid	1 mg/m3	3 mg/m3	
Sodium carbonate	NE	NE	
Sodium bicarbonate	NE	NE	
Sodium hydroxide	None	C 2 mg/m^3	
Potassium chloride	NE	NE	
Uranium	0.05 mg/m^{3*}	0.6 mg/m^{3**}	
	0.02 mg/m^{3**}		

PEL - Permissible exposure limit, or maximum airborne exposure allowed by OSHA.
NE - None established.

Types of PELs include TWAs, STELs, and ceilings.
TWA - Time-weighted average, or average exposure allowed over an eight-hour shift.
STEL - Short-term exposure limit, or maximum average exposure during a 15-minute period
C - Ceiling, or maximum exposure allowed, even instantaneously.
* - Soluble compounds
** - Insoluble compounds

D.4.3 POTENTIAL ROUTES OF EXPOSURE AND HAZARD ASSESSMENT

The identified site contaminants are solid in nature, and the majority of the reagents to be used are liquids. The potential routes of entry into the body are inhalation, absorption, and ingestion. Radioisotopes in the sample pose an external and internal exposure hazard. The internal hazard is largely eliminated by the procedures to be utilized. The external hazard will be controlled through air monitoring. Direct skin contact with the corrosives may result in destruction of skin tissue and absorption of other contaminants if in solution.

To minimize the potential exposure hazards, nearly all of the operations to be carried out during this project will be performed inside a laboratory exhaust hood, which is located inside an environmental containment cubicle. These operations include sample preparation, pouring reagents, and packaging for disposal. The only operations planned to be performed outside the hood are transport of the soil samples to and from the hood and transport of reagents to the hood. All container opening will be done only inside the hood. Reagents have been prepared and packaged offsite to further minimize on-site handling.

The use of the hood greatly minimizes any potential for exposure to the hazards associated with the samples or the reagents. To minimize the potential for radiation exposure, air monitoring will be conducted to quantify the exposure and to ensure that the procedures in use are appropriate.

D.5.0 MONITORING

D.5.1 GOALS

Air monitoring will be performed to ensure that contaminant concentrations in the breathing zone do not exceed the concentrations specified by established exposure levels.

Exposures to chemicals should be kept as low as possible because there are insufficient data to predict the combined effects of most chemical mixtures.

D.5.2 EXTERNAL RADIATION HAZARD MONITORING

A health physics technician will monitor all locations before start of work and will frequently monitor exposures in all areas. When concentrations exceed the one millirem (mrem)/hour action limit, measures such as increasing shielding, increasing distance, or reducing exposure time will be taken to minimize exposures. Radiation monitoring instruments include:

- Ludlum Model 177, or equivalent, with a G-M pancake probe
- Ludlum Model 3, or equivalent, with a ZnS alpha scintillation probe
- Eberline Model Alpha-5A alpha air monitor

D.5.2.1 Action Limits for Radiation

The following table provides types, scheduling, and actions for monitoring.

Instrument/chem.	Need	Interval	Limit	Action
Alpha probe	Y	Pre-job and intermittent	20 cpm[a]	HP Review
Beta/gamma probe	Y	Pre-job and intermittent	500 cpm[a]	HP Review
External radiation	Y	Pre-job	>1 mrem/hour	HP Review
Thermoluminescent dosimetry (TLD) badge	Y	Continuous	N/A, no real time results	

[a]Above background.

D.6.0 PERSONAL PROTECTIVE EQUIPMENT AND EXPOSURE REDUCTION

D.6.1 PERSONAL PROTECTIVE EQUIPMENT

D.6.1.1 Respiratory Protection

The need for respiratory protection will be evaluated by a professional industrial hygienist and health physicist before activities begin.

A comprehensive respiratory protection program has been established by IT. This program is required in all locations where use of such equipment could lessen the potential for adverse health effects to any employee.

As part of the respiratory training program, each employee is instructed in the following elements:

- Nature of the respiratory hazard on the work site and the appraisal of potential consequences if the respiratory protection is not utilized
- Use and proper fitting of the respirator
- Cleaning, disinfecting, inspection, maintenance, and storage of the respirator
- Proper selection, capabilities, and their limitations

Employees must demonstrate proper fit of the equipment in a test atmosphere.

Routinely used respiratory equipment will be inspected, cleaned, and disinfected daily to help assure proper hygienic practices. An inspection of these breathing devices will include the following:

- Examination of the head straps for breaks, loss of elasticity, broken or malfunctioning buckles, and other attachments
- Examination of the facepiece for excessive dirt, cracks, tears, distortion, holes, or inflexibility
- Examination of the exhalation and inhalation valves for any foreign material, cracks, tears, distortion in the valve, and proper installation
- Examination of air purifying elements for incorrect cartridge, expired shelf-life of the cartridge, and cracks or dents in the cartridge or cartridge holder
- Examination of proper insertion of the cartridges into the facepiece and a check of the gaskets inside the cartridge holder

When Level C protection is required, respirator cartridges will be changed daily. All respirators shall be inspected before each day's use. If broken or malfunctioning parts are found during the cleaning process, these parts will be replaced or new respiratory equipment will be issued to the user.

D.6.1.2 Eye Protection

A face shield with goggles is required when performing the tests due to the potential for splash when using concentrated acids and bases.

D.6.1.3 Protective Clothing

A rubber apron and long sleeves are required when performing tests due to the potential for splash when using concentrated acids and bases. Additionally, chemical-resistant gloves will be worn when performing tests.

D.6.2 EXPOSURE REDUCTION

D.6.2.1 Engineering Controls

The operations will be performed under a laboratory exhaust hood in an environmental containment cubicle that is under negative ventilation. This cubicle is located in the environmental containment cubicle room that is also under negative ventilation. A slant manometer or magnehelic gage will be utilized to measure and indicate the pressure differential created by the air flow.

The laboratory exhaust hoods are in the work area and will be kept free of materials placed where they will block the vents, reducing air flow.

D.6.2.2 Administrative Controls

Control Access to Work Area

Access to contamination work areas will be regulated and will be limited to authorized personnel. Warning signs will be affixed in readily visible locations in or near the work area as required by applicable regulations. The work area shall be divided into the following three zones:

- Exclusion zone - This zone will include the highest potential concentrations of contamination. This zone has the highest potential for skin contamination and inhalation exposures. The exclusion zone will be the environmental containment cubicle.

- Contamination reduction zone - This zone includes all areas immediately adjacent to the exclusion zone. Personnel contamination monitoring will take place in this zone.

- Support zone - This area covers all areas outside of the contamination reduction zone. Exposure to harmful chemicals or radioactive materials in this zone is highly unlikely.

D.6.2.3 Safe Work Practices

All personnel will follow the safe work practices outlined in the CHP for the ETDC.

D.6.2.4 Equipment Inspection

All equipment used in the testing will be inspected before use. Defective equipment will be reported to the Project Manager and repaired before use.

D.7.0 LABORATORY ACCESS AND ENTRY PROCEDURES

Access to the environmental containment cubicles during treatability studies will be limited to personnel who have completed required training and who have had required medical exams.

D.7.1 BIOASSAY SAMPLING

A baseline 24-hour urine sample will be taken before starting treatability activities and a postwork 24-hour urine sample will be submitted upon completion of activities.

Additional urine samples will be required if air samples indicate an acute exposure of 40 DAC-hours (2 percent of the annual limit of intake [ALI]). This correlates to a gross alpha activity for U-238 of 6×10^{-10} µCi/mL averaged over a one-hour exposure. No respirator protection factors are built into these action levels.

D.7.2 MEDICAL MONITORING

In accordance with 29CFR1910.120 OSHA requirements, all personnel involved in the treatability study are required to participate in a medical monitoring program that includes:

- A baseline medical examination
- Annual medical examination
- Medical examinations that may be required after potential exposures

D.7.3 TRAINING REQUIREMENTS

All personnel at the ETDC involved in the treatability study have the following training:

- CHP
- ETDC Emergency Contingency Plan (ECP)
- General employee training - rad worker training
- Hazard Communication Training

D.7.4 CONTAMINATION ZONES

The Exclusion Zone is the zone of high potential hazard due to physical, chemical, or radiological dangers. Access to the Exclusion Zone is restricted to employees who are required to enter to perform their job functions. The area inside the environmental containment cubicles is considered to be the Exclusion Zone.

A Contamination Reduction Zone will be established and decontamination will be performed in this zone. All personnel entering or leaving the exclusion zone will pass through this area in order to prevent any cross-contamination and for the purpose of accountability. Tools and any equipment or

machinery will be decontaminated in a specific location. The decontamination of all personnel will be performed on site adjacent to the exclusion zone. Personal protective outer garments and respiratory protection will be removed in the contamination reduction zone and properly labelled.

The Support Zone will consist of an area outside the environmental containment cubicle. The support zone will be located to prevent employees from being exposed to any organic vapors or dust levels above regulatory limits. Eating, drinking, or smoking will be permitted in the support area only after washing face and hands.

D.7.5 LABORATORY ENTRY PROCEDURES

The following activities shall be conducted before and during the work day, as appropriate:

- Perform respirator check out and negative/positive pressure checks before use
- Locate the nearest eyewash/shower and fire extinguisher prior to initiating activities
- Verify all instruments are calibrated
- Visually scan the laboratory for signs of contamination

Note: The Health and Safety Manager and any member of the team have the authority to stop work when imminent or serious safety hazards or conditions exist. Restart of work will be allowed only after the hazard or condition has been abated or reduced to an acceptable level.

D.8.0 LABORATORY EXITING PROCEDURE

D.8.1 CONTAMINATION DETECTION

All personnel are required to follow decontamination procedures themselves and then confirm the effectiveness of the decontamination. The effectiveness will be determined by frisking with a hand-held radiation monitor.

The monitor must be held within 1/2-inch of the surface and moved at a rate of approximately one inch per second for effective radiation monitoring. If frisking count exceeds DETECTABLE, additional decontamination is required. This decontamination will be conducted by gently scrubbing with soap and water.

If contamination cannot be removed to below the action levels (100 cpm beta/gamma or detectable alpha radiation above background), notify the Health & Safety Manager.

D.8.2 DECONTAMINATION

Decontamination reduces contaminant concentrations to acceptable levels, but does not generally remove it totally. Try to avoid contamination where possible by making minimum contact with the contaminant.

Personnel: Dry removal of disposable protective equipment; wash hands, face, and any other exposed skin. Detergent and tepid water should be used to gently scrub skin surfaces that have contacted potentially contaminated wastes.

Equipment: Any exposed areas of the equipment surface will be wiped with a damp paper towel/cloth to remove contamination. Wiping with a cloth dampened with detergent solution may be necessary to remove greasy materials.

The effectiveness of decontamination must be confirmed by frisking.

D.9.0 EXPOSURE SYMPTOMS

Acute exposure to solvents and corrosives may produce dizziness and/or irritation. Exposure to low levels of radioactivity do not produce acute exposure symptoms. The exposures may cause delayed effects such as cancer. Because biological effects from radiation exposures are cumulative, exposures are to be kept as low as reasonably achievable.

No treatment is anticipated for the predicted contaminants and concentrations. Any emergencies arising during the performance of work will covered by an ECP prepared for the ETDC.

D.10.0 OPERATIONALLY DERIVED WASTES

Operationally derived wastes are those generated in the performance of various activities. These wastes include, but are not limited to:

- Disposable ppe such as Tyvek® coveralls, gloves, booties
- Disposable decontamination supplies

Protective clothing will be placed in plastic bags, placed in a B-25 box or metal drum for disposal as compatible, potentially contaminated waste by WEMCO.

Operationally derived wastes are the property of the client and are to be shipped back to WEMCO unless otherwise specified in the written contract.

The client will be responsible for proper transport, shipment, or disposal unless otherwise specified in the written contract.

D.11.0 CONTINGENCY PLANS

Contingency plans for injuries, spills, releases, fires, and explosions are given in the ECP for the ETDC. The ECP identifies ETDC emergency coordinators. Agencies that may be requested to provide assistance in an emergency are also listed along with phone numbers. Copies of the ECP will be available on site to all personnel.

APPENDIX E

INTEGRATED DEMONSTRATION SOIL SAMPLING PROJECT INFORMATION

EM-SMPLPN-SMS-
REQ-91-080.2
REV-0

2907

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

PREPARED BY: Jerome A. Brown DATE: 9-23-91
(ENGINEER/TECHNOLOGIST)
REVIEWED BY: Lawrence Love Jr. DATE: 9-24-91
(ENGINEER/TECHNOLOGIST)
APPROVED BY: _____ DATE: _____
(MANAGER SMS)
APPROVED BY: _____ DATE: _____
(QA/QC)

Note : This document applies to activities to be conducted for Phase II of the Integrated Technology Demonstration Project.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

A request for Environmental Media Sampling (Sample Request # EM-SMS-080) has been forwarded to Environmental Monitoring - Site Media Sampling (EM-SMS) for soil sampling and characterization in support of the Uranium Soils Integrated Demonstration Treatability Project - Phase II.

In June 1991, SMS conducted soil sampling activities in support of the Uranium Soils Integrated Demonstration Treatability Project - Phase I. A total of 10 soil cores were collected from five suspect areas at the Fernald Environmental Management Project (FEMP) facility. The soil cores were shipped to the Oak Ridge National Laboratory in Oak Ridge, Tennessee to determine their physical and chemical properties.

Based on data collected during Phase I, two areas were selected for Phase II operations. The areas selected are: Area A - the grassy area north of the Incinerator near the Sewage Treatment facility, and Area B - the grassy area west of Plant 1 Pad.

Phase II of the Uranium Soils Integrated Demonstration Treatability Project will be split into the following tasks: 1) pre-sampling (soil excavation, sifting, and blending), and 2) sampling and analyses.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

1.2 PURPOSE OF SAMPLING

EM-SMS has received a sampling request SMS-REQ-080 to collect soil samples for homogeneity testing and verification of Resource Conservation and Recovery Act (RCRA) contaminant concentrations. The objective of sampling and characterization is to determine the homogeneity and chemical constituents of the soils in the previously identified areas. Homogenous, non-RCRA soils will be shipped to the appropriate companies participating in the Uranium Soils Integrated Demonstration Treatability Project to improve/validate remediation technology components and systems in terms of risk-reduction, effectiveness, cost savings, regulatory and public acceptability, and duration.

2.0 IDENTIFICATION OF KNOWN/SUSPECTED CONTAMINANTS

The contaminants of concern include a variety of radiological, chemical, and metallic elements and compounds. Radiological contaminants such as **Uranium-238**, and **Uranium-235** are known to be present. The following contaminants may be present: **volatile and semi-volatile hydrocarbons, pesticides and herbicides, and metals** .

3.0 SAMPLE FIELD SITE

The areas selected for Phase II operations are: Area A - the grassy area north of the Incinerator near the Sewage Treatment facility, and Area B - the grassy area west of Plant 1 Pad. Soil materials for each area will be excavated, sieved using a 3/4-inch screen, blended using a concrete mixing device, and transferred to a total of 12 55-gallon storage drums.

3.1 SAMPLE LOCATIONS

At each area identified in section 3.0, approximately 250 cubic feet of soil will be removed from the following excavations:

Area A - 50' long, 10' wide and 0.5' deep
Area B - 25' long, 20' wide and 0.5' deep

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

3.1.1 SAMPLES PER LOCATION

Per Environmental Media Sampling Request #SMS-REQ-080 a soil core will be extracted from each 55-gallon storage drum per each sample area. The soil cores will be split into five (5) equal subsamples. Four subsamples from each drum per each area (total of 48 subsamples/area) will be retained for homogeneity analyses. The remaining subsample for each drum per each area will be retained to produce a composite sample for each respective area.

3.1.2 ANALYTICAL PARAMETERS N/A if not applicable

CONCURRENCE REQUESTOR _____

HOMOGENEITY ANALYSES*
1. GRAIN SIZE
2. RAD. ACTIVITY

RCRA CHARACTERIZATION**
1. TCLP VOLATILES
2. TCLP SEMI-VOLATILES
3. TCLP METALS
4. TCLP PEST./HERB.
5. ALPHA/BETA/GAMMA SCREENING

Yell HSE

Note :
* - For the four subsamples for each drum per sample area.
** - For the composite sample for each sample area.

3.1.3 REQUIRED SAMPLE VOLUME

CONCURRENCE FMPC ANALYTICAL _____

HOMOGENEITY ANALYSES

TO BE PERFORMED BY FEMP ANALYTICAL FACILITY

PARAMETER	VOLUME	CONTAINER TYPE	HOLDING TIME	PRESERVATIVE
1. GRAIN SIZE	250 grams	Glass/Plastic	none	none
2. RAD. ACT.	Note 1	Glass/Plastic	none	none

Note :
1 - Only one (1) sample container will be required to allow for Grain size and radiological activity analyses.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

RCRA ANALYSES

TO BE ANALYZED BY A SUBCONTRACTED LABORATORY

PARAMETER	VOLUME	CONTAINER TYPE	HOLDING TIME*	PRESERVATIVE
1. TCLP VOLATILES	Note 1	Glass	14 days	cool 4 deg C
2. TCLP SEMI-VOL.	1 pint	Glass	14 days	cool 4 deg C
3. TCLP METALS	1 pint	Glass	Note 2	none
4. TCLP PEST./HERB.	1 pint	Glass	14 days	cool 4 deg C
5. ALPHA/BETA/GAMMA	4 ounces	Glass	none	none

Note :

1 - Samples will be retained in three 4 ounce jars with teflon lined closures.

2 - 6 month holding time for all metals except mercury (28 days).

* - Period from time of sample collection to sample extraction by laboratory facility.

4.0 QA/QC REQUIREMENTS

Environmental Monitoring will adhere to the QA/QC requirements as outlined in procedure EM-CS-001 "ENVIRONMENTAL MONITORING ON-SITE MEDIA SAMPLING" for trip blanks, field blanks, and duplicate sampling. Trip and field blanks (deionized water) will be prepared prior to each day of sampling activities and will accompany each sample set to the designated laboratory facility for RCRA analyses indicated in Section 3.1.2.

Equipment rinsate blanks will be collected (on a daily basis) at the completion of sampling activities and will accompany each sample set to the designated laboratory facility for RCRA analyses indicated in Section 3.1.2.

EM-SMS may extract a duplicate sample for this project for RCRA analyses. The duplicate extraction will be noted in the permanent field logbook. The duplicate sample will be contained, sealed, and labeled in such a way that the receiving laboratory will not know that the sample is a duplicate.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

5.0 EQUIPMENT NEEDED

5.1 Task 1 - Pre-sampling

The following equipment will be required as a minimum:

- Bulldozer or Bobcat
- Mechanical Shaker/Sifter
- Conveyor
- Concrete Mixer
- PPE as determined by FEMP Health and Safety groups
- 24 55-gallon storage drums

5.2 Task 2 - Sampling and Analysis

The following equipment will be required as a minimum:

- Hand Auger or Coring Device, Stainless Steel Scoop/Spoon
- Sample Containers indicated in Section 3.1.3
- PPE as determined by FEMP Health and Safety groups
- RO-TAP and Sieves (No. 10, No. 200, and collection pan)
- Drying Oven
- Geiger-Mueller or Sodium Iodide detector

6.0 DECONTAMINATION OF EQUIPMENT

6.1 Task 1 - Pre-sampling

All equipment (except for PPE and drums) will be decontaminated at the FEMP Decontamination Pad using Standard Operating Procedures developed by the Decontamination and Demolition (D&D) facility.

6.2 Task 2 - Sampling and Analysis

All sampling equipment used will be decontaminated as per procedure **EM-CS-001.** Equipment used by the laboratories will be decontaminated in accordance to their respective Standard Operating Procedures.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

7.0 METHODOLOGY

7.1 Task 1 - Pre-sampling

7.1.1 Using the Bobcat or bulldozer blade remove as much of the grass as possible from the designated sample area.

7.1.2 Excavate the soil at the designated area to a total depth of no more than 6 inches below surface grade. If the soil appears to be moist or saturated, then stockpile excavated soils on plastic sheeting materials and cover with Herculite. Allow the soils a period of 12 to 16 hours to dry.

7.1.3 Transfer dry soil materials to the shaker/sifter device and operate for a period of at least 15 minutes to allow for segregation of materials of less than 3/4-inches in diameter.

7.1.4 Transfer sifted materials to the conveyor system to fill the mixer device.

7.1.5 Operate the mixer device for a period of at least 4 hours to ensure that a homogenous blend of soil materials has been created.

7.1.6 Transfer blended soil materials to the drum containers specified for the designated sample area.

7.1.7 Decontaminate equipment at the FEMP D&D facility and proceed to the next designated sample area.

7.2 Task 2 - Sampling and Analysis

7.2.1 Drummed Soil Sampling

7.2.1.1 Using a hand auger or coring device, collect a soil core from the top to the

base of the given drum.

7.2.1.2 Transfer soil core from the collection device to a piece of clean plastic sheeting and divide into 5 equal subsamples.

7.2.1.3 Place the subsamples in glass quart-sized containers. Retain and label four of these containers for homogeneity analyses. Retain the remaining container to produce a composite sample for RCRA analyses for the designated sample area.

Note : Indicate the EM number, the Sample area (A or B), the drum number (1 to 12), and the depth interval on the label for each container retained for homogeneity analyses.

7.2.1.4 Decontaminate all equipment used in the sample collection process.

7.2.1.5 Move to the next drum and repeat steps 7.2.1.1 through 7.2.1.4 until all drums for the designated sample area have been sampled.

7.2.1.6 To produce a composite sample for the designated sample area, combine all subsamples retained for RCRA analyses in the following manner: 1) place four clean stainless steel pans (labeled in accordance to the respective TCLP parameter to be analyzed) on clean plastic sheeting, 2) divide each subsample into four equal portions, 3) transfer a portion of each subsample to each stainless steel pan, and 4) combine the portions in each pan and transfer to the appropriate container specified in Section 3.1.3. Transfer any remaining soil materials to the container labeled

for Alpha/Beta/Gamma screening analysis.

7.2.1.7 Decontaminate the stainless steel pans and equipment used to transfer samples to the appropriate containers.

7.2.1.8 Deliver all samples collected to the FEMP analytical laboratory facility with the appropriate Chain-of-Custody documentation.

7.2.1.9 Proceed to the next sample area and repeat steps 7.2.1.1 through 7.2.1.8.

7.2.2 Homogeneity Analyses

7.2.1.1 The homogeneity analyses will be performed by the FEMP analytical laboratory facility using the procedures provided in Attachment A. The proceduralized steps for conducting grain size analyses are taken and modified from ASTM Method D422-63 "Standard Method for Particle-Size Analysis of Soils" and "Petrology of Sedimentary Rocks"; Robert L. Folk, 1974.

8.0 HEALTH AND SAFETY

The work to be performed and outlined in this sampling plan will be accomplished in accordance with the FEMP Site Health and Safety Plan, the Environmental Monitoring Health and Safety Plan, and the Project Specific Health and Safety Plan (see Attachment B).

EM-SMS technicians will comply to all precautionary surveys performed by the FEMP employees representing Industrial Hygiene, Radiological Safety, and Safety Engineering. EM-SMS shall obtain a FEMP Work Permit and a Radiation Work Permit, which will be posted at the job site. Concurrence to all applicable safety permits (indicated by signature of the EM-SMS technicians assigned to the project) is expected in the performance of their assigned duties.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

The responsible sampling team lead will insure that all EM-SMS technicians performing sampling related to this project has read and understands all applicable surveys that protect worker safety and health. EM-SMS technicians who do not sign the applicable health and safety survey forms will not participate in the execution of sampling activities related to the completion of assigned project responsibilities. A copy of all applicable safety surveys issued for worker safety and health shall be stored for easy reference in the applicable project files maintained by **ENVIRONMENTAL MONITORING.**

9.0 DEPARTMENT OF TRANSPORTATION (DOT) PACKAGING, MARKING/LABELING REQUIREMENTS

CONCURRENCE DOT INTEGRATION _____

As specified in **49 CFR 173.421**, the following criteria will be evaluated to determine the appropriate DOT packaging, marking and labeling requirements:

1) If the package does not contain more than 15 grams of uranium 235, or the radiation level at any point on the external surface does not exceed 0.5 millirem per hour, then use:

   * **Proper Shipping Name for Liquids or Solids:**
     Radioactive Material, Limited Quantity, N.O.S. (laboratory specimen for analysis)

   * **Hazard Class:**
     Radioactive Material

   * **Identification Number:**
     UN2910

   * **Labeling/Marking:**
     The word "Radioactive" shall be on each bottle. Each container shall have "Radioactive Material, Limited Quantity" and "Danger, Cargo Aircraft Only".

   * **Packaging:**
     The materials shall be packaged in strong, tight packages that will not leak any of the radioactive materials during conditions normally incident to transportation.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

2) If the package contains more than 15 grams of Uranium 235, or the radiation level at any point on the external surface of the package exceeds 0.5 millirem per hour, use:

* **Proper Shipping Name for Liquids or Solids:**
  Radioactive Material, LSA N.O.S.
  (laboratory specimen for analysis)

* **Hazard Class:**
  Radioactive Material

* **Identification Number:**
  UN2912

* **Labeling/Marking:**
  Radioactive Yellow II or Radioactive Yellow III label (determined by radiation monitoring levels at a distance of one meter from the surface of the outer container) and "Danger, Cargo Aircraft Only".

* **Packaging:**
  DOT 7A, Type A packaging must be used. The exterior of each package must be marked "USA DOT 7A Type A" and "Radioactive". DOT 17-C (5 gallon pail) is an approved package.

EM-SMS will comply with **49 CFR 173.421** regulations for sample overpackaging to maintain sample preservation temperatures per EPA regulations contained within SW-846.

EM-SMPLPN-SMS-
REQ-91-080.2
REV-0

2907

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

ATTACHMENT B

PROJECT SPECIFIC HEALTH AND SAFETY PLAN

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

ATTACHMENT A

STANDARD OPERATING PROCEDURE FOR HOMOGENEITY ANALYSIS

EM-SMPLPN-SMS-
REQ-91-080.2
REV-0

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

STANDARD OPERATING PROCEDURES FOR HOMOGENEITY ANALYSES BY FEMP ANALYTICAL LABORATORY

Author: Jerome A. Gnoose 9-22-91
Jerome A. Gnoose Jr., EM-SMS

Approved By: _____
Raymond J. Danahy, FEMP Laboratory

Approved By: _____
Victor R. Gill, FEMP Laboratory

Approved By: _____
W. J. Neyer, FEMP Laboratory

1.0 OBJECTIVE

1.1 To determine if the characteristics of soil contained in a single drum are significantly different than the characteristics of soil contained in a set of drums. Homogeneity testing is required to assure that the characteristics of soil being prepared for treatability studies do not differ significantly between drums.

2.0 SCOPE

2.1 This procedure applies to all work being performed by the Fernald Environmental Management Project (FEMP) Analytical Laboratory facility for soil homogeneity analyses.

3.0 DEFINITIONS

3.1 *Balance* - An instrument sensitive to 0.01 grams for weighing the materials retained by No. 10 (2.00 mm) and No. 200 (0.075 mm) sieves, and materials passing through the No. 200 sieve.

3.2 *Oven* - A device of sufficient size, capable of maintaining a uniform temperature of 110 +/- 5 degrees Celsius.

3.3 *Ro-Tap* - A mechanical shaker device (capable of vertical and lateral movement) that aids in segregation of particulate materials.

3.4 *Sieves* - A series of square-mesh woven-wire cloth, conforming to the requirements of ASTM Specification E-11. Sieves to be used for homogeneity analyses are:

No. 10, 2.00 millimeters (mm); and
No. 200, 0.075 millimeters (mm).

4.0 RESPONSIBILITIES

4.1 Environmental Monitoring - Site Media Sampling

4.1.1 Collect soil samples from drum containers for homogeneity analyses.

4.1.2 Deliver soil samples to the FEMP Analytical Laboratory facility with the appropriate Chain-of-Custody documentation.

4.1.3 Provide technical assistance and supervision for homogeneity analyses, when required.

4.2 FEMP Analytical Laboratory

4.2.1 Receive and log all samples collected for homogeneity analyses.

4.2.2 Conduct grain-size analyses in accordance with this procedure.

4.2.3 Conduct radiological activity screening measurements in accordance with this procedure.

4.2.4 Submit analytical results to the appropriate personnel indicated on the Chain-of-Custody documentation.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

5.0 GENERAL

5.1 Soil cores will be obtained from a minimum of twelve (12) 55-gallon drums for two sample areas located at the FEMP facility. Each soil core will be divided into four subsamples for homogeneity analyses. A total of 96 subsamples shall be submitted to the FEMP Analytical Laboratory facility for homogeneity analyses.

5.2 Each soil subsample will be dried in ovens (maximum temperature of 110 degrees Celsius) for a period of at least 6 hours to remove soil moisture.

5.3 Subsequent to soil drying operations, 250 grams of each subsample shall be placed in the sieves and mechanically separated using a Ro-Tap device for a period of at least 10 minutes. The percentage of materials retained by No. 10 and No. 200 sieves, and the percentage of materials passing through the No. 200 sieve will be calculated.

5.4 For each subsample, the materials retained by the No. 10 and No. 200 sieves, and the materials passing through the No. 200 sieve will be screened for radiological activity using a Geiger-Mueller or Sodium Iodide detection device.

5.5 For each sample area, the grain-size and radiological activity data for each drum will be compared to determine the homogeneity of the set of drummed materials. If the set of drummed materials for the given sample area is not homogenous, the drummed materials will be re-blended and resampled for homogeneity analyses.

6.0 PROCEDURE

6.1 Sample Preparation

6.1.1 Sort subsamples by the appropriate depth intervals (indicated on sample container labels) for each sample area into four (4) batches.

Note : Each batch should contain 12 subsamples with identical depth intervals.

6.1.2 Remove the sample container lids for each container for the first batch of subsamples to be dried.

6.1.3 Place the batch of subsamples in an oven (maximum temperature of 110 degrees Celsius) for a period of at least 6 hours to remove excess soil moisture.

6.1.4 Remove the batch of subsamples from the oven. After cooling, transfer approximately 250 grams of each subsample from their original sample containers to clean, pre-weighed containers. Re-weigh containers and subsample contents. Record weights on the appropriate Homogeneity Analysis Form.

6.1.5 Select the next batch of subsamples to be dried. Repeat steps 6.1.2 through 6.1.5 until all batches of subsamples for a given sample area are dried.

6.2 Grain-Size Analysis

6.2.1 Transfer approximately 250 grams of subsample to the series of sieves.

Note : The sieves should be stacked as follows (from top to bottom):

No. 10 (2.00 mm) sieve;
No. 200 (0.075 mm) sieve; and
Collection Pan.

6.2.2 Place the cover lid and rubber protection cover on top of the No. 10 sieve. Place the series of sieves in the Ro-Tap device.

6.2.3 Operate Ro-Tap device for a minimum period of at least 10 minutes to ensure

that all materials have been properly sieved.

6.2.4 Remove the series of sieves from the Ro-Tap device. Remove rubber protection cover and cover lid from the No. 10 sieve.

6.2.5 Transfer the contents from the sieves and collection pan to clean, pre-weighed containers with an known geometry.

6.2.6 Re-weigh containers and sieved contents. Record weights on the appropriate Homogeneity Analysis Form. Retain containers and sieved contents for radiological activity screening analyses.

6.2.7 Decontaminate the sieves, lids and Ro-Tap device using an Alconox + deionized water solution, followed by a deionized water rinse.

6.2.8 Repeat steps 6.2.1 through 6.2.7 until each subsample for a given sample area has been analyzed.

6.2.9 Calculate the percentages of grain-size fractions for a given subsample by dividing the weight of each grain-size fraction by the initial weight of the dried subsample and multiplying by 100%. Record percentages of grain-size fractions on the appropriate Homogeneity Analysis Form.

6.2.10 Repeat step 6.2.9 for each subsample for a given sample area.

6.3 Radiological Activity Screening Analysis

6.3.1 For each grain-size fraction of a given subsample, slowly move the Geiger-Mueller or Sodium Iodide detector above the surface of the sieved materials. Record

the radiological activity screening reading for each grain-size fraction on the appropriate Homogeneity Analysis Form.

Note : The detection device should be kept approximately 1/4-inches above the surface of the sieved materials.

6.3.2 Repeat step 6.3.1 for each subsample for a given sample area.

7.0 APPLICABLE DOCUMENTS

7.1 ASTM Methods D421-85, D422-63, D546-88.

7.2 Appendix A, Uranium Soils Integrated Demonstration Treatability Sampling Plan, August 1991.

7.3 Petrology of Sedimentary Rocks, Robert L. Folk, 1974.

8.0 ATTACHMENTS

8.1 Homogeneity Analysis Form.

SITE MEDIA SAMPLING PLAN

INTEGRATED TECHNOLOGIES DEMONSTRATION PROJECT

HOMOGENEITY ANALYSIS FORM

Sample No.:_____ Date Sample Received:_____
Sample Area:_____ Initial Sample Wt.:_____
Drum No.:_____ Time Drying Started:_____
Depth Int.:_____ Time Drying Stopped:_____

SAMPLE PREPARATION RESULTS Analyst:_____

Weight of Clean Container:_____ grams
Weight of Container and
Dried Soil Contents: _____ grams
Weight of Dried Soil: _____ grams

Weight of Dried Soil = Weight of Container and Dried Soil - Weight of Container

GRAIN-SIZE ANALYSIS RESULTS Analyst:_____

Grain-Size Fraction	Wt. of Container	Wt. of Soil + Container	Wt. of Soil	% of Grain Size Frct.
> No. 10	_____ g	_____ g	_____ g	_____ %
> No. 200	_____ g	_____ g	_____ g	_____ %
< No. 200	_____ g	_____ g	_____ g	_____ %

Wt. of Soil = Wt. of Soil + Container - Wt. of Container

$$\% \text{ Grain Size Frct.} = \frac{\text{Wt. of Soil (per grain size fraction)}}{\text{Weight of Dried Soil}}$$

RADIOLOGICAL ACTIVITY SCREENING RESULTS
Analyst:_____

Grain-Size Fraction	Radiological Activity Reading
> No. 10	_____ cpm
> No. 200	_____ cpm
< No. 200	_____ cpm

ORNL-DWG 91M-15088
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ORNL/TM-11980

CHARACTERIZATION OF URANIUM CONTAMINATED SOILS FROM DOE FERNALD ENVIRONMENTAL MANAGEMENT PROJECT SITE: RESULTS OF PHASE I CHARACTERIZATION

September 16, 1991

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with
Characterization Group
Integrated Technology Demonstration
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Mark Nichelson (HAZWRAP) Dale Perry (LBL)
for
FEMP Contaminated Soil ID
Westinghouse Materials Company of Ohio
and
U.S. Department of Energy
Office of Technology Development

Characterization Information Needs For The Integrated Demonstration Program

Properties	*Where the Information Is Needed*
1. Uranium distribution with depth:	Excavation, Risk Assessment
2. Soil particle size distribution:	Treatability, Risk Assessment, Waste Disposal
3. Uranium distribution with particle size:	Treatability, Risk Assessment
4. Soil chemical and physical properties:	Excavation, Treatability
5. Specific gravity of soil/contaminant:	Treatability
6. Soil solution chemistry:	Treatability, Risk Assessment, Site Operation
7. Mineralogical analysis:	Treatability, Waste Disposal
8. Microscopic analysis:	Treatability
9. Uranium form identification:	Treatability, Risk Assessment
10. Chemical leaching test:	Treatability, Waste Disposal, Risk Assessment
11. Reference soil characterization:	Risk Assessment, Treatability, Regulation

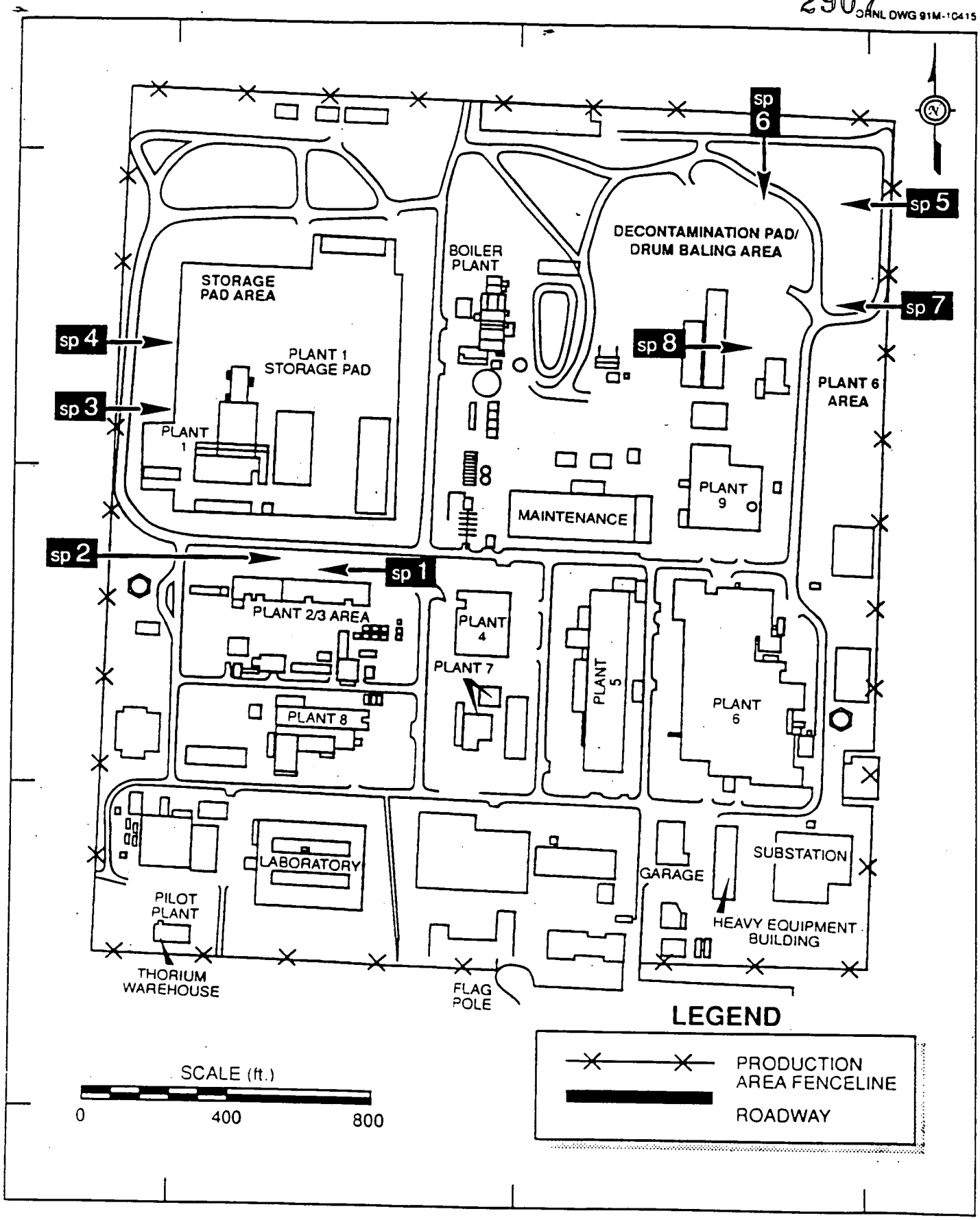

Figure 1. Sampling locations in Operable Unit 3 of Fernald Operation Site.

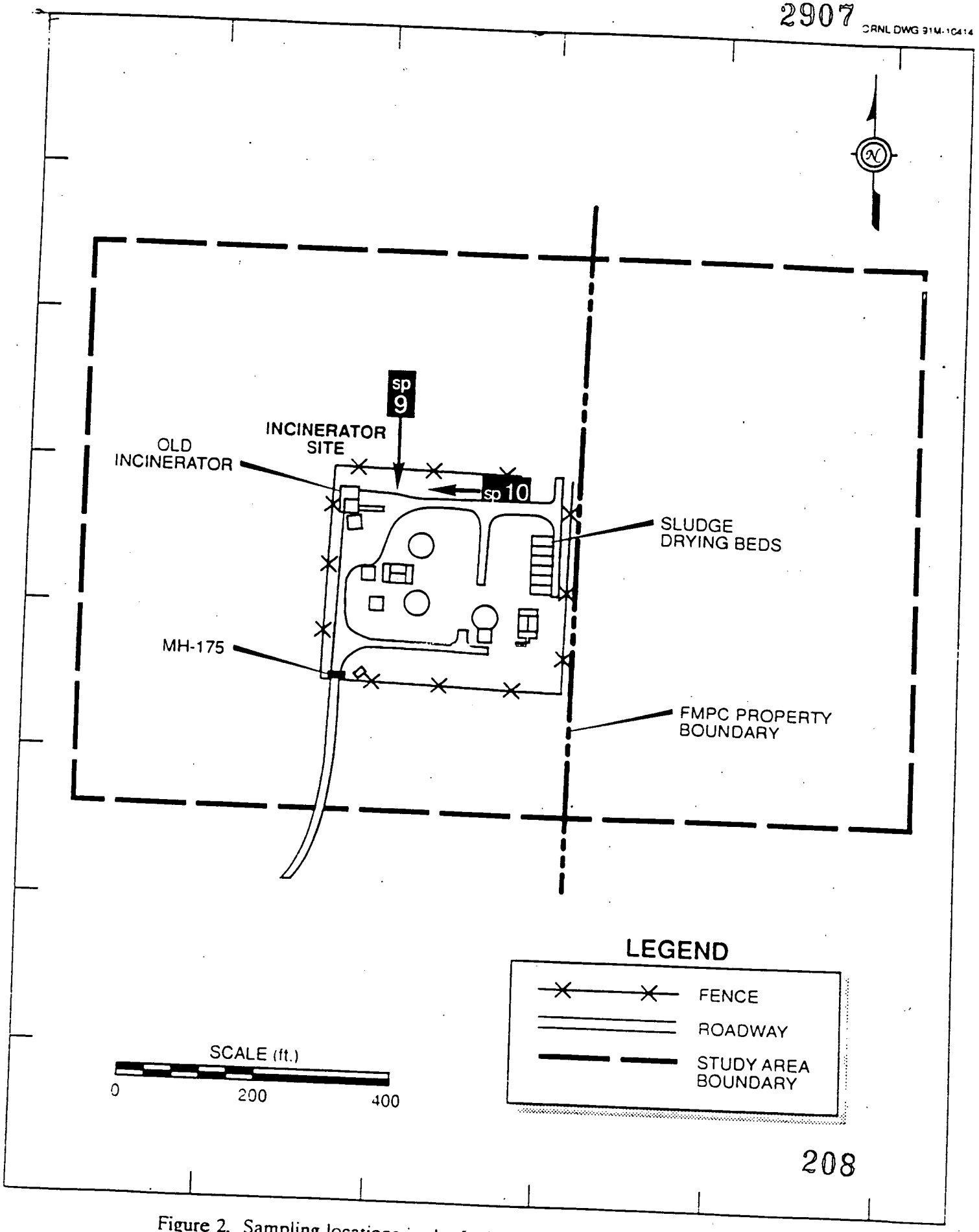

Figure 2. Sampling locations in the Incinerator area of Fernald Operation Site

BUTLER
R. 1 E.
US RESERVATION
ATOMIC ENERGY COMMISSION
US RESERVATION
Scale 1:15,840

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ORNL-DWG 91M-13989

pH Measurements Of Contaminated And Reference Soils

Sample Name	pH	Sample Name	pH
SP1-1-A	8.2	SP6-1-A	8.2
SP1-1-B	8.3	SP6-1-B	8.6
SP1-1-C	8.1	SP6-1-C	8.3
SP1-3-A	8.2	SP6-2-A	8.4
SP1-3-B	8.1	SP6-2-B	8.2
SP1-3-C	7.8	SP6-2-C	8.4
SP2-1-A	7.8	SP7-1-A	8.2
SP2-2-A	8.1	SP7-1-B	8.2
SP2-3-A	8.0	SP7-1-C	8.2
		SP7-1-D	8.2
SP3-1-A	8.3		
SP3-1-B	8.4	SP8-1-A	6.1
SP3-2-A	8.1	SP8-1-B	6.9
SP3-2-B	8.4	SP8-1-C	7.3
SP3-2-C	8.5	SP8-1-D	7.6
SP3-2-D	8.3		
SP3-3-A	8.2	SP9-1-A	7.2
SP3-3-B	8.1	SP9-3-B	7.8
SP3-3-C	8.1	SP9-3-C	8.0
SP3-3-D	8.0	SP9-3-D	8.2
SP4-1-A	7.9	SP10-1-A	7.3
SP4-2-A	8.3	SP10-1-B	7.6
SP4-2-B	8.4	SP10-1-C	8.0
SP4-2-C	8.5	SP10-1-D	8.3
SP4-2-D	8.2		
SP4-3-A	8.2	Henshaw	6.3
SP4-3-B	8.2	Fincastle	5.4
SP4-3-C	8.3		
SP4-3-D	7.6		
SP5-1-A	8.3		
SP5-2-A	7.9		
SP5-2-B	7.9		

Radionuclide Concentrations In Reference Soils At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
Fincastle Soil						
FS-1	0 -6	2.56E+00	8.20E-02	3.2	1.24E+01	1.13E-01
FS-2	6 -12	2.78E+00	8.80E-02	----	1.19E+01	1.72E-02
FS-3	12 - 18	1.55E+00	7.55E-02	2.4	1.46E+00	1.23E-02
FS-4	18 - 24	1.46E+00	1.62E-01	11.1	1.52E+00	1.67E-02
FS-5	24 - 30	2.70E+00	7.62E-02	2.8	1.58E+00	1.41E-02
FS-6	30 - 36	5.74E-01	7.71E-02	13.4	1.35E+01	9.33E-03
Henshaw Soil						
HS-1	0 -6	2.50E+00	6.27E-02	2.5	1.24E+01	9.76E-02
HS-2	6 -12	1.69E+00	3.12E-02	1.8	1.28E+01	2.71E-02
HS-3	12 - 18	1.77E+00	3.51E-02	2.0	1.24E+01	1.57E-02
HS-4	18 - 24	1.51E+00	4.34E-02	2.9	1.39E+01	1.17E-02
HS-5	24 - 30	2.24E+00	4.23E-02	1.9	1.62E+01	1.52E-02
HS-6	30 - 36	1.06E+00	5.57E-02	5.2	1.71E+01	1.08E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP1 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP1-1-A	0 - 4	5.07E+02	3.27E+01	6.4	1.73E+00	2.48E-01
SP1-1-B	4 -7	1.50E+03	1.05E+02	7.0	4.07E+00	3.28E-01
SP1-1-C	7 - 10	2.86E+01	2.25E+00	7.9	1.08E+01	4.63E-02
SP1-2-A	10 - 14	5.77E+02	3.73E+01	6.5	3.33E+00	1.49E-01
SP1-2-B	14 - 18	4.29E+02	2.96E+01	6.9	7.15E+00	1.61E-01
SP1-2-C	18 - 22	5.80E+00	2.43E-01	4.2	1.42E+01	4.85E-02
SP1-3-A	22 - 25	1.85E+01	8.22E-01	4.4	1.13E+01	4.16E-02
SP1-3-B	25 - 28	7.37E+00	8.25E-01	11.2	1.37E+01	4.47E-02
SP1-3-C	28 - 33	3.02E+00	2.09E-01	6.9	1.10E+01	3.74E-02
SP1-3-D	33 - 36	3.83E+00	1.85E-01	4.8	1.22E+01	2.58E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP2 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP2-1-A	0 - 4	5.41E+02	3.26E+01	6.0	5.64E+00	3.28E-01
SP2-1-B	4 -6	1.07E+03	6.12E+01	5.7	5.52E+00	2.64E-01
SP2-1-C	6 - 10	5.84E+02	3.54E+01	6.1	5.53E+00	3.18E-01
SP2-2-A	10 - 13	2.10E+02	1.17E+01	5.6	6.74E+00	1.00E-01
SP2-2-B	13 - 16	2.37E+02	1.34E+01	5.7	7.87E+00	1.22E-01
SP2-2-C	16 - 20	4.75E+02	2.56E+01	5.4	5.54E+00	1.06E-01
SP2-3-A	20 - 24	5.75E+02	3.22E+01	5.6	4.08E+00	2.27E-01
SP2-3-B	24 - 27	1.83E+02	1.07E+01	5.9	1.09E+01	8.58E-02
SP2-3-C	27 - 31	5.29E+02	2.79E+01	5.3	6.74E+00	9.20E-02
SP2-3-D	31 - 32	2.63E+02	1.57E+01	6.0	1.11E+01	1.60E-01

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP3 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP3-1-A	0 - 4	9.08E+01	4.74E+00	5.2	9.59E+00	2.29E-01
SP3-1-B	4 -7	1.67E+01	1.33E+00	8.0	1.25E+01	5.25E-02
SP3-1-A	7 - 10	6.40E+00	4.62E-01	7.2	1.33E+01	4.56E-02
SP3-2-B	10 - 13	6.88E+00	2.26E-01	3.3	1.31E+01	4.26E-02
SP3-2-C	13 - 16	5.82E+00	2.39E-01	4.1	1.24E+01	4.47E-02
SP3-2-D	16 - 18	5.33E+00	2.21E-01	4.1	1.14E+01	3.43E-02
SP3-3-A	18 - 21	4.60E+00	2.07E-01	4.5	9.91E+00	3.87E-02
SP3-3-B	21 - 24	5.98E+00	1.46E-01	2.5	1.09E+01	3.16E-02
SP3-3-C	24 - 27	4.76E+00	2.06E-01	4.3	9.98E+00	3.33E-02
SP3-3-D	27 - 30	5.80E+00	2.00E-01	3.5	1.20E+01	3.74E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP4 Soil Core Samples At Varing Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP4-1-A	0 - 4	2.77E+03	1.19E+02	4.3	1.55E+01	9.77E-01
SP4-2-A	4 - 7	1.05E+02	3.98E+00	3.8	1.07E+01	6.79E-02
SP4-2-B	7 - 10	1.98E+01	9.03E-01	4.6	7.34E+00	3.55E-02
SP4-2-C	10 - 13	8.57E+00	1.49E-01	1.7	6.38E+00	2.65E-02
SP4-2-D	13 - 16	4.48E+00	4.94E-01	11.0	7.83E+00	2.88E-02
SP4-3-A	16 - 19	5.47E+00	2.05E-01	3.8	1.29E+01	4.58E-02
SP4-3-B	19 - 22	4.67E+00	1.49E-01	3.2	1.19E+01	4.39E-02
SP4-3-C	22 - 25	4.75E+00	1.77E-01	3.7	1.15E+01	3.80E-02
SP4-3-D	25 - 28	6.72E+00	2.37E-01	3.5	1.13E+01	4.34E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP5 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP5-1-A	0 - 4	1.51E+02	6.92E+00	4.6	3.24E+00	3.65E-01
SP5-1-B	4 -9	1.32E+02	6.63E+00	5.0	7.88E+00	1.83E-01
SP5-2-A	9 - 12	6.68E+00	3.22E-01	4.8	1.36E+01	1.13E-02
SP5-2-B	12 - 16	6.75E+00	3.22E-01	7.8	1.42E+01	1.60E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP6 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP6-1-A	0 - 4	9.30E+01	3.33E+00	3.6	1.23E+01	3.54E-01
SP6-1-B	4 -8	1.35E+01	7.01E-01	5.2	1.21E+01	3.36E-02
SP6-1-C	8 - 12	8.84E+00	1.63E-01	1.8	1.32E+01	1.47E-02
SP6-2-A	12 - 16	2.86E+00	1.26E-01	4.4	1.36E+01	1.08E-02
SP6-2-B	16 - 20	2.85E+00	1.83E-01	6.4	1.32E+01	1.08E-02
SP6-2-C	20 - 24	2.13E+00	1.59E-01	7.5	1.34E+01	1.12E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

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Radionuclide Concentrations In SP7 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP7-1-A	0 - 3	3.57E+02	1.84E+01	5.2	9.39E+00	3.03E-01
SP7-1-B	3 - 6	1.51E+02	7.91E+00	5.2	1.37E+01	7.69E-02
SP7-1-C	6 - 9	7.40E+01	3.10E+00	4.2	1.44E+01	5.66E-02
SP7-1-D	9 - 12	5.37E+01	2.77E+00	5.2	1.22E+01	3.38E-02
SP7-2-A	0 - 2	3.75E+02	1.78E+01	4.7	1.01E+01	3.01E-01
SP7-2-B	2 - 5	1.46E+02	7.39E+00	5.1	1.22E+01	1.51E-01
SP7-2-C	5 - 8	7.72E+01	3.63E+00	4.7	1.20E+01	1.39E-02
SP7-2-D	8 - 11	4.61E+01	2.05E+00	4.4	1.32E+01	1.95E-02
SP7-3-A	0 - 3	6.00E+02	2.91E+01	4.9	1.21E+01	7.36E-01

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP8 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP8-1-A	0 - 2	7.60E+01	4.51E+00	5.9	1.52E+01	8.47E-01
SP8-1-B	2 - 5	3.02E+01	1.91E+00	6.3	1.38E+01	3.82E-01
SP8-1-C	5 - 8	1.41E+01	7.15E-01	5.1	1.49E+01	1.38E-01
SP8-1-D	8 - 11	5.92E+00	1.70E-01	2.9	1.60E+01	5.66E-01
SP8-2-A	0 - 3	6.30E+01	3.81E+00	6.1	1.43E+01	7.44E-01
SP8-2-B	3 - 6	1.38E+01	7.21E-01	5.2	1.40E+01	1.05E-01
SP8-2-C	6 - 9	6.64E+00	2.95E-01	4.4	1.47E+01	6.15E-02
SP8-2-D	9 - 12	7.05E+00	4.07E-01	5.8	1.55E+01	3.63E-02
SP8-3-A	0 - 3	6.85E+01	4.09E+00	6.0	1.42E+01	9.02E-01

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

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Radionuclide Concentrations In SP9 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP9-1-A	0 - 3	1.68E+03	8.17E+01	4.9	1.12E+01	6.31E-01
SP9-1-B	3 - 6	4.67E+02	2.53E+01	5.4	8.37E+00	4.61E-01
SP9-1-C	6 - 9	1.67E+02	8.90E+00	5.3	1.24E+01	1.33E-01
SP9-1-D	9 - 11	3.95E+01	2.10E+00	5.3	1.14E+01	4.86E-02
SP9-3-A	0 - 3	1.93E+03	9.42E+01	4.9	1.32E+01	7.70E-01
SP9-3-B	3 - 6	3.69E+02	1.97E+01	5.3	1.10E+01	2.58E-01
SP9-3-C	6 - 9	7.35E+01	3.41E+00	4.6	1.17E+01	7.74E-02
SP9-3-D	9 - 12	1.47E+01	1.56E+00	10.6	1.01E+01	7.80E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Radionuclide Concentrations In SP10 Soil Core Samples At Varying Depths

ID	Depth (in)	U-238[a] (pCi/g)	U-235[b] (pCi/g)	%5/8 ActRatio	K-40[c] (pCi/g)	Cs-137[d] (pCi/g)
SP10-1-A	0 - 2	3.26E+02	1.71E+01	5.2	1.08E+01	5.12E-01
SP10-1-B	2 - 5	2.58E+02	1.31E+01	5.1	1.07E+01	3.85E-01
SP10-1-C	5 - 8	5.25E+01	2.52E+00	4.8	1.17E+01	1.38E-01
SP10-1-D	8 - 10	3.13E+01	1.68E+00	5.4	1.31E+01	8.40E-02
SP10-2-A	0 - 2	2.20E+02	1.16E+01	5.3	1.18E+01	4.89E-01
SP10-2-B	2 - 4	1.24E+02	6.14E+00	5.0	1.13E+01	3.48E-01
SP10-2-C	4 - 7	4.40E+01	2.20E+00	5.0	1.23E+01	1.37E-01
SP10-2-D	7 - 10	2.00E+01	9.67E-01	4.8	7.89E+00	5.99E-02

[a]U-238 activity based on the 1001.00 KeV (0.92%) gamma energy line for Pa-234m
[b]U-235 activity based on the 143.77 KeV (10.50%) gamma energy line
[c]K-40 activity based on the 1460.73 KeV (10.70%) gamma energy line
[d]Cs-137 activity based on the 661.65 KeV (85.10%) gamma energy line

Note: The natural 5\8 activity ratio is 4.6% for 0.72% U-235.
Normal atmospheric fallout from Cs-137 is around 1 pCi/g.

Soil Particle Size Distribution And Uranium Distribution With Particle Size Of The Soil Samples

Soil Location	Size Fraction mm	% Particle Size	U conc. µg/g	Particle Size Conc µg/g	% U Contribution by Size Fraction
SP2-2-ABC	>4	48	134	64	8
SP2-2-ABC	4 - 2	11	297	33	4
SP2-2-ABC	2 - .053	14	1070	150	19
SP2-2-ABC	.053 - .002	19	1990	378	49
SP2-2-ABC	<.002	8	1980	158	20
SP2-3-ABC	>4	46	197	91	2
SP2-3-ABC	4 - 2	10	207	21	1
SP2-3-ABC	2 - .053	12	13900	1668	46
SP2-3-ABC	.053 - .002	18	5290	952	26
SP2-3-ABC	<.002	14	6130	858	24
SP4-1A/2A	>2	8	50	4	<1
SP4-1A/2A	2 - .053	20	15900	3180	48
SP4-1A/2A	.053 - .002	54	4560	2462	37
SP4-1A/2A	<.002	18	5560	1001	15
SP5-1-AB	>4	39	159	62	14
SP5-1-AB	4 - 2	15	924	139	30
SP5-1-AB	2 - .053	25	653	163	36
SP5-1-AB	.053 - .002	16	386	62	13
SP5-1-AB	<.002	5	600	30	7
SP8-1A/2A/3A	2 - .053	34	283	96	47
SP8-1A/2A/3A	.053 - .002	47	125	59	28
SP8-1A/2A/3A	<.002	19	267	51	25
SP9-1A/3A	>2	13	791	103	3
SP9-1A/3A	2 - .053	21	8770	1842	48
SP9-1A/3A	.053 - .002	53	2220	1177	31
SP9-1A/3A	<.002	13	5220	679	18

Uranium, Cations, And Anions Dissolved During Particle Size Separation

	Uranium	Al	Ba	Ca	Fe	Mg	Mn	P	Na	Sr	Alk	F	SO4
	μg/g												
SP2-2-ABC	17.2	0	9.3	1404	0	128	0	12	26.1	3.7	812	0	0
SP2-3-ABC	214.9	0	12.5	1344	0	161	0	0	45.5	3.4	1330	126	0
SP4-1A/2A	145.3	0	13.2	1402	0	168	0	0	47.5	3.5	1241	113	0
SP5-1-AB	5.8	0	4.5	896	0	144	0	0	21.6	2.8	1080	0	295
SP8-1A/2A/3A*	0.6	43	12.9	1063	39	222	2	0	14.3	2.3	100	0	0
SP9-1A/3A*	1.2	39	8.1	934	23	174	0	32	16.1	1.5	354	0	0
Fincastle Soil*	0.4	0	28.1	756	0	144	8	0	0	2.5	0	0	0
Henshaw soil*	0.0	0	15.0	807	0	147	0	0	110	2.6	0	0	0

Note: A "0" value means not detected.

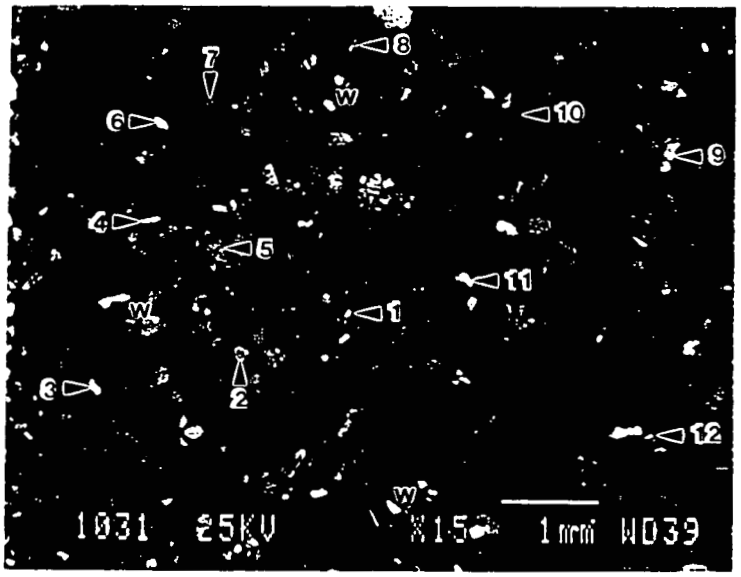
* Uranium values for these soils are preliminary

Weight And Uranium Distribution Of Sand-Size Fractions After Heavy Liquid Density Separation In Lithium Metatungstate Solution With A Density 2.8 g/ml

Sample	Fraction	Weight Distribution %	Uranium Distribution %
SP2-2-ABC	floating	83	49
	heavy	17	51
SP2-3-ABC	floating	79	64
	heavy	21	36
SP4-1A/2A	floating	63	30
	heavy	37	70
SP9-1A/3A	floating	82	49
	heavy	18	51

BSI AND EDX AFTER HEAVY LIQUID SEPARATION OF SP9-1A/3A SAND SIZE FRACTION

BSI OF FLOATING FRACTION

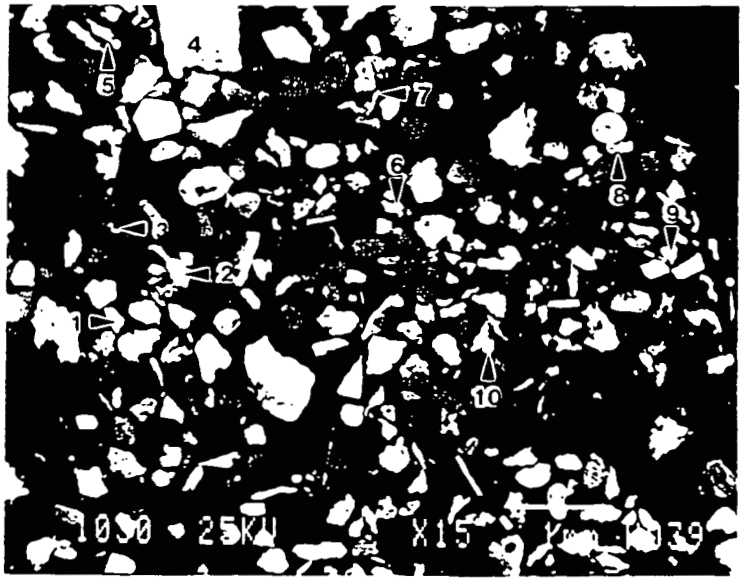


CHEMICAL CONSTITUENTS

Whole Area: Si >>> Ca,O,Al

1. W > Ca
2. W >> Ca
3. Fe > O
4. Fe > Si > Cr = O
5. Si > Al = Fe = O
6. U > Si = P > O > Al
7. P > U > O
8. F > Mg > U >> Si
9. U >> Si > O
10. W >>> O > Ca = K = Fe
11. U > Ca = Si > O > Fe
12. U > Si > Al = O > P

BSI OF HEAVY FRACTION



CHEMICAL CONSTITUENTS

Whole Area: Fe > Ca,Si,O > Mg,Al

1. U >> Fe > P > O
2. Fe > O
3. U = Fe > P > O = Cr
4. Fe >> O
5. P = U > Fe > O > Cr
6. Fe >> P = U = O > Cr = Fe
7. U > Si > Fe > O = Al = Mn
8. U > Ca = Si > P = O
9. Fe > Cr = P > U = O
10. Zr = Si >> Fe = O

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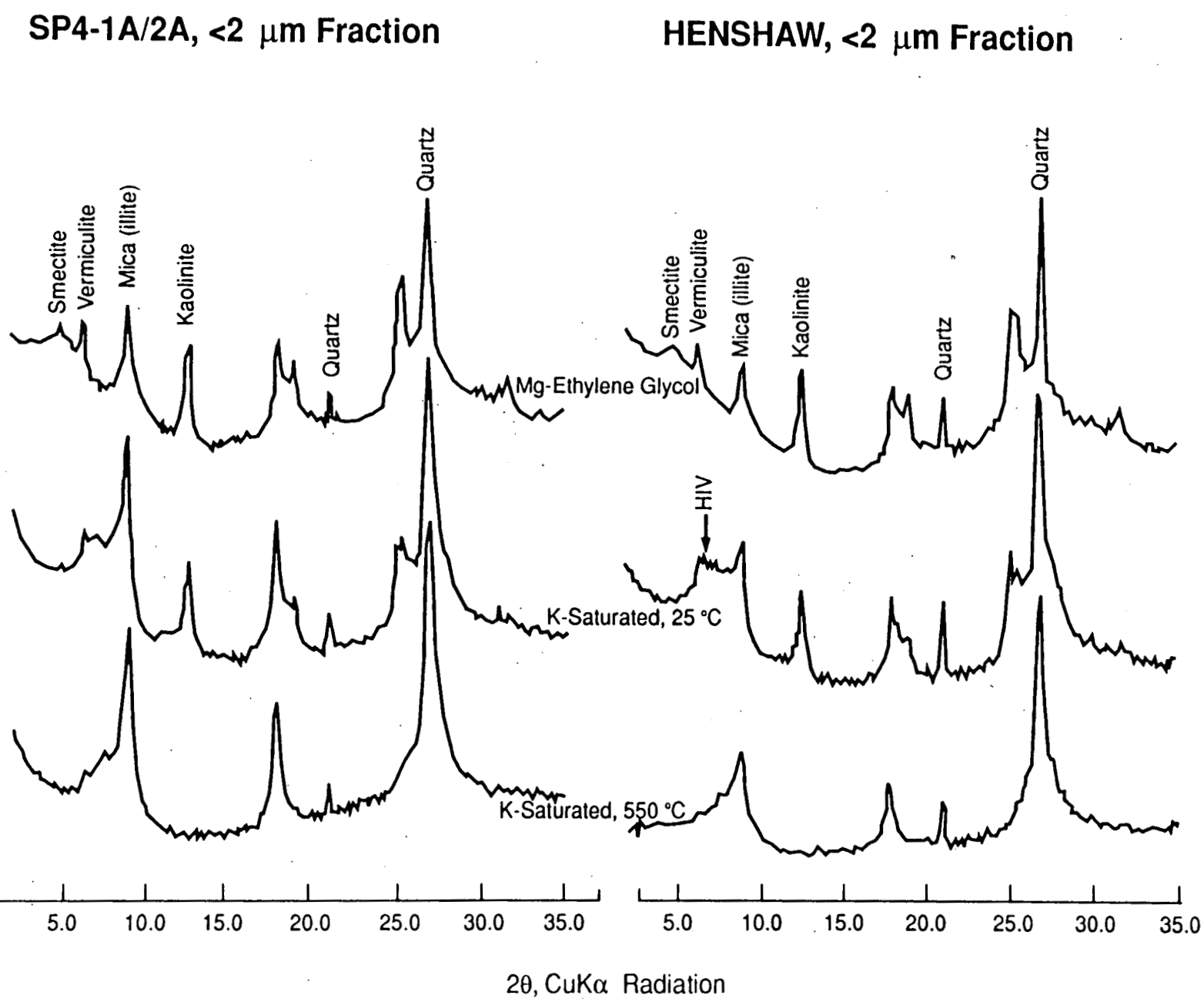

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Percent Extractable Uranium And Total Uranium Concentrations In The Soil Samples

Sample ID pH	Extractants							total U (μg/g)
	0.1 N HNO_3 1.7	0.1 M $NH_3OH.HCl$ 2.4	2% Citric Acid 2.5	0.1 M EDTA 4.6	2% $(NH_4)_2CO_3$ 8.5	5% NaOCl 11.7	CBD 8.5	
SP2-2-ABC	2.	2	32	2	22	9	29	2220
SP2-3-ABC	4	3	32	3	20	7	30	2970
SP4-1A/2A	12	23	75	45	49	25	31	5920
SP5-1-AB	8	6	20	9	10	6	11	575
SP8-1A/2A/3A	15	<1	32	9	47	35	28	224
SP9-1A/3A	6	<1	44	5	14	6	25	5290

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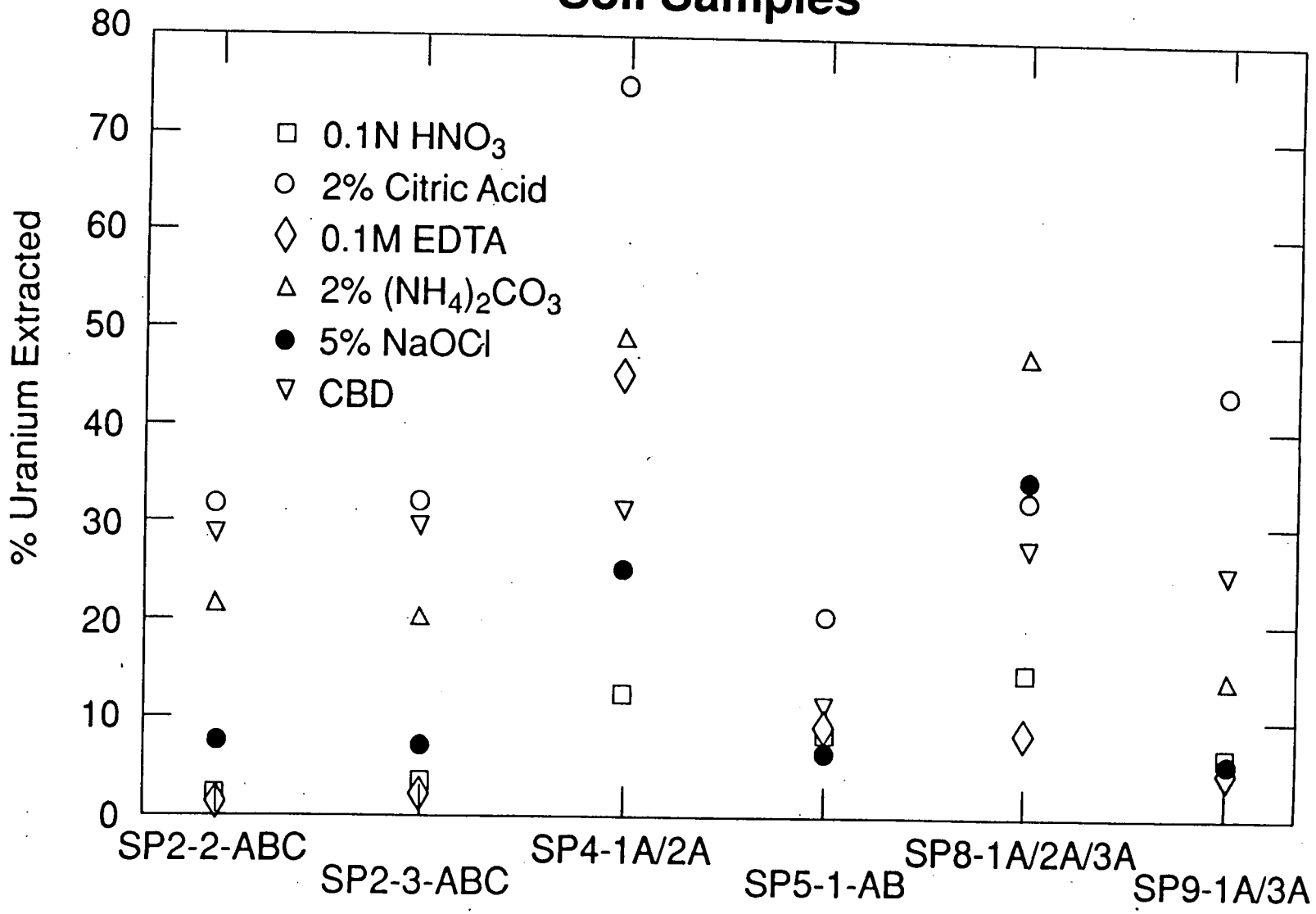
Percent Extracted Uranium From Different Soil Samples



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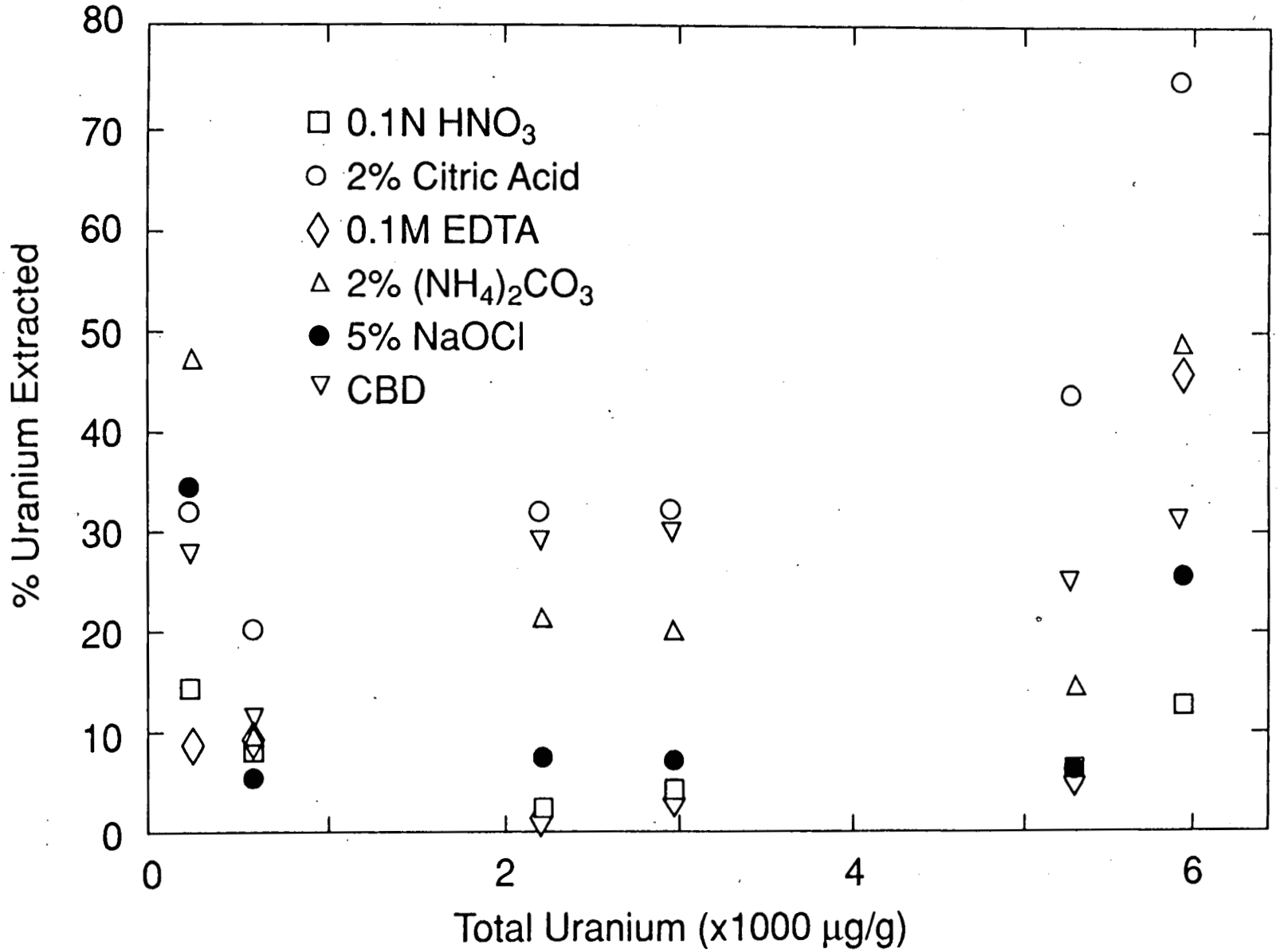
Percent Extracted Uranium vs Total Uranium Concentration Of Soil Samples



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0.1M Nitric Acid Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	<0.02	13.68	<0.01	1.30	0.04	0.02
SP2-3-ABC	<0.02	12.88	<0.01	1.81	0.04	<0.02
SP4-1A/2A	<0.02	13.28	<0.01	1.62	0.04	<0.02
SP5-1-AB	<0.02	16.08	<0.01	0.58	0.06	<0.02
SP8-1A/2A/3A	0.78	4.68	0.05	0.64	0.07	0.40
SP9-1A/3A	0.44	9.84	<0.01	2.05	0.13	0.40

0.1M Hydroxylamine Hydrochloride Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	<0.02	9.60	<0.01	0.27	0.23	<0.02
SP2-3-ABC	<0.02	9.36	<0.01	0.29	0.20	<0.02
SP4-1A/2A	<0.02	9.28	<0.01	0.40	0.28	<0.02
SP5-1-AB	<0.02	8.88	<0.01	0.51	0.89	<0.02
SP8-1A/2A/3A	<0.02	2.75	<0.01	0.46	0.27	0.08
SP9-1A/3A	<0.02	4.43	<0.01	0.46	0.23	0.06

2% Citric Acid Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	0.56	8.40	0.47	1.09	0.30	0.26
SP2-3-ABC	0.40	8.72	0.41	1.12	0.23	0.15
SP4-1A/2A	0.38	11.36	0.60	1.75	0.27	0.07
SP5-1-AB	1.08	6.90	0.26	1.34	0.94	0.02
SP8-1A/2A/3A	0.57	2.65	0.14	0.37	0.14	0.29
SP9-1A/3A	0.62	7.06	0.46	0.82	0.20	0.67

0.1M EDTA Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	0.18	32.00	0.30	1.13	0.32	0.14
SP2-3-ABC	0.15	27.68	0.38	1.65	0.28	0.06
SP4-1A/2A	0.21	22.72	0.39	1.90	0.35	<0.02
SP5-1-AB	0.13	32.16	0.12	0.75	0.64	0.02
SP8-1A/2A/3A	0.19	4.11	0.21	0.41	0.34	0.17
SP9-1A/3A	0.28	7.71	0.61	0.17	0.29	0.51

5% Sodium Hypochlorite Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	<0.02	0.67	<0.01	<0.02	<0.001	<0.02
SP2-3-ABC	<0.02	0.70	<0.01	<0.02	<0.001	<0.02
SP4-1A/2A	<0.02	1.16	<0.01	0.09	<0.001	<0.02
SP5-1-AB	<0.02	0.78	<0.01	0.12	<0.001	<0.02
SP8-1A/2A/3A	<0.02	1.34	<0.01	0.28	<0.001	0.02
SP9-1A/3A	<0.02	1.25	<0.01	0.20	<0.001	0.06

2% Ammonium Carbonate Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	<0.02	0.15	<0.01	0.13	<0.001	0.06
SP2-3-ABC	<0.02	0.16	<0.01	0.14	<0.001	0.03
SP4-1A/2A	<0.02	0.34	<0.01	0.22	<0.001	<0.02
SP5-1-AB	<0.02	0.14	<0.01	0.26	<0.001	<0.02
SP8-1A/2A/3A	<0.02	0.18	<0.01	0.33	<0.001	<0.02
SP9-1A/3A	<0.02	0.22	<0.01	0.26	<0.001	0.10

Citrate, Bicarbonate, dithionite (CBD) Extraction

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	0.32	3.20	2.70	0.18	0.15	*
SP2-3-ABC	0.35	1.50	3.38	0.14	0.13	*
SP4-1A/2A	0.27	1.65	3.04	0.19	0.17	*
SP5-1-AB	0.16	2.19	2.93	0.27	0.51	*
SP8-1A/2A/3A	0.43	1.82	4.04	0.28	0.18	*
SP9-1A/3A	0.32	1.75	2.26	0.22	0.17	*

Total Cation In Soil

	Al	Ca	Fe	Mg	Mn	P
			mg/g			
SP2-2-ABC	115.20	576.00	161.60	167.20	4.54	12.16
SP2-3-ABC	108.00	439.20	176.80	141.60	3.50	8.48
SP4-1A/2A	139.20	364.80	184.80	132.00	4.28	8.40
SP5-1-AB	180.00	1056.00	263.20	206.40	28.88	7.84
SP8-1A/2A/3A	122.40	43.20	164.80	31.92	4.17	8.72
SP9-1A/3A	117.60	116.80	180.00	43.20	5.34	15.84

* Phosphorus could not be determined by ICP due to the large interference of sulfur solubilized by the CBD extraction.

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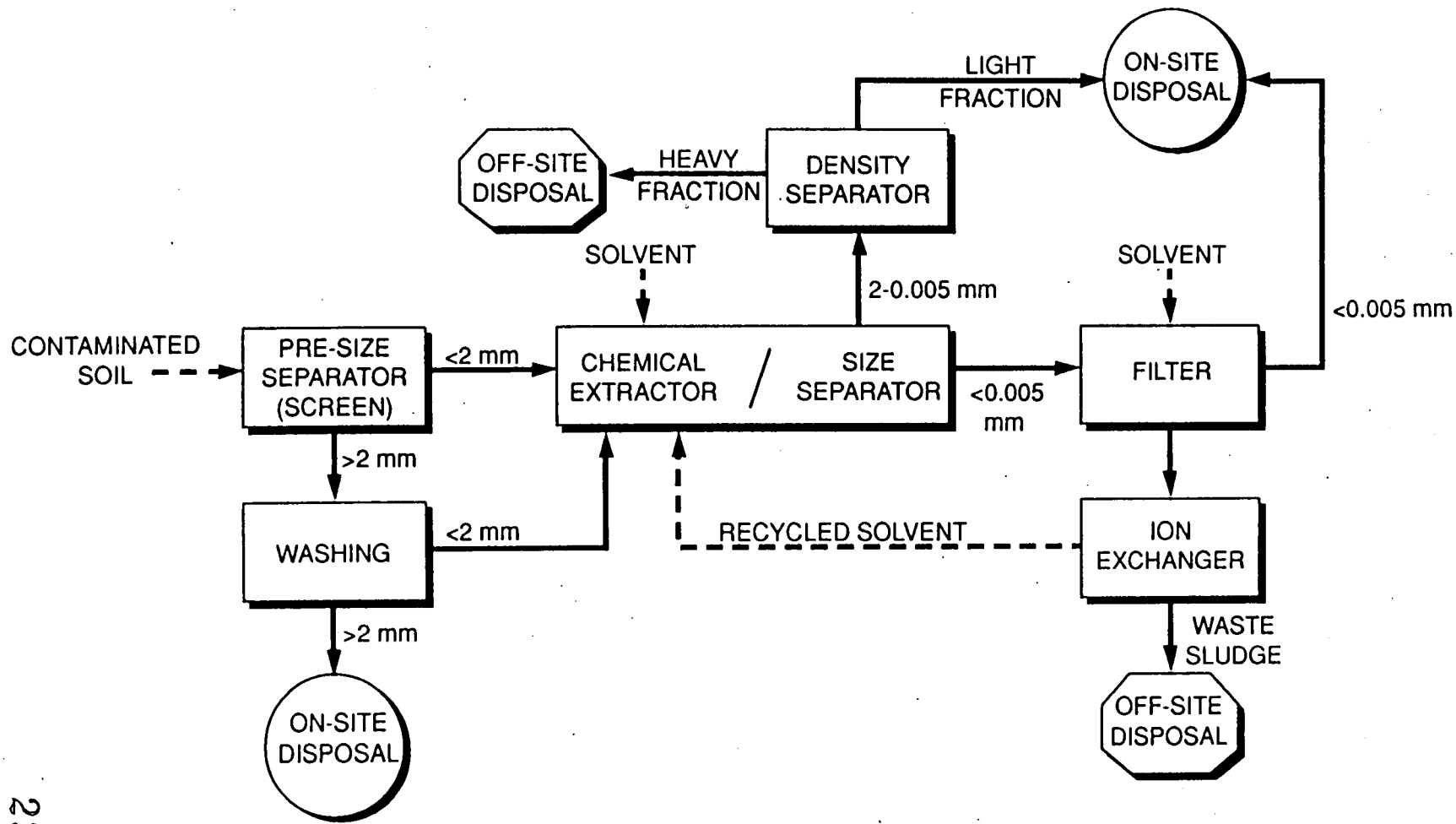

Appendix A

Uranium Soils Integrated
Demonstration
Treatability Sampling Plan

TESTING FOR HOMOGENEITY

Objective:

The objective of this test is to determine if the characteristics of soil contained in a single drum are significantly different than the characteristics of soil contained in a set of drums. This test is necessary to assure that the characteristics of soil being prepared for the treatability studies do not differ significantly between drums.

Approach:

Soil from the Fernald Environmental Management Project (FEMP) will be collected for treatability tests in accordance with the RI/FS QAAP and Project Specific Health and Safety Plan. The soil after screening to <¾ in. will be blended using dry blending equipment and packaged into two subsets of 12 drums each. The two subsets of drums have been established to partition the contaminated soil into uranium source terms of "particulate" and "nonparticulate". The intent of the two subsets are to separate contaminated soil surrounding the waste incinerator (a known particulate form of uranium) from the soil adjacent the Plant 2/3 area where large quantities of nitric acid containing uranium were generated (a source term known to contain soluble forms of uranium). Soil characterization studies presently under way will determine if subsetting of drums by such a source term description will be necessary.

Theory:

To be confident of detecting a particular difference among the population means of a given response (e.g., particle size distribution, uranium concentration, etc.) across the collection of drums, it will be necessary to take a specific number of cores or samples from each drum. The necessary number of cores can be determined at varying levels of confidence by testing the null hypothesis

$$H_o: u_1 = u_2 = \cdots = u_k$$

where u_i (i= 1, 2, ..., k) is the mean of the given response for the ith drum and k is the number of drums under consideration. The method used to determine the sample size is to specify the parameters, α, β, and τ where

α = probability of rejecting the null hypothesis when it is true, i.e., the level of significance;
β = probability of not rejecting the null hypothesis when it is false, i.e., $(1-\beta)$ is the power of the test; and
τ = difference between the largest and smallest of the k means, divided by the standard

deviation.

The assumption is made that the observed random variable under consideration follows a normal distribution with mean u_i and variance σ^2 for the samples from the ith drum, i = 1, 2, ..., k. If this is not the case, a transformation of the random variable (such as the log- or arcsine-transformation) exists such that the distribution of the transformed random variable is reasonably approximated by a normal distribution with mean u_i and variance σ^2.

Once values have been specified for k, α, β and τ, the tables of Kastenbaum et al. (1969) and Bownman (1971) can be used to determine the required sample size. Table 1 gives the sample sizes required for this formulation with different combinations of α, β, and τ for 12 drums (k = 12).

Table 1. Required Number of Samples from Each of the 12 Drums

τ	α=0.2, β=0.2	α=0.1, β=0.3
1	24	25
1.5	11	12
2	7	7
2.5	5	5
3	4	4

To use Table 1, one has to estimate the τ from expected values of the standard deviation (σ). In certain cases, it is easier to think in terms of coefficient of variation (CV) where CV = σ/u_k. For example, a CV of 0.3 (%CV=30%) would be considered in many instances an upper limited for determining the fraction of soil <0.075 mm (silt and clay fractions). Assuming that the soil contains on an average 50% silt and clay, then the value of σ would be estimated to be 15% (0.3 times 50%). To test the null hypothesis that the mean response does not differ in the 12 drums at the 10% level of significance and at the same time have a 70% probability of detecting a maximum difference between the largest and smallest drum means whose silt and clay percent differs by 45% (τ times σ or in this case 3 times 15%), one would have to take at least 4 cores from each of the 12 drums. Obviously, at lower levels of σ, fewer cores per drum would be required or a higher probability of detecting maximum differences between drums could be established. Listed in Table 2 are maximum differences between the largest and smallest of the drum means for α=0.1, β=0.3, k=12, and τ=3 when 4 samples per drum are taken over a range of CVs and expected means. Similar tables with varying values of α, β, etc, can be generated to evaluate the probability and confidence levels of homogeneity of soil in drums.

Table 2. Estimated Difference between Means

%CV	Expected Means				
	50	100	250	500	1000
	Difference between Largest and Smallest of the means				
10	15	30	75	150	300
15	23	45	113	225	450
20	30	60	150	300	600
25	38	75	188	375	750
30	45	90	225	450	900
35	53	105	263	525	1050
40	60	120	300	600	1200
45	68	135	338	675	1350
50	75	150	375	750	1500
55	83	165	413	825	1650
60	90	180	450	900	1800
65	98	195	488	975	1950
70	105	210	525	1050	2100
75	113	225	563	1125	2250

Application:

Four samples weighing at least 250 grams will be taken by coring the filled drums or at the time when the drums are filled. If coring is used, a coring probe of at least 2 inches in diameter should be used extending from the top to the bottom of the drum. These samples will be oven dried to remove moisture (dried to constant weight at a temperature not exceeding 110° C)[1]. Using U.S. Standard Sieves (No. 10 and No. 200) and a mechanical vibrator-shaker (shaking time of 10 minutes) the dried samples will be separated into >2 mm, 2-0.075 mm, and <0.075 mm fractions. The particle size information will be tabulated (% of each fraction) for each of the four samples taken from a drum. For each core sample and its three particle size fractions, uranium levels will be determined by direct counting a known sample size in a calibrated geometry. Uranium levels will be expressed

[1]Initial drying at room temperature to prevent caking of wet-clayey samples may be required.

on a pCi/g basis.

The above method will be used to test for homogeneity of soil characteristics (i.e., particle size distribution and uranium levels) among drums at a confidence level and probability. If desired homogeneity is not achieved, the re-blending of soil into a different set of drums will be required.

References:

Bowman, K. O., "Sample Size Requirement: Continuation," ORNL-4712, Oak Ridge National Laboratory, Oak Ridge, Tennessee, August 1971.

Kastenbaum, M. A., D. G. Hoel, and K. O. Bowman. "Sample Size Requirement: Test of Equality of Several Gaussian Means," ORNL-4468, Oak Ridge National Laboratory, Oak Ridge, Tennessee, November 1969.