N60478.AR.000060
NWS EARLE
5090.3a

WESTON

INSTALLATION RESTORATION PROGRAM

Phase III

FINAL

QUALITY ASSURANCE PROJECT PLAN

For

Naval Weapons Station Earle,
Colts Neck, New Jersey

June 1990

Prepared For:

Naval Weapons Station Earle,
Colts Neck, New Jersey

Richard C. Johnson, P.G.
WESTON Project Manager

Katherine A. Sheedy, P.G.
WESTON Project Director

Work Order No. 1771-15-01

Prepared by:

Roy F. Weston, Inc,
West Chester, Pennsylvania

6572B1

WESTON

TABLE OF CONTENTS

Section	Title	Page
1	QUALITY ASSURANCE/QUALITY CONTROL	1-1
1.1	Introduction	1-1
1.2	Project Description	1-1
1.2.1	List of Sites	1-1
1.2.2	Project Scope	1-1
1.3	Project Organization and Responsibility	1-5
1.4	Quality Assurance Objectives	1-7
1.4.1	Accuracy	1-7
1.4.2	Precision	1-8
1.4.3	Completeness	1-8
1.4.4.	Representativeness	1-9
1.4.5	Comparability	1-9
1.4.6	Regulatory Requirements	1-9
1.5	Sampling Procedures	1-15
1.6	Sample Custody	1-16
1.6.1	Chain-of-Custody	1-17
1.6.1.1	Sample Labels	1-17
1.6.1.2	Chain-of-Custody Records	1-17
1.6.1.3	Transfer of Custody and Shipment	1-17
1.6.1.4	Laboratory Custody Procedures	1-19
1.6.2	Documentation	1-23
1.6.2.1	Sample Identification	1-23
1.6.2.2	Field Logs	1-28
1.6.2.3	Corrections to Documentation	1-28
1.6.2.4	Photographs	1-29
1.6.3	Sample Handling, Packaging, and Shipping	1-29
1.6.3.1	Sample Handling and Packaging	1-29
1.6.3.2	Procedures for Packing Low-Level Environmental Samples	1-30
1.6.3.3	Procedures for Packing Medium-Level Environmental and Hazardous-Level Samples	1-30
1.7	Calibration Procedures and Frequencies	1-30
1.7.1	Field Equipment	1-33
1.7.1.1	HNu Photoionization Analyzer	1-33
1.7.1.2	Organic Vapor Analyzer	1-34
1.7.1.3	Explosimeter/Combustible Gas Indicator	1-35

6572B2

TABLE OF CONTENTS
(continued)

Section	Title	Page
	1.7.1.4 Specific Conductance Meter	1-36
	1.7.1.5 pH Meter	1-36
	1.7.1.6 Magnetometer	1-37
	1.7.2 Laboratory Equipment	1-38
1.8	Field Analytical Procedures	1-38
	1.8.1 Field Testing and Screening	1-38
	1.8.1.1 pH Measurement	1-39
	1.8.1.2 Specific Conductance and Temperature Measurement	1-39
	1.8.2 Laboratory Methods	1-39
1.9	Data Reduction, Validation, and Reporting	1-41
	1.9.1 Field and Technical Data	1-41
	1.9.1.1 Field and Technical Data Reduction and Recording	1-41
	1.9.1.2 Field and Technical Data Validation	1-41
	1.9.2 Laboratory Data	1-42
	1.9.2.1 Laboratory Data Reduction	1-42
	1.9.2.2 Laboratory Data Validation	1-43
	1.9.2.3 Laboratory Data Reporting	1-43
	1.9.3 Data Management	1-43
1.10	Internal Quality Control Checks	1-44
	1.10.1 Internal Quality Control Checks - Field	1-44
	1.10.2 Internal Quality Control Checks - Laboratory	1-45
1.11	Performance and System Audits	1-46
	1.11.1 Project System Audits	1-46
	1.11.2 Technical Performance Audits	1-47
	1.11.3 Field Performance Audits	1-47
	1.11.4 Laboratory System Audits	1-48
	1.11.5 Laboratory Performance Audits	1-48
1.12	Preventive Maintenance of Equipment	1-48
	1.12.1 Field Equipment	1-48
	1.12.2 Laboratory Equipment	1-50
	1.12.2.1 Instrument Maintenance Logbooks	1-50

TABLE OF CONTENTS
(continued)

Section	Title	Page
	1.12.2.2 Instrument Calibration and Maintenance	1-50
	1.12.2.3 Spare Parts	1-52
	1.13 Data Assessment Procedures	1-52
	1.13.1 Field Data	1-52
	1.13.1.1 Precision	1-52
	1.13.1.2 Accuracy	1-52
	1.13.1.3 Completeness	1-52
	1.13.2 Laboratory Data	1-52
	1.13.2.1 Precision	1-52
	1.13.2.2 Accuracy	1-54
	1.13.2.3 Completeness	1-54
	1.14 Corrective Action	1-54
	1.14.1 Field Corrective Action	1-54
	1.14.2 Laboratory Corrective Action	1-54
	1.15 Quality Assurance Reports	1-56
	1.15.1 Field QA Reports	1-56
	1.15.2 Laboratory QA Reports	1-56
2	**METHODS PROTOCOLS**	**2-1**
	2.1 Surface Geophysical Surveys	2-1
	2.1.1 Magnetometry	2-1
	2.2 Test Borings and Exploratory Drilling	2-2
	2.2.1 Test Borings	2-2
	2.2.2 Monitor Wells	2-3
	2.3 Monitor Well Installation and Testing	2-3
	2.3.1 Shallow Monitor Wells	2-3
	2.3.2 Final Development and Hydraulic Testing	2-8
	2.4 Water Level Data Collection	2-8
	2.5 Sample Collection	2-10
	2.5.1 Groundwater Samples	2-10
	2.5.2 Surface Water/Sediment Samples	2-13
	2.5.3 Soil Samples	2-13
	2.5.4 Decontamination Procedures	2-13
	2.5.4.1 Drilling, Soil Sampling, and Monitor Well Installation Equipment Decontamination	2-13
	2.5.4.2 Well Development Equipment Decontamination	2-15
	2.5.4.3 Water Level Measurement Equipment Decontamination	2-15

6572B4

TABLE OF CONTENTS
(continued)

Section	Title	Page
	2.5.4.4 Water and Soil Sampling Equipment Decontamination	2-15
	2.5.4.5 Disposal of Drill Cuttings and Fluids	2-16
	2.5.5 Required Containers, Preservation Techniques, Holding Times, and Sample Volumes	2-17
	2.5.5.1 Sample Containers	2-17
	2.5.5.2 Sample Preservation	2-17
	2.5.5.3 Holding Times	2-17
	2.5.6 Sampling QA/QC Protocols	2-17
2.6	Site Management	2-20
	2.6.1 General Operations and Coordination with US Navy	2-20
	2.6.2 On-Station Project Facilities	2-20
	2.6.3 Site Access and Security	2-20
	2.6.4 Site Logistics	2-21
	2.6.5 Contingencies	2-21

APPENDIX A - ANALYTICAL LABORATORY QUALITY ASSURANCE PLAN
APPENDIX B - ANALYTICAL METHODS, PARAMETERS, AND LIMITS OF DETECTION - IRP PHASE III, NWS EARLE, NEW JERSEY
APPENDIX C - UNIFIED SOIL CLASSIFICATION SYSTEM
APPENDIX D - RESUMES OF KEY MANAGEMENT PERSONNEL
APPENDIX E - MASTER LIST OF SAMPLES
APPENDIX F - PROCEDURES

LIST OF FIGURES

Figure No.	Title	Page
1-1	Site Locations Map	1-3
1-2	Activity Matrix	1-4
1-3	Custody Transfer Record/Lab Work Request	1-18
1-4	Sample Extraction Record	1-21
1-5	Sample Digestion Record	1-22
1-6	Sampling Packaging, Medium-Level Environmental and Hazardous-Level Samples	1-31
1-7	Shipping Container, Medium-Level Environmental and Hazardous-Level Samples	1-32
1-8	Critical Path for Corrective Action, WESTON Analytical Laboratories	1-57
2-1	Drilling Log	2-4
2-2	Well Construction Summary	2-5
2-3	Typical Well Construction	2-9

LIST OF TABLES

Table No.	Title	Page
1-1	Site Names and Designations	1-2
1-2	Applicable Federal and State Regulatory Requirements for LOD of Chemical Analysis	1-10
1-3	Maximum Concentration of Contaminants for Characteristics of EP Toxicity	1-13
1-4	Summary of Site Identifier Numbers	1-25
1-5	Summary of Well Location Identifier Numbers	1-26
1-6	Summary of Analytical Methods	1-40
1-7	Summary of External Performance and Systems Audits, WESTON Analytical Laboratories	1-49
1-8	Instrument Maintenance Schedule, WESTON Analytical Laboratories	1-51
1-9	QA Objectives for Precision of Laboratory Organic Analyses	1-53
1-10	QA Objectives for Accuracy (%) of Laboratory Organic Analyses	1-55
2-1	NJDEP Monitor Well Construction and Grouting ing Specifications for Unconsolidated Formations	2-6
2-2	Summary of Analytical Requirements for Soil and Sediment Analysis	2-12
2-3	Summary of Analytical Requirements for Surface and Groundwater Analysis	2-14
2-4	Summary of Sample Container Specifications	2-18

SECTION 1

QUALITY ASSURANCE/QUALITY CONTROL

1.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) is one of three planning documents describing activities to be undertaken as part of the Installation Restoration Program (IRP) Phase III investigation at Naval Weapons Station Earle (NWS Earle). The other documents are:

- Work Plan for the Installation Restoration Program -- Phase III -- presents the available information concerning the site's history and potential hazards, candidate site remediation technologies, and activities proposed to evaluate the site and select remedial action alternatives.

- Health and Safety Plan (HSP) -- contains site-specific information concerning types of facilities, waste types and characteristics, types of hazards, levels of protection, surveillance equipment to be used, and emergency precautions. A Site Security Plan will be incorporated with a Site Safety Plan to delineate efforts required to secure operations at the site.

The purpose of the QAPP is to describe the following items:

- Quality assurance (QA) objectives.
- Sampling and laboratory procedures.
- Sample custody procedures.
- Calibration procedures, references, and frequencies.
- Protocols for field activities.
- Internal quality control (QC) checks.
- QA performance and system audits.
- Preventive maintenance procedures and schedules.
- Data assessment procedures.
- Corrective actions.
- QA reports to management.

1.2 PROJECT DESCRIPTION

1.2.1 List of Sites

The sites included in this study are listed in Table 1-1 and their locations are shown in Figure 1-1. A detailed description and map for each site is provided in the IRP Phase III Work Plan (WESTON, 1989).

1.2.2 Project Scope

The Phase III Sampling Scope of Work for NWS Earle is summarized in Figure 1-2. Specific protocols for each activity

WESTON

Table 1-1

Study Site Names and Designations,
IRP Phase III, NWS Earle, New Jersey

Site No.	Site Designation
2	Ordnance Demilitarization Site
3	Landfill southwest of "F" Group
4	Landfill west of "D" Group
5	Landfill west of Army Barricades
7	Landfill south of "P" Barricades
10	Scrap Metal Landfill near Building 589
11	Contract Ordnance Disposal Area
19	Paint Chip and Sludge Disposal Area adjacent to Building S-34
20	Grit Blasting Disposal Area, Building 544
22	Paint Chip Disposal Area adjacent to Building D-2
26	Explosive "D" Washout Area adjacent to Building GB-1

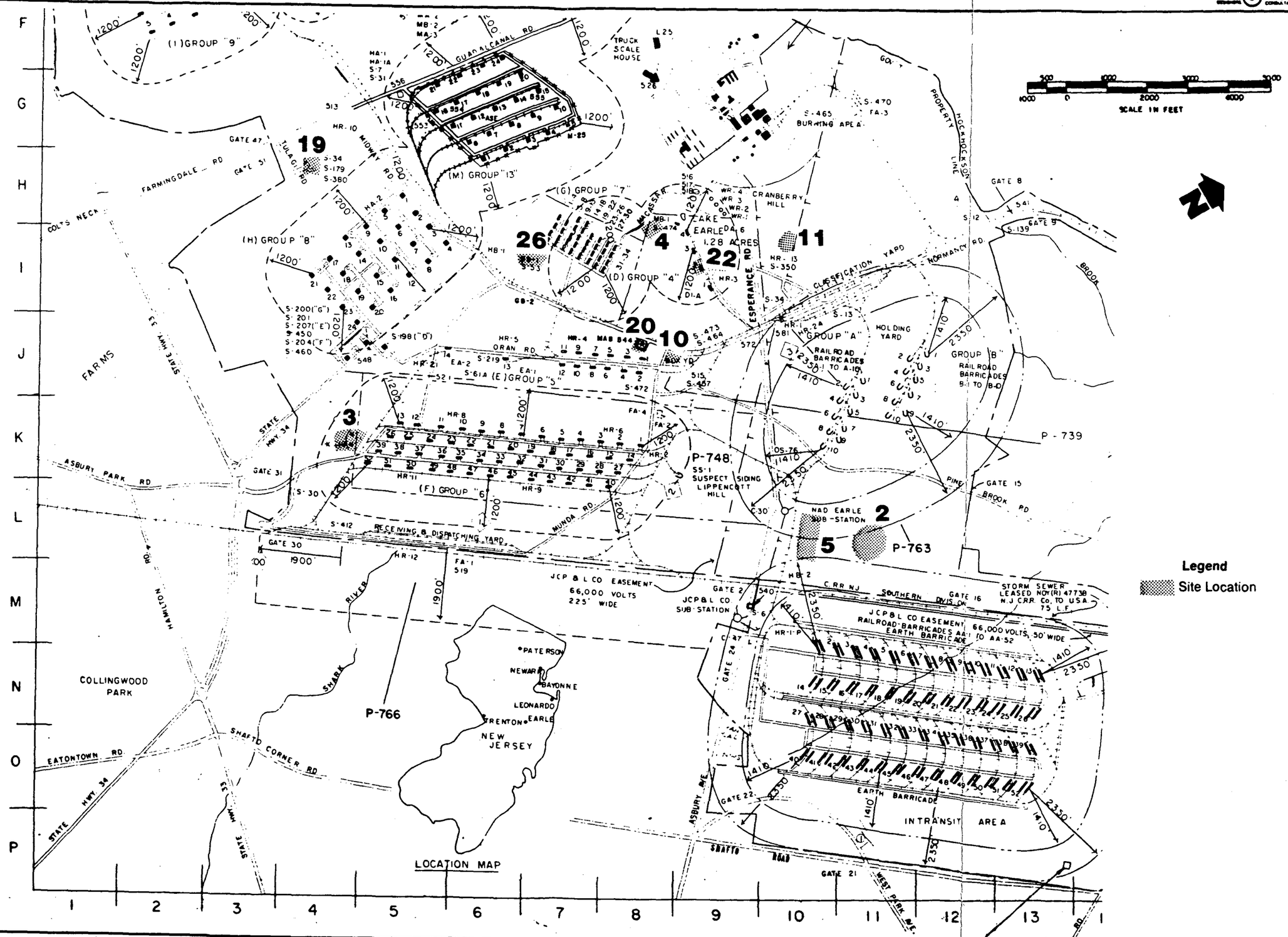


FIGURE 1-1 SITE LOCATIONS

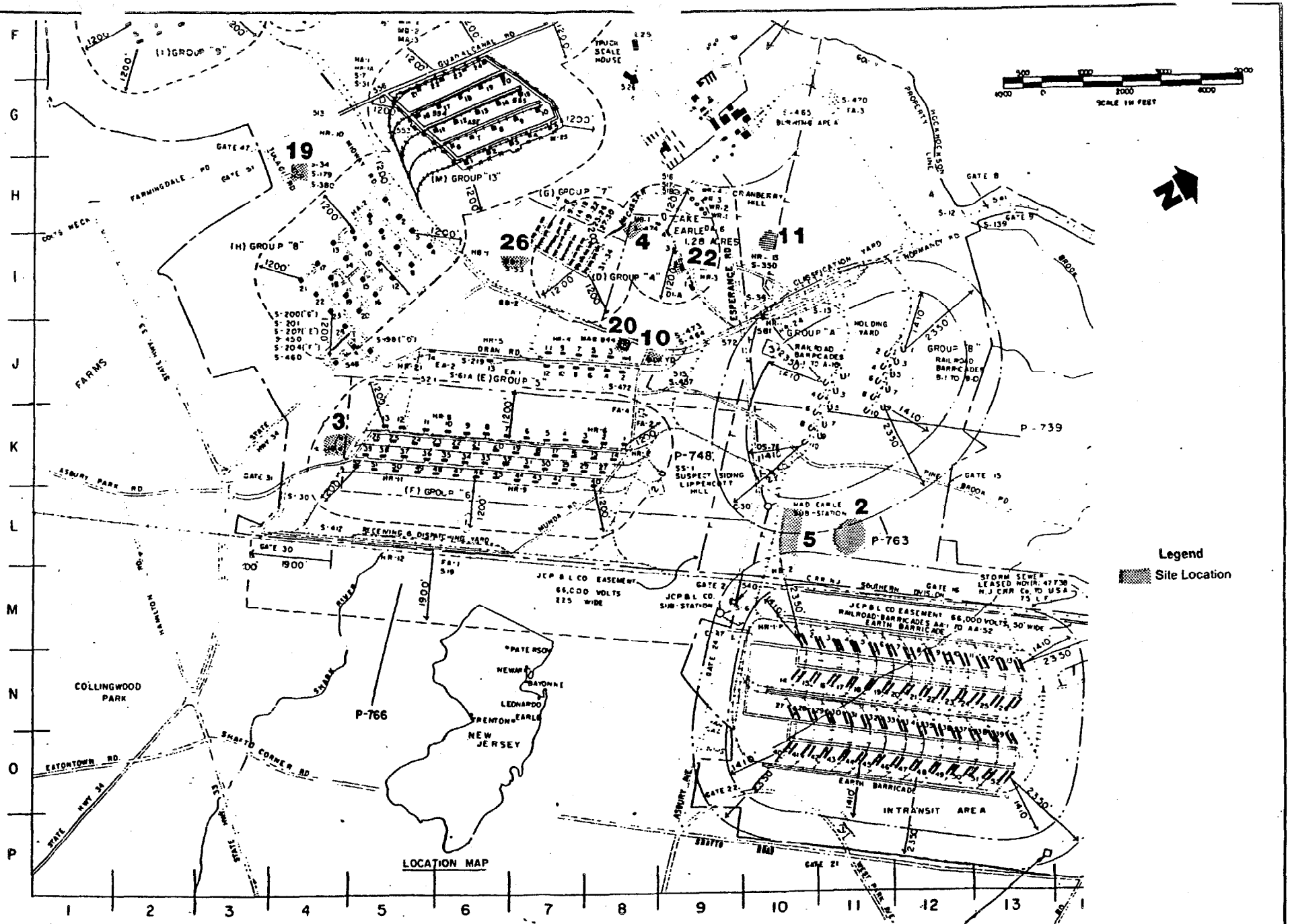


FIGURE 1-1 SITE LOCATIONS

WESTON

RI/FS Activity Matrix

	Facility Wide	Site 2	Site 3	Site 4	Site 5	Site 7	Site 10	Site 11	Site 19	Site 20	Site 22	Site 26
Historical Aerial Photograph Interpretaion		●	●	●	●	●	●	●	●	●	●	
Electromagnetics						●						
Soil Boring/Soil Sampling		●		●			●	●	●	●	●	●
New Monitor Well Installation		●	●	●	●	●	●	●	●			●
Surface Water Sampling				●			●					
Monitor Well Sampling		●	●	●	●	●	●	●	●			●
Slug Test		●		●			●		●			
Additional Geologic Characterization		●	●	●	●	●	●	●	●			

● Proposed Activity

241-1480

FIGURE 1-2 ACTIVITY MATRIX

are addressed in Section 2 of this QAPP and in the Work Plan. The intended use of the data collected during this phase III remedial investigation/feasibility study (RI/FS) is to meet the long-range objectives of they Navy's IRP.

The long-range objectives of the IRP at NWS Earl are to assess the extent and magnitude of contamination at past hazardous waste disposal and spill sites and to develop remedies consistent with the National Contingency Plan (NCP) for those sites that pose a threat to human health or the environment. The goals for the process of selecting the remedial alternatives are to:

- Select remedies that, based on risk analysis findings, will protect human health and the environment.
- Provide cost-effective remedies.
- Attain New Jersey and Federal potentially applicable or relevant and appropriate requirements (ARARs) as a result of remediation.
- Select remedies that use permanent solutions and alternative technologies to the maximum extent practicable.
- Consider the use of interim responses.
- Use on-site mitigation to the maximum extent possible.

A Rough Draft, a Draft, and a Final Report will document the results of field work.

1.3 PROJECT ORGANIZATION AND RESPONSIBILITY

The following is a brief description of project responsibilities. The Project Director, Katherine A. Sheedy, P.G., is responsible for overall management and quality assurance for the U.S. Navy projects, and her responsibility also includes ensuring that all necessary corporate resources for the successful completion of the projects are provided. The Project Director also is the primary point of contact between the Navy and WESTON.

The Project Manager, Richard C. Johnson, P.G., along with the Project Director, is responsible for technical and financial management of this project and is the direct contact individual between the Navy and WESTON.

The Project Manager is responsible for technical management of this assignment including scheduling, subcontracting, communications, technical supervision, and execution of the field

effort. Assisting the Project Manager are the Technical Leads for the project, the Site Manager, and the Data Administrator.

The Technical Leads are responsible for tracking technical progress within the project scope relating to each of their disciplines (engineering; geosciences including geology, hydrology, and soil science; and environmental sciences including biology, toxicology, and public health) and ensuring that the technical objectives of the scope of work are met. The Technical Leads work with the Site Manager to plan data collection efforts. In addition, Technical Leads track and constantly evaluate new technical data as they are generated and notify the Project Manager of any anomalies, data gaps, and/or adjustments to the planned data collection effort that might be required to meet the technical objectives of the project.

The Site Manager is responsible for coordinating the activities of the field teams and directing the work of subcontractors in the field. The Site Manager is directly responsible for implementation of the Work Plan and the QAPP as they apply to the field effort, for keeping the field teams supplied, and for coordination of logistical issues. The Site Manager prepares daily field reports during all field activities and communicates progress and problem areas to the Project Manager on a daily basis. The Site Manager also is responsible for coordination and day-to-day contact with the Station Point Of Contact (POC).

The Data Administrator is responsible for ensuring data validation and entering all data collected in the field into the database for the project. The intent is to check and enter into the database all data generated. To ensure this, the Data Administrator will be present on station during all major data collection activities. The data to be entered will include boring and well logs, geophysical data, water level measurements, field water quality data, and sampling point coordinate locations. In addition, the Data Administrator will assist the Site Manager in keeping the field teams supplied and in maintaining daily progress reports. The job functions of the Data Administrator may be undertaken by the Lead Geoscientist.

The project Quality Assurance Officers (one for each major discipline) report directly to the Project Manager and Project Director. The QA Officer is responsible for conducting unannounced field visits to observe data collection procedures and for periodic review of data generated. The Data Administrator or Technical Lead may request assistance from the project QA Officer in validating a data set or data analysis technique. The QA Officer is also responsible for review of project deliverables. Resumes of all management personnel responsible for these tasks and for performing analytical work are included in Appendix D.

1.4 QUALITY ASSURANCE OBJECTIVES

The level of QC for this project is level D as defined in NEESA 20.2-047B, Section 7.1. The specific standard operating procedures (SOPs) to be used are as follows:

- Organics -- EPA Region II SOP No. HW-6, Revision 6, CLP Organics Data Review, 14 April 1989.
- Inorganics -- EPA Region II SOP No. HW-2, Revision IX, Evaluation of Metals Data for CLP, 27 October 1989.

The overall QA objective for field activities, data analyses, and laboratory analyses is to produce data of sufficient and known quality to support evaluation of environmental effects and selection of remedial alternatives. Specifically, all data will be gathered or developed using procedures appropriate for the intended use. Standard procedures are used so that known and acceptable levels of accuracy, precision, representativeness, completeness, and comparability are maintained for each data set. Descriptions of these criteria are presented in the following subsections.

1.4.1 Accuracy

Accuracy is the degree of agreement of a measurement, X, with an accepted reference or true value, T, usually expressed as the difference between the two values, X-T, or the difference as a percentage of the reference or true value, 100(X-T)/T, and sometimes expressed as a ratio X/T. Accuracy is a measure of the bias in a system.

The accuracy of data collected using field instruments is difficult to quantify. It can be qualitatively maximized, however, by strict adherence to standard protocols and, where applicable, manufacturers' operating and calibration procedures. This will ensure that the data are accurate and within the manufacturers' reported accuracy limits. Specific procedures for instrument calibrations and field protocols are presented in Subsection 1.7 and Section 2, respectively.

Analytical accuracy is expressed as the percentage recovery of an analyte (or a surrogate in the case of organic analytes) that has been added to the sample or standard matrix (e.g., a blank) at a known concentration before analysis and is expressed by the following formula:

$$\text{Accuracy} = \text{percent recovery} = \frac{A_T - A_O}{A_F} \times 100 \text{ percent}$$

where:

A_T = Total amount found in fortified sample.
A_O = Amount found in unfortified sample.
A_F = Amount added to sample.

1.4.2 Precision

Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Various measures of precision exist depending upon the "prescribed similar conditions."

During collection of data using field methods and/or instruments, precision is checked by reporting measurements at one location and comparing results. For example, water level measurements would be taken three times at a well and the values compared. Only if the values are within a specified percentage of each other are the measurements sufficiently precise. Specific precision goals are presented in Subsection 1.13 and Section 2.

Analytical precision is calculated by expressing, as a percentage, the difference between results of analyses of duplicate samples for a given analyte. Precision can be expressed by the formula:

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

where:

RPD = Relative percentage difference.
C_1 = Concentration of analyte in sample.
C_2 = Concentration of analyte in replicate.

1.4.3 Completeness

Completeness is a measure of the relative number of data points that meet all the acceptance criteria including accuracy, precision, and any other required by the specific analytical method used. It is usually a comparison of actual numbers of valid data points and expected numbers of valid data points expressed as a percentage.

Access to various areas and/or media along with unanticipated difficulties with sample collection affect field data completeness. For example, poor sample recovery in a split-spoon sample reduces the number of soil samples that can be collected and, therefore, affects the completeness.

Difficulties encountered while handling samples in the laboratory, as well as unforeseen complications regarding analytical methods, may affect completeness during sample analysis. For example, the proposed analytical methods (particularly for the organics analyses) are intended to analyze "environmental samples" (low- and medium-level concentrations). The applicability of these methods to unknown or hazardous-level samples may result in poor performance and, therefore, have an adverse effect on achieving the data completeness goal. The overall completeness goal for Phase III investigations at NWS Earle is 85 percent for each medium sampled.

Also, there are certain data points that are considered critical to the investigation. Critical data points are sampling locations for which valid data must be obtained for the sampling event to be considered complete and/or that can be expressed by a percentage of samples taken in a medium. An example of a critical data point may be an upgradient well or any other data point considered vital to the decision-making process. Critical data points for the NWS Earle Phase III investigation will be determined by the Project Manager, the Technical Lead, and the Site Manager prior to the initiation of each applicable field activity. Because of the importance of these critical data points, the completeness goal for these points is 100 percent.

1.4.4 Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, a parameter, a variation at a sampling point, a process condition, or an environmental condition. The methods used to select samples that are representative of a site or source are described in the sampling protocols in Section 2.

1.4.5 Comparability

Comparability expresses the confidence with which one data set can be compared with another. The comparability of the data, a relative measure, is influenced by sampling and analytical procedures. By providing specific protocols to be used for obtaining and analyzing samples, data sets should be comparable regardless of who obtains the sample or performs the analysis.

1.4.6 Regulatory Requirements

Wherever possible, given the analytical method specified, the limit of detection (LOD) of any chemical analysis should be less than the established Federal or state standard for the compound in the matrix analyzed to allow comparison of the result with that standard. Applicable Federal and State criteria for the compounds of concern at NWS Earle are listed in Tables 1-2 and 1-3.

Table 1-2

Applicable Federal and State Regulatory Requirements for LOD of Chemical Analysis, IRP Phase III, NWS Earle, New Jersey

Groundwater Quality Criteria Statewide Where the Total Dissolved Solids (TDS, Natural Background) Concentration is less than or equal to 500 mg/L: Class GW2

Primary Statewide Toxic Pollutants	
Pollutant, Substance, Or Chemical	Groundwater Quality Criterion
Aldrin/dieldrin	0.003 ug/L
Arsenic and compounds	0.05 mg/L
Barium	1.0 mg/L
Benzidine	0.0001 mg/L
Cadmium and compounds	0.01 mg/L
Chromium (hexavalent) and compounds	0.05 mg/L
Cyanide	0.2 mg/L
DDT and metabolites	0.001 ug/L
Endrin	0.004 ug/L
Lead and compounds	0.05 mg/L
Mercury and compounds	0.002 mg/L
Nitrate-nitrogen	10 mg/L
Phenol	3.5 mg/L
Polychlorinated biphenyls (PCBs)	0.001 ug/L

Table 1-2
(continued)

Primary Statewide Toxic Pollutants	
Pollutant, Substance, Or Chemical	Groundwater Quality Criterion
Radionuclides	Prevailing regulations adopted by the U.S. EPA pursuant to sections 1412, 1415, and 1450 of the Public Health Services Act as amended by the Safe Drinking Water Act (PL 93-523)
Selenium and compounds	0.01 mg/L
Silver and compounds	0.05 mg/L
Toxaphene	0.005 ug/L
Secondary Standards	
Ammonia	0.5 mg/L
Chloride	250 mg/L
Coliform bacteria	a) by membrane filtration, not to exceed 4 per 100 mL in more than one sample when less than 20 are examined per month, or b) by fermentation tube, with a standard 10-mL portion, not to be present in three or more portions in more than one sample when less than 20 are examined per month, or c) prevailing criteria adopted pursuant to the Federal Safe Drinking Water Act (PL 93-523)

Table 1-2
(continued)

Primary Statewide Toxic Pollutants	
Pollutant, Substance, Or Chemical	Groundwater Quality Criterion
Secondary Standards (continued)	
Color	None noticeable
Copper	1.0 mg/L
Fluoride	2.0 mg/L
Foaming agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor and taste	None noticeable
Oil and grease and petroleum hydrocarbons	None noticeable
pH (standard units)	5-9
Phenol	0.3 mg/L
Sodium	50 mg/L
Sulfate	250 mg/L
Total dissolved solids	500 mg/L
Zinc and compounds	5 mg/L

Table 1-3

Maximum Concentration of Contaminants for Characteristics of EP Toxicity IRP Phase III, NWS Earle, New Jersey

EPA Hazardous Waste Number	Contaminant	Maximum Concentration (mg/L)
D004	Arsenic	5.0
D005	Barium	100.0
D006	Cadmium	1.0
D007	Chromium	5.0
D008	Lead	5.0
D009	Mercury	0.2
D010	Selenium	1.0
D011	Silver	5.0
D012	Endrin	0.02
D013	Lindane	0.4
D014	Methoxychlor	10.0
D015	Toxaphene	0.5
D016	2,4-D	10.0
D017	2,4,5-TP	1.0

WESTON

Table 1-3
(continued)

NJDEP Guidelines[a] For Evaluating
Possible ECRA Cleanup Requirements

Contaminant		Soil (mg/kg-ppm)	Groundwater (ug/L-ppb)
Metals	Arsenic	20	50
	Barium	400	1,000
	Cadmium	3	10
	Chromium	100	50
	Copper	170	1,000
	Lead	100	50
	Mercury	1	2
	Nickel	100	---
	Selenium	4	10
	Silver	5	50
	Zinc	350	5,000
Organics	Total volatiles	1	10[b]
	Total base-neutrals	10	50[b]
	Total acid-extractables	10	50[b]
	Total petroleum hydrocarbons	100	1,000[b]
	Total PCBs	1 to 5	1[b]
Other	Cyanide	12	200

[a]New Jersey Groundwater Standards (NAJC 7:9-6)
[b]Used informally in evaluating possible cleanup requirements

1.5 SAMPLING PROCEDURES

The master list of the numbers of samples, their types, and the matrix of field and laboratory QC samples by site are found in Appendix E. In general, sampling and analysis procedures, including sample preservation and holding times for the relevant chemical analyses and matrices, will strictly comply with applicable techniques contained in the following documents:

Regulations

CODE OF FEDERAL REGULATIONS

40 CFR 136.3e, Table II	Required Containers, Preservation Techniques, and Holding Times
40 CFR 136, Appendix A	Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater
40 CFR 136, Appendix B	Definition and Procedure for the Determination of the Method Detection Limit
40 CFR 136, Appendix C	Inductively Coupled Plasma - Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes Method 200.7
40 CFR 300.61 300.71(Subpart F)	National Contingency Plan

FEDERAL REGISTER

VOL 51, NO 114, 13 June 1986	Toxicity Characteristic Leaching Procedure (TCLP)

Manuals

ENVIRONMENTAL PROTECTION AGENCY

EPA-330/9-S1-002	NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Wastes Sites
--	Superfund Exposure Assessment Manual (January 1986)
EPA-540/1-86-060	Superfund Public Health Evaluation Manual (October 1986)
EPA-600/4-79-020	Methods for Chemical Analysis of Water and Wastes (1983)
SW-846	Test Methods for Evaluating Solid Waste, Third Edition (1986)

AMERICAN PUBLIC HEALTH ASSOCIATION (APHA, AWWA, & WPCF)

16th Edition	Standard Methods for the Examination of Water and Wastes

AMERICAN SOCIETY FOR TESTING AND MATERIALS

D-1452	Soil Investigation and Sampling by Auger Boring
D-1586	Penetration Test and Split-Barrel Sampling of Soils
D-2487	Unified Soil Classification System
D-2488	Recommended Practices for Visual-Manual Description of Soils
Annual Book of ASTM Standards	Section 11, Water and Environmental Technology

Handbooks

ENVIRONMENTAL PROTECTION AGENCY

EPA-600/4-82-029	Handbook for Sampling and Sample Preservation of Water and Wastewater (1982)

Guidance Documents

ENVIRONMENTAL PROTECTION AGENCY

EPA-540/G-85-002	Guidance on Remedial Investigations Under CERCLA
EPA-540/G-85-003	Guidance on Feasibility Studies Under CERCLA

Specific methodologies to be followed, including any revisions to techniques in the above-listed documents required by the Navy or necessary to meet the objectives of the Scope of Work, are detailed in Section 2 of this QAPP.

1.6 SAMPLE CUSTODY

The purpose of sample custody procedures is to document the history of sample containers and samples (and sample extracts or digestates) from the time of preparation of sample containers through sample collection, shipment, and analysis. An item is considered to be in one's custody if one or more of the following conditions apply:

- It is in the physical possession of the responsible party.
- It is in the view of the responsible party.
- It is secured by the responsible party to prevent tampering.
- It is secured by the responsible party in a restricted area.

1.6.1 Chain-of-Custody

1.6.1.1 Sample Labels

All samples will be identified with a label that will be attached directly to the container. Sample labels will be completed using waterproof ink. The labels will contain the following information:

- Sample number.
- Time and date of collection.
- Project (station) name.
- Parameters to be analyzed.
- Preservative (if any).
- Sample source/location.
- Sampler's initials.

As each sample is collected it will be placed in a labeled container. Sample numbers will be determined before the field investigation begins. See Subsection 1.6.2.1 for a description of the sample numbering system.

1.6.1.2 Chain-of-Custody Records

A chain-of-custody record will be filled out for each sample at each sampling location to maintain a record of sample collection, transfer between personnel, shipment, and receipt by the laboratory. Each time the samples are transferred, the signatures of the persons relinquishing and receiving the samples as well as the date and time will be documented. A sample chain-of-custody record is included as Figure 1-3.

1.6.1.3 Transfer of Custody and Shipment

Prior to shipment of samples, the chain-of-custody record will be signed and dated by a member of the WESTON field team who has verified that those samples indicated on the record are indeed being shipped. After packaging has been completed, custody seals, signed and dated by a member of the WESTON field team, will be placed on the cooler.

FIGURE 1-3 CUSTODY TRANSFER RECORD/LAB WORK REQUEST

WESTON DESIGNERS CONSULTANTS

Custody Transfer Record/Lab Work Request

Received By _____ Client _____ RFW Contact _____

Date _____ Client Contact _____ Date Due _____

Assigned to _____ Phone _____ Project Number _____

SAMPLE IDENTIFICATION **ANALYSES REQUESTED**

Sample No.	Client ID No.	Description	Matrix	Date Collected	Container/Preservative								

Matrix:

S- Soil **DS-** Drum Solids
W- Water **DL-** Drum Liquids
O- Oil **X-** Other

Special Instructions:

Items/Reason	Relinquished By	Received By	Date	Time	Items/Reason	Relinquished By	Received By	Date	Time

RFW

All samples will be shipped via courier such as Federal Express, Emery, or other overnight delivery service to the appropriate laboratory. Hazardous- or environmental-level samples may be transported by WESTON personnel in private vehicles if the samples are properly packaged and labeled. Upon receipt of the samples at the laboratory, the receiver will complete the transfer by dating and signing the chain-of-custody record.

1.6.1.4 Laboratory Custody Procedures

Sample containers are to be provided by WESTON; chain-of-custody documentation (see Figure 1-3) will be shipped with the sample containers. These forms should be completed by field personnel with acknowledgment of time and date of transfer and placed in the shipping container in the plastic cover provided.

The following describes laboratory custody procedures associated with sample receipt, storage, preparation, analysis, and general security procedures.

Sample Receipt

- Upon receipt, the sample custodian will inspect sample containers for integrity. The presence of leaking or broken containers will be noted on the chain-of-custody record (see Figure 1-3). The sample custodian will sign (with date and time of receipt) the chain-of-custody record, thus assuming custody of the samples.

- The information on the chain-of-custody record will be compared with that on sample tags and labels to verify sample identity. Any inconsistencies will be resolved with the field sampling representative before sample analysis proceeds.

- Samples will be moved to one of the locked sample storage refrigerators for storage prior to analysis. The storage location will be recorded on the chain-of-custody record.

- The sample custodian will return the original chain-of-custody record to the laboratory Data Manager and provide carbon copies to each laboratory Section Manager and one to the main sample log kept in the laboratory.

- The sample custodian will alert the appropriate Section Managers and analysts of any analyses requiring immediate attention because of short holding times.

Sample Storage

Samples will be maintained in storage in one of the locked storage refrigerators prior to sample preparation and analysis.

The storage refrigerators are maintained at 4°±2°C. The temperature is monitored by the laboratory security system and recorded daily in a bound log by the sample custodian. If during working hours, equipment failure (compressor failure, door left open, etc.) results in the storage refrigerator temperature exceeding the upper or lower control limits, an audible alarm will sound, and the samples will be moved to suitably controlled storage until the problem has been corrected. During off hours, the alarm is automatically transferred to security agency personnel, who alert laboratory and maintenance personnel (via beeper call) so that prompt corrective action can be taken.

Analysts request samples for analysis from the sample custodian. Both sign the chain-of-custody record to acknowledge transfer of custody to the analyst.

Sample Tracking -- Organics Analyses

For samples that require extraction prior to analysis, a sample extraction form is completed during the time of extraction. A copy of this form is shown as Figure 1-4.

When samples are extracted for analysis by gas chromatography, GC/MS, or liquid chromatography, all pertinent data are entered on the sample extraction form and recorded in a bound laboratory notebook. Data are entered onto the form via computer by the person performing the extraction as the extraction proceeds. A hard copy of the form is printed out and is used as the vehicle for custody transfer to the analyst. Copies are provided to the analysts to inform them that extracts are ready for analysis. The bound laboratory notebook is kept in the laboratory. Extracts are maintained in refrigerated storage by the sample preparation section until transferred to the analysts.

Sample Tracking -- Metals Analyses

Samples are received by the sample preparation section for digestion prior to analysis for metals by atomic absorption/inductively coupled plasma spectroscopy. When samples are prepared for digestion, the preparation technician fills out a sample digestion record. The type of information recorded is shown in Figure 1-5.

All information regarding sample digestion is entered onto the sample digestion record via computer as the extraction proceeds and recorded in a bound laboratory notebook. The digestion record is maintained to acknowledge custody transfer of digestates to the metals analysis section. Upon completion of

SAMPLE EXTRACTION RECORD

Sheet No.:

Extract. Date: Extraction Batch No.: Analyst: Method:

Test: Cleanup Date: Analyst: Client:

Solvent: Adsorbent:

Sample No.:	Client ID	pH	Initial WT/VOL	Surr. Mult. 500 ul	Spike Mult. 500 ul	Final VOL ACID	Final VOL BN	Split Mult.	% Solids	C/D Factor

Comments:
Surrogate:
Spike:

Extracts Transferred	Relinquished By	Date Time	Received By	Date Time	Reason for Transfer

FIGURE 1-4 SAMPLE EXTRACTION RECORD

WESTON

SAMPLE DIGESTION RECORD

Digestion Date _____ Digestion Batch No. _____ Analyst _____

Completion Date _____ Type of Prep. _____ Method _____

Parameters _____ Client _____

Type of Analysis _____ Matrix _____

RFW#	Customer ID/ Spike Info	Initial Wt./Vol. g/mL	Final Vol (mL)	pH <2>	DESCRIPTION WATER - Color, Clarity SOIL - Color, Texture, Artifacts	Soil Prep Pan Wt. (g)	Wet Wt. (g)	Dry Wt. (g)

Comments:

FIGURE 1-5 SAMPLE DIGESTION RECORD

sample digestion, a carbon copy of the sample digestion record is provided to the metals analysis section to alert them that digestates are ready for analysis. The bound laboratory notebook is retained by the sample preparation section.

Recordkeeping

Data related to all sample preparation and analysis procedures and observations by laboratory analysts are recorded in bound laboratory notebooks that are issued by the laboratory QA Coordinator. Laboratory notebook pages are signed and dated daily by laboratory analysts. Corrections to notebook entries are made by drawing a single line through the erroneous entry and writing the correct entry next to the one crossed out. All corrections are initialed and dated by the analyst.

Building Security

The WESTON laboratory maintains controlled building access at all times. During working hours, all non-WESTON laboratory personnel are required to sign in with the receptionist and are escorted by laboratory personnel while in the building.

The laboratory is locked by an ADT Security System between the hours of 5:00 p.m. and 8:00 a.m. Monday through Friday and during nonworking hours. This security system not only monitors building access, but also monitors the temperature in the sample storage refrigerators. If the control temperature range is exceeded during working hours, an audible alarm sounds, and during nonworking hours, a silent alarm alerts ADT personnel. The building is accessed by laboratory employees during nonworking hours by using a key and the passcode for the building security system.

Any breach of security during nonworking hours sounds a silent alarm to security agency personnel, who alert the local law enforcement agency and one of three laboratory personnel via beeper call. Police response to security alarms takes place within 5 minutes, and laboratory personnel are onsite within 20 minutes.

1.6.2 Documentation

1.6.2.1 Sample Identification

A numbering system has been developed to identify each well, boring location, and sample taken during water and soil sampling programs. This numbering system provides a tracking procedure to allow retrieval of information concerning a particular sample.

Each sample number will consist of three components that will consist of site, location, and sample identifiers, as described below.

- Site Identifier -- A 2-digit designation will be used to identify the particular site where the sample is being collected, such as Ordnance Demilitarization site (Site 2). The site number will be cross-referenced to the actual site name in the IRP Stage 2 Work Plan and also to the sampler's field notebook. The site identifiers to be used for the Stage 2 investigation are based on the site numbering system used in earlier investigations and are listed in Table 1-4.

- Location Identifier -- A 3-digit designation will be used to identify the sample location within each site, such as the number of a monitor well (see Table 1-5), surface water sample, or soil boring.

- Sample Identifier -- A 4-character alphanumeric designation will be used to identify samples according to sample type. The first character will be a letter to identify the sample type as follows:

  S - Shallow soil
  M - Monitor well
  B - Soil boring
  W - Surface water and seep
  D - Sediment
  P - Production well
  L - Landfill leachate
  G - Tank sample
  H - Drum sample
  A - Air sample

  The remaining three characters will be digits and will be used to provide additional information depending upon the type of sample. For a monitor well or surface water sample, the three digits will indicate from which sampling round the sample came, e.g., 001, 002, etc. For a soil or sediment sample, the three digits will indicate the depth sequence from which the soil sample was obtained, e.g., 001, 002, 010 (S-1, S-2, S-10, etc.). The depth interval for that sample number will be cross-referenced in the field logs.

The sample number will not be related directly to date of collection; however, the date will be documented in the sampler's field log and on the chain-of-custody record.

Provisions will be made where circumstances require a slight modification to the numbering sequence for a specific sample. Two typical sample numbers follow:

Table 1-4

Summary of Site Identifier Numbers
IRP Phase III, NWS Earle, New Jersey

Site No.	Site Name	Site Identifier Number
2	Ordnance Demilitarization Site	02
3	Landfill southwest of "F" Group	03
4	Landfill west of "D" Group	04
5	Landfill west of Army Barricades	05
7	Landfill south of "P" Barricades	07
10	Scrap Metal Landfill near Building 589	10
11	Contract Ordnance Disposal Area	11
19	Paint Chip and Sludge Disposal Area adjacent to Building S-34	19
20	Grit Blasting Disposal Area adjacent to Building 544	20
22	Paint Chip Disposal Area adjacent to Building D-2	22
26	Explosive "D" Washout Area adjacent to Building GB-1	26
Surface Water/Stream System		
Swimming River		30
Shark River		31
Manasquan River		32
Crompton Creek		33

Table 1-5

Summary of Well Location Identifier Numbers
IRP Phase III, NWS Earle, New Jersey

Site No.	Existing Well No.	Well Location Identifier
2	2-1	001
	2-2	002
	2-3	003
	2-4	004
3	3-1	001
	3-2	002
	3-3	003
4	4-1	001
	4-2	002
	4-3	003
5	5-1	001
	5-2	002
	5-3	003
	5-4	004
7	7-1	001
	7-2	002
	7-3	003
10	10-1	001
	10-2	002
	10-3	003
11	11-1	001
	11-2	002
	11-3	003
19	19-1	001
	19-2	002
	19-3	003
26	26-1	001
	26-2	002
	26-3	003

- 02-001-M001 -- Groundwater sample collected from monitor well 1, Site 2 (Ordnance Demilitarization Site) during the first sampling round.

- 02-001-B004 -- Soil sample 4 taken from boring 1 at Site 2 at a depth of 14 to 16 feet (cross-referenced in the notebook).

The last four characters of the numbering system may be used to denote that a sample is one collected for quality control purposes (see Subsection 1.10.1). The site and location identifier will not change. The numbering system for quality control samples is explained below.

Field Duplicates/Field Replicates

The first character of the sample identifier will be a letter to identify the sample type, as previously discussed. For duplicate or replicate samples, the second character will always be the number 1, which will indicate that the sample is a duplicate of the sample denoted in the location identifier. Two typical sample numbers are:

- 07-001-M101 -- Field duplicate of the groundwater sample collected from monitor well 001, Site 7, sampling round 1.

- 11-114-B105 -- Field duplicate soil sample taken from boring 11D at Site 11, sample S-5.

Equipment Blanks

The first character of the sample identifier will denote the sample type. The next three characters will be digits, the first of which will always be a 2 to indicate an equipment blank. The next two digits will indicate from which sampling round the sample was collected. The site and location identifiers for the equipment blank will be the numbers of the location and corresponding site sampled immediately prior to collecting the equipment blank.

- 07-001-M201 -- Equipment blank collected during round 1 immediately after sampling monitor well 001 at Site 7.

Trip and Ambient Blanks

The first character of the sample identifier will denote the sample type. The next three characters will be digits, the first of which will always be a 3 to denote a trip blank. The next two digits will indicate from which round the sample was collected. The site and location identifiers will be the numbers of the location and corresponding site of the last sample on the chain-of-custody record.

- 07-001-M301 -- Trip blank collected during round 1; 07-001 are the site and location identifiers of the last sample on the chain-of-custody record for each batch of samples taken for VOCs analyses.

The first character of the sample identifier will denote the sample type. The next three characters will be digits, the first of which will be a 4 to denote an ambient blank. The next two digits will indicate from which round the sample was collected. The site and location identifiers will be the number of the location and corresponding site of the last sample collected at that site.

- 07-001-M401 -- ambient blank collected during round 1 at Site 7; the last well sampled at that site was monitor well 001.

1.6.2.2 Field Logs

All data collection activities performed at a site will be documented either in a field notebook or on appropriate forms. Entries will be as detailed and descriptive as possible so that a particular situation can be recalled without reliance on the collector's memory. All field log entries should be dated. Field notebooks will be bound books and will be assigned to individual field personnel for the duration of their stay in the field. All field log forms will be kept in ring binders assigned to individual field personnel.

The cover of each notebook or ring binder will contain the following information:

- Person to whom the book is assigned.
- Project name.
- Start date.
- End date.

It will be the responsibility of all field personnel to photocopy at the end of that day all field logs (including notebook pages and field forms) generated during a field day.

1.6.2.3 Corrections to Documentation

All measurements made and samples collected will be recorded. Each field geologist/scientist will initial each page as it is completed. If an incorrect entry is made, the data will be crossed out with a single strike mark and the mark initialed.

Any revisions to field notes will be made on the field log and will be dated and initialed by the person revising the log. There will be no erasures or deletions from the field logs.

1.6.2.4 Photographs

To the extent practicable and permissible within station security requirements, sampling locations will be photographed to provide a visual record of the conditions of the sampling area. All rolls of film will be numbered with roll number and picture number recorded in the field logbook. Pictures of the sampling locations will be taken with 35-mm slide or print film. Sampling locations will be identified in the photographs by placing an 8.5- x 11-in. (or larger) sheet of paper with the sample and/or well number written on it next to the well or sampling point when the photograph is taken.

1.6.3 Sample Handling, Packaging, and Shipping

1.6.3.1 Sample Handling and Packaging

Samples obtained at potentially hazardous waste sites are classified as either environmental or hazardous samples. Within the environmental sample category, a distinction is made between low- and medium-concentration samples for determining both shipping procedures and appropriate analytical protocols such as dilution. These categories apply to both solid and liquid samples.

Low-level environmental samples are considered to be those collected offsite, around the perimeter of a waste site, or in areas where hazards are thought to be significantly reduced by normal environmental processes. Medium-level environmental samples are most often those collected onsite in areas of moderate dilution by normal environmental processes. Hazardous-level samples include samples collected from drums, surface impoundments, direct discharges, and chemical spills where there is little or no evidence of environment dilution. Hazardous-level samples are suspected to contain greater than a 15 percent concentration of any individual chemical contaminant.

Determination of the suspected concentration level of a sample is made in the field based on the point of origin of the sample, visual evidence, evidence from OVA field screening, and past analytical results, if available.

In general, all groundwater and surface water (stream and pond) samples at NWS Earle are expected to be low-level environmental samples. Selected soil samples from source areas may be medium-level environmental or hazardous-level samples. As a conservative approach, all samples suspected of being either medium-level environmental or hazardous-level samples will be handled and shipped in the manner described in Subsection 1.6.3.3. However, based on field data, a distinction between sample level categories will be noted on the chain-of-custody record, whenever possible.

Whatever the suspected level category of a sample, the sample container will be handled with gloves and will be decontaminated in the field by rinsing off any water, preservatives, or soil residue with potable water prior to shipping. All sample containers will be placed on ice in an ice chest immediately after collection. All coolers will receive chain of custody seals.

1.6.3.2 Procedure for Packing Low-Level Environmental Samples

Samples assumed to have no to low concentrations of contaminants (low-level samples) will be collected in glass containers. The sealed and labeled container will then be placed inside a watertight polyethylene bag. The sealed packages will then be placed inside an ice chest and packed with ice and an absorbent packaging material such as vermiculite to prevent breakage. Ice will be placed on top of the samples to keep them cool during shipment. The ice chests will be sealed with a custody seal and strapping tape.

1.6.3.3 Procedures for Packing Medium-Level Environmental and Hazardous-Level Samples

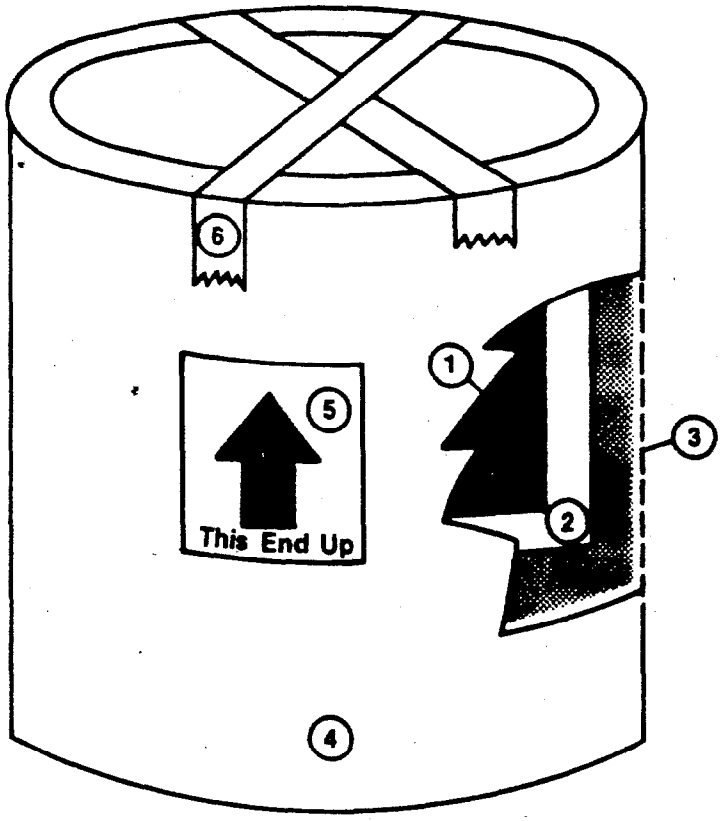
Samples suspected of having medium or hazardous levels of contaminants will be packed according to the following procedure:

- The sample container will be placed in a separate 2-mil thick (or heavier) watertight polyethylene bag. Each sealed bag will be placed inside an appropriately sized metal can with enough noncombustible absorbent packaging material (e.g., bentonite, vermiculite, or diatomaceous earth) to prevent breakage and provide for absorption of liquid with one bag per can. The can will be pressure-closed, and clips or tape will be used to hold the lid securely. An example of this packaging is shown in Figure 1-6.

- The metal cans will be placed in a strong outside container such as an ice chest and surrounded with vermiculite or similar substitute for stability during transport. Ice will be placed on top of the samples to keep them cool during shipment. The ice chest will be sealed with a custody seal and strapping tape. The appropriate stickers, as specified by the U.S. DOT or the State DOT whichever is more stringent, will be placed on the ice chest to indicate that its contents may be hazardous. An example of the cooler labeling for medium-concentration samples is shown in Figure 1-7.

1.7 CALIBRATION PROCEDURES AND FREQUENCIES

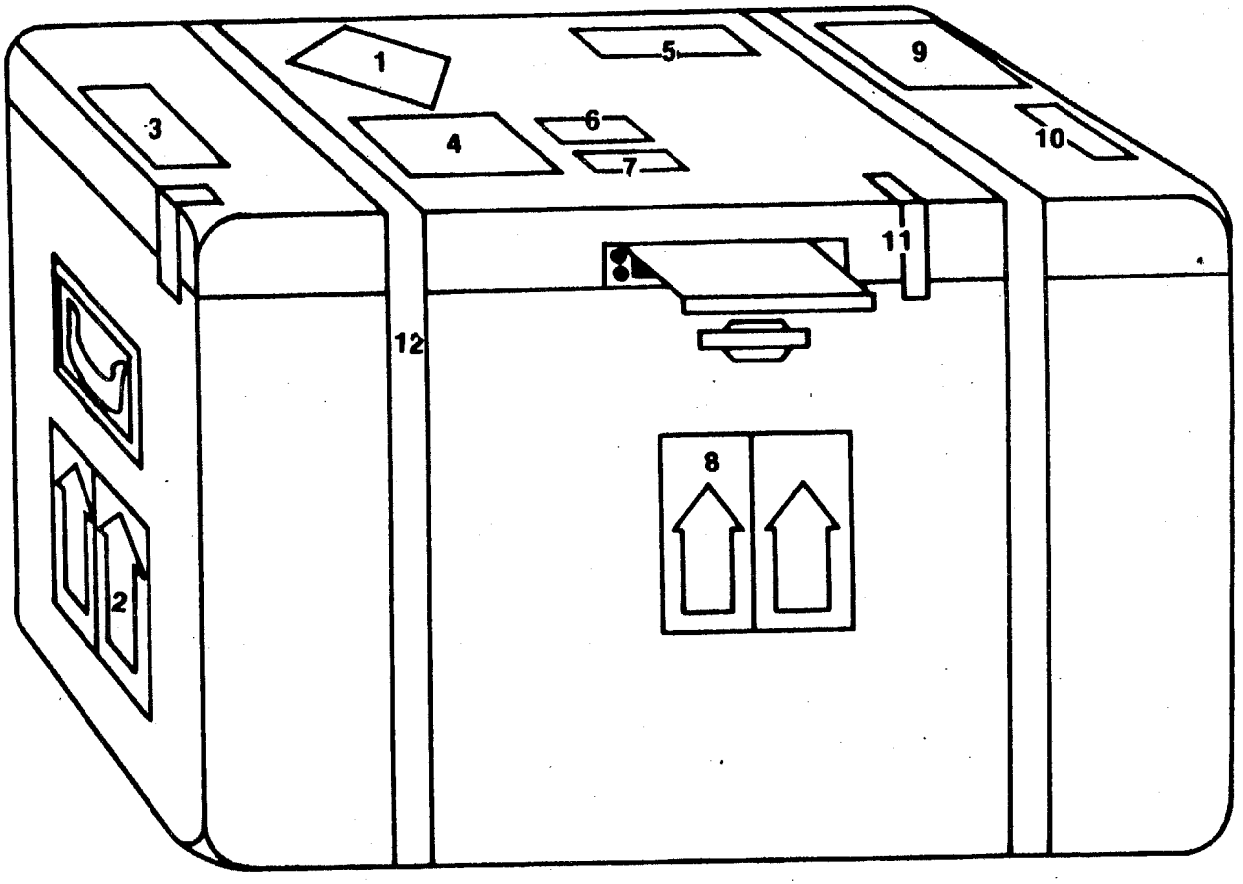
This subsection reviews calibration procedures and frequencies for the following types of equipment:



Legend

1 Sample Container
2 Ziplock Bag (2 Mil Minimum)
3 Vermiculite (or Equivalent) Packing
4 Metal Paint Can With Lid
5 This End Up Sticker
6 Strapping Tape

FIGURE 1-6 SAMPLING PACKAGING, MEDIUM-LEVEL ENVIRONMENTAL AND HAZARDOUS-LEVEL SAMPLES



Legend

1 Flammable Liquid, N.O.S. (DOT Label)
2 Arrows Pointing Cooler in Upright Position
3 This Side Up
4 Laboratory Address
5 Return, or Local Address
6 Flammable Liquid N.O.S.
7 UN 1993
8 Same as #2
9 Danger Cargo Aircraft Only (DOT Label)
10 Limited Quantity
11 Custody Seal (Optional)
12 Tape to Seal Cooler

FIGURE 1-7 SHIPPING CONTAINER, MEDIUM-LEVEL ENVIRONMENTAL AND HAZARDOUS-LEVEL SAMPLES

- Field equipment (including water level recorders, field water and air quality screening equipment, and geophysical equipment).

- Laboratory equipment (including both inorganic and organic analytical equipment).

1.7.1 Field Equipment

The in-field analytical instruments to be used during the Phase III investigation are listed below:

- HNu photoionization analyzer.
- Organic vapor analyzer (OVA).
- Combustible gas indicator (CGI) or explosimeter.
- Specific conductance meter.
- pH meter.
- Magnetometer.

The instruments will be calibrated before and after each field use or as otherwise described below. Instruments will be calibrated each day during field use. Calibration records will contain the following information: instrument name and number, name of person performing the calibration, date of calibration, calibration points, results of the calibration, and manufacturer's lot number of the calibration standards. Where applicable, expiration dates will be indicated on the field standards.

1.7.1.1 HNu Photoionization Analyzer

The HNu photoionization analyzer is designed to measure the concentration of trace gases in many industrial or plant atmospheres. The analyzer employs the principle of photoionization for detection. A sensor, consisting of a sealed ultraviolet light source, emits photons that are energetic enough to ionize many trace species, particularly organics. In general, the instrument will be calibrated by following the listed procedures:

1. Insert one end of T tube into probe. Insert second end of probe into calibration gas in the 20 to 200 ppm range. The third end of probe should have the rotometer (bubble meter) attached.

2. Set the function switch in the 0 to 200 ppm range.

3. Crack the valve on the pressured calibration gas container until a slight flow is indicated on the rotometer. The instrument will draw in the volume required for detection with the rotometer indicating excess flow.

4. Adjust the span potentiometer so that the instrument is reading the exact value of the calibration gas. (Calibration gas value is labeled on the cylinder.)

5. Turn instrument switch to the standby position and check the electronic zero. Reset zero potentiometer as necessary.

6. Record on the form provided all original and readjusted settings as specified by the form.

7. Next, set the function switch to the 0 to 20 ppm. Remove the mid-range (20 to 200 ppm) calibration gas cylinder and attach the low-range (0 to 20 ppm) calibration gas cylinder as described above.

8. Do not adjust the span potentiometer. The observed reading should be ±3 ppm of the concentration specified for the low-range calibration gas. If this is not the case, recalibrate the mid-range scale repeating procedures 1 to 7 above. If the low-range reading consistently falls outside the recommended tolerance range, the probe light source window probably needs cleaning. When the observed reading is within the required tolerances, the instrument is fully calibrated.

The HNu instrument will be calibrated once daily at the start of field operations.

1.7.1.2 Organic Vapor Analyzer

The Century portable organic vapor analyzer (OVA) is designed to detect and measure gases and organic vapors in the atmosphere. The instrument utilizes the principle of hydrogen flame ionization for detection. The organic vapor analyzer measures gases and vapors by producing a response to an unknown sample that can be related to a gas of known composition to which the instrument has been previously calibrated. The instrument is normally calibrated to methane gas. To calibrate the instrument the following step-by-step procedure is used:

1. Set CALIBRATE switch to 10.

2. Adjust meter reading to zero by rotating the CALIBRATE ADJUST (zero) knob.

3. Attach one end of T assembly to calibration gas cylinder and the other to the probe.

4. Crack open calibration gas cylinder until a slight flow of gas can be detected exiting the open end of the T assembly. (Caution: if the calibration gas is toxic or highly flammable, calibration should occur inside a hood.)

5. Adjust GAS SELECT knob on instrument until the meter reads the same level as that of the calibration gas.

6. Turn off calibration cylinder and remove T assembly.

7. The instrument is now calibrated for the specialty gas/vapor. All responses of the instrument should be recorded relative to the specialty gas.

8. Calibration in the x10 range, by adjusting the GAS SELECT knob, automatically calibrates the instrument for the x1 and x100 ranges. No further adjustments are necessary.

9. Shut instrument down by closing the SUPPLY VALVE and TANK VALVE and placing the INSTR and PUMP switches in the OFF position.

10. Record the following on the instrument calibration label: calibration date, span gas and concentration, span setting, and initials of person performing calibration.

Calibration will be performed prior to use on a daily basis in a well-ventilated area.

1.7.1.3 Explosimeter/Combustible Gas Indicator

The explosimeter or combustible gas indicator (CGI) is an air monitoring device designed to indicate a flammable/explosive atmosphere and the level of oxygen present. The CGI registers combustible gas or vapors in terms of their Lower Flammability Limit (LFL), which is the lowest concentration at which a combustible gas may ignite (or explode) under normal atmospheric conditions. Since the instrument measures both the level of oxygen in the atmosphere and the level a combustible gas reaches before igniting, the calibration of the instrument is a two-step process.

The oxygen portion of the instrument is calibrated by placing the meter in normal atmospheric air and rotating the CAL. OXYGEN control knob until the oxygen meter reads exactly 20.9 percent oxygen. This calibration will be done once daily when in use.

The combustible gas indicator is calibrated to methane at the laboratory to indicate directly the percentage LFL of methane in air.

The gas detector will be calibrated at least once every month and whenever the detector filament is replaced. The calibration kit included with the CGI contains a calibration gas cylinder, a valve attachment to release the calibration gas, flexible tubing (delivery tube), and a cylinder to encapsulate the sensor probe.

Recalibration Instructions

1. Disassemble case by removing the four retaining screws.

2. Allow the instrument to warm up for 15 minutes.

3. Assemble the calibration gas tank and delivery tube/ cylinder.

4. Carefully open the valve on the gas tank to bathe the sensor with just enough gas to cause the needle on the LFL meter to move.

5. Adjust the LFL CAL. control screw on circuit board until the percentage LFL meter indicates exactly the correct LFL, as indicated on the calibration gas cylinder.

Calibration in an atmosphere of combustible gases requires a source of methane test gas and a source of compressed air:

1. Using compressed air, bathe the gas sensor in a flow of air, and adjust the ZERO LFL control knob.

2. Calibrate the oxygen meter by rotating the CAL. OXYGEN control knob until the oxygen meter indicates 20.9 percent.

3. Using the methane test gas, bathe the sensor in a flow of test gas and calibrate, if necessary, by adjusting the LFL CAL. control screw on the circuit board.

1.7.1.4 Specific Conductance Meter

The YSI Model 33, or equivalent, is a portable battery-operated transistorized instrument used to measure salinity, specific conductance, and temperature in surface water, groundwater, and wastewater systems. The meter is calibrated daily or each time the meter is turned on (if more than once per day) by turning the MODE control to REDLINE and adjusting the REDLINE control so that the indicator lines up with the redline on the meter face.

1.7.1.5 pH Meter

The Fisher Model No. 107 pH Meter, or equivalent, is a portable pH monitoring instrument for determining pH in surface and groundwaters, waste systems, and other water quality applications.

The instrument requires field calibration daily or each time the meter is turned on (if more than once per day). Distilled water and buffer solutions (pH 7 and pH 4) are required for field calibration. All solutions must be at the same temperature to reduce meter stabilization time and to maintain accuracy. The instrument is calibrated as follows:

1. Rinse the electrode in distilled water.

2. Place the electrode in the pH 7 buffer solution and allow the meter reading to stabilize.

3. Adjust the control using the knob on the front panel of the instrument until the meter reads pH 7.

4. Rinse the electrode in distilled water.

5. Place the electrode in pH 4 solution and allow the meter readout to stabilize.

6. Adjust the control knob until the meter reads the correct value of the pH 4 solution.

7. Rinse probe in distilled water.

8. Repeat steps 2 through 7.

9. Record results in logbook.

1.7.1.6 Magnetometer

Magnetic measurements will be obtained using a Scintrex V-92 portable cesium high-sensitivity magnetometer or equivalent. The magnetometer unit includes a digital readout, a sensor head, and sensor electronics that are connected by a wooden staff and a rechargeable battery belt. A detailed description of the magnetometer's operation principles can be found in the Scintrex operations manual (Scintrex Limited).

The calibration at the magnetometer is performed by the manufacturer. The initial adjustment is done at the start of the survey to ensure that most of the readings can be taken on the most accurate (lowest) scales. Suppose, for instance, that variations of the magnetic field in the area are expected to be within 1,000 gammas:

1. Turn the Main Switch (1) to +.

2. Turn the Range Switch (2) to 1,000 gammas.

3. Turn the Latitude Switch (3) to a position that brings the needle of the meter on scale.

4. Turn the Latitude Fine Control (4) so that the needle of the meter is in an appropriate part of the scale, usually around the mid-point. Replace the cap covering the Latitude Fine Control.

The instrument has now been set to read in the area and the survey can be carried out without altering the Latitude Switch (3) and Latitude Fine Control (4). Should any reading go off

scale, rather than change switches (3) and (4), it is more practical to change the Range Switch (2) to the next higher range.

If the magnetic values in the survey area are expected to vary by less than 300 gammas, the initial adjustment may be made to the mid-point of the 300 gammas scale.

1.7.2 Laboratory Equipment

Before any instrument is used as a measuring device, the instrumental response to known reference materials must be determined. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. All sample measurements are made within the calibrated range of the instrument.

Laboratory instrument calibration typically consists of two types: initial calibration, and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. The instrument response over that range is expressed as a correlation coefficient (e.g., for atomic absorption, inductively coupled plasma, UV-visible/infrared spectrophotometry, ion chromatography) or by a response factor, amount/response (e.g., for gas chromatography, gas chromatography/mass spectrometry, high-performance liquid chromatography).

Continuing calibration usually includes measurement of the instrument response to fewer calibration standards and requires instrument response to compare with certain limits (e.g., 10 percent) of the initial measured instrument response.

The specific instrument calibration procedures for various instruments used in the lab are found in the WESTON Analytics QAP attached as Appendix A.

1.8 FIELD ANALYTICAL PROCEDURES

1.8.1 Field Testing and Screening

As part of the analytical protocol for all samples, several parameters will be tested in the field. All liquid samples will be tested for temperature, pH, specific conductance (SC), and total volatile organic (TVO) vapors in sample headspace. Soil samples will be tested for TVO only. At each sampling location, a sample aliquot will be collected in a clean 8-ounce jar for the purpose of field testing. The following subsections describe the procedures for analysis of field parameters.

1.8.1.1 pH Measurement

The pH of all liquid samples will be measured using a Fisher Model No. 107 portable water pH meter (or equivalent). Before analyzing a sample, the pH meter will be calibrated and checked against the provided buffer solutions. The probe is then rinsed with distilled water and placed in the sample to be tested. One minute should be allowed for the meter to stabilize and the reading then recorded in the field log book. After the reading is taken, the probe will be rinsed with distilled water and placed in 7.0 buffer solution until its next use.

1.8.1.2 Specific Conductance and Temperature Measurement

The specific conductance and temperature of all liquid samples will be taken with a YSI Model 33 meter (or equivalent). When not in use, the probe will be placed in a jar of distilled water. Prior to placing the probe in the sample and after taking the specific conductance and temperature of the sample, the probe will be rinsed with distilled water. The temperature should be taken with the knob set on "temperature" and the specific conductance measured using the appropriate range of the "conductance" setting. One minute should be allowed for the reading to stabilize prior to recording the measurement in the field log book.

1.8.2 Laboratory Methods

Laboratory analytical methods proposed for use in this project to analyze soil, sediment, and water samples are listed in Table 1-6. Appendix B contains a list of parameters to be determined for each analytical method, and the limits of detection (LODs) for each parameter.

The limits of detection listed in Appendix B are based on instrument detection limits for clean water (with no interference). Instrument detection limits are determined by following the procedures detailed in the WESTON standard Analytical Laboratory Quality Assurance Plan (see Appendix A).

For inorganics analyses, the instrument detection limits are expected to be below the required LODs. Therefore, the LODs provided in Appendix B will be used as detection limits for reporting purposes for inorganics analyses.

For organics analyses, the instrument detection limits for clean water are expected to be close to the LODs listed in Appendix B. The actual lower quantification limits of organic compounds in most environmental samples are expected to be higher than the LODs listed. Therefore, the Practical Quantification Limit (PQL) convention will be used for reporting of

WESTON

Table 1-6

Summary of Analytical Methods
IRP Phase III, NWS Earle, New Jersey

Parameter	Method: Soil/Sediment	Method: Water
Organics (TCL)		
VOCs	EPA CLP SOW[a]	EPA CLP SOW[a]
BNAs	EPA CLP SOW[a]	EPA CLP SOW[a]
Pesticides/PCBs	EPA CLP SOW[a]	EPA CLP SOW[a]
Inorganics		
Cyanide	EPA CLP SOW[b]	EPA CLP SOW[b]
Metals (TAL)	EPA CLP SOW[b]	EPA CLP SOW[b]
Total petroleum hydrocarbons	SW9071/E418.1	NA
Nitrate/nitrite	ASTM D3987/E353.1	E353.1
Explosives		
Picric acid	WESTON	USGS
Nitrocellulose[c]	LY02	COE/WESTON
Nitroglycerin[c]	LY02	COE/WESTON
2,4,6-Trinitrotoluene	LW02	UW01
2,4-Dinitrotoluene	LW02	UW01
2,6-Dinitrotoluene	LW02	UW01
Tetryl	LW02	UW01
1,3,5-Trinitrobenzene	LW02	UW01
1,3-Dinitrobenzene	LW02	UW01
HMX	LW02	UW01
RDX	LW02	UW01

NA Not applicable.
a U.S. EPA Contract Laboratory Program Statement of Work for Organics, 2/88 and revisions.
b U.S. EPA Contract Laboratory Program Statement of Work for Inorganics, 7/88.
c These two compounds cannot be distinguished from each other by these methods.

organic analytical data as recommended for specific methods and matrices in "Test Methods for Evaluating Solid Waste" (SW846, November 1986, Third Edition). Values below the stated PQLs will be qualified with a "J" to indicate the presence of a compound that meets the identification criteria but for which the concentration is less than the sample PQL and is, therefore, estimated rather than accurately quantified.

1.9 DATA REDUCTION, VALIDATION, AND REPORTING

1.9.1 Field and Technical Data

The field and technical (nonlaboratory) data that will be collected during the Phase III effort at NWS Earle can generally be characterized as either "objective" or "subjective" data.

Objective data include all direct measurements of field data such as field screening/analytical parameters, water level measurements, and geophysical data. Subjective data include descriptions and observations such as lithologic descriptions of well cuttings and soil borings.

1.9.1.1 Field and Technical Data Reduction and Recording

As described in Subsection 1.6.2.2, all field data will be recorded by field personnel in bound field notebooks and in ring binders on the appropriate field forms. For example, during drilling activities, the field team member supervising a rig will keep a chronologic log of drilling activities, a vertical descriptive log of lithologies encountered, (following the Unified Soil Classification System in Appendix C), other pertinent drilling information (staining, odors, field screening, atmospheric measurements, water levels, geotechnical data), and a labor and materials accounting in his/her bound notebook.

After checking the data in the field notebooks and forms (see Subsection 1.9.1.2), the data will be reduced to tabular form, wherever possible, by entering it in data files. Objective data may be set up in spreadsheet type tabular files (e.g., water level data) or as two-dimensional arrays (e.g., magnetometer data). Subjective data such as soil boring and well logs will be filed as hard copies for later review and for incorporation into technical reports, as appropriate.

1.9.1.2 Field and Technical Data Validation

Validation of objective field and technical data will be performed at two different levels. On the first level, data will be validated at the time of collection by following standard procedures and QC checks (e.g., triplicate measurements) specified in Section 2. At the second level, after data reduction into tables or arrays, the data will be reviewed for anomalous

values. Any inconsistencies or anomalies discovered by this review will be resolved immediately, if possible, by seeking clarification from the field personnel responsible for collecting the data.

Subjective field and technical data will be validated by the review of field reports for reasonableness and completeness. In addition, random checks of sampling and field conditions will be made to check recorded data at that time to confirm the recorded observations. Whenever possible, peer review also will be incorporated into the data validation process, particularly for subjective data, in order to maximize consistency among field personnel. For example, during drilling activities, scheduled periodic reviews of archived lithologic samples will be performed to ensure that the appropriate lithologic descriptions and codes are being consistently applied by all field personnel.

1.9.2 Laboratory Data

All analytical data are recorded into bound laboratory notebooks issued by the QA Coordinator. Data are recorded and associated with the unique WESTON laboratory sample identification number and the field sample identifier. For inorganic (nonmetal) analyses, the bound notebook pages are preformatted for each analytical method. These pages contain the following information:

- Analytical method.
- Analyst.
- Date.
- Reagent concentrations.
- Instrument settings (as applicable).
- Raw data.

The laboratory analysts sign and date all notebook entries daily. The notebook pages are reviewed periodically by the Section Manager prior to final data assembly. Copies of strip-chart outputs (chromatograms, etc.) are maintained on file.

1.9.2.1 Laboratory Data Reduction

At the completion of a set of analyses, all calculations are completed and checked by the analyst. The associated quality control data (blanks, blank spikes, duplicates) are entered onto quality control charts and verified to be within control limits. If all data are acceptable, the data are entered into the laboratory computer system and the data summaries (notebook pages, final concentrations) are submitted to the Section Manager for review. This is the procedure for all inorganic analytical data. For organic analytical data, summary reports are

manually generated for review by the Section Manager. After approval, data are manually entered into a computer terminal (Lotus format). If QC samples do not meet acceptance criteria,the appropriate Laboratory Section Manager and the QA Coordinator are notified, and corrective action is taken as described in Subsection 1.14.2.

Acceptable data are submitted to the Laboratory Section Manager for review. Following approval by the laboratory Section Manager, the laboratory Data Manager is notified that data are ready to be reported, and the completed analyses are removed from the laboratory backlog.

The laboratory Data Manager generates a hard copy data summary that is reviewed and signed by the laboratory Section Manager and the Laboratory Manager.

1.9.2.2 Laboratory Data Validation

In addition to the data review performed by analysts and the appropriate laboratory Section Manager, the laboratory QA Coordinator performs an internal audit of approximately 10 percent of the data reported by the WESTON Analytical Laboratory. This audit focuses on compliance of data with laboratory quality control requirements and client contractual requirements. This audit includes selective checks on calculations, verification of the report format, and completeness of the data report package.

Laboratory data validation and laboratory deliverables for the Remedial Investigation will meet the minimum requirements of NESSA 20.2-047B, Section 7.

1.9.2.3 Laboratory Data Reporting

Laboratory data will be reported in tabular listing using the Wallace system. The laboratory data reports will include sample analytical results, second-column confirmation results, reportable field and laboratory QA/QC sample analytical results (as specified in Subsection 1.10), method limits of detection, and sample practical quantitation limits (PQLs).

1.9.3 Data Management

Laboratory data will be compiled in tabulated databases. These data will be stored in both paper copy and in magnetic form. A copy of both formats shall be submitted to the Navy. In addition, a copy will be on file in WESTON's permanent project files. These data are kept a minimum of 5 years in the permanent project files.

Field notes, technical reports, and original diagrams are keep in the permanent project files. Magnetic media copies, if available, are stored along with a paper copy in the project

files. Originals of large scale maps are stored in the project files. Records for both analytical data and project files are retained by WESTON for a minimum of 5 years.

1.10 INTERNAL QUALITY CONTROL CHECKS

1.10.1 Internal Quality Control Checks -- Field

The quality assurance effort for a field investigation program is developed to ensure and validate that inconsistencies in protocols or the field protocols themselves do not introduce error into the data collection process. To achieve this goal, standard operating procedures (SOPs) have been developed, as described in Section 2, and will be followed as consistently as possible by all field personnel given the variability of natural conditions encountered in the field. Any deviation from SOPs necessitated by unanticipated field conditions will be fully documented as they occur. An integral part of SOPs are the quality control checks for each type of field method (see Section 2).

Specifically, field quality control checks have been introduced into the sample collection procedures to minimize (and identify if it occurs) the potential for interference or introduction of nonenvironmental contaminants during sample collection, storage, transport, and/or equipment decontamination. These checks are provided through collection of field quality control samples. The following types of quality control samples will be included in the sampling quality assurance program:

- One trip blank with every cooler of water VOCs samples sent to the laboratory. Definition of trip blank: a sample bottle is filled with ASTM Type II reagent water (certified analyte free), is transported to the site, is handled like a sample, and is returned to the laboratory for analysis (trip blanks are not to be opened in the field). Type II reagent water is the trip blank for water samples.

- One set of equipment rinse blanks daily for every sampling event. Definition of equipment blank: Type II reagent water is poured into the sampling device (or pumped through it in the case of sampling pumps), is transferred to the sample bottle, and is transported to the laboratory for analysis. Initially, samples from every other day will be analyzed.

- Ten percent of the total number of samples will be obtained as field duplicates (all parameters analyzed) for water samples. Definition of duplicate: two samples collected independently at a sampling location during a single act of sampling. Field duplicates will

be indistinguishable from other analytical samples so that personnel performing the analyses are not able to determine easily which samples are duplicates.

- Ten percent of the total number of samples will be obtained as field duplicate or replicates (all parameters analyzed) for soil/sediment samples. Definition of replicate: a single sample is collected and then divided into two equal parts for the purpose of analysis. Field replicates will be indistinguishable from other analytical samples so that personnel performing the analyses are not able to determine which samples are replicates.

1.10.2 Internal Quality Control Checks -- Laboratory

The quality of analytical data generated daily in the WESTON laboratories is controlled by the implementation of WESTON's standard Analytical Laboratory Quality Assurance Plan (see Appendix A). As specified in the plan under "Method Performance," types and frequencies of internal quality control checks have been developed for each analysis type. In general, internal laboratory QC checks will consist of the following:

- Method Blanks. Method blanks usually consist of laboratory reagent-grade water treated in the same manner as the sample (i.e., digested, extracted, distilled, etc.) that is then analyzed and reported as a standard sample would be.

- Method Blank Spike. A method blank spike is a sample of laboratory reagent-grade water fortified (spiked) with the analytes of interests that is prepared and analyzed with the associated sample batch. Method blank spikes are not included with VOCs analyses since the same function is served by the calibration standard analysis.

- Matrix Spikes. A matrix spike is an aliquot of a field sample that is fortified (spiked) with the analytes of interest and analyzed with an associated sample batch to monitor the effects of the field sample matrix (matrix effects) on the analytical method. Matrix spikes are performed only in association with selected protocols, as specified in Appendix A. For each sample round, matrix spikes will be prepared once every 20 samples per matrix.

- Laboratory Duplicate Samples. Duplicate samples are obtained by splitting a field sample into two separate aliquots and performing two separate analyses on the

aliquots. The analysis of laboratory duplicate monitors sample precision; however, it may be affected by sample inhomogeneity, particularly in the case of nonaqueous samples. Laboratory duplicates will be run and reported for specific analyses only, as specified in Appendix A. For each sample round, a laboratory duplicate will be run with every 20 field samples.

In addition to the quality control samples described above, the following three additional types of independent quality control checks (not associated with field sample batches) are routinely analyzed in the laboratory:

- Laboratory Control Standard for Inorganics. This is a standard solution with a certified concentration that is analyzed as a sample and is used to monitor analytical accuracy.

- Blind Performance Sample. This is a QC sample of known concentration obtained from the U.S. EPA, the National Bureau of Standards (NBS), or a commercial source. The blind performance sample is not recognizable to the analyst as a performance sample and is used to monitor analytical accuracy.

- Known Performance Sample. A known performance sample is the same as a blind performance sample, but is identified to the analyst so that he/she may use it to check the accuracy of an analytical procedure. It is particularly applicable when a minor revision or adjustment has been made to an analytical procedure or instrument.

1.11 PERFORMANCE AND SYSTEM AUDITS

Audits may consist of two types -- system audits, and performance audits. The purpose of a system audit is to determine whether appropriate corporate, division, and project systems are in place. A performance audit is used to indicate whether those systems are functioning properly.

1.11.1 Project System Audits

WESTON's Director of Quality Assurance will periodically, on an unannounced basis, call for a corporate project audit (system audit). The Project Manager must respond by submitting the Project Quality Control Plan (in this case, the project QAPP), and the auditor will then determine whether the QAPP is in-place. The auditor also will determine whether the reviews called for in the QAPP have been and are being conducted. On a scheduled basis, certain projects are identified by the Director of Quality Assurance for a more formal audit. These audits evaluate in depth the implementation of the QA Program for the

project as they apply to field and data analysis and reduction procedures. The Division Operations Manager, in his role as Division Quality Assurance Officer, may request the Director of Quality Assurance to perform an audit or may conduct the audit himself. One corporate project audit will be scheduled for NWS Earle.

1.11.2 Technical Performance Audits

Technical performance audits will be performed on an ongoing basis during the project as field data are generated, reduced, and analyzed. All numerical analyses, including manual calculations, mapping, and computer modeling, will be documented and will be the subject of performance audits in the form of quality control review, numerical analysis, and peer review. All records of numerical analyses will be legible, reproduction quality, and complete enough to permit logical reconstruction by a qualified individual other than the originator.

1.11.3 Field Performance Audits

Periodic in-field performance audits will be conducted by the appropriate technical QA Officers for the particular discipline of field activities (e.g., geoscientist to audit well drilling activities). The purpose of the field audits will be to ensure that the methods and protocols detailed in this QAPP are being consistently adhered to in the field.

Prior to the audit, the auditing QA Officer will prepare checklists to ensure completeness of the review and to document the results of the audit. Items to be examined may include, as appropriate, the availability and implementation of approved work procedures; calibration and operation of equipment; packaging, storage, and shipping of samples obtained; and documentation procedures.

The records of field operations will be reviewed to verify that field-related activities were performed in accordance with appropriate project procedures. Items reviewed will include, but not be limited to, the calibration records of field equipment, daily field activity logs, chain-of-custody documentation, and field logs. Audits of field activities will occur at least once during the activities.

During an audit and upon its completion, the auditors will discuss the findings with the individuals audited and cite any correactive actions to be initiated.

Minor administrative findings that can be resolved to the satisfaction of the auditors during an audit are not required to be cited as items requiring corrective action. Findings that

are not resolved during the course of the audit and findings affecting the overall quality of the project, regardless of when they are resolved, will be noted on the audit checklist and the results provided to the Project Manager, who will ensure that the corrective actions have been implemented.

1.11.4 Laboratory System Audits

WESTON participates in several external system audits sponsored by state regulatory agencies and the U.S. EPA. These system audits involve on-site evaluation of the WESTON laboratory systems. The type of audit, auditing agency, and frequency of these audits for the WESTON Analytical Laboratory are summarized in Table 1-7.

The WESTON laboratory QA Coordinator audits systems at least once annually. The internal audit consists of a review of systems, procedures, and documentation. Any deficiencies/deviations are documented, and a summary report is prepared.

1.11.5 Laboratory Performance Audits

WESTON participates in several external performance audits sponsored by those agencies listed in Table 1-7. These performance audits are in the form of blind performance samples submitted by the auditing agency.

The laboratory QA Coordinator has overall responsibility for monitoring the internal QA/QC program. The QA Coordinator has a staff to provide in-house audits and to review and validate analytical data packages. The QA Coordinator is also responsible for scheduling and coordinating external systems audits and for reviewing data for performance samples received. The QA Coordinator supplies blind performance samples to the laboratory at least semiannually.

1.12 PREVENTIVE MAINTENANCE OF EQUIPMENT

1.12.1 Field Equipment

As discussed in Subsection 1.7, the field equipment will have been properly calibrated, charged, and in good general working condition prior to the beginning of each working day. WESTON's central equipment stores performs maintenance and calibration of equipment prior to field use.

All field instruments will be properly protected against inclement weather conditions during the field investigation. Each instrument is specially designed to maintain its operating integrity during variable temperature ranges that are representative of ranges that will be encountered during cold-weather working conditions. At the end of each working day, all field equipment will be taken out of the field and placed in a cool dry room for overnight storage.

Table 1-7

Summary of External Performance and Systems Audits, WESTON Analytical Laboratories

Agency	Parameters	Type	Frequency	Purpose
Illinois EPA	WS/WP	Performance	Semiannually*	Water/Waste-water Cert. Requirement
NY Department of Health	WS/WP	Performance	Semiannually	Water/Waste-water Cert. Requirement
NY State Dapart-ment of Energy Conservation	Inorganic/ Organic HSL	Performance System	Semiannually Annually	Required for State Analyti-cal Contract
NJ Department of Environmental Protection	WS/WP	Performance System	Annually Every 2 Yrs.	Water/Waste-water Cert. Requirement.
PA Department of Environmental Resources	WS/WP	Performance System	Annually Every 2 Yrs.*	Water/Waste-Water Cert. Requirement
U.S. EPA	Inorganic/ Organic HSL	Performance System	Quarterly Every 2 Yrs.*	Superfund Re-lated Analyti-cal Work
U.S. Army Corps of Engineers (DERA)	Inorganic/ Organic	Performance System	As contract requires	Water/Waste-water Super-fund Analyti-cal Work
U.S. Navy	Inorganic/ Organic	Performance	As required by U.S. Navy	Laboratory Qualification and Approval for Analytical Work

*Last on-site by U.S. EPA was performed in May 1987, last PA DER on-site was performed in May 1987, and last IEPA on-site was performed in June 1987.

WS = Waste supply (drinking water)
? = Water pollution (wastewater)

All subcontractor equipment (e.g., drill rigs, water trucks, etc.) will arrive at the site each day in proper working condition. All lubrication, hydraulic, and motor oils will be checked by the subcontractors prior to the start of each work day to ensure that all fluid reservoirs are full and that there are no leaks.

Prior to the start of each work day, the WESTON Field Supervisor also will inspect all equipment for fluid leaks. If a leak is detected, the equipment will be removed from service for repair or replacement.

1.12.2 Laboratory Equipment

The ability to generate valid analytical data requires that all analytical instrumentation be properly maintained. The WESTON Analytical Laboratory maintains full service contracts on all major instruments. These service contracts not only provide routine preventive maintenance, but also emergency repair service. The elements of the maintenance program are discussed in the following subsections.

1.12.2.1 Instrument Maintenance Logbooks

Each analytical instrument is assigned an instrument logbook, in which all maintenance activities are recorded. The information entered in the instrument log includes:

- Date of service.
- Person performing service.
- Type of service performed and reason for service.
- Replacement parts installed (if appropriate).
- Miscellaneous information.

If service is performed by the manufacturer, a copy of the service record is taped into the page facing the notebook page where the above information is entered.

1.12.2.2 Instrument Calibration and Maintenance

Preventive maintenance and calibration by manufacturers' service representatives are provided on a routine basis. The maintenance procedures and frequencies for major analytical instruments are given in Table 1-8.

WESTON service agreements provide for preventative maintenance, emergency service, and emergency shipping of spare parts. For emergency response, service contracts on the gas chromatographs, GC/MS instruments, and AA/ICP require on-site response within 48 to 72 hours. (Typically, service representatives are on site within 24 hours of a service call.) The service contracts also provide for 24-hour delivery of critical spare parts in response to a service request.

Table 1-8

Instrument Maintenance Schedule
WESTON Analytical Laboratories

Instrument	Preventative Maintenance	Service Contract
Gas Chromatograph/Mass Spectrometers	Semiannually	Yes
Gas Chromatographs	Semiannually	Yes
GC Detectors (FID, EC, PID, Hall, NPD, FPD)	As needed	Yes
High Performance Liquid Chromatographs	As needed	No
Atomic Absorption Spectrometers (Flame and Furnace)	Semiannually	Yes
Inductively Coupled Plasma Spectrometers	Semiannually	Yes
Analytical Balances	Annually	Yes
Ion Chromatographs	Annually	Yes
Spectrophotometers	As needed	No
Cold Vapor Mercury Analyzers	As needed	No
Technicon Autoanalyzers	As needed	No
Conductivity Meters	As needed	No
Ovens	As needed	No
pH/Specific Ion Meters	As needed	No

1.12.2.3 Spare Parts

WESTON's laboratory maintains an inventory of routinely required spare parts (including, for example, sources, vacuum pumps and filaments for GC/MS torches, and burner heads for AA/ICP).

The instrument operators along with the appropriate Section Manager have the responsibility to ensure that an acceptable inventory of spare parts is maintained.

1.13 DATA ASSESSMENT PROCEDURES

1.13.1 Field Data

1.13.1.1. Precision

All liquid samples will be tested for temperature, pH, and specific conductance. Also, geophysical field methods are planned for certain sites. Field parameter and magnetometry measurements will be taken using precision procedures outlined in Section 2. These procedures are developed specifically for each individual measurement.

1.13.1.2 Accuracy

To ensure accuracy of measurement of field parameters, the field instruments will be calibrated daily to standards of known concentrations, if possible, as discussed in Subsection 1.7.

1.13.1.3 Completeness

The Site Manager is responsible for ensuring that all equipment is functioning and calibrated properly so that all field measurements made meet the requirements for accuracy and precision. Together, the Site Manager and Project Manager will review field data as they are compiled to ensure completeness.

1.13.2 Laboratory Data

The QA objectives for precision, accuracy, and completeness are given in Subsection 1.4. This subsection discusses the routine procedures used for assessment of those criteria.

1.13.2.1 Precision

The precision of analyses of replicate samples is calculated as given in Subsection 1.4.2. The precision requirements for organic analyses are given in Table 1-9. All analytical data are reviewed relative to those criteria.

For metal and inorganic analyses, the QA objective for precision is ±20 percent relative percent difference (RPD) between replicate analyses.

Table 1-9

QA Objectives for Precision of Laboratory Organic Analyses, IRP Phase III, NWS Earle, New Jersey

Fraction	Matrix Spike Compound*	Recovery Limits (%) Water	Recovery Limits (%) Soil/Sed	RPD Limits (%) Water	RPD Limits (%) Soil/Sed
VOC	1,1-Dichloroethene	61-145	59-172	14	22
VOC	Trichloroethene	71-120	62-137	14	24
VOC	Chlorobenzene	75-130	60-133	13	21
VOC	Toluene	76-125	59-139	13	21
VOC	Benzene	76-127	66-142	11	21
BNA	1,2,4-Trichloro-benzene	39- 98	38-107	28	23
BNA	Acenaphthene	46-118	31-137	31	19
BNA	2,4-Dinitrotoluene	24- 96	28- 89	38	47
BNA	Di-n-butyl phthalate	11-117	29-135	40	47
BNA	Pyrene	26-127	35-142	31	36
BNA	N-Nitroso-di-n-propylamine	41-116	41-126	38	38
BNA	1,4-Dichlorobenzene	36- 97	28-104	28	27
Acid	Pentachlorophenol	9-103	17-109	50	47
Acid	Phenol	12- 89	26- 90	42	35
Acid	2-Chlorophenol	27-123	25-102	40	50
Acid	4-Chloro-3-methyl-phenol	23- 97	26-103	42	33
Acid	4-Nitrophenol	10- 80	11-114	50	50
Pest.	Lindane	56-123	46-127	15	50
Pest.	Heptachlor	40-131	35-130	20	31
Pest.	Aldrin	40-120	34-132	22	43
Pest.	Dieldrin	52-126	31-134	18	38
Pest.	Endrin	56-121	42-139	21	45
Pest.	4,4'-DDT	38-127	23-134	27	50
PCB	Arochlor 1254	Not Established		30	50

* The list provided includes those compounds most commonly used for QA/QC precision control in the groups of analytes shown based on current U.S. EPA Contract Laboratory Program requirements.

1.13.2.2 Accuracy

The calculation of analytical accuracy for organic compounds is as given in Subsection 1.4.1, and the criteria for assessing accuracy for surrogate recovery are those given in Table 1-10.

For metals, analytical accuracy is measured from analysis of a laboratory control standard and a sample fortified with the element of interest. The QA objectives for accuracy in metals analysis for these QC samples are:

Sample	Recovery (%)
Laboratory Control Standard	80 - 120
Fortified Sample	75 - 125

1.13.2.3 Completeness

Completeness has been defined in Subsection 1.4.3 as a measure of the amount of analytical data of acceptable quality (i.e., data meeting all accuracy and precision criteria) generated by an analytical method or system. The minimum goal for completeness is 85 percent, and the ability to exceed this goal is totally dependent on the applicability of the analytical methods to the sample matrices analyzed (especially for organic analyses).

1.14 CORRECTIVE ACTION

1.14.1 Field Corrective Action

The initial responsibility for monitoring the quality of field measurements and observations lies with the field personnel. The Site Manager is responsible for verifying that all quality control procedures are followed. This requires that the Site Manager assess the correctness of field methods and the ability to meet quality assurance objectives. If a problem that might jeopardize the integrity of the project or cause some specific quality assurance objective not to be met occurs, the Site Manager will notify the Project Manager and the appropriate technical QA Officer. An appropriate corrective action will then be decided upon and implemented. The Site Manager will document the problem, the corrective action, and the results. Copies of the documentation form will be provided to the Project Manager, the appropriate technical QA Officer, and the Project Director.

1.14.2 Laboratory Corrective Action

The initial responsibility to monitor the quality of an analytical system lies with the analyst. In this pursuit, the analyst will verify that all quality control procedures are followed and results of analysis of quality control samples are

Table 1-10

QA Objectives for Accuracy (%) of
Laboratory Organic Analyses,
IRP Phase III, NWS Earle, New Jersey

Fraction	Surrogate Compound	Low/Medium Water	Low/Medium Soil/Sediment
VOC	Toluene-d_8	88-100	81-117
VOC	4-Bromo-fluorobenzene	86-115	74-121
VOC	1,2-Dichloroethane-d_4	76-114	70-121
BNA	Nitrobenzene-d_5	35-114	23-120
BNA	2-Fluorobiphenyl	43-116	30-115
BNA	p-Terphenyl-d_{14}	33-114	18-137
BNA	Phenol-d_5	10- 94	24-113
BNA	2-Fluorophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122
Pest.	Dibutylchlorendate	24-154*	20-150*

*These recoveries are advisory only.

within acceptance criteria. This requires that the analyst assess the correctness of all of the following items, as appropriate:

- Sample preparation procedure.
- Initial calibration.
- Calibration verification.
- Method blank result.
- Laboratory control standard.

If the assessment reveals that any of the QC acceptance criteria are not met, he must immediately assess the analytical system to correct the problem. He notifies the Section Manager and QA Coordinator of the problem and, if possible, identifies potential causes and corrective action.

The nature of the corrective action obviously depends on the nature of the problem. For example, if a continuing calibration verification is determined to be out of control, the corrective action may require recalibration of the analytical system and reanalysis of all samples since the last acceptable continuing calibration standard.

When the appropriate corrective action measures have been defined and the analytical system is determined to be "in control," the analyst documents the problem, the corrective action, and the data demonstrating that the analytical system is in control. Copies of the documentation are provided to the Section Manager and QA Coordinator. The critical path for assessing the correctness and acceptability of analytical data is shown in Figure 1-8.

1.15 QUALITY ASSURANCE REPORTS

1.15.1 Field QA Reports

The Site Manager will provide the appropriate technical QA Officer with daily field progress reports and compiled field data sets at weekly or monthly intervals, as appropriate. In addition, the appropriate technical QA Officer will be copied for all corrective action documentation. The appropriate technical QA Officers will perform unannounced field QA audits. On the basis of this information, each of the technical QA Officers will provide quarterly QA update memos for this project to the Project Manager. The Project Manager will be notified immediately of field QA situations requiring corrective action.

1.15.2 Laboratory QA Reports

The laboratory QA Coordinator provides monthly, quarterly, and annual reports to the WESTON Corporate QA Coordinator. These reports summarize QA activities for the reporting period including results of performance audits (external and internal),

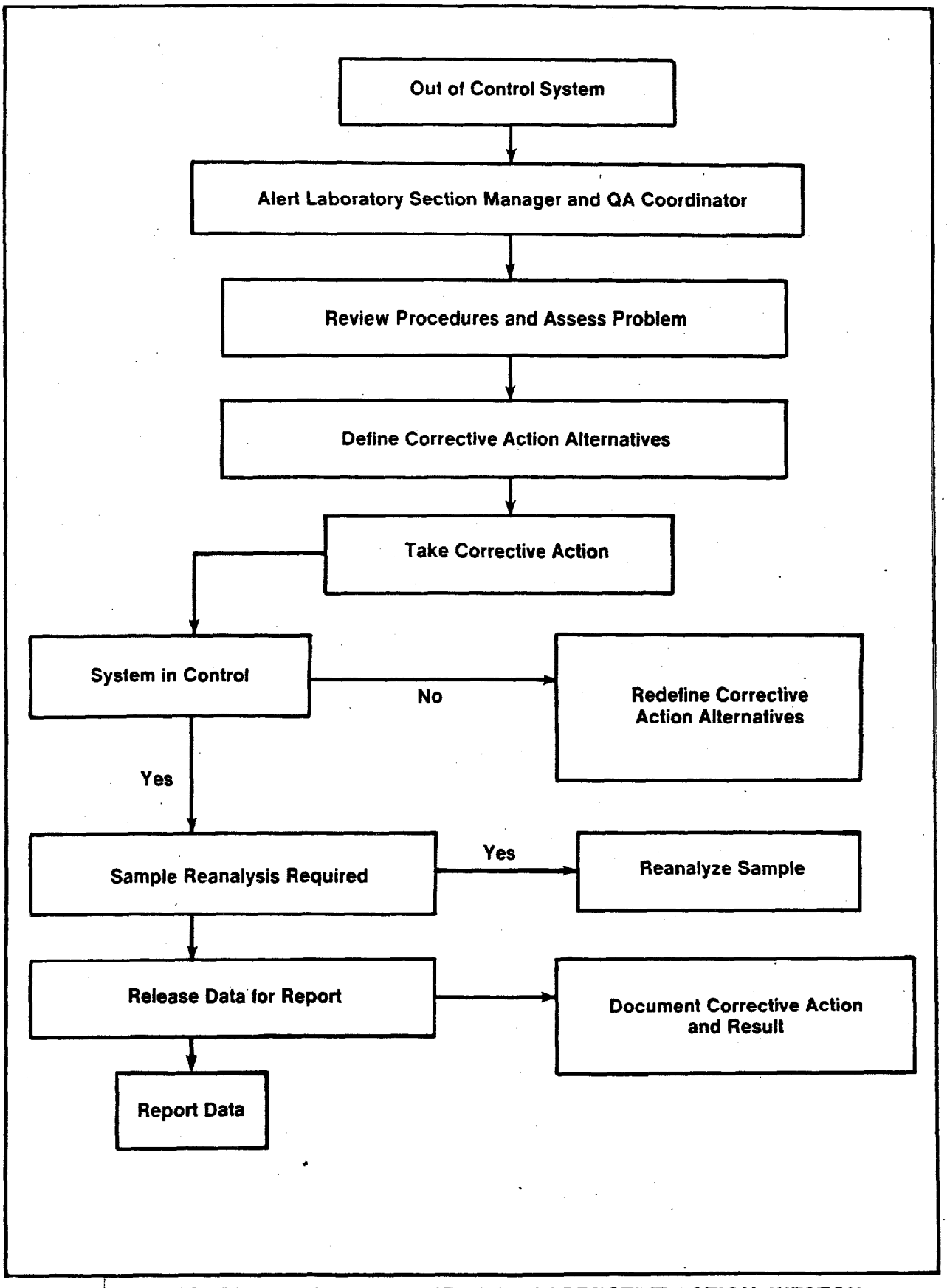


FIGURE 1-8 CRITICAL PATH FOR CORRECTIVE ACTION, WESTON ANALYTICAL LABORATORIES

results of system audits (external and internal), summaries of corrective action to remedy out-of-control situations, and recommendations for revisions of laboratory procedures to improve the analytical systems. In addition, the Laboratory Manager for this project will provide QA update memos for each sampling episode to the Project Manager upon evaluation of the analytical work for that episode. The Project Manager will be notified immediately of laboratory QA situations requiring immediate corrective action.

SECTION 2

METHODS PROTOCOLS

This section describes specific field and laboratory protocols to be applied to the IRP Phase III investigation at NWS Earle.

2.1 MAGNETOMETER SURVEY

A magnetometer survey is planned for sites where monitor well drilling or soil borings are to be performed. This is not a general survey and is only intended to fieldcheck the drilling locations.

This subsection describes the objectives to be met and general methodologies to be followed in performing magnetometer surveys at these sites. The magnetometer will also be used to survey the area of a suspected underground storage tank at Site 7.

The magnetic surveys will be performed using a Scintrex fluxgate magnetometer or equivalent instrument. The magnetometer is sensitive to ferromagnetic minerals and ferrous metals. Measurements will be taken on a 5- by 5-foot grid over a limited area to increase the probability of locating the suspected buried objects. These surveys will be used to avoid encountering the buried tank during drilling and to locate the suspected buried objects at Site 7.

Depending on the results of the data from the initial survey, a denser grid size may be required to resolve any magnetic anomalies. All profiles will be oriented approximately from south to north.

The following QA/QC procedures will be followed during the magnetic surveys:

- Background readings will be obtained in the immediate vicinity of the site.
- Base station readings will be taken at a maximum of every 30 minutes to measure the diurnal variation of the earth's magnetic field. These readings will be taken on or near the landfill where background magnetic readings are expected. Diurnal corrections will be applied if the variation is found to be significant in relation to magnetic anomalies present at the landfill.

- The first and last station readings along each traverse will be recorded in the field notebook and compared daily with data downloaded from the automatic recording device.

Corrections for diurnal variations of the earth's magnetic field will be applied to the data only if they are significant with regard to magnetic anomalies identified. For the suspected tank at Site 7 a computer-generated contour map of magnetic data will be produced for data analysis purposes.

2.2 TEST BORINGS AND EXPLORATORY DRILLING

A combination of two different drilling methods, hollow-stem augering and mud rotary drilling, will be used to install wells at NWS Earle. Hollow-stem auger techniques will be used for test borings and monitor well installation that will require soil samples. Descriptive drilling logs will be completed for each test boring and monitor well. All well/borehole cuttings will be removed by the Navy where specified by the Station Point of Contact (POC), and the general area of the borehole will be cleaned following completion of the well/borehole.

Drill cuttings suspected to be contaminated will be containerized in new, unused 55-gallon drums provided by WESTON. An HNu photoionization meter will be used to monitor the breathing zone during drilling operations and also to screen soil samples for total volatile organics. Soils will be suspected of contamination if abnormal discoloration or odor is present or if meter readings greater than 5 ppm above background are encountered. Drums will be sealed and marked with the well/boring number and the depths from which the suspected contaminated soil cuttings were collected. The drums will be transported to an on-base location designated by the POC. The station will be responsible for ultimate disposal of contaminated soils. All drilling equipment will be decontaminated as described in Subsection 2.5.4.

2.2.1 Test Borings

Test borings will be installed using hollow-stem auger drilling techniques and split-spoon sampling following ASTM method D1586-84 (see Appendix F). With split-spoon sampling, two length-wise halves of a hollow 2-inch diameter, 24-inch long steel tube are fitted together and fastened to the drill rods, driven by repeated hammer blows at appropriate 2-foot intervals, and recovered containing a soil core. Split-spoon samples will be taken at continuous 2-foot intervals.

The soil sample will be extruded from the remaining sections onto a clean surface and described for lithology following the Unified Soil Classification System (see Appendix C).

Samples will be selected for analyses from specific depth intervals specified in the Work Plan and in Table 1-2. Where semivolatile or volatile compounds are specified for analysis, other intervals will be substituted if field instruments readings warrant. Obvious discoloration or other physical peculiarities will also be considered when selecting the sampling intervals. Samples for volatile compounds analysis will be taken immediately upon opening the core barrel with as little disturbance as possible to the sample portion. After the sample is described and logged, the remaining portion will be homogenized in a stainless steel bowl, and an appropriately sized aliquot will be selected for analysis.

2.2.2 Monitor Wells

Well borings will be advanced using 8-inch ID hollow-stem augers without the use of drilling fluids. Case and wash techniques, using 8-inch ID hardened-steel casing and tricone roller bits, will be used if running sands become a problem. Split-spoon samples will be collected continuously for descriptive purposes. Lithology will be described following the Unified Soil Classification System (see Appendix C). Drinking-quality water from the station water supply will be used in all casing and washing operations.

2.3 MONITOR WELL INSTALLATION AND TESTING

Monitor wells will be installed similarly for shallow and deep wells. Well logs and well construction summaries will be completed for each well installed (see Figures 2-1 and 2-2). The monitor wells will be constructed in accordance with NJDEP guidance on monitor well installation as shown in Table 2-1.

2.3.1 Shallow Monitor Wells

Shallow monitor wells will be installed using truck- or all-terrain vehicle-mounted auger rigs. These wells will be screened such that the screened interval extends 3 to 5 feet above the water table.

After completion of each boring, the monitor well will be constructed using nominal 4-inch ID Schedule 40 PVC pipe with flush-fitting threaded joints and Schedule 40 PVC No. 10 slot (0.010-inch) machine-slotted well screen with a threaded bottom cap. Where natural gravel and sand is clean and caves around the screen it will be used for a natural sand pack at the discretion of the WESTON site geologist. The annular space around the screen will be backfilled with clean sand as the augers are withdrawn. A seal consisting of 1 foot of bentonite pellets will be placed above the sand pack followed by a neat cement slurry concrete plug of Type I portland cement 2 to 3 feet from the surface.

WESTON

DRILLING LOG

WELL NUMBER: _____ OWNER: _____

LOCATION: _____ ADDRESS: _____

_____ _____

_____ TOTAL DEPTH _____

SURFACE ELEVATION: _____ WATER LEVEL: _____

DRILLING COMPANY: _____ DRILLING METHOD: _____ DATE DRILLED: _____

DRILLER: _____ HELPER: _____

LOG BY: _____

SKETCH MAP

NOTES:

DEPTH (FEET)	GRAPHIC LOG	SAMPLE NUMBER	SAMPLE TYPE	SAMPLE BLOWS*	DESCRIPTION / SOIL CLASSIFICATION (COLOR, TEXTURE, STRUCTURES)

* A.S.T.M. D1586

SHEET ____ OF ____

FIGURE 2-1 DRILLING LOG

WESTON

Well _____

Well Construction Summary

Location or Coords: _____ Elevation: Ground Level _____

_____ Top of Casing _____

Drilling Summary:

Total Depth _____

Borehole Diameter _____

_____

Driller _____

_____

_____

Rig _____

Bit(s) _____

_____

Drilling Fluid _____

_____

Surface Casing _____

Well Design:

Basis: Geologic Log _____ Geophysical Log _____

Casing String(s): C = Casing S = Screen

___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___
___	-	___	___	___	-	___	___

Casing: C1 _____

_____

C2 _____

_____

Screen: S1 _____

_____

S2 _____

_____

Centralizers _____

_____

_____

Filter Material _____

_____

Cement _____

_____

Other _____

_____

_____

_____

Construction Time Log:

Task	Start Date	Start Time	Finish Date	Finish Time
Drilling:				
_____	___	___	___	___
_____	___	___	___	___
_____	___	___	___	___
Geophys. Logging:	___	___	___	___
Casing:				
_____	___	___	___	___
_____	___	___	___	___
_____	___	___	___	___
Filter Placement:	___	___	___	___
Cementing:	___	___	___	___
Development:	___	___	___	___
Other:				
_____	___	___	___	___
_____	___	___	___	___
_____	___	___	___	___
_____	___	___	___	___
_____	___	___	___	___

Well Development:

_____

_____

_____

_____

_____

_____

_____

Comments:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

FIGURE 2-2 WELL CONSTRUCTION SUMMARY

Table 2-1

NJDEP Monitor Well Construction and Grouting Specifications for Unconsolidated Formations*

1. The monitor well must be installed by a New Jersey-licensed well driller.

2. Monitor well design must conform with NJAC 7:9-7, 8, and 9.

3. The borehole diameter must be a minimum of 4 inches greater than the casing diameter.

4. Acceptable grouting materials are:

   Neat Cement - 6 gallons of water per 94-pound bag of cement.

   Bentonite - 1 gallon of water per 1.5 pounds of bentonite.

   Cement-Bentonite - 8 gallons of water to 5 pounds of bentonite dry mixed per 94-pound bag of cement.

   Cement-Bentonite - 10 gallons of water per 8 pounds of bentonite water-mixed with a 94-pound bag of cement.

   Nonexpandable cement - 7.5 gallons of water per half teaspoon of aluminum hydroxide mixed with 4 pounds of bentonite and 94 pounds of cement.

   Nonexpandable cement - 7 gallons of water per half teaspoon of aluminum hydroxide mixed with 94 pounds of cement (Type I or Type II).

5. Potable water must be used for mixing grouting materials and drilling fluids.

6. Only threaded joints are acceptable as couplings.

7. The driller must maintain an accurate written log of all materials encountered, and record construction details for each well and the depth of water-bearing zones. This information must be submitted to the Bureau of Water Allocation as required by NJSA 58:4A.

8. A length of protective steel casing with a locking cap must be securely set in cement around the well casing. Flush mount monitor wells are acceptable provided they have manholes, locking caps, and seals to prevent leakage of surface water into the well.

Table 2-1
(continued)

9. The top of each well casing (excluding cap) must be surveyed to the nearest 0.01 foot by a New Jersey-licensed surveyor. The survey point must be marked on each well.

10. NJDEP well permits well be obtained for all wells. Permit members will be affixed to the outer casing of each well via a metal tag.

11. NJDEP must be notified at least 2 weeks prior to drilling.

*From specification for monitor wells NJDEP.

A protective casing of 6-inch black steel with a locking cap will be placed over the PVC and set in the concrete plug except where the well is required to be finished with a valve box mounted flush with ground surface. All locks used will be keyed alike. A small diameter drillhole (0.25- to 0.375-inch) will be made near the bottom of each protective casing above the concrete plug to allow for drainage in the event that artesian conditions are encountered. Figure 2-3 shows the typical construction of the monitor wells. The outer casing will have a steel plate attached containing the identification number of the well in raised letters. The borings and temporary piezometers will be surveyed and tied horizontally to the existing coordinate system and vertically to a U.S. Coast and Geodetic Survey (USCGS) or United States Geological Survey (USGS) benchmark.

2.3.2 Final Development and Hydraulic Testing

Development will be performed using a centrifugal pump or submersible pump. All pumps will have a minimum rating of 20 gpm and will be equipped with clean wiring and polyethylene tubing.

All pumps, including tubing, will be decontaminated between wells. All wells will be pumped continuously for a minimum of five well volumes and 20 minutes, unless they pump dry, in which case they will be pumped intermittently. The pump intake will initially be set at the bottom of the well and later moved toward the top of the screen or borehole to ensure that water is drawn through all portions of the screen or borehole.

Groundwater pH, temperature, and specific conductance will be measured at regular 3-minute intervals during development. Well development will continue until these readings have not changed over successive 3-minute intervals.

2.4 WATER LEVEL DATA COLLECTION

As required by NJDEP, the tops of the inside well casings of all monitor wells will be surveyed for elevation to the nearest 0.01 foot. The wells will be horizontally located to an accuracy of 1 foot and located on the topographic site maps to be prepared or provided for this project. All work will be done by a New Jersey licensed surveyor.

Groundwater level measurements will be taken in all wells prior to sampling using an electric water level probe. Measurements will be taken from a surveyed reference point marked on the top of the PVC or steel risers. These data will determine the amount of water to be evacuated from each well prior to sampling (see Subsection 2.6.1). Using the water level probe, water level measurements will be taken three times per well or

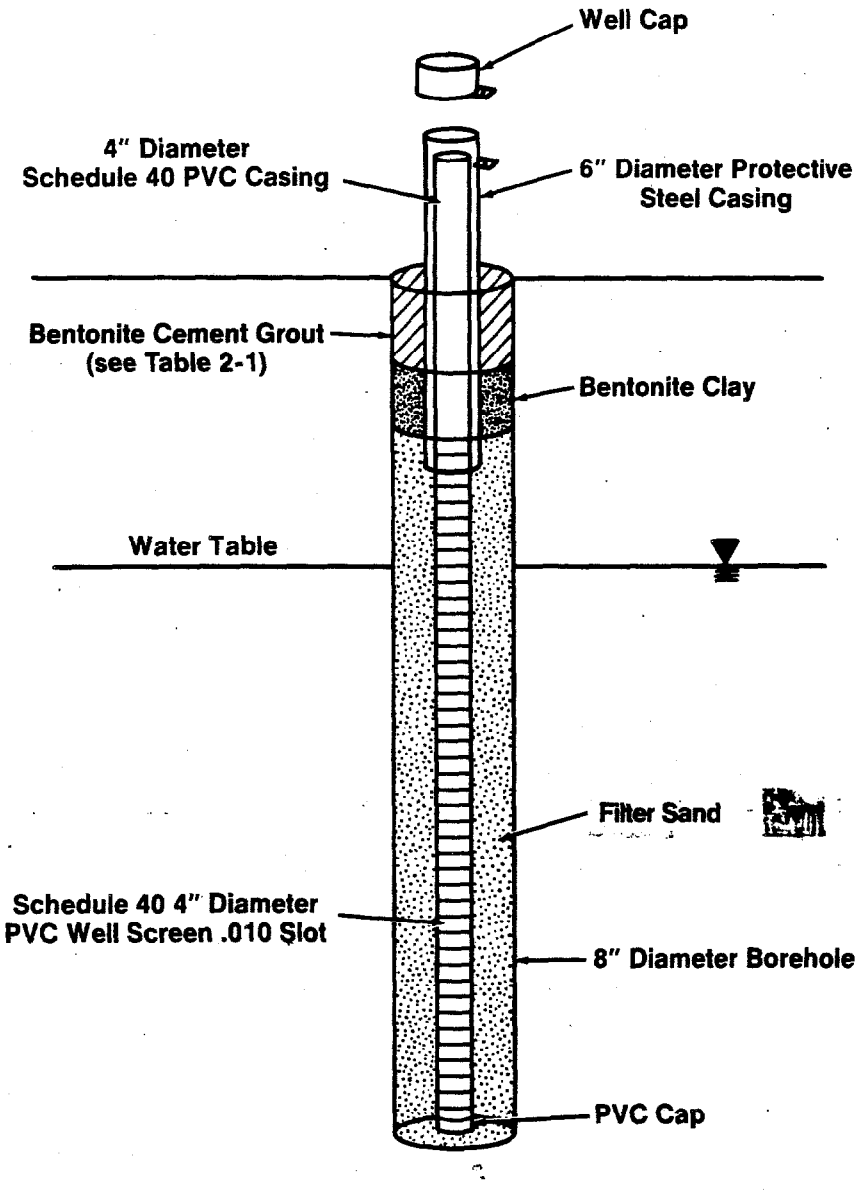


FIGURE 2-3 TYPICAL WELL CONSTRUCTION

until measurements are within ±0.01 foot. Measurements will be recorded in the field notebook and on field sampling sheets.

Surface water staff gages will be established at surface water sampling locations at Sites 4 and 10. The surface water levels will be measured with a ruler against the metal staff gage to the nearest 0.01 foot.

2.5 SAMPLE COLLECTION

2.5.1 Groundwater Samples

As discussed in Subsection 1.8, groundwater samples will be taken from each well for pH, temperature, and specific conductance. After initially calibrating the instruments according to the methods in Subsection 1.7, measurements will be taken, and the data will be recorded in the field log and on the field sampling sheet. Three sets of measurements will be taken for each parameter. If the three measurements differ by greater than 10 percent for specific conductance, 0.5 pH units for pH measurements, or 1°C for temperature measurements, the instrument will be recalibrated. The instrument probes will be flushed with distilled/deionized water between sample measurements.

Groundwater sampling will be accomplished only after the wells have been properly developed and purged. Groundwater sampling will occur no earlier than 14 calendar days after well development has been completed.

Upgradient wells will be sampled first at each site. In general, wells suspected of having low levels of contamination will be sampled prior to those suspected of having medium or high levels.

Procedures for sampling monitor wells are as follow:

- Water level measurements will be taken to the nearest 0.01 foot with respect to the established survey point on top of the well casing. All measuring devices used in the well will be thoroughly rinsed with distilled water prior to reuse. The depth to the top of the water will be subtracted from the total casing depth to determine the height and, subsequently, the volume of standing water in the casing.

- The surface of the water column will be examined for the presence of hydrocarbons; if hydrocarbons are present, the thickness of the hydrocarbons layer will be measured and sampled using a teflon bailer.

- To ensure collection of samples representative of groundwater quality, a submersible pump or bailer will be used to remove a quantity of water from the well equal to three to five times the calculated volume of water in the well casing (purging of the well). If a measurable thickness of floating product is observed, the sample will be taken from the top of the column without purging.

- Dedicated polypropylene tubing and bailer line will be used at each well.

- Samples will be obtained using a teflon bailer. Samples will be collected for volatile organic compounds (VOCs) analyses immediately after purging is complete. A separate sample will be obtained in the field to determine pH, specific conductance, and temperature. All samples from the well will be collected within 3 hours of the purge.

- Groundwater samples collected for soluble metals will be field filtered through a 0.45-micron filter before being preserved with nitric acid.

- All samples for chemical analyses will be placed in laboratory-prepared bottles (see Subsection 2.6.5.1). The bottles will be filled and capped securely. Each sample bottle will be placed in an insulated cooler chest immediately after sampling. Sample handling and shipping procedures are discussed in Subsection 1.6.3.

All nonexpendable sampling equipment will be decontaminated after sampling to prevent cross-contamination between wells, as detailed in Subsection 2.6.4. Bailer line will be dedicated to each well and will consist of high-test monofilament, polypropylene rope, or stainless steel wire. Sampling equipment will be protected from contamination between sampling points by wrapping in aluminum foil.

Groundwater samples will be analyzed for selected parameters outlined in Table 2-2.

Groundwater and seeps, if present may be sampled at several sites. The samples will be collected by digging out a pit at the seep location with a stainless steel trowel. Once enough water has accumulated in the pit, sample bottles will be submerged until full. For preserved bottles, a separate clean bottle will be used to transfer the sample from the seep to the preserved bottle.

Table 2-2

Summary of Analytical Requirements for Surface Water and Groundwater Analyses, NWS Earle, New Jersey

Parameter	No. of Samples	MS/MSD	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Explosives[a]	16	3	3	3	3	28
Metals (TAL)	55	5	6	0	6	72
Cyanide (total)	55	5	6	0	6	72
Volatile organic compounds (TCL)	55	5	6	6	6	78
Volatile organic compounds[b]	7	2	2	2	2	15
Total petroleum hydrocarbons	7	2	2	2	2	15
pH[c]	57	0	0	0	0	57
Specific conductance[c]	57	0	0	0	0	57

Note: Additional QA/QC samples may be necessary due to sampling logistics.

a Explosives compounds include: picric acid, nitrocellulose, nitroglycerin, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, tetryl, 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, HMX, and RDX.

b Non-TCL surface water only.

c Field-easured parameters.

2.5.2 Surface Water/Sediment Samples

Surface water/sediment samples may be collected by WESTON personnel from several locations around the station. Surface water will be analyzed for selected parameters listed in Table 2-2; soil samples will be analyzed for selected parameters listed in Table 2-3. At each location, sediment samples will be taken with a stainless steel trowel. Samples for VOCs analysis will be taken directly; all other samples will be homogenized in a stainless steel bowl.

A sample from each location will be collected and placed in a laboratory-prepared sample bottle. Dedicated trowels and spatulas will be used to collect sediment samples from the bottom of the stream. Every attempt will be made to exclude twigs, rocks, vegetation, and debris from the samples. Surface water samples will be collected before the sediment samples at each location by submerging the sample bottles in the stream. If the bottle contains a preservative, a separate clean bottle will be used to transfer the sample from the stream to the preserved bottle. Samples will be collected so as not to cause cross-contamination; downstream samples will be collected first. Temperature, pH, and specific conductance will be measured at each sampling point in the same manner as for groundwater samples (see Subsection 2.5.1). The location of each surface water and sediment sample collection point will be logged in the field notebook and marked in the field and on a project map for each specific site.

2.5.3 Soil Samples

Soil samples from test borings will be collected through hollow-stem augers with split-spoons.

Samples from each boring will be retained for chemical analysis. Chemical characterization will be achieved following the protocol in Table 2-3.

2.5.4 Decontamination Procedures

All material and equipment will arrive on site in a clean condition. Recommended procedures for equipment decontamination, as described in the following subsections, will be followed where applicable.

2.5.4.1 Drilling, Soil Sampling, and Monitor Well Installation Equipment Decontamination

Prior to the start of drilling, all drill rods, augers bits, tank, and split-spoons will be steam cleaned, scrubbed with laboratory detergent, and rinsed at an area set up on site for this purpose. Augers, tools, drill rods, casings, and screens

Table 2-3

Summary of Analytical Requirements for Soil and Sediment Analyses
NWS Earle, New Jersey

	Number of Samples	MS/MSD	Trip Blanks	Field Blanks	Total Analyses
Explosives	26	5	0	5	36
Metals (TAL)	41	7	0	7	55
Cyanide (total)	38	7	0	7	52
Volatile organic compounds(TCL)	17	3	3	3	26
Total petroleum hydrocarbons	33	5	0	5	43

Note: Explosives compounds include: picric acid, nitrocellulose, nitroglycerin, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, tetryl, 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, HMX, and RDX.

will be inspected to ensure that residue such as muds and machine oils have been removed. Similar decontamination procedures will be implemented between each boring to prevent cross-contamination and to ensure the integrity of soil samples.

2.5.4.2 Well Development Equipment Decontamination

Submersible pumps or similar equipment used for well development will be decontaminated between wells. Pumps will be decontaminated by submerging the pump intake first in a washing solution (nonphosphate-type detergent), then in clean potable water, and then pumping the solutions through the pump and line.

2.5.4.3 Water Level Measurement Equipment Decontamination

Water level indicators used in the wells will be decontaminated by flushing the electrical probe with an Alconox solution followed by an ASTM Type II reagent water rinse. Pressure transducers will be decontaminated by rinsing in an Alconox solution followed by an ASTM Type II reagent water prior to and after each use. If floating product or high levels of organic contamination are evident in a well, the decontamination procedure for sampling equipment (see Subsection 2.5.4.4) will be used, except that no solvents will be used to clean pressure transducers.

2.5.4.4 Water and Soil Sampling Equipment Decontamination

Bailers used for water sampling and other miscellaneous sampling equipment (split-spoons, spatulas, trowels) will be decontaminated between sampling points. Pumps used for well purging will be decontaminated by submerging the pump intake first in a washing solution (laboratory-grade detergent), then in clean potable water, and then pumping these solutions through the pump system until the discharge is free of detergent. Dedicated propylene tubing will b used in each well.

The procedure for decontaminating sampling equipment is as follows:

- Place dirty equipment (e.g., bailers, pumps, buckets, etc.) on a plastic ground sheet at the head of the "decon line."
- Rinse equipment in a tub of potable water to remove surface dirt and mud, if necessary.
- Scrub equipment with a bristle brush in a basin filled with laboratory-grade detergent and potable water.
- Rinse with 10 percent nitric acid (ultra-pure grade) (1 percent solution for carbon steel spoons).
- Rinse off soap in a tub of potable water.

- Rinse with ASTM Type II reagent water.
- Rinse with pesticide-grade methanol.
- Final rinse with pesticide-grade hexane.
- Allow equipment to air dry before use.
- Wrap sampling equipment in aluminum foil following decontamination.
- Sampling equipment used to collect samples for organic analyses will not be allowed to come in contact with any type of plastic after decontamination.

2.5.4.5 Disposal of Drill Cuttings and Fluids

Most well drilling locations for this investigation are outside the site boundaries. Only very low levels of contamination have been found in groundwater and soils during past sampling. On-site drilling will occur in areas where contaminants were deposited on the surface, so that mixing cuttings from borings with surface soils will not worsen surface soil quality. Therefore, it is prudent to leave purge water and cuttings on site.

Drilling cuttings will be disposed of by spreading around the drilling site, unless noticeable odors, color, or vapor detection readings indicate the possibility that the material is hazardous. In that case the on-site geologist will have the material drummed and staged on site for testing and eventual off-site disposal. Final disposition of containerized material will be the responsibility of NWS Earle

Purge water from wells previously installed will be returned to the ground since contaminants were found in only a few wells and then only trace levels of contaminants were observed. Purge water from new wells will be containorized and staged on site pending analysis of well samples. If analysis shows no contamination, then the water will be spread around the site. Observed contamination may require special disposal to be determined.

Decontamination water from initial rinses containing detergent or cleaning solvent will be collected on plastic sheeting and allowed to evaporate. Remaining liquids will be containerized. Clean water from final rinses will be allowed to run to the ground.

Protective clothing and disposables will be placed in secure steel containers on site. They will be disposed of as general solid waste if the results of the RI indicate this is acceptable.

2.5.5 Required Containers, Preservation Techniques, Holding Times, and Sample Volumes

All samples submitted for analysis on this project will be collected by WESTON personnel. Sampling containers and preservatives will be provided on request by WESTON Analytical Laboratories. The specific requirements for sample containers, preservatives, and analytical holding times are discussed in the following subsections and are listed in Table 2-4.

2.5.5.1 Sample Containers

All containers provided by WESTON will be 300 series obtained from I-Chem, Hayward, California, the bottle contractor to the U.S. EPA Contract Laboratory Program. The containers provided are those described in 40 CFR Part 136, No. 209, 26 October 1984, page 28. These containers are cleaned by I-Chem in accordance with U.S. EPA protocols. The containers purchased from I-Chem are I-Chem Series 300 containers. Each lot of these containers is analyzed in accordance with I-Chem quality control requirements and is not shipped by I-Chem unless the QC requirements are met.

All sample containers provided by WESTON will be shipped with chain-of-custody records (see Subsection 1.6). These chain-of-custody records will be completed by the field sampling personnel and returned with the samples.

2.5.5.2 Sample Preservation

The preservatives required for all analyses will be provided by WESTON with the sample containers. The required preservation methods for target analyses are listed in 40 CFR Part 136, No. 209, 26 October 1984.

2.5.5.3 Holding Times

Holding times for analytes will be those given in 40 CFR Part 136, No. 209, 26 October 1984.

Upon sample receipt at the WESTON laboratory, all sample collection dates are noted by the sample custodian. The required date for completion of analysis (or extraction) is noted on the chain-of-custody record and is keyed to the holding time. All analyses with holding times of 48 hours or less are identified by the sample custodian, and the appropriate Laboratory Section Manager and analyst are notified that the samples are in house.

2.5.6 Sampling QA/QC Protocols

Field QA/QC samples will be collected and analyzed as part of all field sampling activities including soil, groundwater, surface water, and sediment sampling. The number of field QA/QC

Table 2-4

Summary of Sample Container Specifications

Analyte	Minimum Sample Volume	Container	Preservative	Holding Time
Groundwater/Surface Water				
VOCs	40 mL	Glass	Cool 4°C	14 days
Pesticides/PCBs	950 mL	Amber glass	Cool 4°C	7 days extraction 40 days analysis
BNAs	950 mL	Amber glass	Cool 4°C	7 days extraction 40 days analysis
Metals	1 L	Plastic	HNO_3	180 days (except Hg 28 days)
Cyanide	1 L	Plastic	NaOH	14 days
Explosives				
Nitrocellulose Nitroglycerin Picric acid	250 mL	Plastic	Cool 4°C	No established protocol
	1 L	Amber glass	$HgCl_2$	7 days extraction 40 days analysis
2,4,6-TNT 2,4-DNT 2,6-DNT Tetryl 1,3,5-Trinitrobenzene 1,3-Dinitrobenzene HMX RDX	250 mL	Amber glass	Cool 4°C	7 days
Soil/Sediment				
VOCs	125 mL	Glass	Cool 4°C	14 days
Pesticides/PCBs BNAs Metals	500 mL	Glass	Cool 4°C	14 days extraction 40 days analysis 180 days (except Hg 28 days)
Cyanide TPH	250 mL	Glass	Cool 4°C	28 days
Explosives				
Nitrocellulose Nitroglycerin	250 mL	Amber glass	Cool 4°C	7 days extraction 40 days analysis
2,4,6-TNT 2,4-DNT 2,6-DNT Tetryl 1,3,5-Trinitrobenzene 1,3-Dinitrobenzene HMX RDX	250 mL	Amber glass	Cool 4°C	7 days 40 days analysis

samples to be collected are detailed in Subsection 1.10.1 and Tables 2-2 and 2-3. The sample identifier numbers for QA/QC samples are outlined in Subsection 1.6.2.1. The following protocols will be followed for collection of QA/QC samples.

Trip blanks will be prepared in the laboratory, shipped to the site with the sample bottles, and handled as a sample. One trip blank will be sent to the laboratory with every cooler of VOCs samples for both soils and water.

Field blanks will be collected at each site where water samples are collected for analyses. These samples will be collected by pouring ASTM Type II reagent water into a sample bottle. These blanks will be handled as samples and shipped back to the laboratory with the other samples from that site or zone.

Equipment rinse blanks will be collected daily for each sampling medium and analyzed for the parameters shown in Tables 2-2 and 2-3. These samples will be collected by pouring ASTM Type II reagent water through the decontaminated sampling device (i.e., bailer) and into the appropriate sampling container. Equipment blanks for soluble metals will be run through the filtering apparatus exactly as the groundwater samples. These rinse blanks will be analyzed for the same analytes as the samples.

Field duplicates will be collected for water samples and all soil samples requiring analysis for either VOCs or BNAs. The number of field duplicates will equal 10 percent of the total number of samples in that matrix. A field duplicate will be collected as a separate sample immediately after the collection of the field sample for which it is a duplicate. Collection procedures for field duplicates are identical to those for the original samples.

Field splits will be collected for soil/sediments samples only in those cases where sample volumes are adequate and the samples do not require analysis for VOCs or BNAs. The number of field splits will be equal to approximately 10 percent of the total number of samples. Splits will be collected by placing the soil in a stainless steel tray and dividing the soil into two equal parts with a stainless steel trowel. One-half of the soil is placed in the appropriate jars labeled for the soil sample, and the other half is placed in the appropriate jars labeled for the splits sample.

Duplicate groundwater samples will be collected from the same bailerful of groundwater extracted from the same well after pumping. Duplicate surface water samples will be collected as separate grab samples from the same location, one immediately after another.

2.6 SITE MANAGEMENT

The basic components of site management in support of the IRP Phase III planned field activities are described in the following subsections.

2.6.1 General Operations and Coordination with U.S. Navy

The Station POC on this project will be Mr. Bill Matthaey of the Station Public Works Office. All coordination with other parties on station will be performed by WESTON through the POC and the Engineer in Charge, Mr. Steve Vukelich. All contacts from outside parties concerning the project will be made either through the POC or the Station Public Affairs Officer, Lieutenant Commander Jeffery Tubello.

The Site Manager will be responsible for day-to-day coordination of WESTON field teams and subcontractors as well as day-to-day contact with the POC. The POC will be responsible for arranging for personnel and vehicle passes for WESTON and subcontractor personnel, locating utilities, and coordinating issuance of digging permits for all sites designated for subsurface investigations.

For each field activity involving more than one person, a Field Team Leader will be designated by the Site Manager in agreement with the Project Manager from among the WESTON personnel present on station. The Field Team Leader will be responsible for coordinating the activities of his/her team, including subcontractors, and for notifying the Site Manager of progress and/or logistical problems.

2.6.2 On-Station Project Facilities

A construction trailer will be used as an on-station project office and indoor storage space and will be on station for the duration of the field portions of this project. The trailer will be equipped with telephone and electrical utilities and may contain a refrigerator, a copy machine, and a personal computer. It will be used as a central meeting point for planning field activities, daily debriefings, and, in case of contingencies or emergencies, it will serve as a field office for the Site Manager and Data Administrator. In addition, it will contain dry storage space for staging of field equipment and sampling containers, as necessary.

2.6.3 Site Access and Security

It is anticipated that all field work will be performed within the boundaries of NWS Earle. Access to NWS Earle is limited to Navy military and civilian personnel, dependents, and authorized visitors. Travel within station boundaries is restricted

to authorized personnel. In most cases, the individual sites are not fenced.

During actual field operations, access to working areas will be limited to WESTON and subcontractor personnel and visitors authorized by the POC. All visitors will be requested to keep clear of field activities. If the presence of visitors creates a situation perceived by the WESTON Field Team Leader as dangerous, all work will be terminated until appropriate working conditions can be restored. If necessary, the Field Team Leader will notify the Site Manager, who will notify the POC.

2.6.4 Site Logistics

All water for field operations (except where ASTM Type II reagent water is specified) will be obtained from on-station drinking water sources to be specified by the POC. In general, water for drilling operations will be supplied from the nearest station fire hydrant.

Decontamination of drilling and sampling equipment will be performed either in source areas at each site or in the centralized paved decontamination area to be designated by the Station POC, whichever is logistically and technically appropriate. The centralized decontamination area will be used to collect the decontamination water, which then will be drummed and temporarily stored for disposal by the Navy. The Station POC will be responsible for arranging pickup and disposal of any waste that may accumulate. All decontamination will be performed using water from a station potable supply, except where ASTM Type II reagent water is specified (for sampling equipment only).

Electricity will be provided to the field office and field lab trailers by the station. Electricity for all remote field operations will be provided from portable generators to be supplied by WESTON.

2.6.5 Contingencies

In the event that any unforeseen circumstances arise during the course of the field activities that would endanger anyone on site, the site will be vacated, and both the Project Manager and the POC will be notified. Due to the nature of the contaminants found on site, it is not anticipated that a fire or explosive conditions will be a problem. In an emergency, all personnel will be evacuated to the nearest point of safety, and if possible, will regroup at the field office.

Wherever appropriate, the provisions of the project Health and Safety Plan (provided under separate cover) will be followed in an emergency.

APPENDIX A

ANALYTICAL LABORATORY QUALITY ASSURANCE PLAN

Roy F. Weston, Inc.

October 1988

6818B

LABORATORY QUALITY ASSURANCE PLAN

ROY F. WESTON, INC.
Analytics Division
208 Welsh Pool Road
Lionville, PA 19353

October 1988
[revised January 1989 (page 46)]

Approval: Date:

Carter P. Nulton, Ph.D.
Manager
Lionville Laboratory — 4/27/89

Dianne Therry
QA Coordinator
Lionville Laboratory — 4-27-89

Earl M. Hansen, Ph.D.
Technical Director
Analytics Division — 4/27/89

TABLE OF CONTENTS

		Page #
1.0	Introduction	5
2.0	Organizational Chart and Individual Responsibilities	6
2.1	Introduction	6
2.2	Project Director & Project Manager	6
2.3	Technical Director	6
2.4	Laboratory Manager	6
2.5	Section Managers	6
2.6	Chemists-Technicians	7
2.7	Quality Assurance Coordinator	7
2.8	Report Manager	7
3.0	Quality Assurance Objectives	10
3.1	Introduction	10
3.2	Quality Assurance Objectives for Accuracy	10
3.2.1	Metals/Inorganic Analysis	11
3.2.2	Organic Analysis (GC and GC/MS)	11
3.3	Quality Assurance Objectives for Precision	12
3.3.1	Metals and Miscellaneous Inorganic Analyses	12
3.3.2	Organic Analyses (GC, GC/MS	12
3.4	QA Objective for Data Completeness	13
4.0	Sampling Procedures	16
4.1	Introduction	16
4.2	Sampling Plan	16
4.2.1	Safety	17
4.2.2	Sampling Points	18
4.2.3	Volume of Samples	18
4.2.4	Sampling Equipment	18
4.3	Sampling Containers	19
4.4	Sample Preservation & Holding Times	20
4.5	Sampling Procedures	20
4.6	Sample Handling and Packing	21
5.0	Chain of Custody	25
5.1	Introduction	25
5.2	Sample Receipt	25
5.3	Sample Storage	26
5.4	Sample Tracking	27
5.4.1	Organic Analysis	27

5.4.2 Metals Analysis 27
5.4.3 Record Keeping 27
5.4.4 Building Security 28

6.0 Calibration Procedures and Frequency 32

7.0 Analytical Procedures 33

7.1 Gas Chromatography/Mass Spectroscopy (GC/MS) 33
7.1.1 Tuning and GC/MS Mass Calibration 33
7.1.2 GC/MS: Initial Calibration 34
7.1.3 GC/MS: Continuing Calibration 34
7.1.4 GC/MS: Quality Control 34
7.1.5 GC/MS: Detection Limits 35
7.2 Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC) 35
7.2.1 GC & HPLC: Initial Calibration 35
7.2.2 GC & HPLC: Continuing Calibration 35
7.2.3 GC & HPLC: Quality Control 35
7.2.4 GC & HPLC: Detection Limits 35
7.3 Atomic Absorption Spectrophotometry (AA): Flame & Furnace 37
7.3.1 AA: Initial Calibration 37
7.3.2 AA: Continuing Calibration 37
7.3.3 AA: Quality Control 37
7.3.4 AA: Detection Limits 38
7.4 Inductively Coupled Argon Plasma (ICP) 38
7.4.1 ICP: Initial Calibration 38
7.4.2 ICP: Continuing Calibration 39
7.4.3 ICP: Quality Control 39
7.4.4 ICP: Detection Limits 40
7.5 Cold Vapor Mercury Analysis: Flameless AA (CVAA) 40
7.5.1 CVAA: Initial Calibration 40
7.5.2 CVAA: Continuing Calibration 40
7.5.3 CVAA: Quality Control 40
7.5.4 CVAA: Detection Limits 41
7.6 Total Organic Carbon (TOC) 41
7.6.1 TOC: Initial Calibration 41
7.6.2 TOC: Continuing Calibration 42
7.6.3 TOC: Quality Control 42
7.6.4 TOC: Detection Limits 42
7.7 Ion Chromatography (IC) 42
7.7.1 IC: Ion Chromatography 42
7.7.2 IC: Ion Chromatography 43
7.7.3 IC: Ion Chromatography 43
7.7.4 IC: Ion Chromatography 43
7.8 Spectrometry (Colorimetric Methods) 43
7.8.1 Spectrophotometry: Initial Calibration 43
7.8.2 Spectrophotometry: Continuing Calibration 44
7.8.3 Spectrophotometry: Quality Control 44
7.8.4 Spectrophotometry: Detection Limits 44
7.9 Balances 45

7.10 Thermometers 45
8.0 Data Reduction, Validation, and Reporting 47

8.1 Introduction 47
8.2 Data Reduction 47
8.3 Data Review/Validation 47
8.4 Data Reporting 48
8.4.1 Level 1: Standard Commercial Report 49
8.4.2 Level 2: Tier II Report 50

9.0 Internal Quality Control Checks: Laboratory 51

9.1 QC Monitoring 52

10.0 Performance and System Audit 53
10.1 External Audits 53
10.2 Internal Audits 53

11.0 Preventative Maintenance 55

11.1 Introduction 55
11.2 Instrument Maintenance Log Books 55
11.3 Instrument Calibration and Maintenance 55
11.4 Spare Parts 56

12.0 Procedures Used to Assess Data Quality 59

12.1 Introduction 59
12.2 Precision 59
12.3 Accuracy 59
12.4 Completeness 60

13.0 Corrective Action 61

14.0 Quality Assurance Reports to Management 63

LIST OF TABLES

		Page #
3-1	Quality Assurance Objectives for Accuracy for Organic Surrogate Analyses	14
3-2	Quality Assurance for Accuracy & Precision for Organic TCL Analyses	15
4-1	Sampling Points for Most Waste Receptacles	22
4-2	Sampling Equipment	23
4-3	Sampling Equipment for Particular Waste Types	24
7-1	GC/MS Calibration check Compounds (CCC's) and System Performance Check Compounds (SPCC's)	46
10-1	External Performance and Systems Audits WESTON Analytical Laboratories	54
11-1	Calibration Frequency and Mechanism for Major Instruments	57
11-2	Instrument Maintenance Schedule	58

LIST OF FIGURES

		Page #
2-1	WESTON Analytics Division Organizational Chart	8
2-2	Lionville Laboratory Organizational Chart	9
5-1	WESTON Custody Transfer-Work Request Form	29
5-2	WESTON Sample Extraction Form	30
5-3	WESTON Sample Digestion Record	31
13-1	Critical Path for Corrective Action	62

ROY F. WESTON, INC.
LABORATORY QUALITY ASSURANCE PLAN

1.0 Introduction

This document describes the Quality Assurance (QA) procedures employed by WESTON Analytics, a Division of Roy F. Weston, Inc., to ensure that all data generated in the laboratory conform to specific requirements for accuracy, precision, and completeness. These procedures are routinely incorporated into all analyses performed by the WESTON laboratory for the purpose of producing reliable data.

Customized, client-specific quality control measures can be added to or can supersede these basic guidelines to satisfy the needs of individual programs. Laboratory personnel are available to discuss the design, advantages, and disadvantages of other quality control options, and to aid the data user in developing a project specific Quality Assurance Project Plan (QAPP). At a minimum, the information provided for these project specific plans will include:

- background and overall project objectives,
- intended use of the acquired data,
- list of measurement parameters,
- number of samples to be taken,
- kinds of samples to be taken (e.g. soil, surface water, groundwater, biological, sludge, drums, etc.), and
- dates anticipated for project start and completion.

2.0 Organization Chart and Individual Responsibilities

2.1 Introduction

The organization of WESTON Analytics is shown in Figures 2-1 and 2-2. The specific duties and responsibilities of the Laboratory Manager, Quality Assurance Coordinator, Section Managers, Project Manager, Project Director, and Technical Director are described in detail in the relevant standard operating procedures (SOPs). These duties and responsibilities are summarized in the following sections.

2.2 Project Director and Project Manager

WESTON recognizes the importance of efficient project management. WESTON has established a Project Director (PD), Project Manager (PM) group which is responsible for managing all analytical projects. The PD is responsible for the overall direction of the project. The project managers are responsible for maintaining the laboratory schedule, ensuring that technical requirements are understood by the laboratory, and ensuring that project deliverables are submitted on-time and in the required format.

2.3 Technical Director

The WESTON Analytics Division Technical Director serves as technical liaison and assists in resolving any technical issues. He will coordinate these activities with the Project Manager and Quality Assurance Coordinator.

2.4 Laboratory Manager

The Laboratory Manager has the responsibility to see that all tasks performed in the laboratory are conducted according to the requirements of this Quality Assurance Plan (QAP).

2.5 Section Managers

The Section Managers are responsible for implementation of established polices and procedures. The responsibilities of the Section Managers are summarized below:

1. Provide technical direction to analysts in conformance with project requirements.

2. Monitor laboratory work schedules to ensure compliance with project commitments.

3. Review all analytical data prior to reporting to ensure conformance with this QAP.

4. With the Laboratory Manager and Quality Assurance Coordinator, identify and resolve technical problems consistent with the requirements of this QAP.

5. Ensure that assigned personnel are adequately trained to perform required analyses.

2.6 Chemists-Technicians

An effective laboratory quality assurance program depends on the performance of all laboratory staff who perform analyses. The responsibility of laboratory chemists and technicians include:

1. Initial review of QC data for acceptability.

2. Recording of data in bound laboratory notebooks (including any observations made during the analyses).

3. Informing direct supervisors of any problems with instruments or methods to ensure that prompt and effective corrective action is taken.

2.7 Quality Assurance Coordinator

The Laboratory Quality Assurance Coordinator has oversight responsibility for implementation of the quality assurance objectives. These responsibilities include:

1. Ensure that QA objectives of this QAP are met.

2. Submit performance samples for analysis appropriate to laboratory analytical requirements at least annually.

3. Provide an internal audit of representative analytical data reports.

4. Perform an internal laboratory systems audit at least once semi-annually.

5. Provide quality assurance reports to WESTON management.

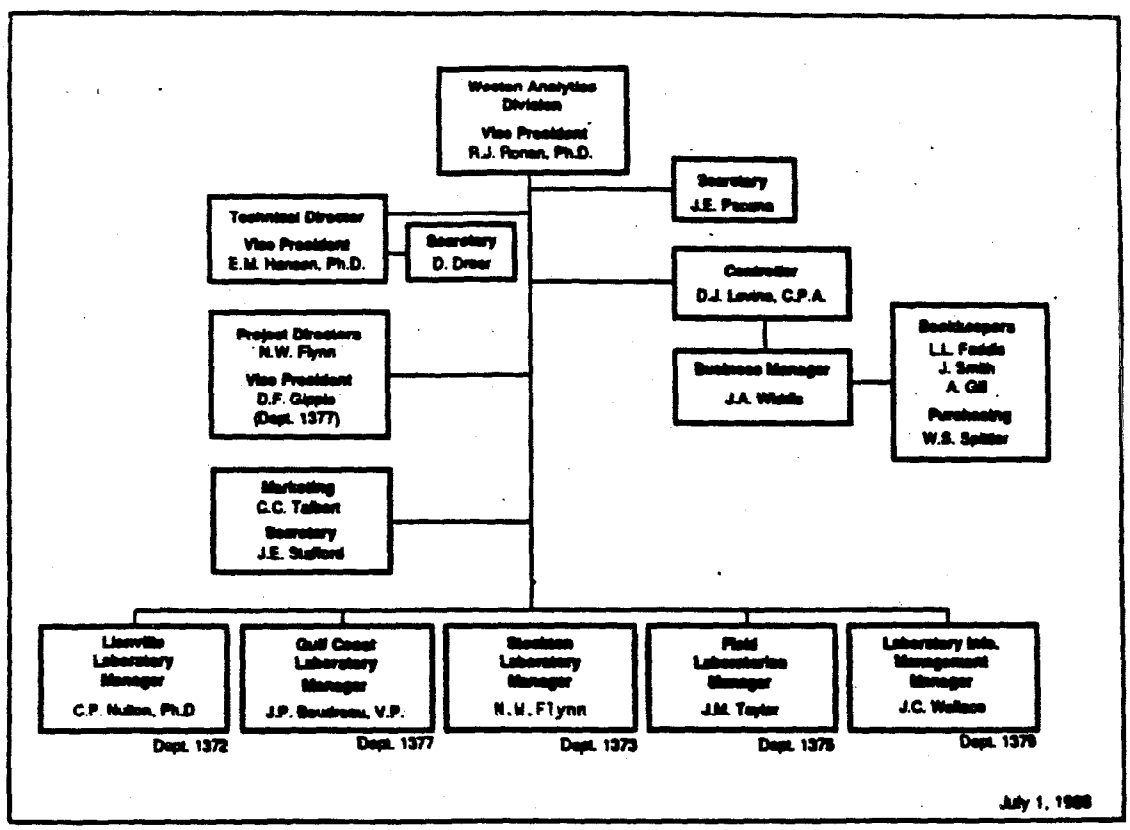
6. Coordinate on-site QA laboratory audits and ensure that any questions regarding QA requirements are resolved.

2.8 Report Manager

The Laboratory Report Manager is responsible for monitoring the status of all samples in the laboratory and ensuring that data are reported in a timely manner and in the proper format.

FIGURE 2-1

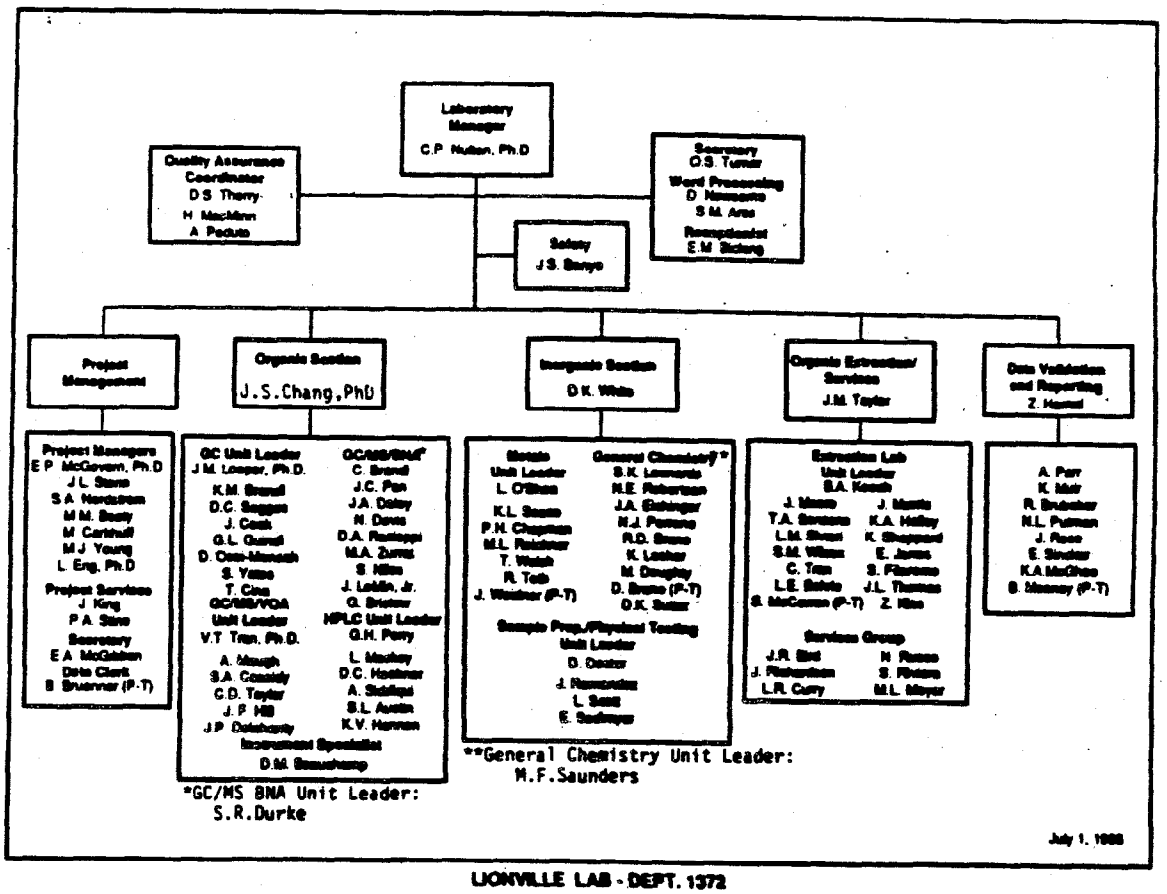
**WESTON ANALYTICS DIVISION
ORGANIZATIONAL CHART**



WESTON ANALYTICS DIVISION - DEPT. 1371

FIGURE 2-2

LIONVILLE LABORATORY ORGANIZATIONAL CHART



LIONVILLE LAB - DEPT. 1372

3.0 Quality Assurance Objectives

3.1 Introduction

The objective of this Quality Assurance Plan is to provide a framework to ensure that all analytical data which are reported are of known quality. The minimum requirements of an effective Quality Assurance program include:

- Sample Management: sampling, sample preservation, chain-of-custody
- Analytical Methodology: documented analytical procedures, calibration, data handling
- Laboratory Records: measurement data, maintenance records, equipment manuals
- Quality Control/Quality Assessment: control charts, quality control samples
- Data Review, Validation and Reporting
- Performance and System Audits/Corrective Action
- QA Reports to Management
- Personnel Training

All measurements made in this program will be representative of the matrix and conditions being measured. The data will be calculated and reported in units consistent with standard reporting conventions to enable comparability to existing data, standards, and/or regulatory action limits.

The specific procedures utilized by WESTON for these systems will be described in subsequent sections of this QAP. All of these systems help to establish the QA objectives, which are measured in terms of accuracy, precision, and completeness.

3.2 Quality Assurance Objectives for Accuracy

Analytical accuracy is expressed as the percent recovery of an analyte which has been used to fortify an investigative sample or a standard matrix (e.g., blank soil, analyte-free water, etc.) at a known concentration prior to analysis, and is expressed by the following formula:

$$\text{Accuracy} = \%\ \text{Recovery} = \frac{A_T - A_O}{A_F} \times 100\%$$

where:

A_T = Total amount found in fortified sample

A_O = Amount found in unfortified sample
A_F = Amount added to sample

The fortified concentration will be specified by laboratory quality control requirements, or may be determined relative to background concentrations observed in the unfortified sample. In the latter case, the fortified concentration should be enough different (2 to 5 times higher) from the background concentration to permit a reliable recovery calculation.

The quality assurance objectives for organic and inorganic analyses are tailored to the analytical technique used, and are discussed separately in subsequent sections of this QAP.

3.2.1 Metals/Inorganics Analysis

For metals analysis, analytical accuracy is obtained from the analyte recovery measured in a laboratory control standard and/or a sample fortified with the element of interest. The QA objectives for accuracy in routine metals analysis for these QC samples are summarized below:

Sample	Recovery (%)
Laboratory Control Standard (LCS)	80-120*
Fortified Field Sample	75-125

Recovery values outside the QC limits for an LCS (* with the exception of antimony and silver) will trigger corrective action. Recovery values for fortified field samples are advisory only.

For non-routine metals and inorganic parameters, laboratory control charts have been established and will be used to define Quality Assurance objectives.

3.2.2 Organic Analysis (GC and GC/MS)

For organic analysis, analytical accuracy is obtained from the surrogate recovery measured in each sample and blank and/or from the analysis of samples or blanks which have been fortified with a select number of target analytes.

The Quality Assurance objectives for accuracy are summarized in Table 3-1 for GC/MS surrogates and in Table 3-2 for GC/MS target analytes from fortified samples. The recovery values for surrogates and target analytes in investigative sample analyses are advisory for routine laboratory analysis. Only recovery values for standard matrix samples (e.g., blanks) are used for triggering corrective action, except for work performed under U.S. EPA CLP contract conditions, at which time CLP requirements are followed.

3.3 Quality Assurance Objectives for Precision

Analytical precision is calculated by expressing as a percentage the difference between results of analysis of duplicate samples relative to the average of those results for a given analyte. Precision can be expressed by the formula:

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

where:

RPD = Relative Percent Difference
C_1 = Concentration of analyte in sample
C_2 = Concentration of analyte in replicate

On the occasion when three or more replicate analyses are performed, precision is calculated by expressing as a percentage, the standard deviation of the analytical results of the replicate determinations relative to the average of those results for a given analyte. This precision measurement, percent relative deviation (% RSD), will have QA objectives identical to those for % RPD, and can be expressed by the formula:

$$\% \text{ RSD} = \frac{\sqrt{\Sigma c^2 - (\Sigma c)^2/n(n-1)}}{(C1 + C2 + \ldots Cn)/n} \times 100\%$$

where:

RSD = percent relative deviation
C = concentration of analyte in the sample, and (C_1 + C_2 + ...C_n) represents the sum of the concentration of each replicate
n = number of replicate analyses
Σ = "the summation of"

The QA objectives for metals (and other inorganic parameters) analysis are different from those for organic analyses. These QA objectives are discussed separately in the sections below.

3.3.1 Metals and Miscellaneous Inorganic Analyses

For metals (except antimony and silver) and inorganic analyses the QA objective for precision is ± 20% relative percent difference (% RPD) between replicate analyses. % RPD values outside the QC limits for duplicate LCS analyses will trigger corrective action. % RPD for duplicate investigative sample analyses are advisory only.

3.3.2 Organic Analyses (GC, GC/MS)

For organic analyses, precision is measured by comparison of the recovery of surrogate compounds in the standard matrix (e.g., blank, blank spike) and/or by comparison of the recovery of a

select number of target analytes in duplicate fortified samples or duplicate fortified blanks (e.g., matrix spike/matrix spike duplicate: MS/MSD, and/or blank spike/blank spike duplicate: BS/BSD). The QA objectives for precision as expressed by the % RPD for duplicate analysis of target analytes are given in Table 3-2. For surrogate compounds, laboratory control charts have been established and will be used to define QA objectives. These RPD limits are advisory only for investigative samples. Only evaluation of precision for standard matrices will trigger corrective action.

3.4 QA Objective for Data Completeness

Completeness is a measure of the relative number of analytical data points which meet all the acceptance criteria for accuracy, precision, and any other criteria required by the specific analytical methods used. The level of completeness can also be affected by loss or breakage of samples during transport, as well as external problems which prohibit collection of the sample.

The WESTON QA objective for completeness is to have 80% of the data usable without qualification. The ability to meet or exceed this completeness objective is dependent on the nature of samples submitted for analysis. For example, if the analytical methods proposed for use (particularly for organics analyses) are intended for analysis of environmental samples of low and medium hazard, the applicability of these methods to non-routine matrices such as drum samples, wipes, air samples, etc. may result in poor method performance and therefore adversely impact achievement of the data completeness goal.

TABLE 3-1

QUALITY ASSURANCE OBJECTIVES FOR ACCURACY FOR ORGANIC SURROGATE ANALYSES

Fraction	Surrogate Compound	Percent Recovery Low/Medium Water	Percent Recovery Low/Medium Soil/Sediment
VOA	Toluene-d8	88-100	81-117
VOA	4-Bromofluorobenzene	86-115	74-121
VOA	1,2-Dichloroethane-d4	76-114	70-121
BNA	Nitrobenzene-d5	35-114	23-120
BNA	2-Fluorobiphenyl	43-116	30-115
BNA	p-Terphenyl-d14	33-114	18-137
BNA	Phenol-d5	10- 94	24-113
BNA	2-Fluorophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122
PEST	Dibutylchlorendate	24-154*	20-150*

* These recoveries are advisory only. No corrective action (i.e., sample reanalysis) will be taken if these criteria are not met.

TABLE 3-2

QA OBJECTIVES FOR ACCURACY AND PRECISION FOR ORGANIC TARGET COMPOUND ANALYSES

Fraction	Matrix Spike Compound	% Recovery Limits Water	% Recovery Limits Soil/Sed	% RPD Limits Water	% RPD Limits Soil/Sed
VOA	1,1-Dichloroethene	61-145	59-172	14	22
VOA	Trichloroethene	71-120	62-137	14	24
VOA	Chlorobenzene	75-130	60-133	13	21
VOA	Toluene	76-125	59-139	13	21
VOA	Benzene	76-127	66-142	11	21
BN	1,2,4-Trichloro-benzene	39- 98	38-107	28	23
BN	Acenaphthene	46-118	31-137	31	19
BN	2,4-Dinitrotoluene	24- 96	28- 89	38	47
BN	Pyrene	26-127	35-142	31	36
BN	N-nitroso-di-N-propylamine	41-116	41-126	38	38
BN	1,4-Dichlorobenzene	36- 97	28-104	28	27
ACID	Pentachlorophenol	9-103	17-109	50	47
ACID	Phenol	12- 89	26- 90	42	35
ACID	2-Chlorophenol	27-123	25-102	40	50
ACID	4-Chloro-3-methyl-phenol	23- 97	26-103	42	33
ACID	4-Nitrophenol	10- 80	11-114	50	50
PEST	Lindane	56-123	46-127	15	50
PEST	Heptachlor	40-131	35-130	20	31
PEST	Aldrin	40-120	34-132	22	43
PEST	Dieldrin	56-126	31-134	18	38
PEST	Endrin	56-121	42-139	21	45
PEST	4,4-DDT	38-127	23-134	27	50
PCB	Arochlor 1254	Not Established		30	50

% RPD = Relative Percent Difference

This list includes those compounds most commonly used for QA/QC accuracy and precision control in the groups of analytes shown based on current U.S. EPA Contract Laboratory Program (CLP) requirements. (USEPA SOW 10/86 as revised through 8/87). Stated control limits will be updated to the current CLP protocol, as required.

4.0 Sampling Procedures

4.1 Introduction

While samples submitted to the laboratory for analysis are generally collected by non-laboratory personnel, WESTON fully recognizes the importance of the sample collection program in the overall assessment of data quality and usability. Sampling procedures must ensure the integrity of the samples collected, provide representative samples of the media being evaluated, and be compatible with planned laboratory analysis.

4.2 Sampling Plan

The objective of sampling is to obtain information that provides a qualitative and quantitative measure of site conditions, so that appropriate action can be taken relative to project goals. These goals encompass areas such as:

- preliminary site investigation,
- emergency cleanup operations,
- remedial response operations,
- backup for litigation purposes,
- monitoring, and
- research or technology transfer.

It is important, therefore, that the sampling effort be preceded by a well-planned, custom-tailored sampling plan for each project. This will help ensure that goals are met, that sampling is completed in a timely, cost effective manner, safety of sampling personnel is maximized, samples are representative of the site, sampling errors are reduced, and integrity of the sample is preserved during and after sampling.

The sampling plan should address: (1) the definition of objectives, (2) selection of representative sampling sites, (3) collection of sufficient volumes of material, (4) selection and preparation of proper sample containers, (5) preservation of sample integrity, (6) identification of samples, (7) proper sample holding times, (8) safe handling and transportation procedures, and (9) standard chain-of-custody procedures.

The following steps are essential in preparation of the sampling plan:

1. Research background information on the site and samples: evaluate the site history, review any data available from prior sampling excursions, review available geotechnical data, consider the materials to be sampled (composition, form, expected concentrations, etc.), determine what analyses will best address the issues at the site.

2. Determine safety requirements and arrange for equipment and procedural needs for safe sampling.

3. Consider proper locations for sampling.

4. Determine the sample volume required for each location, with special considerations given to the type of sample container and preservative needed for each analyte. Analytes with the same container/preservative requirement may be able to be combined into one larger container (i.e., 1 L rather than three 250 mL bottles). Allow sufficient volume for field and laboratory QC samples.

5. Determine the sampling equipment needed and arrange to have the necessary facilities and supplies for proper decontamination between samples.

6. Review procedures for sample collection and plan training or refresher courses for samplers.

7. Review procedures for containing and handling samples.

8. Properly execute chain-of-custody procedures, beginning with bottle preparation.

9. Identify necessary packaging, labeling, and shipping requirements, including the following:

   a. Identify samples and protect from tampering (secure evidence tape if available).

   b. Record all sample information in a bound field notebook.

   c. Fill out the chain-of-custody sample analysis request form.

10. Deliver or ship the samples to the laboratory for analysis.

11. Consider analyte holding times when determining shipping frequency. Many laboratory contractual agreements measure holding times from the date of receipt at the laboratory, while regulatory holding times are measured from the date of sample collection.

4.2.1 <u>Safety</u>

The sampling plan will delineate the safety procedures for sample collection, such as respiratory protection required while sampling concentrated sources, procedures for entering buildings

or enclosed structures, length of time personnel are to remain in protective clothing while sampling, and identification of the person handling the field samples. Proper procedures must be used when opening drums, tanks, or other vessels, and all personnel must be notified of potential hazards when closed containers will be opened.

The sampling plan will also list telephone numbers, addresses, and directions to the nearest medical facility, ambulance service, fire department, police department, and the client contact. The fire department should be alerted to possible incidents during a very hazardous inspection.

4.2.2 Sampling Points

A representative sample is crucial to decision-making and to enforcement proceedings and is dependent on proper selection of sampling points. Special consideration will be required for hazardous wastes, which are usually multi-phase mixtures and are stored in receptacles of different sizes and shapes. No single series of sampling points can be specified for all types of waste receptacles. Table 4-1 lists most types of receptacles used for hazardous waste and the corresponding recommended sampling points.

In some cases, it may be appropriate to conduct a preliminary survey of the facility prior to sampling. This would consist of a brief site visit and survey, during which time safety requirements for the site would be ascertained and a sampling plan established by the inspector.

4.2.3 Volume of Samples

Sufficient volume of a sample, representative of the main body of the water or waste, must be collected. This sample must be adequate in size for all needs, including laboratory analysis, splitting with other organizations involved, etc. In all cases, the laboratory should be consulted for guidance prior to sampling. As general guidance, the sample containers provided by the laboratory should be filled. This will provide adequate volumes to perform analysis once. Choose at least one sample per twenty (20) for each matrix and collect triple volumes for all analytes to allow sufficient sample for laboratory duplicate and spike analysis.

4.2.4 Sampling Equipment

Receptacles (i.e., drums, tanks, etc.), should only be sampled when necessary to meet enforcement or cleanup requirements. Opening of drums or other sealed receptacles may be hazardous to sampling personnel unless proper safety procedures are followed.

Samples of waste materials, water, soil, or sediments will be collected through the use of peristaltic, mechanical or automatic pumps, soil augers, sediment dredges, hand scoops, and other equipment (see Table 4-2) as required. All samples should be collected in a manner that assures no contamination between samples. When possible, dedicated equipment should be used for each site to avoid the need for field cleaning of utensils.

Samples from drums, bags, reservoirs, or other small vessels are generally obtained by a dip or insertion tube (coliwasa sampler). After agitation of the vessel or container, if possible, the tube is inserted diagonally, sealed, and removed. Thus, the sample obtained is a cross-sectional representative sample, avoiding bias due to stratification of material in the container. Sometimes it is difficult to obtain a representative sample of large containers, such as bulk liquid storage tanks. In these cases, often the only sampling location is a bottom valve, and the sample obtained is from the bottom layer within the tank. Many times this may be a "worst case" sample, especially for PCB's and other dense substances. Whenever possible, surface, middle, and bottom samples are collected from large bulk liquid storage tanks in order to avoid possible stratification bias. Using this tiered sampling technique helps to accurately characterize the overall concentration of the parameter of interest. A general list of usage of sampling equipment is given in Table 4-3.

Sampling personnel frequently are required to split samples collected with facility personnel or EPA laboratories. It is essential that a true duplicate split be made, otherwise analytical results will not be comparable.

To obtain a true duplicate, a large quantity of sampled material will be collected, thoroughly mixed, and equally proportioned into similar containers. If preservation is necessary, both are preserved with an appropriate chemical from a common dispenser at the same time. Both duplicates are labeled with the same sample location description and marked as splits and logged into a field notebook.

4.3 Sample Containers

Upon request from the client, WESTON will provide, within 7 days, the required number and type of sample containers for a specific sampling episode.

All containers provided by WESTON will be obtained from I-Chem, Hayward, California, or be of equivalent quality. I-Chem is the bottle contractor to the U.S. EPA-Contract Laboratory Program. These containers are cleaned by I-Chem in accordance with U. S. EPA protocols. The containers purchased from I-Chem are I-Chem Series 200 containers. Each lot of these containers is analyzed

in accordance with I-Chem quality control requirements and is not shipped by I-Chem unless the QC requirements are met.

All sample containers provided by WESTON will be shipped with chain-of-custody sheets (see Section 5). These chain-of-custody sheets will be completed by the field sampling personnel and returned with the samples.

4.4 Sample Preservation and Holding Times

The preservatives required for all analyses will be provided by WESTON with the sample containers. The required preservation methods will be in accordance with those given in 40 CFR, Part 136, No. 209, October 26, 1984, for water and in SW-846, Test Methods for Evaluating Solid Waste, Third Edition, November 1986, for soils.

The holding times for all required analyses are measured from sample collection, and are given in SW-846, Test Methods for Evaluating Solid Waste, Third Edition, November 1986. (This reference includes 40 CFR, Part 136, No. 209, October 1984 holding times for routine water samples, as well as holding times for waste samples.)

Some programs, e.g. the U.S. EPA Contract Laboratory Program (CLP) and CLP-type agency or client programs, measure holding times from verified time of sample receipt (VTSR) at the laboratory. Samples designated as CLP must specify in the project plan that holding times from sample collection are superseded by holding times from VTSR.

Upon sample receipt at the WESTON Laboratory all sample collection dates are noted by the sample custodian. The required date for completion of analysis (or extraction) is noted on the chain-of-custody sheet (see Section 5) and is keyed to the holding time if it falls sooner than the required reporting date for analyses.

All analyses which have holding times of 48 hours or less are identified by the sample custodian, and the appropriate section manager, unit leader and analyst are notified that samples are in house.

4.5 Sampling Procedures

Sampling procedures will vary depending on the medium sampled (liquid, solid, or gas) and the type of structure the waste is contained in, as indicated in Table 4-1. Sampling procedures to be used will be standardized as described in the "NPDES Compliance Sampling Manual," U.S. EPA, Office of Water Enforcement (October, 1979), "Samplers and Sampling Procedures for Hazardous Waste Streams," U.S. EPA, Municipal Environmental

Research Laboratory (January, 1980), and SW-846 Test Methods for Evaluating Solid Waste, Third Edition (November 1986). Sample collection of project sites in the state of New Jersey will conform to the New Jersey Department of Environmental Protection Field Sampling Procedures Manual, February 1988.

4.6 Sample Handling and Packing

Sample handling and packing procedures are in accordance with the User's Guide to the U.S. EPA Contract Laboratory Program. The collected sample and its container represent one of the major avenues of personnel and environmental exposure. Precautions will be taken to ensure that all the samples removed from the site are within the sample container and that no residue remains on the outside of the container.

A unique code number is assigned to each sample. All sample bottles will be differentiated by use of a sample label. All information pertinent to the field activities will be recorded in bound field notebooks. The notebooks must contain the following information:

- source of sample (including plant name, location, and sample point description),
- analysis required and preservative type (where applicable),
- name of collector, date and time of collection, physical/environmental conditions during field activity,
- matrix sampled, sample collection method, number and volume of samples taken,
- sample identification number(s), custody seal numbers,
- any field measurements, and
- documentation of shipping dates and methods.

Samples will be packed and shipped following U.S. EPA recommended procedures and in accordance with applicable DOT regulations. Chain-of-custody is initiated in the field and will travel with the samples. Custody seals will be affixed to the shipping container. A detailed discussion of chain-of-custody procedures is found in Section 5.

Table 4-1

SAMPLING POINTS FOR MOST WASTE RECEPTACLES

Receptacles	Sampling Point
Drum, bung on one end	Withdraw sample through the bung opening.
Drum, bung on side	Sample drums only if they are laying on side with bung up. Withdraw sample through the bung opening.
Barrel, fiberdrum, buckets, sacks, bags	Withdraw samples through the top of barrels, fiberdrum, buckets, and similar receptacles. Withdraw samples through fill openings of bags and sacks. Withdraw samples through the center of the receptacles and to different points diagonally opposite the point of entry.
Vacuum truck and similar containers	Withdraw sample through open hatch. Sample all other hatches.
Pond, pit, lagoons	Divide surface area into an imaginary grid.* Take three samples, if possible; one sample near the surface, one sample at mid-depth or at center, and one sample at the bottom. Repeat the sampling at each grid section over the entire pond or site.
Waste pile	Withdraw samples through at least three different points near the top of pile to points diagonally opposite the point of entry.
Storage tank	Sample from the top through the sampling hole.
Soil	Divide the surface area into an imaginary grid.* Sample each grid section.

* The number of grid sections is determined by the desired number of samples to be collected which, when combined, should give a representative sample of the wastes.

Table 4-2

SAMPLING EQUIPMENT

Sampling plan
Sample containers (plastic and glass), caps, liners
Shovels
Soil Samplers (auger, scoop, steel spoon, etc.)
Stainless steel buckets
Remote barrel opener equipment, non-sparking bung wrench
Thermometer
Drager tubes
Tenax columns and power packs
Ambient air monitor
Surveyor's ribbon
Glass pipets and glass tubing
Wooden paddles (tongue depressors)
Monitoring well sampling equipment
Well sounder
Radiation detector (beta, gamma)
Explosimeter
pH paper
pH meter, spare probes

Table 4-3

SAMPLING EQUIPMENT FOR PARTICULAR WASTE TYPES

Type of Waste	Sampling Point: Drum	Sacks and Bags	Open Bed Truck	Closed Bed Truck	Storage Tanks or Bins	Waste Piles	Ponds, Lagoons & Pits	Con-veyor Belt	Pipe
Free Flowing Liquids and Slurries	Coli-wasa	N/A	N/A	Coli-wasa	Weighted Bottle	N/A	Dipper	N/A	Dipper
Sludge	Scoop	N/A	Scoop	Scoop	Scoop	N/A		N/A	N/A
Moist Powders or Granules	Scoop	Scoop	Scoop	Scoop	Scoop	Scoop	Scoop	Shovel	
Dry Powders or Granules	Thief	Thief	Thief	Thief	Thief	Thief	Thief	Shovel	
Sand or Packed Powders	Auger	Auger	Auger	Auger				N/A	
Large Grained Solids	Large Scoop	Large Scoop	Large Scoop	Large Scoop	Large Scoop	Large Scoop	Large Scoop	Large Scoop	

5.0 Chain-of-Custody

5.1 Introduction

The purpose of chain-of-custody procedures is to document the history of sample containers and samples (and sample extracts or digestates) from the time of preparation of sample containers, through sample collection, shipment and analysis. An item is considered to be in one's custody if:

1. it is in the physical possession of the responsible party,

2. it is in the view of the responsible party,

3. it is secured by the responsible party to prevent tampering, or

4. it is secured by the responsible party in a restricted area.

As discussed in Section 4, when sample containers are provided by WESTON, chain-of-custody documentation (see Figure 5-1) will be shipped with the sample containers. These forms will be completed by field personnel, with acknowledgment of time and date of transfer and placed in the shipping container in the plastic Ziploc container provided.

The following sections describe chain-of-custody procedures associated with sample receipt, storage, preparation, and analysis and general security procedures.

5.2 Sample Receipt

A designated sample custodian is responsible for samples received at WESTON. This individual is trained in all custody requirements and in the potential hazards of dealing with hazardous waste materials. In addition to receiving samples, the sample custodian is also responsible for documentation of sample receipt, storage before and after sample analysis, and eventual proper disposal of samples.

1. Upon receipt, the sample custodian will inspect the sample container for integrity. The presence of leaking or broken containers will be noted on the chain-of-custody form (see Figure 5-1). The sample custodian will sign (with date and time of receipt) the chain-of-custody form, thus assuming custody of the samples. If chain-of-custody forms are not included, the sample custodian will initiate these forms.

2. The information on the chain-of-custody form will be compared with that on sample tags and labels to verify sample identity. Any inconsistencies will be resolved with the field sampling representative before sample analysis proceeds.

3. Samples will be moved to one of the locked sample storage refrigerators (maintained at 4° ± 2°C) for storage prior to analysis. The storage location will be recorded on the chain-of-custody form.

4. The sample custodian will maintain the original of the chain-of-custody form in the sample log-in area and require all analysts to sign receipt and return of the sample when it is obtained for analysis. Copies of the chain-of-custody are provided to the laboratory Report Manager, to each laboratory Section Manager, to the respective Unit Leaders, and to the Project Manager.

5. The sample custodian will alert appropriate section managers and analysts of any analyses requiring immediate attention because of short holding times.

6. The sample custodian will log the sample information into the Laboratory Information Management System (LIMS). These data include laboratory number, field sample number, dates collected and received, project or client identification, and parameters to be analyzed.

5.3 Sample Storage

Samples will be maintained in storage in one of the locked storage refrigerators prior to sample preparation and analysis. The standard operating procedures for sample storage are described in detail in WESTON SOPs; a summary of these procedures follows.

Storage refrigerators are maintained at 4° ± 2°C. The temperature is monitored by the laboratory security system and recorded daily in a bound log by the sample custodian. During working hours, if equipment failure (compressor failure, door left open, etc.) results in the temperature of the storage refrigerator exceeding the upper or lower control limits, an audible alarm will sound and the samples will be moved to suitably controlled storage until the problem has been corrected. During off working hours, the alarm is automatically transferred to the security agency who alerts (via beeper call) laboratory and maintenance personnel so that prompt corrective action can be taken.

Refrigerator storage is designed to segregate samples to prevent cross-contamination and to prevent sample mix-up. This includes

storage of volatiles samples separate from semivolatiles and inorganics samples. Within the refrigerators, samples are stored by RFW batch # for easy retrieval. Analysts request samples for analysis from the sample custodian. Both sign the chain-of-custody acknowledging transfer of custody to the analyst.

5.4 Sample Tracking

The standard operating procedures for sample tracking are described in detail in WESTON SOPs. They are summarized in this section.

5.4.1 Organic Analysis

Samples are received by the Organic Sample Preparation Section for extraction prior to analysis by gas chromatography, GC/MS, or liquid chromatography. All pertinent data are recorded in a bound laboratory notebook. This information is transferred to the Laboratory Information Management System (LIMS) and a hard-copy Sample Extraction Record is generated. A copy of this form is shown in Figure 5-2. The original is placed on the facing page of the laboratory notebook where extraction data have been entered and is used for custody transfer documentation to the analyst. Copies are provided to the analyst to inform them that extracts are ready for analysis.

Extracts are maintained by the Organic Sample Preparation Section in refrigerated storage until transferred to the analysts.

5.4.2 Metals Analysis

Samples are received by the Metals Sample Preparation Section for digestion prior to analysis for metals by Atomic Absorption Spectroscopy or Inductively Coupled Plasma Spectroscopy. When samples are prepared for digestion, the preparation technician records the pertinent information in a laboratory digestion notebook. This information is then transferred to LIMS and a hard-copy Sample Digestion Record is generated. A copy of this form is shown in Figure 5-3. The digestion record is maintained to acknowledge custody transfer of digestates to the metals analysis section. A copy of the Sample Digestion Record is provided to the metals analysis section to alert them that digestates are ready for analysis.

The original copy of the Sample Digestion Record is retained by the Metals Sample Preparation Section.

5.4.3 Record Keeping

Data related to all sample preparation and analysis procedures and observations by laboratory analysts are recorded in bound

laboratory notebooks which are issued by the Laboratory Quality Assurance Coordinator. Laboratory notebook pages are signed and dated daily by laboratory analysts. Corrections to notebook entries are made by drawing a single line through the erroneous entry and writing the correct entry next to the one crossed out. All corrections are initiated and dated by the analyst.

5.4.4 Building Security

The WESTON Laboratory maintains controlled building access at all times. During working hours, all non-WESTON laboratory personnel are required to sign in with the receptionist and are escorted by laboratory personnel while in the building.

The laboratory is locked between the hours of 5:00 p.m. and 8:00 a.m. Monday through Friday and during the weekend. The building is secured during non-working hours by an ADT Security System. This security system not only monitors building access but also monitors the temperature in the sample storage refrigerators. If the control temperature range is exceeded during working hours, an audible alarm sounds. During non-working hours, a silent alarm alerts ADT. Response by laboratory personnel is described below.

The building is accessed by laboratory employees during non-working hours by using a key and the passcode for the Building Security System.

Any breach of security during non-working hours releases a silent alarm to the security agency who alert the local law enforcement agency and one of three laboratory personnel via beeper call. Police response to security alarms takes place within 5 minutes and laboratory personnel are on-site within 20 minutes.

FIGURE 5-1

WESTON CUSTODY TRANSFER-WORK REQUEST FORM

WESTON Analytics Use Only

Custody Transfer Record/Lab Work Request

WESTON

Client _____
Work Order _____
Date Rec'd. _____ Date Due _____
RFW Contact _____
Client Contact/Phone _____

		Refrigerated									
		#/Type Container									
		Volume									
		Preservative									
		ANALYSES REQUESTED									
WA Use Only Lab ID	Client ID/Description	Matrix	Date Collected								

Matrix:
S - Soil
SE - Sediment
SO - Solid
W - Water
O - Oil
A - Air
WI - Wipe
DS - Drum Solids
DL - Drum Liquids
F - Fish
X - Other

Special Instructions:

Item/Reason	Relinquished by	Received by	Date	Time	Item/Reason	Relinquished by	Received by	Date	Time

WESTON Analytics Use Only

Samples Were:
1 Shipped or Hand-Delivered
NOTES:

2 Ambient or Chilled
NOTES:

3 Received Broken/Leaking (Improperly Sealed)
Y N
NOTES:

4 Properly Preserved
Y N
NOTES:

5 Received Within Holding Times
Y N
NOTES:

COC Tape Was:
1 Present on Outer Package Y N
2 Unbroken on Outer Package Y N
3 Present on Sample Y N
4 Unbroken on Sample Y N
NOTES:

COC Record Was:
1 Present Upon Receipt of Samples Y N

Discrepancies Between Sample Labels and COC Record? Y N
NOTES:

RFW 21-21-001/A-7/88

7-115

FIGURE 5-2

WESTON SAMPLE EXTRACTION FORM

SAMPLE EXTRACTION RECORD

Sheet No: 1

Extract. Date: Extraction Batch No: Analyst: Method:

Test: Cleanup Date: Analyst: Client:

Solvent: Adsorbent:

Sample No:	Client ID	pH	Initial WT/VOL	Surr. Mult.	Spike Mult.	Final VOL	Final VOL N/A	Split Mult.	% Solids	C/D FACTOR

Comments:
Surrogate:
Spike:

Extracts Transferred	Relinquished By	Date Time	Received By	Date Time	Reason for Transfer

FIGURE 5-3

WESTON SAMPLE DIGESTION RECORD

SAMPLE DIGESTION RECORD

Sheet No: 1 of 1

Digestion Date: Digestion Batch No: Analyst: Client:

Completion Date: Type of Prep.: Method: Matrix:

Parameters:

Type of Analysis:

Sample No:	Initial WT/VOL	Final VOL	Spike Mult.	pH <2>	% Solids	C/D FACTOR	Comments	PAN WT	WET WT	DRY WT

DIGESTION CUSTODY SHEET

Extracts Transferred	Relinquished By	Date Time	Received By	Date Time	Reason for Transfer

6.0 Calibration Procedures

Before any instrument is used as a measurement device, the instrumental response to known reference materials must be determined. The manner in which various instruments are calibrated is dependent on the particular type of instrument and its intended use. All sample measurements are made within the calibrated range of the instrument. Preparation of all reference materials used for calibration will be documented in a standards preparation notebook.

Instrument calibration typically consists of two types: initial calibration and continuing calibration. Initial calibration procedures establish the calibration range of the instrument and determine instrument response over that range. Typically, three to five analyte concentrations are used to establish instrument response over a concentration range. The instrument response over the range is generally absorbance, peak height, etc., which can be expressed as a linear model with a correlation coefficient (e.g. for Atomic Absorption, Inductively Coupled Plasma, UV-Visible-Infrared Spectrophotometry, Ion Chromatography) or as a response factor or amount vs. response plot (e.g. for Gas Chromatography, Gas Chromatography/Mass Spectrometry, High Performance Liquid Chromatography).

Continuing calibration usually includes measurement of the instrument response to fewer calibration standards and requires instrument response to compare with certain limits (e.g. $\pm$ 10%) of the initial measured instrument response. Continuing calibration may be used within an analytical sequence to verify stable calibration throughout the sequence, and/or to demonstrate that instrument response did not drift during a period of non-use of the instrument.

Specific instrument calibration procedures for various instruments are detailed in Section 7 of this QAP.

7.0 Analytical Procedures

Routine analytical services are performed using standard EPA-approved methodology. In some cases, modification of standard methods may be necessary to provide accurate analyses of particularly complex matrices. When modifications to standard analytical methods are performed, the specific alterations, as well as the reason for the change, will be reported with the results of analysis. Choice of method is determined by the type of samples and the client/agency program represented. These programs include, but are not limited to the following:

- Drinking Water,
- Wastewater,
- Hazardous Waste, and
- Air.

For non-routine analytical services (e.g. special matrices, research projects, non-routine compound lists, etc.), the method of choice is selected based on client needs and available technology.

The laboratory's reported method detection limits (MDL's) are based on program requirements, sample matrix, and in-house instrument capabilities. These MDL's may be higher than published method detection limits. However, published MDL's are generally determined using clean matrices which are free of interferences, such as deionized water, and which are analyzed under optimal laboratory conditions. For actual sample analysis, these MDL's may not be routinely achievable. Procedures in place to demonstrate that reported detection limits are obtainable, are described in the ensuing subsections of this section.

Individual sample detection limits may vary from the laboratory's routinely reported detection limits. This may be due to dilution requirements, variability in sample weight or volume used to perform the analysis, dry weight adjustment for solid samples, the presence of analytical background contaminants, or other sample-related or analysis-related conditions.

7.1 Gas Chromatography/Mass Spectrometry (GC/MS)

7.1.1 Tuning and GC/MS Mass Calibration

Mass spectrometers are calibrated with perfluorotributylamine (FC-43) as required to ensure correct mass assignment. In addition, once per 12-hour shift these instruments are tuned with decafluorotriphenylphosphine (DFTPP) for semivolatiles analysis and 4-bromofluorobenzene for volatiles analysis . Ion abundances will be within the windows dictated by the specific program requirements.

7.1.2 GC/MS: Initial Calibration

Once an instrument has been tuned, initial calibration curves for analytes appropriate to the analyses to be performed are generated for at least five solutions containing known concentrations of authentic standards of compounds of concern. These solutions are generally cocktails of the method target analytes. The calibration curves will bracket the anticipated working range of analyses. For some compounds in the calibration standard cocktail, such as benzoic acid, 2,4-dinitrophenol, 2,4,5-trichlorophenol, 2-nitroaniline, 3-nitroaniline, 4-nitroaniline, 4-nitrophenol, 4,6-dinitro-2-methylphenol, and pentachlorophenol, the detection is difficult at the lowest calibration appropriate for the majority of the compounds in the mix. In these instances, a four-point initial calibration will be acceptable. Linearity is verified by evaluating the response factors (RF) for the initial calibration standards. For an acceptable calibration, the percent relative standard deviation (% RSD) for the RF's of specified Calibration Check Compounds (CCC's) will be <30 percent. In addition, a minimum average RF of 0.050 must be demonstrated for specified System Performance Check Compounds (SPCC's). These specified CCC's and SPCC's are listed in Table 7-1.

Calibration data, to include linearity verification, will be maintained in the laboratory's permanent records of instrument calibrations.

7.1.3 GC/MS: Continuing Calibration

During each 12-hour operating shift, a daily midpoint calibration standard is analyzed to verify that the instrument responses are still within the initial calibration determinations. The response factor for each target compound in the daily standard is calculated and recorded, then compared to the average RF from the initial calibration. If significant (>30%) RF drift is observed for the CCC's, appropriate corrective actions will be taken to restore confidence in the instrumental measurements. In addition, a minimum RF of 0.050 must be reported for SPCC's.

7.1.4 GC/MS: Quality Control

All GC/MS analyses will include analysis of a method blank, a method blank spike (semi-volatiles and pesticides/PCB's), a matrix spike, and a laboratory duplicate in each lot of twenty (20) or fewer samples. The matrix spike solutions will contain the compounds listed in Table 3-2 and will be used for both matrix spikes and blank spikes. In addition, appropriate surrogate compounds as specified in Table 3-1 will be spiked into each sample. Recoveries from method spikes and surrogate compounds are calculated and recorded on control charts to maintain a history of system performance.

A method blank spike duplicate sample may be analyzed in place of the matrix spike for analytical lots of less than ten (10) samples.

Audit samples will be analyzed periodically to compare and verify laboratory performance against standards prepared by outside sources.

7.1.5 GC/MS: Detection Limits

The laboratory's detection limits routinely used for reporting GC/MS data are compared with laboratory-determined instrument detection limits to ensure that the reported values are attainable. Instrument detection limits are determined from triplicate analysis of target compounds measured at three to five times the reporting limit. The calculated instrument detection limit is three times the standard deviation of the measured values.

7.2 Gas Chromatography (GC) and High Performance Liquid Chromatography (HPLC)

7.2.1 GC & HPLC: Initial Calibration

Gas chromatographs and high performance liquid chromatographs will be calibrated prior to each day of use. Calibration standard mixtures will be prepared from appropriate reference materials and will contain analytes appropriate for the method of analysis.

Working calibration standards for initial calibration will be prepared fresh daily. The working standards will include a calibration blank and five (5) calibration standards covering the anticipated range of measurement. At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of this calibration must be equal to or greater than 0.990 to consider the response linear over a range. If a correlation coefficient of 0.990 cannot be achieved, additional standards must be analyzed to define the calibration curve.

7.2.2 GC & HPLC: Continuing Calibration

The response of the instrument will be verified for each analysis sequence by evaluation of a mid-range calibration check standard. In order to demonstrate that the initial calibration curve is still valid, the calibration check standard must be within ± twenty percent (20%) recovery of the initial calibration for the compounds of interest or the instrument must be recalibrated. For multi-analyte methods, this check standard may contain a representative number of target analytes rather than the full

list of target compounds. Optionally, initial calibration can be performed at the beginning of the analysis sequence.

Within the analysis sequence, instrument drift will be monitored by analysis of a mid-range calibration standard every 10 samples. The % difference (% D) in calibration factors (CF's) for the continuing calibration standard compared to the average CF from the initial calibration will be calculated and recorded. If significant (> 20%) calibration factor drift is observed for the compounds of interest, appropriate corrective actions will be taken to restore confidence in the instrumental measurements.

7.2.3 GC & HPLC: Quality Control

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the matrix being processed, the method spikes and blanks will be in aqueous media. Method spikes will be at a concentration of approximately five (5) times the detection limits.

The method blanks will be examined to determine if contamination is being introduced in the laboratory.

The method spikes will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery of the spikes. These recoveries will be plotted on control charts to monitor method accuracy. Precision will be measured by the reproducibility of both method spikes and will be calculated as relative percent difference (% RPD). These % RPD's will be plotted on control charts to monitor method precision.

7.2.4 GC & HPLC: Detection Limits

The laboratory's detection limits routinely used for reporting GC pesticide data are compared with laboratory determined instrument detection limits to ensure that the reporting values are attainable. Instrument detection limits are determined from triplicate analysis of target compounds measured at three to five times the reporting limit. The calculated instrument detection limit is three times the standard deviation of the measured values. For non-routine compounds, the reported detection limits will be limited by the lowest calibration standard analyzed for the respective method.

The reported detection limits for HPLC analyses are limited to the concentration of the lowest calibration standard analyzed on a particular day. The only exception to this for HPLC analyses are analyses conducted according to USATHAMA quality assurance plan," December 1985, 2nd Edition, March 1987 (U.S. Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD 21010-5401).

7.3 Atomic Absorption Spectrophotometry (AA): Flame & Furnace

7.3.1 AA: Initial Calibration

Atomic absorption spectrophotometers will be calibrated prior to each day of use. Calibration standards will be from appropriate reference materials, and working calibration standards prepared fresh daily. Initial calibration will include analysis of a calibration blank and a minimum of three (3) calibration standards covering the anticipated range of measurement. Duplicate injections will be made for each concentration. At least one of the calibration standards will be at or below the reported detection limit. The calibration curve generated must have a correlation coefficient equal to or greater than 0.996 in order to consider the responses linear over a range. If the correlation coefficient criteria of 0.996 are not met, the instrument will be recalibrated prior to analysis of samples.

Prior to analysis of samples, the initial calibration will be verified using a mid-range calibration standard from a source other than that used for initial calibration, and an initial calibration verification blank (ICB). The analysis result for the initial calibration verification standard (ICV) must be ± ten percent (10%) recovery of the true value. The ICB must be free of target analytes at and above the reporting limit. If the ICV or ICB are outside these criteria, the initial calibration must be repeated.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibration.

7.3.2 AA: Continuing Calibration

The initial calibration is verified during the analysis sequence by evaluation of a continuing calibration blank (CCB) and a continuing calibration verification standard (CCV) after every ten (10) samples are analyzed. The response of the continuing calibration verification standard must be within ± ten percent (10%) recovery of the true value. The continuing calibration blank must be free of target analytes at and above the reported detection limit.

7.3.3 AA: Quality Control

At least one method blank and two method blank spikes (laboratory control samples: LCS) will be included in each labortory lot of samples. Regardless of the matrix being processed, the LCS and blanks will be in aqueous media. The LCS will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory and will be analyzed at a frequency of one per analytical lot or five (5) percent of the samples, whichever is more frequent. The LCS will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must be within the range 80-120 percent to be considered acceptable, with the exception of antimony and silver, due to documented method deficiencies in achieving reliable recovery (reference EPA's Contract Laboratory Program). Additionally, the LCS % R will be plotted on control charts to monitor method performance.

Precision will be measured by the reproducibility of both LCS's and will be calculated as relative percent difference (% RPD). Results must agree within twenty (20) percent RPD in order to be considered acceptable. The LCS RPD will be plotted on control charts to monitor performance.

7.3.4 AA: Detection Limits

The laboratory's routinely reported detection limits are compared with laboratory-determined Instrument Detection Limits (IDL's) on a quarterly basis to ensure that the reported values are attainable. IDL's are determined from three nonconsecutive day's analysis of seven consecutive measurements of target compounds at three to five times the IDL. Each day's seven measured values are averaged and the respective standard deviation calculated. Three times the standard deviation of the average of the standard deviations obtained from the three days' analysis is defined as the IDL. The IDL's must be at or below the routinely reported detection limits.

7.4 Inductively Coupled Argon Plasma (ICP)

7.4.1 ICP: Initial Calibration

The inductively coupled argon plasma spectrophotometer will be calibrated prior to each day of use. Calibration standards will be prepared from reliable reference materials and will contain all metals for which analyses are being conducted. Working calibration standards will be prepared fresh daily. Quarterly, calibration will be performed with a blank and a minimum of five (5) concentrations to cover the anticipated range of measurement. Duplicate readings will be made for each concentration. At least one of the calibration standards will be at or below the reporting limit. The calibration curve generated must have a correlation coefficient equal to or greater than 0.996 in order to consider the responses linear over a range. If the correlation coefficient criteria of 0.996 are not met, the instrument will be recalibrated prior to analysis of samples.

On a daily basis, the instrument will be calibrated using a standard at the high end of the calibration range and a blank. Prior to analysis of samples, the initial calibration will be verified using a mid-range calibration standard from a source other than that used for initial calibration, and an initial calibration verification blank (ICB). The analysis result for the initial calibration verification standard (ICV) must be ± ten percent (10%) recovery of the true value. The ICB must be free of target analytes at and above the reporting limit. If the ICV or ICB are outside these criteria, the initial calibration must be repeated.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibration.

7.4.2 ICP: Continuing Calibration

The initial calibration is verified during the analysis sequence by analysis of a continuing calibration blank (CCB) and a continuing calibration verification standard (CCV) after every ten (10) samples are analyzed. The response of the continuing calibration verification standard must be within ± ten percent (10%) recovery of the true value. The continuing calibration blank must be free of target analytes at and above the reported detection limit.

7.4.3 ICP: Quality Control

At least one method blank and two method blank spikes (laboratory control sample: LCS) will be included in each laboratory lot of samples. Regardless of the matrix being processed, the LCS's and blanks will be in aqueous media. The LCS will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the labortory.

The LCS results will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must be within the range 80-120 percent to be considered acceptable. Additionally, the LCS % R will be plotted on control charts to monitor method accuracy.

Precision will be measured by the reproducibility of both LCS and will be calculated as relative percent difference (% RPD). Results must agree within twenty (20) percent RPD in order to be considered acceptable.

7.4.4 ICP: Detection Limits

The laboratory routinely reported detection limits are compared with laboratory-determined Instrument Detection Limits (IDL's) on a quarterly basis to ensure that the reported values are attainable. IDL's are determined from three nonconsecutive day's analysis of seven consecutive measurements of target compounds at three to five times the IDL. Each day's seven measured values are averaged and the respective standard deviation calculated. Three times the standard deviation of the average of the standard deviations obtained from the three days' analysis is defined as the IDL. The IDL's must be at or below the routinely reported detection limits.

7.5 Cold Vapor Mercury Analysis: Flameless AA (CVAA)

7.5.1 CVAA: Initial Calibration

The initial calibration procedures are as described in subsection 7.3.1 except that initial calibration requires analyses of a calibration blank and five (5) working standards. The correlation coefficient of the standard curve must be equal to or greater than 0.996. The initial calibration is verified by analysis of a calibration standard from an independent source prior to sample analysis. The response of the initial calibration verification standard must be within ± twenty percent (20%) recovery of the true value. If it is outside these limits, the instrument is recalibrated.

7.5.2 CVAA: Continuing Calibration

After every ten (10) samples, a continuing calibration blank (CCB) and continuing calibration verification standard (CCV) are analyzed. The response of the CCV must be within ± twenty percent (20%) recovery of the true value. The CCB must be free of target analyte at and above the reported detection limit.

7.5.3 CVAA: Quality Control

At least one method blank and two method blank spikes (laboratory control samples: LCS) will be included in each labortory lot of samples. Regardless of the matrix being processed, the LCS and blanks will be in aqueous media. The LCS will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory and will be analyzed at a frequency of one per analytical lot or five (5) percent of the samples, whichever is more frequent. The LCS will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must

be within the range 80-120 percent to be considered acceptable, with the exception of antimony and silver, due to documented method deficiencies in achieving reliable recovery (reference EPA's Contract Laboratory Program). Additionally, the LCS % R will be plotted on control charts to monitor method performance.

Precision will be measured by the reproducibility of both LCS's and will be calculated as relative percent difference (% RPD). Results must agree within twenty (20) percent RPD in order to be considered acceptable. The LCS RPD will be plotted on control charts to monitor performance.

7.5.4 CVAA: Detection Limits

The laboratory's routinely reported detection limits are compared with laboratory-determined Instrument Detection Limits (IDL's) on a quarterly basis to ensure that the reported values are attainable. IDL's are determined from three nonconsecutive day's analysis of seven consecutive measurements of target compounds at three to five times the IDL. Each day's seven measured values are averaged and the respective standard deviation calculated. Three times the standard deviation of the average of the standard deviations obtained from the three days' analysis is defined as the IDL. The IDL's must be at or below the routinely reported detection limits.

7.6 Total Organic Carbon (TOC)

7.6.1 TOC Initial Calibration

The total organic carbon analyzer will be calibrated prior to each day of use.

Calibration standards will be prepared from potassium hydrogen phthalate, and working calibration standards will be prepared fresh daily. The working standards will include a blank and a minimum of five (5) concentrations to cover the anticipated range of measurement.

At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of the plot of known versus found concentrations will be at least 0.996 in order to consider the responses linear over a range. If a correlation coefficient of 0.996 cannot be achieved, the instrument will be recalibrated prior to analysis of samples. Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

7.6.2 TOC: Continuing Calibration

A continuing calibration standard and blank will be analyzed at a frequency of ten percent (10%) and at the end of the analysis shift. The response calculated as a percent recovery of the standard must be ± fifteen percent (15%) of the true value. The response of the blank must be less than the detection limit.

7.6.3 TOC Quality Control

At least one method blank and two method spikes will be included in each laboratory lot of samples. Method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory. The method spikes will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must be within the range 80-120 percent to be considered acceptable. In addition, % R will be plotted on control charts to monitor method accuracy.

Precision will be measured by the reproducibility of both method spikes and will be calculated as relative percent difference (% RPD). Results must agree within twenty percent (20%) RPD in order to be considered acceptable.

7.6.4 TOC Detection Limits

The detection limits are based on the concentration of the lowest standard analyzed. Results below the lowest standard are reported as below the detection limit.

7.7 Ion Chromatography (IC)

7.7.1 IC Initial Calibration

The ion chromatograph will be calibrated prior to each day of use. Calibration standards will be prepared from appropriate reference materials, and working calibration standards for the ions of interest will be prepared fresh daily. The working standards will include a blank and a minimum of five (5) concentrations to cover the anticipated range of measurements. At least one of the calibration standards will be at or below the desired instrument detection limit. The correlation coefficient of the plot of known versus found concentrations will be at least 0.996 in order to consider the response linear over a range. If a correlation coefficient of 0.996 cannot be achieved, the instrument will be recalibrated prior to analysis of samples.

Calibration data, to include the correlation coefficient, will be entered into laboratory notebooks to maintain a permanent record of instrument calibrations.

7.7.2 IC: Continuing Calibration

A continuing calibration standard and blank will be analyzed at a frequency of ten percent (10%) and at the end of the analysis shift. The response calculated as a percent recovery of the standard must be ± fifteen percent (15%) of the true value. The response of the blank must be less than the detection limit.

7.7.3 IC: Quality Control

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the matrix being processed, the method spikes and blanks will be in aqueous media. Method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the laboratory.

The method spikes will be examined to determine both precision and accuracy. Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must be within the range of 80-120% to be considered acceptable. Additionally, % R will be plotted on control charts to monitor method accuracy.

Precision will be measured by the reproducibility of both method spikes and will be calculated as relative percent difference (% RPD). Results must agree within twenty percent (20%) RPD in order to be considered acceptable.

7.7.4 IC: Detection Limits

The detection limits are based on the concentration of the lowest standard analyzed. Results below the lowest standard are reported as below the detection limit.

7.8 Spectrophotometry (Colorimetric Methods)

7.8.1. Spectrophotometry: Initial Calibration

Spectrophotometers will be calibrated prior to each day of use. The calibration standards will be prepared from reference materials appropriate to the analyses being performed, and working standards will include a minimum of five (5) concentrations which cover the anticipated range of measurement. At least one of the calibration standards will be at or below the desired detection limit. Additionally, a calibration blank will be analyzed. The requirement for an acceptable initial

calibration will be a correlation coefficient equal to or greater than 0.996 in order to consider the response linear over the measured range. If the correlation coefficient criteria of 0.996 is not met, the instrument will be recalibrated prior to analysis of samples. Calibration data, to include the correlation coefficient, will be entered into the laboratory notebook with the sample data to maintain a permanent record of instrument calibrations.

Before sample analysis, an initial calibration verification standard is analyzed. The response calculated as percent recovery of this standard must be within ± fifteen percent (15%) of the true value or the instrument is recalibrated.

7.8.2 Spectrophotometers: Continuing Calibration

A continuing calibration verification standard (CCV) and blank (CCB) will be analyzed at a frequency of ten percent (10%) and at the end of the analysis sequence. The response, calculated as a percent recovery of the true value, must be ± fifteen percent (15%) of the true value. The response of the blank must be less than the detection limit.

7.8.3 Spectrophotometers: Quality Control

At least one method blank and two method spikes will be included in each laboratory lot of samples. Regardless of the the matrix being processed, the method spikes and blanks will be in aqueous media. Method spikes will be at a concentration of approximately five (5) times the detection limit.

The method blanks will be examined to determine if contamination is being introduced in the labortory.

The method spikes will be examined to determine both precision and accuracy.

Accuracy will be measured by the percent recovery (% R) of the spikes. The recovery must be in the range (80-120 percent) in order to be considered acceptable. Additionally, % R will be plotted on control charts to monitor method accuracy.

Precision will be measured by the reproducibility of both method spikes and will be calculated as relative percent difference (% RPD). Results must agree within twenty (20) percent RPD in order to be considered acceptable.

7.8.4 Spectrophotometers: Detection Limits

The detection limits are based on the concentration of the lowest standard analyzed. Results below the lowest standard are reported as below the detection limit.

7.9 Balances

Laboratory balances will be calibrated and serviced annually by a factory representative. In addition, the analyst will check the balance before each use with two masses: one in the gram range and one in the milligram range. A record of calibrations and daily checks will be kept in the balance log.

The Class P weights used by the analysts for daily balance checks will be calibrated annually against a set of Class S certified weights.

7.10 Thermometers

Oven and refrigerator thermometers will be calibrated annually against a National Bureau of Standards (NBS) certified thermometer in the range of interest. Annual calibrations will be recorded in a calibration notebook. Daily readings will be recorded with the respective oven or refrigerator.

TABLE 7-1

GC/MS CALIBRATION CHECK COMPOUNDS (CCC's) AND SYSTEM PERFORMANCE CHECK COMPOUNDS (SPCC's)

Volatiles

chloromethane
* vinyl chloride
* 1,1-dichloroethene
# 1,1-dichloroethane
* chloroform
* 1,2-dichloropropane
# bromoform
# 1,1,2,2-tetrachloroethane
* toluene
# chlorobenzene
* ethylbenzene

Semivolatiles

* phenol
* 1,4-dichlorobenzene
# N-nitroso-di-N-propylamine
* 2-nitrophenol
* 2,4-dichlorophenol
* hexachlorobutadiene
* 4-chloro-3-methylphenol
# hexachlorocyclopentadiene
* 2,4,6-trichlorophenol
* acenaphthene
# 2,4-dinitrophenol
# 4-nitrophenol
* N-nitrosodiphenylamine
* pentachlorophenol
* fluoranthene
* di-N-octylphthalate
* benzo-a-pyrene

* = calibration check compounds
(exception: di-N-octylphthalate is deleted from the list for all but specific EPA-CLP SOW contracts)

= system performance check compounds

(revised January 1989)

8.0 Data Reduction, Validation and Reporting

8.1 Introduction

All analytical data are recorded into bound laboratory notebooks issued by the QA Coordinator. Data are recorded and associated with a unique WESTON sample identification number and a client sample identity. These pages minimally contain the following information: analytical method, analyst, date, reagent concentrations, instrument settings (as applicable), and raw data.

The laboratory analysts sign and date all notebook entries daily. The notebook pages are reviewed periodically by the Section Manager. Copies of instrument outputs (chromatograms, strip charts, etc.) are maintained on file.

8.2 Data Reduction

Data reduction is performed by the individual analysts and consists of calculating concentrations in samples from the raw data obtained from the measuring instruments. The complexity of the data reduction will be dependent on the specific analytical method and the number of discrete operations (extractions, dilutions, and concentrations) involved in obtaining a sample that can be measured.

For those methods utilizing a calibration curve, sample response will be applied to the linear regression line to obtain an initial raw result which is then factored into equations to obtain the estimate of the concentration in the original sample. Rounding will not be performed until after the final result is obtained to minimize rounding errors, and results will not normally be expressed in more than two (2) significant figures.

Copies of all raw data and the calculations used to generate the final results will be retained on file to allow reconstruction of the data reduction process at a later date.

8.3 Data Review/Validation

System reviews are performed at all levels. The individual analyst constantly reviews the quality of data through calibration checks, quality control sample results, and performance evaluation samples. These reviews are performed prior to submission to the Section Managers or the Analytical Project Manager.

The Section Manager and/or the Analytical Project Manager review data for consistency and reasonableness with other generated data and determine if program requirements have been satisfied. Selected hard copy output of data (chromatograms, spectra, etc.)

will be reviewed to ensure that results are interpreted correctly. Unusual or unexpected results will be reviewed, and a resolution will be made as to whether the analysis should be repeated. In addition, the Analytical Project Manager or Section Manager will recalculate selected results to verify the calculation procedure.

The Quality Assurance Officer independently conducts a complete review of selected projects to determine if laboratory and client quality assurance/quality control requirements have been met. Discrepancies will be reported to the appropriate Section Manager and/or Analytical Project Manager for resolution.

The final routine review is performed by the Laboratory Manager prior to reporting the results to the client. Non-routine audits are performed by regulatory agencies and client representatives. The level of detail and the areas of concern during these reviews are dependent on the specific program requirements.

8.4 Data Reporting

Reports will contain final results (uncorrected for blanks and recoveries), methods of analysis, levels of detection, surrogate recovery data, and method blank data. In addition, special analytical problems, and/or any modifications of referenced methods will be noted. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method. Consequently, most analytical results will be reported to no more than two (2) significant figures. Data are normally reported in units commonly used for the analyses performed. Concentrations in liquids are expressed in terms of weight per unit volume (e.g., milligrams per liter). Concentrations in solid or semi-solid matrices are expressed in terms of weight per unit weight of sample (e.g., micrograms per gram).

Reported detection limits will be the concentration in the original matrix corresponding to the low level instrument calibration standard after concentration, dilution, and/or extraction factors are accounted for, unless otherwise specified by program requirements.

The final data report provided by WESTON Analytics conforms to one of three types:

1. Level 1: WESTON Standard Client Report,

2. Level 2: A Tier II Report (as specified by the State of New Jersey). This Report provides support data including a case narrative, quality control data, and a chain-of-custody report,

3. Level 3: U.S. EPA-CLP format report as described in WESTON OP 21-20-020, Section B, or

4. Level 4: Tier 1 Report (as specified by the State of New Jersey). This Report provides support data including a case narrative, quality control data, a methods summary, negative proofs of mass spectral quantitation library search "false positives", and a lab chronicle, and chain-of-custody for receipt and analyses. The basis submittal is U.S. EPA-CLP format (Level 3 above) with a few NJDEP-specified extras.

8.4.1 Level 1: Standard Client Report

The standard commercial report contains a transmittal letter and the following for Organic Analyses:

- cover page describing: data qualifiers, sample collection, extraction and analysis dates, and a description of any technical problems encountered with the analysis,
- spreadsheet sample data and QC result summaries, and
- five-peak library search report for GC-MS volatiles and semivolatiles.

QC for batches of twenty (20) samples or less includes a method blank, a method blank spike (semivolatiles and pesticide/PCB's), a matrix spike, a laboratory duplicate or spike duplicate, and surrogate recoveries. For sample batches of less than ten (10), laboratory duplicates and matrix spikes may be taken from other samples processed at the same time. Also, a method blank spike duplicate may be substituted for a matrix spike in smaller batches.

Although the EPA CLP methodology is used for Level 1, re-analyses will not be required for surrogate outliers unless poor recoveries are determined to be due to laboratory error.

Inorganic Analyses Level 1 reports contain a transmittal letter and the following:

- cover page describing: data qualifiers, sample receipt, digestion and analysis dates, and a description of any technical problems encountered with the analyses,
- sample data summary report including lab blanks, and
- QC summary report on laboratory control samples (accuracy).

8.4.2 Level 2: Tier II Report

The Level 2 report contains a transmittal letter and the following for Organic Analyses:

- cover page,
- chain of custody-sample request form,
- case narrative and laboratory chronicle,
- tune summaries,
- sample data results, with accompanying chromatograms and appropriate spectra, and
- QC data including:
  - method blanks,
  - surrogate recoveries, and
  - matrix spike-matrix spike duplicate recoveries.

Inorganic Analyses Level 2 reports contain a transmittal letter and the following:

- lab chronicle,
- cover page describing: data qualifiers, sample receipt, digestion and analysis dates, and a description of any technical problems encountered with the analyses,
- sample data summary report including lab blanks,
- QC summary report on laboratory control samples (accuracy),
- QC summary report on sample matrix spike (accuracy) and duplicate (precision analyses), and
- chain-of-custody/analysis request form.

9.0 Internal Quality Control Checks: Laboratory

The daily quality of analytical data generated in the WESTON laboratories is controlled by the implementation of this Analytical Laboratory Quality Assurance Plan. The types of internal quality control checks are described in this section.

- Method Blanks. Method blanks usually consist of laboratory reagent grade water treated in the same manner as the sample (i.e., digested, extracted, distilled, etc.) which is then analyzed and reported as a standard sample would be.

- Method Blank Spike. A method blank spike is a sample of laboratory reagent grade water fortified (spiked) with the analytes of interest which is prepared and analyzed with the associated sample batch. Method blank spikes are not included with volatiles analyses since the same function is served by the calibration standard analysis.

- Laboratory Control Sample for Inorganics. This is a standard solution with a certified concentration which is analyzed as a sample and is used to monitor analytical accuracy. (Equivalent to a method blank spike).

- Matrix Spikes. A matrix spike is an aliquot of an investigative sample which is fortified (spiked) with the analytes of interest and analyzed with an associated sample batch to monitor the effects of the investigative sample matrix (matrix effects) on the analytical method. Matrix spikes are performed only in association with selected protocols. Frequency of matrix spikes will be specified in the project-specific Quality Assurance Project Plan.

- Laboratory Duplicate Samples. Duplicate samples are obtained by splitting a field sample into two separate aliquots and performing two separate analyses on the aliquots. The analysis of laboratory duplicates monitors sample precision; however, it may be affected by sample inhomogeneity, particularly in the case of nonaqueous samples. Laboratory duplicates are performed only in association with selected protocols and at the client's request. Frequency of duplicates will be specified in the project-specific Quality Assurance Project Plan.

- Known QC Check Sample. This is a QC sample of known concentration obtained from the U.S. EPA, the National Bureau of Standards (NBS) or a commercial source. This

QC sample is to check the accuracy of an analytical procedure. It is particularly applicable when a minor revision or adjustment has been made to an analytical procedure or instrument.

9.1 QC Monitoring

The analyses of quality control samples are entered chronologically onto quality control charts specifically maintained for each analytical procedure. These control charts are labeled with upper and lower warning and control limits, the analysis which is being charted and the value (e.g., % recovery, % RPD, etc.) which is being monitored. Control charts are updated monthly and are used to demonstrate method performance and help identify system errors.

10.0 Performance and System Audits

10.1 External Audits

WESTON participates in several external audits sponsored by State Regulatory Agencies and the U.S. EPA. These audits include performance and system audits.

The performance audits are in the form of blind performance samples submitted by the auditing agency. System audits involve on-site evaluation of the WESTON laboratory systems. A representation of the number, type, and auditing agency are summarized in Table 10-1. WESTON is certified in over states, and many of these states (e.g., Ohio, Utah, Colorado, etc.) also perform on-site audits as part of their certification requirement.

10.2 Internal Audits

The laboratory QA Coordinator has overall responsibility for monitoring the internal Quality Assurance/Quality Control program. The QA Coordinator has a staff to provide in-house audits, and to review and validate analytical data packages. The QA Coordinator is also responsible for scheduling and coordinating external systems audits and reviewing data for performance samples received.

The QA Coordinator supplies blind performance samples to the laboratory at least semi-annually.

The QA Coordinator audits laboratory systems and procedures at least once annually. Unique client audit procedures and data requirements will be complied with as contractually specified. The internal audit consists of a review of laboratory systems, procedures and documentation. Any deficiencies and/or deviations are documented and a summary report is prepared. (See also Section 13)

TABLE 10-1

EXTERNAL PERFORMANCE AND SYSTEMS AUDITS
WESTON ANALYTICAL LABORATORIES

Agency	Parameters	Type	Frequency	Required for
Illinois EPA	WS-WP	Performance System	Semi-annually	Water/Waste Water Cert.
NY Dept of Health	WS-WP	Performance	Semi-annually	Water/Waste Water Cert.
NY State Dept. Env. Conserv.	Inorganic-Organic TCL	Performance System	EPA CLP Qtrly Blind	State Analytical Contract
NJ Dept. of Environ. Protection	WS-WP	Performance System	Annually Every 2 Yrs.	Water/Waste Water Cert.
	Haz.Waste	Performance	EPA CLP Qtrly	Haz.Waste Approval
Oklahoma WRB	WS-WP	Performance	Semi-annually	Water/Waste Water Cert.
PA Dept. of Environ. Res.	WS	Performance System	Annually Every 2 Yrs.	Water Cert.
	Haz.Waste	Performance	EPA CLP Qtrly	State Anal. Contract
U.S.EPA	Inorganic-Organic TCL	Performance System	Quarterly Every 2 Yrs.	Superfund Related Analytical Work
U.S. Army Corps of Engineers (DERA)	Inorganic-Organic	Performance System	As Contract Requires	Water/Waste Water, Superfund Analytical Work

- Last on-site by U.S.EPA was performed in May 1988
- Last PA DER on-site was performed in May 1987, and last IEPA on-site was performed in September 1988.

WS = Water Supply (Drinking Water)
WP = Water Pollution (Wastewater)

11.0 Preventive Maintenance

11.1 Introduction

The ability to generate valid analytical data requires that all analytical instrumentation be properly and regularly maintained. The WESTON Analytical Laboratory maintains full service contracts on all major instruments. These service contracts not only provide routine preventative maintenance but also emergency repair service. The elements of the maintenance program are discussed in the following sections.

11.2 Instrument Maintenance Log Books

Each analytical instrument is assigned an instrument log book. All maintenance activities are recorded in the instrument log. The information entered in the instrument log includes:

1. date of service,
2. person performing service,
3. type of service performed and reason for service,
4. replacement parts installed (if appropriate), and
5. miscellaneous information.

If service is performed by the manufacturer, a copy of the service record is taped into the page facing the notebook page where the above information is entered.

11.3 Instrument Calibration and Maintenance

The routine calibration procedures used for analytical instrumentation are described in Section 6 and shown in Table 11-1. Preventative maintenance and calibration by manufacturer service representatives are provided on a routine basis.

The maintenance procedures and frequencies for major analytical instrumentation are given in Table 11-2.

WESTON service agreements provide for preventative maintenance, emergency service, and emergency shipping of spare parts. For emergency response, service contracts on the Gas Chromatographs, GC/MS instruments and AA-ICP require on-site response within 48-72 hours. (Typically, service representatives are on site within 24 hours of a service call.) The service contracts also provide for 24-hour delivery of critical spare parts in response to a service request.

11.4 Spare Parts

WESTON Laboratory maintains an inventory of routinely required spare parts (for example, spare sources, vacuum pumps and filaments for GC/MS, spare torches, burner heads for AA-ICP).

The instrument operators have the responsibility, with the appropriate Section Manager, to ensure that an acceptable inventory of spare parts is maintained.

TABLE 11-1

CALIBRATION FREQUENCY AND MECHANISM FOR MAJOR INSTRUMENTS WESTON ANALYTICAL LABORATORY

Instrument	Frequency of Calibration	Standard	Indicator Parameters
GC/MS	Daily (or every 12 hrs)	Standard soln of analytes to be measured	Response-Sensitivity
GC (Hall, PID,EC,NPD, FID,FPD)	Daily (or more frequently as required)	Standard soln of analytes to be measured	Retention Time Response-Sensitivity
HPLC	Daily	Standard soln of analytes to be measured	Retention Time Response-Sensitivity
AA	Daily (or more frequently	Standard soln of analytes to be measured	Response Linear Range
ICP	Daily (or more more frequently)	Standard soln of analytes to be measured	Response Linear Range
Ion Chromatograph	Daily	Standard soln of analytes to be measured	Retention Time Response
Spectro-photometers	Daily	Standard soln of analytes to be measured	Response Linear Range
Technicon AutoAnalyzer	Daily	Standard soln of analytes to be measured	Response Linear Range
Conductivity Meter	Daily	Standard soln of analytes to be measured	Response
Analytical Balance	Daily, when used	Class S wts. (NBS cert)	Accuracy
Ovens	Quarterly	Thermometer (NBS-cert)	Accuracy

TABLE 11-2

INSTRUMENT MAINTENANCE SCHEDULE
WESTON ANALYTICAL LABORATORY

Instrument	Preventative Maintenance	Service Contract
Gas Chromatograph-Mass Spectrometer	Semi-annually	Yes
Gas Chromatographs	Semi-annually	Yes
GC Detectors (FID,EC,PID,Hall,NPD,FPD)	As needed	Yes
High Performance Liquid Chromatographs	As needed	No
Atomic Absorption Spectrometer (Flame and Furnace)	Semi-annually	Yes
Inductively Coupled Plasma Spectrophotometer	Semi-annually	Yes
Analytical Balance	Annually	Yes
Ion Chromatograph	Annually	Yes
Spectrophotometers	As needed	No
Cold Vapor Mercury AA	As needed	No
Technicon Autoanalyzer	As needed	No
Conductivity Meter	As needed	No
Ovens	As needed	No
pH-Specific Ion Meter	As needed	No

12.0 Procedures Used to Assess Data Quality

12.1 Introduction

The QA objectives for precision, accuracy, and completeness were given and discussed in Section 3. All analytical data are reviewed relative to these criteria and specific project requirements to assess the quality of the analytical data. Where all criteria are met, data are deemed acceptable without qualification. Where precision and accuracy goals are not met, the sample set is re-analyzed or reported with qualification in the case narrative. Some of the factors affecting this final sample disposition include:

- project-specific QA/QC requirements,
- availability of sufficient sample for re-analysis,
- holding time considerations, and
- regulatory action limits.

12.2 Precision

Precision is measured through analyses of replicate QC controls and field samples. Results from these measurements are calculated as relative percent difference (% RPD) or percent relative standard deviation (% RSD) and evaluated according to the criteria set forth in subsections 3.3-3.3.2. Laboratory QC control samples are used to demonstrate acceptable method performance, and are used to trigger corrective action when control limits are exceeded.

Precision measurements from field samples give an indication of sample homogeneity. Problems with sample homogeneity are more likely to occur with soil and sediment samples, water samples containing a noticeable amount of solids, and non-standard matrices.

12.3 Accuracy

Accuracy is measured through the analysis of fortified reagent free matrices and fortified field samples. Results from these measurements are calculated as percent recovery and evaluated according to the criteria set forth in subsections 3.2-3.2.2. Laboratory QC control samples are used to demonstrate acceptable method performance, and are used to trigger corrective action when control limits are exceeded.

Accuracy measurements from field samples give an indication of physical or chemical interferences present which can either enhance or mask the actual presence of target analytes. Determination of percent recovery (% R) requires analysis of a fortified sample and a non-fortified sample, so that any background analyte already present in the sample can be accounted

for in the recovery determination. Thus, sample homogeneity also becomes a factor in recovery determinations, as variable background can affect the apparent analyte recovery. Problems with sample recovery are more likely to occur with soil and sediment samples, water samples containing a noticeable amount of solids, and non-standard matrices.

12.4 Completeness

Completeness has been defined in subsection 3.4 as a measure of the amount of analytical data generated by an analytical method or system meeting all accuracy and precision criteria. As stated, the minimum goal for completeness is 80% and the ability to exceed this goal (especially for organic TCL analyses) is dependent on the applicability of the analytical methods to the sample matrices analyzed. However, even if data have not met this laboratory definition of data able to be reported without qualification, project completion goals may still be met if the qualified data, i.e. data of know quality even if not perfect, is suitable for specified project goals.

13.0 Corrective Action

The initial responsibility to monitor the quality of an analytical system lies with the analyst. In this pursuit, the analyst will verify that all quality control procedures are followed and results of analysis of quality control samples are within acceptance criteria. This requires that the analyst assess the correctness of all of the following items as appropriate:

- sample preparation procedure,
- initial calibration,
- calibration verification,
- method blank result,
- duplicate analysis,
- laboratory control standard, and
- fortified sample result.

If the assessment reveals that any of the QC acceptance criteria are not met, the analyst must immediately assess the analytical system to correct the problem. The analyst notifies the appropriate supervisor and the QA Coordinator of the problem and, if possible, identifies potential causes and corrective action.

The nature of the corrective action obviously depends on the nature of the problem. For example, if a continuing calibration verification is determined to be out of control, the corrective action may require recalibration of the analytical system and reanalysis of all samples since the last acceptable continuing calibration standard.

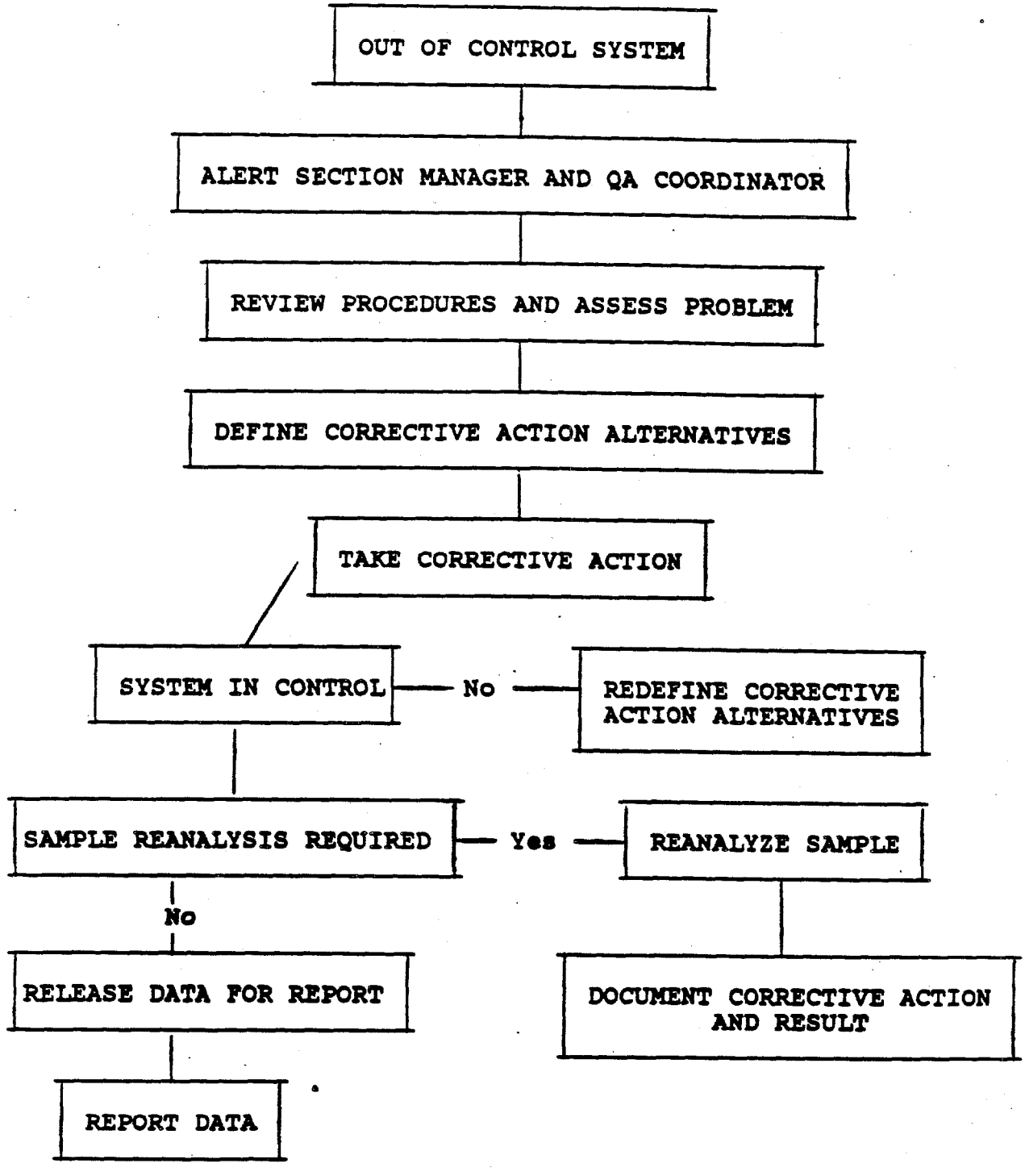
When the appropriate corrective action measures have been defined and the analytical system is determined to be "in control", the analyst documents the problem, and the corrective action. Copies of the form summarizing these actions are provided to the Section Manager and QA Coordinator.

Data generated concurrently with an out-of-control system will be evaluated for usability in light of the nature of the deficiency. If the deficiency does not impair the usability of the results, data will be reported and the deficiency noted in the case narrative. Where sample results are impaired, the Laboratory Project Manager is notified and appropriate corrective action (e.g., reanalysis) is taken.

The critical path for assessing the correctness and acceptability of analytical data is shown in Figure 13-1.

FIGURE 13-1

CRITICAL PATH FOR CORRECTIVE ACTION IN THE WESTON LABORATORY



14.0 Quality Assurance Reports to Management

The QA Coordinator provides quarterly and annual reports to the WESTON management. These reports summarize QA activities for the reporting period including results of performance audits (external and internal), results of system audits (external and internal), summaries of corrective action to remedy out of control situations and recommendation for revision in laboratory procedures to improve the analytical systems. The Project Manager will be notified immediately of laboratory QA situations requiring immediate corrective action.

APPENDIX B

ANALYTICAL METHODS, PARAMETERS, AND LIMITS OF DETECTION

NWS EARLE, NEW JERSEY

6574B19

WESTON.

Summary of Analytical Methods
IRP Phase III, NWS Earle, New Jersey

Parameter	Method: Soil/Sediment	Method: Water
Organics (TCL)		
VOCs	EPA CLP SOW[a]	EPA CLP SOW[a]
BNAs	EPA CLP SOW[a]	EPA CLP SOW[a]
Pesticides/PCBs	EPA CLP SOW[a]	EPA CLP SOW[a]
Inorganics		
Cyanide	EPA CLP SOW[b]	EPA CLP SOW[b]
Metals (TAL)	EPA CLP SOW[b]	EPA CLP SOW[b]
Total petroleum hydrocarbons	SW9071/E418.1	NA
Nitrate/nitrite	ASTM D3987/E353.1	E353.1
Explosives		
Picric acid	WESTON	USGS
Nitrocellulose[c]	LY02	COE/WESTON
Nitroglycerin[c]	LY02	COE/WESTON
2,4,6-Trinitrotoluene	LW02	UW01
2,4-Dinitrotoluene	LW02	UW01
2,6-Dinitrotoluene	LW02	UW01
Tetryl	LW02	UW01
1,3,5-Trinitrobenzene	LW02	UW01
1,3-Dinitrobenzene	LW02	UW01
HMX	LW02	UW01
RDX	LW02	UW01

NA Not applicable.
a U.S. EPA Contract Laboratory Program Statement of Work for Organics, 2/88 and revisions.
b U.S. EPA Contract Laboratory Program Statement of Work for Inorganics, 7/88.
c These two compounds cannot be distinguished from each other by these methods.

HSL

Table 1

SOIL CRDL CONVERSION TABLE

Element	CRDL	ug/g SOW 784	ug/g SOW 785 + SOW 787
Aluminum	200	100	40
Antimony	60	30	12
Arsenic	10	5	2
Barium	200	100	40
Beryllium	5	2.5	1
Cadmium	5	2.5	1
Calcium	5000	2500	1000
Chromium	10	5	2
Cobalt	50	25	10
Copper	25	12.5	5
Iron	100	50	20
Lead	5	2.5	1
Magnesium	5000	2500	1000
Manganese	15	7.5	3
Mercury	0.2	0.1	0.12
Nickel	40	20	8
Potassium	5000	2500	1000
Selenium	5	2.5	1
Silver	10	5	2
Sodium	5000	2500	1000
Thallium	10	5	2
(Tin)	40	20	8
Vanadium	50	25	10
Zinc	20	10	4
CN	10	CN } 2.5 for 1g. sample	
(Phenolics)	5	0.5 for 5g. sample	

SOW 784: Water Detection Limit $\times \underbrace{\frac{0.1L}{1g}}_{\text{digestion}} \times \underbrace{5}_{\text{dilution of digestate}}$ = Soil Detection Limit ÷ fraction solids = Soil Detection Limit (dry wt.)

SOW 785: Water Detection Limit $\times \frac{0.2L}{1g}$ = Soil Detection Limit ÷ fraction solids = Soil Detection Limit (dry wt.)

INORGANIC TARGET ANALYTE LIST (TAL)

Analyte	Contract Required Detection Limit (1,2) (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20
Cyanide	10

(1) Subject to the restrictions specified in the first page of Part G, Section IV of Exhibit D (Alternate Methods - Catastrophic Failure) any analytical method specified in SOW Exhibit D may be utilized as long as the documented instrument or method detection limits meet the Contract Required Detection Limit (CRDL) requirements. Higher detection limits may only be used in the following circumstance:

If the sample concentration exceeds five times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the Contract Required Detection Limit. This is illustrated in the example below:

For lead:

Method in use = ICP
Instrument Detection Limit (IDL) = 40
Sample concentration = 220
Contract Required Detection Limit (CRDL) = 5

7/87

The value of 220 may be reported even though instrument detection limit is greater than CRDL. The instrument or method detection limit must be documented as described in Exhibit E.

(2) The CRDL are the instrument detection limits obtained in pure water that must be met using the procedure in Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

Table 2

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)*

Volatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[d] ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-34-3	5	5
10. 1,2-Dichloroethene (total)	544-59-0	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,2-Dichloropropane	78-87-5	5	5
19. cis-1,3-Dichloropropene	10061-01-5	5	5
20. Trichloroethene	79-01-6	5	5
21. Dibromochloromethane	124-48-1	5	5
22. 1,1,2-Trichloroethane	79-00-5	5	5
23. Benzene	71-43-2	5	5
24. trans-1,3-Dichloropropene	10061-02-6	5	5
25. Bromoform	75-25-2	5	5
26. 4-Methyl-2-pentanone	108-10-1	10	10
27. 2-Hexanone	591-78-6	10	10
28. Tetrachloroethene	127-18-4	5	5
29. Toluene	108-88-3	5	5
30. 1,1,2,2-Tetrachloroethane	79-34-5	5	5

(continued)

1/87 Rev.

Volatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[d] ug/Kg
31. Chlorobenzene	108-90-7	5	5
32. Ethyl Benzene	100-41-4	5	5
33. Styrene	100-42-5	5	5
34. Xylenes (Total)	1330-20-7	5	5

[d]Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 100 times the individual Low Soil/Sediment CRQL.

*Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

**Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

Table 3

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)*

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Quantitation Limits** Low Soil/Sediment[b] ug/Kg
35. Phenol	108-95-2	10	330
36. bis(2-Chloroethyl) ether	111-44-4	10	330
37. 2-Chlorophenol	95-57-8	10	330
38. 1,3-Dichlorobenzene	541-73-1	10	330
39. 1,4-Dichlorobenzene	106-46-7	10	330
40. Benzyl alcohol	100-51-6	10	330
41. 1,2-Dichlorobenzene	95-50-1	10	330
42. 2-Methylphenol	95-48-7	10	330
43. bis(2-Chloroisopropyl) ether	108-60-1	10	330
44. 4-Methylphenol	106-44-5	10	330
45. N-Nitroso-di-n-dipropylamine	621-64-7	10	330
46. Hexachloroethane	67-72-1	10	330
47. Nitrobenzene	98-95-3	10	330
48. Isophorone	78-59-1	10	330
49. 2-Nitrophenol	88-75-5	10	330
50. 2,4-Dimethylphenol	105-67-9	10	330
51. Benzoic acid	65-85-0	50	1600
52. bis(2-Chloroethoxy) methane	111-91-1	10	330
53 2,4-Dichlorophenol	120-83-2	10	330
54. 1,2,4-Trichlorobenzene	120-82-1	10	330
55. Naphthalene	91-20-3	10	330
56. 4-Chloroaniline	106-47-8	10	330
57. Hexachlorobutadiene	87-68-3	10	330
58. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
59. 2-Methylnaphthalene	91-57-6	10	330
60. Hexachlorocyclopentadiene	77-47-4	10	330
61. 2,4,6-Trichlorophenol	88-06-2	10	330
62. 2,4,5-Trichlorophenol	95-95-4	50	1600
63. 2-Chloronaphthalene	91-58-7	10	330
64. 2-Nitroaniline	88-74-4	50	1600

(continued)

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[b] ug/Kg
65. Dimethylphthalate	131-11-3	10	330
66. Acenaphthylene	208-96-8	10	330
67. 2,6-Dinitrotoluene	606-20-2	10	330
68. 3-Nitroaniline	99-09-2	50	1600
69. Acenaphthene	83-32-9	10	330
70. 2,4-Dinitrophenol	51-28-5	50	1600
71. 4-Nitrophenol	100-02-7	50	1600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-Dinitrotoluene	121-14-2	10	330
74. Diethylphthalate	84-66-2	10	330
75. 4-Chlorophenyl-phenyl ether	7005-72-3	10	330
76. Fluorene	86-73-7	10	330
77. 4-Nitroaniline	100-01-6	50	1600
78. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
79. N-nitrosodiphenylamine	86-30-6	10	330
80. 4-Bromophenyl-phenylether	101-55-3	10	330
81. Hexachlorobenzene	118-74-1	10	330
82. Pentachlorophenol	87-86-5	50	1600
83. Phenanthrene	85-01-8	10	330
84. Anthracene	120-12-7	10	330
85. Di-n-butylphthalate	84-74-2	10	330
86. Fluoranthene	206-44-0	10	330
87. Pyrene	129-00-0	10	330
88. Butylbenzylphthalate	85-68-7	10	330
89. 3,3'-Dichlorobenzidine	91-94-1	20	660
90. Benzo(a)anthracene	56-55-3	10	330
91. Chrysene	218-01-9	10	330
92. bis(2-Ethylhexyl)phthalate	117-81-7	10	330
93. Di-n-octylphthalate	117-84-0	10	330
94. Benzo(b)fluoranthene	205-99-2	10	330

(continued)

Semivolatiles	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[b] ug/Kg
95. Benzo(k)fluoranthene	207-08-9	10	330
96. Benzo(a)pyrene	50-32-8	10	330
97. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
98. Dibenz(a,h)anthracene	53-70-3	10	330
99. Benzo(g,h,i)perylene	191-24-2	10	330

[b]Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

*Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

**Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

Table 4

Target Compound List (TCL) and Contract Required Quantitation Limits (CRQL)*

Pesticides/PCBs	CAS Number	Quantitation Limits** Water ug/L	Low Soil/Sediment[c] ug/Kg
100. alpha-BHC	319-84-6	0.05	8.0
101. beta-BHC	319-85-7	0.05	8.0
102. delta-BHC	319-86-8	0.05	8.0
103. gamma-BHC (Lindane)	58-89-9	0.05	8.0
104. Heptachlor	76-44-8	0.05	8.0
105. Aldrin	309-00-2	0.05	8.0
106. Heptachlor epoxide	1024-57-3	0.05	8.0
107. Endosulfan I	959-98-8	0.05	8.0
108. Dieldrin	60-57-1	0.10	16.0
109. 4,4'-DDE	72-55-9	0.10	16.0
110. Endrin	72-20-8	0.10	16.0
111. Endosulfan II	33213-65-9	0.10	16.0
112. 4,4'-DDD	72-54-8	0.10	16.0
113. Endosulfan sulfate	1031-07-8	0.10	16.0
114. 4,4'-DDT	50-29-3	0.10	16.0
115. Methoxychlor	72-43-5	0.5	80.0
116. Endrin ketone	53494-70-5	0.10	16.0
117. alpha-Chlordane	5103-71-9	0.5	80.0
118. gamma-Chlordane	5103-74-2	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. Aroclor-1016	12674-11-2	0.5	80.0
121. Aroclor-1221	11104-28-2	0.5	80.0
122. Aroclor-1232	11141-16-5	0.5	80.0
123. Aroclor-1242	53469-21-9	0.5	80.0
124. Aroclor-1248	12672-29-6	0.5	80.0
125. Aroclor-1254	11097-69-1	1.0	160.0
126. Aroclor-1260	11096-82-5	1.0	160.0

[c]Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB TCL compounds are 15 times the individual Low Soil/Sediment CRQL.

*Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

**Quantitation limits listed for soil/sediment are based on wet weight. The quantitation Limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

1/87 Rev.

APPENDIX C

UNIFIED SOIL CLASSIFICATION SYSTEM

APPENDIX A

ENGINEERING FIELD MANUAL
FOR CONSERVATION PRACTICES

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
THIRD PRINTING JUNE 1979
pp 4-9 to 4-19

THE UNIFIED SOIL CLASSIFICATION SYSTEM

General

The Unified Soil Classification System is used by the Soil Conservation Service in classifying soils for engineering purposes. This system is based on the identification of soils according to their particle size, gradation, plasticity index and liquid limit. (ASTM D 2487, D 2488). Gradation and particle size are determined by sieve analyses. Plastic and liquid limits are determined by standard methods of laboratory testing. (ASTM D 423 and D 424).

SYMBOLS

The Unified System, which is based on the minus 3-inch fraction of the material, uses letters as symbols of the soil's properties. The soil properties and the letters that represent them are listed below.

Gravel - G	Clay - C	Organic - O
Sand - S	Silt - M	Peat - Pt

Well Graded - W	High Liquid Limit - H
Poorly Graded - P	Low Liquid Limit - L

Soils are placed in groups having similar engineering properties according to their behavior characteristics. Each group is delineated by two of the above characteristics. The most important engineering characteristic of this group is listed first and the next most important, second.

U. S. sieve sizes are used in separating some classes of materials from others. The important sieves and the size of their openings are:

Table . Sieve sizes and size of openings

U. S. Standard Sieve Sizes	Size of Opening in mm.	Size of Opening in inches
3"	--	3"
3/4"	--	3/4"
#4	4.76	1/4" (Approx.)
#10	2.00	--
#40	0.42	--
#200	0.074	--

BASIC MATERIAL BREAKDOWN

Soils are divided into coarse materials or fine materials by the #200 sieve. If more than 50 percent of the material, by dry weight, is larger than the #200 sieve, it is a coarse material. If 50 percent or more will pass the #200 sieve, it is a fine material.

Coarse Materials

Coarse material is subdivided into sand and gravel by the #4 sieve. If 50 percent or more of the coarse portion of the material by dry weight is retained on the #4 sieve, the material is classified as a gravel. If more than 50 percent passes the #4 sieve, it is classified as a sand.

Materials With Less Than 5 Percent Fines

If less than 5 percent of the total sample by dry weight is fines, there is not enough of these fines to affect its engineering properties. In this case, only the characteristics of the coarse portion are important

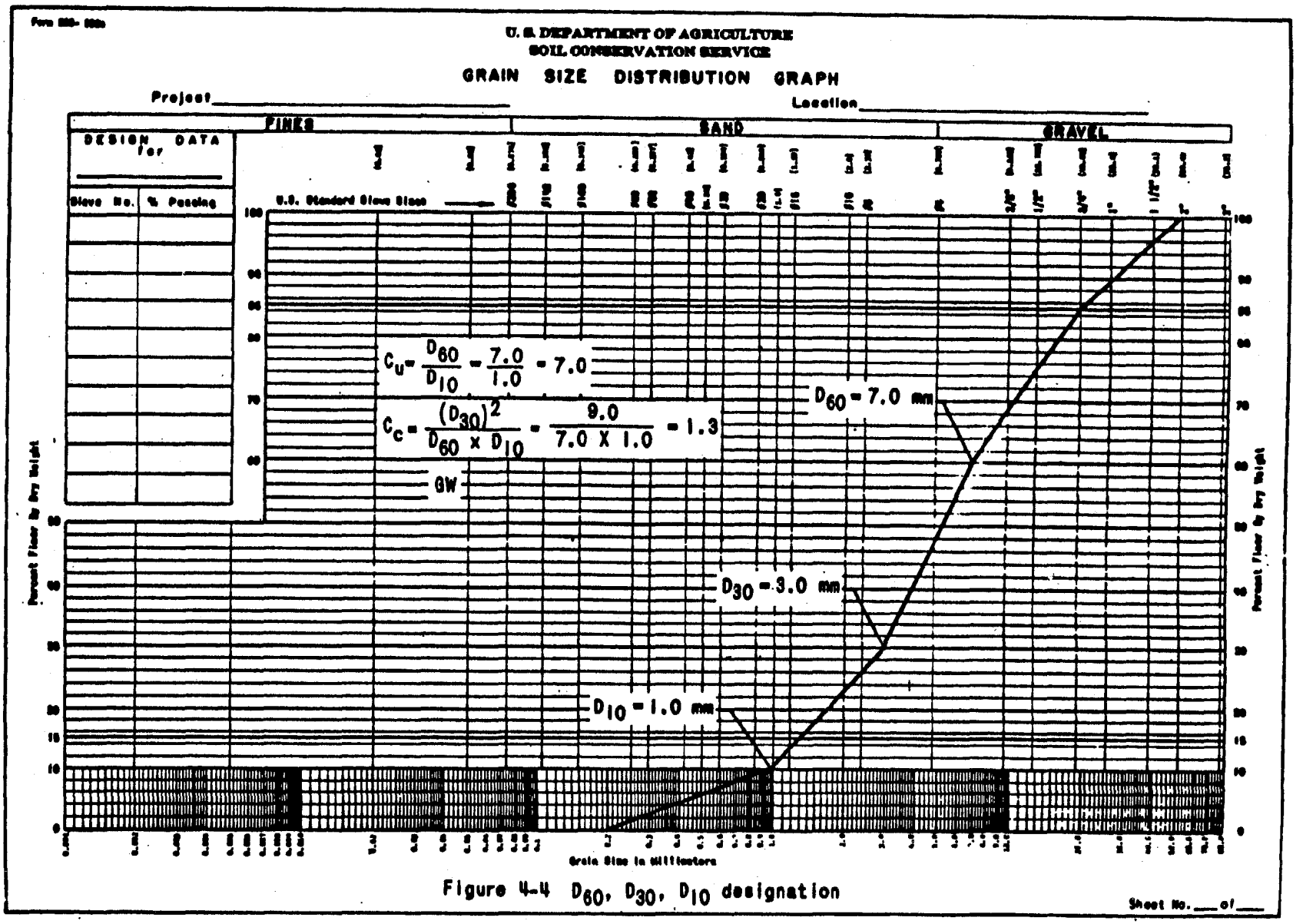


Figure 4-4 D_{60}, D_{30}, D_{10} designation

and the fines may be ignored in classifying the material. The classification as sand or gravel is the material's primary characteristic.

The secondary characteristic of material with less than 5 percent fines is its gradation (range of particle sizes). The material may consist predominantly of only one size of material; a mixture of coarse and fine materials with the intermediate sizes missing; or a mixture consisting of some of every size of particle. Materials in the first two groups are classified as poorly graded and those in the last group as well graded. The range of particle sizes may be obtained by shaking the sample through sieves. The results when plotted on a grain size distribution graph (see Figure 4-4) and analyzed will meet the following criteria if the material is well graded.

Gravels are well graded under the criteria of the Unified Classification System when:

$$C_u = \frac{D_{60}}{D_{10}} \text{ is greater than 4, and}$$

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ lies between 1 and 3.}$$

Sand are well graded when:

$$C_u = \frac{D_{60}}{D_{10}} \text{ is greater than 6, and}$$

$$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} \text{ lies between 1 and 3.}$$

Where:

C_u = Coefficient of uniformity

C_c = Coefficient of curvature

D = Diameter of particles determined by a sieve or hydrometer analysis

D_{60}, D_{10}, D_{30} = Diameter of particles such that 60 percent, 10 percent and 30 percent of the sample is smaller than that diameter. It is also the diameter read from a grain size distribution graph opposite 60, 10 and 30 percent finer by dry weight, respectively.

Both conditions (C_u and C_c) must be fulfilled in order to have a well graded soil. If one or both of the conditions are not fulfilled, the soil is poorly graded.

Some materials can be classified by visual inspection of the graph. When their plot is smooth and has concave curvature upwards between the 10 percent and 60 percent lines on a grain size distribution graph, they are well graded.

All other combinations of material with less than 5 percent fines are poorly graded.

There are four classifications of coarse materials where the percent of fines is less than 5 percent. They are well graded gravels (CW), poorly graded gravels (GP), well graded sands (SW), and poorly graded sands (SP).

Classifications of the coarse materials described above are based on sieve analysis only.

Materials With 12 to 50 Percent Fines

If the soil is a coarse material (either sand or gravel) but has a fines content of from 12 to 50 percent, the behavior characteristic of the portion smaller than the #40 sieve will determine the secondary characteristic of the material. If this portion of the material is clayey (can readily be molded), the material is coarse grained with clayey fines. If not, it is coarse grained with silty fines. To determine whether the material is classed as clay or silt, the plastic limit and liquid limit are measured.

A Plasticity Chart, Figure 4-5, is made with the LL as the abscissa and PI as the ordinate. On this chart, a line known as the "A" line has been plotted such that it lies approximately parallel to the plot of many basic geologic materials and originates at PI = 4, LL = about 25. For purposes of classification, all materials that plot above this line are designated as clay and all that plot below as silt. A small (cross hatched) area having a PI between 4 and 7 percent extending from the "A" line toward zero percent LL has a special dual designation and may be considered as an extension of the "A" line in separating materials.

There are four breakdowns of coarse materials where the percent of fines is over 12 percent. They are gravels with clayey fines (GC), gravels with silty fines (GM), sands with clayey fines (SC), and sands with silty fines (SM).

Materials With 5 to 12 Percent Fines

Materials with a fines content between 5 and 12 percent do not have separate classification breakdowns. They have a dual classification which consists of both the zero to 5 percent and the over 12 percent groups. The dual classification means that the material is borderline in its most significant engineering characteristics.

Fine Materials

Material is designated as being fine when 50 percent or more by weight passes the #200 sieve.

Clay or Silt

Plasticity is the most important engineering property of a fine grained soil. Therefore a fine grained material is classified first according to its plasticity.

The plasticity of the fine grained soils is determined on that portion of the soil which passes the #40 sieve. The material whose plot of the liquid limit and plasticity index falls above the "A" line (Figure 4-5) is classed as a fine grained clayey material. If it plots below the "A" line the material is classed as a fine grained silty material.

Under the Unified Classification System, "clay" or "clayey" is designated as any material that plots above the "A" line. "Silt" or "silty" is any material that plots below the "A" line. The break is the "A" line and is based on the PI.

High or Low Liquid Limit

The second most important characteristic in classifying fine grained material is its liquid limit.

Soil that has a liquid limit over 50 has a high liquid limit and may be either a clayey or silty high liquid limit material. Soil that has a liquid limit less than 50 has a low liquid limit and may be either a clayey or silty low liquid limit material.

There are four breakdowns of fine grained materials: Clayey material with low liquid limit (CL), clayey material with high liquid limit (CH), silty material with low liquid limit (ML) and silty material with high liquid limit (MH).

Organic Material

Materials containing a large percent of organic matter usually can be identified by their color and odor. The characteristics of organic materials are such that they have no easily definable boundaries. They are poor construction materials and need special consultation from an engineer, if used in construction. Some of these materials can be designated as organics of high liquid limit and organics of low liquid limit when tested by a laboratory. Fibrous organics that do not lend themselves even to laboratory tests are called peats. There are three breakdowns of organics: Organics with high liquid limit (OH), organics with low liquid limits (OL) and peats (Pt).

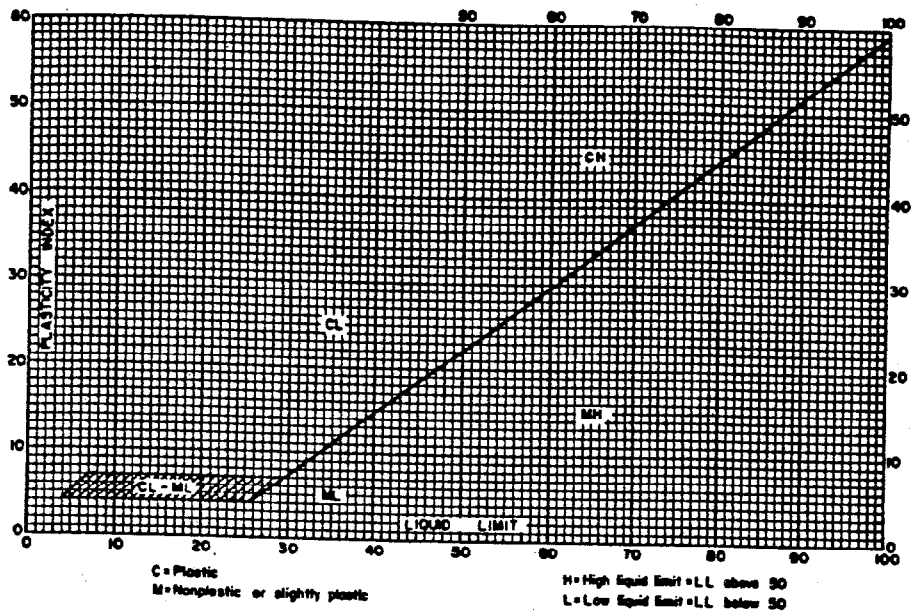


Figure 4-5 Plasticity chart

SUMMARY

Figure 4-6 gives the basic outline of the Unified Classification System.

The Unified Classification System has several outstanding features:

1. It is simple. There are 12 materials with which techicians are normally concerned--four coarse grained materials, four fine grained materials and four combined materials. In addition, there are three organics that require special attention, 15 in all.

2. It provides important physical characteristics, such as size, gradation, plasticity, strength, brittleness, consolidation potential, etc.

3. It is reliable. Engineering properties inferred by the classification are realistic.

TYPICAL NAMES	IMPORTANT PROPERTIES						UNIFIED SOIL CLASSES
	SHEAR STRENGTH	COMPRESS-IBILITY	WORKABILITY AS CONSTRUCTION MATERIAL	PERMEABILITY WHEN COMPACTED	PERMEABILITY K CM. PER SEC.	PERMEABILITY K FT. PER DAY	
Well graded gravels, gravel-sand mixtures, little or no fines.	Excellent	Negligible	Excellent	Pervious	$K > 10^{-2}$	$K > 30$	GW
Poorly graded gravels, gravel-sand mixtures, little or no fines.	Good	Negligible	Good	Very Pervious	$K > 10^{-2}$	$K > 30$	GP
Silty gravels, gravel-sand-silt mixtures.	Good to Fair	Negligible	Good	Semi-Pervious to Impervious	$K = 10^{-3}$ to 10^{-6}	$K = 3$ to 3×10^{-3}	GM
Clayey gravels, gravel-sand-clay mixtures.	Good	Very Low	Good	Impervious	$K = 10^{-6}$ to 10^{-8}	$K = 3 \times 10^{-3}$ to 3×10^{-5}	GC
Well graded sands, gravelly sands, little or no fines.	Excellent	Negligible	Excellent	Pervious	$K > 10^{-3}$	$K > 3$	SW
Poorly graded sands, gravelly sands, little or no fines.	Good	Very Low	Fair	Pervious	$K > 10^{-3}$	$K > 3$	SP
Silty sands, sand-silt mixtures	Good to Fair	Low	Fair	Semi-Pervious to Impervious	$K = 10^{-3}$ to 10^{-6}	$K = 3$ to 3×10^{-3}	SM
Clayey sands, sand-clay mixtures.	Good to Fair	Low	Good	Impervious	$K = 10^{-6}$ to 10^{-8}	$K = 3 \times 10^{-3}$ to 3×10^{-5}	SC
Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	Fair	Medium to High	Fair	Semi-Pervious to Impervious	$K = 10^{-3}$ to 10^{-6}	$K = 3$ to 3×10^{-3}	ML
Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Fair	Medium	Good to Fair	Impervious	$K = 10^{-6}$ to 10^{-8}	$K = 3 \times 10^{-3}$ to 3×10^{-5}	CL
Organic silts and organic silty clays of low plasticity.	Poor	Medium	Fair	Semi-Pervious to Impervious	$K = 10^{-4}$ to 10^{-6}	$K = 3 \times 10^{-1}$ to 3×10^{-3}	OL
Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Fair to Poor	High	Poor	Semi-Pervious to Impervious	$K = 10^{-4}$ to 10^{-6}	$K = 3 \times 10^{-1}$ to 3×10^{-3}	MH
Inorganic clays of high plasticity, fat clays.	Poor	High to Very High	Poor	Impervious	$K = 10^{-6}$ to 10^{-8}	$K = 3 \times 10^{-3}$ to 3×10^{-5}	CH
Organic clays of medium to high plasticity, organic silts.	Poor	High	Poor	Impervious	$K = 10^{-6}$ to 10^{-8}	$K = 3 \times 10^{-3}$ to 3×10^{-5}	OH
Peat and other highly organic soils.	NOT SUITABLE FOR CONSTRUCTION						Pt

SHEET 1 OF 4

Figure 4-6 Unified classification and properties of soils

EMBANKMENTS								UNIFIED SOIL CLASSES
COMPACTION CHARACTER-ISTICS	STANDARD PROCTER UNIT DENSITY LBS. PER CU. FT.	TYPE OF ROLLER DESIRABLE	RELATIVE CHARACTERISTICS		RESISTANCE TO PIPING	ABILITY TO TAKE PLASTIC DEFORMATION UNDER LOAD WITHOUT SHEARING	GENERAL DESCRIPTION & USE	
			PERME-ABILITY	COMPRESS-IBILITY				
Good	125-135	crawler tractor or steel wheeled & vibratory	High	Very Slight	Good	None	Very stable, pervious shells of dikes and dams.	GW
Good	115-125	crawler tractor or steel wheeled & vibratory	High	Very Slight	Good	None	Reasonably stable, pervious shells of dikes and dams.	GP
Good with close control	120-135	rubber-tired or sheepsfoot	Medium	Slight	Poor	Poor	Reasonably stable, not well suited to shells but may be used for impervious cores or blankets.	GM
Good	115-130	sheepsfoot or rubber-tired	Low	Slight	Good	Fair	Fairly stable, may be used for impervious core.	GC
Good	110-130	crawler tractor & vibratory or steel wheeled	High	Very Slight	Fair	None	Very stable, pervious sections, slope protection required.	SW
Good	100-120	crawler tractor & vibratory or steel wheeled	High	Very Slight	Fair to Poor	None	Reasonably stable, may be used in dike with flat slopes.	SP
Good with close control	110-125	rubber-tired or sheepsfoot	Medium	Slight	Poor to Very Poor	Poor	Fairly stable, not well suited to shells, but may be used for impervious cores or dikes.	SM
Good	105-125	sheepsfoot or rubber-tired	Low	Slight	Good	Fair	Fairly stable, use for impervious core for flood control structures.	SC
Good to Poor Close control essential	95-120	sheepsfoot	Medium	Medium	Poor to Very Poor	*Very Poor	Poor stability, may be used for embankments with proper control. *Varies with water content.	ML
Fair to Good	95-120	sheepsfoot	Low	Medium	Good to Fair	Good to Poor	Stable, impervious cores and blankets.	CL
Fair to Poor	80-100	sheepsfoot	Medium to Low	Medium to High	Good to Poor	Fair	Not suitable for embankments.	OL
Poor to Very Poor	70-95	sheepsfoot	Medium to Low	Very High	Good to Poor	Good	Poor stability, core of hydraulic fill dam, not desirable in rolled fill construction.	MH
Fair to Poor	75-105	sheepsfoot	Low	High	Excellent	Excellent	Fair stability with flat slopes, thin cores, blankets & dike sections.	CH
Poor to Very Poor	65-100	sheepsfoot	Medium to Low	Very High	Good to Poor	Good	Not suitable for embankments.	OH
DO NOT USE FOR EMBANKMENT CONSTRUCTION								Pt

SHEET 2 OF 4

Figure Unified classification and properties of soils

TENTATIVE
FOR TRIAL USE ONLY

CHANNELS LONG DURATION TO CONSTANT FLOWS.		FOUNDATION FOUNDATION SOILS, BEING UNDISTURBED, ARE INFLUENCED TO A GREAT DEGREE BY THEIR GEOLOGIC ORIGIN. JUDGEMENT AND TESTING MUST BE USED IN ADDITION TO THESE GENERALIZATIONS.					UNIFIED SOIL CLASSES
RELATIVE DESIRABILITY			RELATIVE DESIRABILITY		REQUIREMENTS FOR SEEPAGE CONTROL		
EROSION RESISTANCE	COMPACTED EARTH LINING	BEARING VALUE	SEEPAGE IMPORTANT	SEEPAGE NOT IMPORTANT	PERMANENT RESERVOIR	FLOODWATER RETARDING	
1	-	Good	-	1	Positive cutoff or blanket	Control only within volume acceptable plus pressure relief if required.	GW
2	-	Good	-	3	Positive cutoff or blanket	Control only within volume acceptable plus pressure relief if required.	GP
4	4	Good	2	4	Core trench to none	None	GM
3	1	Good	1	6	None	None	GC
6	-	Good	-	2	Positive cutoff or upstream blanket & toe drains or wells.	Control only within volume acceptable plus pressure relief if required.	SW
7 if gravelly	-	Good to Poor depending upon density	-	5	Positive cutoff or upstream blanket & toe drains or wells.	Control only within volume acceptable plus pressure relief if required	SP
8 if gravelly	5 erosion critical	Good to Poor depending upon density	4	7	Upstream blanket & toe drains or wells	Sufficient control to prevent dangerous seepage piping.	SM
5	2	Good to Poor	3	8	None	None	SC
-	6 erosion critical	Very Poor, susceptible to liquefication	6, if saturated or pre-wetted	9	Positive cutoff or upstream blanket & toe drains or wells.	Sufficient control to prevent dangerous seepage piping.	ML
9	3	Good to Poor	5	10	None	None	CL
-	7 erosion critical	Fair to Poor, may have excessive settlement	7	11	None	None	OL
-	-	Poor	8	12	None	None	MH
10	8 volume change critical	Fair to Poor	9	13	None	None	CH
-	-	Very Poor	10	14	None	None	OH
-	-	REMOVE FROM FOUNDATION					Pt

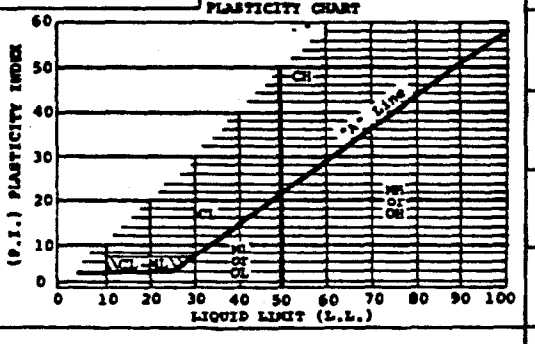
No. 1 is best numerical rating.

SHEET 3 OF 4

Figure Unified classification and properties of soils

		LABORATORY CRITERIA				UNIFIED SOIL CLASSES
COARSE-GRAINED SOILS Less than half of material passes the No. 200 sieve size.	GRAVELS Less than half of the coarse fraction passes the No. 4 sieve size.	CLEAN GRAVELS Less than 5% passing the No. 200 sieve size.	Borderline cases require the use of dual symbols.	WELL GRADED Meets gradation requirements	GRADATION REQUIREMENTS ARE: $C_u = \frac{D_{60}}{D_{10}} > 4$ and, $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	GW
				POORLY GRADED Does not meet gradation requirements		GP
		GRAVELS WITH FINES More than 12% passing the No. 200 sieve size.		Plasticity limits of material passing No. 40 sieve size plots below "A" line or P.I. less than 4.	Plasticity limits above "A" line with P.I. between 4 and 7 are border-line cases and require use of dual symbols	GM
				Plasticity limits of material passing No. 40 sieve size plots above "A" line with P.I. more than 7.		GC
	SANDS More than half of the coarse fraction passes the No. 4 sieve size.	CLEAN SANDS Less than 5% passing the No. 200 sieve size.	Borderline cases require the use of dual symbols.	WELL GRADED Meets gradation requirements	GRADATION REQUIREMENTS ARE: $C_u = \frac{D_{60}}{D_{10}} > 6$ and, $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	SW
				POORLY GRADED Does not meet gradation requirements		SP
		SANDS WITH FINES More than 12% passing the No. 200 sieve size.		Plasticity limits of material passing No. 40 sieve size plots below "A" line or P.I. less than 4.	Plasticity limits above "A" line with P.I. between 4 and 7 are border-line cases and require use of dual symbols	SM
				Plasticity limits of material passing No. 40 sieve size plots above "A" line with P.I. more than 7.		SC
FINE-GRAINED SOILS More than half of material passes the No. 200 sieve size.	SILTS AND CLAYS Liquid limit less than 50	Below "A" line or P.I. less than 4		Above "A" line with P.I. between 4 and 7 are border-line cases requiring use of dual symbols		ML
		Above "A" line with P.I. more than 7				CL
		Below "A" line or P.I. less than 4 and $\frac{\text{L.L.(oven dry soil)}}{\text{L.L.(air dry soil)}} < 0.7$				OL
	SILTS AND CLAYS Liquid limit greater than 50	Below "A" line				MH
		Above "A" line				CH
		Below "A" line and $\frac{\text{L.L.(oven dry soil)}}{\text{L.L.(air dry soil)}} < 0.7$				OH
HIGHLY ORGANIC SOILS				$\frac{\text{L.L. (oven dry soil)}}{\text{L.L. (air dry soil)}} < 0.7$		Pt

PLASTICITY CHART



SHEET 4 OF 4

Figure Unified classification and properties of soils

APPENDIX D

RESUMES

Katherine A. Sheedy

Fields of Competence

Geologic investigation and site evaluation; environmental impact assessment, quantitative and qualitative groundwater analysis, design of groundwater monitoring systems.

Experience Summary

Nine years experience in geological investigations including environmental impact analysis in geology, groundwater, and soils; hydrogeologic investigations of hazardous waste sites, preparation and delivery of expert testimony; assessment and mitigation of low-level radioactive contamination of groundwater and soils; migration of low-level radioactive contamination of groundwater and soils; migration of radionuclides in groundwater; site stability in limestone terrains; development of evaluation criteria for site search and selection projects; pre-mine opening hydrologic investigations for surface and underground coal mines; development of clean-up strategies for hazardous and radioactive waste disposal sites; Environmental Impact Statement preparation and review; site suitability investigations of waste disposal facilities for industrial and residential developments.

Credentials

B.A.—Queens College, CUNY (1969)

M.S., Geology—University of Delaware (1975)

American Geophysical Union

Geological Society of America

National Water Well Association, Technical Division

Employment History

1974-Present	WESTON
1972-1974	University of Delaware

Key Projects

Preparation of RCRA Part B permit application for facilities in the Midwest and on the West coast.

Initial Assessment Studies to identify possible contamination resulting from past practices at military installations.

Assessment of groundwater contamination from a municipal landfill in the Atlantic Coastal Plain including aquifer simulation to determine migration 10, 20 and 30 years in the future.

Hydrogeologic assessment of a multi-source military installation. The project includes groundwater modeling for the installation and for areas outside the installation in conjunction with State and Federal agencies.

Design of monitoring systems for a large industrial complex in Montana.

Assessment of regulatory requirements for hazardous waste lagoon closure in over forty states.

Assessment and analysis of emerging trends in groundwater research as applied to the utility industry.

Preparation of EPA Remedial Action Master Plans for five uncontrolled hazardous waste sites.

Principal investigator for geology, soils and groundwater portion of an Environmental Impact Statement for the decontamination of a radioactive waste disposal site in Canonsburg, Pennsylvania.

Project manager and principal investigator on clean-up of a site contaminated by pharmaceutical wastes in New Jersey.

Project manager and principal investigator for assistance in EIS preparation for five synthetic fuel plants in east-central United States.

Evaluation of environmental impact and operation of 23 municipal landfills in the Atlantic Coastal Plain.

Hydrogeologic investigations at mine sites prior to, during and after mining operations in Illinois.

Hydrogeologic investigations to determine site suitability for landfills, sewage sludge disposal, spray irrigation and industrial waste disposal.

Principal investigator on a dredge material disposal site feasibility study for Interstate Division for Baltimore City. This project was conducted to evaluate the feasibility of specific sites for disposal of 5 million cubic yards of

Professional Profile

material dredged from the Fort McHenry Tunnel in Baltimore. The evaluation included examination of costs, engineering feasibility, site stability, impact on biology and groundwater and ultimate use of the site as an inner-city park.

Supervision of an investigation to determine groundwater quality, delineate the extent of groundwater pollution and develop a groundwater-quality management program for a six-county area. Evaluated the adequacy of existing groundwater-quality standards and interacted with regulatory agencies.

Evaluation of groundwater quality, quantity and facilities; impact on groundwater for sites in semi-arctic environments and within the Columbia River Basin Project area.

Environmental assessment for a 200,000-BPCD refinery on a semi-arid island with extensive groundwater use in the West Indies.

Evaluation of structural stability problems in limestone solution area in Pennsylvania.

Supervision of a leachate collection system and groundwater monitoring program for an industrial landfill.

Investigation of potential sources of petroleum product found to be discharging through the subsurface, at the shore of Lake Erie.

Development of a state-of-the-art study and environmental analysis of the geothermal steam industry.

Publications

Sheedy, K. A., 1979, "Three-Phase Approach to Determination of Site Stability in Limestone". Presented at Association of Engineering Geologists 1979 Annual Meeting, Chicago, Illinois.

Sheedy, K. A., Schoenberger, R. J., Haderer, P., Dovey, R., 1979, "Solid Waste Disposal in the Coastal Plain: A Case Study." Presented at Association of Engineering Geologists 1979 Annual Meeting, Chicago, Illinois.

Sheedy, K. A., Leis, W., Thomas, A., 1980, "Land Use in Limestone Terrain, Problems and Case Study Solutions". In *Applied Geomorphology*, (The "Binghamton" symposia; 11) George Allen and Unwin, 1982.

Sheedy, K. A., Leis, W. Bopp, F., Anderson, J., "Use of Ground Penetrating Radar in Limestone Terrain". American Geographers Association, 1981.

Sheedy, K. A., "Methodology for the Selection of Low-Level Radioactive Waste Disposal Sites". American Nuclear Society, 1982.

Alan H. Tamm, C.P.G.S.

Registration

Certified Professional Geological Scientist, American Institute of Professional Geologists.

Certified Water Laboratory Technician in the State of Oklahoma.

Fields of Competence

Geological, hydrogeological, geochemical, and geophysical site characterization. Planning, managing, conducting, and reporting of field investigations; sub-surface stratigraphic and structural interpretation of sites; evaluating potential groundwater problems; and groundwater modeling. Field sampling, detection and abatement of groundwater pollution, digital modeling of groundwater flow and solute transport, supervision of drilling, logging, installation, and sampling of monitor wells. Geophysical data interpretation. Economic analysis of projects.

Experience Summary

Twelve years experience in hydrogeology and geochemistry, involving such activities as: assessment of subsurface water and soil contamination; development of contamination profiles; evaluation of remedial actions for groundwater quality restoration; quantitative chemical analysis of water and soil; petroleum fluid behavior analysis and evaluation; ore-assay and ore-body evaluation; drilling supervision; hydrogeologic assessment; pollution detection and abatement; application of flow and solute transport computer models; computer programming; project management.

Credentials

Bachelors of Science—Brooklyn College, New York (1974)

Master of Arts in Geology—Brooklyn College (1977)

American Institute of Professional Geologists

Society of Petroleum Engineers

Association of Ground Water Scientists and Engineers

Geological Society of America

American Association of Petroleum Geologists

Employment History

1988-Present	WESTON
1985-1987	Alan H. Tamm, C.P.G.S.
1982-1985	Bracken Exploration Company
1981-1982	Buckeye Petroleum Corporation
1980-1981	Hunt Energy Corporation
1977-1980	Texas International Petroleum Corp.
1974-1976	Intercontinental Energy Corp.

Key Projects

State of Oklahoma Water Resources Board, Enforcement Branch—Hydrogeologic analysis of over 30 groundwater/surface water pollution sites. Determined nature and extent of hazardous compounds in the soil and groundwater. Assessed human and environmental impact, and helped in the development of cost-effective solutions to reduce or mitigate the potential effects.

Lance Ruffel Oil and Gas—Evaluated extent of oil contaminants in fractured rock, rock characterization for porosity, permeability, and contaminant containment.

Modeled groundwater flow and transport of hydrocarbon contaminanats at eight specific sites within a regional USDW.

Hydrologic and geochemical evaluation of a potential underground source of drinking water historically contaminated by underground injection.

Monitored drilling waste disposal pits for contaminant migration in fractured media.

Evaluated geochemical and hydrogeologic constraints on a proposed waste recycling process. Provided site selection criteria and hazard delineation and analysis of applicable state and Federal regulations.

Fluid-flow modeling in a subsurface aquifer containing radionuclides and hazardous material.

Site evaluation of hydrocarbon-bearing aquifers utilizing hydrologic, geophysical, and geological techniques. This included parameter mapping (permeability, porosity, fluid character, etc.), cross-section preparation, and environmental reconstruction.

Professional Profile

Dianne S. Therry

Fields of Competence

Laboratory QA/QC development and implementation; data management coordination, including quality assurance and quality control procedures; identification and quantification of chemicals through the use of instrumental and wet methods of analysis; chemical and microbiological analysis of potable, surface, and wastewater.

Audit of laboratory fate-and-effect studies to ensure conformance to EPA-Good Laboratory Practices for regulated substances. Data validation of organic/inorganic analyses for hazardous substance list compounds. Technical audits of the analytical laboratory to evaluate laboratory performance facilities, and conformance to client program requirements. Development, implementation, and management of laboratory quality assurance and quality control programs.

Experience Summary

Documentation of major contract laboratory projects for government agencies, including USATHAMA and EPA. Data validation for the U.S. EPA - Contract Laboratory Program. Client/agency audits of the WESTON laboratories and required audit response with laboratory management. Coordinate functions for application/maintenance of laboratory licenses and certifications, including participation in interlaboratory performance evaluation audit studies. Internal QA/QC audits of WESTON laboratories to monitor and evaluate ongoing QA programs.

Laboratory QA/QC requirements including compilation of analytical lab SOP's and maintaining and updating the lab QA/QC Manual; conducting laboratory audits, maintenance of certification records and requirements.

As Data Management Coordinator: track sample status from log-in through final reporting and sample disposal; prepare lab QA samples and subsequent performance reports; interface with clients and regulatory agencies for monitoring/auditing purposes.

Analysis of process and industrial waters; quality control checks of water treatment chemicals; chemical and microbiological analysis of streams, drinking water, and domestic and industrial wastewater using EPA and APHA Standard Methods of Analysis. Methodology includes wet methods of analysis, AA, GC, Auto Analyzer, and TOC.

Courtroom experience at local and Federal levels with regard to laboratory analyses.

Credentials

B.S., Chemistry Education—West Chester State College (1974), ACS Accredited Program.

Post-graduate courses in priority pollutants techniques of analysis; gas chromatography; water microbiology; toxicology; geochemistry; geological field studies; physics of the atom. Refresher courses in AA and GC.

Certified by EPA and the State of Pennsylvania to perform and supervise water microbiology.

American Chemical Society, Philadelphia Local Section, Division of Environmental Chemistry

Remedial Response Health and Safety Training Course (1985)

Project Management Course (1985)

Employment History

1982-Present	WESTON
1977-1982	Chester County Health Department, Public Health Laboratory
Winter-Summer 1977	Nalco Chemical Company
1974-1976	West Windsor-Plainsboro High School

Key Projects

Developed, implemented, and coordinated a system for the assembly and audit of QA deliverable packages for the EPA Contract Laboratory Program, including compilation of a standard practices manual and training of personnel.

Professional Profile

Principal Investigator of groundwater modeling of Uranium Mill Tailings Remedial Action projects.

Water quality modeling Task Leader of EPA Needs Survey Project.

Project Manager of water quality modeling and wasteload allocation state-wide projects in: Arkansas and Louisiana; South Fork, Shenandoah and Quail Run in Virginia; Muskingum and Scioto Rivers in Ohio; and Kennebunk Estuary in Maine.

Project Manager for waste heat management modeling in Scioto and Muskingum Rivers for Columbus and Southern Ohio; in Great Egg Estuary for Atlantic City Electric Co.; and in Delaware Estuary for Public Service Electric and Gas Co.

Project Manager for the Army Corps of Engineers project on evaluation of Buffalo water systems. Evaluated technical, institutional and financial aspects of the Buffalo water system. Rehabilitation need, cost and shortfall identified.

Principal investigator and project manager for National Science Foundation research project on alternative technologies for small water systems.

Principal investigator and project manager for National Science Foundation research project on water reuse and conservation for urban water management. Conducted several national workshop-seminars on water reuse and dual water supply.

Principal systems engineer for several 208 Areawide Wastewater Planning and Management projects. Responsible for point and nonpoint source analysis involving the use both of mathematical models and of hand-calculation techniques.

Developed mathematical models for optimization of water distribution systems. Project manager of Water Distribution System Analysis Project for the City of Laconia, North Conway, New Hampshire and the City of Valparaiso, Florida.

Principal Systems Engineer on complex thermal-plume modeling studies for the Atlantic City Electric Company and the Columbus and Southern Ohio Electric Company.

Publications

Has presented or published over 80 technical papers.

Judith L. Stone

Fields of Competence

Project management and data management for analytical projects, including U.S. EPA Contract Laboratory Organics Program, U.S. EPA-CLP dioxin program, USATHAMA IRP program management, quality assurance/quality control.

Experience Summary

Twelve years of environmental analytical experience as a chemist, data manager, project manager and senior project scientist. Coordinate USATHAMA and U.S. Air Force installation restoration with field and laboratory personnel, monitor sample schedules, track samples and data, interface with client, maintain quality control charts. Project coordination for state and Federal CLP programs. Experience as project manager on U.S. EPA dioxin programs for Eastern Missouri cleanups. Preparation of Standard Operating Procedures, QC plans; development of sample tracking and chain-of-custody systems.

Additional experience includes monitoring laboratory QC procedures and supervising analysis of audit samples. Preparation of client reports.

Credentials

B.S., Chemistry—Dickinson College (1973)

American Chemical Society

Association of Official Analytical Chemists

Employment History

1986-Present	WESTON
1974-1986	Envirodyne Engineers, Inc.
1973-1974	Chilton Publishing
1969-1973	Dickinson College

Key Projects

Project Manager of two-year analytical contract with New York State Department of Environmental Conservation. Coordinator between laboratory and numerous client personnel in scheduling sample receipt. Monitor sample status and reporting.

Laboratory coordinator and central communications person for Air Force tasks. Coordinate sampling and analysis schedule with task managers and laboratory personnel. Monitor analytical progress and data reporting.

Program Manager for U.S. EPA-CLP dioxin IFB and SAS programs. Scheduled sample receipt and analysis. Reviewed data, prepared reports, submitted billing information to accounting and supervised document control. Prepared Standard Operating Procedures for the dioxin and IFB projects.

Project Manager for two-year contract with U.S. Army Corps of Engineers district for sampling and analysis in the Great Lakes. Scheduled tasks with client, prepared invoices, monitored labor costs and prepared data reports.

Data Manager and Project Coordinator for U.S. EPA Effluent Guidelines Division contracts for organics, plastics, rubber and timber industries. Developed laboratory record-keeping system including chain-of-custody, work request, extraction records and sample log forms. Revised company sampling manual for Consolidated Permits Program.

Laboratory Project Manager for USATHAMA multi-installation contract. Supervised preparation and shipment of sample bottles, receipt of samples. Monitored scheduling of sample analysis and tracked sample flow. Reviewed inorganic and organic data. Supervised laboratory certification, established and maintained quality control charts to monitor compliance with client's QA program. Wrote analytical sections of proposals, reports, QA and technical plans.

Professional Profile

APPENDIX E

MASTER LIST OF SAMPLES

Table E-1

Analytical Results for Surface Water Samples Collected in July 1986 -- Site 2, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 2-A (1st hour)	2-A (6th hour)	2-A (blank)	Regulatory Limit
Total organic halogens (ug/L)	40.0	35.0	NR	NRC
Total organic carbon (mg/L)	4.13	4.13	NR	NRC
Nitrate/nitrite (mg/L)	1.0 (1.0)**	1.0	ND	NRC
Base/neutral/acid compounds (ug/L)	ND	ND	NR	NRC
Explosives:				
HMX (ug/L)	ND	ND	ND	NRC
RDX (ug/L)	ND	ND	ND	NRC
2,4,6-TNT (ug/L)	ND	ND	ND	NRC
Nitroglycerin (mg/L)	ND	ND	ND	NRC
Picric acid (ug/L)	ND	ND	ND	NRC
Soluble metals (mg/L):				
Sb	ND	ND	NR	NRC
As	ND	ND	NR	0.050
Be	ND	ND	NR	NRC
Cd	ND	ND	NR	0.010
Cr	0 .016	0.017	NR	0.050
Cu	0.021	0.022	NR	NRC
Pb	0.014	0.014	NR	0.050
Hg	ND	ND	NR	0.002
Ni	0.04	0.04	NR	NRC
Se	ND	ND	NR	0.010
Ag	ND	ND	NR	0.050
Tl	ND	ND	NR	NRC
Zn	0.018	0.045	NR	NRC
pH (lab measured)	4.20	4.20	NR	---
Chloride (mg/L)	ND	ND	NR	NRC
Specific conductance (umho/cm)	36.1	35.8	NR	NRC

ND Not detected
NR Analysis not requested
** Duplicate sample
NRC No specific regulatory concentration

Table E-2

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 2, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 2-1	2-1B	2-2	2-3	2-4	Regulatory Limit
Total organic halogens (ug/L)	20.0	1.00	35.0	18.0	27.0	NRC
Total organic carbon (mg/L)	2.39	1.58	2.25	4.12	2.25	NRC
Nitrate/nitrite (mg/L)	ND	ND	ND	0.70	0.20	10
Base/neutral/acid compounds (ug/L)	ND	ND	ND	ND	ND	100
Explosives:						
HMX (ug/L)	ND	ND	ND	ND	ND	NRC
RDX (ug/L)	ND	ND	ND	ND	ND	NRC
2,4,6-TNT (ug/L)	ND	ND	ND	ND	ND	NRC
Nitroglycerin (mg/L)	ND	NR	ND	ND	ND	NRC
Picric acid (ug/L)	ND	ND	ND	ND	ND	NRC
Soluble metals (mg/L):						
Sb	ND	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	ND	NRC
Cd	ND	ND	ND	ND	ND	0.010
Cr	0.023	0.014	ND	ND	ND	0.050
Cu	0.024	0.014	ND	ND	ND	NRC
Pb	ND	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	ND	0.002
Ni	0.03	0.04	ND	ND	ND	NRC
Se	ND	ND	ND	ND	ND	0.010
Ag	0.004	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	ND	NRC
Zn	0.016	ND	0.03	0.04	0.02	NRC
pH	5.10	6.10	4.90	4.80	4.90	---
pH*	5.3	NR	7.0	5.2	6.8	---
Chloride (mg/L)	7.00	ND	8.60	5.00	7.60	NRC
Specific conductance (umho/cm)	40.6	1.12	50.1	47.2	38.6	NRC
Specific conductance* (umho/cm)	40	NR	40	40	30	NRC
Temperature (°C)	20	NR	14	16	14	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
NRC No specific regulatory concentration

6575B

Table E-3

Summary of Analytical Requirements for Soil and Sediment Analyses -- Site 2, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	3	0	0	0	3
Picric acid	3	0	0	0	3
Metals (TAL)	3	0	0	0	3
HMX	3	0	0	0	3
RDX	3	0	0	0	3
TNT	3	0	0	0	3
Nitroglycerin	3	0	0	0	3

Table E-4

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 2, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	8	1	0	1	10
Total organic halogens	8	1	0	1	10
Metals (TAL)	8	1	0	1	10
Volatile organic compounds	2	1	1	1	5
Total organic carbon	8	1	0	1	10
Semivolatile organic compounds	2	1	1	1	5
pH	8	0	0	0	8
Specific conductance	8	0	0	0	8
Nonmetals (TAL)	2	1	0	1	4
HMX	8	1	0	1	10
RDX	8	1	0	1	10
TNT	8	1	0	1	10
Nitroglycerin	8	1	0	1	10
Picric acid	8	1	0	1	10

Table E-5

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 3, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 3-1	3-2	3-3	3-3A	3-3B	Regulatory Limit
Total organic halogens (ug/L)	28.0	12.0	25.0	35.0	17.0	NRC
Total organic carbon (mg/L)	7.10	4.44	3.60	3.39	2.15	NRC
Volatile organic compounds (ug/L)	ND	ND	ND	ND	ND	10
Petroleum hydrocarbons (mg/L)	1.00	ND	ND	ND	ND	1
Pesticides (ug/L)	ND	ND	ND	ND	ND	Compound specific
Nitrate/nitrite (mg/L)	ND	ND	0.20	NR	ND	10
Base/neutral/acid compounds (ug/L)	ND	ND	ND	ND	ND	100
Soluble metals (mg/L):	ND	ND	ND	ND	ND	---
Sb	ND	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	ND	NRC
Cd	0.008	ND	ND	ND	ND	0.010
Cr	0.017	0.013	ND	ND	ND	0.050
Cu	0.015	0.016	ND	ND	ND	NRC
Pb	ND	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	ND	0.002
Ni	0.05	0.05	ND	ND	ND	NRC
Se	ND	ND	ND	ND	ND	0.010
Ag	ND	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	ND	NRC
Zn	0.226	0.087	0.11	0.20	ND	NRC
pH	2.90	3.80	4.70	NR	7.10	**
pH*	3.9	—	5.5	NR	NR	**
Chloride (mg/L)	8.80	5.80	7.80	NR	ND	NRC
Specific conductance (umho/cm)	609	103	54.3	NR	2.48	NRC
Specific conductance* (umho/cm)	290	100	40	NR	NR	NRC
Temperature (°C)	17	18	17	NR	NR	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
NRC No specific regulatory concentration
** pH standard for groundwater is a range between 5 and 9. Soil and water in the NWS Earle area commonly have natural pH below the standard.

Table E-6

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 3, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	7	1	0	1	9
Total organic halogens	7	1	0	1	9
Metals (TAL)	7	1	0	1	9
Volatile organic compounds	7	1	1	1	10
Total organic carbon	7	1	0	1	9
Semivolatile organic compounds	7	1	1	1	10
pH	7	0	0	0	7
Specific conductance	7	0	0	0	7
PCBs	7	1	0	1	9
Nonmetals (TAL)	7	1	0	1	9
Pesticides	7	1	0	1	9

Table E-7

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 4, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 4-1	4-2	4-3	Regulatory Limit
Total organic halogens (ug/L)	17.0	18.0	17.0	NRC
Total organic carbon (mg/L)	1.94	4.74	2.15	NRC
Volatile organic compounds (ug/L)	ND	ND	ND	10
Petroleum hydrocarbons (mg/L)	ND	ND	ND	1
Pesticides (ug/L)	ND	ND	ND	Compound specific
Nitrate/nitrite (mg/L)	ND	ND	ND	10
Base/neutral/acid compounds (ug/L):		ND	ND	100
Bis(2-ethylhexyl) phthalate	53	ND	ND	
Soluble metals (mg/L):				
Sb	ND	ND	ND	NRC
As	ND	ND	ND	0.050
Be	ND	ND	ND	NRC
Cd	ND	ND	ND	0.010
Cr	ND	ND	ND	0.050
Cu	ND	ND	ND	NRC
Pb	ND	ND	ND	0.050
Hg	ND	ND	ND	0.002
Ni	ND	ND	ND	NRC
Se	ND	ND	ND	0.010
Ag	ND	ND	ND	0.050
Tl	ND	ND	ND	NRC
Zn	0.06	0.03	0.06	NRC
pH	4.50	6.50	4.50	---
pH*	5.0	6.0	5.0	---
Chloride (mg/L)	6.80	6.40	6.40	NRC
Specific conductance (umho/cm)	77.8	72.3	56.0	NRC
Specific conductance* (umho/cm)	60	160	40	NRC
Temperature (°C)	14	17	14	NRC

ND Not detected
NR Analysis not requested
* Field measured
NRC No specific regulatory concentration

6575B

Table E-8

Summary of Analytical Requirements for Soil Analyses -- Site 4, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Metals (TAL)	4	1	0	1	6
Total petroleum hydrocarbons	4	1	0	1	6
Total organic halogens	4	1	0	1	6
Total organic carbon	4	1	0	1	6

Table E-9

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 4, NWS Earle, Colts Neck, NJ

Parameter	Number of				
	Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Total organic halogens	7	1	0	1	9
Metals (TAL)	1	1	0	1	3
Volatile organic compounds	7	1	1	1	10
Total organic carbon	7	1	0	1	9
Semivolatile organic compounds	9	1	1	1	12
pH	9	0	0	0	9
Specific conductance	9	0	0	0	9
PCBs	1	1	0	0	2
Nonmetals (TAL)	1	1	0	0	2
Pesticides	1	1	0	0	2

Table E-10

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 5, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 5-1	5-1B	5-2	5-3	5-4	Regulatory Limit
Total organic halogens (ug/L)	241	NR	68.0	41.0	29.0	NRC
Total organic carbon (mg/L)	6.44	NR	1.18	7.45	4.85	NRC
Volatile organic compounds (ug/L):						
Methylene chloride	8J	420	8J	7J	5J	
Acetone	110	5J	6J	12	ND	
2-Butanone	12	7J	6J	8J	9J	
Petroleum hydrocarbons (mg/L)	ND	NR	ND	ND	ND	1
Pesticides (ug/L)	ND	ND	ND	ND	ND	Compound specific
Nitrate/nitrite (mg/L)	ND	NR	ND	0.20	ND	10
Base/neutral/acid compounds (ug/L):						100
Pentachlorophenol	81	NR	10J	150	ND	
Soluble metals (mg/L):						
Sb	ND	NR	ND	ND	ND	NRC
As	ND	NR	ND	ND	ND	0.050
Be	ND	NR	ND	ND	ND	NRC
Cd	ND	NR	ND	ND	ND	0.010
Cr	ND	NR	ND	ND	0.019	0.050
Cu	ND	NR	ND	ND	0.022	NRC
Pb	ND	NR	ND	ND	ND	0.050
Hg	ND	NR	ND	ND	ND	0.002
Ni	ND	NR	ND	ND	0.04	NRC
Se	ND	NR	ND	ND	ND	0.010
Ag	ND	NR	ND	ND	ND	0.050
Tl	ND	NR	ND	ND	ND	NRC
Zn	0.017	NR	0.016	0.033	0.035	NRC
pH	4.25	NR	4.25	4.20	4.40	---
pH*	5.1	NR	4.5	5.0	5.1	---
Chloride (mg/L)	10.5	NR	9.80	13.7	8.60	NRC
Specific conductance (umho/cm)	72.3	NR	68.6	142	76.0	NRC
Specific conductance* (umho/cm)	50	NR	50	80	70	NRC
Temperature (°C)	16	NR	15	16	18	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
J Estimated concentration less than quantification limits but greater than instrument detection limits.
NRC No specific regulatory concentration

Table E-11

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 5, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Total organic halogens	8	1	0	1	10
Metals (TAL)	1	1	0	1	3
Volatile organic compounds	8	1	1	1	11
Total organic carbon	8	1	0	1	10
Semivolatile organic compounds	8	1	1	1	11
pH	8	0	0	0	8
Specific conductance	8	0	0	0	8
PCBs	1	1	0	0	2
Nonmetals (TAL)	1	1	0	0	2
Pesticides	1	1	0	0	2

Table E-12

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 7, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 7-1	7-2	7-2B	7-3	Regulatory Limit
Total organic halogens (ug/L)	23.0	18.0	12.0	18.0	NRC
Total organic carbon (mg/L)	1.73	6.51	1.42	2.15	NRC
Volatile organic compounds (ug/L):					NRC
Methylene chloride	7J	9J	11	6J	
Acetone	22	380	141	ND	
Petroleum hydrocarbons (mg/L)	ND	ND	ND	ND	1
Pesticides (ug/L)	ND	ND	ND	ND	Compound specific
Nitrate/nitrite (mg/L)	ND	ND	ND	0.20	10
Base/neutral/acid compounds (ug/L):		ND	ND	ND	100
Di-n-butyl phthalate	54	ND	ND	ND	
Soluble metals (mg/L):		ND	ND		
Sb	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	NRC
Cd	ND	ND	ND	ND	0.010
Cr	ND	ND	ND	ND	0.050
Cu	ND	ND	ND	ND	NRC
Pb	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	0.002
Ni	ND	ND	ND	ND	NRC
Se	ND	ND	ND	ND	0.010
Ag	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	NRC
Zn	0.03	0.03	ND	0.09	NRC
pH	4.70	4.20	6.70	4.70	—
pH*	5.5	—	NR	6.0	—
Chloride (mg/L)	12.3	32.6	11.1	ND	NRC
Specific conductance (umho/cm)	63.3	235	1.23	90.6	NRC
Specific conductance* (umho/cm)	40	—	NR	60	NRC
Temperature (°C)	14	—	NR	16	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
J Estimated concentration less than quantification limits but greater than instrument detection limits.
NRC No specific regulatory concentration

6575B

Table E-13

Summary of Analytical Requirements for Soil and Sediment Analyses -- Site 7, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Metals (TAL)	4	1	0	1	6

Table E-14

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 7, NWS Earle, Colts Neck, NJ

Parameter	No. of Samples	Dup/Rep	Trip Blanks	Field BLanks	Total Analyses
Total organic halogens	6	1	0	1	8
Metals (TAL)	9	1	0	1	11
Volatile organic compounds	9	1	1	1	12
Total organic carbon	9	1	0	1	11
Semivolatile organic compounds	9	1	1	1	12
pH	9	0	0	0	9
Specific conductance	9	0	0	0	9
PCBs	1	1	0	1	3
Nonmetals (TAL)	1	1	0	0	2
Pesticides	1	1	0	0	2

Table E-15

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 10, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 10-1	10-2	10-2A	10-3	Regulatory Limit
Total organic halogens (ug/L)	67.0	36.0	108	20.0	NRC
Total organic carbon (mg/L)	4.62	5.73	4.92	3.81	NRC
Volatile organic compounds (ug/L):					10
Methylene chloride	16	9J	14	9J	
Acetone	ND	7J	ND	10	
2-Butanone	ND	10	ND	11	
Petroleum hydrocarbons (mg/L)	ND	ND	ND	ND	1
Nitrate/nitrite (mg/L)	0.10	ND	ND	0.10	10
Base/neutral/acid compounds (ug/L)	ND	ND	ND	ND	100
Soluble metals (mg/L):					
Sb	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	NRC
Cd	0.006	ND	ND	ND	0.010
Cr	ND	ND	ND	ND	0.050
Cu	0.03	ND	ND	ND	NRC
Pb	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	0.002
Ni	0.014	ND	ND	ND	NRC
Se	ND	ND	ND	ND	0.010
Ag	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	NRC
Zn	0.09	1.01	0.82	0.08	NRC
pH	4.40	4.25	4.30	4.35	----
pH*	4.4	4.3	NR	4.0	----
Chloride (mg/L)	20.1	8.20	8.50	11.0	NRC
Specific conductance (umho/cm)	161	125	122	135	NRC
Specific conductance* (umho/cm)	140	105	NR	85	NRC
Temperature (°C)	13	16	NR	16	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
J Estimated concentration less than quantification limits but greater than instrument detection limits
NRC No specific regulatory concentration

6575B

Table E-16

Analytical Results for Surface Water Samples Collected in July 1986 -- Site 10, NWS Earle, Colts Neck, NJ

Analyte	Sample Number				Regulatory Limit
	10-A (1st hour)	10-A (6th hour)	10-B (1st hour)	10-B (6th hour)	
Total organic halogens (ug/L)	10.0	15.0	43.0	29.0	NRC
Total organic carbon (mg/L)	3.93	4.03	4.34	4.85	NRC
Volatile organic compounds (ug/L)	ND	ND	ND	ND	NRC
Petroleum hydrocarbons (mg/L)	ND	ND	ND	ND	1
Nitrate/nitrite (mg/L)	ND	ND	ND	ND	10
Base/neutral/acid compounds (ug/L):					100
N-nitrosodiphenylamine	ND	ND	31	30	
Di-n-butyl phthalate	ND	2J	70	42	
Soluble metals (mg/L):					
Sb	ND	—	ND	ND	NRC
As	ND	—	ND	ND	0.050
Be	ND	—	ND	ND	NRC
Cd	ND	—	ND	ND	0.010
Cr	ND	—	ND	ND	0.050
Cu	ND	—	ND	ND	NRC
Pb	ND	—	ND	ND	0.050
Hg	0.3	—	ND	ND	0.002
Ni	ND	—	ND	ND	NRC
Se	ND	—	ND	ND	0.010
Ag	ND	—	0.004	ND	0.050
Tl	ND	—	ND	ND	NRC
Zn	ND	—	ND	ND	NRC
pH	6.70	6.70	6.60	6.60	—
pH*	NR	NR	NR	NR	—
Chloride (mg/L)	6.80	7.20	7.20	6.80	NRC
Specific conductance (umho/cm)	74.6	78.8	81.6	81.3	NRC
Specific conductance* (umho/cm)	NR	NR	NR	NR	NRC
Temperature (°C)	NR	NR	NR	NR	NRC

ND Not detected
NR Analysis not requested
* Field measured
— Sample not analyzed
NRC No specific regulatory concentration

6575B

Table E-17

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 10, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	8	1	0	1	10
Picric acid	8	1	0	1	10
Total organic halogens	8	1	0	1	10
Metals (TAL)	2	1	0	1	4
TNT	8	1	0	1	10
Volatile organic compounds	2	1	1	1	5
Total organic carbon	8	1	0	1	10
Semivolatile organic compounds	2	1	1	1	5
pH	8	0	0	0	8
Specific conductance	8	0	0	0	8
Nonmetals (TAL)	2	1	0	1	4
HMX	8	1	0	1	10
RDX	8	1	0	1	10
Nitroglycerin	8	1	0	1	10

Table E-18

Analytical Results for Soil Samples Collected in March 1986 -- Site 11, NWS Earle, Colts Neck, NJ

Sample Number	Oil and Grease (Method 413.3) (mg/kg)
11-A	
(6" - 9")	37,300
(2' - 2.5')	76.3
11-B	
(6" - 9")	112
(2' - 2.5')	15.5
11-C	
(6" - 9")	2.60
(2' - 2.5')	1.75
11-D	
(6" - 9")	8.20
(2' - 2.5')	3.70
Detection Limit	1.0

Oil and grease has no specific regulatory concentration.

Table E-19

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 11, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 11-1	11-2	11-2B	11-3	11-3A	Regulatory Limit
Total organic halogens (ug/L)	202	60.0	13.0	169	123	NRC
Total organic carbon (mg/L)	11.9	3.91	0.977	7.66	8.77	NRC
Base/neutral/acid compounds (ug/L):						
Pentachlorophenol	120	ND	ND	ND	ND	100
Oil and grease (mg/L)	ND	ND	ND	ND	ND	NRC
Nitrate/nitrite (mg/L)	0.30	ND	ND	ND	ND	10
Explosives:						
HMX (ug/L)	ND	ND	ND	ND	ND	NRC
RDX (ug/L)	ND	ND	ND	ND	ND	NRC
2,4,6-TNT (ug/L)	ND	ND	1.85	ND	NR	NRC
Nitroglycerin (mg/L)	ND	ND	ND	ND	NR	NRC
Picric acid (ug/L)	ND	ND	ND	ND	ND	NRC
Soluble metals (mg/L):						
Sb	ND	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	ND	NRC
Cd	ND	ND	ND	ND	ND	0.010
Cr	ND	ND	ND	ND	ND	0.050
Cu	ND	ND	ND	ND	ND	NRC
Pb	ND	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	ND	0.002
Ni	ND	ND	ND	ND	ND	NRC
Se	ND	ND	ND	ND	ND	0.010
Ag	ND	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	ND	NRC
Zn	0.03	0.07	0.010	0.06	0.04	NRC
pH	4.50	3.95	7.30	4.25	4.95	---
pH*	5.0	4.5	NR	4.7	NR	---
Chloride (mg/L)	6.20	9.60	ND	7.60	8.50	NRC
Specific conductance (umho/cm)	53.6	77.7	1.78	64.6	63.7	NRC
Specific conductance* (umho/cm)	40	70	NR	50	NR	NRC
Temperature (°C)	20	20	NR	18	NR	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
NRC No specific regulatory concentration

Table E-20

Summary of Analytical Requirements for Soil and Sediment Analyses -- Site 11, NWS Earle, Colt Neck, NJ

Parameter	Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Total petroleum hydrocarbons	9	1	0	1	11

Table E-21

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 11, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	4	1	0	1	6
Metals (TAL)	1	1	0	1	3
Volatile organic compounds	4	1	1	1	7
Semivolatile organic compounds	1	1	1	1	4
pH	4	0	0	0	4
Specific conductance	4	0	0	0	4
HMX	4	1	0	1	6
RDX	4	1	0	1	6
TNT	4	1	0	1	6
Nitroglycerin	4	1	0	1	6

Table E-22

Analytical Results for Soil Samples Collected in January 1986 -- Site 19, NWS Earle, Colts Neck, NJ

Sample Number	TOX (ug/kg)	VOCs (ug/kg)		Petroleum Hydrocarbons (mg/kg)	Priority Pollutant Metals (mg/kg)	
19-A composite	0.320	Chloromethane	3J	ND	Ag	<0.251
		Acetone	460		As	1.53
		2-Butanone	67		Be	<0.637
		Dilution Factor	1.3		Cd	26,800
		Detection Limit	13		Cr	59.6
					Cu	4.84
					Hg	<0.285
					Ni	1.4
					Pb	49.5
					Sb	<0.005
					Se	<0.637
					Tl	<0.251
					Zn	289
19-B composite	2.15	Chloromethane	4J	751	Ag	<0.222
		Methylene.chloride	12		As	4.53
		Acetone	14		Be	<0.561
		2-Butanone	7J		Cd	31,900
		Dilution Factor	1.1		Cr	639
		Detection Limit	11		Cu	13.5
					Hg	<0.300
					Ni	2.5
					Pb	1,560
					Sb	0.747
					Se	<0.637
					Tl	<0.222
					Zn	776

ND Not detected
J Estimated concentration less than quantification limit but greater than instrument detection limit.

Table E-23

Analytical Results for Surface Water Samples Collected in July 1986 -- Site 19, NWS Earle, Colts Neck, NJ

Analyte	Sample Number						Regulatory Limit
	19-A (1st hour)	19-A (6th hour)	19-A (dup)	19-A (blank)	19-B (1st hour)	19-B (6th hour)	
Total organic halogens (ug/L)	65.0	9.00	29.0	NR	49.0	36.0	NRC
Total organic carbon (mg/L)	17.3	30.0	17.0	0.962	22.6	19.3	NRC
Volatile organic compounds (ug/L)	ND	ND	ND	ND	ND	ND	NRC
Petroleum hydrocarbons (mg/L)	ND	ND	ND	ND	ND	4.20	None detectable
Nitrate/nitrite (mg/L)	ND	ND	ND	ND	ND	ND	
Base/neutral/acid compounds (ug/L)	ND	ND	ND	ND	ND	ND	NRC
Soluble metals (mg/L):							
Sb	ND	ND	ND	ND	ND	ND	NRC
As	ND	ND	ND	ND	ND	ND	0.050
Be	ND	ND	ND	ND	ND	ND	NRC
Cd	ND	ND	ND	ND	ND	ND	0.010
Cr	0.014	0.016	0.021	0.018	0.014	0.014	0.050
Cu	0.018	0.017	0.018	0.019	0.017	0.018	NRC
Pb	ND	ND	ND	ND	ND	ND	0.050
Hg	ND	ND	ND	ND	ND	ND	0.002
Ni	0.03	0.04	0.04	0.04	0.04	0.03	NRC
Se	ND	ND	ND	ND	ND	ND	0.010
Ag	ND	ND	ND	ND	ND	ND	0.050
Tl	ND	ND	ND	ND	ND	ND	NRC
Zn	0.027	0.028	0.033	ND	0.122	0.014	NRC
pH	5.20	5.20	5.10	6.00	4.80	4.80	---
pH*	NR	NR	NR	NR	NR	NR	---
Chloride (mg/L)	15.0	13.2	14.6	ND	14.6	13.8	NRC
Specific conductance (umho/cm)	56.6	53.7	55.6	1.03	61.9	55.2	NRC
Specific conductance* (umho/cm)	NR	NR	NR	NR	NR	NR	NRC
Temperature (°C)	NR	NR	NR	NR	NR	NR	NRC

ND Not detected
NR Analysis not requested
* Field measured
NRC No specific regulatory concentration

Table E-24

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 19, NWS Earle, Colts Neck, NJ

Analyte	Sample Number 19-1	19-2	19-3	Regulatory Limit
Total organic halogens (ug/L)	63.0	71.0	50.0	NRC
Total organic carbon (mg/L)	4.01	6.95	4.92	NRC
Volatile organic compounds (ug/L):				10
Methylene chloride	14	13	8J	
Acetone	ND	ND	16	
2-Butanone	ND	ND	10	
Petroleum hydrocarbons (mg/L)	ND	ND	ND	1
Nitrate/nitrite (mg/L)	0.80	ND	ND	10
Base/neutral/acid compounds (ug/L)	ND	ND	ND	100
Soluble metals (mg/L):				
Sb	ND	ND	ND	NRC
As	ND	ND	ND	0.050
Be	ND	ND	ND	NRC
Cd	0.004	0.007	0.006	0.010
Cr	0.015	ND	ND	0.050
Cu	ND	ND	ND	NRC
Pb	0.006	ND	ND	0.050
Hg	ND	ND	ND	0.002
Ni	0.02	0.016	ND	NRC
Se	ND	ND	ND	0.010
Ag	ND	ND	ND	0.050
Tl	ND	ND	ND	NRC
Zn	0.09	0.09	0.06	NRC
pH	3.85	3.95	4.10	---
pH*	4.3	4.6	4.5	---
Chloride (mg/L)	7.60	11.4	10.5	NRC
Specific conductance (umho/cm)	189	103	80.5	NRC
Specific conductance* (umho/cm)	160	70	60	NRC
Temperature (°C)	20	17	17	NRC

ND Not detected
NR Analysis not requested
* Field measured
A Duplicate sample
B Field blank
J Estimated concentration less than quantification limits but greater than instrument detection limits.
NRC No specific regulatory concentration

Table E-25

Analytical Results for Sediment Samples Collected in July 1986 -- Site 19, NWS Earle, Colts Neck, NJ

Analyte	Sample Number						Regulatory Limit**
	19-A (1st hour)	19-A (6th hour)	19-A (dup)	19-A (blank)	19-B* (1st hour)	19-B* (6th hour)	
Total organic halogens (ug/kg)	ND	ND	ND	NR	NR	NR	NRC
Volatile organic compounds (ug/kg):							1
Methylene chloride	8J	NRP	75	7J (ug/L)	210	NRP	
Acetone	7J	230	53	2J	1,200	730	
Chloroform	ND	ND	25	ND	37	ND	
2-Butanone	ND	ND	ND	ND	240	ND	
Toluene	ND	2J	ND	ND	170	ND	
Dilution factor	1.46	1.48	1.55	1.0	13.1	11.1	
Detection limit	15	15	16	10	130	110	
Petroleum hydrocarbons (mg/kg)	82.8	14.9	129	ND	445	681	100
Total metals (mg/kg):							
Sb	<14.1	<14.4	<13.0	<0.05	<100	<123.5	NRC
As	<2.82	<2.89	<2.76	<0.01	<19.9	<25.0	20
Be	<14.1	<14.4	<13.0	<0.05	<100	<123.5	1
Cd	<0.7	<0.7	<0.7	<0.0025	<5	<6.25	3
Cr	<28.2	<28.8	<26.0	<0.1	<200	<247.0	100
Cu	<14.1	<14.4	<13.0	<0.05	<100	<123.5	170
Pb	5.83	4.65	6.86	<0.005	<94.7	<96.0	250 - 1,000
Hg	<0.250	0.423	<0.250	<0.250	<0.250	<0.250	1
Ni	<28.2	<28.8	<26.0	<0.1	<200	<247	100
Se	<1.41	<1.44	<1.38	<0.005	<9.95	<12.5	4
Ag	<2.82	<2.89	<2.75	<0.01	286	<25.0	5
Tl	<2.82	<2.89	<2.76	<0.01	<19.9	<25.0	NRC
Zn	<14.1	<14.4	<13.0	<0.05	214	<331	350

ND Not detected
NR Analysis not requested
NRP Not reported; see lab report
* Sample 19-B sediment had high water content
J Estimated concentration less than quantification limits but greater than instrument detection limits.
NRC No specific regulatory concentration
** ECRA limits

Table E-26

Summary of Analytical Requirements for Soil and Sediment Analyses -- Site 19, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Metals (TAL)	24	2	0	2	28
Volatile organic compounds	24	2	2	2	30
Semivolatile organic compounds	24	2	2	2	30
Soil moisture	12	0	0	0	12
Grain size distribution	12	0	0	0	12

Table E-27

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 19, NWS Earle, Colts Neck, NJ

Parameter	Number of				
	Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Total organic halogens	8	1	0	1	10
Metals (TAL)	8	1	0	1	10
Volatile organic compounds	8	1	1	1	11
Semivolatile organic compounds	1	1	1	1	4
Total petroleum hydrocarbons	8	1	0	1	10
pH	8	0	0	0	8
Specific conductance	8	0	0	0	8
PCBs	1	1	0	0	2
Nonmetals (TAL)	1	1	0	0	2
Pesticides	1	1	0	0	2

WESTON

Table E-28

Analytical Results for Soil Samples Collected in March 1986 -- Site 20, NWS Earle, Colts Neck, NJ

Sample Number	Analyte				
	Petroleum Hydrocarbons (mg/kg)	EPTOX (mg/L)			
		Zn	Cr	Pb	Ti
20-A					
(0.5' - 1')	ND	ND	ND	ND	ND
(2.5' - 3')	ND	ND	ND	ND	ND
20-B					
(0.5' - 1')	65.7	ND	ND	ND	ND
(2.5' - 3')	ND	ND	ND	ND	ND
20-C					
(0.5' - 1')	2.20	ND	ND	1.64	ND
(2.5' - 3')	ND	ND	ND	ND	ND
20-D*					
(0.5' - 1')	ND	<0.05	<0.50	0.051	0.41
(2.5' - 3')	ND	<0.05	<0.50	0.05	0.039
20-E*					
(0.5' - 1')	ND	<0.05	<0.50	0.072	<0.003
(2.5' - 3')	ND	<0.05	<0.50	0.057	0.024
Detection Limits		0.50	0.50	0.50	0.50
Regulatory Limits	100	350	100	100	NRC

ND Not detected
* Samples collected July 1986
NRC No specific regulatory concentration

Table E-29

Analytical Results for Soil Samples Collected in March 1986 -- Site 22, NWS Earle, Colts Neck, NJ

Sample Number	Analyte				
	Petroleum Hydrocarbons (mg/kg)	EPTOX (mg/L)			
		Zn	Cr	Pb	Ti
22-A					
(0.5' - 1')	ND	ND	ND	ND	ND
(2.5' - 3')	ND	ND	ND	ND	ND
22-B					
(0.5' - 1')	ND	ND	ND	ND	ND
(2.5' - 3')	ND	ND	ND	ND	ND
22-C					
(0.5' - 1')	4.20	ND	ND	ND	ND
(2' - 2.5')	39.0	ND	ND	ND	ND
22-D*					
(0.5' - 1')	ND	ND	ND	ND	ND
(2' - 2.5')	ND	ND	ND	ND	ND
Detection Limits		0.50	0.50	0.50	0.50
Regulatory Limits	100	350	100	100	NRC

ND Not detected
* Samples collected July 1986
NRC No specific regulatory concentration

Table E-30

Analytical Results for Groundwater Samples Collected in July 1986 -- Site 26, NWS Earle, Colts Neck, NJ

Analyte	Sample Number						Regulatory Limit
	26-1	26-1B	26-2	26-2A	26-2B	26-3	
Picric acid	ND	ND	ND	ND	ND	ND	NRC
Field measured parameters:							
pH	4.8	NR	4.0	NR	NR	4.5	---
Temperature (°C)	18	NR	17	NR	NR	17	NRC
Specific conductance (umho/cm)	60	NR	225	NR	NR	50	NRC

ND Not detected
NR Analysis not requested
A Duplicate sample
B Field blank
NRC No specific regulatory concentration

Table E-31

Summary of Analytical Requirements for Soil and Sediment Analyses -- Site 26, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrite	10	1	0	1	12
Picric acid	10	1	0	1	12

Table E-32

Summary of Analytical Requirements for Surface Water and Groundwater Analyses -- Site 26, NWS Earle, Colts Neck, NJ

Parameter	Number of Samples	Dup/Rep	Trip Blanks	Field Blanks	Total Analyses
Nitrate/nitrate	4	1	0	1	6
Picric acid	4	1	0	1	6
Metals (TAL)	4	1	0	1	6
pH	4	0	0	0	4
Specific conductance	4	0	0	0	4

APPENDIX F

PROCEDURES

Designation: D 1586 - 84

Standard Method for PENETRATION TEST AND SPLIT-BARREL SAMPLING OF SOILS[1]

This standard is issued under the fixed designation D 1586; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This method has been approved for use by agencies of the Department of Defense and for listing in the DOD Index of Specifications and Standards.

1. Scope

1.1 This method describes the procedure, generally known as the Standard Penetration Test (SPT), for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For a specific precautionary statement, see 5.4.1.

1.3 The values stated in inch-pound units are to be regarded as the standard.

2. Applicable Documents

2.1 *ASTM Standards:*

D2487 Test Method for Classification of Soils for Engineering Purposes[2]

D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D4220 Practices for Preserving and Transporting Soil Samples[2]

3. Descriptions of Terms Specific to This Standard

3.1 *anvil*—that portion of the drive-weight assembly which the hammer strikes and through which the hammer energy passes into the drill rods.

3.2 *cathead*—the rotating drum or windlass in the rope-cathead lift system around which the operator wraps a rope to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.

3.3 *drill rods*—rods used to transmit downward force and torque to the drill bit while drilling a borehole.

3.4 *drive-weight assembly*—a device consisting of the hammer, hammer fall guide, the anvil, and any hammer drop system.

3.5 *hammer*—that portion of the drive-weight assembly consisting of the 140 ± 2 lb (63.5 ± 1 kg) impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampling and penetration.

3.6 *hammer drop system*—that portion of the drive-weight assembly by which the operator accomplishes the lifting and dropping of the hammer to produce the blow.

3.7 *hammer fall guide*—that part of the drive-weight assembly used to guide the fall of the hammer.

3.8 *N-value*—the blowcount representation of the penetration resistance of the soil. The *N*-value, reported in blows per foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 in. (150 to 450 mm) (see 7.3).

3.9 ΔN—the number of blows obtained from each of the 6-in. (150-mm) intervals of sampler penetration (see 7.3).

3.10 *number of rope turns*—the total contact angle between the rope and the cathead at the

[1] This method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Investigations.

Current edition approved Sept. 11, 1984. Published November 1984. Originally published as D 1586 - 58 T. Last previous edition D 1586 - 67 (1974).

[2] *Annual Book of ASTM Standards*, Vol 04.08.

beginning of the operator's rope slackening to drop the hammer, divided by 360° (see Fig. 1).

3.11 *sampling rods*—rods that connect the drive-weight assembly to the sampler. Drill rods are often used for this purpose.

3.12 *SPT*—abbreviation for Standard Penetration Test, a term by which engineers commonly refer to this method.

4. Significance and Use

4.1 This method provides a soil sample for identification purposes and for laboratory tests appropriate for soil obtained from a sampler that may produce large shear strain disturbance in the sample.

4.2 This method is used extensively in a great variety of geotechnical exploration projects. Many local correlations and widely published correlations which relate SPT blowcount, or *N*-value, and the engineering behavior of earthworks and foundations are available.

5. Apparatus

5.1 *Drilling Equipment*—Any drilling equipment that provides at the time of sampling a suitably clean open hole before insertion of the sampler and ensures that the penetration test is performed on undisturbed soil shall be acceptable. The following pieces of equipment have proven to be suitable for advancing a borehole in some subsurface conditions.

5.1.1 *Drag, Chopping, and Fishtail Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjuction with open-hole rotary drilling or casing-advancement drilling methods. To avoid disturbance of the underlying soil, bottom discharge bits are not permitted; only side discharge bits are permitted.

5.1.2 *Roller-Cone Bits*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used in conjunction with open-hole rotary drilling or casing-advancement drilling methods if the drilling fluid discharge is deflected.

5.1.3 *Hollow-Stem Continuous Flight Augers*, with or without a center bit assembly, may be used to drill the boring. The inside diameter of the hollow-stem augers shall be less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm).

5.1.4 *Solid, Continuous Flight, Bucket and Hand Augers*, less than 6.5 in. (162 mm) and greater than 2.2 in. (56 mm) in diameter may be used if the soil on the side of the boring does not cave onto the sampler or sampling rods during sampling.

5.2 *Sampling Rods*—Flush-joint steel drill rods shall be used to connect the split-barrel sampler to the drive-weight assembly. The sampling rod shall have a stiffness (moment of inertia) equal to or greater than that of parallel wall "A" rod (a steel rod which has an outside diameter of 1⅝ in. (41.2 mm) and an inside diameter of 1⅛ in. (28.5 mm).

NOTE 1—Recent research and comparative testing indicates the type rod used, with stiffness ranging from "A" size rod to "N" size rod, will usually have a negligible effect on the *N*-values to depths of at least 100 ft (30 m).

5.3 *Split-Barrel Sampler*—The sampler shall be constructed with the dimensions indicated in Fig. 2. The driving shoe shall be of hardened steel and shall be replaced or repaired when it becomes dented or distorted. The use of liners to produce a constant inside diameter of 1⅜ in. (35 mm) is permitted, but shall be noted on the penetration record if used. The use of a sample retainer basket is permitted, and should also be noted on the penetration record if used.

NOTE 2—Both theory and available test data suggest that *N*-values may increase between 10 to 30 % when liners are used.

5.4 *Drive-Weight Assembly:*

5.4.1 *Hammer and Anvil*—The hammer shall weigh 140 ± 2 lb (63.5 ± 1 kg) and shall be a solid rigid metallic mass. The hammer shall strike the anvil and make steel on steel contact when it is dropped. A hammer fall guide permitting a free fall shall be used. Hammers used with the cathead and rope method shall have an unimpeded overlift capacity of at least 4 in. (100 mm). For safety reasons, the use of a hammer assembly with an internal anvil is encouraged.

NOTE 3—It is suggested that the hammer fall guide be permanently marked to enable the operator or inspector to judge the hammer drop height.

5.4.2 *Hammer Drop System*—Rope-cathead, trip, semi-automatic, or automatic hammer drop systems may be used, providing the lifting apparatus will not cause penetration of the sampler while re-engaging and lifting the hammer.

5.5 *Accessory Equipment*—Accessories such as labels, sample containers, data sheets, and groundwater level measuring devices shall be provided in accordance with the requirements of the project and other ASTM standards.

6. Drilling Procedure

6.1 The boring shall be advanced incrementally to permit intermittent or continuous sampling. Test intervals and locations are normally stipulated by the project engineer or geologist. Typically, the intervals selected are 5 ft (1.5 mm) or less in homogeneous strata with test and sampling locations at every change of strata.

6.2 Any drilling procedure that provides a suitably clean and stable hole before insertion of the sampler and assures that the penetration test is performed on essentially undisturbed soil shall be acceptable. Each of the following procedures have proven to be acceptable for some subsurface conditions. The subsurface conditions anticipated should be considered when selecting the drilling method to be used.

6.2.1 Open-hole rotary drilling method.

6.2.2 Continuous flight hollow-stem auger method.

6.2.3 Wash boring method.

6.2.4 Continuous flight solid auger method.

6.3 Several drilling methods produce unacceptable borings. The process of jetting through an open tube sampler and then sampling when the desired depth is reached shall not be permitted. The continuous flight solid auger method shall not be used for advancing the boring below a water table or below the upper confining bed of a confined non-cohesive stratum that is under artesian pressure. Casing may not be advanced below the sampling elevation prior to sampling. Advancing a boring with bottom discharge bits is not permissible. It is not permissible to advance the boring for subsequent insertion of the sampler solely by means of previous sampling with the SPT sampler.

6.4 The drilling fluid level within the boring or hollow-stem augers shall be maintained at or above the in situ groundwater level at all times during drilling, removal of drill rods, and sampling.

7. Sampling and Testing Procedure

7.1 After the boring has been advanced to the desired sampling elevation and excessive cuttings have been removed, prepare for the test with the following sequence of operations.

7.1.1 Attach the split-barrel sampler to the sampling rods and lower into the borehole. Do not allow the sampler to drop onto the soil to be sampled.

7.1.2 Position the hammer above and attach the anvil to the top of the sampling rods. This may be done before the sampling rods and sampler are lowered into the borehole.

7.1.3 Rest the dead weight of the sampler, rods, anvil, and drive weight on the bottom of the boring and apply a seating blow. If excessive cuttings are encountered at the bottom of the boring, remove the sampler and sampling rods from the boring and remove the cuttings.

7.1.4 Mark the drill rods in three successive 6-in. (0.15-m) increments so that the advance of the sampler under the impact of the hammer can be easily observed for each 6-in. (0.15-m) increment.

7.2 Drive the sampler with blows from the 140-lb (63.5-kg) hammer and count the number of blows applied in each 6-in. (0.15-m) increment until one of the following occurs:

7.2.1 A total of 50 blows have been applied during any one of the three 6-in. (0.15-m) increments described in 7.1.4.

7.2.2 A total of 100 blows have been applied.

7.2.3 There is no observed advance of the sampler during the application of 10 successive blows of the hammer.

7.2.4 The sampler is advanced the complete 18 in. (0.45 m) without the limiting blow counts occurring as described in 7.2.1, 7.2.2, or 7.2.3.

7.3 Record the number of blows required to effect each 6 in. (0.15 m) of penetration or fraction thereof. The first 6 in. is considered to be a seating drive. The sum of the number of blows required for the second and third 6 in. of penetration is termed the "standard penetration resistance", or the "*N*-value". If the sampler is driven less than 18 in. (0.45 m), as permitted in 7.2.1, 7.2.2, or 7.2.3, the number of blows per each complete 6-in. (0.15-m) increment and per each partial increment shall be recorded on the boring log. For partial increments, the depth of penetration shall be reported to the nearest 1 in. (25 mm), in addition to the number of blows. If the sampler advances below the bottom of the boring under the static weight of the drill rods or the weight of the drill rods plus the static weight of the hammer, this information should be noted on the boring log.

7.4 The raising and dropping of the 140-lb

(63.5-kg) hammer shall be accomplished using either of the following two methods:

7.4.1 By using a trip, automatic, or semi-automatic hammer drop system which lifts the 140-lb (63.5-kg) hammer and allows it to drop 30 ± 1.0 in. (0.76 m ± 25 mm) unimpeded.

7.4.2 By using a cathead to pull a rope attached to the hammer. When the cathead and rope method is used the system and operation shall conform to the following:

7.4.2.1 The cathead shall be essentially free of rust, oil, or grease and have a diameter in the range of 6 to 10 in. (150 to 250 mm).

7.4.2.2 The cathead should be operated at a minimum speed of rotation of 100 RPM, or the approximate speed of rotation shall be reported on the boring log.

7.4.2.3 No more than 2¼ rope turns on the cathead may be used during the performance of the penetration test, as shown in Fig. 1.

NOTE 4—The operator should generally use either 1¾ or 2¼ rope turns, depending upon whether or not the rope comes off the top (1¾ turns) or the bottom (2¼ turns) of the cathead. It is generally known and accepted that 2¾ or more rope turns considerably impedes the fall of the hammer and should not be used to perform the test. The cathead rope should be maintained in a relatively dry, clean, and unfrayed condition.

7.4.2.4 For each hammer blow, a 30-in. (0.76-m) lift and drop shall be employed by the operator. The operation of pulling and throwing the rope shall be performed rhythmically, without holding the rope at the top of the stroke.

7.5 Bring the sampler to the surface and open. Record the percent recovery or the length of sample recovered. Describe the soil samples recovered as to composition, color, stratification, and condition, then place one or more representative portions of the sample into sealable moisture-proof containers (jars) without ramming or distorting any apparent stratification. Seal each container to prevent evaporation of soil moisture. Affix labels to the containers bearing job designation, boring number, sample depth, and the blow count per 6-in. (0.15-m) increment. Protect the samples against extreme temperature changes. If there is a soil change within the sampler, make a jar for each stratum and note its location in the sampler barrel.

8. Report

8.1 Drilling information shall be recorded in the field and shall include the following:

8.1.1 Name and location of job,

8.1.2 Names of crew,

8.1.3 Type and make of drilling machine,

8.1.4 Weather conditions,

8.1.5 Date and time of start and finish of boring,

8.1.6 Boring number and location (station and coordinates, if available and applicable),

8.1.7 Surface elevation, if available,

8.1.8 Method of advancing and cleaning the boring,

8.1.9 Method of keeping boring open,

8.1.10 Depth of water surface and drilling depth at the time of a noted loss of drilling fluid, and time and date when reading or notation was made,

8.1.11 Location of strata changes,

8.1.12 Size of casing, depth of cased portion of boring,

8.1.13 Equipment and method of driving sampler,

8.1.14 Type sampler and length and inside diameter of barrel (note use of liners),

8.1.15 Size, type, and section length of the sampling rods, and

8.1.16 Remarks.

8.2 Data obtained for each sample shall be recorded in the field and shall include the following:

8.2.1 Sample depth and, if utilized, the sample number,

8.2.2 Description of soil,

8.2.3 Strata changes within sample,

8.2.4 Sampler penetration and recovery lengths, and

8.2.5 Number of blows per 6-in. (0.15-m) or partial increment.

9. Precision and Bias

9.1 Variations in N-values of 100 % or more have been observed when using different standard penetration test apparatus and drillers for adjacent borings in the same soil formation. Current opinion, based on field experience, indicates that when using the same apparatus and driller, N-values in the same soil can be reproduced with a coefficient of variation of about 10 %.

9.2 The use of faulty equipment, such as an extremely massive or damaged anvil, a rusty cathead, a low speed cathead, an old, oily rope, or massive or poorly lubricated rope sheaves can significantly contribute to differences in N-values

obtained between operator-drill rig systems.

9.3 The variability in *N*-values produced by different drill rigs and operators may be reduced by measuring that part of the hammer energy delivered into the drill rods from the sampler and adjusting *N* on the basis of comparative energies. A method for energy measurement and *N*-value adjustment is currently under development.

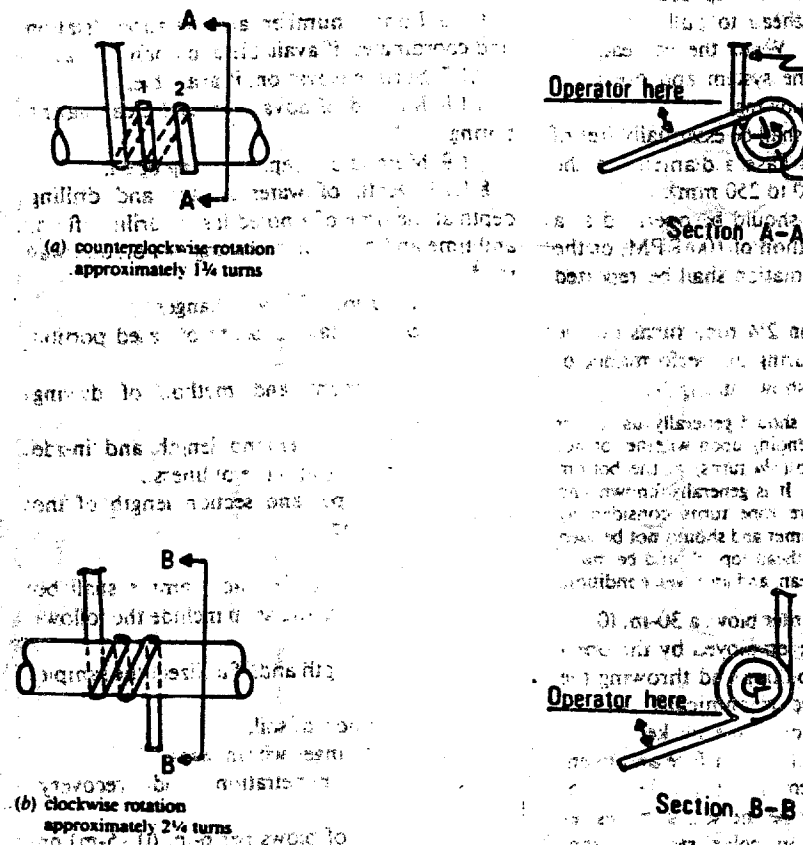
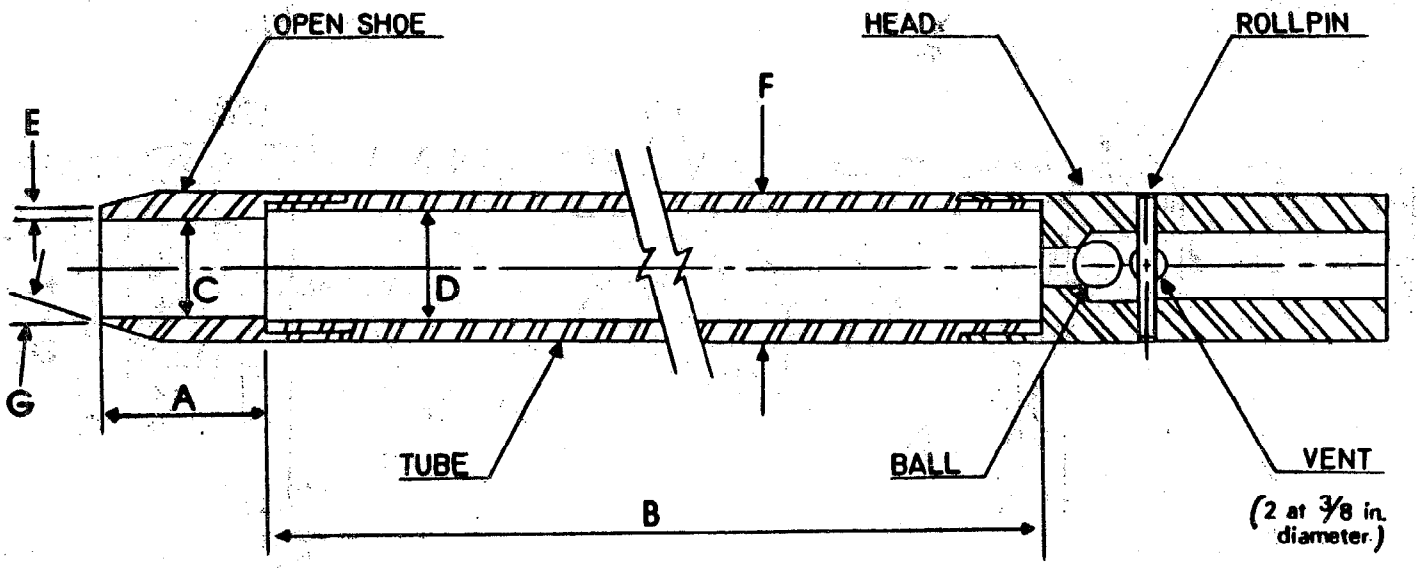


FIG. 1 Definitions of the Number of Rope Turns and the Angle for (*a*) Counterclockwise Rotation and (*b*) Clockwise Rotation of the Cathead



A = 1.0 to 2.0 in. (25 to 50 mm)
B = 18.0 to 30.0 in. (0.457 to 0.762 m)
C = 1.375 ± 0.005 in. (34.93 ± 0.13 mm)
D = 1.50 ± 0.05 − 0.00 in. (38.1 ± 1.3 − 0.0 mm)
E = 0.10 ± 0.02 in. (2.54 ± 0.25 mm)
F = 2.00 ± 0.05 − 0.00 in. (50.8 ± 1.3 − 0.0 mm)
G = 16.0° to 23.0°

The 1½ in. (38 mm) inside diameter split barrel may be used with a 16-gage wall thickness split liner. The penetrating end of the drive shoe may be slightly rounded. Metal or plastic retainers may be used to retain soil samples.

FIG. 2 Split-Barrel Sampler

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, Pa. 19103.