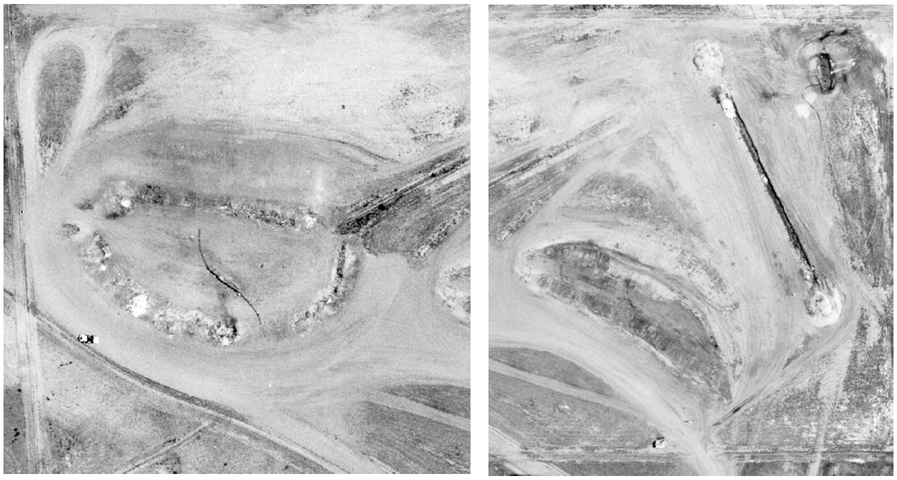
Final

MANAGEMENT PLAN
PHASE II REMEDIAL INVESTIGATION

EAST GATE DISPOSAL YARD AND LOGISTICS CENTER
Fort Lewis, Washington



Prepared for

U.S. Army Corps of Engineers
Seattle District
4735 East Marginal Way South
Seattle, Washington 98134

July 2001

URS
1501 4th Avenue, Suite 1400
Seattle, Washington 98101-1616

53F0074209

TABLE OF CONTENTS

Work Plan

Sampling and Analysis Plan

Field Sampling Plan

Quality Assurance Project Plan

Site Safety and Health Plan

FINAL

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TABLE OF CONTENTS

TABLE OF CONTENTS

Tables

Figures

bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
cis-1,2-DCE	cis-1,2-dichloroethene
CLP	Contract Laboratory Program
CPT	cone penetrometer testing
CRREL	Cold Regions Research Laboratory
CSM	conceptual site model
DCQCR	daily chemical quality control report
DNAPL	dense nonaqueous-phase liquid
DRMO	Defense Reutilization Marketing Office
DQO	data quality objective
DSITMS	direct sampling ion trap mass spectrometer
Ecology	Washington State Department of Ecology
EE/CA	engineering evaluation/cost analysis
EGDY	East Gate Disposal Yard
EPA	U.S. Environmental Protection Agency
ESI	expanded site investigation
FLUTe	Flexible Liner Underground Technologies
FSP	field sampling plan
g/cc	gram per cubic centimeter
GIS	geographic information system
GPR	ground-penetrating radar
GPS	Global Positioning System
I-5	Interstate Highway 5
IDW	investigation-derived waste
IRP	Installation Restoration Program
ISRM	in situ redox manipulation
L/m^3	liter per cubic meter
LFI	limited field investigation
LIF	laser-induced fluorescence
LNAPL	light nonaqueous-phase liquid
m/mm	meter per minute
MCL	maximum contaminant level
MIP	membrane interface probe
mg/kg	milligram per kilogram
mg/L	milligram per liter
mm Hg	millimeters of mercury
MROD	Mount Rainier Ordnance Depot
msl	mean sea level
NAPL	nonaqueous-phase liquid
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NPL	National Priorities List
ORP	oxidation-reduction potential
P/C	polyvinyl chloride

PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PID	photoionization detector
PNNL	Pacific Northwest National Laboratory
POL	petroleum, oils, and lubricants
PPE	personal protective equipment
ppm	part per million
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RABITT	reductive anaerobic biological in situ treatment technology
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
RPD	relative percent difference
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SCAPS	Site Characterization and Analysis Penetrometer System
SVOC	semivolatile organic compound
1,1,1-TCA	1,1,1-trichloroethane
TAL	target analyte list
TCE	trichloroethene
TOC	total organic carbon
TPH	total petroleum hydrocarbon
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
VOC	volatile organic compound
µg/kg	microgram per kilogram
µg/L	microgram per liter

The U.S. Army Corps of Engineers (USACE), Seattle District, on behalf of Fort Lewis Public Works, is conducting a remedial investigation (RI) at the East Gate Disposal Yard (EGDY), also known as Landfill 2, located in the Logistics Center at Fort Lewis, Washington. This Work Plan defines the objectives of the investigation and provides details of the work to be performed to meet the project objectives.

1.1 OBJECTIVES

EGDY is the source area for widespread trichloroethene (TCE) contamination at the Fort Lewis Logistics Center. Soil and groundwater at the EGDY site are contaminated primarily with chlorinated and nonchlorinated hydrocarbons. This contamination results from the past disposal of waste streams that likely consisted of spent degreasing solvents, lubricating oils, and fuel oils. It exists in the subsurface as free-phase product, dissolved in groundwater, and adsorbed on solids. The final engineering evaluation/cost analysis (EE/CA) for EGDY and the Logistics Center at Fort Lewis (URSGWC 2001b) recommends in situ thermal technologies to remediate the free-phase product, and optimization of the existing groundwater pump-and-treat system to remove remaining dissolved-phase contamination. Alternatively, a reactive barrier wall could be used in place of the optimized groundwater pump-and-treat system.

The objective of this RI is to collect data required for design of in situ thermal treatment remedies and evaluation of the options for optimization of the existing groundwater pump-and-treat system or placement of a reactive barrier wall. To support this objective, results of this RI will be used to better define the type and extent of nonaqueous-phase liquid (NAPL) contamination and subsurface geologic constraints. Site-specific factors that might impact the effectiveness/deployment of in situ thermal technologies include vertical and horizontal distribution of NAPL with varying compositions; physical and chemical characteristics of the NAPL; depth of NAPL penetration; type, thickness, and heterogeneity of subsurface geologic material; and the presence of manmade subsurface structures/materials. Data quality objectives (DQOs) are discussed in Section 6 of this Work Plan.

1.2 SCOPE

A dynamic investigation approach has been developed to allow for an evolution of the conceptual site model (CSM) (Section 5) as new data are collected. Some initial sampling locations have been selected; however, the majority of the locations will be selected in the field based on assessment of the evolving CSM. The scope of work for this RI consists of the following sampling and analytical toolbox components:

- Exploratory trenching to investigate suspected waste disposal areas located outside of EGDY
- Site Characterization and Analysis Penetrometer System (SCAPS) cone penetrometer testing (CPT) to provide geotechnical and stratigraphic information
- Geophysical investigations, as an alternative or supplement to the CPT, to define the lateral extents and thicknesses of stratigraphic features
- Data collection using laser-induced fluorescence (LIF), GeoVIS, and the Flexible Liner Underground Technologies (FLUTe) ribbon sampler in conjunction with the SCAPS CPT to

determine the presence and extent of light nonaqueous-phase liquid (LNAPL) and dense nonaqueous-phase liquid (DNAPL)

- Membrane interface probe (MIP) data collection using the SCAPS direct-push system to measure concentrations of volatile organic compounds (VOCs) in groundwater using a direct sampling ion trap mass spectrometer (DSITMS)
- SCAPS soil and PowerPunch™ groundwater sampling to verify and assist with interpretation of SCAPS LIF and MIP data, delineate dissolved phase contaminant extent, and characterize contaminant composition
- Surface water sampling, with analysis using DSITMS, to enhance understanding of the contaminant plume interaction with Murray Creek
- Soil boring and shallow monitoring well installation and sampling between the water table and the intermediate aquitard (upper Vashon aquifer) using a sonic drilling technique to characterize stratigraphy; verify the presence, physical and chemical composition, and determine the vertical extent of DNAPL and LNAPL; and to collect groundwater elevation data
- Multiport monitoring well installation and sampling using a sonic drilling technique to characterize stratigraphy, collect groundwater chemical and elevation data, and verify extent of DNAPL and groundwater contaminants between the intermediate aquitard and Kitsap aquitard
- Piezometer installation using the SCAPS direct-push system to collect groundwater elevation data in the greater EGDY area
- Off-site chemical analysis and physical testing
- Field monitoring of air (primarily for health and safety) and groundwater quality parameters
- Surveying using Global Positioning System (GPS) with ± 10 feet accuracy and other methods with 0.05-foot accuracy

Details of these work items are provided in the overview of the sampling and analysis program (Section 6.4).

1.3 WORK PLAN CONTENTS

In accordance with USACE guidance EM 200-1-3 (USACE 2001), this Work Plan is intended to serve as the "umbrella" document for the site investigation. It addresses each of the topics listed in EM 200-1-3 and the scope of work for this project. This Work Plan has been organized in the following sections:

1. Introduction
2. Project Organization and Responsibilities
3. Site Background and Setting
4. Previous and Ongoing Investigations and Remediation Efforts
5. Conceptual Site Model
6. Investigation Rationale and Approach

7. Presentation, Interpretation, and Review
8. Communications, Data Management, and Reporting
9. References

Key positions and personnel assigned to this project are described in this section. A summary of personnel contact information is presented in Tables 2-1 and 2-2.

2.1 FORT LEWIS PUBLIC WORKS

2.1.1 Installation Restoration Program Project Manager: Rich Wilson

The Installation Restoration Program (IRP) Project Manager is the Fort Lewis Public Works authority for this project. All recommendations regarding cost and scope variations will be reviewed by Mr. Rich Wilson and approved by Mr. Paul Steucke, Program Manager, prior to implementation. Fort Lewis Public Works is the recipient of all project documents and will provide comments on draft versions of the documents to the USACE. Changes to documents and final versions will be approved by Mr. Wilson.

2.1.2 RCRA/Investigation-Derived Waste Disposal Administrator: Jana Nelson

The Resource Conservation and Recovery Act (RCRA) /Investigation-Derived Waste (IDW) Disposal Administrator is responsible for disposing of IDW generated during RI field activities. Disposal will be in accordance with the Off-site Disposal Rule.

2.1.3 EPA, USGS, and PNNL

Representatives from the U.S. Environmental Protection Agency (EPA) (Mr. Bob Kievit and Ms. Marcia Knadle) provide regulatory oversight for EGDY and the Logistics Center. The U.S. Geological Survey (USGS) and Battelle Pacific Northwest National Laboratory (PNNL) hold technical advisory roles for Fort Lewis projects.

2.2 USACE SEATTLE DISTRICT

2.2.1 Project Manager: Bill Goss

The USACE Project Manager will maintain specific project management authority throughout the life of the project, and is responsible for overall management and execution of the project to include project quality, cost and schedule. Specific tasks include:

- Providing the project team with funding for each task
- Modifying contracts
- Tracking and reporting to Fort Lewis Public Works financial expenditures, obligations and schedule
- Facilitating the resolution of issues arising during the project
- Obtaining feedback from the team and customer, and ensuring that feedback, both positive and negative, is used to improve the project

2.2.2 Technical Team: Kira Lynch (Senior Chemist), Richard Smith (Senior Geologist), Jeff Powers (Project Geologist), and Gwyn Puckett (Project Chemist)

The technical team members are the primary liaisons with the USACE Project Manager for this field program, and are responsible for keeping the USACE Project Manager and the Fort Lewis IRP Project Manager informed of project schedule, budget, and changes. Ms. Lynch and Mr. Smith have overall responsibility for achieving the technical objectives of this project. Ms. Lynch and Mr. Smith, working with other project and technical team members, will be ultimately responsible for decisions regarding sampling locations and evolution of the dynamic work plan in the field. They will be supported by Ms. Puckett and Mr. Powers.

They will work closely with the other task managers, will be immediately notified if problems occur, and will approve changes to the Sampling and Analysis Plan (SAP), with approval from EPA, if such changes are warranted. In the event that changes are needed, they will immediately notify, discuss the proposed changes with, and furnish a description of the changes to the USACE Project Manager prior to implementing those changes. Changes in the SAP will not be made without prior approval from the technical team unless conditions require immediate response in the field or laboratory. Any changes that involve additional funding beyond the existing scope must be approved by the USACE Project Manager.

The technical team’s responsibilities also include development of data quality objectives, selection of analytical methods and laboratories, approval of quality assurance/quality control (QA/QC) procedures and review of daily field reports.

As the USACE Senior Chemist for this project, Ms. Lynch is responsible for overseeing quality of all URS and USACE sampling and analysis activities associated with the RI. Ms. Lynch will oversee all aspects of the sampling and analysis events to ensure that the appropriate procedures and methods meet project QA/QC objectives. As Project Chemist, Ms. Puckett also will support the Senior Chemist with project QA/QC and laboratory issues.

As the USACE Senior Geologist for this project, Mr. Smith is responsible for planning site intrusive activities designed to fill geology data gaps and for the design and installation of new wells at the site. He also has responsibility for management, display, and interpretation of geologic data and revisions to the geologic and hydrogeologic portions of the CSM. As Project Geologist, Mr. Powers will support the Senior Geologist with geologic interpretation of data and revisions to the CSM.

The USACE technical team on-site representative is responsible for on-site performance of the field activities, including adherence to the SAP, initiating change orders, scheduling, liaison with the project and technical teams, sample logging and custody, and uploading of data to eRoom. During field activities, this representative will be responsible for oversight of URS and USACE Tulsa District personnel.

2.3 URS

2.3.1 Contract Manager: Dave Haddock

The Contract Manager is responsible for URS' total project performance. While the Contract Manager will not direct the daily activities of the project, he will coordinate closely with the URS Project Manager to ensure that the project is completed successfully.

2.3.2 Project Manager: Janette Rau

The URS Project Manager has overall responsibility for implementing URS' project activities and monitoring the project progress. Ms. Rau is responsible for planning, scheduling, cost control, and completion of project tasks. She also has overall responsibility for the development and implementation of this management plan, for monitoring the quality of the technical and managerial aspects of the project, interfacing with the USACE, and ensuring the timeliness of all project deliverables.

2.3.3 Quality Assurance/Quality Control Manager and Project Chemist: Kathryn Carpenter

As URS Quality Assurance/Quality Control Manager for this project, Ms. Carpenter is responsible for the quality of all sampling and analysis activities associated with this RI. She will oversee all aspects of the sampling and analysis events to ensure that the appropriate procedures and methods are used to meet the programs' QA objectives. Ms. Carpenter also will be responsible for laboratory oversight and will direct the quality review of analytical data. She will work closely with the URS Project Manager, the USACE Technical Leaders, and the laboratories.

2.3.4 Field Investigation Manager: John Rapp

The URS Field Investigation Manager is responsible for the overall performance of the URS field operations including adherence to the SAP, scheduling, liaison with USACE Seattle and Tulsa District personnel and URS subcontractors, and sample logging and custody. Mr. Rapp also will function as the Site Safety Officer and will be responsible for the safe operation of the field teams. He will be responsible for the implementation of the Site Safety and Health Plan, review its contents with all personnel, confirm that all personnel have received the required health and safety training, determine personal protection levels, provide necessary personal protective equipment and supplies, and correct any unsafe work practices.

2.3.5 Health and Safety Officer: Heather Boge

The Health and Safety Officer will prepare the Site Safety and Health Plan for all field activities being performed for this RI. Ms. Boge works directly with the URS Project Manger and has the responsibility to monitor and verify that the work is performed in accordance with the Site Safety and Health Plan. She will advise the Project Manager regarding health and safety issues, but will function independently.

2.3.6 Database Manager: Crystal Neirby

The Database Manager is responsible for ensuring that project data are properly organized and imported into the EGDY Access database. Ms. Neirby also is responsible for exporting data to the EGDY Website in a timely manner.

2.4 USACE TULSA DISTRICT

Table 2-2 lists the Tulsa District SCAPS team supporting this exploration.

2.4.1 SCAPS Manager: Steve Brewer

The SCAPS Manager is responsible for the overall performance of the SCAPS rig, laboratory, and all associated direct push probes and tools. Mr. Brewer also will be responsible for implementation of the SCAPS Site Safety and Health Plan, and adherence to SCAPS standard operating procedures. He will be supported by the SCAPS team.

2.5 CONTRACTOR SERVICES

Table 2-3 is a list of all subcontractors and the services they will be providing for this project.

2.6 COLD REGIONS RESEARCH LABORATORY

Ms. Martha Folley and Mr. Joe Schlagel, Cold Regions Research Laboratory (CRREL), are responsible for the development and maintenance of a project-specific, web-based mapping tool used for visualization of sampling point locations and some of the associated data.

Table 2-1

CONTACT INFORMATION FOR USACE SEATTLE DISTRICT, URS, AND OTHER PERSONNEL

NAME[a] AND TITLE	ROLE/RESPONSIBILITY	ORGANIZATION	CONTACT INFO
Rich Wilson IRP Project Manager	Fort Lewis Public Works Authority and POC	Fort Lewis Public Works	Phone: 253-966-1801 Fax: 253-966-4958 Email: wilsonr@lewis.army.mil
Jana Nelson RCRA Waste/ IDW Disposal Administrator	Regulatory oversight and guidance regarding RCRA waste and IDW disposal	Fort Lewis Public Works	Phone: 253-966-1767 Fax: 253-966-4985 Email: nelsonj2@lewis.army.mil
Bob Kievit Remedial Project Manager	Regulatory oversight and support	EPA	Phone: 360-753-9014 Fax: 360-753-8080 Email: kievit.bob@epamail.epa.gov
Marcia Knadle Hydrogeologist	Technical oversight and support	EPA	Phone: 206-253-1641 Fax: 206-253-0119 Email: knadle.marcia@epamail.epa.gov
Rick Dinicola Hydrologist	Technical oversight and support	USGS	Phone: 253-428-3600 Fax: 253-428-3614 Email: dinicola@usgs.gov
Ron Smith Soil Chemist	Technical oversight and support	Battelle PNNL	Phone: 509-376-5831 Fax: 509-372-1704 Email: rmsmith@pnl.gov
Bill Goss Project Manager	POC for Seattle District Responsible for decisions regarding budget and scope changes	USACE Seattle District	Phone: 206-764-3267 Fax: 206-764-3706 Email: william.a.goss@usace.army.mil
Kira Lynch Technical Team Member, Senior Chemist	Responsible for decisions regarding sampling locations and evolution of dynamic work plan in the field Chemistry POC	USACE Seattle District	Phone: 206-764-6918 Fax: 206-764-3706 Email: kira.p.lynch@usace.army.mil
Richard Smith Technical Team Member, Senior Geologist	Responsible for decisions regarding sampling locations and evolution of dynamic work plan in the field Geology POC	USACE Seattle District	Phone: 206-764-3309 Fax: 206-764-3706 Email: richard.e.smith@nws02.usace.army.mil
Jeff Powers Technical Team Member, Project Geologist	Supports Senior Geologist	USACE Seattle District	Phone: 206-764-6586 Fax: 206-764-3706 Email: jefferey.g.powers@nws02.usace.army.mil
Gwyn Puckett Project Chemist	Supports Senior Chemist	USACE Seattle District	Phone: 206-764-6184 Fax: 206-764-3706 Email: gwyn.l.puckett@usace.army.mil
David Haddock Program Manager	Responsible for overall performance and quality of URS' work on this project	URS	Phone: 206-438-2137 Fax: 206-438-2699 Email: david_haddock@urscorp.com
Janette Rau Project Manager	POC for URS Present during part of field activities	URS	Phone: 206-438-2283 Fax: 206-438-2699 Email: janette_rau@urscorp.com
Kathryn Carpenter QA/QC Manager Project Chemist	Monitors quality of sampling and analysis Present during part of field activities Oversight of laboratories	URS	Phone: 206-438-2053 Fax: 206-438-2699 Email: kathryn_carpenter@urscorp.com

Table 2-1 (Continued)
CONTACT INFORMATION FOR USACE SEATTLE DISTRICT, URS, AND OTHER PERSONNEL

NAME[a] AND TITLE	ROLE/RESPONSIBILITY	ORGANIZATION	CONTACT INFO
John Rapp Field Investigation Manager Site Safety Officer	Site POC for URS when Project Manager not present Implements field events and adheres to Sampling and Analysis Plan Monitors site health and safety	URS	Phone: 206-438-2281 Fax: 206-438-2699 Cell: 360-620-5090 Email: john_rapp@urscorp.com
Crystal Neirby Database Manager	Coordinates data and ensures input of it into project database and eRoom Present during part of field activities	URS	Phone: 206-438-2248 Fax: 206-438-2699 Email: crystal_neirby@urscorp.com
Martha Folley Physical Scientist and Application Programmer	Development and maintenance of data visualization software tool	CRREL	Phone: 603-646-4871 Fax: 603-646-4570 Email: Martha.J.Folley@erdc.usace.army.mil
Joel Schlagel Physical Scientist and Systems Developer	Development and maintenance of data visualization software tool	CRREL	Phone: 603-646-4387 Fax: 603-646-4570 Email: Joel.D.Schlagel@erdc.usace.army.mil

Notes:

[a] Other EGDY Phase II RI team members may visit site periodically; however, they do not have a primary role in field sampling activities.

CRREL – Cold Regions Research Laboratory

POC – point of contact

See Table 2-2 for USACE Tulsa District personnel contact information.

Table 2-2
CONTACT INFORMATION FOR USACE TULSA DISTRICT SCAPS TEAM

Name	Primary Role/Responsibility	Alternate Role/Responsibility	USACE District	Primary Location	Office Number	Mobile
Steve Brewer	**SCAPS Manager**; Provides supervision and technical oversight for the project, coordinates preparation and maintenance of SCAPS equipment, prepares cost estimates, reviews work plans, manages investigative derived waste. **(email: billy.s.brewer@usace.army.mil)**	**Site Safety Health Officer** **Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-832-4122	**918-605-9342**
Karl Konecny	**SCAPS Operator/Driller**, operates and maintains SCAPS vehicle and other site equipment. **(email: karl.f.konecny@wes02.usace.army.mil)**		ERDC-EL (WES)	Field	601-634-3972	**918-605-9343**
Chuck Joyce	**SCAPS Assistant Operator**, supports SCAPS operator, threads pipe/rods, mixes grout, cleans equipment and parts, containerizes waste. **(email: chcuk.g.joyce@swt03.usace.army.mil)**	**Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-832-4122	
Dave Jones	**SCAPS Assistant Operator**, supports SCAPS operator, threads pipe/rods, mixes grout, cleans equipment and parts, containerizes waste. **(email: david.p.jones@swt03.usace.army.mil)**	**Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-669-7168	
Greg Snider	**SCAPS Assistant Operator**, supports SCAPS operator, threads pipe/rods, mixes grout, cleans equipment and parts, containerizes waste. **(email: greg.snider@swt03usace.army.mil)**	**Site Safety Health Officer** **Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-832-4122	**918-605-9341**
Dan Eng	**SCAPS Technical Support**; support repair and purchasing of SCAPS related equipment and instrumentation. **(email: dan.y.eng@wes02.usace.army.mil)**	**SCAPS Assistant Operator**	ERDC-ITL (WES)	Office	601-634-3409	
Jeff Powell	**SCAPS Technical Support**; support repair and purchasing of SCAPS related equipment and instrumentation. **(email: jeff.f.powell@wes02.usace.army.mil)**	**SCAPS Assistant Operator**	ERDC-ITL (WES)	Office	601-634-3407	
Frank Roepke	**Analytical Chemist**; prepares, maintains and operates field analytical instrumentation. **(email: frank.roepke@swt03.usace.army.mil)**	**SCAPS Assistant Operator** **Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-669-7444	
Eddie Mattioda	**Analytical Chemist**; prepares, maintains and operates field analytical instrumentation, develops draft and final reports. **(email: edward.mattioda@swt03usace.army.mil)**	**SCAPS Assistant Operator** **Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-669-7445	**918-605-9346**
Chris Kennedy	**Analytical Chemist**; prepares, maintains and operates field analytical instrumentation, prepares cost estimates, develops SOPs, reviews work plans, develops draft and final reports. **(email: christopher.kennedy@swt03usace.army.mil)**	**SCAPS Assistant Operator** **Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-669-7072	**918-645-1213**

Table 2-2

CONTACT INFORMATION FOR USACE TULSA DISTRICT SCAPS TEAM (cont.)

Name	Primary Role/Responsibility	Alternate Role/Responsibility	USACE District	Primary Location	Office Number	Mobile
Cliff Murray	**GMS Coordinator**; Reviews work plans, prepares GMS software and equipment, updates daily GMS data files, develops draft and final reports. **(email: cliff.murray@swt03usace.army.mil)**	**SCAPS Manager Environmental Sampler**	CESWT-EC (Tulsa)	Field	918-669-7573	**918-605-5789**
Jed Constanza	**GMS Data Management Support**; provides support and training regarding GMS, reviews data and provides input for draft and final reports. **(email: jed64@bellsouth.net)**	**SCAPS Assistant Operator**	NFESC (Navy)	Office	615-699-7573	
SCAPS Truck						**918-688-5243**

Table 2-3
CONTRACTOR SERVICES

CONTRACTOR	SERVICE	ADDRESS AND CONTACT
URS	Oversight of sonic, site prep, geophysics, sampling, and surveying	1501 Fourth Avenue, Suite 1400 Seattle, WA 98101-1616 Contact: Janette Rau Phone: 206-438-2700 Fax: 206-438-2699
USACE Tulsa District	SCAPS, CPT, GeoVIS, LIF, MIP, DSITMS, FLUTe, and piezometer installation	1645 South 101 East Ave. Tulsa, OK 74128 Contact: Steve Brewer Phone: 918-832-4122 Cell: 918-669-9342
Drilling Contractor	Sonic drilling boring and monitoring well installation	To be determined
Sound Analytical Services, Inc.	Soil, groundwater, and NAPL analyses	Sound Analytical Services 5755 8th Street East Fife, WA 98424 Contact: Dawn Werner Phone: 253-922-2310 Fax: 253-922-5047
PTS Laboratories, Inc.	Soil and NAPL physical testing	8100 Secura Way Santa Fe Springs, CA 90670 Contact: Richard Young Phone: 562-907-3607 Fax: 562-907-3610
Environmental Resource Associates	Performance evaluation samples	5540 Marshall Street Arvada, CO 80002 Contact: Anne Rager Phone: 800-372-0122 Fax: 303-431-0159
Don Leonard and Sons	Site clearing	1335 192nd Street East Spanaway, WA 98387 Contact: Randy Wellen Phone: 253-847-7193 Fax: 253-847-7481
Thornton Land Surveying, Inc.	Surveying	PO Box 249 Gig Harbor, WA 98335 Contact: Joe Phone: 253-858-8106 Fax: 253-858-7466

Table 2-4
SITE ADDRESS

U.S. Army Corps of Engineers
East Gate Disposal Yard
Intersection of Rainier Drive and Lincoln Road
Fort Lewis, WA 98433
Phone: 253-966-5687
Fax: 253-966-5688

This section describes the site location, topography, and layout (Section 3.1); the general site history (Section 3.2); regulatory history (Section 3.3); geology (Section 3.4); and hydrogeology (Section 3.4). The primary sources of information for this section are the remedial investigation report (Envirosphere 1988), the site history and conceptual site model (Woodward-Clyde 1997a), the expanded site investigation (ESI) report (URSGWC 1999), and the engineering evaluation/cost analysis (EE/CA) report (URSGWC 2001b).

3.1 SITE LOCATION, TOPOGRAPHY, AND LAYOUT

The Logistics Center is located in Pierce County, Washington, about 11 miles south of Tacoma and about 17 miles northeast of Olympia (Figure 3-1, Inset A). The Logistics Center occupies about 650 acres of the Fort Lewis Military Reservation, located at Township 19 North, Range 2 East, Sections 21, 22, 26, and 27. It is bounded on the northwest by Interstate 5 and beyond by the town of Tillicum, on the southwest by the Madigan Army Medical Center, and on the north by the American Lake Gardens Tract.

EGDY (also known as Landfill No. 2) is located southeast of the Logistics Center in an otherwise undeveloped portion of Fort Lewis (Figure 3-1, Inset B). The EGDY site consists of a previously fenced area of approximately 13.5 acres. Waste was disposed of outside of the fenced area. Therefore, the study area for the ESI (URSGWC 1999) included the fenced area and property outside of the fence for a total area of 35 acres (Figure 3-2). Other areas in the vicinity of the Logistics Center are also shown on Figure 3-2, including the Defense Reutilization Marketing Office (DRMO), Well LC-6 and Pit Area, Former Low-Humidity Storage Buildings, and the North Uses Area (includes Landfill No. 6).

The Logistics Center and EGDY are situated on an extensive upland glacial drift plain that occupies much of central Pierce County. The elevation of the area ranges from approximately 235 feet above mean sea level (msl) at American Lake to 290 feet at EGDY, with some slightly higher hills adjacent to the border of the Logistics Center. The drift plain is crossed by the Puyallup River to the north and east, and by the Nisqually River to the south, which are major drainages for the area. The area has a poorly developed drainage system due to the high infiltration capacity of the soil and level topography. Murray Creek, which flows into American Lake, is the only perennial stream draining from the site vicinity (Envirosphere 1988).

The greater EGDY area is vegetated primarily with Douglas fir, black cottonwood, red alder and wild cherry trees, Scotch-broom and other hardwood shrubs, and grasses. However, most trees have been cleared from the EGDY area where trenches are present. The roads in EGDY are unpaved; however, most roads and parking areas in other areas of the Logistics Center are paved.

3.2 GENERAL SITE HISTORY

Initial development of the Logistics Center site began with construction of the Quartermaster Motor Base in 1941 (Envirosphere 1988). This facility was activated in April 1942. The facility was transferred to ordnance jurisdiction in August 1942 and renamed the Mount Rainier Ordnance Depot (MROD). It operated as the MROD, furnishing ordnance supplies, maintenance, and rebuilding services for Fort Lewis, until 1963. In 1963, the facility was turned over to the Logistics Center to serve as the primary non-aircraft maintenance facility for the post. Table 3-1 summarizes the history of operations at EGDY. Table 3-2 summarizes site features within and immediately adjacent to EGDY observed during a review of historical aerial photographs conducted during the ESI (Section 4).

TCE was used as a degreasing agent at this facility until the mid-1970s when its use was replaced with 1,1,1-trichloroethane. Waste TCE was disposed of with waste oils at several locations. EGDY was used between 1946 and 1960 as a disposal site for waste generated at the MROD (Shannon & Wilson 1986a). Trenches were excavated in the yard and on adjacent land south and west of the yard (Figure 3-3). The trenches reportedly received TCE and petroleum, oils, and lubricants (POL) from cleaning and degreasing operations. This material was transported to EGDY in barrels and vats from the various use areas. About six to eight barrels of waste TCE and POL may have been disposed of per month (Shannon & Wilson 1986a). At times this material was used to assist in burning other waste products. Table 3-4 summarizes waste types known or suspected to have been disposed of in EGDY. These trenches were subsequently covered and are not now visible. The locations and duration of use of these trenches are also discussed in the CSM (Section 5).

Subsequent to the ESI, the USACE conducted an aerial photograph interpretation to aid in locating potential additional historic source areas distant from EGDY (USACE 2001). A collection of aerial photographs from 1951, 1955, 1960, 1964, 1965, 1971, 1978, and 1981 was reviewed. The potential source areas are shown on Figure 3-4 and the site features are summarized in Table 3-3. Potential source areas were identified to the north and east of Madigan Army Medical Center and south of the DRMO Yard in undeveloped areas, and within the DRMO Yard. These features include one pit/solid waste disposal area (Pit 1/SW 1), two cleared areas (CA 1 and CA 2), one disturbed area (DA 1), one ditch (Ditch 1), and two trenches (Trench 12 through Trench 14). These areas currently are being evaluated by the USACE to determine which of these features match potential former TCE disposal practices. Based on the results of a site reconnaissance conducted by the USACE, only those areas with a reasonable probability of being TCE source areas will be investigated further under this RI.

3.3 REGULATORY HISTORY

The Fort Lewis Logistics Center was assigned a Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) No. WA72100900670, and was placed on the National Priorities List (NPL) in December 1989 under the Comprehensive Environmental Response, Liability and Compensation Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The lead agency for the Logistics Center investigations and cleanup is the U.S. Army. An installation-wide Federal Facilities Interagency Agreement between the U.S. Army, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) became effective in January 29, 1990. Under the U.S. Army lead, the RI actions are being conducted under the Installation Restoration Program (IRP). The following paragraphs provide an overview of the investigations and actions taken at the site.

In 1983, EPA and the Tacoma-Pierce County Health Department initiated studies to investigate potential contamination in the American Lake Gardens Tract area to the north of the Logistics Center. This study confirmed the presence of TCE and cis-1,2-dichloroethene (DCE) in several domestic water supply wells in the American Lake Gardens Tract area, possibility originating from McChord Air Force Base. Potential contamination beneath the Logistics Center was also discovered and indicated as a potential source of contamination to the American Lake Gardens Tract area. This prompted an investigation in 1984 into the extent of groundwater contamination in the Logistics Center, where groundwater with a plume of TCE (and lesser concentrations of DCE) was shown to be moving along the centerline of the Logistics Center. A groundwater study of the Tillicum area (a small town immediately downgradient of the Logistics Center) was prompted by the EPA in 1985 to investigate the potential impact to public water supply wells. This study indicated widespread, low-concentration, TCE groundwater contamination in the upper, unconfined aquifer beneath Tillicum, originating from the Logistics Center. Contamination was also detected in the lower aquifer. A subsequent groundwater study was initiated in 1985 to identify the extent of groundwater contamination beneath the Logistics Center and potential sources of contamination. The groundwater plume was found to be at least 10,000 feet in length, 2,500 feet in width, and 80 feet below the water table, primarily originating from EGDY at the southeast end of the Logistics Center.

A remedial investigation/feasibility study (RI/FS) under CERCLA was initiated in 1986 and completed in 1990. A Record of Decision (ROD) signed on September 25, 1990, prescribed two long-term groundwater pump-and-treat systems for the upper unconfined aquifer (U.S. Army, USEPA, and WDOE 1990). In addition, the ROD required further investigation of the lower aquifer and potential sources of soil contamination. The ROD specified that if the lower aquifer was found to be contaminated, the contaminated groundwater from the lower aquifer would be pumped and treated in the on-site treatment facilities. Operation of the groundwater pump-and-treat systems—one near EGDY, the source area, and one near Interstate Highway 5 (I-5), the leading edge of the plume—started in 1995. The systems consist of groundwater extraction wells, air stripping towers for treatment of contaminants (primarily TCE), and recharge wells or infiltration trenches for groundwater discharge. These systems operate primarily to maintain hydraulic control of the groundwater contaminant plume for protection of downgradient drinking water sources beyond the Fort Lewis boundary.

Further investigation of the lower aquifer conducted from 1991 through 1994 found that the hydrogeology beneath the Logistics Center is complex and may allow contamination from the upper aquifer to migrate through permeable soil to the lower aquifer. Therefore, treatment of the lower aquifer through the existing pump-and-treat systems may pull additional contaminated groundwater down from the upper aquifer. Based on these findings, an Explanation of Significant Difference (ESD) from the ROD was signed in 1998 (U.S. Army, USEPA, and WDOE 1998). The changes are described below.

The 1998 ESD specified:

> …using innovative technologies to accelerate treatment and/or control of the source area and the contaminant plume in the unconfined aquifer in addition to utilizing groundwater extraction and treatment in on-site treatment facilities. The extraction and treatment systems may be shut down at some time in the future if no longer required.

where the 1990 ROD had specified:

> …using groundwater extraction and treatment in on-site treatment facilities.

The 1998 ESD specified:

> …accelerating the cleanup of the unconfined aquifer through source control at the EGDY and the use of innovative technologies in the unconfined aquifer, and conduct[ing] additional studies on the transport of contaminants to and through the lower aquifer.

where the 1990 the ROD had specified:

> …extending the groundwater extraction and treatment in on-site treatment facilities to the lower aquifer at this time.

A working group for the Fort Lewis IRP, made up of Fort Lewis Public Works, EPA, Ecology, PNNL, and the USGS, was established in November 1997. The USACE was included in the group in 2000. This group meets periodically to discuss future progress and future directions of the cleanup effort at Fort Lewis. As a result of the USACE's recommendation, and in concurrence with the regulators, drum removal at EGDY was initiated in December 2000 under an Emergency Response Time-Critical Removal Action dated July 24, 2000. The group's focus on the remediation then shifted toward its present emphasis on source removal.

These enhancements are being implemented in the overall strategy for remediating the site and have become part of the Administrative Record pursuant to Section 300.825(a)(2) of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP).

3.4 SITE GEOLOGY

The geology of the Fort Lewis Logistics Center and EGDY area reflects many of the processes and events that affected the Puget Sound Lowland. The series of Pleistocene glaciations and interglacial periods have left a distinct depositional record and include the following geological units in the order of sequence from most recent to latest:

- Vashon Glacial Drift deposits
- Undifferentiated glacial and nonglacial deposits
- Kitsap Nonglacial deposits
- Salmon Springs Glacial Drift and Puyallup Nonglacial deposits

These units are highly variable and may be discontinuous at the site. A description of the geology specific to the site is provided in Section 5.1 of this plan and a general overview is provided below.

The Vashon Drift represents those units deposited during the Vashon Stage of the Fraser Glaciation and contains distinct units. In descending order, these units are Steilacoom Gravel, Vashon Recessional Outwash, Vashon Till, and Vashon Advance Outwash gravel and sand. Two undifferentiated units underlying the Vashon Glacial Drift deposits include undifferentiated glacial till and nonglacial deposits. The Kitsap formation underlies the Vashon Drift. The Salmon Springs Drift represents those units deposited during the Salmon Springs Glaciation. In descending order, the Salmon Springs units are the Recessional Outwash, Till, and Advance Outwash. Underlying the Salmon Springs Drift deposits are nonglacial deposits of the Puyallup formation. These nonglacial deposits are characterized as alluvial deposits of interbedded silt and coarse-grained sediment with mudflow deposits and ash (Ebasco 1994).

3.5 HYDROGEOLOGY

The Vashon Drift aquifer (upper aquifer) is present in several water-bearing units. The Kitsap formation underlying the Vashon Drift serves as the principal aquitard separating the upper aquifer from the Salmon Springs Drift aquifer (lower aquifer).

The upper aquifer is present predominantly in the permeable Steilacoom Gravel (Qvs), Vashon Recessional Outwash (Qvr), Vashon Glacial Outwash Gravel (Qv[Gg]), and Vashon Glacial Outwash Sand (Qv[Gs]). It is also present in the less permeable Vashon Till (Qvt), undifferentiated silt and till layers (tu), and undifferentiated nonglacial deposits (ng). The lower aquifer is present in the Salmon Springs Drift (Qssr, Qsst, and Qssa). Most of the lower aquifer wells are screened in the Salmon Springs Recessional Outwash (Qssr).

The upper aquifer groundwater elevation ranges from approximately 270 feet above msl beneath EGDY to 250 feet above msl in the western portion of the Logistics Center. The depth to groundwater is typically approximately 10 to 30 feet below ground surface (bgs). Beneath the Logistics Center and EGDY, the upper aquifer groundwater flow direction is predominantly toward the northwest.

The lower aquifer groundwater elevation ranges from approximately 267 feet above msl beneath the EGDY to approximately 173 feet above msl in the western portion of the Logistics Center. The depth to groundwater ranges from 5 to 97 feet bgs. The lower aquifer groundwater flow direction is predominantly toward the west-northwest.

Table 3-1
"TIMELINE" HISTORY OF THE FACILITY OPERATIONS AND INVESTIGATIONS AT EGDY

DATE	ACTIVITY	SOURCE
1942-1963	Operation of the Quartermaster Motor Base began in 1942; later that year, the site was transferred to ordnance jurisdiction and renamed the Mount Rainier Ordnance Depot (MROD). MROD furnished ordnance supplies, maintenance, and rebuilding services for Ft. Lewis until 1963.	Envirosphere 1988
1963	MROD turned over to Logistics Center to serve as the primary non-aircraft maintenance facility in 1963. TCE was used as degreasing agent at this facility until the mid-1970s when its use was replaced with 1,1,1-trichlorethane. Waste TCE was disposed of with waste oils at several locations.	Envirosphere 1988
1946-1971	EGDY was used in this approximate time period as a disposal site for waste generated at the MROD/Logistics Center. Two large disposal pits (western and eastern) were used primarily for solid waste and trenches may have been used for disposal of liquid wastes. After 1957, major use of the disposal pits ended and trenches were used for both liquid and solid waste.	Woodward-Clyde 1997a
1985	Army identified traces of TCE in several monitoring wells installed in the unconfined aquifer beneath the Logistics Center.	Woodward-Clyde 1997a
1986	Limited site investigation was performed under the DoD Installation Restoration Program.	Woodward-Clyde 1997a
1987	Remedial investigation in accordance with CERCLA began.	Woodward-Clyde 1997a
1990	CERCLA Record of Decision specified that a pump-and-treat system be installed to prevent further migration of plume.	Woodward-Clyde 1997a
1995	Pump-and-treat system began operation.	Woodward-Clyde 1997a
1995-2000	Expanded Site Investigation conducted to determine if NAPL is present in EGDY as a source to the TCE plume.	URSGWC 1999
2000-2001	EGDY drum removal conducted.	USACE 2001

Notes:
EGDY - East Gate Disposal Yard
DoD - Department of Defense
CERCLA - Comprehensive Environmental Response Compensation and Liability Act
MROD - Mount Rainier Ordnance Depot
TCE - trichloroethene

Table 3-2

TRENCH CHARACTERISTICS AND FEATURES WITHIN AND IMMEDIATELY ADJACENT TO EGDY OBSERVED FROM AERIAL PHOTOGRAPHS

TRENCH NUMBER[a]	LOCATION	YEARS VISIBLE	DIMENSIONS AND BEARING	CHARACTERISTIC FEATURES
Trench 1	W corner of EGDY, W of western disposal area	1951 to pre-1960	L-shaped trench: 140 ft east-west leg and 65 ft north-south leg by 20-ft wide	1951 photo shows this trench as a stained run-off channel. In 1955, photo area has been modified into an L-shaped trench that likely penetrates the groundwater table. Trench appeared to be filled with solid waste by 1957. Trench was covered by 1960.
Trench 2	Trench exits in SW corner of eastern disposal pit	1955 to present	320 ft x 20 ft bearing NE to SW	This trench appears to have been constructed to provide drainage for the eastern disposal pit. Western end of trench appears to be connected with Trench 3 in 1955 photo. West end of trench is filled in 1970 photo. Portions of this trench were observed during September 1997 site reconnaissance.
Trench 3	W portion of EGDY, S of western disposal pit	1955 to pre-1957	320 ft x 15 ft bearing NW to SE	Trench appears to be connected with Trench 2. Trench filled with solid waste material by 1957.
Trench 4	SW end of EGDY, partially extending outside SW fenced boundary	1957 to pre-1960	450 ft x 12 ft bearing NW to SE	Trench exhibited stains in central portion in 1958 photo. Trench covered in 1960 photo.
Trench 5	W-central portion of EGDY	1960 to 1961	300 ft x 10 ft bearing NW to SE	Trench appeared to penetrate groundwater table in 1960 photo.
Trench 6 (enclosed rectangular pit)	SE corner of EGDY	1960 to pre-1978	50 ft x 20 ft bearing NW to SE	This is the rectangular feature of unknown use. Area is associated with extensive staining in 1960, 1964, 1970, and 1971 photos. Area is devoid of vegetation in 1997.
Trench 7	W portion of EGDY	1961 to 1964	250 ft x 12 ft bearing NW to SE	Trench appeared to be partially full of solid waste in 1961. A plume of smoke indicates burning took place in 1961 photo. Trench full of solid wastes by 1964.
Trench 8	W portion of EGDY, S side of W disposal area	1964 to pre-1965	225 ft x 10 ft bearing W to E	Trench appeared to be partially full of solid wastes in 1964. Trench covered by 1965.
Trench Area 9	NE corner of EGDY	1965 to 1971	3 trenches each 200 ft x 25 ft bearing ENE to WSW in an area of ~13,200 ft^2	Trench filled with gray and white debris in 1965 photo. Grading scars indicate two other trenches may have been covered in this area.
Trench Area 10	SE end of EGDY	pre-1955 to 1961	3 trenches each 180 ft long bearing NE to SW and 1 trench 90 feet long bearing NNE to SSW in an area of ~25,000 ft^2	Visible scars in 1951 photo.

Table 3-2 (Continued)
TRENCH CHARACTERISTICS AND FEATURES WITHIN AND IMMEDIATELY ADJACENT TO EGDY OBSERVED FROM AERIAL PHOTOGRAPHS

TRENCH NUMBER[a]	LOCATION	YEARS VISIBLE	DIMENSIONS AND BEARING	CHARACTERISTIC FEATURES
Trench Area 11	Far west end of EGDY	pre-1951 to 1955	13 major trenches each 140 to 230 ft long and 2 minor trenches 40 ft long predominantly bearing W to E in an area ~132,000 ft^2	Visible scars in 1951 photo.

Notes:
[a] See Figure 3-3
EGDY – East Gate Disposal Yard
ft – feet
ft^2 – square feet

Table 3-3
ADDITIONAL POTENTIAL SOURCES, CHARACTERISTICS, AND FEATURES DISTANT FROM EGDY OBSERVED FROM AERIAL PHOTOGRAPHS

FEATURE	AERIAL PHOTOGRAPH DATES	LOCATION[a]	DIMENSIONS AND BEARING
Pit 1, SW 1	1951, 1955	Approx. 150 ft NE of the intersection of McKinley Avenue and Garfield Street, E of RR, NW of Lynn Lake	General circular shape
CA 1	1955, 1964, 1965	Approx. 300 ft SE of the intersection of McKinley Avenue and Garfield Street, E of RR, W of N end of Lynn Lake	General polygon, approximately 77,200 sf
CA 2	1964, 1965	S of the S end of Lynn Lake	General polygon, approximately 25,700 sf
DA 1	1951, 1955	Approx. 1,000 ft E of Coolidge Avenue (Madigan Family Housing area) and 1,200 ft due S of the S corner of the DRMO Yard fence	General polygon, approximately 55,800 sf
Trench 12	1951	Approx. 1,300 ft SSE of the S corner of the DRMO Yard fence and 1,700 feet SW of the SW corner of the EGDY fence in an undeveloped area off of a trail system in an undeveloped area	Approximately 100 feet in length bearing N to S
Trench 13	1951	Approx. 1,300 ft SSE of the S corner of the DRMO Yard fence and 1,500 feet SW of the SW corner of the EGDY fence in an undeveloped area off of a trail system in an undeveloped area	Approximately 5,700 sf, bearing N to S
Trench 14	1964, 1971	Approx. 1,000 ft W of the S corner of the DRMO Yard fence and 3,200 feet W of the SW corner of the EGDY fence in an undeveloped area off of a trail system in an undeveloped area	L-shaped trench: 50 ft NW to SE leg and 45 ft SW to NE leg
Trench 15	1964, 1971	On the W side in the N end of Tank Trail located E of Madigan Hospital in an undeveloped area	330 feet in length bearing SW to NE with 42-inch culvert ~15 feet below grade that discharges into depression near Murray Creek

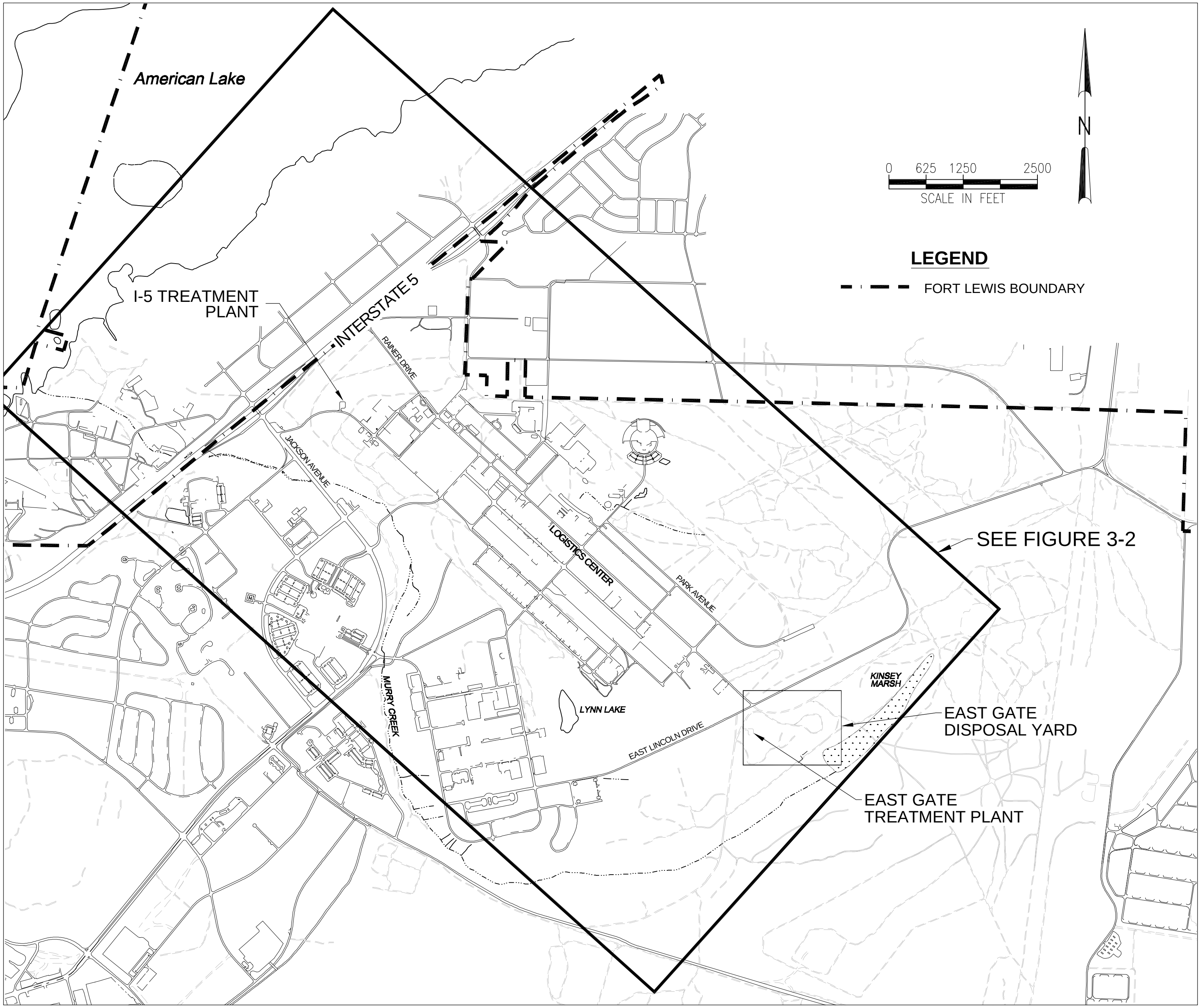
[a]See Figure 3-4

Notes:
CA – cleared area
DA – disturbed area
DRMO – Defense Reutilization Marketing Office
SW – solid waste disposal area
sf – square feet

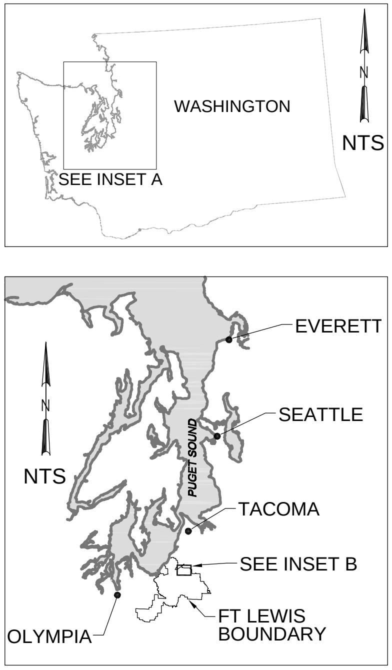
Table 3-4
SUMMARY OF WASTE TYPES AND POTENTIAL CONTAMINANTS IN EGDY

WASTE TYPE	POTENTIAL CONTAMINANTS
Waste degreasing agent	TCE, cis-1,2-DCE, 1,1,1-trichloroethane, PCE
Waste oil	Total petroleum hydrocarbons, PCBs
Waste burning trenches	Dioxins/furans
Miscellaneous solid waste	Unknown
Sandblasting waste	Arsenic, chromium, cadmium, lead, copper, antimony
Compressed gas cylinders	Methyl bromide, acetylene

Notes:
TCE - trichloroethene
cis-1,2-DCE - cis-1,2-dichloroethene
PCE - tetrachloroethene
PCBs - polychlorinated biphenyls



INSET B



INSET A

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

SITE LOCATION

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 3-1 WP

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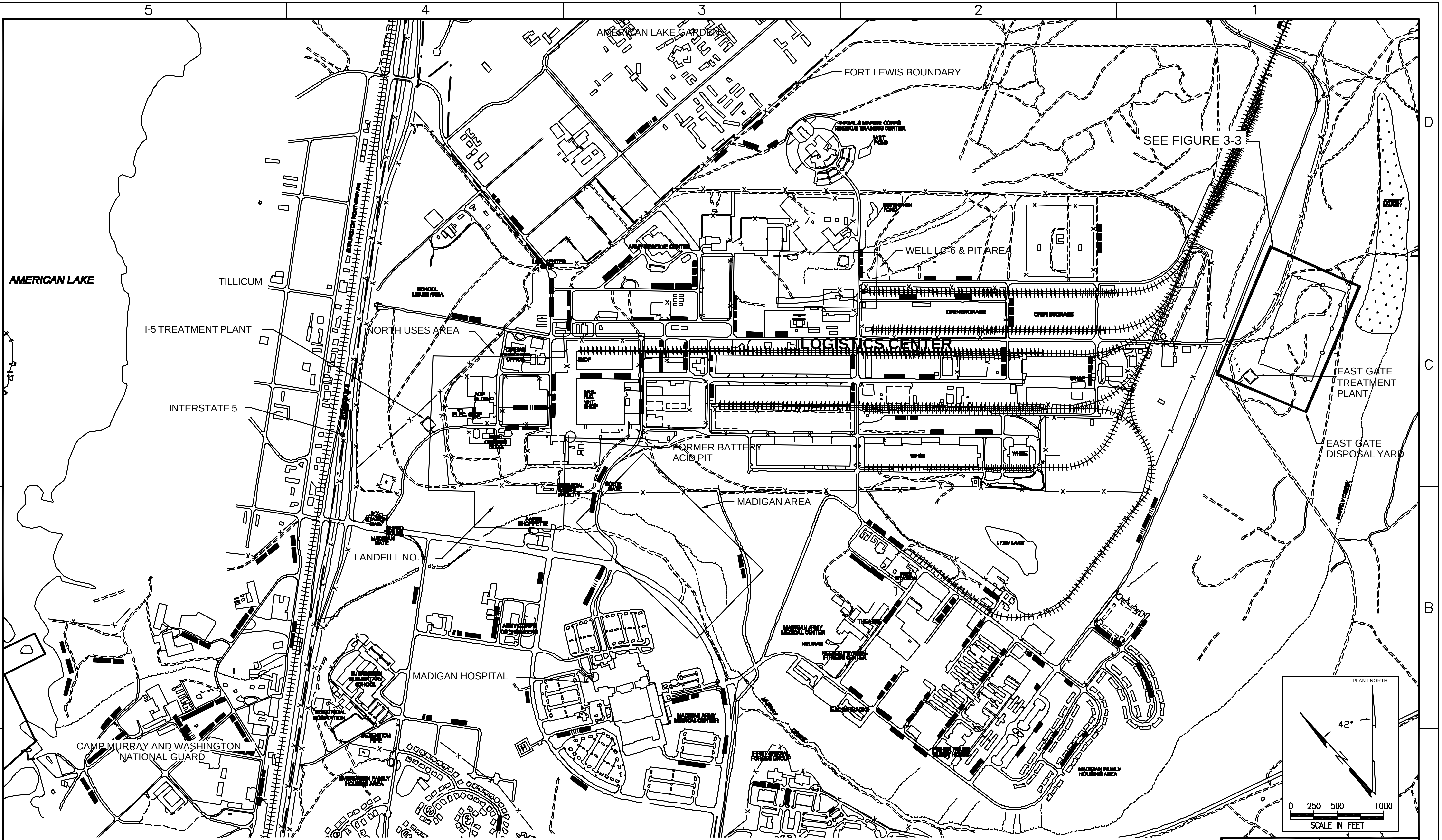

LEGEND

CREEK
RAILROAD TRACKS
FENCE
HISTORICAL FENCE
TRAIL
FORT LEWIS BOUNDARY

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

SITE LAYOUT

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 3-2 WP

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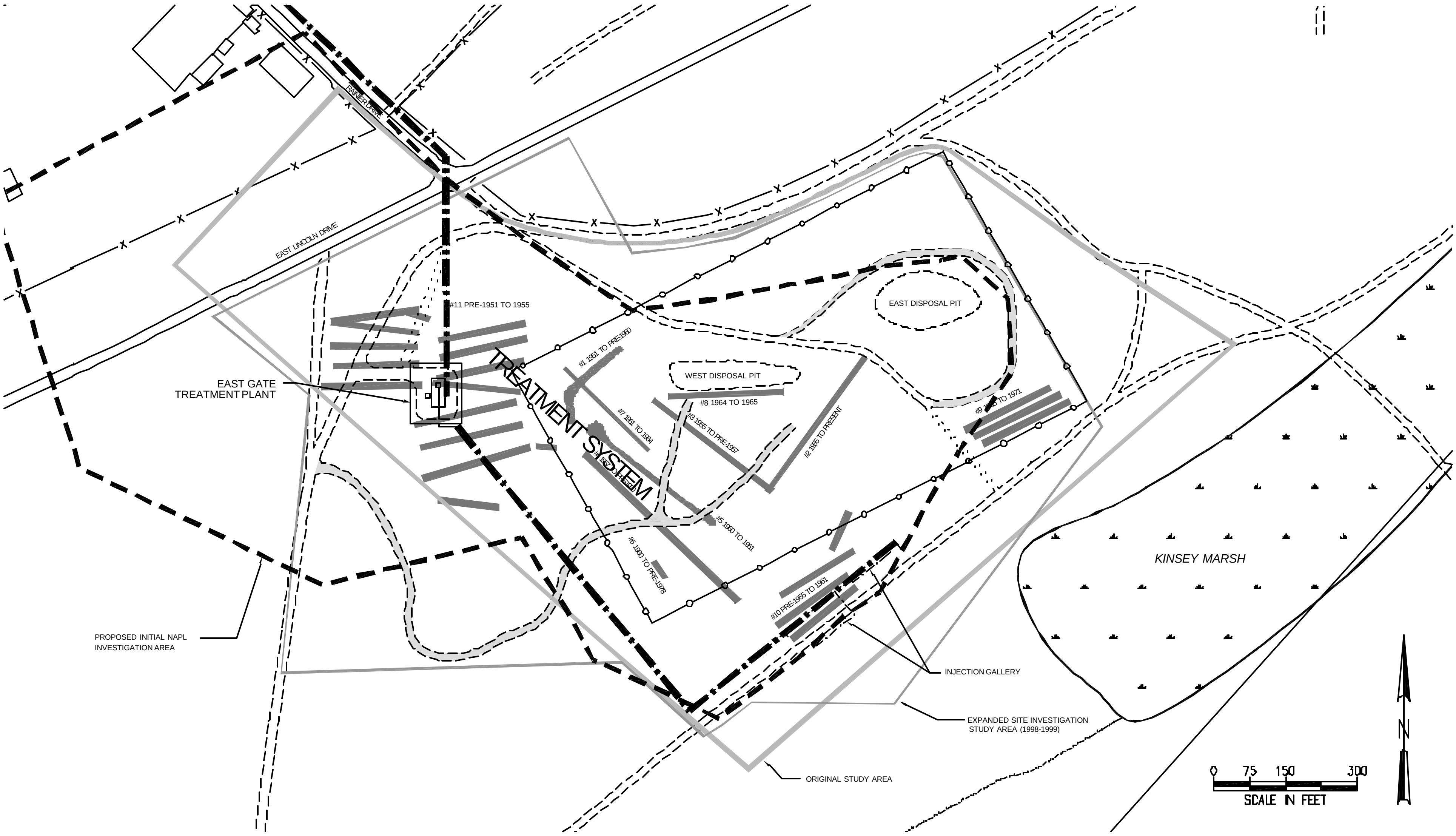

LEGEND

—×—	FENCE
—o—	HISTORICAL FENCE
- - -	TRAIL
- - -	OVERGROWN TRAIL
⋮⋮⋮	APPROXIMATE TRAIL LOCATION
—·—	MAIN GW TREATMENT SYSTEM LINE
▬	HISTORICAL DISPOSAL TRENCH

SOURCE: URS GREINER WOODWARD CLYDE 1999

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

IDENTIFIED FROM AERIAL PHOTOGRAPHS
EAST GATE DISPOSAL YARD FEATURES

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 3-3 WP

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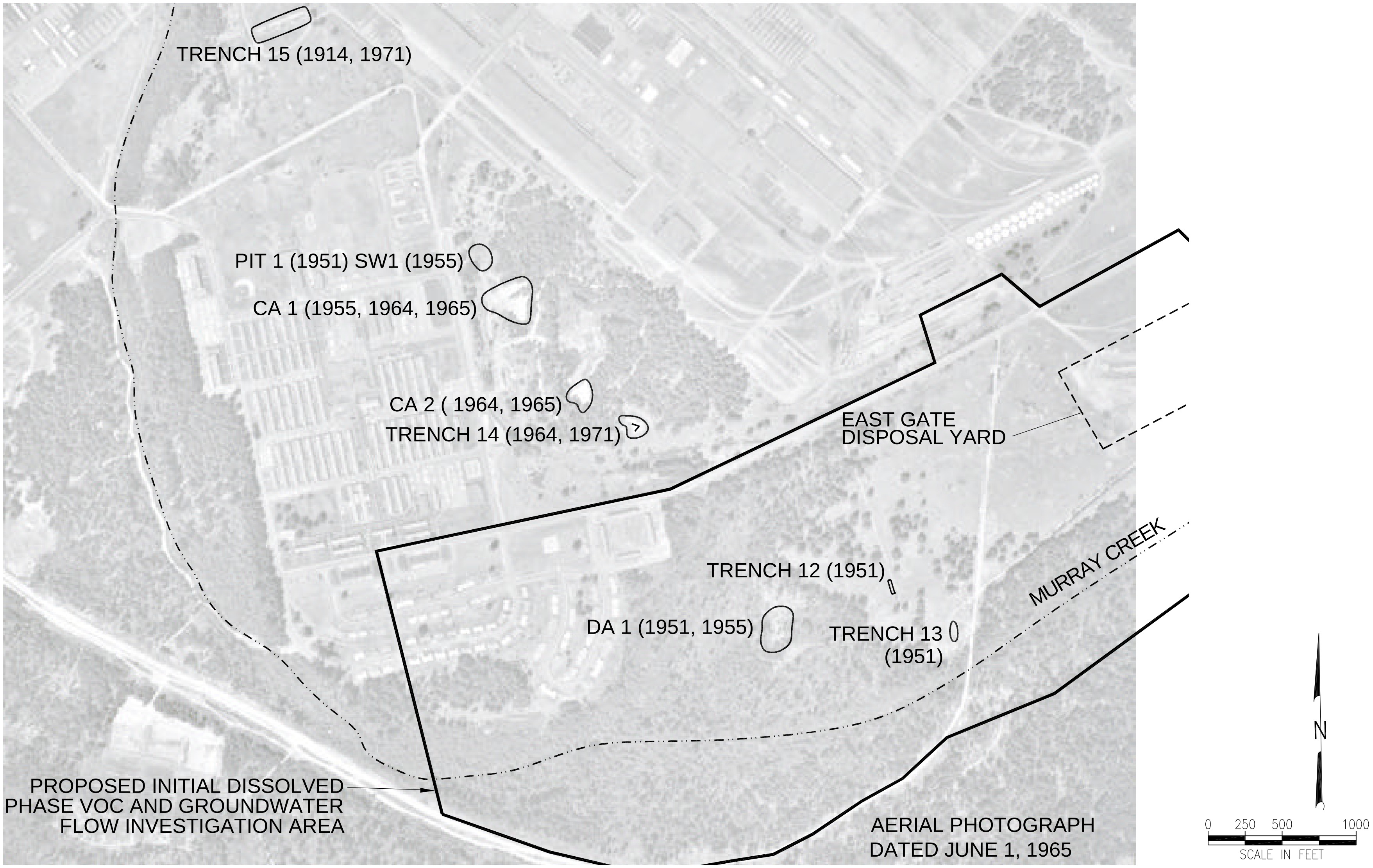

AERIAL PHOTOGRAPH
DATED JUNE 1, 1965

LEGEND

⬭	PROPOSED SOURCE AREAS TO INVESTIGATE OUTSIDE OF EASTGATE DISPOSAL YARD

CA - CLEARED AREA
DA - DISTURBED AREA
SW - SOLID WASTE AREA

SOURCE: USACE 2001

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EDIT DATE: 05/25/01 AT: 16:11

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

ADDITIONAL POTENTIAL
SOURCE AREAS IDENTIFIED
FROM AERIAL PHOTOGRAPHS

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 3-4 WP

Previous and ongoing investigations and activities conducted at the Logistics Center and in its vicinity are summarized in Table 4-1. The table identifies 13 investigations or activities dating back to 1983, including 5 before the Record of Decision (ROD) was drafted in 1990, and 9 efforts after completion of the ROD. Sampling locations (including soil gas, soil, and groundwater) for the investigations conducted are shown on Figure 4-1 and on Figure 4-2 for the Logistics Center and EGDY, respectively. The following discussion is a brief description of contaminated media at EGDY that may provide a continuing source of TCE contamination to the groundwater and potential data gaps. A more detailed review of the nature and extent of contamination can be found in the EE/CA (URSGWC 2001b).

4.1 NATURE AND EXTENT OF CONTAMINATION

This section provides a brief overview of the nature and extent of contamination that originated at EGDY and has migrated off site. EGDY is designated as the "source area" in the discussion that follows because the previous RI showed that it represents the most significant source of TCE contamination of the aquifer. The Logistics Center area that extends from the west boundary of EGDY toward Interstate 5 is designated as the "downgradient area." The discussion that follows is organized by medium, including soil gas, soil, and groundwater; it is further divided into source and downgradient areas. The groundwater section is also separated into discussions for the upper and lower aquifers. In addition, NAPL and drums/debris present in the source area are discussed.

4.1.1 Soil Gas

4.1.1.1 Source Area

Soil gas sampling locations are shown on Figure 4-1. Soil gas samples (Figure 4-2, designated A-1 through H-4) were collected during the RI in 1987 to a depth of 2 feet bgs at approximately 36 locations throughout EGDY (Envirosphere 1988). Soil gas samples were analyzed for TCE, DCE, tetrachloroethene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), benzene, and toluene. TCE and 1,1,1-TCA were the primary chemicals observed, although DCE and PCE were detected in two or fewer samples. Soil gas screening was collected from a depth of 5 feet bgs at 45 locations (Figure 4-2, designated SG-1 though SG-45) at EGDY during the ESI in 1998 (URSGWC 1999). TCE and DCE were detected in over 50 percent of the sampling locations at EGDY.

4.1.1.2 Downgradient Area

Soil gas samples were collected during the RI in 1987 to a depth of 2 feet bgs at the DRMO Yard, Well LC-6 and Pit Area, the North Uses Area (includes Landfill No. 6), Camp Murray, and the Madigan Area (areas shown on Figure 3-2). Soil gas samples were analyzed for TCE, DCE, PCE, 1,1,1-TCA, benzene, and toluene. The primary chemical detected in the DRMO Yard was 1,1,1-TCA, while TCE was detected at a higher frequency in the Well LC-6 and Pit Area and the North Uses Area. TCE and DCE were not detected above the method reporting limit in samples collected from the Camp Murray and Madigan Areas.

4.1.2 Soil

4.1.2.1 Source Area

Soil sampling locations for the source area are shown on Figure 4-2. A summary of the results for the surface and subsurface soil sampling are provided below.

Surface Soil. During a test pit excavation in 1993 (Figure 4-2), four surface soil samples were collected at approximately 0.5 feet below ground surface (bgs) and were analyzed for total organic carbon (TOC). TOC ranged from approximately 48,000 to 77,000 milligrams per kilogram (mg/kg). A surface sample was also collected from one sample location for the ESI in 1998 and was analyzed for VOCs, semivolatile organic compounds (SVOCs), organochlorinated pesticides, and PCBs. Only TCE and SVOCs were detected in the sample.

Subsurface Soil. Subsurface soil sampling in the source area was conducted in 1987 and 1988 during the RI, during the limited field investigation (LFI) in 1993, and during the ESI in 1998. For the RI, samples were analyzed for TCE and DCE, and one sample for metals. TCE was detected in over 80 percent of the samples analyzed, and DCE was detected in half of the samples. During the LFI, samples were analyzed for VOCs, pesticides, PCBs, total petroleum hydrocarbons (TPH), and TOC. TCE was detected in over 70 percent of the samples analyzed, and TPH was detected in over 85 percent of the samples. Other VOCs, pesticides, PCBs were detected to a lesser extent. As part of the ESI in 1998, soil samples were collected from exploratory trenches and were analyzed for VOCs, SVOCs, PCBs, and TPH (gasoline, mineral spirits, diesel, oil-range, and total). TCE was detected in over 75 percent of analyzed samples up to a maximum concentration of 3,400,000 micrograms per kilogram (µg/kg). Other VOCs, including ethylbenzene, toluene, and cis-1,2-DCE, were also detected, but at a lower frequency. TPH results for oil-range constituents yielded a detection frequency of over 80 percent, while the other ranges were detected at 50 percent or less.

Based on these results, high TCE concentrations in source area subsurface soil suggest that the soil is a likely source of contamination to the groundwater.

4.1.2.2 Downgradient Area

Surface Soil. Surface soil samples were collected from the DRMO Yard and the Battery Acid Pit (area shown on Figure 3-2) during the LFI in 1994 (Woodward-Clyde 1995). DRMO samples were analyzed for PCBs, total metals, TPH, and polycyclic aromatic hydrocarbons (PAHs). Battery Acid Pit samples were analyzed for total metals. Aroclors 1254 and 1260 were detected in about one-third of the total samples from the DRMO Yard. TPH and metals including arsenic, barium, chromium, copper, lead, and zinc were detected in over 95 percent of the samples analyzed. Some PAHs were detected in approximately 10 percent or less of analyzed samples from the DRMO Yard. Surface soil samples were collected from the Former Low-Humidity Storage Buildings area (area shown on Figure 3-2) in 1996 (Woodward-Clyde 1997b). Samples were analyzed for lead and TPH. TPH was not detected, but lead was detected in each sample up to a maximum concentration of 5,820 mg/kg.

Subsurface Soil. Subsurface soil samples were collected during the RI in 1987 from soil borings in the DRMO Yard, North Uses Area, Madigan Area, and Well LC-6 and Pit Area

(Envirosphere 1988). Samples were collected to a maximum depth of 150 feet bgs and analyzed for TCE and DCE. In addition, four samples were analyzed for metals. TCE was detected in less than 30 percent of analyzed samples from these areas and was generally not detected below a depth of 85 feet bgs in the downgradient area. DCE was not detected in the analyzed samples. Subsurface soil samples were collected from the DRMO Yard and the Battery Acid Pit during the limited field investigation in 1994 (Woodward-Clyde 1995). DRMO samples were collected at a depth of 2 feet bgs and were analyzed for PCBs, total metals, TPH, and PAH. Battery Acid Pit samples were collected to a maximum depth of 13 feet bgs and analyzed for total metals. PCBs, metals, and TPH were detected in DRMO Yard samples. Subsurface soil samples were collected from the Former Low-Humidity Storage Buildings area in 1996 (Woodward-Clyde 1997b). Samples were collected at a depth of 2 feet bgs and analyzed for lead and TPH. TPH was not detected but lead was detected in each sample up to a maximum concentration of 265 µg/kg.

Based on these results, relatively low (compared to the source area) TCE concentrations in downgradient area subsurface soil suggest that the soil may not be a major source for groundwater re-contamination.

4.1.3 Groundwater

Groundwater sampling locations are shown on Figure 4-1 and Figure 4-2 for the Logistics Center and EGDY, respectively. Sample results indicated that TCE is the primary chemical of concern. The TCE groundwater plume for the Vashon Drift aquifer (upper aquifer) is shown on Figure 4-3. The primary source of the plume appears to be the EGDY. The groundwater flow (major axis of the plume) is to the northwest, and the plume is approximately 2 miles in length along its major axis and 1 mile in width along it minor axis.

4.1.3.1 Source Area

Groundwater samples in the source area were collected only for the upper aquifer. During the RI in 1987 and 1988 (Envirosphere 1988) groundwater samples were collected from monitoring wells and were analyzed for TCE, DCE, and metals. TCE and DCE were detected in the analyzed samples. During the limited field investigation in 1993 (Woodward-Clyde 1993) groundwater samples were collected from five transect wells and were analyzed for VOCs. TCE and DCE were detected in each sample. Drivepoint samples were collected during the ESI in 1998 (URSGWC 1999) and were analyzed for VOCs and metals. As part of the remedial action monitoring program (URSGWC 2001a), groundwater samples were collected from monitoring wells and were analyzed for TCE, DCE, TCA, PCE, and vinyl chloride. Maximum TCE concentrations detected in monitoring wells have been up to 190,000 micrograms per liter (µg/L).

4.1.3.2 Downgradient Area

Groundwater samples in the downgradient area were collected from both upper and lower aquifer monitoring wells. Results for each aquifer are separated in the following discussion.

Upper Aquifer. Groundwater samples collected from the upper aquifer during the source areas investigation in 1985 and 1986 (Shannon & Wilson 1986a), during the RI in 1987 and 1988 (Envirosphere 1988), and during the lower aquifer groundwater study in 1993 and 1994 (Ebasco 1994) were analyzed for TCE and DCE. Groundwater collected from upper aquifer monitoring wells as part of the remedial action monitoring program between 1995 and 2000 (URSGWC 2000a, 2000b) were analyzed for TCE, DCE, TCA, PCE, and vinyl chloride.

Lower Aquifer. Groundwater samples collected from lower aquifer monitoring wells during the lower aquifer groundwater study in 1991 and 1992 (Ebasco 1993) were analyzed for VOCs and total metals. Groundwater samples collected from lower aquifer monitoring wells during the lower aquifer groundwater study in 1993 and 1994 (Ebasco 1994) were analyzed for TCE and DCE. Vinyl chloride was analyzed in a limited number of samples but was not detected in the samples. Groundwater samples collected from lower aquifer monitoring wells as part of the remedial action monitoring program between 1995 and 2000 (URSGWC 2001b) were analyzed for TCE, DCE, TCA, PCE, and vinyl chloride.

Previous investigations looked at potential source areas in the Logistics Center area, including the DRMO, Well LC-6 and Pit Area, North Uses Area, an area northwest of Madigan Hospital, and EGDY. Results of the RI indicated that the only significant source of TCE contamination remaining is in EGDY (Envirosphere 1988), although lesser nearby sources of contamination could be masked by contamination emanating from the EGDY. Investigations following the RI confirmed that accumulations of DNAPL and the product in the drums found in EGDY represent the primary sources of current and future TCE contamination to groundwater. Additional areas outside EGDY will be investigated as part of the Phase II RI.

4.1.4 NAPL

A summary of NAPL contamination is provided in this section, and divided into LNAPL and DNAPL. The estimated lateral extent of NAPL contamination is shown on Figure 4-4 and is based on the ESI in 1998 which included 50 drivepoints and 8 trenches. It should be noted that the primary focus of the ESI was to determine the presence of NAPL, rather than placing bounds on its vertical and lateral extent.

4.1.4.1 LNAPL

Exploratory trenching was conducted during the ESI in 1998 to better characterize debris, measure soil and water contamination, and identify LNAPL on the water table, if present. LNAPL was encountered in five of the eight exploratory trenches. Samples were collected from this NAPL and analyzed for VOCs, SVOCs, PCBs, and TPH (diesel-, gasoline-, motor-oil-, and mineral-spirits-ranges, and total). Sample results indicated that the LNAPL was primarily TPH, although VOCs, SVOCs, and PCBs were detected in some of the samples.

4.1.4.2 DNAPL

Drivepoint groundwater sampling was conducted during the ESI in EGDY to identify the potential presence of DNAPL, assess the vertical variation in contaminated groundwater, and locate the top of the aquitard surface (URSGWC 1999). Samples were collected in two phases in

1998 and 1999 at 50 locations in EGDY. Evidence of DNAPL was encountered at nine drivepoint locations based on analytical results (TCE concentrations greater than 10,000 µg/L). Also shown on Figure 4-4 is the estimated extent of groundwater contamination in EGDY that exceeds 1,000 µg/L TCE, which may indicate additional areas where DNAPL may be present. During drivepoint sampling, the relative rate of penetration of the drivepoint and the color and relative infiltration rate of groundwater were used to estimate the locations of low-permeability units that might impede the vertical flow of DNAPL. In seven of the drivepoint locations, a correlation was made between elevated concentrations of DNAPL and the aquitard. During the ESI, NAPL was encountered at multiple locations within EGDY absorbed onto soil in the vadose zone, as LNAPL floating on the water table, as DNAPL in the upper aquifer as indicated visually and by TCE concentrations greater than 1 percent of the solubility limit, and in drums in the disposal areas. Based on previous investigations, there is no indication of NAPL in the downgradient area. However, the vertical extent of DNAPL contamination is unknown.

4.1.5 Drums/Debris

During the ESI a geophysical investigation was conducted in areas where historical trenches were identified within the EGDY from aerial photographs to locate former disposal trenches (URSGWC 1999; Woodward-Clyde 1997a). The historical trenches identified from aerial photos and geophysical results are shown on Figure 4-5. Eight test trenches were excavated to identify potential buried materials. Drums (55-gallon) were observed in five of the eight exploratory trenches during the ESI in 1998 (URSGWC 1999). Trench locations were selected based on geophysical survey results (Figure 4-2) and soil gas results. The trench locations were designated T-1 through T-8. A total of 14 drums were observed during trench exploration, including crushed, intact, and partially intact drums. Many of the drums were observed on the trench sidewall and were classified as being partially intact or intact based only on appearance. Other buried debris encountered during trench exploration generally included concrete, metal (pipes, wire, strapping, cable), glass, wood, and brick. Evidence of burning, including soot, ash, and charred paper, was observed in two of the trenches. Two mortar shells were observed in trench T-8, causing the exploratory trench investigation to be abandoned after excavating approximately half of the originally planned trenches. A sample was collected from a drum removed from an exploratory trench. The sample was analyzed for VOCs, SVOCs, PCBs, and pesticides. TCE and PCE were the only detected VOCs. SVOCs, PCBs, and pesticides were not detected in the sample. The sample results indicated that the drum contents were primarily pure-phase TCE. Trenching activities in EGDY that are currently ongoing are described in Section 4.2.

4.2 PREVIOUS AND ONGOING REMEDIAL ACTIONS

The ROD for the Logistics Center selected groundwater extraction and treatment (air stripping) as the remedy for groundwater contamination. The USACE completed the remedial design for the installation of two groundwater extraction and treatment systems (the I-5 system and the EGDY system are the two extraction wellfields, with associated treatment plants and recharge systems) to implement the remedy required by the ROD. Descriptions of the two systems are provided in Table 4-1. The remedial action includes groundwater extraction and treatment, and recharge of treated groundwater back into the upper aquifer. The objective of the remediation is to restore the upper aquifer to drinking water standards by reducing the TCE concentration to less than 5 µg/L within 30 to 40 years.

The Seattle District USACE, on behalf of the U.S. Army, Fort Lewis Public Works, has conducted remedial action monitoring of the groundwater pump-and-treat system at the Fort Lewis Logistics Center since operation commenced in August 1995. Remedial action monitoring is required to ensure that the treatment system is functioning adequately and to verify that the remedial action is achieving cleanup goals and meeting other performance standards. Remedial action monitoring consists of performance monitoring and compliance monitoring.

The VOCs of concern defined in the ROD are TCE, DCE, PCE, TCA, and vinyl chloride. All of these compounds can be treated using air stripping. TCE, DCE, and TCA have been consistently detected in many wells in a number of sampling rounds; PCE and vinyl chloride have been detected in only a few wells. Results of plume containment monitoring indicate that the upper aquifer TCE plume has not expanded in width on the southeast or northeast side of the plume. Two monitoring wells (T-01 and T-04) in the town of Tillicum have shown a general decrease in TCE concentrations since the start of remediation. Two other Tillicum wells have shown a slight increase in TCE since the start of sampling. Detection of low levels of TCE in EGDY monitoring wells located upgradient of the EGDY recharge area suggests that reinfiltration of treatment plant effluent may have affected the shallowest portions of the aquifer immediately upgradient of the recharge trenches.

Currently, insufficient data are available to evaluate the total extent of TCE and DCE contamination in the lower aquifer. In addition, the relationship of contamination between the lower and upper aquifers is unclear. The set of lower aquifer wells monitored under the current remedial action monitoring program does not sufficiently define the lateral and terminal boundaries of the plume in the lower aquifer.

Mass removal of TCE is occurring with the current system operation. The estimated total mass of TCE removed from EGDY and I-5 systems through February 2000 is 3,021 pounds and 1,698 pounds, respectively.

The trenching activities for source removal at EGDY were initiated in December 2000 under an Emergency Response Time-Critical Removal Action dated July 24, 2000. As of May 2001, 401 55-gallon drums and 146 5-gallon buckets containing RCRA-hazardous waste have been removed from the site and incinerated. In addition, 433 55-gallon drums, 45 35-gallon drums, and 785 5-gallon buckets designated as RCRA-empty have been removed and disposed of off site. In addition to these containers of varying size and content, the removal activities uncovered UXO training rounds and compressed-gas cylinders containing acetylene, methyl bromide, and air. The final results of drum removal activities are pending and will be used to guide the RI NAPL delineation strategy.

4.3 PREVIOUS TREATABILITY STUDY RESULTS

Three treatability studies have been initiated since 1998. The USGS completed a study using tracer tests to estimate hydraulic properties in the upper aquifer at EGDY. Two studies to evaluate effectiveness of remedial technologies have been completed. Battelle Memorial Institute and Cornell University tested anaerobic biological methods for TCE reduction in groundwater based on Battelle's reductive anaerobic biological in situ treatment technology

(RABITT); PNNL tested in situ redox manipulation (ISRM). A summary of treatability results is provided in Table 4-2.

Table 4-1
SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Pre-ROD Investigations and Activities					
1982-1983	Installation assessment of Fort Lewis	• No wells installed during assessment • Water supply wells 1 through 29 were in existence during assessment; however wells 3, 4, 12, and 22 through 29 had been abandoned; and 1, 2, 6, 7, and 8 were inactive	NA	• Assessment identified improper procedures related to the use of toxic and hazardous materials at Fort Lewis. • Assessment indicated past disposal of solvents and sludges by burial.	U.S. Department of the Army 1983
1984-1986	Groundwater contamination investigations at Fort Lewis Logistics Center	• 28 monitoring wells (LC-1 through LC-28)	VOCs	• General groundwater flow through the Logistics Center is northwest along alignment similar to the center line of the Logistics Center complex. • Based on soil testing during drilling, highest zone of contamination appears to be 16 to 37 feet bgs. • Groundwater from well LC-6 was analyzed for priority pollutants and results confirmed that TCE, cis-1,2-DCE, and trans-1,2-DCE were the only contaminants present.	USACE 1986
1986	Investigated source areas and occurrence, and recommended remedial alternatives for TCE in groundwater at Fort Lewis Logistics Center	• 61 monitoring wells (LC-1 through LC-58, LC-6A, LC-14A, and LC-21-1)	VOCs	• Identified large zone of contaminated groundwater beneath Logistics Center containing TCE and DCE. • TCE-contaminated groundwater zone at Logistics Center was found to extend at least 10,000 feet in length, 2,500 feet in width, and to at least 80 feet below the water table.	Shannon & Wilson 1986a

Table 4-1 (Continued)

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Post-ROD Investigations and Activities					
1986	Geohydrology and spill migration/ recovery analysis at Fort Lewis Logistics Center	• 2 monitoring wells (RW-1 and LC-59)	TCE	• Significant shifting of the groundwater flow path seen from summer to winter. • Groundwater gradients remain steady throughout the year at about 12 to 13 feet/mile. • Transmissivity range estimated at 80,000 to 240,000 gpd/ft.	Shannon & Wilson 1986b
1987-1988	Remedial investigation of Fort Lewis Logistics Center	• 14 shallow monitoring wells (LC-60A,B through LC-66A,B) • 6 intermediate wells (LC-21B,C; LC-40B,C; and LC-44B,C) • 4 deep wells (LC-41D,E and LC-55D,E) • 249 soil gas samples	VOCs (water); TCE and DCE (soil); TCE, TCA, PCE, DCE, benzene, and toluene (soil gas)	• Two areas of source material confirmed by soil gas sampling: one area at NE end of fenced landfill to depth of 13 feet bgs; the other area at opposite end of the fenced area extending NW outside landfill towards Logistics Center, extends to depth of 7 feet bgs. • The primary source of groundwater contamination is the EGDY.	Enviro-sphere 1988
1990-1993	Lower aquifer groundwater study, Fort Lewis Logistics Center	• 10 monitoring wells (LC-26D, LC-35D, LC-41A, LC-41B, LC-47D, LC-50D, LC-67D, LC-68D, LC-69D, and LC-70D)	VOCs, SVOCs, PCBs, metals	• TCE was only contaminant found in Salmon Springs aquifer that exceeded ROD remediation goal (5 µg/L) • High levels of TCE were not found in the lower aquifer near EGDY, suggesting that significant non-aqueous phase TCE had not been transported to the deeper aquifer. • Contaminants appear to be entering the deeper aquifer about 1 mile downgradient of EGDY through a permeable window in the Kitsap aquitard.	Ebasco 1993

Table 4-1 (Continued)
SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Post-ROD Investigations and Activities					
1993	Confirmational soil sampling, Fort Lewis Logistics Center	• 2 monitoring wells (LC-161 and LC-162) • 10 test pits (TP-1 through TP-6, TP-10, TP-12, TP-13, and TP-14)	VOCs, PCBs, TPH, and soil TOC	• Organic vapors observed during drilling of LC-162. • Buried 55-gallon drums were encountered in 3 test pits.	Woodward-Clyde 1993
1993-1994	Lower aquifer groundwater study, Fort Lewis Logistics Center	• 5 monitoring wells (LC-71D, LC-72D, LC-73D, LC-40D, LC-60D)	TCE, DCE, and VOCs	• Modeling indicated that TCE and DCE contamination will travel beneath north Fort Lewis from the Logistics Center to the vicinity of southern Cormorant Passage, where it will pass into Puget Sound. • Once the unconfined aquifer is remediated, the Salmon Springs Recessional Outwash aquifer could flush the remaining TCE/DCE plume into Puget Sound in as little as 50 years. • Groundwater supply wells are not expected to be impacted by the TCE/DCE plume.	Ebasco 1994
1995	Confirmational soil sampling, Fort Lewis Logistics Center	• 72 random soil samples and 12 biased soil samples collected from DRMO yard • 4 soil samples collected from the battery acid pit	PCBs, PAH, TPH, and RCRA metals; pH for battery acid pit only	• 39 of 72 random samples and 7 of 12 biased samples exceeded the MTCA Method A for TPH (200 mg/kg) at the DRMO yard. • PCBs were detected in 22 of 72 random samples from the DRMO yard. • Arsenic, mercury, lead, and zinc exceeded the respective Puget Sound basin natural background concentrations in one or more of the 4 soil samples collected from the battery acid pit. • Soil pH in battery acid pit samples was 3.8 to 4.2 (not low enough to classify the soil as corrosive).	Woodward-Clyde 1995

Table 4-1 (Continued)
SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Post-ROD Investigations and Activities					
Startup August 1995	Groundwater extraction and treatment system (GETS)	• 15 I-5 GETS extraction wells (LX-1 through LX-15) • 6 East Gate GETS extraction wells (primary: LX-17, LX-18, LX-19, and LX-21; secondary: LX-16 and RW-1) • 2 East Gate GETS recharge wells (LR-1 and LR-2) • A network of monitoring wells	VOCs	• Two air stripper systems extract water from the upper aquifer: I-5 system provides hydraulic containment of contaminated groundwater at the installation boundary, East Gate system extracts contaminated groundwater near the source. • I-5 GETS consists of 15 extraction wells and 4 infiltration galleries and is designed to operate at 2,000 gpm. • East Gate GETS consists of 6 extraction wells (4 primary and 2 secondary), 2 recharge wells, and 2 infiltration galleries. • Primary wellfield designed to extract 600 gpm. Secondary wellfield designed to extract 230 gpm. • In September 2000, TCE efficiency rate at I-5 GETS was 98.42%, and at East Gate GETS was 99.89%	USACE 1998, URSGWC 2001a
1995 – 1996	Stream flow measurement	• Stream data measured at five sites along Murray Creek	None	• Data show shallow (Vashon) aquifer to discharge into Murray Creek between Kinsey Marsh and MAMC, and reversal of flow from creek to aquifer between MAMC and American Lake	Shapiro 1996
1995 – ongoing	Remedial action monitoring program	• Sampling of network of monitoring wells	VOCs	• Program includes monitoring of plume containment and reduction, and monitoring of the treatment plant by the following activities:	URSGWC 2001a

Table 4-1 (Continued)

SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Post-ROD Investigations and Activities					
				• Quarterly sampling of a network of 52 monitoring wells • Water level measurements in extraction wells and selected monitoring wells • Quarterly extraction well sampling • Quarterly sampling of surface water from Murray Creek • Monthly sampling of treatment plant influent and effluent	
1996	Former low-humidity storage buildings site soil sampling	• 148 surface soil samples for lead analysis • 47 subsurface soil samples collected for lead at 47 of the 148 surface locations • 84 surface and subsurface soil samples collected for TPH analysis	Lead, TPH	• Surface soils contain lead at concentrations exceeding the MTCA Method A Industrial soil cleanup level of 1,000 mg/kg (surface samples collected at 19% of locations exceeded this criterion). • Petroleum hydrocarbons were not detected in any of 84 screened samples or in 10 confirmation samples submitted for lab analysis. • Ecology verifies closure of this site January 21, 1999.	Woodward-Clyde 1997b
1998 – 2000	ESI, Phase I East Gate Disposal Yard	• 50 drive point groundwater sampling locations (DP-1 through DP-50) • 45 soil gas sampling locations (SG-1 through SG-45) • 8 exploratory trench locations (T-1 through T-8)	VOCs, halogenated aromatic hydrocarbons, BTEX, iron, and manganese	• Approximate locations of DNAPL in the subsurface were identified by results of drive point analyses. • Source of TCE exists as NAPL in drums, as NAPL sorbed into soil in the vadose zone, as LNAPL floating on the water table, and as DNAPL in the shallow aquifer. • Geophysical survey was conducted to locate former disposal trenches.	URSGWC 1999

Table 4-1 (Continued)
SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS AND REMEDIAL ACTIONS

DATE	TYPE OF WORK PERFORMED	WELLS OR SOIL BORINGS INSTALLED OR SAMPLED	ANALYSES CONDUCTED	SUMMARY OF RESULTS OR DESCRIPTION OF ACTIVITIES	SOURCE
Post-ROD Investigations and Activities					
2000 – ongoing	Expanded lower aquifer study of the Logistics Center, Fort Lewis	NA	NA	• Purpose of study is to gain understanding of sources, extent, and fate of chlorinated VOCs in lower aquifer to determine if contaminants represent a risk to downgradient users and how remediation activities for the shallow aquifer may affect risks. • Study will update and expand the hydrogeologic and contaminant transport conceptual models. • New data collected will include additional water-level measurements, borehole geophysical logs, environmental tracer analyses, and contaminant chemistry analyses. • Study has been initiated and is ongoing.	Dinicola 2000
2000 – ongoing	EGDY drum removal	NA		• At approximately 5 months of trenching operations, approximately 250 tons of RCRA-regulated hazardous waste removed for off-site incineration, including 401 55-gallon drums and 146 5-gallon buckets • Compressed gas cylinders removed containing acetylene, MB, or air	Smith 2001

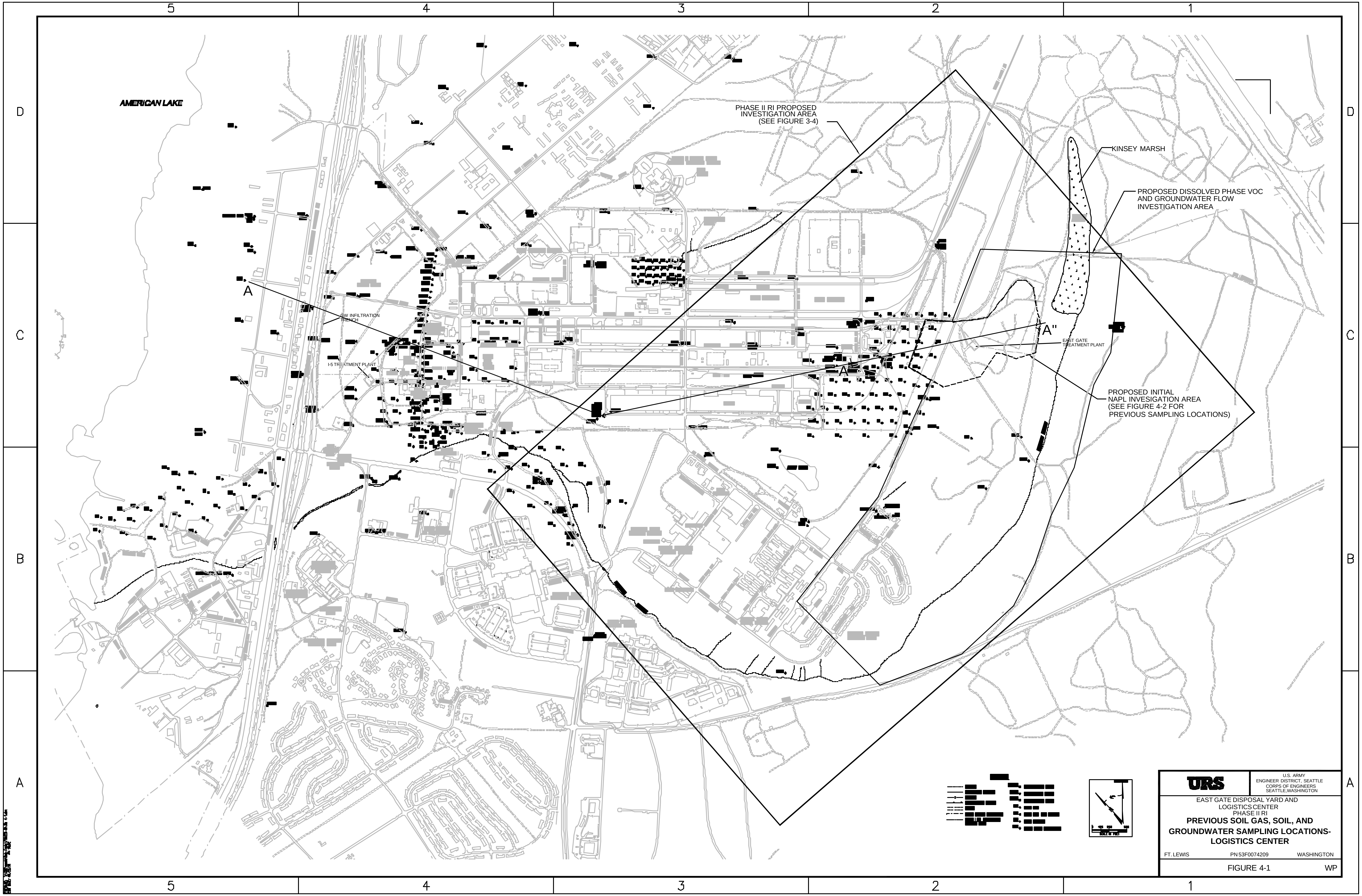
Notes:

bgs - below ground surface
BTEX - benzene, toluene, ethylbenzene, and total xylenes
DCE - dichloroethene
DNAPL - dense nonaqueous-phase liquid
DRMO - Defense Reutilization and Marketing Office
EGDY - East Gate Disposal Yard
GETS - groundwater extraction and treatment system
gpd - gallons per day
gpm - gallons per minute
LNAPL - light nonaqueous-phase liquid
MAMC – Madigan Army Medical Center
MB - methyl bromide
mg/kg - milligram per kilogram
MTCA - Model Toxics Control Act
NA - not applicable
PAH - polycyclic aromatic hydrocarbon
PCBs - polychlorinated biphenyls
PCE - tetrachloroethene
RCRA - Resource Conservation and Recovery Act
ROD - Record of Decision
SVOCs - semivolatile organic compounds
TCA - trichloroethane
TCE - trichloroethene
TOC - total organic carbon
TPH - total petroleum hydrocarbons
VOCs - volatile organic compound

Table 4-2
SUMMARY OF PREVIOUS TREATABILITY STUDIES

DATE	TYPE OF TREATABILITY STUDY	DESCRIPTION OF STUDY	SUMMARY OF RESULTS	SOURCE
1998	Tracer test to estimate hydraulic conductivities and dispersivities in sediments in the shallow aquifer at East Gate Disposal Yard	• Tracer test conducted using existing pump and treat system: Outflow from system dosed with potassium bromide before being returned to groundwater system through re-infiltration • Specific conductance, bromide concentrations, and water levels were measured	• Based on measurements, water levels in observation wells indicate general flow is to the northwest at the site. • Flow patterns are complex and probably controlled by local distribution of fine- and coarse-grained units and by the groundwater pump-and-treat system. • Estimates of vertical hydraulic conductivity range from 8 to 590 feet/day for subsurface sediments less than 30 feet below the water table.	USGS 1999
1999-ongoing	RABITT treatability testing at East Gate Disposal Yard	• RABITT treatability testing is currently ongoing and includes pre-demonstration sampling and an on-site demonstration. • Pre-demonstration activities include site selection, pre-demonstration sampling and analysis, and microcosm testing.	• RABITT rating system score for East Gate Disposal Yard was 45 out of 75; 36 to 55 indicates satisfactory. • Pre-demonstration activities are complete. • Demonstration site is near groundwater sampling location GD-18. • After 8 weeks of electron donor injection, the influent TCE concentration was reduced 99.94% from 8,500 ppb to 0.04 ppb, which represents a TCE removal half-life of 4.7 hours. After 24 weeks, the half-life was 4.4 hours.	Battelle and Cornell 1999, Battelle Memorial Institute, 2001.
1999-ongoing	ISRM of subsurface sediments from Fort Lewis: iron reduction and TCE dechlorination mechanisms	• Column and batch tests conducted in laboratory experiments to investigate the feasibility of chemically treating soil from Fort Lewis to develop a permeable barrier for dechlorination of TCE • Effects of temperature, partial iron reduction, and flow on the redox reactions studied • Proof-of-principle field testing at Fort Lewis Logistics Center from November 1998 through March 2000.	• Dithionite-reduced Fort Lewis sediments were shown to degrade TCE in Fort Lewis groundwater at rates of 1.2 to 19 hours (expressed as a half-life for TCE) during static and transport experiments (i.e., bench-scale testing) • Products of TCE dechlorination show that 99.5% to 100% is occurring via reduction elimination. During field testing, TCE concentrations were reduced from approximately 140 µg/L to 11 µg/L or 92%	PNNL 1998, 2000

Notes:
ISRM - in situ redox manipulation
µg/L - micrograms per liter
MCL - maximum contaminant limit
RABITT - reductive anaerobic biological in-situ treatment technology
TCE - trichloroethene



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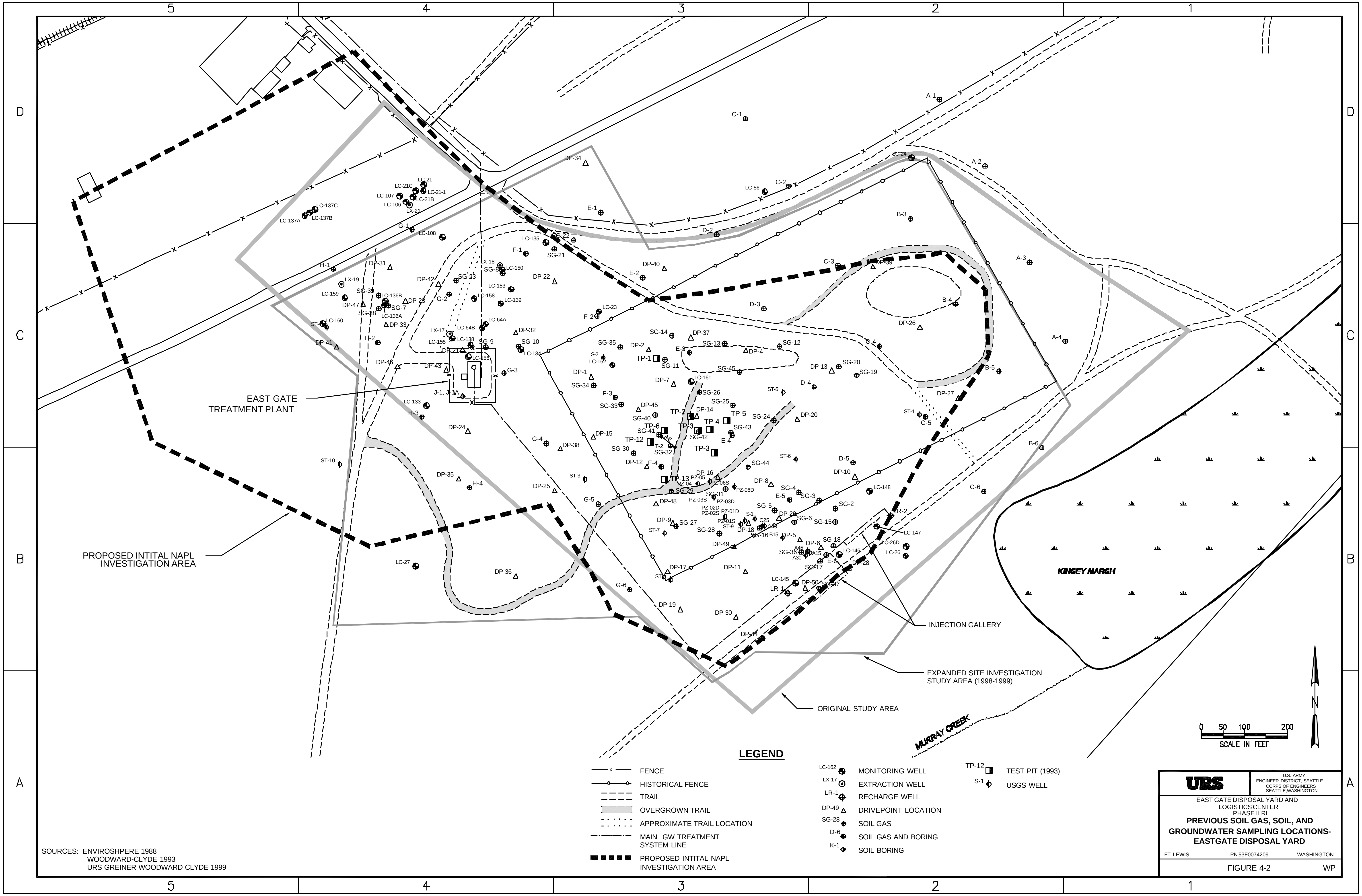
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

PREVIOUS SOIL GAS, SOIL, AND GROUNDWATER SAMPLING LOCATIONS-LOGISTICS CENTER

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 4-1 WP



SOURCES: ENVIROSHPERE 1988
WOODWARD-CLYDE 1993
URS GREINER WOODWARD CLYDE 1999

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EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

PREVIOUS SOIL GAS, SOIL, AND GROUNDWATER SAMPLING LOCATIONS- EASTGATE DISPOSAL YARD

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FIGURE 4-2 WP

PLOT CUSTOM SIZE OF 42X27; PLOT TO FIT. 1050 PLOTTER

LEGEND

GROUNDWATER TCE CONCENTRATION (UG/L)

- 🟩 >100,000
- 🟩 10,000 to 100,000
- 🟩 1,000 to 10,000
- 🟩 100 to 1,000
- 🟩 10 to 100
- 🟩 5 to 10

• UPPER VASHON AQUIFER WELL\PIEZOMETER

Notes:

1. GRAPH Y-AXIS IS TCE CONCENTRATION IN UG/L; X-AXIS IS THE DATE.
2. TCE PLUME WAS CONTOURED USING KRIGING INTERPOLATION OF MEASURED TCE CONCENTRATIONS FROM SEPT 2000 AND OLDER DATA FROM WELLS WHERE SEPT 2000 DATA WHERE NOT AVAILABLE.

N

0 500 1000
SCALE IN FEET

\SEAGIS\GIS\COE\EGATE\SUB-TASKS\PHASEII-RI\PLATE 1b.SRF

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UPPER VASHON AQUIFER
HISTORICAL
TCE CONCENTRATIONS

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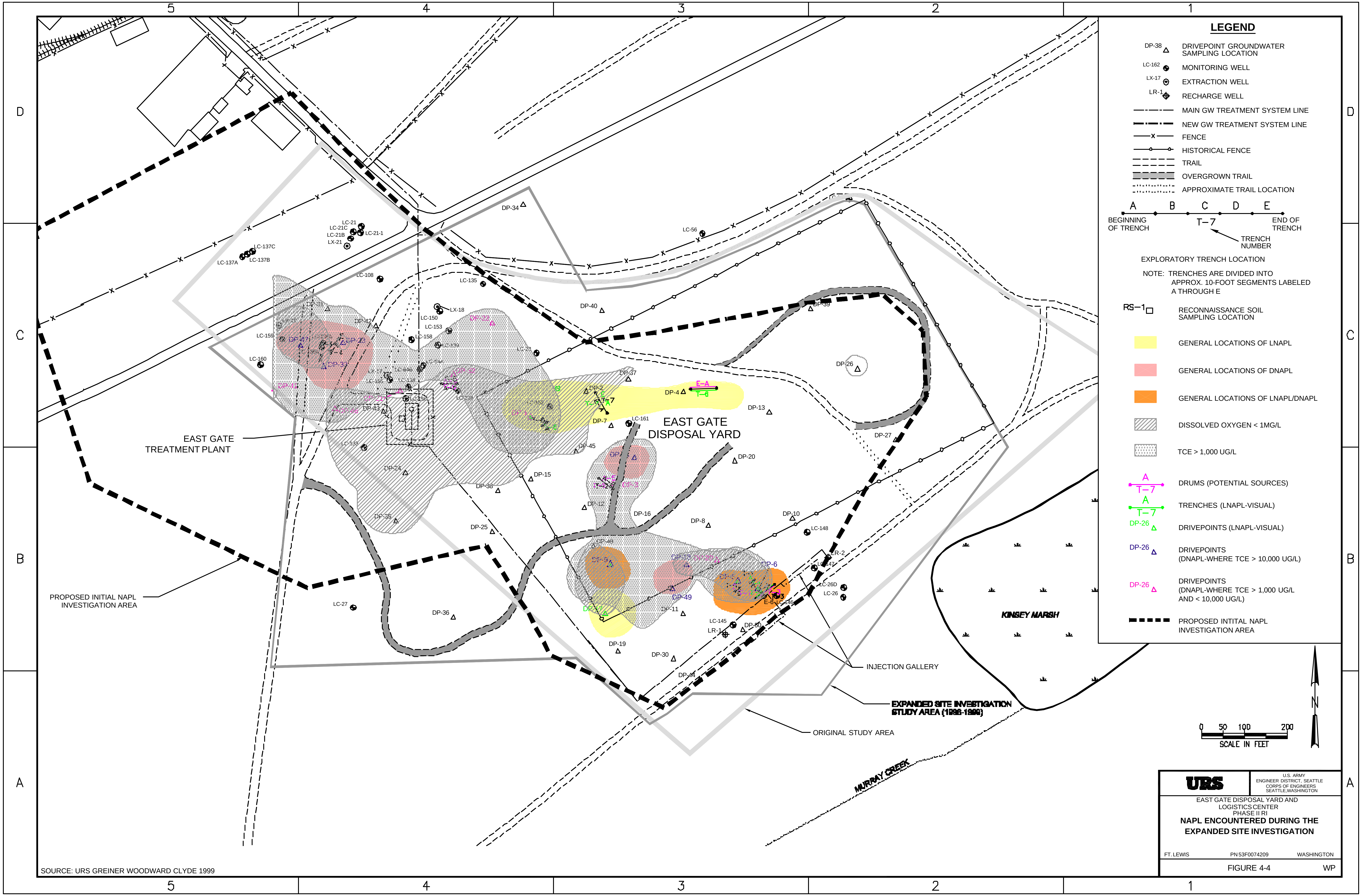
FIGURE 4-3



SOURCE: URS GREINER WOODWARD CLYDE 1999

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EAST GATE DISPOSAL YARD AND
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NAPL ENCOUNTERED DURING THE
EXPANDED SITE INVESTIGATION

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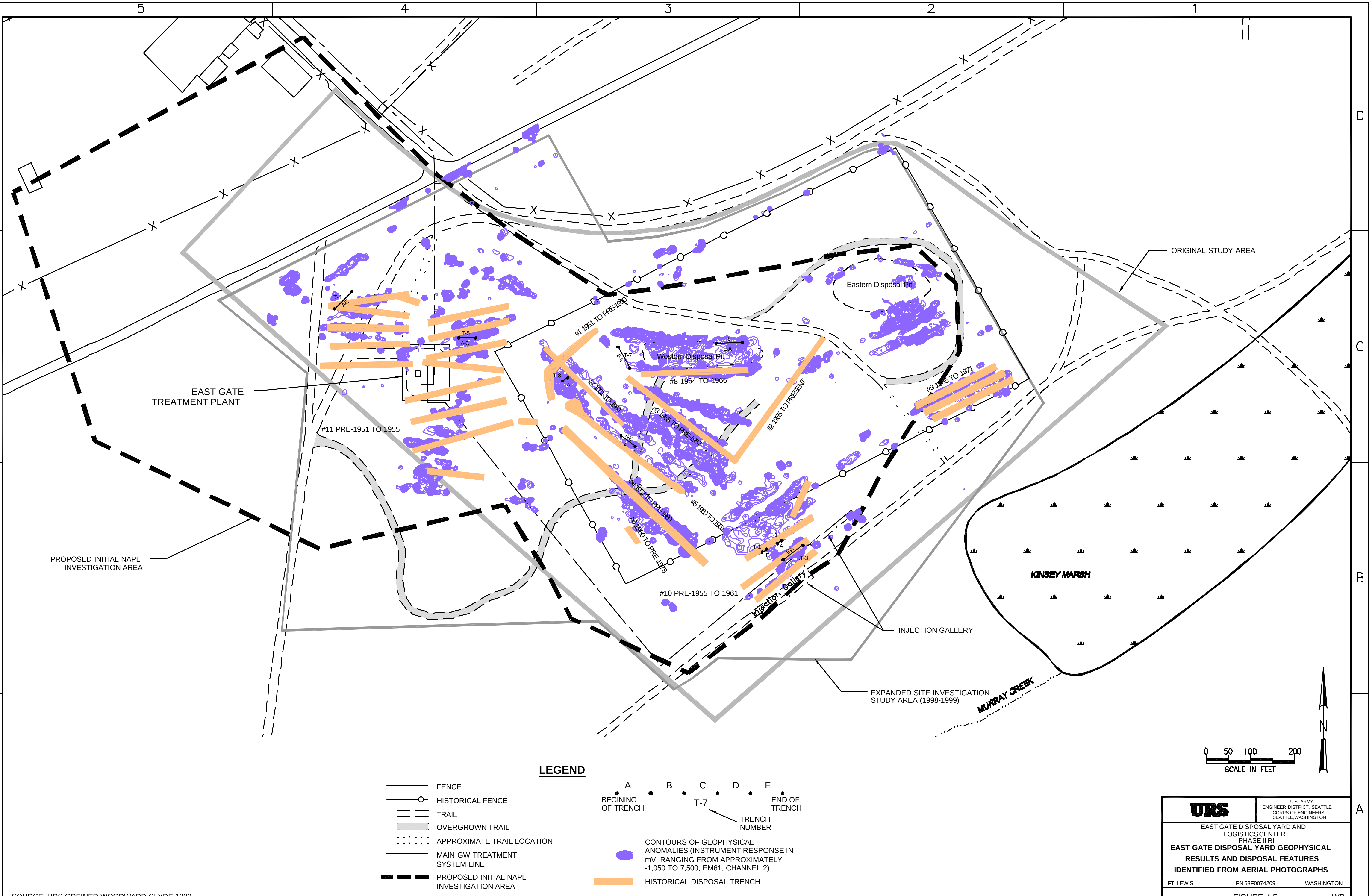
FIGURE 4-4 WP



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EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

EAST GATE DISPOSAL YARD GEOPHYSICAL
RESULTS AND DISPOSAL FEATURES
IDENTIFIED FROM AERIAL PHOTOGRAPHS

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FIGURE 4-5 WP

A conceptual site model (CSM) is a schematic representation that shows chemical sources, chemical transport mechanisms, environmental transport media, and affected media. A CSM illustrates where contaminants have been found and potential migration pathways across affected media at a site. Investigations at the site have concluded that NAPL is present at EGDY. TCE and DCE in the dissolved phase have also been found in the upper groundwater aquifer at EGDY and in the upper and lower aquifers in the downgradient areas of the Logistics Center.

This section provides a CSM that is a compilation of information known about the site. It has been used to develop the overall project DQOs and identify the initial sampling and analytical decisions for the proposed investigation in Section 6 of this plan. The physical system of the CSM for the site is discussed in Section 5.1 and the occurrence of NAPL is discussed in Section 5.2. The physical and chemical properties of the NAPL source material are described in Sections 5.3 and 5.4, respectively. Transport mechanisms for the NAPL source material detected in each medium are briefly described in Section 5.5. The CSM will be refined as new data are acquired, to identify gaps in information and to allow new sampling locations to be selected without the need for remobilization.

5.1 PHYSICAL SYSTEM

The physical CSM used to evaluate conditions at the site is described in this section and is illustrated on Figures 5-1 and 5-2 for the Logistics Center and EGDY, respectively. The CSM provides a basic description of site characteristics by which the fate and transport processes are evaluated. The CSM is based upon a geological cross section of monitoring wells extending from EGDY on the east to I-5 and Tillicum on the west. The TCE concentrations depicted on these figures are from the Logistics Center remedial action monitoring 18th quarter sampling event conducted in March 2000. Where other sampling events are referenced, they are indicated on the figures. As indicated on Figure 5-1, the CSM is divided into two areas: (1) the source area (EGDY), where NAPL has been detected, and (2) the downgradient area (Logistics Center), which includes a TCE groundwater plume approximately 2 miles long and 1 mile wide.

5.1.1 Geology

The surficial and subsurface geology of the Fort Lewis Logistics Center and EGDY study area have been characterized using logs of numerous borings drilled throughout several years. The boring logs have been generated by different geologists for various projects, using many types of drilling methods. Also, the stratigraphy of the Puget Sound Lowland is extremely heterogeneous. Therefore, the soil descriptions on the logs vary tremendously. The cross section presented on Figure 5-1 has been developed from a combination of the logs of borings located in or near the study area and information presented in the Fort Lewis Logistics Center lower aquifer study (Ebasco 1994). This cross section describes the stratigraphy in the Logistics Center and EGDY study area. It is located in a general east-west transect through the Logistics Center and EGDY study area. (The orientation of the cross section is shown on Figure 4-1).

5.1.1.1 Vashon Glacial Drift Deposits

The geologic interpretation of the study area has been simplified on the cross section. The Steilacoom Gravel and Vashon Recessional Outwash are combined as one unit on the cross section and in the following descriptions. The Advance Outwash gravel and sand deposits are not specifically identified as advance outwash deposits because other types of outwash may be present. Therefore, the outwash gravel and sand deposits are presented as Vashon Glacial Outwash (Sand) and Vashon Glacial Outwash (Gravel).

Steilacoom Gravel (Qvs) and Vashon Recessional Outwash (Qvr). Recent deposits (not presented on the cross section) were encountered at the ground surface in a thickness of up to 4 feet in some of the boreholes. These deposits consist of brown to black alluvial sand and gravel, with localized silt and clay.

The Steilacoom Gravel is the predominant upper geologic unit. The sand and gravel of this unit were deposited in braided channels formed by the rapid discharge of glacial Lake Puyallup. The generally flat glacial outwash plain is broken by swales produced by the intersections of braided stream channels, kettles, and ice-contact depressions of irregular shape.

The Steilacoom Gravel unit ordinarily is encountered in all boreholes in the study area. It is generally a brown, loose to dense, well-graded, sandy, coarse, cobbly gravel. The Vashon Recessional Outwash unit of the Vashon Drift deposit typically lies between the Steilacoom Gravel and the Vashon Till. This unit is principally a brown-gray, variegated, poorly graded sandy gravel and gravelly sand, but locally contains lenses of sand, silty sand, and clay. Together, the approximate thickness of the Steilacoom Gravel and the Vashon Recessional Outwash units ranges from 6 to 30 feet throughout the study area. The typical thickness is approximately 20 feet.

Vashon Till (Qvt). The Vashon Till underlies the Vashon Recessional Outwash discontinuously throughout the study area. This unit is typically a brown-gray, dense, well-graded gravel in a matrix of sand, silt, and clay. Where present, this unit ranges in thickness from 4 to 40 feet. The typical thickness is approximately 20 feet.

Vashon Glacial Outwash Sand (Qv[Gs]) and Vashon Glacial Outwash Gravel (Qv [Gg]). Underlying the Vashon Till typically is the Advance Outwash of the Vashon Drift, which generally is denser than the Vashon Recessional Outwash but has a similar distribution of particle sizes. As presented on the cross section, the generalized Vashon Glacial Outwash deposits underlie the Vashon Till. The Vashon Glacial Outwash Sand deposits consist of very fine to coarse sand with lenses of gravelly sand and sandy silt. The Vashon Glacial Outwash Gravel deposits encountered in the borings generally consist of a brown-gray, medium to coarse sandy gravel with cobbles. These Vashon Glacial Outwash deposits are separated in places by undifferentiated deposits, described below.

5.1.1.2 Undifferentiated Glacial and Nonglacial Deposits

Two undifferentiated units have been identified: undifferentiated glacial till (tu) and nonglacial deposits (ng) (Ebasco 1994). As shown on the cross section, the undifferentiated till unit appears to contain two distinct subunits. The first is a confining silt layer that possibly was deposited in a glaciolacustrine environment; the second is a confining till layer.

Silt (tu). An undifferentiated silt unit occurs from an elevation of approximately 240 to 250 feet msl, and is encountered at a maximum thickness of 14 feet. The cross sections shown on Figures 5-1 and 5-2 indicate that this silt aquitard is encountered beneath the EGDY study area and extends westward to LC-144. The continuity of this unit is unknown. It is composed of hard, fine, sandy silt and clayey silt, grading to very dense, silty, clayey, very fine sand toward the west. The color variations of this unit include dark gray, blue-gray, gray-brown, tan, and light gray to light brown.

Till (tu). This undifferentiated till unit occurs at a greater depth than the undifferentiated silt layer; it is encountered at an elevation ranging from approximately 200 to 220 feet above msl. This confining unit is encountered from approximately LC-136 (near EGDY) westward to LC-68. It also was encountered in the western portion of the study area. The continuity of this unit is unknown. This unit is comprised of a dense, light brown to gray brown, silty gravel with sand and clay seams.

Nonglacial (ng). The undifferentiated nonglacial deposits are characterized by alluvial sand and gravel with silt, clay, and scattered wood (Ebasco 1994). These deposits are laterally continuous at varying thicknesses throughout most of the Logistics Center and EGDY study area. The thickness of this unit beneath the western portion of the Logistics Center is approximately 12 to 20 feet thick. Between LC-69D and LC-137, the typical thickness is approximately 100 feet. Directly beneath EGDY, the thickness or presence of this unit is undetermined. The elevation of the top of the nonglacial deposits is approximately 200 feet above msl. These deposits described as nonglacial deposits also could be Vashon glaciolacustrine deposits.

5.1.1.3 Kitsap Nonglacial Deposits (Qk)

Beneath the Logistics Center and EGDY study area, the Kitsap formation underlies the Vashon Drift. It does not appear to be present generally between LC-41 and LC-144 beneath the central portion of the Logistics Center. The thickness of this unit ranges from approximately 10 to 60 feet, and the typical thickness is approximately 20 feet. It occurs between 60 and 190 feet above msl in elevation. Where encountered in the borings, this unit generally consists of nonglacial brown to black clayey silt, silty sand, and sandy silt with occasional fine gravel. The unit typically contains peat, other organic debris, and ash. It contains layers of permeable gravel and sand and thin ash layers.

5.1.1.4 Salmon Springs Glacial Drift and Puyallup Nonglacial Deposits

The Salmon Springs Drift represents those units deposited during the Salmon Springs Glaciation. In descending order, the Salmon Springs units are the Recessional Outwash, Till, and Advance Outwash. Underlying the Salmon Springs Drift deposits are nonglacial deposits of the Puyallup formation. These nonglacial deposits are characterized as alluvial deposits of interbedded silt and coarse-grained sediment with mudflow deposits and ash (Ebasco 1994). The Salmon Springs Advance Outwash and Puyallup formation are combined as one unit on the cross section and in the following descriptions.

Salmon Springs Recessional Outwash (Qssr). This unit underlies the Kitsap formation and the nonglacial deposits beneath the Logistics Center and EGDY study area. The top of this unit is located at an approximate elevation ranging from 50 to 160 feet above msl, and its thickness ranges from 8 to 46 feet. This glacial unit consists of brown, slightly silty, sandy gravel and gravelly sand with organic debris and sand lenses. It is oxidized at the surface and occasionally interbedded.

Salmon Springs Till (Qsst). This unit typically underlies the Salmon Springs Recessional Outwash. The top of this unit is encountered at an approximate elevation ranging from 0 to 115 feet above msl. It is composed of a very dense, heterogeneous mixture of gravel, sand, clay, and silt (Ebasco 1994).

Salmon Springs Advance Outwash (Qssa)/Puyallup Formation (Qpy). Typically the Salmon Springs Advance Outwash unit underlies the Salmon Springs Till. However, either or both of the Salmon Springs Advance Outwash and Puyallup formation units have been encountered underlying the Salmon Springs Recessional Outwash deposits beneath the center portion of the Logistics Center. In the boreholes, the deposits encountered consist of sandy gravel.

The Salmon Springs outwash is composed of till, lacustrine silt and fine sand, and glaciofluvial sand and gravel. The Puyallup Formation is composed of mud flows, ash, and alluvial deposits (Ebasco 1994).

5.1.2 Hydrogeology

The Vashon Drift aquifer (upper aquifer) is present in several water-bearing units. The upper aquifer is present predominantly in the permeable Steilacoom Gravel (Qvs), Vashon Recessional Outwash (Qvr), Vashon Glacial Outwash Gravel (Qv[Gg]), and Vashon Glacial Outwash Sand (Qv[Gs]). It is also present in the less permeable Vashon Till (Qvt), undifferentiated silt and till layers (tu), and undifferentiated nonglacial deposits (ng). The Kitsap formation underlying the Vashon Drift serves as the principal aquitard separating the upper aquifer from the Salmon Springs Drift aquifer (lower aquifer). The lower aquifer is present in the Salmon Springs Drift (Qssr, Qsst, and Qssa). Most of the lower aquifer wells are screened in the Salmon Springs Recessional Outwash (Qssr). Groundwater elevations depicted on Figures 5-1 and 5-2 are based on measurements collected in October 1999.

Upper aquifer groundwater elevation contours for the Logistics Center are shown on Figure 5-3 for measurements conducted by the USGS in March 2000 and October 2000. The groundwater elevation typically ranges from approximately 270 feet above mean sea level (msl) beneath EGDY to 250 feet above msl in the western portion of the Logistics Center. The depth to groundwater (upper aquifer) is typically approximately 10 to 30 feet bgs. Beneath the Logistics Center and EGDY, groundwater flow is predominantly toward the northwest. A possible groundwater divide and local reversal of flow to Murray Creek may exist (Section 5.1.3).

As shown on Figures 5-1 and 5-2, aquitard properties appear to be located within several units beneath the Logistics Center and EGDY. The following description provides an interpretation of the aquitards beneath the Logistics Center and EGDY. However, there is substantial uncertainty whether these units are laterally continuous and act as aquitards due to the complexity of the hydrogeology of the site.

- Weak, localized aquitard properties may exist in the Vashon Till (Qvt). The occasional high silt content, density, and horizontal orientation of cobbles in the Vashon Till may restrict downward flow of water or contaminants in this unit. It is possible that these aquitard conditions are enhanced by the relatively low permeability of the Vashon Till unit (compared to the overlying gravel and sand) as well as the presence of clay, silt, and sand lenses.
- The undifferentiated silt and till layers (tu) each appear to act as a relatively thin aquitard within the upper aquifer and may locally restrict downward migration of water and

contaminants. The elevation of the upper silt layer beneath EGDY is shown on Figure 5-4. This intermediate aquitard is at approximately 35 to 40 feet bgs. The elevation of this unit was estimated based on monitoring well and drive point locations (URSGWC 1999). The upper silt layer is potentially laterally continuous beneath EGDY and the eastern portion of the Logistics Center. Likewise, the lower till layer appears to be laterally continuous from the eastern to central portion of the Logistics Center. These units also occur discontinuously beneath other parts of the Logistics Center.

- The fine-grained undifferentiated nonglacial deposits (ng) are less permeable relative to the overlying glacial outwash gravel and sand.
- The Kitsap formation (Qk) appears to be a mostly continuous aquitard that laterally separates the upper and lower aquifers. On the cross section, this unit is interpreted to be absent beneath the central portion of the Logistics Center.
- Weak, localized aquitard properties may exist in the Salmon Springs Till (Qsst), as in the Vashon Till.

The extent of the upper aquifer TCE groundwater plume is shown on Figure 4-3. The TCE groundwater plume is approximately 2 miles long and varies between one-half and 1 mile wide. Dissolved-phase TCE is present at high concentrations (in excess of 100 μg/L) approximately 2,500 feet west of EGDY. The predominant groundwater flow direction is to the northwest, however, locally it may be to the west approximately 45 degrees counterclockwise from the regional flow direction (Figure 5-3). Data collected to date suggest a seasonal reversal of groundwater flow related to aquifer discharge to Murray Creek. This reversal may be responsible for the migration of TCE to southwest of EGDY. In order to evaluate optimization of the groundwater pump-and-treat system or the position of potential barrier technologies, groundwater flow direction in this area needs to be understood. In addition, there may be additional potential source areas that may be contributing to the elevated TCE concentrations as shown on Figure 3-4.

As indicated previously, the Kitsap formation appears to be laterally continuous, except in the central portion of the Logistics Center. As visible on the cross section, a trough appears to be present from around LC-41 eastward to LC-137. This trough results from erosion of the Kitsap formation and subsequent deposition of permeable and impermeable materials that allow for the downward migration of groundwater in the vicinity of LC-69D. Because of this potential discontinuity in the Kitsap aquitard, a permeable "window" may exist through which contaminants from the upper aquifer may be transported to the lower aquifer. Groundwater monitoring results indicate that TCE has entered the lower aquifer upgradient of the known "window" that exhibits interbedded aquitard properties. The transport pathway of this upgradient contamination is unknown.

The source of contamination in the deeper aquifer is likely contaminated groundwater moving vertically downward from the Vashon Drift aquifer to the Salmon Springs Recessional Outwash aquifer through a permeable "window" in the aquitard that normally separates these two units (Ebasco 1993). The "window" is believed to contain a geologic unit with intermediate aquitard properties. This permeable zone in the aquitard occurs about 1 mile downgradient of EGDY and is depicted on Figure 5-1. Groundwater monitoring results indicate that TCE has entered the lower aquifer upgradient of the known "window." The concentration of TCE (<1 μg/L) in lower aquifer wells upgradient of the window (e.g., LC-47D) is less than the concentration of TCE (>100 µg/L) in the lower aquifer wells downgradient of the window (e.g., LC-41D). The transport pathway of this upgradient contamination is unknown.

5.1.3 Surface Water/Groundwater Interaction

Murray Creek flows in a broad, shallow valley from Kinsey Marsh in the east to American Lake in the west. Murray Creek is the only stream located within the study area as shown on Figure 4-3. The creek flows primarily from east to west, across the Madigan Area and southern part of the Logistics Center at Fort Lewis. The creek reach near the west side of the Madigan Family Housing area changes its direction and flows north, where it changes back to an east/west flow near the North Uses Area. A study of the surface water and groundwater Murray Creek and the upper aquifer was conducted in 1996 (Shapiro 1996). Murray Creek is incised into coarse gravel and cobbles of highly permeable Steilacoom gravel from Kinsey Marsh to American Lake. Along most of the channel, a layer of saturated organic silt and clay approximately 18 inches thick or less overlies the gravel, which are occasionally overlain by a thin layer (i.e., less than 6 inches thick) of sand and gravel. The hydraulic gradient data from the study indicate that the general relationship between the groundwater and surface water in Murray Creek changes over distance and time. In the upper part of the reach between Kinsey Marsh and the intersection of Madigan Avenue and Jackson Avenue by Madigan Hospital, water seeps into the channel (gaining reach), and seeps out of it (losing reach) in the lower part of the reach between Madigan Hospital and American Lake. In addition, there is generally an increase in stream flow between Kinsey Marsh and Madigan Hospital, and a decrease in stream flow between Madigan Hospital and American Lake.

5.2 NAPL OCCURRENCE

The locations of DNAPL/LNAPL mixtures, LNAPL, and buried drum locations along the CSM cross section in EGDY were based on observations and analytical results obtained during ESI trenching activities and drivepoint groundwater sampling. Figure 5-2 shows that DNAPL pools may be present on the aquitard below the groundwater table, and contamination may be moving laterally and vertically into the lower aquifer. The location of potential TCE/DNAPL pools (defined as TCE concentrations greater than 10,000 µg/L) are based on drivepoint well sampling results for the NAPL regions portrayed on Figure 4-4. The boundaries of the vertical and lateral extent of DNAPL and LNAPL contamination are unknown. The buried drums (which are currently undergoing removal) represent sources of ongoing and/or future contamination until removal is complete. Also, NAPL is solubilizing into groundwater that is migrating downgradient. It should be noted that drivepoint sampling during the ESI was discontinued at the aquitard at approximately 39 feet bgs. Therefore, the stratigraphy of the aquitard and the concentrations of TCE in the aquifer below the aquitard represent a data gap. No analytical results for TPH in groundwater are available.

5.3 PHYSICAL PROPERTIES OF THE SOURCE MATERIAL

The types of NAPL reportedly disposed of at EGDY were spent chlorinated solvents (primarily TCE with perhaps small amounts of DCE) and POL. The primary known sources of chemical release at the site are LNAPL and DNAPL generated from equipment cleaning and degreasing activities conducted at Fort Lewis, which were disposed of in EGDY. This LNAPL and DNAPL both contain varying mixtures of POL and TCE. NAPL, drums containing NAPL, and debris were disposed of in trenches and pits in EGDY (URSGWC 1999). There are surface expressions of some of the trenches in EGDY. Results for limited surface soil samples collected in EGDY do not indicate surface soil contamination. The physical and chemical properties of the individual compounds are fairly well known; however, because the compositions of the mixtures are so variable, there is considerable uncertainty in predicting the fate and transport of these mixtures in the subsurface. There are no site-specific physical property data available for DNAPL or LNAPL. These data are needed to design thermal treatment and/or evaluate its effectiveness. Estimated physical values of DNAPL and LNAPL are described below.

The compositions of product collected from trenches and drums during the ESI showed a wide spectrum of materials ranging from almost pure TCE (drum samples from trench T-1) to LNAPLs (mineral-spirit and oil-range TPH) with very little TCE (NAPL samples from trenches T-6 and T-7) (URSGWC 2001b). In addition, soil analytical results showed up to tens of thousands of mg/kg TPH with TCE at over 3,000 mg/kg (URSGWC 2001b). These levels suggest a residual NAPL component attached to the soil.

If the mole fraction of the material is known for the product, vapor pressures and water solubilities of contaminants can be calculated using Raoult’s Law. However, because the few products that have been analyzed are so variable in composition and probably represent only a small fraction of the variability, it can be concluded only that the site contains LNAPL and DNAPL with TCE present in the NAPL over the entire range of concentrations from nondetectable to close to 100 percent. As pure products, TCE and DCE are DNAPLs. The important physical properties of these substances that impact movement in the subsurface are listed in Table 5-1.

The high volatility of TCE and DCE, as reflected in the vapor pressure, results in loss of these compounds from the liquid phase to the vapor phase (soil gas) in the unsaturated zone. The vapor densities of TCE and DCE are greater than air, therefore the gas phase containing these compounds will tend to sink in the unsaturated zone and settle on the water table. Henry’s Constant relates the concentrations in the vapor phase to the equilibrium dissolved concentration in soil water or groundwater. If the TCE/DCE DNAPL reaches the water table it can sink into the aquifer because it has a density greater than water. The low kinematic viscosity of the DNAPL enhances the movement of the separate liquid phase through the aquifer.

POL compounds are generally LNAPLs that are less dense than water. If sufficient LNAPL is disposed of in the subsurface, it will flow through the unsaturated zone and float on the water table. Soluble components (primarily benzene, toluene, ethylbenzene, and xylene [BTEX] compounds) can contaminate groundwater; however, that is not an issue at the site as BTEX compounds other than isolated detections during the ESI do not occur as contaminants. If LNAPL and DNAPL are disposed of together, mixtures will produce liquids with physical properties that reflect the relative proportion of each component. The mixture will be less dense than the pure DNAPL but more dense than the LNAPL. It may or may not be more dense than water. The vapor pressure of each component will be less than the pressure in the original liquid.

Other components of POL such as TPH were found to be present in NAPL/soil samples analyzed during the ESI. However, TPH has not been analyzed in groundwater from the EGDY source area. If these mixtures exist at the site, they will need to be sampled and characterized in order to quantify their physical properties.

5.4 CHEMICAL PROPERTIES OF NAPL

Limited site-specific chemical data are available for NAPL; however, different NAPL product types/mixtures may exist at the site other than those sampled. Chemical property data from the saturated zone NAPL are limited. These data are needed to design thermal treatment and/or evaluate its effectiveness. Estimated physical values of DNAPL and LNAPL and NAPL mixtures are described below. The primary chemical properties of NAPL compounds that impact fate and transport are solubility and partitioning of the contaminant between the dissolved phase and the soil solid (adsorption).

5.4.1 Solubility

The aqueous solubilities of pure phases of the potential contaminants from spent solvents and POL at EGDY are listed in Table 5-2. For a NAPL mixture, the aqueous phase concentration of each component of the mixture that is in equilibrium with groundwater can be approximated using Raoult's Law as shown in the equation below:

$$C_{sat,m} = X_m C^o_{sat}$$

where

$C_{sat,m}$ is the aqueous solubility of component m from the mixture (sometimes referred to as the "effective solubility" from the mixture)

X_m is the mole fraction of component m of interest in the NAPL mixture

C^o_{sat} is the solubility of the pure compound

For example, the solubility of benzene is 1,750 mg/L, and typical gasoline contains 10 percent benzene; therefore, the expected dissolved concentration of benzene in water in equilibrium with gasoline is 175 mg/L (10 percent of 1,750).

At EGDY, the spent solvent probably contained some fraction of POL; therefore, the effective solubility of TCE in DNAPL located beneath the water table is probably less than 1,600 mg/L (at 10^oC).

5.4.2 Water/Soil Partitioning

The partitioning of a compound between the dissolved phase and the soil solids can be theoretically represented by the distribution coefficient shown below:

$$K_d = C_s/C_{aq}$$

where

K_d is the distribution coefficient

C_s is the concentration (mg/g) of the contaminant on the solid phase

C_{aq} is the concentration (mg/mL) in the aqueous phase (dissolved)

For organic compounds such as TCE, the primary adsorbent is soil organic matter and the K_d can be derived from the laboratory-measured organic carbon partition coefficient (K_{oc}) and the fraction of organic carbon present in the soil (f_{oc}) using the following equation:

$$K_d = K_{oc} f_{oc}$$

Estimated K_d values for the constituents of interest are listed in Table 5-3 using available K_{oc} data in literature and the median f_{oc} of 0.004 measured in soil samples collected just above the water table during the confirmational soil sampling (Woodward-Clyde 1993). However, because K_{oc} can vary based on site-specific factors, the estimated K_d values may not be reliable.

Once the K_d has been determined, the relative rate of movement of the dissolved contaminant (v_c) versus the average groundwater flow velocity (v_{gw}) can be calculated using the following retardation equation:

$$R = v_{gw}/v_c = 1 + (\rho/h)K_d$$

where

R is the retardation factor

ρ is the bulk density of the soil

η is the effective porosity

Calculated R values are provided in Table 5-3 assuming a bulk density of 1.75 grams per cubic centimeter (g/cc) and an effective porosity of 0.3. These calculations show that all the compounds will be retarded in their movement through the aquifer as a dissolved phase, but that the chlorinated solvents will be the least retarded.

5.4.3 Transformation Reactions

As the dissolved constituents move through the unsaturated zone and the aquifer they may be affected by transformation reactions, which are primarily a result of biodegradation. Biodegradation is an attenuation process that lowers contaminant concentrations by the biological transformation of an organic contaminant into another organic compound and/or the inorganic building blocks (e.g., carbon, nitrogen, phosphorus, potassium, etc.) of the original compound. Biodegradable organic compounds are used by microbes for energy and growth.

The primary water-soluble components in POL are BTEX compounds. Up to 90 percent of the groundwater contamination from gasoline is due to the BTEX fraction, and it forms a major component of groundwater contamination from other fuel hydrocarbons such as fuel oil and kerosene. Experience at numerous BTEX groundwater contamination sites shows that these compounds are readily biodegradable under both aerobic and anaerobic aquifer conditions (Wiedemeier et al. 1995, Rice et al. 1995). Under aerobic conditions (where dissolved oxygen [O_2] exceeds 1 mg/L), dissolved oxygen serves as the electron acceptor required for the biodegradation reaction, while under anaerobic conditions (where dissolved oxygen is less than 1 mg/L) other naturally occurring compounds (NO_3^-, SO_4^{2-}, Fe^{3+}, Mn^{4+}) serve as the electron acceptors. Because the electron acceptors are normally available in the environment for the biodegradation reaction to occur, it is common that biodegradation effectively removes the BTEX contaminants from groundwater within a short distance (hundreds of meters) downgradient of a spill or disposal site. At EGDY, it is likely that if a source of BTEX contamination exists in the unsaturated zone, the dissolved contaminants are biodegraded a short distance from the source. BTEX contamination was found in several drivepoint groundwater samples and floating on water in trenches during the ESI. In addition, Figure 4-4 shows the lateral extent of oxygen at concentration less than 1 milligram per liter (mg/L) in the EGDY area, which may indicate the presence of LNAPL due to oxygen levels being reduced from biodegradation.

The common chlorinated solvents such as TCE are also biodegradable in the subsurface, but not because they provide a source of carbon for bacterial growth. These compounds can act as alternative electron acceptors under anaerobic conditions (Wiedemeier et al. 1996). Whereas the carbon in fuel hydrocarbons is oxidized during biodegradation, the carbon in TCE can be reduced by the acceptance of electrons.

Biodegradation of TCE commonly occurs only under anaerobic conditions because under aerobic conditions oxygen will be the preferred electron acceptor rather than TCE. As an example, environmental conditions beneath most solid waste landfills are strongly anaerobic as a result of the consumption of oxygen and other electron acceptors by the readily degradable organic matter in the landfill leachate. TCE disposed of with the solid waste will be available to accept electrons. TCE will be transformed to DCE, which may then be degraded to vinyl chloride and, after complete dechlorination, ethene. The transformation TCE → DCE → vinyl chloride → ethene is called reductive dechlorination because in each step, carbon in the compound gains an electron, becoming more reduced (having a lower valence state). The compound also loses a chlorine atom at each step.

Ethene is relatively easily oxidized as it moves into the more aerobic, downgradient portions of a groundwater plume. In contrast, TCE and DCE are progressively less degradable as conditions become more aerobic. For this reason, the chlorinated solvents are relatively mobile in the environment compared to BTEX. If TCE is not degraded close to the source in the strongly anaerobic zone, it can move many miles downgradient from the source area. This is especially true in situations where the solvents are disposed of in non-landfill situations or at old landfills that no longer produce anaerobic conditions in the aquifer. The situation at the Logistics Center, where the TCE plume extends over 2 miles downgradient from the EGDY source area, probably reflects the fact that the system was not sufficiently anaerobic to accomplish complete biodegradation of TCE.

In addition, lack of widespread high concentrations of dissolved iron suggests that widespread reducing conditions (low oxidation-reduction potential [ORP]) do not exist at the site. The dissolved oxygen and ORP field measurements also show only localized reducing conditions. It should be noted that some of the highest DCE concentrations in groundwater are found near the water table in drivepoints DP-5, DP-6, and DP-9, which also have very high concentrations of TCE and likely DNAPL. In addition, elevated concentrations of DCE are detected in areas of the aquifer where oxygen levels are low (<1 mg/L). It is likely that the DCE is produced in these locations as an anaerobic biological degradation product of TCE (the initial degradation product of TCE in this process is DCE) with POL as a carbon source, since 1,2-cis-DCE is detected and not 1,2-trans-DCE. The natural breakdown product of TCE is 1,2-cis-DCE, and the commercial product of DCE is 1,2-trans-DCE. In addition, widespread biodegradation of TCE is likely limited to low natural organic content (i.e., a carbon source) of the soil in the hydrogeologic system at the site.

5.5 TRANSPORT MECHANISMS

The transport mechanisms of the source material (NAPL in the unsaturated and saturated zones) at the site were evaluated using site observations and the known physical and chemical properties of NAPL (Section 5.2 and Section 5.3, respectively). This discussion primarily focuses on the source area in EGDY, which has been investigated since the RI. Information from the site history and CSM memorandum (Woodward-Clyde 1997a) and the ESI report (URSGWC 1999) were used as the basis of this evaluation.

5.5.1 Volatilization

TCE and DCE are quite volatile, with vapor pressures of 75 and 315 torr (millimeters of mercury [mm Hg] at 25°C), respectively. Numerical modeling of the unsaturated zone vaporization of a generic organic compound having a vapor pressure of 182 torr has been conducted (Mendoza et al. 1990, as described in Feenstra and Cherry 1996). The source zone was considered to have a radius of 1.05 meters (m), a height of 0.9 m and to contain 125 kilogram (kg) of NAPL. In this simulation, 83 percent of the source was depleted after 8 days, and 94 percent of the source was depleted after 16 days. However, the rate of volatilization can vary greatly depending on the mixture of NAPL present.

The vapors move away from the source by diffusing into the soil gas; however, the vapor densities of TCE and DCE (Table 5-1) are greater than typical soil gas. Thus gravity will cause the vapors to sink in the unsaturated zone. As the dense volatile compounds sink, they will spread laterally as they encounter less permeable zones. The TCE-laden soil gas will thus move away from the NAPL and spread across the water table.

5.5.2 Unsaturated Zone Transport

A variety of petroleum products and TCE were found in drums with exposed contents and in the soil. During the ESI, LNAPL was found floating on the water table in five of eight exploratory trenches, and LNAPL contained TCE in addition to TPH in two exploratory trenches (URSGWC 1999). Additional LNAPL and drum contents were observed during recent drum removal activities. TCE has entered the subsurface at EGDY in the unsaturated zone. It has moved through this zone as DNAPL, a mixture of DNAPL and LNAPL, a volatile component of the soil gas, and as a dissolved constituent in percolating water. These pathways are described below, with the exception of soil gas, which is discussed in Section 4.1.1.

5.5.2.1 NAPL Transport in the Unsaturated Zone

A TCE/DNAPL or a DNAPL/LNAPL mixture that enters the subsurface will move as a separate phase under the influence of gravity until the fluid no longer holds together and breaks up into separate globules that adhere to (wet) the soil grains. In the unsaturated zone, NAPL will migrate vertically downward, but will spread laterally at less permeable interfaces, especially if they have high water content. Because of the stratified nature of geologic material, the downward movement of NAPL may be stepwise instead of vertical. For this reason, residual NAPL may not necessarily occur directly beneath former disposal trenches.

If a limited amount of NAPL is disposed of, or it is spread over a wide enough area, the retention capacity of the unsaturated zone may be sufficient to contain all of the material. However, because of the large amount of liquids (reportedly 6 to 8 barrels per month) disposed of in the narrow trenches at EGDY, the high number of drums removed to date, and the high concentrations of dissolved TCE measured in the groundwater, it is likely that the retention capacity of the unsaturated zone was exceeded at this site.

An important parameter for NAPL at EGDY is the residual saturation. Residual NAPL consisting of disconnected blobs and ganglia at the trailing edge of a migrating NAPL body is caused by pore-scale snap-off and trapping mechanisms (Kueper and Frind 1996). The residual saturations of NAPLs measured in the laboratory for sandy aquifer materials range from about 5 to 25 percent of the pore space (Mercer and Cohen 1990, as reported in Feenstra and Cherry 1996). Based on these values, the residual concentration of NAPL at a site after drainage of free product is on the order of 15 to 75 liters per cubic meter (L/m^3). This residual material is subject to depletion by volatilization in soil gas and dissolution into percolating recharge water.

5.5.2.2 Aqueous (Dissolved) Transport in the Unsaturated Zone

Water infiltrating through the unsaturated zone will dissolve TCE present in soil gas and as residual globules adhered to the soil grains. The solubility of pure TCE in water at 10°C is reported to be about 1,600 mg/L (Pankow and Johnson 1996). This is also the TCE concentration in water in equilibrium with a soil gas containing TCE at its vapor pressure. This can be calculated from the Henry's Constant (H) (Table 5-1), which relates the concentration of the volatile compound in the vapor phase (C_{gas}) to its dissolved concentration (C_{aq}), as shown in the equation below:

$$C_{gas}/C_{aq} = H$$

Column experiments have shown that water flowing at a rate of 1 meter per day becomes saturated with residual TCE after flowing through only 1 meter of contaminated porous material. Thus only a relatively short contact time is necessary to produce high concentrations of dissolved chlorinated solvents in infiltrating precipitation or groundwater (Schwille 1988). As a consequence, residual TCE in the unsaturated zone has the ability to cause significant levels of contamination in groundwater. At the same time, percolating water will dissolve and remove some, and possibly all, of the residual product.

5.5.2.3 Conclusions on Subsurface Soil/Unsaturated Zone Contamination

The ESI demonstrated that NAPL in the form of buried drums is still present in the unsaturated zone in the source area of EGDY. Therefore it is likely that in the nearly 30 years since the last actual disposal of NAPL, there are areas of contamination residing in the unsaturated zone as product adhering to solid particles, gases in soil vapor, and dissolved constituents in percolating water. Following the removal of buried drums, it is likely that at least some LNAPL would still be present in the unsaturated zone of the source area because many LNAPL components (long-chain hydrocarbons) can persist for decades in soil. Furthermore, the LNAPL cannot sink beneath the water table. The DNAPL components have overall greater volatility and solubility than typical POL mixtures. Also, DNAPL can sink below the water table. TCE partitioning among soil, water, and gas (assuming TCE is present as a pure product) has been calculated to show that the TCE soil concentration for typical sandy material must be greater than about 300 mg/kg for liquid TCE to be present (Feenstra and Cherry 1996). At concentrations below this level, all the TCE could be accounted for dissolved in water, as a component of the soil gas, and adsorbed onto the solid soil material. Only one of the soil samples collected during EGDY investigations prior to the ESI had a TCE concentration greater than 300 mg/kg. During the ESI, three trench soil samples contained TCE concentrations greater than 300 mg/kg while TPH was detected at high concentrations in soil and NAPL samples. Buried drums were discovered in EGDY, including a drum in trench T-1 that contained 832,000 mg/kg of TCE. Product contained in decaying drums in the subsurface may represent a significant source of TCE to groundwater at EGDY. These drums currently are being removed from the subsurface at the EGDY. Drum removal activities are expected to be complete by mid-July, 2001.

5.5.3 Groundwater/Saturated Zone Transport

Results from the drivepoint sampling conducted for the ESI indicated that DNAPL is present in the saturated zone at EGDY. The drivepoint locations with probable DNAPL can be grouped into four distinct areas: northwest of the treatment plant, near the southern fence corner (DP-9), near the infiltration galleries (DP-5 and DP-6), and at DP-14 in the west-central portion of the EGDY (Figure 4-4). The drum removal activities conducted to date have confirmed this NAPL presence in these areas. TCE can be transported beneath the water table as a DNAPL or as a dissolved constituent of the groundwater. These pathways are described below.

5.5.3.1 NAPL Transport in the Saturated Zone

If sufficient NAPL enters the subsurface, it may exceed the retention capacity of the unsaturated zone and reach the water table. At this boundary, an LNAPL will accumulate but a DNAPL such as TCE can continue below the water table if there is sufficient force exerted by the mass of TCE to overcome the fluid entry pressure at the water table. The liquid TCE will continue downward until it no longer exceeds the retention capacity in this zone. The occurrence of residual TCE in the saturated zone is different than that in the unsaturated zone. In the unsaturated zone, the TCE attaches itself to and wets the grains. In the saturated zone, wetting is done by water and the TCE is present as isolated drops in the pore spaces (Schwille 1988). TCE will accumulate on zones of lower permeability in the saturated zone as it did in the unsaturated zone. This may lead to pooling within the aquifer cross section depending on the permeability of the aquitard materials.

If the retention capacity of the aquifer beneath the disposal area is exceeded, TCE will reach the first aquitard and spread laterally across this low-permeability unit. If the aquitard surface is flat, sandbox experiments have shown that the TCE will form a low-lying mound on the surface that is shaped like a watch glass (Schwille 1988). If the aquitard surface has depressions, the TCE fluid will collect in these features, displacing the water and filling the pore spaces. These accumulations have been called pools, although in reality they are depressions in the aquitard surface where the aquifer material has been saturated with TCE. The TCE liquid may sink to greater depth if it flows along the aquitard surface and encounters more permeable aquitard zones ("windows" to deeper aquifers). NAPL can penetrate low permeability aquitards either via fractures or pore space, and has been observed at other sites where DNAPL is present. However, based on the groundwater sampling conducted to date, it does not appear that a TCE DNAPL has impacted the deeper Salmon Springs Recessional Outwash aquifer at EGDY. However, vertical hydraulic gradients for Logistics Center wells screened in the upper and lower aquifers indicate that the aquifers may be hydraulically connected in the EGDY area (URSGWC 2001a). The aquitard surface map for the source area developed from drivepoints during the ESI (Figure 5-4) shows multiple depressions in the aquitard surface across EGDY. However, the surface generally slopes in the direction of groundwater flow.

5.5.3.2 Dissolved Phase Transport in the Saturated Zone

Groundwater may encounter and dissolve TCE DNAPL residing in several areas of the aquifer. The DNAPL may be present in (1) separate globules spread throughout the aquifer thickness that were left behind as the DNAPL sank through the aquifer, (2) thin accumulation areas on less permeable aquifer units, (3) thin layers on the surface of the aquitard, (4) relatively deep pools associated with depressions on the aquitard surface, and (5) within and beneath the aquitard units. The extent of a groundwater plume downgradient from any of these features will be affected by the permeability of the strata within the aquifer. Assuming little dispersion downgradient of the source, the extent of a plume downgradient of a zone of low permeability will be less than that from a zone of high permeability because of differences in groundwater flow velocity.

As described in Section 5.5.2, column experiments have shown that even water flowing at a rate of 1 meter per day would become saturated with residual TCE after flowing through only 1 meter of contaminated porous material. Only a relatively short contact time is thus necessary to produce high concentrations of dissolved chlorinated solvents in groundwater flowing past globules held under residual saturation conditions (Schwille 1988). In contrast to this situation where the DNAPL is disseminated along the flow path in relatively small globules with large surface areas, if the DNAPL is present in a pool or thin layer on an aquitard surface, the surface area of the solvent in contact with the water is much reduced. Because of this, it is less likely that the dissolved concentration of the solvent will reach its water saturation value. A TCE solubilization experiment was conducted (Schwille 1988) using a 1.5-meter-long trough with TCE pooled on the bottom. With water flow velocities of 0.45 to 2.7 meters per day, the TCE concentrations in the effluent water were 90 and 77 mg/L, respectively (Schwille 1988). This is on the order of 5 percent of the TCE solubility (1,600 mg/L at 10^{o}C).

It has been suggested that if the dissolved concentration of a DNAPL constituent is greater than about 1 percent of its solubility in water, it is a good indication that DNAPL is present in the aquifer (Feenstra and Cherry 1996). For TCE as a pure product, this rule of thumb would equate to a concentration of about 10,000 µg/L. Figure 4-4 shows drivepoint locations at EGDY containing concentrations greater than 10,000 µg/L. LC-136A, located west of the treatment system, has shown concentrations of TCE from 19,000 to 190,000 µg/L during the quarterly monitoring program. Since DNAPL present at the site may contain a mixture of TCE and POL, thereby resulting in a lower effective solubility of TCE, DNAPL may also be present in areas where TCE has been detected at high concentrations (greater than 1,000 µg/L), as indicated on Figure 4-4. In addition, because localized groundwater flow direction may vary, the concentration of TCE near a NAPL source may have been lower than theoretically expected.

5.5.3.3 Conclusions on Saturated Zone Contamination

The occurrence of dissolved TCE at concentrations greater than 10,000 µg/L in the study area strongly suggests the presence of a TCE DNAPL in the Vashon Drift aquifer. DNAPL may also be present in areas where TCE has been detected at high concentrations (i.e., greater than 1,000 µg/L as shown on Figure 4-4). Therefore, the lateral extent of DNAPL contamination is uncertain. The DNAPL may be spread throughout the aquifer under residual saturation conditions; however, it is likely that the majority of the DNAPL resides on the upper aquitard surface that lies about 30 feet bgs. It should be noted that drivepoint samples were not collected beyond approximately 39 feet bgs in the ESI, and therefore the extent of DNAPL through the intermediate aquitard and vertical extent of DNAPL contamination are unknown. However, dissolved-phase TCE is present beneath the aquitard, indicating that contamination in the source area has penetrated beneath the aquitard. Laboratory solubilization experiments (Schwille 1988) indicate that it could require decades to remove pooled TCE from an aquitard surface by dissolution into groundwater.

5.6 SUMMARY

Based on the data collected to date, NAPL present in leaking and non-leaking drums, in vadose zone soils, and saturated zone soils in the subsurface at the EGDY represent the major current and future sources of contamination of groundwater at the site. NAPL present in the source area likely will act as a continuous source to groundwater contamination for hundreds of years. The lateral LNAPL and the lateral and vertical extent of DNAPL are not sufficiently defined to appropriately design thermal treatment and/or barrier technologies. In addition, site-specific physical and chemical property data for DNAPL and LNAPL are unavailable or very limited.

Groundwater in the lower aquifer may be contaminated because of permeable “windows” and discontinuities in the Kitsap aquitard in EGDY and downgradient of EGDY. The intermediate aquitard encountered at approximately 35 to 40 feet bgs beneath the EGDY may consist of several distinct lithological layers that can act separately or together as aquitards. This intermediate aquitard is a potential barrier to vertical migration of contaminants. Information regarding the characteristics of this confining layer (aquitard thickness, composition, continuity), lateral extent, and physical characteristics are needed for evaluation of thermal treatment and/or barrier technologies. In addition, dissolved phase TCE is present at high concentrations (greater than 100 µg/L) up to approximately 2,500 feet west of EGDY, approximately 45 degrees from the regional northwest flow direction. It is possible that there are local groundwater flow regimes and/or additional source(s) of TCE groundwater contamination. These uncertainties should be investigated prior to optimizing the existing groundwater pump-and-treat systems or developing the design for thermal treatment and/or barrier technologies.

Physical and biological natural attenuation processes act to lower dissolved contaminant concentrations, but are not sufficient to achieve the maximum contaminant level (MCL) of 5 µg/L. Given the current concentrations of TCE in the groundwater and the presence of NAPL in the source area, natural attenuation alone cannot be considered a remedy. The solubility of TCE in groundwater in contact with DNAPL exceeds the attenuation ability of the system. DCE in the form of 1,2-cis-DCE likely is a degradation product of TCE.

Table 5-1
SUMMARY OF PHYSICAL PROPERTIES OF TCE AND DCE AT 25°C

PHYSICAL PROPERTIES	TCE	1,2-DCE
Vapor pressure, torr	75	315
Relative vapor density	1.35	1.97
Henry's Constant, atm-m^3/mol	0.00937	0.00916
Density, g/cm^3	1.46	1.26
Kinematic viscosity, Cs	0.39	0.32

Notes:
atm-m^3/mol - atmosphere-cubic meter per mole
g/cm^3 - gram per cubic centimeter

Source: Pankow and Johnson 1996

Table 5-2
AQUEOUS SOLUBILITY OF PURE COMPOUNDS IN WATER AT 10°C AND AT 25°C

COMPOUND	SOLUBILITY AT 10°C (mg/L)	SOLUBILITY AT 25°C (mg/L)
Trichloroethene	1,600	1,100
cis-1,2-Dichloroethene	7,300	3,500
Benzene	1,750	1,780
Toluene	535	524
Ethylbenzene	1520	206
o-Xylene	175	204

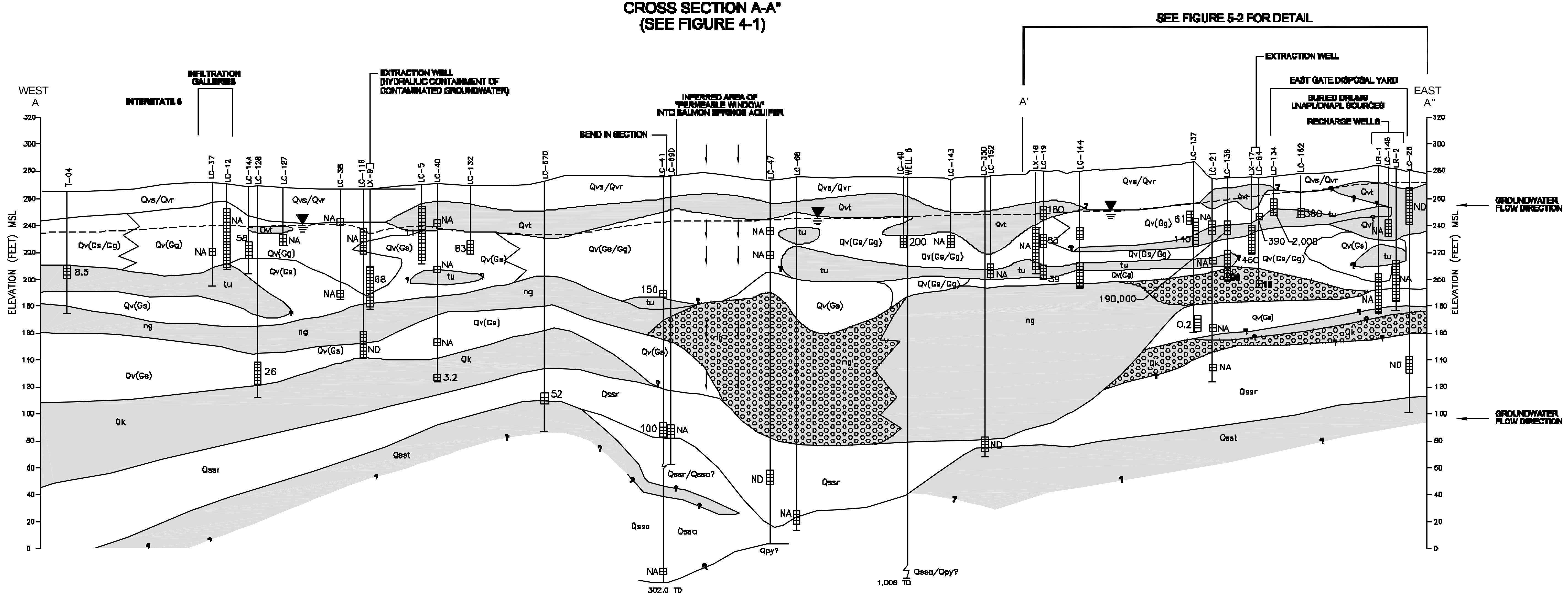
Source: Pankow and Johnson 1996; Montgomery and Welcom 1990

Table 5-3
CALCULATED DISTRIBUTION COEFFICIENTS AND RETARDATION FACTORS

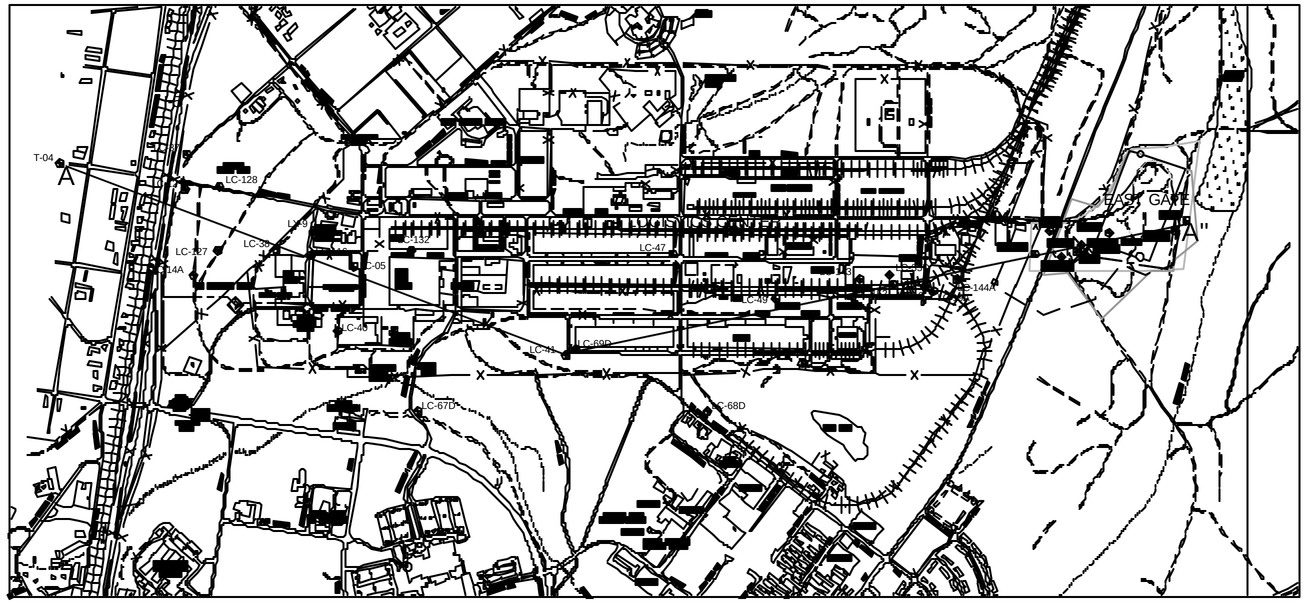
COMPOUND	K_{OC} (mL/g)	Kd (mL/g)	RETARDATION FACTOR
Trichloroethene	126	0.5	4
cis-1,2-Dichloroethene	86	0.3	2.8
Benzene	97	0.4	3.3
Toluene	242	1	6.8
Ethylbenzene	622	2.5	16
o-Xylene	363	1.5	9.8

Source: Pankow and Johnson 1996

DOWNGRADIENT GROUNDWATER CONCENTRATION AREA
CROSS SECTION A-A"
(SEE FIGURE 4-1)



CROSS SECTION A-A" LOCATION



SOURCE: ADAPTED FROM BORING LOQv(Gs) AND *FORT LEWIS LOGISTICS CENTER LOWER AQUIFER STUDY FINAL ADDENDUM TO FINAL TECHNICAL MEMORANDUM* (EBASCO/SHANNON & WILSON JUNE 1994)

GEOLOGIC UNITS

Qvs/Qvr:	STEILACOOM GRAVEL/VASHON RECESSIONAL OUTWASH
Qvt:	VASHON TILL
Qv(Gs):	VASHON GLACIAL OUTWASH (SAND)
Qv(Gg):	VASHON GLACIAL OUTWASH (GRAVEL)
tu:	UNDIFFERENTIATED TILL
ng:	NONGLACIAL DEPOSITS
Qk:	KITSAP FORMATION
Qssr:	SALMON SPRINQv(Gs) RECESSIONAL OUTWASH
Qsst:	SALMON SPRINQv(Gs) TILL
Qssa:	SALMON SPRINQv(Gs) ADVANCE OUTWASH
Qpy:	PUYALLUP FORMATION

LEGEND

⊥	MONITORING WELL
▦ 270	WELL SCREEN INTERVAL WITH 18TH QUARTER (MARCH 2000) TCE RESULT IN UG/L
☐	UNIT WITH AQUIFER PROPERTIES
▨	UNIT WITH INTERMEDIATE OR INTERBEDDED AQUITARD PROPERTIES
▩	UNIT WITH AQUITARD PROPERTIES
- - ▼ - -	GROUNDWATER LEVEL
?—?	ASSUMED GEOLOGIC INTERPRETATION FOR AREAS BETWEEN EXPLORATIONS (FOR GRAPHIC PURPOSES ONLY)
ND	NOT DETECTED ABOVE ANALYTICAL DETECTION LIMIT
NA	NOT AVAILABLE

NOTE: WATER TABLE ELEVATIONS MEASURED OCTOBER 11 AND 12, 1999

DATUM: NGVD 29

HORIZONTAL SCALE: 0 250 500 1000 SCALE IN FEET

VERTICAL SCALE EXAGGERATION: 12.5X

URS

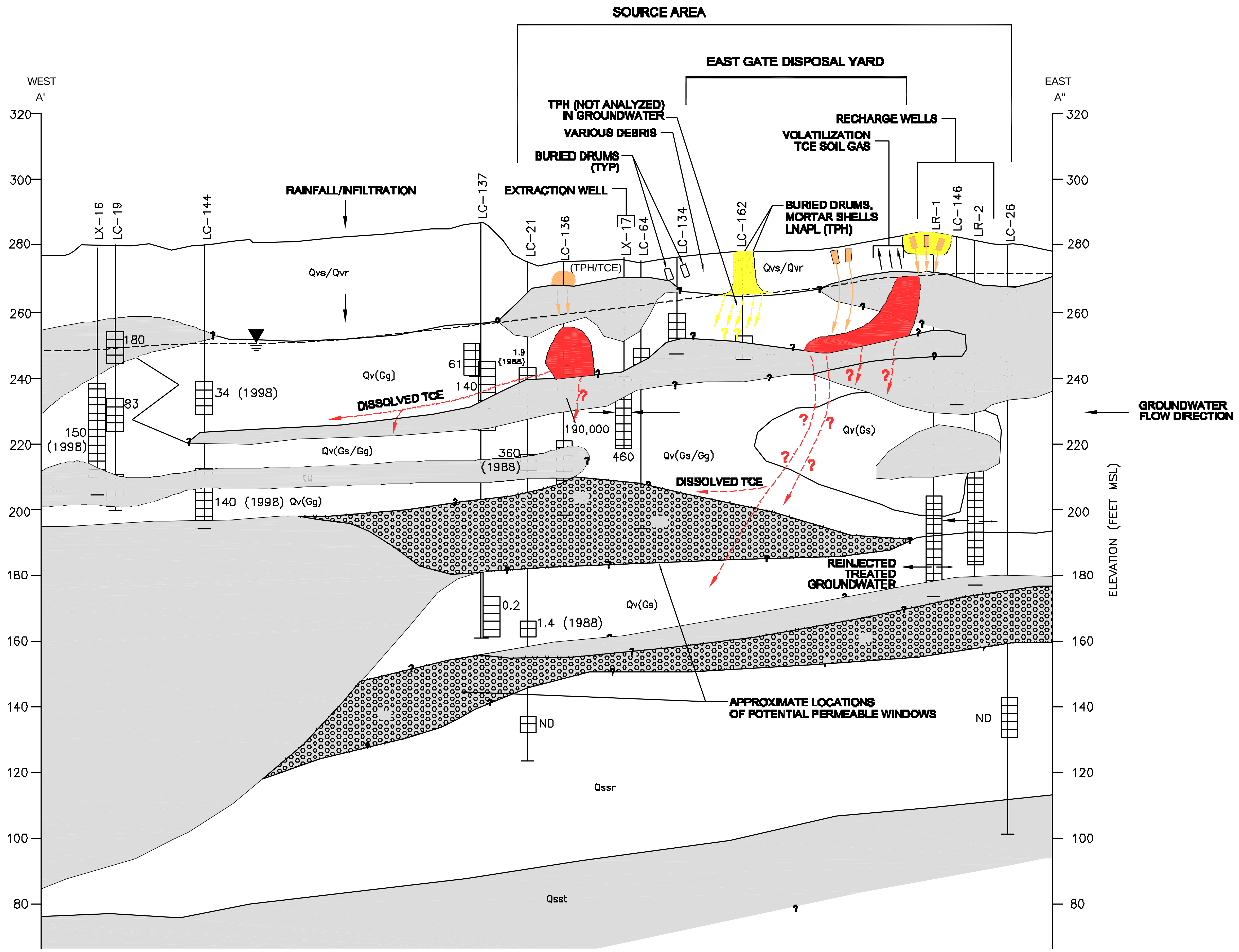
U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

**CONCEPTUAL SITE MODEL-
LOGISTICS CENTER**

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 5-1 WP



LEGEND

⊥ MONITORING WELL

270 ⊞ WELL SCREEN INTERVAL WITH 18TH QUARTER TCE RESULT IN UG/L, EXCEPT WHERE NOTED

☐ UNIT WITH AQUIFER PROPERTIES

▨ UNIT WITH AQUITARD PROPERTIES

▨ UNIT WITH INTERMEDIATE OR INTERBEDDED AQUITARD PROPERTIES

▼ GROUNDWATER LEVEL

?—? ASSUMED GEOLOGIC INTERPRETATION FOR AREAS BETWEEN EXPLORATIONS (FOR GRAPHIC PURPOSES ONLY)

🟥 DNAPL (TCE)

🟧 DNAPL/LNAPL

🟨 LNAPL (TPH)

NOTE: WATER TABLE ELEVATIONS MEASURED OCTOBER 11 AND 12, 1999

DATUM: NGVD 29

GEOLOGIC UNIT

Qvs/Qvr: STEILACOOM GRAVEL/VASHON RECESSIONAL OUTWASH
Qvt: VASHON TILL
Qv(Gs): VASHON GLACIAL OUTWASH (SAND)
Qv(Gg): VASHON GLACIAL OUTWASH (GRAVEL)
tu: UNDIFFERENTIATED TILL
ng: NONGLACIAL DEPOSITS
Qk: KITSAP FORMATION
Qssr: SALMON SPRINGS RECESSIONAL OUTWASH
Qsst: SALMON SPRINGS TILL
Qpy: PUYALLUP FORMATION

WELL KEY

LC-16 MONITORING WELL
LX-9 EXTRACTION WELL
LR-1 RECHARGE WELL

HORIZONTAL SCALE: 0 100 200 400 SCALE IN FEET

VERTICAL SCALE EXAGGERATION: 12.5X

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CONCEPTUAL SITE MODEL-
EAST GATE DISPOSAL YARD

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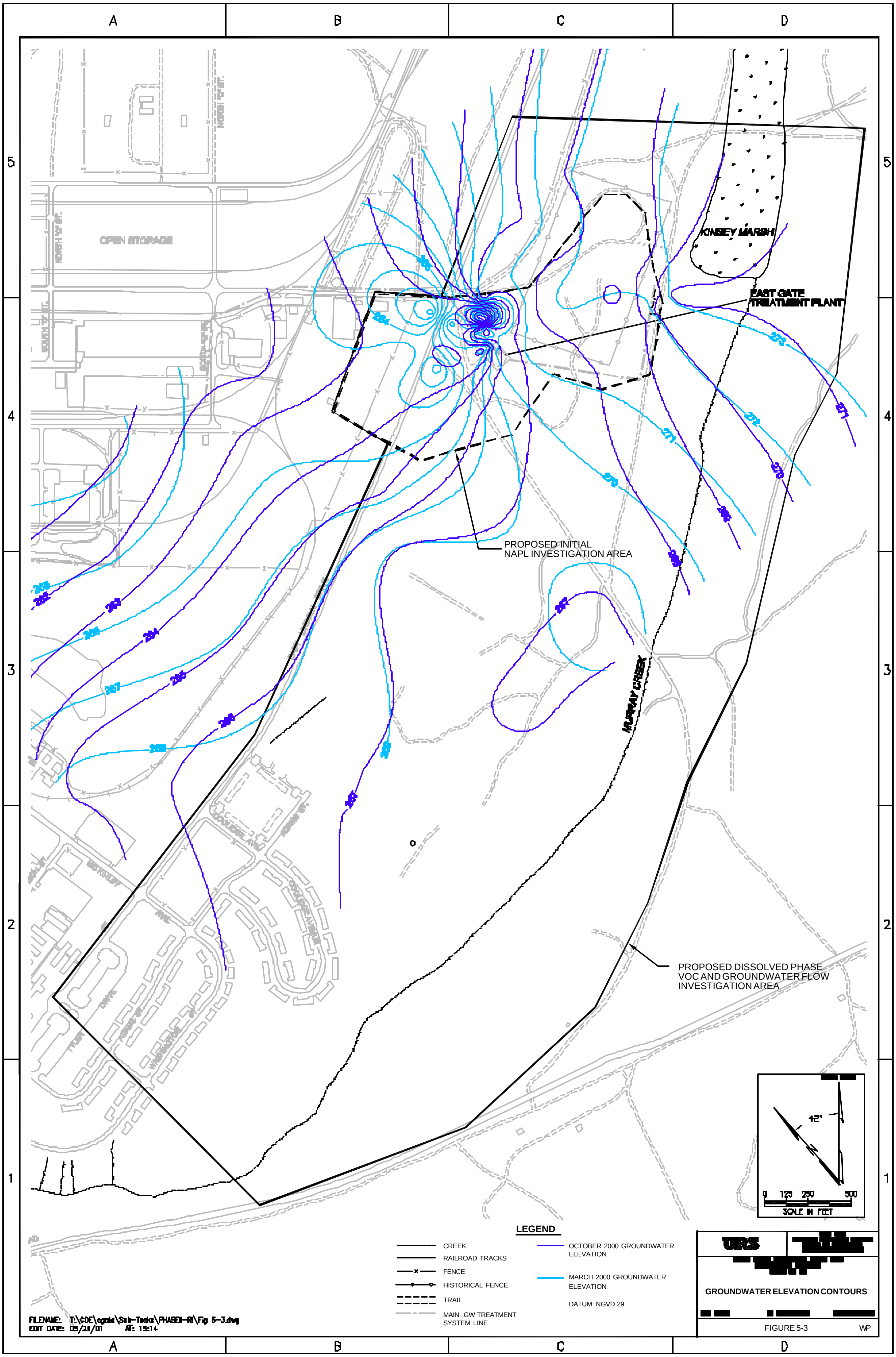
FIGURE 5-2 WP



LEGEND

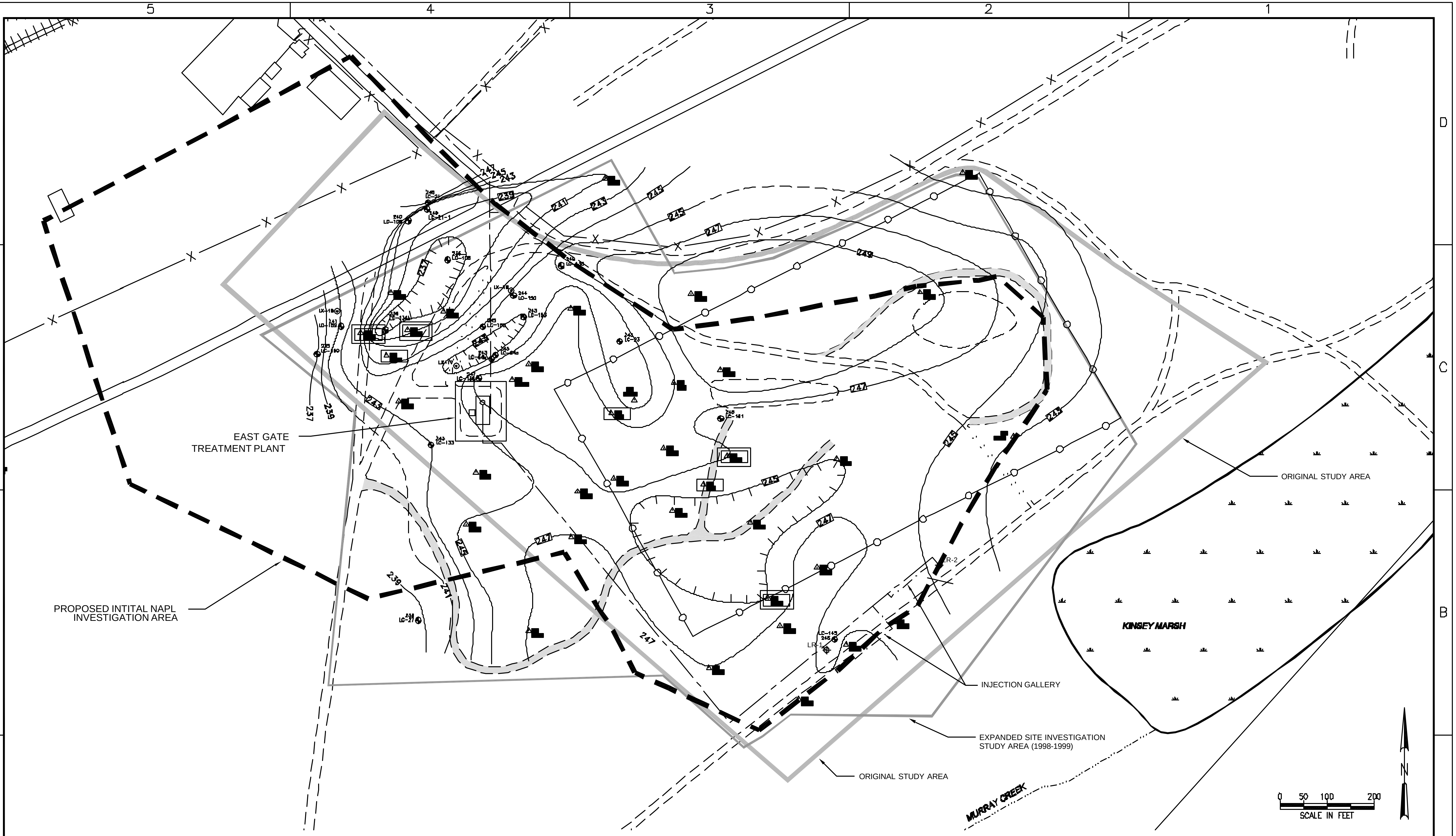
CREEK	OCTOBER 2000 GROUNDWATER ELEVATION
RAILROAD TRACKS	
FENCE	MARCH 2000 GROUNDWATER ELEVATION
HISTORICAL FENCE	
TRAIL	DATUM: NGVD 29
MAIN GW TREATMENT SYSTEM LINE	

FILENAME: T:\CDE\egcdis\Sub-Tasks\PHASEII-RI\Fig 5-3.dwg
EDIT DATE: 05/29/01 AT: 15:14

URS

GROUNDWATER ELEVATION CONTOURS

FIGURE 5-3 WP



LEGEND

───	FENCE
──○─	HISTORICAL FENCE
═ ═	TRAIL
▨	OVERGROWN TRAIL
═ ⁞ ═	APPROXIMATE TRAIL LOCATION
── - ──	MAIN GW TREATMENT SYSTEM LINE
243	CONTOURS OF ELEVATION OF POTENTIALLY CONTINUOUS AQUITARD SURFACE (FEET MSL)
242 LC-25	MONITORING WELL AND ELEVATION (FEET MSL)
LX-17	EXTRACTION WELL
	DATUM: NGVD 29
△ 243 DP-27	DRIVEPOINT LOCATION
△ 246 DP-6	LOCATION OF TCE > 1,000 ug/L ON SURFACE OF AQUITARD
△ 246 DP-6	LOCATION OF TCE > 10,000 ug/L ON SURFACE OF AQUITARD

SOURCES: URS GREINER WOODWARD CLYDE 1999

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SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

TOPOGRAPHY OF POTENTIALLY CONTINUOUS
AQUITARD AND ASSOCIATED ZONE
OF ELEVATED CONTAMINATION/DNAPL

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FIGURE 5-4 WP

6.1 CHEMICALS OF CONCERN

Materials disposed in EGDY consist of construction debris, partially incinerated materials, and hazardous waste. Past disposal practices of hazardous waste are believed to include liquid disposal directly into trenches and containerized (drums) disposal of hazardous materials. Present knowledge of contamination suggests that liquid hazardous waste is mainly chlorinated and nonchlorinated petroleum hydrocarbons. These waste streams were most likely spent degreasing solvents, and lubricating and fuel oils.

EGDY is the source area for widespread TCE contamination at the Fort Lewis Logistics Center. TCE is present in the upper and lower aquifers as a result of past disposal practices at EGDY. During previous investigations in 1997 and 1998, trenching revealed drums containing TCE and nonchlorinated hydrocarbons. Additionally, NAPL was observed at the soil/groundwater interface in the open trenches. During drum removal activities in 2001 (Smith 2001), three distinct product types were observed in intact drums removed from the site:

- Product Type A – Heavy, viscous, dark brown waste oil with TCE
- Product Type B – Light, iridescent oil with TCE
- Product Type C – Pure TCE

Chemical and physical testing of these observed product types, plus any additional product types observed during this investigation, will be performed to identify specific additional chemicals of potential concern associated with these products (e.g., TCE, DCE, PCE, vinyl chloride, PAHs, and non-carcinogenic TPH carbon fractions).

6.2 DATA QUALITY OBJECTIVES

Data quality objectives (DQOs) are quantitative and qualitative statements specified to ensure that data of appropriate quality are collected during field activities. The DQO process ensures that sufficient data are collected to make required decisions within a reasonable certainty and that only the minimum amount of necessary data are collected (U.S. Army 1998). It is difficult to determine the amount of data that will be sufficient to characterize the extent and composition of material like NAPL in the subsurface because of subsurface heterogeneities, variable flow paths, and diverse modes of occurrence. Therefore, instead of establishing numerical “DQO decision rules” and “decision error tolerances” for this investigation, the number of sampling locations and the depth of the investigation will be chosen based on professional judgment using existing data and the current CSM. The dynamic nature of this investigation allows for changes in the number of locations/samples as the investigation progresses, and results from the early stages will be utilized in refining the CSM. Additional data collection will continue until the project team decides that further data would not provide information that would help in substantially reducing the uncertainty in the CSM, or that further data would not be necessary for the development/design of a cost-effective thermal remedy, or until funding limitations are reached. In this manner the investigation has been designed as an iterative approach allowing for new information, as it becomes available, to be evaluated and integrated into the CSM in order to help guide the characterization of areas with TCE and NAPL contamination.

This investigation focuses on collecting data that may be used to aid in the design of an in situ thermal treatment system that will enhance removal of contaminants from the subsurface. These data include the following:

- Chemical composition of contaminated soil, water, and NAPL phases
- Physical characteristics of the contaminated soil and NAPL
- Geologic/hydrogeologic properties of the subsurface
- Distribution of NAPL in the subsurface

A dynamic investigation approach with use of a toolbox of sampling and analytical options has been developed for this investigation. A variety of intrusive measurements and sample collection methods will be used, ranging from in situ sensors to soil borings and monitoring wells. In each case, the performance specification for the investigation method is based on the need to locate and characterize very high levels of contamination and to aid in the design of a method for successfully removing NAPL from the subsurface. The overall project DQOs are as follows:

- DQO 1 – Obtain data required for design of a thermal remedial action for NAPL source area treatment
- DQO 2 – Obtain data required to complete an evaluation of options for optimization of the existing pump-and-treat system
- DQO 3 – Obtain data required to complete an evaluation of reactive barrier wall placement options
- DQO 4 – Provide analytical results that can be used to segregate and classify investigation-derived waste as solid, hazardous, or dangerous waste according to RCRA and Washington state Dangerous Waste Regulations
- DQO 5 – Ensure that the turn around time for the field generated data supports the real-time decision making needs of the dynamic work plan

6.3 DATA GAPS

Site information was reviewed to identify data gaps that must be filled to provide sufficient data to determine the feasibility and estimate costs of using a particular remediation technology. Proposed remediation technologies and associated data gaps are listed in Table 6-1. Data gaps and their relationship to specific DQOs are detailed below.

6.3.1 Intermediate Aquitard Properties

The intermediate aquitard (approximately 35 to 40 feet below ground surface) is a unit that may consist of several distinct lithologic layers that can act separately or together as aquitards. Vashon Till, glaciolacustrine clay/fine sand, and nonglacial deposits are suspected to act as aquitard material at this elevation. Information regarding the thickness, composition, continuity, lateral extent and physical characteristics of this confining unit is required for DQOs 1, 2, and 3 identified above.

6.3.2 DNAPL Extent

The horizontal extent of DNAPL above the intermediate aquitard is presumed to be limited to four areas, each 1 acre or less in size, based upon groundwater concentration data and a criterion for TCE of 10 parts per million (ppm) as an indication of DNAPL. The maximum vertical extent of DNAPL is unknown. DNAPL is suspected to be resting on top of the intermediate aquitard (possibly pooled on other discontinuous low permeability units above the intermediate aquitard) based upon dissolved groundwater concentration data. It is unknown whether or not DNAPL has penetrated into the intermediate aquitard or below the intermediate aquitard. There are only two monitoring wells (LC-64B and LC-136B) screened below the intermediate aquitard within the EGDY DNAPL source area, and concentrations in these wells have historically been around 50 and 100 µg/L, respectively. It is possible that DNAPL may have penetrated below the intermediate aquitard either through a permeable “window” or by direct seepage through the aquitard materials. The chosen remedy for DNAPL remediation will require the vertical extent and a more definitive horizontal resolution of NAPL to be determined. The cost of implementing a thermal treatment remedy for the source area is very sensitive to treatment area and volume. The treatment area and volume definition needs to encompass all NAPL source areas. Information regarding the extent of DNAPL is required for DQOs 1, 2, and 3 identified above.

6.3.3 LNAPL Extent

LNAPL was observed floating on water in trenches and at several direct-push groundwater sampling locations during the ESI (URSGWC 1999). However, no data are available concerning the maximum lateral extent of LNAPL in the vicinity of EGDY. Information regarding the extent of LNAPL is required for DQOs 1, 2, and 3 identified above.

6.3.4 Physical and Chemical Properties of NAPL

Limited physical and chemical property data are available for site NAPL. Three distinct product types were observed during drum removal activities (Section 6.1). However, different NAPL product types may exist at the site other than those sampled. These data are required for DQO 1 to design thermal treatment and/or evaluate the effectiveness of thermal treatment.

6.3.5 Groundwater Flow Directions in the Greater EGDY Area

Dissolved-phase TCE is present at high levels (in excess of 100 µg/L) up to 2,500 feet west of EGDY. It is possible that locally, flow may be toward the west within and west of EGDY. This proposed westerly flow might have carried dissolved-phase contamination cross-gradient from EGDY. These data are needed to determine the extent and location of additional extraction wells for the pump-and-treat system (DQO 2) or to determine the length and position of a barrier technology to contain/treat the dissolved-phase plume emanating from the source area (DQO 3).

6.3.6 Extent of Dissolved-Phase Plume Surrounding EGDY

Dissolved-phase TCE occurs west of EGDY in a direction up to 90 degrees counterclockwise from the regional northwestward flow direction. The full extent and source of the dissolved-phase TCE in this area should be evaluated. It is possible that additional sources of TCE could be present in this area. These data are required for DQOs 2 and 3 identified above.

6.3.7 Identification of Additional Source Areas Outside EGDY

If the investigation of the dissolved-phase plume west of EGDY indicates the potential presence of additional NAPL source areas (Figure 3-4), these must be defined. Additional sources of TCE in this or other areas would affect all proposed remediation options for the source area. Information regarding any additional NAPL source areas will be required for DQOs 1, 2, and 3 identified above.

6.4 FIELD EXPLORATION APPROACH

To fill the data gaps identified above, a dynamic investigation approach with use of a toolbox of data collection options has been developed for this investigation. A dynamic investigation process is an approach to data collection, analysis, and evaluation that promotes on-site decision making based on an evolving CSM. It is called “dynamic” because data collection methods employed may change continually as new information is obtained (e.g., drum removal trenching; aquitard delineation with geophysics). Thus, the environmental investigation can consist of iterative data collection events that occur in the field during a single mobilization. It contrasts with a more traditional approach, where data are evaluated off site and multiple mobilizations are typically necessary before decisions can be reached. When implemented correctly, the dynamic investigation process can result in significant cost and time savings while fostering greater confidence in site decisions. The key features of a dynamic investigation are:

- Flexible sampling and analytical plans
- Reliance on field-based analytical methods to provide data in real time
- Emphasis on experienced technical staff in the field
- On-site decision making to allow investigation goals to be reached in a single mobilization, if possible

The current EGDY CSM is presented in Section 5, and will be used to identify the initial sampling and analytical decisions for the proposed investigation. These decisions will be updated in the field as new data are acquired and the current CSM is refined. In this way, gaps in the information can be assessed and new sampling locations can be selected without the need for remobilization.

Site information will be gathered and data gaps filled by using a toolbox of sampling and analytical options (Section 1.2). Data gaps and specific analytical tools selected to fill those gaps are listed in Table 6-2. Details on each tool’s purpose, advantages, and disadvantages are listed in Table 6-3. Several of the tools will be used to gather data necessary to fill more than one data gap and some tools may not be used. These components are detailed in the SAP.

6.5 OVERVIEW OF SAMPLING AND ANALYSIS PROGRAM

The site investigation will consist of iterative data collection events staged to fill the data gaps identified above. An overview of the initial approach to filling data gaps is presented in this section. Once the investigation begins and data begin to be generated and analyzed by the project and technical teams, the dynamic component of the investigation starts. Data collection tools will change continually as new information is reported and the CSM is refined (e.g., aquitard delineation; NAPL presence or absence). The technical team will select locations of subsequent measurements that best test the crucial features of the CSM. The site investigation will continue until the data gaps have been filled and the CSM has been refined enough to meet the project objectives.

6.5.1 NAPL Area Investigation

The site investigation may begin with initial sonic drilling and SCAPS pushes to define the extent of NAPL contamination. Initial sonic drilling and well installations may be performed in the four areas of the site identified in the CSM (Section 5) as having DNAPL contamination. Four shallow sonic borings may be completed as DNAPL collection wells at the top of the intermediate aquitard (approximately 40 feet bgs). Eleven sonic borings may be completed to the top of the Kitsap aquitard, and likely would be completed as multiport wells. These borings are intended to provide information on the nature and thickness of the intermediate aquitard, whether DNAPL has penetrated the intermediate aquitard, and whether DNAPL is present below the intermediate aquitard. Additionally, four shallow LNAPL collections wells may be installed using the sonic drill rig. Locations of these wells will be determined based in part on the first sonic drilling results and SCAPS pushes.

SCAPS LIF (simultaneously with the CPT) and MIP/DSITMS may be used to determine the extent of NAPL. The SCAPS LIF can be used to identify zones of POL and PAH that presumably are commingled with VOCs. The SCAPS LIF may be used to identify POL and PAHs exceeding site-specific threshold concentrations in the vadose zone, capillary fringe, and below the water table. Site-specific threshold POL and PAH concentrations in soil may be determined from site-specific data as the field investigation progresses by relating LIF response to co-located soil sample results from fast turnaround PAH analysis by the analytical laboratory.

Based on the SCAPS LIF and MIP/DSITMS results, limited locations for GeoVIS or FLUTe ribbon samplers may be selected. If the SCAPS LIF and MIP/DSITMS results are of sufficient quality to meet project objectives, use of the GeoVIS and FLUTe ribbon samplers may not be necessary. GeoVIS will be used as necessary to view and map NAPL distribution and pore space, and to confirm NAPL presence. Also LIF can be employed simultaneously with GeoVIS, so these locations can be used to confirm LIF response in NAPL areas and to aid in LIF interpretation. Representative NAPL samples collected during the drum removal excavation work have been tested and responded to the LIF tool.

Soil and/or NAPL samples from the sonic borings and/or SCAPS rig may be collected at the discretion of the technical team and submitted for analysis of physical and/or chemical characteristics.

6.5.2 Define Intermediate Aquitard

The SCAPS CPT may be used to provide continuous geotechnical and stratigraphic information that will aid in defining the intermediate aquitard and interpreting contaminant distribution. Final decisions regarding density of sample collection will be made in the field by consensus among the technical team. Final decisions regarding the total number of samples collected also will be made by the USACE. Actual placement of the SCAPS equipment may be adjusted due to physical obstructions. Continuous LIF measurements may be collected for the entire length of each SCAPS push to provide an indication of relative concentrations of contaminants.

Sonic drilling likely would occur simultaneously with the SCAPS work. The 11 borings that may be completed to the top of the Kitsap aquitard can provide information on the nature and thickness of the intermediate aquitard. Soil samples from these borings and/or the SCAPS rig may be collected at the discretion of the technical team and submitted for analysis of physical and/or chemical characteristics.

If additional information is needed for defining the intermediate aquitard, then geophysical methods could be employed.

6.5.3 Groundwater Flow Direction and Extent of Dissolved Phase Plume

The groundwater flow direction may be evaluated by collecting groundwater level measurements from existing monitoring wells, monitoring wells installed during sonic drilling, and piezometers installed by the SCAPS team.

Dissolved-phase TCE occurs west of EGDY. Using existing site groundwater data and new SCAPS LIF results, additional SCAPS pushes may be completed. The MIP may be used to delineate areas with elevated concentrations (>100 µg/L). The SCAPS direct groundwater sampling may be used to delineate the lower level portions and edges of the plume. Depending on site conditions, in situ VOC measurements may be collected with the MIP. If necessary, groundwater samples will be collected using SCAPS direct sampling capabilities and analyzed by the SCAPS team on site using the DSITMS method. The DSITMS method also can be used to analyze surface water from Murray Creek. Data will be reviewed by the technical team and used to select locations of subsequent measurements that best test the crucial features of the CSM.

Groundwater samples may be collected from the 11 new multiport wells in EGDY and analyzed by the off-site laboratory for VOCs, SVOCs, and TPH. It is possible that each well may be sampled prior to installation of additional wells; data from these wells may be used to choose locations of subsequent wells. Preliminary results will be reported by the laboratory within 48 hours of sample receipt. Data will be reviewed by the technical team and used to select locations of subsequent measurements that best test the crucial features of the CSM.

6.5.4 Identification of Additional Potential Source Areas Outside EGDY

Based on aerial photo review conducted by the USACE, there may be additional NAPL source areas outside of the EGDY area. These potential disposal areas may be investigated using reconnaissance followed by exploratory trenching techniques by an independent contractor to the USACE. If the results from this reconnaissance, exploratory trenching, or the investigation of the dissolved phase TCE plume west of the EGDY area indicate the presence of additional source areas, investigation to identify these areas would employ the same tools used to fill the data gaps discussed above. SCAPS and sonic drilling data will be reviewed and locations for pushes and/or borings will be determined by the technical team.

Table 6-1

APPLICABLE REMEDIATION TECHNOLOGIES AND ASSOCIATED DATA GAPS

APPLICABLE TECHNOLOGY	DATA GAPS
Thermal treatment	Intermediate aquitard thickness, composition, continuity, lateral extent, and physical/hydrogeologic properties
P&T optimization	
Reactive barrier	
Thermal treatment	DNAPL horizontal and vertical extent
P&T optimization	
Reactive barrier	
Thermal treatment	LNAPL horizontal extent
P&T optimization	
Reactive barrier	
Thermal treatment	Physical and chemical properties of DNAPL and LNAPL
P&T optimization	Groundwater flow directions in the greater EGDY area
Reactive barrier	
P&T optimization	Horizontal and vertical extent of dissolved phase plume in the greater EGDY area
Reactive barrier	
Thermal treatment	Identification of additional NAPL source areas outside the boundaries defined for EGDY
P&T optimization	
Reactive barrier	
P&T optimization	Horizontal and vertical extent of dissolved phase plume in the greater EGDY area below the intermediate aquitard
Reactive barrier	

Note:

P&T - Groundwater pump-and-treat system

Table 6-2
DATA GAPS AND SAMPLING AND ANALYTICAL TOOLS

DATA GAP	SAMPLING AND ANALYTICAL TOOLS[a]	ASSOCIATED DQOS[b]
Determine intermediate aquitard thickness, composition, continuity, lateral extent, and physical/hydrogeologic properties	• Ground penetrating radar (GPR) (1) • Electrical Resistivity Imaging (2) • SCAPS CPT (4), GeoVIS (9), and MOSTAP® soil sampling (10) • Sonic drilling and soil sampling (3) • Soil testing (14): – Grain size – Permeability – Density – Porosity – Cation exchange capacity – Total organic carbon • Surveying (20, 21)	1, 2, 3
Determine horizontal and vertical DNAPL extent	• SCAPS with FLUTe ribbon samplers (5), MIP with DSITMS (6), LIF (8), GeoVIS (9) • Sonic drilling and shallow well installation (3), NAPL and soil sampling (18, 19) • NAPL and soil analysis (14, 15): – VOCs – SVOCs – TPH • Surveying (20, 21)	1, 2, 3
Determine horizontal LNAPL extent	• SCAPS with FLUTe ribbon samplers (5), MIP with DSITMS (6), LIF (8), GeoVIS (9) • Sonic drilling and shallow well installation (3), NAPL and soil sampling (18, 19) • NAPL and soil analysis (14, 15): – VOCs – SVOCs – TPH • Surveying (20, 21)	1, 2, 3
Evaluate physical and chemical properties of DNAPL and LNAPL	• Sonic drilling and well installation (3), and DNAPL/LNAPL sampling (18, 19) • NAPL analysis and testing (14, 15): – Oil/water interfacial tension – Density – Viscosity – Boiling point distribution – VOCs – SVOCs – TPH • Surveying (21)	1
Determine groundwater flow directions in the greater EGDY area	• Sonic drilling and well installation (3) • Water level measurement (17) • SCAPS piezometers (11) • Surveying (20, 21)	2, 3

Table 6-2 (Continued)

DATA GAPS AND ANALYTICAL TOOLS

DATA GAP	SAMPLING AND ANALYTICAL TOOLS[a]	ASSOCIATED DQOS[b]
Determine the extent of dissolved phase plume in the greater EGDY area, above and below the intermediate aquitard	• Sonic drilling and deep well installation (3), and groundwater sampling (16) • Groundwater analysis (15): – VOCs • SCAPS groundwater sampling/analysis with MIP/DSITMS (6) or PowerPunch™ /DSITMS (7) • Surface water sampling with DSITMS (12) • Surveying (20, 21)	2, 3
Assess the presence of additional NAPL source areas outside EGDY	• Exploratory excavating (13) • SCAPS with FLUTe ribbon samplers (5), LIF (8), GeoVIS (9) • SCAPS groundwater sampling/analysis with MIP/DSITMS (6) or Power Punch™ /DSITMS (7) • SCAPS MOSTAP® soil sampling (10) • Soil testing (14): – Grain size – Permeability – Density – Porosity – Cation exchange capacity – Total organic carbon • Surveying (20, 21)	1, 2, 3

[a] Numbers in parentheses are cross references to tools in Table 6-3.
[b] DQOs are defined in Section 6.2.

Note:

Not all tools presented in Tables 6-2 and 6-3 may be used.

Table 6-3
SAMPLING AND ANALYTICAL TOOLS: PURPOSES, ADVANTAGES, AND LIMITATIONS

TOOL	PURPOSE	ADVANTAGES	LIMITATIONS
GEOPHYSICS			
(1) Ground-penetrating radar (GPR)	Characterize the surface topography of the intermediate aquitard (30-40 ft bgs) and other less continuous shallow aquitards	• High definition • Non-invasive • Rapid	• High cost • Need confirmation stratigraphic data collected from drilling or SCAPS • Relatively shallow penetration depth • Possible signal interference due to presence of rounded metallic objects (drums), backfilled areas, and electrically conductive groundwater • Unobstructed ground surface required to carry/tow GPR
(2) Electrical resistivity imaging (including induced polarization)	Characterize deeper stratigraphic units	• High definition • Non-invasive • Rapid • Relatively deep penetration depth	• High cost • Need confirmation stratigraphic data collected from drilling or SCAPS
DRILLING			
(3) Sonic drilling	Install borings and monitoring wells for collection of soil, groundwater, and NAPL samples, and stratigraphic characterization to top of Kitsap aquitard	• Can reach maximum proposed study depth • Allows installation of 2-inch diameter NAPL collection wells • Allows accurate collection of soil, groundwater, and/or product samples for laboratory analysis • Minimizes generation of IDW more than other drilling techniques • Appropriate for site geology	• High cost • Produces some IDW
SCAPS			
(4) Cone penetrometer testing (CPT)	Define stratigraphic units	• Inexpensive technique to quantify grain size/stratigraphy • Can collect coincident with other SCAPS technologies (e.g. LIF, GeoVIS, MIP) • Continuous record • Up to 2 cm vertical spatial resolution • Minimal generation of IDW • Grouting through the tip	• May be difficult to employ due to coarse gravel and cobbles • May not be accurate in lithologies of mixed grain size • Geologic information limited to grain size; no other data such as depositional origin • Likely will not penetrate to maximum depths of investigation

Table 6-3 (Continued)
SAMPLING AND ANALYTICAL TOOLS: PURPOSES, ADVANTAGES, AND LIMITATIONS

TOOL	PURPOSE	ADVANTAGES	LIMITATIONS
SCAPS			
(5) FLUTe Ribbon Sampler	Determine DNAPL/LNAPL extent	• Wide range of installation configurations • Easy installation • Results available within one hour of installation • Allows physical map of NAPL • Provides depth discrete distribution of NAPL • Inverting liner minimizes cross-contamination • Stained sections of sampler can be submitted to laboratories for analysis • Low cost	• May be difficult to employ due to coarse gravel and cobbles • Not quantitative • Does not determine product types or characteristics • Dependent upon depth reached by SCAPS
(6) MIP with DSITMS	Determine the extent of dissolved phase VOC groundwater plume surrounding EGDY and indirectly identify NAPL	• More efficient than fixed lab (more samples, less time and cost) • Rapid (<5 minutes), real-time horizontal and vertical assessment of dissolved phase TCE • Up to 2 cm vertical spatial resolution in one hole • Minimal generation of IDW • Measures VOCs in soil, water and air in vadose and/or saturated zones • Deployment with CPT allows identification of depths for sampling • Grouting through the tip • Dynamic range of 10^4	• May be difficult to employ due to coarse gravel and cobbles • Likely will not penetrate to maximum depths of investigation • MIP cleaning required when high concentrations of solvents saturate the device's membrane and transfer line • Detection limit typically 100-200 µg/L • Reduced TAL • Difficult to differentiate compounds with similar mass • Uncertainty associated with spiking method for calibration • Potential for interference for vinyl chloride
(7) PowerPunch™ or direct water sampling with DSITMS	Collect groundwater samples and determine the extent of dissolved phase plume surrounding EGDY	• More efficient than standard monitoring well sampling and fixed lab analysis (more samples, less time and cost) • Provides discrete depth information • Rapid horizontal and vertical assessment of dissolved phase TCE	• May be difficult to employ due to coarse gravel and cobbles • Likely will not penetrate to maximum depths of investigation • Must be decommissioned • Samples could be turbid • One time sampling only • Reduced TAL

Table 6-3 (Continued)
SAMPLING AND ANALYTICAL TOOLS: PURPOSES, ADVANTAGES, AND LIMITATIONS

TOOL	PURPOSE	ADVANTAGES	LIMITATIONS
SCAPS			
		• Greater sensitivity than MIP/DSITMS (2.5 to 5.0 μg/L) • Allows for repeat sampling • Grouting through the tip • Dynamic range of 10^4	• Difficult to differentiate compounds with similar mass • Uncertainty associated with spiking method for calibration • Potential for interference for vinyl chloride
(8) Laser-induced fluorescence (LIF)	Determine horizontal and vertical DNAPL/LNAPL extent	• More efficient than fixed lab (more samples, less time and cost) • Can be used to characterize mixed NAPLS (POL/TCE) • Basic site NAPL types collected during excavation were tested and will fluoresce; confirms ability of LIF to indirectly delineate NAPL source areas • Up to 2 cm vertical spatial resolution with rapid measurement • Minimal generation of IDW • Grouting through the tip	• May be difficult to employ due to coarse gravel and cobbles • Likely will not penetrate to maximum depths of investigation • Not quantitative; need to confirm results with fixed lab analyses • Does not identify chlorinated hydrocarbons (TCE) • Does not identify aliphatic hydrocarbons • Subject to interference from moisture in soil or naturally occurring compounds or minerals that fluoresce
(9) GeoVIS soil video imaging system	Obtain stratigraphic information Determine horizontal and vertical DNAPL/LNAPL extent	• Rapid • Provides discrete depth information • Can deploy coincident with CPT and LIF • Relatively inexpensive • Can obtain information on soil structure, pore space, and movement of NAPL • Provides information on depth discrete distribution of NAPL	• May be difficult to employ due to coarse gravel and cobbles • Not quantitative • Likely will not penetrate to maximum depths of investigation • Colorless NAPL not visible
(10) MOSTAP® sampler	Collect confirmation soil samples for SCAPS work	• Allows accurate collection of soil samples for stratigraphic characterization and chemical/physical testing	• May be difficult to employ due to coarse gravel and cobbles (designed for use in clay, silt, and sand) • Likely will not penetrate to maximum depths of investigation

Table 6-3 (Continued)

SAMPLING AND ANALYTICAL TOOLS: PURPOSES, ADVANTAGES, AND LIMITATIONS

TOOL	PURPOSE	ADVANTAGES	LIMITATIONS
(11) Piezometer installation	Determine groundwater flow directions in the greater EGDY area and groundwater interaction with Murray Creek	• Less expensive than installing standard 2-inch diameter monitoring wells (more locations, less time and cost) • Minimal generation of IDW	• May be difficult to employ due to coarse gravel and cobbles
SURFACE WATER SAMPLING			
(12) Surface water sampling with DSITMS	Map TCE concentrations in Murray Creek to enhance understanding of the plume/creek interaction	• Numerous samples can be collected quickly • Minimal generation of IDW • Rapid availability of data	• Access could be difficult • Might not capture seasonal VOC concentration fluctuations
EXPLORATORY EXCAVATING			
(13) Exploratory excavating	Assess the presence of additional NAPL source areas outside EGDY	• Low cost • Will provide basic information quickly (i.e. whether additional former disposal areas are present)	• Limited to shallow subsurface
ANALYTICAL LABORATORY ANALYSES			
(14) Physical testing of soils and NAPL	Determine physical characteristics of soil and NAPL	• Provides determinative data	• High cost • Slow turn around time
(15) Analytical testing of soil, groundwater, surface water and NAPL	Determine nature and extent of chemicals of concern	• Provides determinative data • Complete TAL	• High cost • Slow turn around time
FIELD MONITORING INSTRUMENTS			
(16) Groundwater monitoring using water quality meter	Assess stability of groundwater conditions prior to sample collection	• Allows collection of representative samples	• None
(17) Depth to groundwater measurement using water level indicator	Assess groundwater flow direction	• Provides definitive data	• None
(18) Air monitoring for volatile organic compounds using PID	Assess health and safety conditions and presence of chemicals of concern at potential sampling locations	• Indicates when potential hazards may be present	• May not have adequate detection limits for some chemicals of concern
(19) NAPL measurement using interface probe	Determine presence/absence of NAPL in monitoring wells	• Allows selection of appropriate sample collection tool	• None

Table 6-3 (Continued)
SAMPLING AND ANALYTICAL TOOLS: PURPOSES, ADVANTAGES, AND LIMITATIONS

TOOL	PURPOSE	ADVANTAGES	LIMITATIONS
SURVEYING			
(20) Global positioning system survey (GPS)	Determine horizontal coordinates of all sampling locations	• Rapid • Inexpensive • Provides adequate accuracy (+/- 10 feet) for display and processing of data for field decision making	• Not as accurate as traditional survey techniques • Does not determine vertical coordinates
(21) Traditional survey	Provide accurate locations and elevations of monitoring wells, piezometers, and other sampling locations	• Provides elevation accuracy necessary to map groundwater elevation and determine flow directions	• Expensive • Relatively slow

Notes:
IDW – investigation-derived waste
TCE – trichloroethene
TAL – target analyte list

7.1 DATA PRESENTATION

Site investigation results will be presented in text, tables, and graphics. As data become available, draft and final results will be posted on eRoom, the project Website. This eRoom is an Internet site where project team members can access site information from their own computers. Text will be created in Microsoft Word 6.0/95 format. Tabular data will be presented in Microsoft Excel 5.0/95 or Microsoft Word 6.0/95 formats. All chemical and physical data will be compiled in a Microsoft Access database. Data will be exported to Excel for preparation of reports and other documents. Schematic graphical data will be presented using Macromedia Freehand 5.0, CorelDraw 8.0, or similar software. Computer-aided drafting of site plans and other scale-intensive graphics will be performed using Intergraph Microstation. Where appropriate, geographic presentation of analytical data will be presented using GMS software. Boring logs will be prepared with appropriate software, such as gINT. It is also possible to present text, tabular data, and graphics in PDF.

7.2 DATA INTERPRETATION

The primary objectives of the field investigation are to define the extent and composition of NAPL in the subsurface and to evaluate the geologic constraints that will be used to assess appropriate remedial technologies. Some of the data that potentially will be collected to better define the presence and characteristics of the NAPL and the subsurface include the following:

- Geophysical data
- SCAPS, MIP, LIF, GeoVIS, CPT, and FLUTe data
- Site geology and stratigraphy
- Off-site laboratory chemical analysis of soil, groundwater, and NAPL samples collected from SCAPS penetrations, soil borings, and monitoring wells
- DSITMS chemical analysis of groundwater samples collected from SCAPS penetrations and sonic drilling monitoring wells, and surface water samples collected from Murray Creek
- Groundwater elevations
- Physical testing of soil and NAPL samples

The data from these analyses, tests and techniques will be used to map the extent of NAPL at the site, estimate the amount, and classify it into groups with similar physical/chemical properties, if possible. Geotechnical and stratigraphic data collected using the SCAPS and sonic drilling and geophysical surveys will be used to identify high- and low-permeability zones. The results of the field work and tests will be used to develop a stratigraphic map of the subsurface that may help explain the distribution of NAPL at the site.

Groundwater chemical data from monitoring wells and SCAPS MIP/DSITMS, groundwater elevation data from monitoring wells and piezometers, and surface water chemical data from Murray Creek will be used to estimate the current extent and flow direction of the TCE plume, to evaluate concentration trends, and to determine interaction between the plume and the creek. Rapid turnaround will be requested for VOC, SVOC, and TPH data reported by the fixed lab.

Results will be analyzed by the core technical team and used to determine the next measurements that best test the crucial features of the evolving CSM.

The NAPL distribution/characteristics data and the subsurface stratigraphy of the site will be used to evaluate the feasibility of in situ treatment technologies and may be used to aid in the design of a thermal treatment system. The groundwater and surface water results and stratigraphic data will be used to evaluate the feasibility of optimization of the existing groundwater pump and treat systems and evaluate alternative dissolved phase treatment options.

7.3 QUALITY ASSURANCE REVIEW

The field method review process for this project will include USACE site representative supervision and review of the procedures being implemented in the field for consistency with the established protocols. Field forms and data will be reviewed on a daily basis by the USACE technical team. An initial data quality assessment will be performed in the field before data are used to make decisions. Field QC and PE samples will be monitored on continual basis.

The chemical data review process for this project will include data generation, reduction, and two levels of QA review. The first level of review will be conducted by the analytical laboratory data reviewer. After receipt of data packages, the project QA/QC Officer or a designee will conduct an independent data quality review and generate a QA summary report that will evaluate attainment of data quality objectives of the overall project.

7.3.1 Field Measurement Quality Assurance

The technical team is responsible for field QA. The USACE site representative will review the procedures being implemented in the field for consistency with the established protocols. He or she is responsible for supervising and checking that samples are collected and handled in accordance with this management plan and that documentation of work is adequate and complete. Sample collection, preservation, labeling, etc., will be checked for completeness. Where procedures are not strictly in compliance with established protocol, the deviations will be field documented and reported to the project QA/QC Officer. Corrective actions will be defined and implemented and documented as appropriate, as defined in the Quality Assurance Project Plan (QAPP).

7.3.2 SCAPS Laboratory Quality Assurance Review

One hundred percent of mobile field laboratory data will be reviewed. The review will include evaluation of method performance as outlined in the SCAPS standard operating procedures and evaluation of threshold limits, replicate analyses, precision and accuracy, representativeness, comparability, and completeness. Reviews will be performed by USACE Tulsa District and included in a separate SCAPS results report.

7.3.3 Fixed Laboratory Quality Assurance

One hundred percent of the fixed laboratories’ data will be reviewed by URS against laboratory performance criteria and sample-specific criteria. The quality review on the data will include evaluation of precision, accuracy, representativeness, comparability, and completeness, sampling documentation, holding times, instrument calibration, and tuning. The USACE will evaluate overall completeness and determine if DQOs have been met. After receipt and initial review of all data from Sound Analytical Services, Inc., and PTS Laboratories, Inc., Contract Laboratory Program (CLP)-like deliverables will be requested for 10 percent of all data packages. These data will receive a full validation according to EPA functional guidelines (USEPA 1994a and 1994b) and site-specific criteria. A data quality review of the remaining data will be performed by URS using the DQOs, the EPA's functional guidelines, and the EPA Region 9 standard operating procedures.

This section of the Work Plan describes the important project elements of communications between team members and the flow and management of data that have been collected. The method of reporting project results is also described.

8.1 COMMUNICATIONS STRATEGY

Accelerated approaches to sampling and analysis, as required for this project, integrate various characterization tasks and measurements into a single coordinated effort. Accelerated approaches are conducted by a multidisciplinary group of experienced professionals, working as a team in the field to evaluate the data to further refine the CSM and plan the next measurement steps. The dynamic nature of this approach requires an outlined communication effort. Team and inter-group communication strategies are described below and shown on Figure 8-1. Contact information for all parties involved is presented in Tables 2-1, 2-2, and 2-3.

8.1.1 Project Team

The project team consists of representatives from Fort Lewis Public Works, USACE Seattle District, USACE Tulsa District, and URS. Project personnel and responsibilities are described in Section 2. The project team provides the overall framework for the sampling and analysis approach by defining project objectives and data quality requirements, and ensuring that both the objectives and data quality requirements are met. Technical oversight and support also are provided by EPA, USGS, and PNNL.

Providing oversight for the project team throughout the process are individuals identified to ensure that project QA/QC and health and safety issues are addressed. At any time, any individual working on the project may contact the QA/QC Manager or the Health and Safety Officer to discuss project issues or concerns. It is the responsibility of the QA/QC Manager and the Health and Safety Officer to implement corrective actions if project requirements are not being met.

The project team, EPA, USGS, and PNNL will be kept informed of the project progress via eRoom, weekly email summaries, conference calls involving major decisions, and biweekly meetings at the site. The approval of Fort Lewis Public Works and EPA is required for any major deviations in the work. Project updates will be given to Fort Lewis Public Works and the USACE Project Manager by the technical team during regularly scheduled meetings, phone calls, emails, or faxes.

8.1.2 Technical Team

Within the project team is a technical team made up of USACE individuals who have expertise in geologic, hydrologic, and chemical analytical methods appropriate for the site. They provide a continual, integrated, and multidisciplinary presence throughout the process. Each member of the technical team is involved in all steps of the process and may be present in the field when data collection related to their areas of expertise is taking place. The optimization of field investigation activities and the quality of the evolving and final CSM depend on the interaction among the members of the technical team and the project team, each providing their own special perspective on the site. At least one member of the technical team will be on site during field activities. This person will be the site point of contact and will be responsible for daily field decisions.

Technical team members include:

- Senior Chemist – Kira Lynch
- Senior Geologist – Richard Smith
- Project Geologist – Jeff Powers
- Project Chemist – Gwyn Puckett

The technical team oversees analysis of the raw data, evaluates the data to further refine the CSM, and decides on the next measurements that best test the crucial features of the CSM. Members of the technical team should have whole-site-systems understanding of geology, hydrogeology, and contaminant chemistry. They work together to evaluate the data as they are obtained. Their most important role is integrating and understanding inconsistencies between the data and the CSM. The ability to integrate their technical expertise with that of the other members of the technical team is crucial to the success of the project.

During this project, the technical team will use field-based site characterization methods that will generate data that will be evaluated and integrated into the CSM in the field. The technical team will follow a dynamic management plan that allows and requires on-site decision making by the team. Successive steps are based on the evaluation and integration of field data into the CSM.

During decisionmaking, the technical team will use eRoom as a major communication tool (Section 8.2). Another communication tool will be provided by CRREL. CRREL developed a software tool that searches a website that contains SCAPS and survey data, then incorporates the data into a web-based GIS tool. This tool will allow users to see where data has been collected and view some of the data.

The technical team is ultimately responsible for all decisions related to the design and implementation of this project, within the framework provided by the approved dynamic work plan. They are tasked with informing the project team about all decisions that may impact project schedule or budget. Final decisions that impact budget and schedule will be made by the USACE Project Manager and Fort Lewis Public Works in concurrence with EPA.

The technical team also is responsible for ensuring data quality and effective data management, interpreting data, and integrating the results into the evolving CSM and reports. The on-site technical team representative has the final authority on site technical decision making concerning field operations. The USACE on-site representative team, in telephone consultation with the technical and/or project team members, makes decisions concerning the present and next day’s activities. Other technical team members may be in the field for data collection involving their primary area(s) of expertise and will be available for telephone consultation when they are not present in the field. Technical team members will review data posted on eRoom daily.

Although data management and QA/QC are specific project support functions, the technical team members are responsible for ensuring that (1) data collection is relevant to the objectives of the project (that is, necessary to satisfy data quality requirements), (2) QA/QC procedures for data collection and processing for respective areas of expertise are strictly followed, and (3) field data reduction and processing do not introduce errors into the data and evolving CSM.

The technical team will be in daily contact to discuss project process and any changes with Fort Lewis Public Works. Additionally, daily meetings to discuss project technical issues will be held in the field with technical team members present or linked by conference call. Representatives of subcontractors or project support team members (Section 8.1.3) may also be asked to attend these meetings.

8.1.3 Project Support Team

The project support team includes technical and support personnel and equipment operators directly involved in data collection and sampling. The project support team is made up of representatives from USACE Tulsa District, URS, the USACE sonic drilling contractor, and URS' subcontractors. Project personnel and responsibilities are described in Section 2.

The project support team will be in daily contact with the USACE site representative during field activities. They may be asked to attend technical team meetings to present results or other technical issues, if needed. Off-site laboratories will be contacted by the URS Field Investigation Manager, or designee, as necessary.

8.2 DATA FLOW

Two primary categories of data will be generated for this project: field data and fixed laboratory data. The procedures to be used for each type of data are described below.

8.2.1 Field Data

Field measurements/observations will be recorded by technical support team members in logbooks and on the appropriate field forms. SCAPS data will be generated on a daily basis and reported in formats that can be interpreted by the technical team. SCAPS data deliverables are described in detail in the QAPP. Boring logs will be generated during sonic drilling.

All field data will be transferred to the site field office. A temporary file will be established and maintained at the site field office to ensure proper hardcopy storage during field operations. These files will be added to and used by the technical team as data are generated by the project field support team.

Daily chemical quality control reports (DCQCRs) will be generated daily by project support staff and submitted to the USACE on-site representative. The DCQCR will include all field data generated on a daily basis, including boring logs, mobile laboratory data, chain of custody forms, and field sampling forms. The reports and supporting documentation will be scanned and posted on eRoom. If generated electronically in the field, reports may be posted directly to eRoom from the field office. Incoming project-related material, including correspondence, authorizations, chain of custody forms, or other information, will be marked with the date received and the project name.

Upon completion of the field program, the temporary file will be transferred from the site field office and incorporated into the USACE Seattle District office project file. Copies of all field documents may be made and retained by the originator for use in report preparation and later reference. The originals will be filed in the office project file.

On-site field measurements and laboratory data will be input into an electronic database. The data will then be printed out and compared to the original field records to ensure input accuracy. All review documentation will be initialed and dated by the reviewer, then filed with the quality review documentation. All data and forms will be input into eRoom daily (Section 8.2.3).

8.2.2 Fixed Laboratory Data

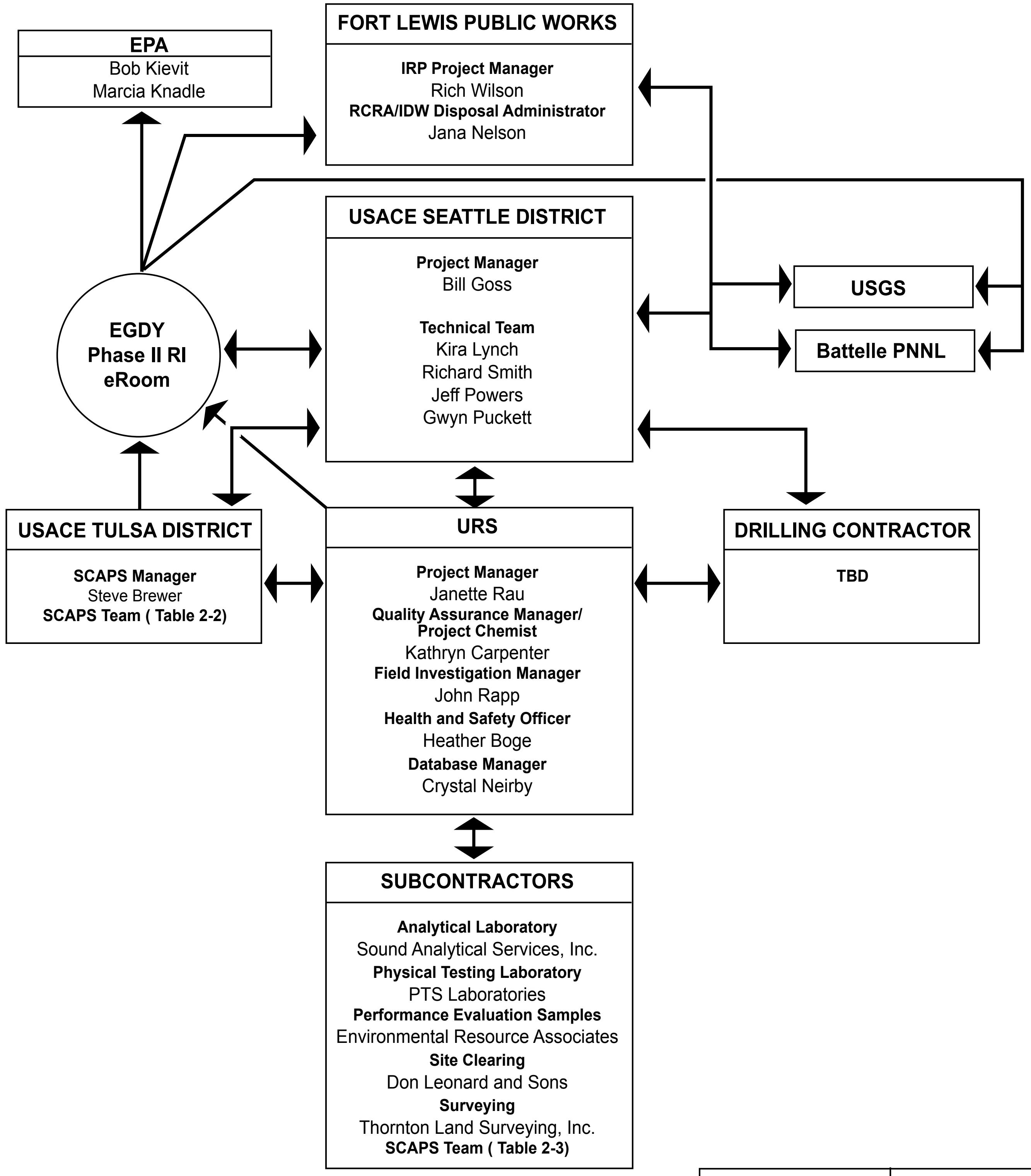
Fixed laboratory data will be transferred from the project laboratories to the URS Project Manager or Project Chemist in hardcopy and electronic formats. The VOCs, SVOCs, and TPH data produced by Sound Analytical Services, Inc., on quick turnaround will be emailed to URS. Data will be loaded into the electronic database and eRoom. Hard copies of the laboratory deliverables will be used to verify the accuracy of electronic data. The original hard copies of laboratory deliverables will then be stored in the office project file.

The laboratories will maintain and follow their own detailed procedures for laboratory record keeping in order to support the validity of all analytical work. Each data package submitted will contain the laboratory's written certification that the requested analytical method was run and that all QA/QC checks were within established control limits on all samples, with exceptions noted.

8.2.3 Reporting

Information on project status and available data will be posted daily on eRoom by the technical team. These postings will include all data, including the SCAPS graphical files described in detail in the QAPP. The GMS support files and plots of site data will be made available on the project ftp site.

Results of this Phase II RI will be documented in preliminary draft, draft, and final versions in report format. The report will include a discussion of field activities, results of soil/NAPL/groundwater sampling and testing, the nature/extent/character of site contamination, stratigraphy, relationship of the chemicals of concern to the stratigraphy, and an updated CSM. Field notes, calculations, field forms, analysis results, and resultant interpretations will be included. This report will also include an analysis of the results in relation to the purpose and objectives of the investigation. A review conference will be held to discuss the report and recommendations. Formal, written responses to Fort Lewis Public Works and project team review comments will be prepared and incorporated into the final reports as necessary.



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U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE, WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

COMMUNICATION STRATEGY

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 8-1 WP

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FINAL

SAMPLING AND ANALYSIS PLAN

PHASE II REMEDIAL INVESTIGATION

East Gate Disposal Yard and Logistics Center
Fort Lewis, Washington

Prepared for

U.S. Army Corps of Engineers
Seattle District
4735 East Marginal Way South
Seattle, Washington 98134

July 11, 2001

URS

1501 Fourth Avenue, Suite 1400
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PART I

FIELD SAMPLING PLAN

TABLE OF CONTENTS

Tables

Figures

Appendices

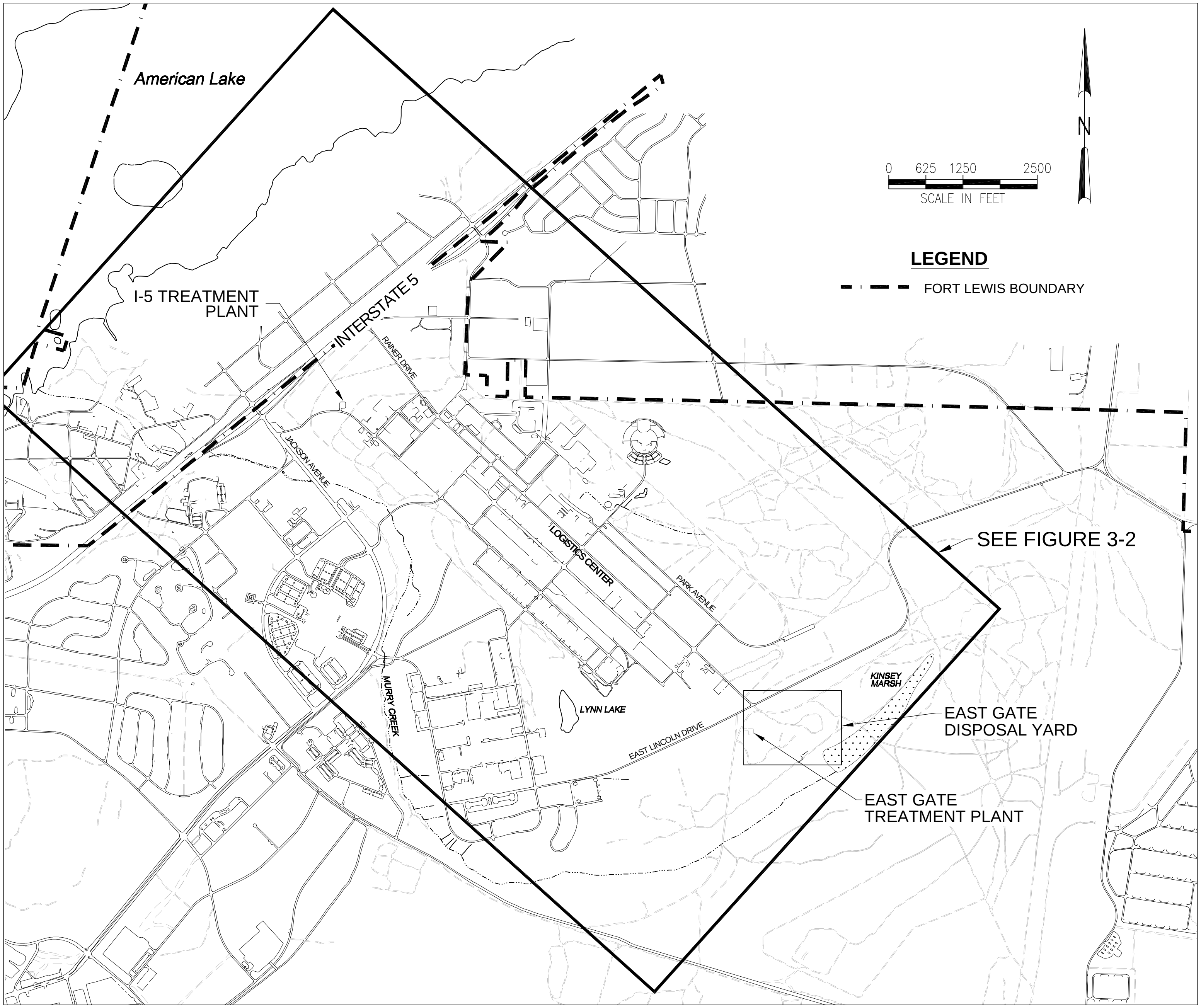
ASTM	American Society for Testing and Materials
bgs	below ground surface
CLP	Contract Laboratory Program
cm	centimeter
CPT	cone penetrometer testing
CSM	conceptual site model
DCQCR	daily chemical quality control report
DNAPL	dense nonaqueous-phase liquid
DQO	data quality objective
DSITMS	direct sampling ion trap mass spectrometer
EGDY	East Gate Disposal Yard
EPA	U.S. Environmental Protection Agency
FLUTe	Flexible Liner Underground Technologies
FSP	field sampling plan
GC/FID	gas chromatography/flame ionization detector
GC/MS	gas chromatography/mass spectroscopy
GPR	ground-penetrating radar
GPS	Global Positioning System
ITMS	ion trap mass spectrometer
LIF	laser-induced fluorescence
LNAPL	light nonaqueous-phase liquid
m/min	meter per minute
MIP	membrane interface probe
MS/MSD	matrix spike/matrix spike duplicate
NAD	North American Datum
NAPL	nonaqueous-phase liquid
NGVD	National Geodetic Vertical Datum of 1929
NTU	nephelometric turbidity unit
ORP	oxidation-reduction potential
P/C	polyvinyl chloride
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PE	performance evaluation
PID	photoionization detector
POL	petroleum, oils, and lubricants
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RPD	relative percent difference
SAP	sampling and analysis plan
SCAPS	Site Characterization and Analysis Penetrometer System

SDG	sample delivery group
SOP	standard operating procedure
SVOC	semivolatile organic compound
TAL	target analyte list
TCE	trichloroethene
TCL	target cleanup level
TOC	total organic carbon
TPH	total petroleum hydrocarbon
TPH-Dx	total petroleum hydrocarbon – diesel extended
USACE	U.S. Army Corps of Engineers
UV	ultraviolet
VOC	volatile organic compound

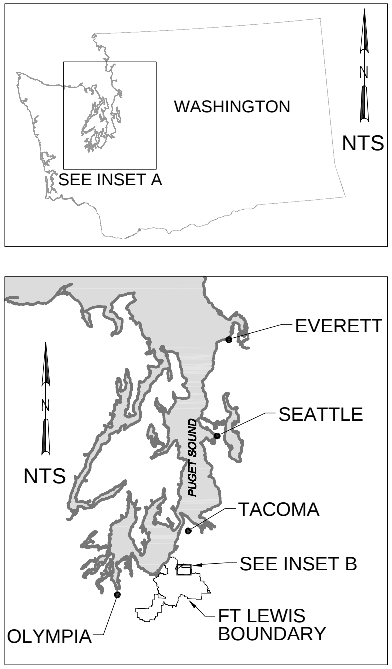
This Sampling and Analysis Plan (SAP) is an integral part of the Management Plan for the Phase II Remedial Investigation (RI) at the East Gate Disposal Yard (EGDY) (also known as Landfill No. 2) and other parts of the Fort Lewis Logistics Center. The site, located at the Fort Lewis Military Reservation in Washington State, is shown on Figure 1-1.

The SAP has two major components: Part I – the Field Sampling Plan (FSP) and Part II – the Quality Assurance Project Plan (QAPP). The FSP presents the detailed scope of work associated with field activities (e.g., sampling types, sampling locations, etc.) and specifies the procedures to be used for sampling and other field operations. The QAPP describes the analytical data quality objectives (DQOs), laboratory analytical procedures, quality assurance/quality control (QA/QC) procedures, and data quality evaluation criteria.

The purpose of the SAP is to ensure production of high quality data that meet the project objectives and requirements and accurately characterize measurement parameters. It provides the protocol for collecting samples, measuring and controlling data, and documenting field and laboratory data so that the data are technically and legally defensible.



INSET B



INSET A

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

SITE LOCATION

FT. LEWIS	PN 53F0074209	WASHINGTON
	FIGURE 1-1	FSP

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A dynamic approach has been designed for this RI to allow for an evolution of the conceptual site model (CSM) presented in the Work Plan. A tool box of sampling and analytical options will be used to collect information that will allow for modification of the investigation while in the field. This dynamic approach and availability of tools will prevent the need for future mobilizations and promote on-site decisionmaking. A summary of the investigation rationale and approach is presented in Section 6 of the Work Plan. A summary of the field program is presented on Table 2-1. Standard operating procedures (SOPs) of specific field techniques are presented in Appendix A.

The purpose of the RI field program is to collect data required for design of in situ thermal treatment remedies and evaluation of the options for optimization of the existing groundwater pump-and-treat system or placement of a reactive barrier wall. To meet this objective, the field program is designed to fill four major data gaps:

- Identification of additional potential source areas outside of EGDY
- Definition of the intermediate aquitard
- Assessment of the extent and composition of light nonaqueous-phase liquid (LNAPL) and dense nonaqueous phase liquid (DNAPL)
- Investigation of the groundwater flow direction and extent of the dissolved phase plume in the greater EGDY area

The field program may begin with exploratory excavating at additional potential source areas outside of EGDY. The next stage of field work likely would be the definition of the intermediate aquitard using the Site Characterization and Analysis Penetrometer System (SCAPS), cone penetrometer testing (CPT), and GeoVIS (a downhole camera) operated by the U.S. Army Corps of Engineers (USACE) Tulsa District SCAPS Team. If the SCAPS CPT cannot be used effectively to define the intermediate aquitard, then the option of conducting geophysical surveys might be exercised to define the site stratigraphy. Exploratory borings using a sonic drilling technique can be installed for the purpose of defining the physical properties of the intermediate aquitard and confirming results from the SCAPS CPT and/or geophysical surveys.

The characterization of the nature and extent of nonaqueous phase liquid (NAPL) may begin concurrently with the investigation of the intermediate aquitard. SCAPS tools that may be used for this portion of the RI include laser-induced fluorescence (LIF) and GeoVIS, both of which may be used concurrently with the CPT. A Flexible Liner Underground Technologies (FLUTe) ribbon sampler may be used to aid in the determination of the NAPL extent. Shallow wells can be installed using a sonic drilling technique to investigate the presence and characteristics of LNAPL and DNAPL.

Investigation of the groundwater flow direction, extent of the dissolved phase plume, and assessment of NAPL in the greater EGDY area may involve the use of SCAPS equipped with a membrane interface probe (MIP) with a direct sampling ion trap mass spectrometer (DSITMS) for analysis. The DSITMS may be used with the collection of in situ samples using the MIP, or with water samples collected using a PowerPunch™ sampler. Surface water samples may be collected from Murray Creek and analyzed using DSITMS for the purpose of assessing the interaction between the creek and the dissolved-phase plume. Deep wells (to the Kitsap Formation) may be used to collect groundwater samples and water level information. The

SCAPS direct-push technique may be used to install piezometers for the purpose of obtaining data to determine groundwater flow directions.

Selected soil, groundwater, and NAPL samples collected throughout the field program will be analyzed for chemical constituents or physical parameters at off-site laboratories.

Some initial sampling locations have been selected for each of the investigation methods based on the existing CSM presented in the Work Plan. However, the majority of the locations will be selected in the field based on continual collection of chemical and physical results. During the field program, locations involving the use of the SCAPS system will be surveyed using the Global Positioning System (GPS). After completion of the field program, every location will be surveyed using traditional survey techniques.

2.1 EXPLORATORY EXCAVATING

Based on an aerial photo review conducted by the USACE Seattle District, additional potential waste disposal areas have been identified outside EGDY (Figure 2-1). Exploratory excavations may be completed in these areas to evaluate the potential presence of buried drums, NAPL, or other possible sources of trichloroethene (TCE) in the former potential waste disposal areas. The exploratory excavation locations may be based on information obtained from the aerial photograph review and site reconnaissance. Some locations may not be investigated, and other locations may be investigated further using non-excavation methods. The shape and estimated size of each potential disposal feature are presented in Section 3 of the Work Plan. A representative from the Fort Lewis Public Works Department of Natural Resources may be present during excavation activities.

Exploratory excavations will be completed using a backhoe. Shoring or sloping of the excavation walls will not be required because field personnel will not be allowed to enter the excavations, and no structures will be endangered. All excavations will be closed and backfilled prior to the end of each shift. The exploratory excavations will be located both perpendicular and parallel to portions of the former potential waste disposal areas. Initially, the surface soils of selected locations will be removed with the backhoe bucket to look for evidence of disturbed soils. The excavation will continue in layers and will be completed to maximum depths between 5 and 10 feet below ground surface (bgs), to the base of non-native material or to the top of the water table. Excavation activities will be photographed and documented. The stratigraphy and non-native material encountered will be recorded in detailed trench logs (Appendix B).

If evidence of past disposal activities is observed, organic vapor monitoring will be performed with a photoionization detector (PID) during excavation activities. Results of the organic vapor monitoring will be used as a field screening tool and to set the level of health and safety protection required during excavation activities. The PID will be calibrated according to the manufacturer's instruction manual.

It is not necessary to place excavated material on plastic sheeting. Excavating and contaminant removal (if required) will proceed in compliance with the drum removal management plan (USACE 2000). After completion of excavation activities at each location, the excavation will be backfilled with the original material in the order that it was removed from the excavation. Excavations will be backfilled as soon as reasonably possible after excavation and sampling.

Excavations will not be left open overnight, and thus will not require safety guards or temporary fencing.

2.2 SITE PREPARATION

Site preparation will entail clearing of vegetation and construction of trails to provide access to locations for sonic and SCAPS drill rigs. The site preparation activities will be conducted by Don Leonard and Sons, Inc., of Spanaway, Washington. The trail surfaces will be constructed with 4-inch minus crushed rock. All vegetation clearing and road construction must be coordinated with Fort Lewis Public works. Due to the phased approach of this RI, more than one mobilization may required to clear additional areas.

The location of utilities in all proposed investigation areas will be marked prior to the beginning field activities. A digging permit including a utility survey must be obtained through Fort Lewis Department of Public Works prior to beginning drilling or excavation activities.

2.3 GEOPHYSICAL INVESTIGATION

If the geophysical survey option is exercised, it would consist of a combination of electrical resistivity imaging (including induced polarization) and ground penetrating radar (GPR). The intent of the GPR survey is to characterize with high definition the surface topography of the intermediate aquitard (30 to 40 feet bgs) and other less continuous shallow aquitards. The resistivity survey will provide definition of deeper stratigraphic units.

Initially, a pilot test of the geophysical techniques would be conducted at a site of limited acreage to evaluate the suitability of the geophysical techniques to provide the accuracy and level of detail required for this investigation. Initially, geophysical data would be collected on 100-foot line spacing. After review of the initial data, the survey might be changed to 50-foot line spacing. Additional acreage might be selected for additional geophysical surveys if the technique proves useful. The core technical team would select the initial site, technique, and spacing. If geophysical survey options are exercised, a geophysical survey supplement to this management plan will be completed.

2.4 SCAPS EXPLORATION

SCAPS uses surveying and mapping methods, special penetrometers with sensors for contaminant detection, and subsurface sampling equipment to map soil characteristics and contaminant distribution. The following sections describe the various applications of the SCAPS techniques that potentially will be used in this RI.

SCAPS may be used in the field investigation to define the intermediate aquitard, characterize the composition and vertical and horizontal extent of NAPL, and investigate the groundwater flow direction and extent of the dissolved-phase plume in the greater EGDY area. The proposed initial dissolved-phase volatile organic compound (VOC) and groundwater flow investigation area and initial piezometer locations are presented in Figure 2-2. The proposed initial NAPL investigation area and proposed initial SCAPS NAPL investigation locations are presented in Figure 2-3. The total number of SCAPS penetrations will be determined in the field based on results of the initial SCAPS penetrations and other information collected during the investigation. All SCAPS exploration locations will be marked with a flag or stake with the site ID number.

2.4.1 CPT/LIF/GeoVIS

One stage of the RI field program may be to characterize the subsurface stratigraphy and determine the intermediate aquitard thickness, composition, continuity, lateral extent, and physical/hydrogeologic properties. Another stage involves determining the extent of NAPL in the subsurface. These stages of data collection will be completed using SCAPS equipped with MIP/DSITMS, CPT, GeoVIS, and LIF. The CPT equipment may be used to collect geotechnical and stratigraphic data. The GeoVIS soil video imaging system may be used to map stratigraphy and the extent of NAPL. The LIF technique may be employed concurrently with the CPT to conduct subsurface in situ contaminant characterization.

The SCAPS uses a truck-mounted CPT platform to advance its chemical and geotechnical-sensing probe. The CPT platform provides a 20-ton static reaction force associated with the weight of the truck. The forward portion of the truck-mounted laboratory is the push room. It contains the rods, hydraulic rams, and associated system controllers. Underneath the SCAPS CPT push room is the steam manifold for the rod and probe decontamination system. The rear portion of the truck-mounted laboratory is the isolatable data collection room in which components of the CPT, onboard computers, and related support instruments are located.

Soil strength and type is determined by monitoring tip resistance and sleeve friction when the CPT probe is advanced through the subsurface soil. The probe can be advanced into the ground at a rate of 1 meter per minute in accordance with American Society for Testing and Materials (ASTM) Methods D3441 and D5778. The tip resistance is measured by means of a system of strain gauges that form an internal load cell as the cone tip is advanced. Friction developed along a floating cylindrical sleeve, just behind the core tip, is measured similarly as the device passes through the soil tip penetration resistance, and sleeve friction is measured independently and continuously The SCAPS instruments are capable of discriminating porous sands from tighter, finer-grade silts and clays.

The CPT sensors and sampling tools may be difficult to advance in subsurface lithologies containing cemented sands and clays, buried debris, gravel units, cobbles, boulders, and shallow bedrock.

The SCAPS LIF method provides data on the in situ distribution of petroleum hydrocarbons based on the fluorescence response induced in the polycyclic aromatic hydrocarbon (PAH) compounds that are components of petroleum hydrocarbons. PAHs in petroleum products are induced to fluorescence by excitation with ultra-violet (UV) light. The method provides a “detect/nondetect” field-screening capability relative to a detection limit derived for a specific fuel product on a site-specific soil matrix. The SCAPS LIF is primarily used as a qualitative method but can be semi-quantitative at concentrations within two orders of magnitude of its detection limit for fluorescent petroleum hydrocarbons. Measurements from the SCAPS LIF are recorded every 2 centimeters (cm).

Fluorescence emission spectra are collected once per second as the probe is advanced into the subsurface soil. An on-board computer is used to generate real-time depth plots of fluorescent intensity at the spectral peak, wavelength of spectral peak, sleeve friction and tip resistance, and soil type characteristics as interpreted from the strain gauge data. The fluorescent intensity in the spectral window is plotted as a function of depth in real time as the probe is pushed into the soil.

Because the SCAPS fluorescence intensity is generally proportional to the in situ concentration of contaminants, the LIF data can be used to identify zones of probable high concentrations of contaminants. The proportional feature of the SCAPS LIF data can be used to pinpoint the zones of highest contaminant concentration and screen the variation in concentration across the site. The SOP for SCAPS/LIF (SOP No. M-0003-SWT-03) is provided in Appendix A.

2.4.2 MIP/DSITMS

This section describes the procedures used to identify and determine the concentration of VOCs in the subsurface environment using the MIP/DSITMS system coupled with direct push techniques. Samples may be introduced into the ITMS by one of two methods described in the following paragraphs.

2.4.2.1 Membrane Interface Probe

This in situ technique allows the analyst to vertically profile a subsurface location for the presence of VOCs. The MIP/DSITMS is composed of the MIP, a metal/Teflon composite membrane that samples VOCs in situ, and the DSITMS, which identifies and quantifies the VOCs. The MIP/DSITMS is capable of multiple, discrete VOC measurements in a single penetration; sampling depths/resolution are determined on a site-specific basis.

The MIP is a permeable membrane device used to detect volatile contaminants as it is driven to depth in soil or other unconsolidated materials. A thin film membrane is impregnated into a stainless steel screen on the face of the probe. This membrane is heated to 100 to 120 degrees Celsius leading to quick diffusion of VOC contaminants across the membrane into the helium carrier gas that flushes the back of the membrane and transports the contaminants to the aboveground DSITMS.

The MIP/DSITMS technique requires no sample handling other than the collection of soil and groundwater samples necessary to meet project QA/QC objectives.

2.4.2.2 Direct Sampling/Vial Sparging

This technique requires the collection and containerization of water samples prior to analysis. This technique allows the analyst to introduce the sample by directly sparging a vial containing a water sample with helium and analyzing the effluent vapor with the SCAPS ion trap mass spectrometer (ITMS). An SOP for SCAPS MIP/DSITMS (SOP No. M-0005-SWT-01) is provided in Appendix A.

2.4.3 FLUTe Ribbon Sampler

FLUTe ribbon samplers are used with the SCAPS direct-push rig to confirm DNAPL presence relative to groundwater concentrations and refine DNAPL and LNAPL extent. A ribbon sampler is a Tyvek tube coated with a hydrophobic compound that turns color on contact with NAPL. The tube is inflated in a push hole as casing is retracted. The ribbon is removed after a certain contact time and examined for NAPL stains. Many sampling intervals have been advanced at about 30 feet per hour, including bentonite plugs every 40 feet and the associated hydration procedure. Information regarding the FLUTe ribbon sampler is provided in Appendix A.

2.4.4 SCAPS Soil and Groundwater Sampling

In conjunction with the results obtained using the CPT, LIF, MIP/DSITMS, GeoVIS, and FLUTe ribbon samplers, soil and groundwater samples will be collected to obtain more detailed contamination information and to assist in interpreting indirect measurement results. Table 2-1 provides a summary of potential sample types and analyses for SCAPS data collection. Actual numbers of penetrations and sample intervals will be determined in the field.

Groundwater samples will be collected using the SCAPS direct-push technique and a PowerPunch™ sampler. The direct sampling/vial sparging method requires the collection and containerization of water samples prior to analysis. Groundwater samples will be collected in 40-milliter certified vials (amber or clear) with Teflon liners. Samples may either be preserved (with hydrochloric acid) or unpreserved prior to analysis. Preserved samples are required to be analyzed within 14 days; unpreserved samples are required to be analyzed within 7 days.

Soil samples will be collected using the SCAPS direct-push technique and a MOSTAP sampler. The collection and containerization of soil samples for VOC analysis will follow the procedures set forth in U.S. Environmental Protection Agency (EPA) SW-846 Method 5035 (Section 2.5.2).

2.4.5 SCAPS Piezometer Installation and Water Level Measurement

Piezometers will be installed in the area presented on Figure 2-2 for the purpose of obtaining data to be used to determine groundwater elevation and flow direction. Figure 2-2 presents the initial 19 piezometer locations. Piezometer locations were selected to fill data gaps in the current monitoring well/piezometer network that is used to determine groundwater flow direction. The locations and numbers of piezometer may be changed depending on access restrictions. Piezometers will be installed using the SCAPS direct-push technique (SOP No. M-0002-SWT-04 in Appendix A). Within the NAPL investigation area, annular seals will consist of silica cement grout. Outside of this area, they can consist of high-solids bentonite grout.

Water level measurements will be collected after the piezometers have been allowed to stabilize for 48 hours. Measurements will be collected after the piezometer cap has been removed and the well has stabilized for a minimum of 5 minutes. Water levels will be measured using an electronic water level indicator. All meters will be properly decontaminated between each piezometer location. The water level will be measured to the nearest 0.01 foot with respect to the established measuring point (notch) on the piezometer. The measurement will be checked against previous water level data if available, and where an anomalous reading is indicated, remeasurement will occur. All measurements will be recorded in a field book with indelible ink and will include the piezometer number, date, time, measuring device (serial number), and field technician initials. The depth of the piezometer will be measured and compared to the installation depth to determine if the well is accumulating fine-grained material.

Water levels in the piezometers and all existing monitoring wells in the greater EGDY area will be measured within a 24-hour period at least once during this RI. A list of these wells/piezometers is presented in Table 2-2.

2.4.6 Exploration Hole Abandonment

After collection of samples and measurements is complete, each SCAPS exploration hole will be abandoned. The holes will be grouted to prevent vertical cross contamination within the hole. In the NAPL investigation area, silica cement grout will be pumped into the hole as rods are retrieved. Outside of the NAPL investigation area, the holes will be filled with high-solids bentonite grout. Following extraction of the rods, additional grout will be added to bring the grout level to ground surface. Exploration holes will be marked with a flag or stake with the site ID number.

2.5 SOIL BORING AND MONITORING WELL INSTALLATION

Soil borings will be completed and monitoring wells installed using a sonic drilling technique to provide the following:

- Control for geophysics, if necessary
- Retrieval of samples of aquitard material for visual identification and physical property testing for characterization of thickness and continuity of the intermediate aquitard.
- Assessment and collection of LNAPL and DNAPL for chemical and physical property testing
- Collection of groundwater samples to determine the nature of the upper aquifer below the intermediate aquitard
- Retrieval of soil samples to determine the presence and nature of the Kitsap aquitard below EGDY

The potential analyses and tests to be conducted on samples are presented in Table 2-1. The SOPs used to drill soil borings, collect subsurface soil samples, install and develop monitoring wells, and abandon the borings, if necessary, are presented in Appendix A. During drilling, care will be taken to ensure that cross-contamination between stratigraphic layers will not occur.

2.5.1 Soil Borings and Monitoring Well Locations and Depths

The placement of the borings and monitoring wells may be based on the results of the SCAPS and other analyses, and any results obtained from the initial four DNAPL monitoring wells. It is expected that the borings may be completed in areas of significant NAPL contamination, but with different contamination signatures, if possible, and where representative stratigraphic data can be collected.

Initially, four shallow monitoring wells may be installed to the top of the intermediate aquitard (between 30 and 40 feet bgs) (Figure 2-3). These shallow monitoring wells may be used to determine whether DNAPL is pooled above the intermediate aquitard. The horizontal extent of DNAPL above the intermediate aquitard is presumed to be limited to four areas within the study area (Figure 2-3).

Eleven deep monitoring wells may be installed to the top of the Kitsap Formation (100 and 110 feet bgs) to sample and measure the dissolved-phase contamination in the aquifer between the intermediate and Kitsap aquitards. These deep wells may be completed as multiport wells to allow sampling from multiple levels. Water levels from these deep wells may also be used to determine the groundwater gradient in the aquifer between the intermediate aquitard and the Kitsap aquitard. During drilling, these borings also can be used for retrieval of intermediate aquitard material for visual identification and measurement of physical properties.

Four shallow, 2-inch-diameter wells may be installed and screened across the water table to measure LNAPL thickness and allow for the installation of passive hydrocarbon skimmers for LNAPL collection.

Locations of soil borings not completed as wells will be marked with a flag or stake with the site ID number.

2.5.2 Soil Boring Sampling

Soil borings will be logged by a qualified field geologist during drilling to identify and record formation stratigraphy. The log for each sample will include depth, estimated density based on penetration rate, color, soil type, and qualitative moisture content. The logs will be recorded on a 1 inch equals 1 foot scale. Soil will be classified according to ASTM D2488-90, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) (ASTM 1990). In addition, any unusual features such as odor, unusual solid constituents, and the presence of NAPL will be noted on the soil boring log. Visual monitoring and field screening with a PID will be used to evaluate the presence of TCE and other potential contaminants in the soil. The observations and results of the field screening will be recorded on the boring log (Appendix B). High resolution digital photos will be taken of each sample and named with the location number and depth interval represented.

Soil samples will be visually examined for the presence of NAPL. The following descriptions of NAPL will be documented on the boring logs (Appendix B) for each soil boring and SCAPS penetration location:

- *No visible evidence* – No visible evidence of oil on soil sample
- *Sheen* – Sheen as described by the sheen testing methodology presented below
- *Staining* – Visible brown or black staining on soil. Can be visible as mottling or in bands. Typically associated with fine-grained soils.
- *Coating* – Visible brown or black oil coating soil grains. Typically associated with coarse-grained soils.
- *Oil Wetted* – Visible brown or black oil wetting the soil sample. Oil appears as a liquid and is not held by soil grains. Soils oozing petroleum typically contain approximately 2 to 3 percent petroleum.

Sheen screening is a sensitive method that can be effective in detecting petroleum-based products in concentrations lower than regulatory cleanup guidelines. Water sheen testing involves placing soil in water and observing the water surface for signs of a sheen. Sheens are classified as follows:

- *No Sheen (NS)* – No visible sheen on water surface

- *Slight Sheen (SS)* – Light colorless film; spotty to globular; spread is irregular, not rapid; areas of no sheen remain; film dissipates rapidly
- *Moderate Sheen (MS)* – Light to heavy film, may have some color or iridescence, globular to stringy, spread is irregular to flowing; few remaining areas of no sheen on water surface
- *Heavy Sheen (HS)* – Heavy colorful film with iridescence; stringy, spread is rapid; sheen flows off the sample; most of water surface may be covered with sheen

After logging each sample, soil will be collected for analysis at selected locations. Sampling personnel will don clean nitrile gloves prior to collecting a sample. Samples will be placed into chilled coolers immediately. Intact soil samples will be collected using either a solid-tube or split-tube core barrel. This intact material will be used for physical testing.

To minimize volatilization during chemical sample collection and handling, soil for VOC analysis will be preserved in the field using EPA SW-846 Method 5035. Soil samples collected for VOC analysis will be collected as follows:

- Using a sampling syringe, collect approximately 5 grams of soil and place it into a laboratory-supplied jar containing methanol. The jar has been pre-weighed and pre-labeled by the analytical laboratory.
- After the soil and methanol have been added, wipe the lid and jar threads, if necessary, to ensure that the lid fits securely on the jar. Any material on the threads may allow methanol to leak out, thus compromising the sample integrity. Note on the sample custody form if any methanol spillage occurred.
- Fill one 2-ounce jar with the soil to provide additional sample material for percent moisture determination if no other testing by the fixed laboratory is required. Methanol is not added to this sample.

After VOC samples have been collected, a sufficient volume of material will be transferred from the soil samples to a decontaminated, large stainless steel bowl. This material will be used for the remaining chemical analyses. Large grains of gravel and pieces of debris will be removed from the soil. Any unusual pieces removed will be noted in the logbook or boring log form. The sample material will then be thoroughly homogenized by stirring with a decontaminated stainless steel spoon. Sample containers will be completely filled to minimize headspace in the container. The type and number of jars required for the samples are discussed in Section 3.

2.5.3 Groundwater Monitoring Well Installation and Development

Monitoring wells may be installed in the 19 soil borings. The designation of the soil borings/monitoring wells will be determined by the USACE, and may fit with the existing numbering system at Fort Lewis. SOPs that discuss monitoring well installation, development, purging, and sampling methods are presented in Appendix A. The monitoring wells will be constructed in accordance with Washington State Department of Ecology minimum standards for construction and maintenance of wells (WAC 173-360) and EM 1110-1-4000, *Monitor Well*

Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites (USACE 1998a). The most current version of the Washington State document, at the time of installation, will take precedence over all other well drilling and construction practices discussed elsewhere in this document. Well installation will be performed by a licensed drilling subcontractor whose employees are qualified to work at hazardous waste sites. All drilling, well installation, development and testing, and sampling operations will be supervised or performed by a qualified scientist or engineer. The drilling contractor will be responsible for obtaining and submitting all well drilling permits and logs, as required by the State of Washington. The drilling company will be contracted directly to the USACE.

Following installation, the 11 multiport monitoring wells installed to the top of the Kitsap Formation will be developed using the procedure described in Appendix A. Development will cease if NAPL is encountered to prevent loss of NAPL for sampling or to prevent production of a large volume of highly contaminated water. All other borings completed as monitoring wells will be used to monitor and/or sample NAPL and will not be developed.

2.5.4 Groundwater Monitoring Well Sampling

The objective of the groundwater sampling is to determine the extent of the dissolved-phase plume in the upper aquifer in the greater EGDY area. The monitoring wells may also be used to attempt to obtain NAPL samples. Deep wells below the intermediate aquitard will be constructed as multiport monitoring systems in a single boring to allow for sampling from multiple levels. Deep wells will also be used to determine the groundwater gradient in the aquifer between the intermediate aquitard and the Kitsap aquitard.

Approximately 44 groundwater samples will be collected from the 11 multiport monitoring wells (4 samples per well). A low-flow, minimal drawdown technique will be used for groundwater purging and sampling according to the USACE standard operating procedure (Appendix A). A WaTerra hand pump will be used to purge and sample the groundwater. The intake of the check valve at the base of the tubing will be positioned at a level that is adjacent to or slightly above the midpoint of the screened interval. Purging shall proceed by pumping (low-flow) the calculated casing volume to ensure a volume in excess of this volume has been removed. This will ensure that formation water is sampled and not well casing water.

Specific conductance, temperature, pH, dissolved oxygen, turbidity, and oxidation-reduction potential (ORP) will be measured during purging using a water quality meter with a flow-through cell, or an equivalent meter. Measurements will be collected at intervals of approximately 2 to 5 minutes. When readings stabilize, purging will cease and samples will be collected. The stabilization guidelines are three successive readings within +/- 0.1 for pH, +/- 3 percent for conductance, +/- 10 percent for temperature, turbidity, and dissolved oxygen, and +/- 10 mV for ORP. A turbidity reading of 10 nephelometric turbidity units (NTUs) or less is desirable. The information will be documented on a groundwater sampling data sheet (Appendix B). If the indicator parameters do not stabilize, purging will cease at the discretion of the USACE on-site representative and samples will be collected.

Before collecting samples, personnel will don clean nitrile gloves. The pumping rate for collecting the samples will be at the rate established during low-flow purging. Samples will be collected directly from the end of the pump discharge line and placed immediately into a chilled cooler.

2.5.5 NAPL Sampling

The objective of the NAPL sampling is to determine the horizontal and vertical DNAPL extent, the horizontal LNAPL extent, and the physical and chemical properties of DNAPL and LNAPL.

Prior to sampling, the depth and thickness of LNAPL and DNAPL will be determined using an interface probe. A disposable bailer will be used to further check for the presence of NAPL if none is detected with the interface probe. Wells with appreciable LNAPL will be sampled with a weighted, disposable bailer. If a minimal thickness of LNAPL is present in the well, a passive hydrocarbon skimmer will be used to collect it. DNAPL will be sampled with a weighted, disposable bailer. If sample volume permits, NAPL samples will be archived at the project laboratory for possible future analysis.

2.5.6 Laboratory Program

Soil, groundwater, and NAPL samples and associated QA/QC samples collected for chemical analysis and physical testing will be analyzed using the methods presented in Tables 2-3 through 2-5 and discussed in the QAPP. Laboratory chemical analysis will be conducted by Sound Analytical Services, Inc. Physical testing will be conducted by PTS Laboratories, Inc.

2.5.7 Documentation

Records of drilling operations and related activities will be documented by the overseeing geologist and by the drilling subcontractor. These records will consist of the soil boring log (Appendix B) and information recorded in the project field notebook. Copies of these records will be maintained at the drill site while drilling is in progress, and will be provided with the final report. Boring logs will be drafted electronically using gINT® software format (1-inch equals 1-foot scale) in the field and placed on the project Website at the completion of each boring. Sonic drill cores will be digitally photographed in 5-foot increments and cross-referenced in the field notebook. Each photo will be named with the location ID and the depth interval represented.

The soil boring log will include descriptions of soil encountered, total depth of the boring, diameter of the hole, formation contacts, occurrence of first water, sampling depths, water level measurements, amount of sealing material used for abandonment, and any other information deemed appropriate by field personnel. Descriptions of soil will be according to ASTM D 2488-90, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)* (ASTM 1990).

A field drilling report will be prepared and maintained by the drilling contractor on a daily basis. The report will specify the number of hours worked, materials used, unusual problems, and other special comments and observations. A copy of this report will be approved by and provided to USACE staff at the end of each day.

2.6 SURFACE WATER SAMPLING

Surface water samples will be collected from Murray Creek and analyzed for VOCs using DSITMS to assess the interaction between the creek and the groundwater contaminant plume. Surface water quality measurements of specific conductance, temperature, pH, dissolved oxygen, turbidity, and

ORP will be measured using a water quality meter with a flow-through cell, or an equivalent meter. Surface water quality measurements will be recorded at the time of sampling.

The surface water samples will be collected from as close as possible to the bottom of the central channel of the creek. The samples are collected by placing the tip of a disposable glass burette near the bottom of the central portion of the creek. The upper end of the burette is covered by the sampling technician's thumb. The technician then slowly removes his thumb to allow water to rise within the burette. The top of the burette is then covered by the technician's thumb and the burette removed from the water. The sample containers are then gently filled directly from the burette.

2.7 SURVEYING

GPS with an accuracy of approximately 10 feet will determine the approximate horizontal and vertical coordinates of investigation locations during the field investigation. All investigation data collection locations will be marked for relocation by traditional surveying. Upon completion of the field work, all data collection locations created during the investigation (e.g., wells, borings, and SCAPS push locations) will be surveyed. Horizontal and ground surface elevation coordinates will be surveyed by a licensed surveyor in the State of Washington. Horizontal and ground surface elevation coordinates will be provided for all data collection locations and reported in NAD27 (horizontal) and NGVD29 (vertical). For all wells and piezometers, the elevation of the top of the polyvinyl chloride (PVC) well riser and the top of the steel protective casing will also be measured. All survey measurements will be made to the nearest 0.05 foot. GPS measurements will be collected by the SCAPS team. Traditional surveying will be conducted by Thornton Land Surveying, Inc., Gig Harbor, Washington.

2.8 DECONTAMINATION OF DRILLING AND SAMPLING EQUIPMENT

Equipment used during the field investigation and sampling activities will be decontaminated before use at the site and between sampling locations to prevent cross-contamination. The field activities in which decontamination procedures will be followed include drilling, monitoring well installation, and all associated sampling activities. The specific procedures for decontamination are outlined in this section.

SCAPS decontamination occurs as rods are retracted from the penetration hole and water is collected in a bucket.

Downhole drilling and sampling equipment will be decontaminated before field personnel enter and leave the EGDY study area and between sampling locations. Downhole equipment (e.g., drilling casing, drilling rods, soil samplers) and other equipment in direct contact with the sampled materials, soil cuttings, and fluids will be cleaned between borings or other sampling locations.

Decontamination of large drilling equipment is required to prevent cross-contamination of sampling locations, especially those in which groundwater monitoring wells will be established, or from which soil samples will be retrieved for chemical analysis. This process also provides for the protection of personnel subsequent to demobilization from restricted areas. During decontamination of drilling equipment and accessories, it is especially critical to clean the inside of casing, drill rods, drill bits, and all couplings and threads. Prior to leaving the facility, the drill rig will be decontaminated. Decontamination water will be allowed to drain onto the ground surface at a location chosen by the USACE. The drilling tools will be cleaned by a high-pressure hot water wash until all visible soil and other debris have been removed.

Before installation, all sections of well screen and riser will be rinsed with a high pressure hot water washer, using potable water. If the well casings are obtained pre-cleaned by the manufacturer in factory-sealed containers, high pressure hot water washing is not required.

Sampling equipment includes all non-disposable sampling devices that are used to collect or contain a sample prior to placement into a laboratory-provided sample container. Such equipment may include split spoons, stainless steel spoons and bowls, and stainless steel cable. Disposable equipment may include bailers and tubing. Before initial use, all sampling equipment that may contribute to the contamination of a sample must be thoroughly decontaminated, unless specific documentation exists to show that the sampling equipment has already been decontaminated. Pre-cleaned equipment in factory-sealed containers does not require decontamination.

The remaining sampling equipment will be decontaminated between sample locations according to the following procedure:

- Scrub equipment thoroughly with phosphate-free detergent and warm potable water and use a brush to remove any particulate matter or surface film
- Triple rinse and/or flush with clean potable water
- Rinse and/or flush with clean deionized water
- Package and seal equipment in plastic bags or other appropriate containers to prevent recontamination

Small nondisposable sampling equipment that comes in contact with NAPL will be decontaminated as described previously, followed by a solvent rinse with isopropyl alcohol and hexane.

Decontamination wash water generated from this procedure will be contained temporarily in the buckets used for this process. The disposal of decontamination wash water and other waste material is described in the following section.

2.9 INVESTIGATION-DERIVED WASTE

Water generated during drilling, development, and sampling will be temporarily containerized in a Baker tank then disposed of in the installation's sanitary sewer system. Decontamination wash water will be allowed to drain onto the ground surface. If any laboratory waste is generated, it will be contained in a lab pack then disposed of at an off-site Resource Conservation and Recovery Act (RCRA) facility. Soil generated during drilling and exploration will be stored in a covered stockpile at EGDY. At the conclusion of the investigation, the soil will be buried in one of the existing trenches that is slated for follow-on thermal treatment. Personal protective equipment (PPE) will be disposed of in a conventional dumpster to be disposed of off-site in a non-RCRA landfill. Necessary coordination with Fort Lewis Public Works will be done by the USACE site representative. All facilities used for solid waste and RCRA waste will be in compliance with the CERCLA Off-Site Disposal Rule. The Generator EPA ID number for this site is WA9214053465.

2.10 FIELD QUALITY CONTROL SAMPLES

Field QC samples will be collected and analyzed to evaluate data quality. QC samples are controlled samples introduced into the analysis stream whose results are used to review data quality and to calculate the accuracy and precision of the chemical analysis program. The purpose of each type of field QC sample, collection and analysis frequency, evaluation criteria, and methods of collection are described in this section.

Field QC checks are accomplished through the analysis of controlled samples that are introduced to the laboratory from the field. Rinsate and field blanks, field duplicates, matrix spike/matrix spike duplicates (MS/MSDs), and performance evaluation (PE) samples will be collected and submitted to both SCAPS and Sound Analytical Services, Inc., where applicable, to provide a means of assessing the quality of data resulting from the field sampling program. All field ITMS and LIF QC samples will be sent to an off-site lab to assist with controlling uncertainty in data and interpreting results.

2.10.1 Rinsate and Field Duplicates

Rinsate blanks are collected to determine the potential for cross-contamination of samples during collection. Rinsate blanks will be collected and analyzed at the rate of 5 percent if using non-dedicated sampling equipment. If dedicated or disposable sampling equipment is used, field blanks will be collected instead. Rinsate and field blanks will be submitted to the fixed laboratory. Rinsate blanks will consist of store-bought distilled water collected from the final rinse of sampling equipment after decontamination. Field blanks will consist of store-bought distilled water transferred directly into sample containers in the field.

The rinsate soil blank will be collected from the stainless steel bowls that will be used to collect soil samples prior to placing them in sample containers. After the decontamination is complete, the bowl will be rinsed with approximately 2 gallons of distilled water, then pre-labeled sample containers will be filled.

All rinsate or field blanks will be submitted blind to the laboratory, with sample numbers that are indistinguishable from primary samples. Quality control criteria and corrective actions are the same as for method blanks (as described in the QAPP). Blank samples will be analyzed for the same parameters as the associated field samples.

2.10.2 Field Duplicates

Field duplicate samples will be used to check for sampling reproducibility. Field duplicates will be submitted at a frequency of 10 percent of the field samples for every analytical method. Field duplicate samples are collected in conjunction with and by the same methods as the primary sample. Field duplicate samples will be submitted from locations having significant concentrations of target analytes. Control limits for field duplicate precision are 30 percent relative percent difference (RPD) for aqueous samples and 50 percent RPD for soil and NAPL samples.

Field duplicates samples will be submitted blind to the laboratories, with sample numbers that are indistinguishable from primary samples. Quality control criteria for field duplicates and calculation and reporting of the RPD are described in the QAPP.

2.10.3 Matrix Spike/Matrix Spike Duplicates

MS/MSDs are used to assess sample matrix interferences and analytical errors, as well as to measure the accuracy and precision of applicable analytical methods. The MS/MSDs will be collected and analyzed at a rate of 5 percent of the field samples for each applicable analytical method or at least one for each analytical batch, whichever frequency is greater. Known concentrations of analytes are added to environmental samples; the MS or MSD is then processed through the entire analytical procedure and the recovery of the analytes calculated. Results are expressed as percent recovery of the known spiked amount (and RPD for MS/MSD pairs).

Field duplicate and MS/MSD samples will be collected from different locations. Additionally, MS/MSD samples should not be collected from locations with potentially high concentrations of target analytes that may mask the added MS/MSD compounds. Because of the high concentrations of target analytes, MS/MSD samples will not be submitted with NAPL samples.

2.10.4 Performance Evaluation Samples

PE samples will be submitted to the laboratories to evaluate the accuracy of the analyses; PE samples will be submitted blind for chemical analysis. Five to 10 water VOC PE samples will be submitted to Sound Analytical Services, Inc., for VOC analysis. PE samples will also be submitted to SCAPS lab for analysis by ITMS. The PE samples will be spiked by the commercial supplier with the site COCs at concentrations consistent with those previously observed in groundwater at the site. The PE sample results will immediately be compared to the vendor’s documented acceptable control limits by a USACE representative. Sample analysis will not continue until the laboratory has met certified PE sample acceptance limits and approval has been obtained from the USACE. The PE supplier will fill pre-cleaned sample bottles with the PE material. Fictitious sample identification numbers will be assigned in the field as described in Section 3.2.

2.10.5 Temperature Blanks

One temperature blank will be prepared and submitted to the fixed laboratory with each cooler. The temperature blank will consist of a sample jar containing water, which will be packed in the cooler in the same manner as the rest of the samples. The temperature blank is to be used to measure the cooler temperature upon receipt of the cooler at the laboratory.

Table 2-1
SUMMARY OF POTENTIAL FIELD PROGRAM

FIELD TECHNIQUES	LABORATORY	SOIL COLUMN	SOIL	GROUND-WATER	SURFACE WATER	NAPL
SCAPS CPT with LIF						
TPH by fluorescence	SCAPS	X				X
Stratigraphy	SCAPS	X				
Permeability	PTS Laboratories, Inc./SCAPS		X			
SCAPS MIP						
VOCs	SCAPS	X		X	X	X
SCAPS DSITMS						
VOCs	SCAPS	X		X	X	X
SCAPS GeoVIS						
Stratigraphy	PTS Laboratories, Inc.	X				
NAPL extent	None					X
FLUTe Ribbon Sampler						
NAPL extent	None					X
SCAPS Piezometer Installation						
Water level measurements	None			X		
Soil Borings						
Grain size	PTS Laboratories, Inc.		X			
Bulk density	PTS Laboratories, Inc.		X			
Effective porosity	PTS Laboratories, Inc.		X			
Cation exchange capacity	PTS Laboratories, Inc.		X			
Total organic carbon	PTS Laboratories, Inc.		X			
TPH-Dx	Sound Analytical Services, Inc.		X			
VOCs	Sound Analytical Services, Inc.		X			
SVOCs	Sound Analytical Services, Inc.		X			
NAPL Sampling (LNAPL and DNAPL Monitoring Wells)						
TPH-Dx	Sound Analytical Services, Inc.					X
VOCs	Sound Analytical Services, Inc.					X
SVOCs	Sound Analytical Services, Inc.					X
Viscosity/density	PTS Laboratories, Inc.					X
Oil/water interfacial tension	PTS Laboratories, Inc.					X
Boiling point distribution	PTS Laboratories, Inc.					X
Groundwater Sampling (Multiport Monitoring Wells)						
VOCs	Sound Analytical Services, Inc./ITMS			X		
Water level measurements	None			X		
Field measurements (specific conductance, pH, temperature, ORP, dissolved oxygen, and turbidity)	None			X		
Visual Logging of Cores						
NAPL extent	None					X
Stratigraphy	None	X				

Table 2-2
EXISTING MONITORING WELLS AND PIEZOMETERS IN THE GREATER EGDY AREA

WELL ID	NORTHING STATE PLANE (NAD27)	EASTING STATE PLANE (NAD27)	MEASURING POINT STATE PLANE (NGVD29)
A15	651902.165	1497340.226	278.90
A30	651895.904	1497330.587	279.00
A45	651905.628	1497334.590	278.83
B15	651937.026	1497276.482	280.88
C25	651964.785	1497229.546	279.94
C40	651964.603	1497235.287	279.89
FL-01	651256.513	1494019.450	
FL-01	651256.513	1494019.450	278.24
FL-02	651333.983	1495617.278	
FL-02	651333.983	1495617.278	282.42
FL-04A	652011.255	1493047.933	
FL-04A	652011.255	1493047.933	279.19
FL-04B	651984.254	1492994.643	
FL-04B	651984.254	1492994.643	279.64
LC-017	653475.125	1494544.937	291.14
LC-018	653004.459	1494114.614	283.71
LC-019A	653095.046	1495139.513	290.52
LC-019B	653093.530	1495135.565	290.60
LC-019C	653098.392	1495137.567	290.33
LC-020	653851.583	1495822.106	290.72
LC-021	652756.393	1496445.893	280.27
LC-024	652818.998	1497576.415	286.50
LC-026	651895.107	1497562.466	276.89
LC-026	651895.107	1497562.466	277.20
LC-026	651895.107	1497562.466	277.00
LC-026D	651916.377	1497564.783	277.78
LC-026D	651916.377	1497564.783	278.00
LC-026D	651916.377	1497564.783	277.00
LC-027	651870.479	1496425.147	279.20
LC-048	653197.871	1495468.881	290.08
LC-050A	652191.249	1495526.802	272.59
LC-050D	652149.574	1495546.617	272.80
LC-051	651777.998	1495356.476	274.07
LC-052	650532.202	1496018.168	
LC-053	651926.976	1494335.902	277.14
LC-055D sh	653766.222	1497114.162	291.12
LC-055E de	653766.222	1497114.162	291.14
LC-056	652739.507	1497236.090	287.19
LC-057	650863.972	1496169.283	285.59
LC-064A	652433.380	1496587.707	278.10
LC-064B	652423.773	1496580.014	277.81
LC-108	652635.249	1496486.580	281.20
LC-133	652243.964	1496451.784	281.78
LC-134	652374.945	1496669.994	277.72
LC-135	652622.666	1496727.731	282.32

Table 2-2 (Continued)

EXISTING MONITORING WELLS AND PIEZOMETERS IN THE GREATER EGDY AREA

WELL ID	NORTHING STATE PLANE (NAD27)	EASTING STATE PLANE (NAD27)	MEASURING POINT STATE PLANE (NGVD29)
LC-136A	652475.363	1496351.390	279.60
LC-136B	652485.086	1496355.393	279.21
LC-137A	652684.757	1496168.412	291.46
LC-137B	652690.953	1496180.101	291.26
LC-137C	652698.795	1496191.637	291.48
LC-138	652383.610	1496552.265	279.49
LC-139	652479.863	1496623.251	278.25
LC-144A	653031.195	1495392.375	292.00
LC-145	651831.014	1497305.951	281.72
LC-146	651898.357	1497408.445	279.56
LC-146	651898.357	1497408.445	279.57
LC-147	651962.901	1497495.663	279.63
LC-147	651962.901	1497495.663	279.60
LC-148	652045.527	1497478.791	281.76
LC-148	652045.527	1497478.791	281.73
LC-149A	651051.484	1498329.690	307.67
LC-150	652558.545	1496627.186	280.78
LC-153	652513.590	1496646.897	
LC-155	652401.398	1496509.116	279.05
LC-156	652355.838	1496547.894	278.77
LC-158	652493.337	1496560.880	278.09
LC-159	652493.028	1496260.420	278.13
LC-160	652435.539	1496209.546	
LC-161	652298.362	1497065.288	282.62
LC-161	652298.362	1497065.288	283.48
LC-161	652298.362	1497065.288	282.62
LC-162	652338.664	1496881.865	279.43
LC-162	652338.664	1496881.865	280.40
LC-162	652338.664	1496881.865	279.43
MW-1	651427.096	1494007.292	278.13
MW-2	651483.459	1493864.746	278.76
MW-3	651473.305	1493882.832	279.14
PZ-01D	651976.496	1497189.006	279.35
PZ-01D	651976.496	1497189.006	279.44
PZ-01S	651976.418	1497188.963	279.46
PZ-02D	651985.764	1497142.759	279.45
PZ-02S	651985.621	1497142.618	279.53
PZ-03D	652031.059	1497117.550	279.40
PZ-03S	652031.222	1497117.248	279.56
PZ-04	652062.523	1497079.728	279.76
PZ-05	652067.797	1497107.465	279.73
PZ-06D	652055.749	1497165.003	280.18
PZ-06S	652055.849	1497164.770	280.27

Table 2-2 (Continued)

EXISTING MONITORING WELLS AND PIEZOMETERS IN THE GREATER EGDY AREA

WELL ID	NORTHING STATE PLANE (NAD27)	EASTING STATE PLANE (NAD27)	MEASURING POINT STATE PLANE (NGVD29)
S-1	651980.265	1497212.557	279.65
S-2	652354.916	1496860.314	
ST-1	652222.625	1497594.262	
ST-10	652107.621	1496248.775	
ST-2	650645.826	1495287.297	
ST-3	652072.523	1496817.770	
ST-4	652425.019	1496218.873	
ST-5	652274.224	1497277.964	
ST-6	652118.825	1497307.665	
ST-7	651947.225	1497002.869	
ST-8	651839.325	1497016.770	
ST-9	651968.925	1497179.668	

Table 2-3

SAMPLING AND ANALYSIS SUMMARY—SOIL

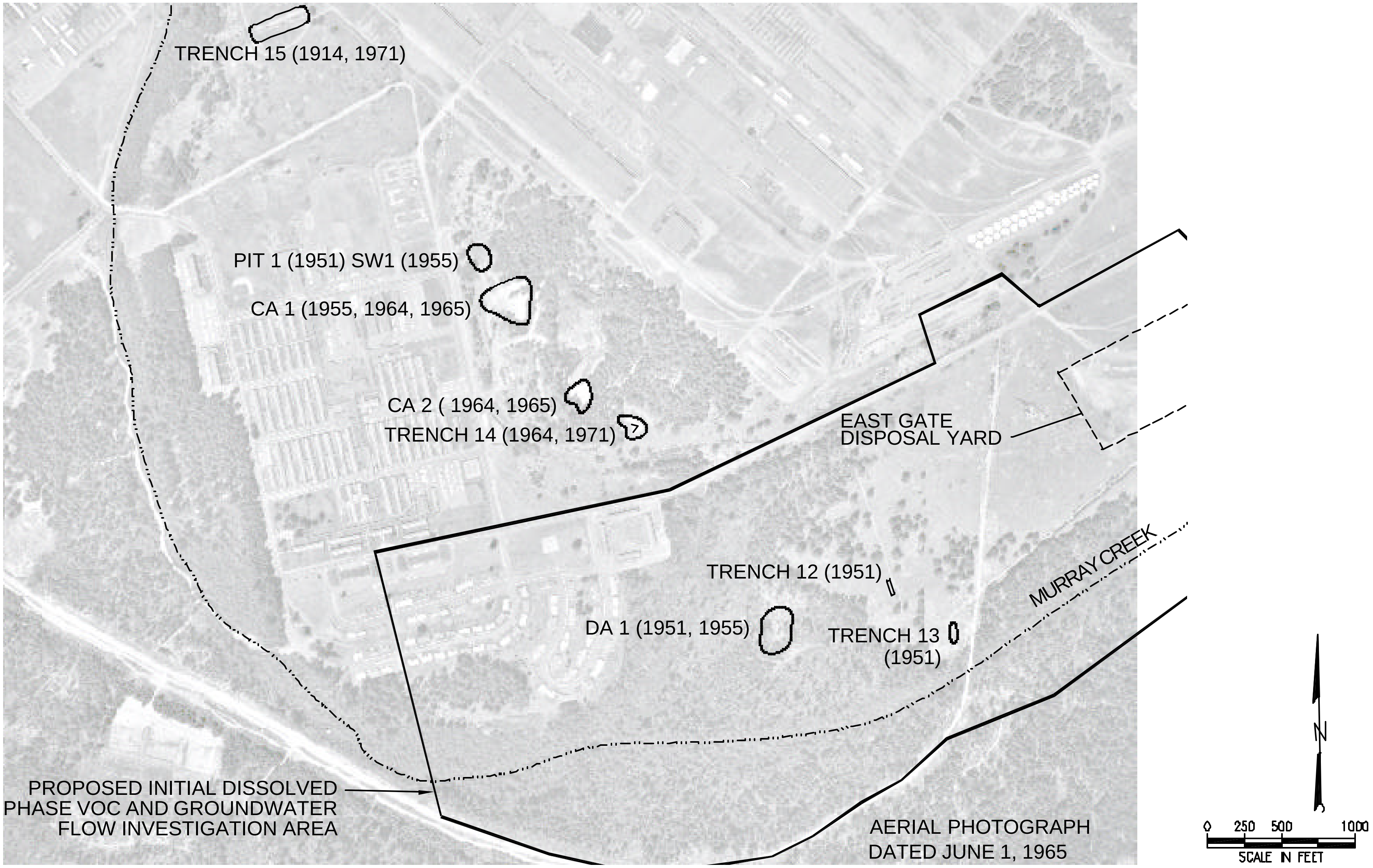
METHOD	METHOD REFERENCE
SCAPS Soil Sampling	
TPH by fluorescence	SCAPS SOP
VOCs by ITMS	SW-846 8265 5035 (SCAPS SOP)
Soil Borings	
SVOCs	SW-846 8270C
VOCs	SW-846 8260B/5035
TPH-Dx	NWTPH-Dx
Grain size	ASTM D 422/D4464
Permeability	ASTM D5084
Density	ASTM D2937
Porosity	PTS SOP (API RP40)
Cation exchange capacity	SW-846 9081
Total organic carbons	SW-846 9060

Table 2-4
SAMPLING AND ANALYSIS SUMMARY—NAPL

METHOD	METHOD REFERENCE
VOCs	SW-846 8260B
SVOCs	SW-846 8270C
TPH-Dx	NWTPH-Dx
Oil/water interfacial tension	ASTM D971
Viscosity/density	ASTM D445/D1481
Boiling point distribution	ASTM D86

Table 2-5
SAMPLING AND ANALYSIS SUMMARY—GROUNDWATER

METHOD	METHOD REFERENCE
SCAPS Groundwater Sampling	
VOCs by DSITMS	SW-846 8265/5035 (SCAPS SOP)
Monitoring Well Sampling	
VOCs	SW-846 8260B/5035



AERIAL PHOTOGRAPH
DATED JUNE 1, 1965

LEGEND

⬭ PROPOSED SOURCE AREAS TO INVESTIGATE OUTSIDE OF EASTGATE DISPOSAL YARD

CA - CLEARED AREA
DA - DISTURBED AREA
SW - SOLID WASTE AREA

SOURCE: USACE 2001

URS

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SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

**ADDITIONAL POTENTIAL
SOURCE AREAS IDENTIFIED
FROM AERIAL PHOTOGRAPHS**

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 2-1 FSP

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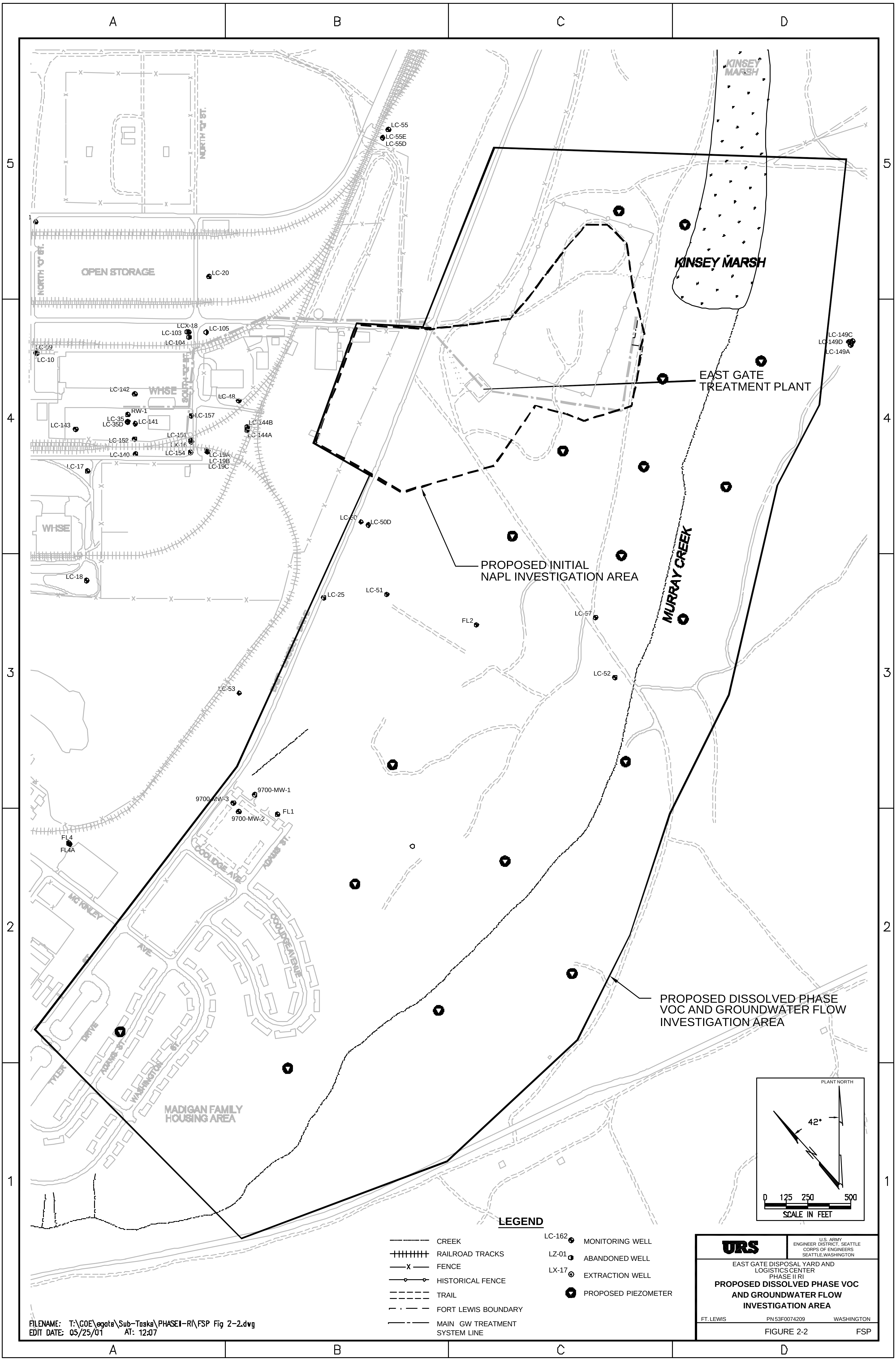

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SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

PROPOSED DISSOLVED PHASE VOC AND GROUNDWATER FLOW INVESTIGATION AREA

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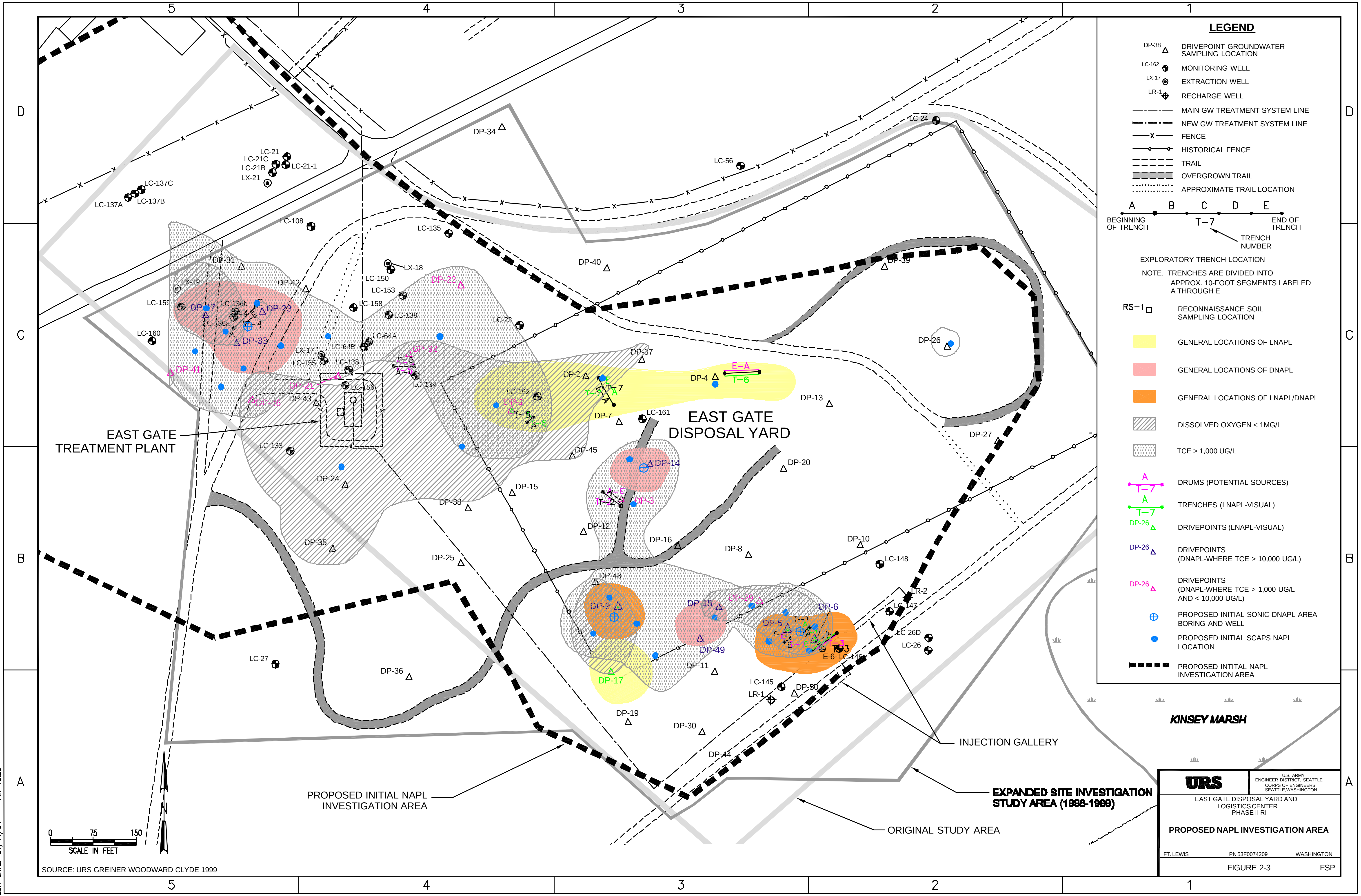
FIGURE 2-2 FSP



SOURCE: URS GREINER WOODWARD CLYDE 1999

FILENAME: T:\COE\egate\Sub-Tasks\PHASEII-RI\FSP Fig 2-3-a.dwg
EDIT DATE: 07/11/01 AT: 10:29

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EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

PROPOSED NAPL INVESTIGATION AREA

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 2-3 FSP

This section describes sample handling and documentation procedures. The procedures described are designed to provide a thorough record of events surrounding the collection of each sample, and to ensure, as far as can be accomplished in the field, that data collected are useable.

3.1 FIELD LOGBOOKS

Permanently bound field books with waterproof paper will be used as field logbooks because of their compact size, durability, and secure page binding. The pages of the logbook should be numbered consecutively and should not be removed for any reason. Entries will be made in black waterproof indelible ink.

Logbooks will document the procedures performed by field personnel. Each entry should be dated, legible, and contain accurate and complete documentation of the individual’s activities. Documentation in the field logbook will be at a level of detail sufficient to explain and reconstruct field activities without relying on recollection by the field team members. Because the logbook is a complete documentation of field procedures, it should contain only facts and observations. Language should be objective, clear, concise, and free of personal interpretation or terminology that might be misconstrued.

No erasures will be allowed. If an incorrect entry is made, the information will be crossed out with a single strike mark and the change initialed and dated by the team member making the change.

Field logbooks will be identified by the project name and a project-specific number (e.g., “Logbook #1 for Phase II RI, Fort Lewis East Gate Disposal Yard, Project Number 53F0074209”), and stored in the field project files when not in use. Field logbooks will be photocopied after the field investigation, and photocopies will be stored in the project files. After field activities are completed, logbooks will be stored in the permanent project file.

3.2 SAMPLE IDENTIFICATION AND LABELING

To provide a sample tracking mechanism, each sample collected will be given a sample identification number. The sample identification number will include the sample type, station number, and an identification of the type of sample (primary, field split, etc.). The site name will not be included in the sample identification number because this information will be recorded on the sample label and chain of custody form. Sample type, station number, and depth or date of sampling round designations are shown in Table 3-1. A sample identification number will be based on digits from each column, separated by dashes as shown in the table.

Matrix spike/matrix spike duplicate (MS/MSD) samples will not be designated in the primary sample number. The sample to be used for MS/MSD will be specified in the comments section of the chain of custody. Trip blanks will be identified with “TB-date” (month/day/year). The field duplicate, field/rinsate blank and PE samples will be identified with a fictitious station number of the primary sample.

The fictitious station numbers used to identify QC field duplicate, field/rinsate blanks, and PE samples will consist of a constant integer added to the number of the primary sample location that has been chosen as the QA station. A field duplicate sample will be designated by adding the integer 3000 to the station number from which it was collected. A field/rinsate blank sample will be designated by adding the integer 6000 to the station number from which the blank is collected. A PE sample will be designated by adding the integer 9000 to the primary station number that has been designated as the QA station. No indication that a sample is a duplicate will be provided on the sample label or chain of custody form. Cross-references for duplicate and blank sample numbers will be clearly recorded in the field book and field logs.

Example 1: At the second SCAPS location, LIF is used from a depth of 6 to 7 feet bgs. This location would designated SL0002-6-7.

Example 2: A SCAPS soil sample collected from this same location from a depth of 10.5 to 11.5 feet bgs would be labeled SS0002-10.5-11.5.

Example 3: A duplicate sample collected from SS0002-10.5-11.5 would be labeled SS3002-10.5-11.5

Example 4: A groundwater sample collected from the second port from the surface of the newly installed multiport monitoring well LC-201 on August 10, 2001, would be labeled LC0201-02-081001.

Example 5: A NAPL sample collected from the newly installed NAPL monitoring well LC-202 on August 10, 2001, would be labeled LC0202-081001.

Example 6: A field/rinsate blank sample associated with sample LC0202-081001 would be designated LC6202-081001.

Sample labels, whether blank or pre-printed, will contain an abbreviated summary of the logbook entry for the sample. The following information should be included on sample container labels:

- Project number (53F0074209)
- Sample identification number
- Date and time of sampling
- Name of sampling personnel
- Type of sample preservatives added
- Matrix
- Analyses to be performed

3.3 SAMPLE DELIVERY GROUP

Soil and groundwater samples will be sent to the analytical laboratories in sample delivery groups (SDGs). Each SDG will consist of primary samples, blind field duplicates, associated MS/MSD samples, trip blanks, and rinsate blanks.

3.4 SAMPLE PRESERVATION AND HANDLING

Soil and groundwater samples (primary as well as QA/QC) will be collected in glass or plastic containers supplied by the contract analytical laboratories and appropriate for the respective analysis. The containers will have screw-type lids to assure the bottles are adequately sealed. Teflon inserts located inside the lids of the containers will prevent sample reaction with the lid and improve the quality of the seal. Tables 3-2 through 3-4 list the specific container types, volumes, and number of containers required for each analysis.

3.4.1 Sample Containers

The containers will be precleaned and certified under chain of custody. Commercially available pre-cleaned jars are acceptable. The contract laboratory's bottle shipment documentation will record batch numbers for the bottles. With this documentation, bottles can be traced and bottle wash analyses can be reviewed. The bottle wash analyses will be retained in the project file.

3.4.2 Sample Preservation

Prior to shipping sample bottles to the field, the analytical laboratory will add the required preservatives to the sample bottles that will be used for groundwater and rinsate blanks. The laboratory will affix waterproof labels to the bottles, on which the type of analysis and the type and amount of preservative will be written.

Sample preservation procedures are used to maintain the original character of analytes during storage and shipment. Regardless of the nature of the sample, absolute stability for all constituents cannot be achieved. Preservation techniques, such as pH control and refrigeration, may retard physicochemical and biochemical changes. As a general rule, analyzing the sample as soon as possible is the best way to minimize physicochemical and biochemical changes.

All samples will be placed in the appropriate sample container and refrigerated immediately upon sample collection. Samples will be transferred to the fixed laboratory approximately every 1 to 2 days. The analytical laboratory will meet all specified holding times and should make every effort to prepare and analyze the samples immediately after they are received.

3.4.3 Storage Requirements

Samples will be placed in secure, on-site storage, or remain in the possession of the sampling personnel until they are shipped or delivered to the laboratory. Immediately after collection, and during shipment to the analytical laboratory, samples will be stored in a refrigerator in the field office, in coolers on ice or an ice-substitute at approximately 4°C. Either ice packaged in plastic storage bags or prepackaged ice-substitute will be used to maintain the temperature in the shipping containers at approximately 4°C. Ice will be replenished as needed to ensure adequate cooling of samples during storage and shipping. Samples to be archived by the project laboratory will be stored at 4°C.

3.5 SAMPLE DOCUMENTATION

Entries into the logbook or other relevant sampling forms for sampling events will include, but not necessarily be limited to, the following:

- Project name, location, and number
- Rationale for collecting the sample

- Date and time of sampling
- Sample numbers
- Cross-reference of numbers for split and blank samples
- Media sampled
- Geographical location of the sampling point in reference to site facilities
- Physical location of the sampling point, such as depth below surface
- Method of sampling, including procedures, equipment, and any departure from the procedures specified in the Work Plan or the SAP
- Rationale for any deviations from Management Plan procedures and documentation of URS and USACE approval
- Results of field measurements (e.g., PID readings)
- Sample preservation
- Type and quantity of container used for each sample
- Weather conditions at the time of sampling and previous events which may influence the representative nature of a sample—at a minimum, include temperature, approximate wind speed and direction, and sky cover
- Photographic information—briefly describe what was photographed and why, the date and time, the compass direction of the picture, number of the frame on the roll, and roll number
- Sketches, when appropriate, with reference points tied to existing structures in the area (i.e., trees, existing monitoring wells)
- Analyses requested
- Disposition of the sample (i.e., where it is being shipped)
- Airbill number of sample shipment, when applicable
- Other pertinent observations, such as the presence of other persons on the site (those associated with the job or members of the press, special interest groups, or passersby), and actions by others that may affect performance of site tasks
- Type of health and safety clothing/equipment used
- Name(s) of sampling personnel

3.6 CHAIN OF CUSTODY PROCEDURES

Verifiable sample custody is an integral part of all field and laboratory operations associated with this site investigation. The primary purpose of the chain of custody procedures is to document the possession of the samples from collection through storage and analysis to reporting. Chain of custody forms will become the permanent records of sample handling and shipment. The Field

Investigation Manager or his/her designee will be responsible to the Project Manager for monitoring compliance with chain of custody procedures.

Field sampling personnel are responsible for the care and security of samples from the time the samples are collected until they have been turned over to the shipping agent or laboratory. A sample is considered to be in one's custody if it is in plain view at all times, in the physical possession of the sampler, or stored in a locked place where tampering is prevented.

Empty coolers containing ice or ice substitute will be available at the study area for use each day in the field. Samples collected during the day will be stored in shipping coolers or a refrigerator in the field office beginning at the time of collection. The coolers will be locked inside the field vehicle or other secure location when sampling personnel are not present.

A chain of custody form will be filled out for samples in each cooler, starting when the first sample of each batch is collected. Each chain of custody form will contain the following information:

- Sample identification numbers
- Date and time of sampling
- Type of sample and number of sample containers associated with each sampling point
- Total number of sample containers in cooler
- Unique cooler identification number
- List of analyses requested
- Name and signature of sampling personnel
- Shipping air bill number, when applicable
- Comments regarding MS/MSD samples, or any other information that is necessary for the lab
- Spaces for transfer of custody acknowledgment

When the chain of custody forms are complete, field team members will cross-check the form for possible errors. If samples are repackaged for shipping or delivery, one team member will cross-check the chain of custody with the samples that are packed while another team member packages the samples. Any corrections will be made to each record with a single strike mark that is dated and initialed. The person who initials corrections will be the same person that relinquishes custody of the samples. The chain of custody forms will be signed and dated, placed in zipper-locking bags, and taped to the inside lid of the respective cooler.

3.6.1 Transfer to Project Laboratory

After a cooler of samples is packaged and the chain of custody form has been completed, the cooler will be closed, sealed with packing tape, and sampling personnel will affix two signed and dated custody seals so that if it is opened the seals will be broken. Custody seals will contain the following information:

- Sample team member's signature (signature must match signature on chain of custody forms)
- Date

Coolers will be hand-delivered or shipped by Federal Express to the fixed laboratories by the sampling team. The Federal Express shipping agent will not enter into the formal chain of custody procedures, and therefore will not sign the chain of custody form. Copies of bills of lading provided by the shipping agent will be kept with chain of custody forms in order to document shipping procedures.

3.6.2 Laboratory Custody Procedures

A cooler receipt form will be filled out by the laboratory (Appendix B). Upon receipt by the laboratory, custody seals will be inspected and the chain of custody forms signed and dated by laboratory personnel. Laboratory personnel will verify sample numbers and the conditions of each cooler. Shipping manifests and chain of custody forms signed and dated by laboratory personnel will be considered sufficient documentation of sample custody transfer from the sampler, through the shipping agent, to the analyst in the contracted analytical laboratory.

A copy (pink) of each chain of custody form will be retained by the sampling team for the project file and the original (yellow and white) will be sent with the samples. Bills of lading will also be retained as part of the documentation for the chain of custody records. In conjunction with data reporting, the analytical laboratory will return the original chain of custody forms to the project manager for inclusion into the central project file.

3.7 DAILY CHEMICAL QUALITY CONTROL REPORTS

Field activities will be documented via the daily chemical quality control report (DCQCR) form (Appendix B). The reports will be prepared and submitted daily, and will summarize field and laboratory activities and results. The DCQCR will contain at a minimum the following information:

- Project information
- Work performed, samples collected including associated QA/QC samples, and personnel involved
- Weather
- Available analytical results, physical parameter measurements, calculation results, and required QC data
- Field audits performed and results
- Sampling, sample handling, chemical parameter measurement problems, deviations from the approved plan, and corrective actions taken
- Signatures of field personnel completing the DCQCR and initials of personnel making changes
- Summary of verbal or written instructions for retesting or changes of work

The DCQCR will be completed at the end of each day and posted on eRoom. Copies of field forms, pages of the field logbook completed for that day's work, boring logs, and photographs will be referenced on the form and attached to minimize transcription errors. Forms and attachments will be completed within 24 hours and posted on eRoom. The USACE site representative will be responsible for completing and posting the final DCQCR.

Table 3-1
SAMPLE IDENTIFICATION

LOCATION TYPE	SYMBOL	LOCATION ID [A]	DEPTH OR INTERVAL	SAMPLING DATE
SCAPS				
SCAPS-CPT	SC	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-LIF	SL	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-MIP	SM	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-groundwater	SG	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-soil	SS	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-FLUTe	SF	0001-	Top depth – bottom depth (feet bgs)	none
SCAPS-GeoVis	SV	0001-	Top depth – bottom depth (feet bgs)	none
Sonic Drilling				
Sonic borings - soil	RS	0001-	Top depth – bottom depth (feet bgs)	none
Multiport wells - groundwater	LC	0169- [B]	Top port (01) through bottom port (04)	-mmddyy
Piezometers - groundwater	LC	0170- [B]	none	-mmddyy
Monitoring wells-NAPL	LC	0171- [B]	none	-mmddyy
Other Types				
Murray Creek – surface water	SWMC	0006- [C]	none	-mmddyy
Exploration trenches	TS	0001-	Segment [D] and Depth (feet bgs)	none
Investigation-derived waste	IDW	0001	none	none

Notes:

[A] Duplicate - add integer of **3000** to station number
Field/rinsate blank - add integer of **6000** to station number
Performance evaluation - add integer of **9000** to station number

[B] Monitoring wells and piezometers to be labeled beginning with the next available number (approximately LC-169)

[C] Surface water sampling locations to be labeled beginning with the next available number (approximately SWMC-006)

[D] Trench segments to be labeled beginning with “a”

Table 3-2
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES—SOIL

ANALYSIS	CONTAINER	PRESERVATIVE	HOLDING TIME
Sound Analytical Services, Inc.			
TPH-Dx	8-oz glass wide mouth	None	14 days to extraction/ 40 days to analysis
SVOCs	Use TPH-Dx jar	None	14 days to extraction/ 40 days to analysis
VOCs	2-oz glass wide mouth	MeOH 4 ± 2 °C	14 days to extraction/ 30 days to analysis
PTS Laboratories, Inc.			
Density	16-oz glass wide mouth (or tube)	None	None
Permeability	Intact sample	None	None
Total organic carbon	Combine into two 16-oz glass wide mouth (or one 4-oz if TOC only)	4 ± 2 °C	28 days
Grain size		None	None
Porosity		None	None
Cation exchange capacity		None	None

Table 3-3
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES—NAPL

ANALYSIS	CONTAINER	REQUIRED VOLUME	PRESERVATIVE	HOLDING TIME
Sound Analytical Services, Inc.				
VOCs, SVOCs, and TPH-Dx	40-mL amber glass vial	5 mL	4 ± 2 °C	None
PTS Laboratories, Inc.				
Viscosity Density Boiling point distribution Oil/water interfacial tension	1-L amber glass	< 20 mL 100 mL 100 mL 750 mL	4 ± 2 °C	None

Table 3-4
SAMPLE CONTAINERS, PRESERVATION, AND HOLDING TIMES—GROUNDWATER

ANALYSIS	CONTAINER	PRESERVATIVE	HOLDING TIME
Sound Analytical Services, Inc.			
VOCs	4-40 ml VOA vials	4 ± 2 °C HCL pH<2	14 days to analysis

4.1 PACKAGING

The procedures and material used for sample packaging must adequately protect the sample container from accidental breakage during shipping. Sample packaging and labeling will conform to the requirements of Appendix F of USACE Engineering Regulation ER-1110-1-263 Engineering and Design – Chemical Data Quality Management for Hazardous, Toxic, Radioactive Waste Sites (USACE 1998b). Glass sample containers will be placed into plastic bags, and will be wrapped and cushioned in inert packing material such as Styrofoam, closed-cell foam packing material, or plastic bubble wrap. Plastic sample containers do not require individual cushioning material, but should be packed well to prevent movement during transport. Caps will be screwed on tightly. The plastic sample containers will be placed into individual, resealable plastic bags, which will then be sealed. Ice or ice-substitute will be placed in the container in a manner to ensure adequate and equal cooling for all samples.

4.2 SAMPLE SHIPPING

All sample containers will be placed inside a strong shipping container, such as a metal or plastic picnic cooler with a hard plastic liner. The shipping container should be sufficient to prevent leaks or spills of ice water or potentially broken sample containers. The drainage hole at the bottom of the cooler will be taped shut so that the contents from potential broken containers of prepackaged ice, ice substitute, or sample will not escape. The shipping container lid will be adequately secured with tape to prevent opening during shipping. The shipping container will be adequately cleaned between shipments to prevent cross-contamination of samples.

Transfer of samples from the project site to the project analytical laboratory is expected to be performed by the field personnel. Deliveries that will arrive at a laboratory or at the courier’s office to be picked up by laboratory personnel must be arranged with the laboratory before shipping occurs. There will be daily communication with the laboratory to avoid overloading the laboratory with samples. Communication with the laboratory will enable more regular delivery of samples and smoother receipt of analytical results.

Addresses, telephone numbers, and contacts of the laboratories analyzing samples for the project are presented in the QAPP. Samples will be hand-delivered to Sound Analytical Services, Inc. Federal Express will be used for shipping samples to PTS Laboratories, Inc.

American Society for Testing and Materials (ASTM). 1990. *Standard Practice for Description and Identification of Soil (Visual-Manual Procedure).* Practice D 2488-90.

United States Army Corps of Engineers (USACE). 2000. *Management Plan for Trenching/ Drum Removal, East Gate Disposal Yard, Fort Lewis, Washington.* Prepared by Gary Struthers Associates, Inc., Contract No. DACA67-00-C-0235. October 9, 2000.

______. 1998a. *Monitor Well Design, Installation, and Documentation at Hazardous and/or Toxic Waste Sites.* ENG 5056-R, ENG 5056A-R056. EM1110-1-4000. Proponent: CECW-EG. November 1, 1998.

______. 1998b. *Engineering and Design – Chemical Data Quality Management for Hazardous, Toxic, Radioactive Waste Remedial Activities*. Engineering Regulation ER-1110-1-263. Proponent: CECW-EG. April 30, 1998.

Appendix A
Field Standard Operating Procedures

CONTENTS

SOP for Site Characterization and Analysis Penetrometer System/Laser Induced Fluorescence (SCAPS/LIF)

SOP for Membrane Interface Probe and Direct Sampling Ion Trap Mass Spectrometer

Brief Summary of FLUTe Water Sampling Systems and Installation Procedures

SOP for Microwell Installation and Environmental Sampling by SCAPS

SOP for Installation and Development of Monitoring Wells, Phase II RI, East Gate Disposal Yard, Fort Lewis, Washington

USACE Seattle District HTRW Design Center SOP for Low-Flow Ground Water Purging and Sampling Using Dedicated Bladder Pump System

Standard Operating Procedure

For

Site Characterization and Analysis Penetrometer System/Laser Induced Fluorescence (SCAPS/LIF)

SOP No: M-0003-SWT-03

PREPARED BY: ______________________________
(Author) (Date)

REVIEWED BY: ______________________________
(SCAPS Manager) (Date)

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1.0 Scope and Application

1.1 Introduction

This standard operating procedure (SOP) is based on several technical reports and methods, which are referenced at the end of this document. This SOP describes the procedures used to conduct a subsurface ***in-situ*** petroleum hydrocarbon investigation with the Site Characterization and Analysis Penetrometer System and Laser Induced Fluorescence technique (SCAPS/LIF) currently deployed by the US Army Corps of Engineers Tulsa District.

1.2 Application

This SOP is applicable to the rapid investigation of subsurface petroleum hydrocarbon contamination at hazardous waste sites.

1.3 Personnel and Training

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of SCAPS technology and familiar with cone penetrometer testing, soil boring installation, grouting techniques, and laser-induced fluorescence.

The SCAPS manager will ensure all personnel are qualified and have received training relevant to the equipment and instruments currently possessed by the Investigations Section and used to support the District's SCAPS program. Additional District technical resources (chemists, industrial hygienists, geologists, etc.) will be used to support and enhance SCAPS operations whenever required.

2.0 Method Summary

2.1 Introduction

This SOP describes the process by which a subsurface ***in-situ*** petroleum hydrocarbon investigation will be conducted with SCAPS/LIF system.

The SCAPS system incorporates surface geophysical methods, surveying and mapping methods, special penetrometers with sensors for contaminant detection, and subsurface sampling equipment to map soil characteristics and contaminant distribution.

2.2 Cone Penetrometer System

Cone penetrometer testing (CPT) and standard penetrometer testing have been widely used in the geotechnical industry for determining soil strength and soil type from measurements of tip resistance and sleeve friction on an instrumented probe. The SCAPS uses a truck-mounted CPT platform to advance its chemical and geotechnical-sensing probe. The CPT platform provides a 20-ton static reaction force associated with the weight of the truck. The forward portion of the truck-mounted laboratory is the **push room**. It contains the rods, hydraulic rams, and associated system controllers. Underneath the SCAPS CPT push room is the steam manifold for the rod and probe decontamination system. The rear portion of the truck-mounted laboratory is the isolatable **data collection room** in which components of the CPT, onboard computers, and related support instruments are located.

2.3 Initial Site Survey

The site will be initially surveyed to locate underground utilities and underground obstacles to prevent damage to the SCAPS, ensure crew safety, and to prevent damage to utilities. Many sites contain a variety of underground anomalies, such as telephone cables, gas lines, electrical power cables, water pipes, sanitary sewer lines, drainage pipes, and steam lines.

Once the survey has been completed, approximate locations for each planned penetration are determined based on such factors as proximity to suspected contaminant sources, anticipated groundwater flow patterns, suspected underground obstacles, cultural features, topography variations, and mobility limitations.

Dependent upon site conditions and field results, the SCAPS manager and technical manager will modify all penetrometer locations when appropriate.

2.4 "Dummy" Exploration

At the discretion of the SCAPS manager, a "dummy" tip will be advanced into the subsurface soil to probe for any unanticipated anomalies, which may hinder the intrusive exploration of the location. The "Dummy" tip contains no sensors or sampling tools that may be damaged.

2.5 Soil Classification by Cone Penetrometer Test

A series of locations will be selected to conduct soil classifications. Soil strength and type is determined by monitoring tip resistance and sleeve friction when the CPT probe is advanced through the subsurface soil.

The combination of the SCAPS's reaction mass and hydraulics can advance the probe into the ground at a rate of 1m/min in accordance with ASTM Methods D3441 and D5778. The tip resistance is measured by means of a system of strain gauges that form an internal load cell as the cone tip is advanced. Friction developed along a floating cylindrical sleeve, just behind the cone tip, is measured similarly as the device passes through the soil. Tip penetration resistance and sleeve friction is measured independently and continuously. The point and sleeve friction load cells are independently calibrated in the field prior to cone penetrometer operation.

Soil classification is conducted on-board the SCAPS during field operations using a computer-based routine that references the strain gauge readings, the calibration curves and an empirical relationship between cone resistance and friction. The SCAPS instruments are capable of discriminating porous sands from tighter, finer-grade silts and clays.

2.6 Laser-Induced Fluorescence (LIF)

A series of locations will be selected to conduct an ***in-situ*** analysis for petroleum hydrocarbon contamination. The District's SCAPS supports a Laser-Induced Fluorescence (LIF) Sensor and Support System operated in accordance with ASTM Method D6187, except when noted otherwise within this SOP.

The SCAPS/LIF method provides data on the in-situ distribution of petroleum hydrocarbons based on the fluorescence response induced in the polycyclic aromatic hydrocarbon (PAH) compounds that are components of petroleum hydrocarbons. PAHs in petroleum products are induced to fluorescence by excitation with ultra-violet (UV) light. The method provides a "detect/non-detect" field screening capability relative to a detection limit derived for a specific fuel product on a site-specific soil matrix. The SCAPS LIF is primarily used, as a field screening, qualitative method but can be semi-quantitative at concentrations within two orders of magnitude of its detection limit for fluorescent petroleum hydrocarbons.

The LIF system uses a pulsed nitrogen laser (**PTI ™ 2300**) with an optical multichannel analyzer (**EG&G™ Model 1460**) and photodiode array detector (**EG&G™ Model 1421**) to make fluorescence measurements via optical fibers. These fibers are integrated with the penetrometer probe and umbilical of the SCAPS. The measurement is made through a sapphire window on the probe.

Fluorescence emission spectra are collected once per second as the probe is advanced into the subsurface soil. An on-board computer is used to generate real-time depth plots of fluorescent intensity at the spectral peak, wavelength of spectral peak, sleeve friction and tip resistance, and soil type characteristics as interpreted from the strain gauge data. The fluorescent intensity in the spectral window is plotted as a function of depth in real time as the probe is pushed into the soil.

2.7 Borehole Abandonment and Grouting

Grouting will be performed to ensure that vertical cross contamination does not occur in the penetration and borehole locations. To accomplish this a silica flour cement mixture will either be automatically pumped into the hole as the penetrometer probe/sensor is retracted or manually placed into the open borehole.

2.8 Decontamination

Dependent upon push depth and number of locations, a small volume of decontamination fluids is generated by at each location. As the penetrometer/probe is retracted, a high pressure hot water/steam-cleaning system is used to wash each rod section and remove possible contamination. The decontamination fluid is collected in a five-gallon bucket from under the truck and transferred to a DOT certified steel drum or other approved container.

3.0 Method Limitations

3.1 Truck-Mounted Cone Penetrometer Access Limit

The SCAPS CPT support platform is a 20-ton freightliner all-wheel-drive diesel powered truck. The dimensions of the truck require a minimum access width of 10 feet and a height clearance of 16 feet. Some sites, or areas of sites, might not be accessible to a vehicle the size of the SCAPS CPT truck. The access limits of the SCAPS CPT truck are similar to those for conventional drill rigs and heavy excavation equipment.

3.2 Cone Penetrometer Advancement Limits

The CPT sensors and sampling tools may be difficult to advance in subsurface lithologies containing cemented sands and clays, buried debris, gravel units, cobbles, boulders, and shallow bedrock. As with all intrusive site characterization methods, it is extremely important that all underground utilities and structures is located using reliable geophysical equipment operated by trained professionals before undertaking activities at a site. Local utility companies should be contacted for the appropriate information and approval when applicable.

3.3 Response to Different Petroleum Hydrocarbons

The relative response of SCAPS LIF sensor depends on the specific analyte being measured. The instrument's sensitivity to different hydrocarbon compounds can vary by as much as two orders of magnitude.

3.4 Matrix Effects

The in-situ fluorescence response of the LIF sensor to hydrocarbon compounds is also sensitive to variations in the soil matrix. Matrix properties that affect LIF sensitivity include soil grain size, mineralogy, moisture content, and surface area. Each of these factors influences the relative amount of analyte that is adsorbed on or absorbed into the soil. Only the relative fraction of analyte that is optically accessible at the window of the probe can contribute to the fluorescence signal.

3.5 Spectral Interferences

The SCAPS LIF sensor is sensitive to any material that fluoresces when excited with ultraviolet wavelengths of light. Although intended to specifically target petroleum hydrocarbons, the excitation energy produced by the LIF system's laser may cause other naturally occurring substances to fluoresce as well.

4.0 Quality Assurance/Quality Control

4.1 Overview

Geotechnical and chemical data generated by field crews during the SCAPS investigation will be reviewed by personnel possessing the required skills necessary to evaluate and validate the results. A quality assurance officer will be assigned to the project to ensure that all data quality objectives for the project are adequately being met.

4.2 SCAPS CPT QA/QC

Initial system setup will require the calibration of a few components including, but not limited to, the point and sleeve friction load cells, strain gauges. Calibrations will occur whenever a different probe assembly is used.

4.3 SCAPS LIF QA/QC

Initial system setup will require the calibration of a number of components including, but not limited to, the laser, the detector, strain gauges.

An evaluation of the sensitivity of the LIF sensor and contamination encountered at the site is completed by collecting a number of confirmation soil samples from various depths, and either analyzing these samples on-site or at an analytical laboratory. The field or laboratory analytical tests should adequately characterize the soil sample for the presence of petroleum hydrocarbon contaminants, especially polyaromatic hydrocarbons. Acceptable methods include, but are not limited to, EPA method 418.1, modified 8015, modified 8270.

Due to the nature of the ***in-situ*** measurement, duplicate samples cannot be measured by LIF. Soil heterogeneity and variation in contaminant distribution can be significant over short distances both horizontally and vertically. A number of soil samples will be collected at various depths and locations such that equal numbers of nondetects and detects relating to the LIF readings can be adequately analyzed and evaluated.

5.0 Waste Disposal

Decontamination fluids and other investigative derived wastes (IDW) generated during SCAPS activities will be properly containerized, staged, labeled, and managed in accordance with the project work plan. The volume of waste will be minimized whenever applicable. Soil, liquid, and personal protective equipment (PPE) IDW will be separately containerized and segregated. The PPE will be disposed of as nonhazardous waste unless it has been grossly contaminated or is determined to be contaminated by on-site field data.

6.0 Health and Safety

A site-specific safety and health plan will be developed for SCAPS and related SCAPS activities. All field personnel will attend safety meetings scheduled by SCAPS field manager and industrial hygiene officer.

All field personnel will follow current OSHA standards and regulations documented within USACE's EM385-1-1.

7.0 References

U.S. Army Corps of Engineers, (1993). "Site Investigations with the Site Characterization and Analysis Penetrometer System at Fort Dix, New Jersey." Technical Report GL-93-17, Waterways Experiment Station, Vicksburg, MS

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U.S. Army Corps of Engineers, (1996). "Cone Penetrometer Grouting Evaluation." Technical Report GL-96-33, Waterways Experiment Station, Vicksburg, MS

U.S. Environmental Protection Agency. (1997). "The Site Characterization and Analysis Penetrometer System (SCAPS) Laser-Induced Fluorescence (LIF) Sensor and Support System." Innovative Technology Verification Report EPA/600/R-97/019, Sandia National Laboratories, Albuquerque, New Mexico

American Society for Testing and Materials (ASTM). (1995). "Standard Test for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils". Designation D5778-95. Philadelphia, PA

American Society for Testing and Materials (ASTM). (1997). “Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence”. Designation D6187-97. Philadelphia, PA

American Society for Testing and Materials (ASTM). (1998). “Standard Test Method for Mechanical Cone Penetrometer Tests in Soil”. Designation D3441-98. Philadelphia, PA

Standard Operating Procedure

For

Membrane Interface Probe and Direct Sampling Ion Trap Mass Spectrometer

SOP No: M-0005-SWT-01

PREPARED BY: ______________________________
(Author) (Date)

REVIEWED BY: ______________________________
(Technical Manager) (Date)

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(Project Chemist) (Date)

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(Quality Assurance Officer) (Date)

1.0 Scope and Application

1.1 Introduction

This standard operating procedure (SOP) describes the procedures used to identify and determine the concentration of volatile organic compounds (VOCs) in the subsurface environment using the Membrane Interface Probe/Direct Sampling Ion Trap Mass Spectrometer (MIP/DSITMS) system coupled with direct push techniques.

1.2 Application

This SOP is applicable to all locations where direct push techniques can be employed. The DSITMS technique may be used to examine individual groundwater samples properly containerized in 40ml vials. The MIP/DSITMS technique is only applicable to characterizing VOCs in the vadose and saturated zones.

1.3 Personnel and Training

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of mass spectrometers and familiar with general analytical chemistry techniques, sample extraction procedures, and waste management practices.

The project chemist will ensure all personnel are qualified and have received training relevant to the equipment and instruments currently possessed by the HTRW Design Branch and used to support the District's field analytical program.

2.0 Method Summary

2.1 Introduction

Samples may be introduced into the Ion Trap Mass Spectrometer (ITMS) by one of two methods:

<u>Direct Sampling/Vial Sparging</u>: One of the more common techniques which allows the analyst to introduce a sample by directly sparging a vial containing a groundwater sample with helium and analyzing the effluent vapor with the DSITMS.

<u>Membrane Interface Probe</u>: This in situ technique allows the analyst to vertically profile a subsurface location for the presence of VOCs. The MIP/DSITMS is comprised of the MIP, a metal/teflon composite membrane that samples VOCs in situ and the DSITMS that identifies and quantifies the VOCs. The MIP/DSITMS is capable of multiple, discreet VOC measurements in a single penetration, sampling depths/resolution are determined on a site-specific basis.

The MIP is a permeable membrane device used to detect volatile contaminants as it is driven to depth in soil or other unconsolidated materials. A thin film membrane is impregnated into a stainless steel screen on the face of the probe. This membrane is heated to 100 - 120 degrees Celsius leading to quick diffusion of VOC contaminants across the membrane into the He carrier gas which flushes the back of the membrane and transports the contaminants to the above ground DSITMS.

2.2 Background Information

Geoprobe Systems, Inc. (www.georprobesystems.com) developed the MIP. The MIP/DSITMS has been used by U.S. Army Waterways Experiment Station with a standard geophysical cone penetrometer truck (CPT) capable of advancing direct push sampling tools but has also been deployed using other vehicles capable of advancing direct push tools (Geoprobe, Earth Probe, etc.).

3.0 Method Limitations and Potential Interferences

Direct Sampling Ion Trap Mass Spectrometry is a method for the quantitative measurement, continuous real-time monitoring, and quantitative and qualitative preliminary screening of VOCs in water, soil, and air (Wise et al, 1997). It is applicable to the determination of VOCs in batch samples taken to the laboratory and to on-site measurement and monitoring. It is best suited for the routine quantitative monitoring of sampling locations characterized once using standard gas chromatography mass spectrometry methods, for analyzing samples for the presence of VOCs, and for support of site characterization and remediation activities requiring the analysis of large numbers of samples in a short period of time or requiring on-line continuous monitoring. It is applicable to the qualitative and quantitative analysis of unknown (previously uncharacterized) samples provided that the absence of interferences can be documented. This procedure is not applicable if results are required for individual positional isomers (e.g.; ortho, meta, para-xylenes) or individual geometric isomers (e.g., cis/trans ethenes) unless unique operating conditions are developed and demonstrated which make it possible. Isomer distribution must be determined at least once using gas chromatography or gas chromatography mass spectrometry methods.

The DSITMS demonstrates the capability of meeting the precision and accuracy QC performance criteria establish for water analysis by EPA Method 624 (40 CFR Part 136).

Validation data collected for in situ MIP/DSITMS data in saturated soils as compared to data for samples collected by US EPA sampling Method 5035 and analysis Method 8260 indicate that the system provides quantitative estimates of subsurface contamination distribution.

4.0 Health and Safety

The toxicity or carcinogenicity of chemicals used in this procedure has not been precisely defined. Each chemical will be treated as a potential health hazard, and exposure to these chemicals will be minimized whenever possible. The project chemist will be responsible for maintaining awareness of OSHA regulations regarding safe handling and disposal of chemicals.

All USACE personnel will follow current safety and health requirements published by OSHA and stated within USACE's EM385-1-1 Manual. Material safety data sheets will be kept on-site regarding all reagents. Emergency numbers and a hospital route will be openly displayed near the work area.

5.0 Sample Preservation and Handling

The MIP/DSITMS technique requires no sample handling other than the collection of soil and groundwater samples necessary to meet project quality assurance and quality control objectives. During the direct sampling/vial sparging method, the DSITMS requires the collection and containerization of groundwater samples prior to analysis.

Groundwater samples will be collected in 40ml certified vials (amber or clear) with teflon liners. Samples may either be preserved (with hydrochloric acid) or unpreserved prior to analysis. Preserved samples shall be analyzed within 14 days. Unpreserved samples may be analyzed within 7 days.

The collection of soil samples will follow the procedures set forth in SW846 Method 5035 and generally will be collected in tared and prepreserved 40ml certified vials (amber or clear) with teflon liners. Samples may either be preserved with methanol or sodium bisulfate dependent upon the required quantitation limits or headspace readings from field instruments. Preserved samples shall be analyzed within 14 days. An alternative to the prepreservation of vials is to use the Encore sampler, which requires preservation by the laboratory within 48 hours.

6.0 Quality Assurance/Quality Control

6.1 Mass Axis Calibration

Mass axis calibration of the DSITMS should be ran initially at start up and checked daily using an acceptable calibration compound such as perflourotributylamine (PFTBA). Refer to the manufactures recommendation for frequency. Record the results of mass axis calibration for future reference.

6.2 Background Subtraction

A blank sample should be run for background subtraction, to ensure there is no carryover in the transfer line, any time samples are run having > 500 ppm of VOC contamination, and between analysis of samples from different sources. During the MIP/DSITMS, a system blank check should be performed before and after each set of in situ measurements.

6.3 Calibration Curve

A calibration curve should be developed using laboratory prepared standards of known concentrations bracketing the expected contaminant concentrations for a particular site.

Once calibration is achieved, analyze calibration check standards a minimum of twice a day during the direct sampling method and once after each penetration is completed while using the MIP/DSITMS. Corrective action is required whenever the calibration factor (slope of calibration curve) varies by > 2 standard deviations from the mean value developed during calibration (see 3.) and subsequent analyses of calibration check standards. Corrective actions include, but are not limited to, system leak checking, evaluation of current calibration standard relative to the Performance Evaluation Check Standard (PECS; see 6.4 below) and/or complete recalibration.

Operating conditions used to generate the calibration curve should not be changed during sample analysis. Critical operating parameters that affect system sensitivity are carrier gas flow rate of the MIP, membrane temperature and DSITMS set points for electron multiplier voltage (EM), ionization time (IT) and filament current.

6.4 Performance Evaluation Check Standards

Performance Evaluation Check Standards (externally prepared) should be run daily at startup and at the conclusion of each day. Corrective action is required whenever the PECS results are significantly different from the true value (i.e. results do not fall within 2 standard deviations of the historic mean value developed for the analytical system).

6.5 Verification Sampling

The MIP/DSITMS system is intended to be used as a high-level field screening technique to rapidly delineate the distribution of VOC contaminants in the subsurface. The direct sampling/vial sparging method is more amenable to low level concentrations. The data collected can be used to accurately place a minimum number of conventional sampling points (soil bores and/or monitoring wells) for site characterization and monitoring. Verification sampling and off site analysis by US EPA Method 8260 will be performed on a site-specific basis and in accordance with the project work plan to confirm the results obtained using the DSITMS.

Select locations and depths for verification sampling to include a range of contaminant concentrations from non-detect to the maximum concentrations detected DSITMS. Obtain soil for verification samples of the MIP/DSITMS by using direct push soil sampler advanced to depth using the CPT at locations offset no greater than 1 to 1.5 ft horizontally from the MIP push location. Soil cores obtained for verification sampling should be subsampled using US EPA Method 5035 (i.e. subsamples placed immediately into tarred vials containing 5 mL methanol, or the Encore sampler). Note that clay subsamples that do not readily break up in the methanol when shaken should be manually broken into smaller pieces using a stainless steel spatula until the sample is completely submerged by the methanol. If soil remains above the surface of the methanol, the VOC contaminants will escape the extract and partition into the headspace of the vial causing erroneously low concentrations during analysis. Verification samples for the direct sampling/vial sparging technique should be collected in 40 ml vials as described in section 5.0. Verification samples should be place on ice until shipped to the off site laboratory for analysis by US EPA Method 8260.

7.0 Procedure

The steps listed in the following sections outline the general procedure for operating the MIP/DSITMS. Operation of the DSITMS alone to characterize individual groundwater samples is performed in accordance with Section 7.2 below and as outlined in Draft EPA Method 8265. Additional procedures are followed in accordance with operating instructions provided by the manufacturer and software designer.

7.1 Membrane Interface Probe

7.1.1 Set flow rate of He to MIP module between 80-120 mL/minute (do not exceed 18 psi back pressure). This will cause the helium carrier gas to flow out of the membrane.

7.1.2 Interface MIP carrier gas return line to inlet of heated (100 ^{o}C) DSITMS interface.

7.1.3 Using the MIP controller, heat the membrane of the MIP to 120 ^{o}C and acquire 3-minute background data file using the DSITMS.

7.1.4 Cool MIP to < 40 ^{o}C using air or with the aid of deionized water, place calibration jig around membrane, simultaneously add clean sand and water (refer to sec. 7.3.3). Acquire 3-minute soil background data file using DSITMS. Repeat three times for establishment of baseline.

7.2 Direct Sampling Ion Trap Mass Spectrometer

7.2.1 Check DSITMS heater temperature, adjust if necessary per instrument manufactures instructions (normally between 150 – 200 ^{o}C).

7.2.2 Check carrier gas flow rate, adjust if necessary.

7.2.3 Check critical DSITMS parameters: EM voltage, filament current and IT, adjust if necessary per instrument manufactures instructions.

7.2.4 Calibrate the DSITMS mass axis according to the manufactures' instruction. Print a hard copy of the mass axis calibration and archive.

7.2.5 Analyze a middle to low concentration calibration standard to access system sensitivity (see details of calibration standard analysis in **Quantitative Calibration of MIP/DSITMS sensor** below). Adjust DSITMS operating parameters as needed to achieve desired sensitivity.

7.3 Quantitative Calibration of MIP/DSITMS Sensor

7.3.1 Prepare stock standard solutions for analytes of interest by weighing neat (99%) VOC analytes into a 10-mL vol. flask containing approximately 7-8 mL methanol. Be careful to ensure that the neat analyte is dropped directly into the methanol and does not touch the unwetted glass surface of the vol. flask. Prepare stock solutions in the concentration ranges of 1-5 mg/mL. Multiple analyte mixtures in a single stock solution are acceptable as long as no analytes yielding identical m/z are mixed (see **Inferences**). Details of VOC stock solution preparation can be found in US EPA Method 8260. Alternatives to the preparation of stock solutions can be made based on volume measurements rather than weight.

7.3.2 Prepare aqueous dilutions of the calibration standards using the equation $C_1V_1 = C_2V_2$ in reagent water by filling a 1 liter graduated cylinder with water and injecting a measured volume of the methanol stock solution to obtain the desired aqueous concentration (Note: Be sure units are the same). For the purpose of vial sparging, 40 ml vials will be used. A gas tight syringe should be used for this dilution (rinse thoroughly with methanol after use). It is important to inject the methanol solution **below** the water surface in the graduated cylinder/vial and gently stir to mix the aqueous standard dilution. Vigorous shaking of the standard dilution will cause low, erratic response during subsequent analysis. A list of initial calibration concentrations is reported in Section 7.10 of this SOP for both the MIP/DSITMS and DSITMS.

7.3.3 During the MIP/DSITMS, insure that the MIP heater is turned off and the membrane is < 40 C. Place calibration jig on MIP with the membrane section in the middle of the jig. Using an aqueous standard prepared as described in 7.3.2, gently pour standard and sand at constant rates into the calibration jig. Simultaneously turn on MIP heater and begin DSITMS data acquisition. For the direct sampling/vial sparging method, immediately place the vial on the sparging apparatus and begin acquisition while sparging.

7.3.4 Analyze at a minimum of three different concentrations of dilutions in duplicate covering the desired concentration range. Make dilutions, one at a time as described in 7.3.2 and **analyze immediately**. Do not batch the preparation of dilutions in water as VOCs defuse out of the water in a short period of time.

7.3.5 Analyze calibration standards at various intervals, such as when problems operating instrument occur, or whenever sample concentrations vary widely and at least once after every penetration during the MIP/DSITMS and twice a day during the direct sampling/vial sparging method.

7.3.6 Analyze a PECS at least once each day of operation when using the MIP/DSITMS and twice a day when using the direct sampling/vial sparging method or after each 20 sample analyses. Keep a continuing graphical or tabular record of daily calibration check standards and PECS for determination of system performance. Take corrective action whenever calibration standards or PECS results do not meet QC criteria.

7.4 Analytical Procedure for MIP/DSITMS

7.4.1 Analyze blank water/sand sample before each penetration.

7.4.2 Prepare DSITMS data acquisition files for all planned sampling depths before penetration begins. Record data file names and sampling depths in the field-sampling logbook.

7.4.3 In moderately contaminated areas, insure the MIP membrane <40 ^{o}C. Push the MIP to the first sampling depth. Continuous heating of the membrane is preferred when high dissolved phase or free-phase Non Aqueous Phase Liquid (NAPL) is encountered.

7.4.4 Begin data acquisition as soon as depth is achieved (generally a 3 minute acquisition).

7.4.5 Once acquisition is complete, turn off membrane heater and prepare the next DSITMS acquisition file before advancing to the next sampling depth.

7.4.6 Repeat 7.4.2 through 7.4.5 for each sampling depth during penetration.

7.4.7 Analyze a system blank and at least one calibration check standard after retraction of MIP from penetration. Check system response of both the blank and standard to insure no contaminant carryover and continuing calibration.

7.4.8 PECS will be run at the frequency stated in section 7.3.6.

7.5 Calculate Results

7.5.1 Determine relevant m/z values to quantify specific analytes of interest.

7.5.2 Plot selected ion profiles for m/z of each analyte.

7.5.3 Integrate area for relevant m/z values over a consistent number of scans (typically 50 to 100 scans). Actual sample integration intervals should **always** be the same number of scans as that used for calibration data quantification. Print and save integrated data file.

7.5.4 Use response factor determined from calibration curve for each analyte to calculate the concentration of analyte present in the sample.

7.5.5 Depending on the manufacturer of the ITMS, software for automation of calibration and sample data reduction may be available. Otherwise, manual integration using the DSITMS software and common spreadsheet means can be used for calculation of results.

7.6 Method Performance

7.6.1 Accuracy and Precision

The DSITMS has been shown to be capable of meeting the precision and accuracy QC performance criteria establish for water analysis by EPA Method 624 (40 CFR Part 136).

Validation data collected for in situ MIP/DSITMS data in saturated soils and compared to data for samples collected by US EPA sampling Method 5035 and analysis Method 8260 indicate that the system provides quantitative estimates of subsurface contamination distribution. However, there appears to be a matrix moisture-content effect for vadose soils.

7.6.2 Detection Limits

Limit of detection (LOD) calculations are conducted using the U.S. EPA method proscribed in SW 846 (U.S. EPA 1995). This method involves n replicate measurements of a low but detectable analyte concentration, estimation of analytical system noise as the variance of the n replicate measurements and calculation of LOD using the equation:

$\mathrm{LOD} = t_{n-1,\ \alpha/s}\ S$ (Equation 1)

where, $t_{n-1,,\ \alpha/s}$ is the student t value for n replicates at the 95% confidence level and S estimate of the standard deviation. For n values between 5 and 9, the $t_{n-1,\ /s}$ ranges between 2.78 and 2.23, respectively. Measurements for LOD calculations are made using the entire MIP/DSITMS sensing system, therefore measuring the expected system performance in the direct push well. Typical LOD values calculated for data obtained in actual field operations are on the order of 100 to 200 ug/L (as water).

7.6.3 Time Considerations

Absolute time required for a single iteration of pushing to multiple sampling depths and making a number of MIP/DSITMS measurements is dependent on the total depth and sampling resolution desired. Each DSITMS analysis requires 3 minutes to complete. Estimates of time required for a single complete iteration range from one hour for penetrations < 25 ft with up to ten discrete DSITMS measurements to approximately 3 hours for penetrations up to 150 ft with up to 25 discrete DSITMS measurements.

7.7 Critical Parameters and Troubleshooting

7.7.1 MIP/DSITMS

The MIP carrier gas flow rate and system response (i.e. slope of calibration curves) are linked. If the flow is change, re-calibration may be needed. The MIP operating temperature is critical to sensitivity and reproducibility. The membrane is impermeable to VOCs at temperatures less than 100 C. Recommended operating temperature for the MIP is 120 ^{o}C.

The transfer line may become contaminated whenever highly contaminated soil and groundwater are analyzed (> 500 ppm). If the analyte transfer line becomes contaminated with VOCs disconnect the analyte transfer line and the He supply line at the DSITMS inlet. Using a reducing union, back flush 1/8" analyte transfer line with 1/16" He supply line. Back flush for approximately 20 minutes, check the condition of the transfer line by reconnecting to the DSITMS inlet and analyzing system performance blank (air or water). Repeat back flush as necessary.

Closely monitor the calibration check standards and PECS as data is collected throughout the day. If a change is noted in the calibration check standard response, immediately analyze a PECS. If the PECS meets QC limits (see **Quality Control)**, remake the standard stock solution as specified in **Quantitative Calibration of MIP/DSITMS VOC Sensor (section 7.3)**. If the response of the PECS changes while the calibration check standard response meets QC limits, open a new vial of PECS and analyze. If the check standard and PECS both fail to meet QC limits, the problem is likely with the DSITMS or a leak in the MIP/DSITMS membrane or gas carrier line. Leak check MIP membrane, if applicable. If no leak is found and the response factors for both the check standard and PECS are low compared to QC limits, try adjusting the EM voltage upward to regain acceptable response. Periodic upward adjustment of the EM over its life is common.

7.7.2 DSITMS

In addition to the details listed in Section 7.7.1 it should be noted that directly purging water into the DSITMS entrains significant water vapor and the life span of an EM in DSITMS is shorter than that of a conventional gas chromatograph/mass spectrometer system. The analyst should ensure to leave adequate space between the lip and neck of the 40ml vial when individual analyses are performed on the DSITMS during the direct sampling/vial sparging method.

7.8 Reagents

The following reagents are required:

Helium, 99.9999% purity
Methanol, purge and trap grade
Milli-Q or equivalent Water (ASTM Type II Reagent Water)
Neat Volatile Materials, 99% purity for standards preparation or purchased
Pre-made stock solutions
Externally prepared performance evaluation check standard solutions

7.9 Apparatus

The following apparatus are required:

Cone penetrometer truck with direct push well capability (American Standard Testing Methods, 1995 Annual book of ASTM standards. 04.08 (D-3441), American Society for Testing and Materials, Philadelphia).

Direct Sampling Ion Trap Mass Spectrometer (Finnigan Magnum/ITMS 40 or Varian Saturn; retrofitted with direct sampling inlet; wise et al, 1997).
Membrane Interface Probe and controller (Geoprobe Systems, Inc.)
Gas-Tight Syringes (10uL to 10 mL)
250 mL Volumetric flasks
10 mL volumetric flasks
1 L graduated cylinder
4-10 mL screw cap vials with teflon lined caps
Flow Meter (digital type preferred)
40 mL vials for direct sampling
Silica sand for MIP
Calibration jig for MIP
Leak detector for Helium gas
Uninterrupted Power Supply (UPS) - Preferred

7.10 Initial Calibration Concentrations

The following series of calibration standards may be created to produce an initial calibration curve for the project. Individual standards may be added or removed to enhance the calibration curve and satisfy project-specific data quality objectives.

MIP/DSITMS (water)

100 ppb	200 ppb	500 ppb	1000 ppb	5000 ppb

DSITMS (water)

2.5 ppb	5.0 ppb	50 ppb	500 ppb	1000 ppb

8.0 Waste Disposal

All waste will be disposed of by a local certified disposal company (i.e., **SafetyKleenä)** and will be managed in accordance with the project work plan. All waste will be properly containerized, labeled, staged, and managed. Soil and liquid wastes will be containerized separately. Personal protective equipment (PPE) will be disposed of as non-hazardous waste, unless otherwise noted within the project work plan.

9.0 References

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(2) Davis, W. M., M. B. Wise, J. S. Furey, and C. V. Thompson, "Rapid Detection of Volatile Organic Compounds in Groundwater by *In Situ* Purge and Direct-Sampling Ion-Trap Mass Spectrometry," *Field Analytical Chemistry and Technology* 2(2):89-96, 1998

(3) Davis, W.M., J.S. Furey and B. Porter, 1998b, "Field Screening of VOCs in Ground Water using the Hydrosparge VOC Sensor" *in press* in Current Protocols in Field Analytical Chemistry, V. Lopez-Avila, ed.; J. Wiley and Sons, Inc., New York, NY.

(4) Davis, W. M. and Costanza, J., "Rapid Detection of Volatile Organic Compounds in the Subsurface by Membrane Introduction into a Direct Sampling Ion Trap Mass Spectrometer," *August 2000*

(5) Environmental Security Technology Certification Program, "Cost and Performance Report for SCAPS Hydrosparge VOC Sensor", July 1999, available at http://www.estcp.org/technical_documents.htm

(6) T. Christy, United States Patent Number 5,639,956, Permeable Membrane Soil Probe, June 17, 1997.

(7) M. B. Wise, C. V. Thompson, R. Merriweather, and M. Guerin, "Review of Direct MS Analysis of Environmental Samples", *Field Analytical Chemistry and Technology*, 1(5):251-276, 1997

(8) EPA. 1995. "Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846 Third Edition" Washington, DC.

(9) M. Wise, M. Guerin, R. Merriweather, C. Thompson, and W. Davis, "Draft Method 8265, Direct Sampling Ion Trap Mass Spectrometery for the Measurement of Volatile Organic Compounds in Water, Soil, and Air," Submitted to Environmental Protection Agency Methods Workgroup by Oak Ridge National Laboratory, June 1997.

Flexible Liner Underground Technologies, Ltd. Co.
The subtle approach to the geosciences
6 Easy Street, Santa Fe, NM 87501
505-455-1300, or ckmist @ aol.com

Description of *NAPL FLUTe* system

The system once emplaced:

This system consists of an impermeable flexible liner and an exterior covering on the liner which reacts with pure product (e.g., NAPL and DNAPL) to form a bright red dye stain on a white background. The liner/cover system can be emplaced via several push rod methods. The pressurized liner forces the reactive cover tightly against the hole wall. The reactive cover is recovered from the hole by inverting/peeling the liner from the hole. In this manner, the cover does not touch the hole wall anywhere else as it is removed. The cover can then be examined for the presence and extent of layers, and even globules, of NAPL in the subsurface. This technique of installation and removal of the reactive covering through the interior of push rods provides a relatively inexpensive method for mapping of NAPLs and DNAPLs in the source region.

The installation technique

This liner installation method can be applied to the many driven casing "drilling" methods. The same trick is employed regardless of the casing diameter to allow the casing to be withdrawn without excessive drag of the liner on the casing. As the casing/rods are withdrawn, the liner is dilated against the hole wall at high pressure to support the hole wall against collapse and to seal the hole against vertical flow.

Experience:

This installation technique was first developed for the installation of color reactive liners for the mapping of NAPL layers in sediments. The technique has been employed at Savannah River Site, NC, Cape Canaveral, FL, Paducah, KY, and Murdock, NB. Only the Murdock site (6 three port wells to 80 ft.) included miniwells in cone penetrometer holes. The rest had liners installed via cone penetrometer rods for color mapping by inversion of the liner from the hole (see the *Mini FLUTe* description for water well installations).

Procedure:

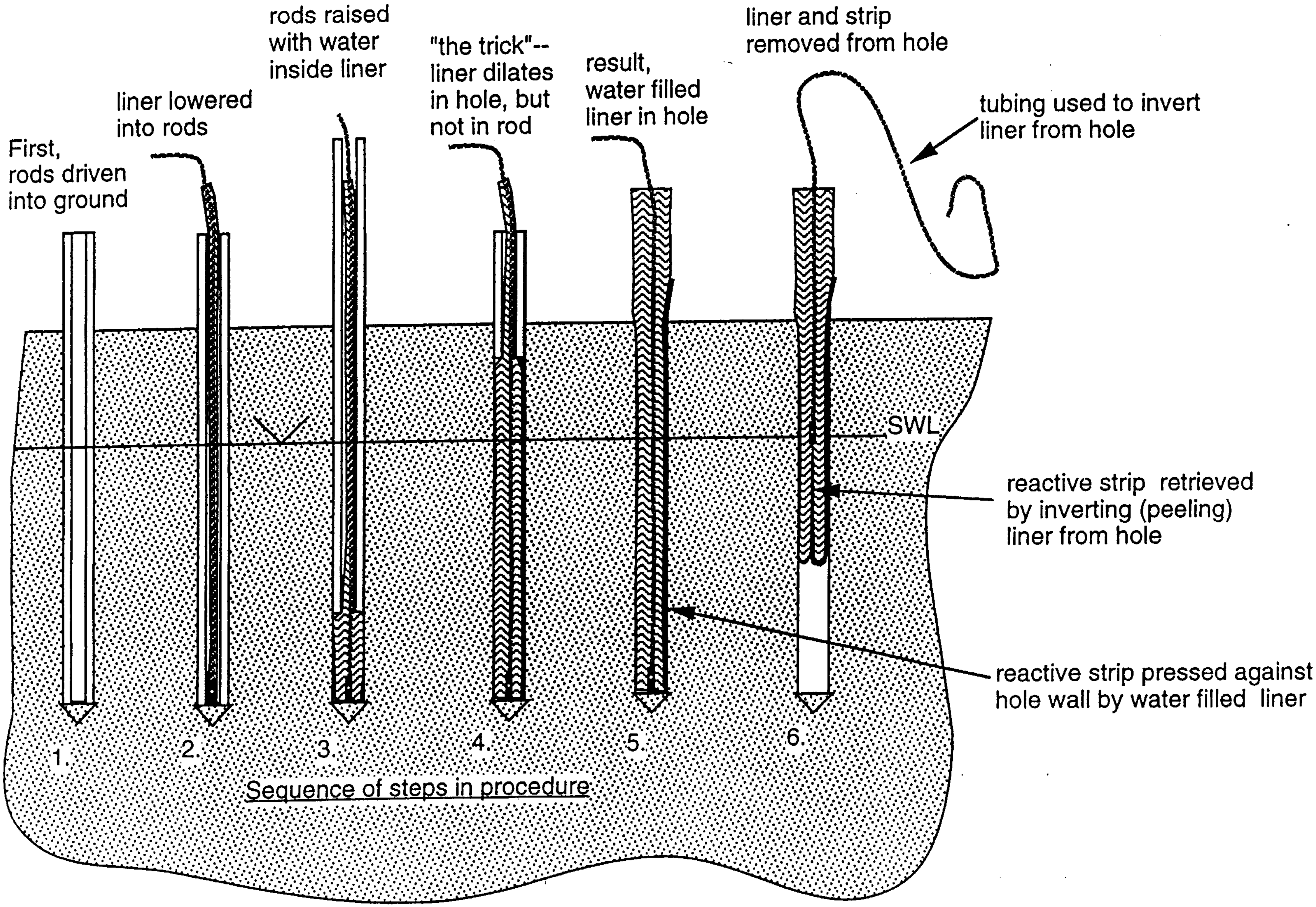
The procedure is illustrated in the attached drawing. The rods are pushed to the full depth of interest. The liner with its reactive covering is inserted into the interior hole in the rods to the full depth. The rods are then filled with water. The rods are raised by one rod section to expose the hole wall. The liner is pressurized with a charge of water to hold the hole open and to anchor the liner in the hole. More water is added to the interior of the liner as the rods are pulled. Once the rods are fully removed, the hole is supported and sealed by the water filled liner. The covering is pressed against the hole wall for an hour, or so, and then the liner is inverted (peeled inside out) from the hole. The covering is therefore interior to the inverted liner. The covering is then peeled from the interior of the liner to reveal the stained map of the distribution of NAPLs in the subsurface.

The liner can be reused to install another reactive covering in another pushed hole.

For information on this technique, call toll free 888-333-2433.

Note: This technique is a proprietary method devised by Flexible Liner Underground Technologies, Ltd. Co. of Santa Fe, NM. Several patents are pending on the method and hardware for several kinds of applications.

NAPL FLUTe method of installing color reactive liners in a punched hole pat. pend.



This technique allows mapping of NAPL/DNAPL layers in punched holes

For details,
phone: 888-333-2433

Mapping of DNAPL locations just became much easier!

The Westinghouse group at the Savannah River Site (SRS) installed a ribbon manufactured by Flexible Liner Underground Technologies (*FLUTe*) in a cone penetrometer hole, let it sit for an hour, and recovered the ribbon shown below. The red dye marks were spectacular in the regions of high DNAPL concentrations. The white ribbon was installed against the wall of a 1.4" hole with a *FLUTe* everting liner deployed from a small pressure canister. The ribbon was recovered by inverting the liner from the hole. The inverting liner surrounds the ribbon and prevents any other contact with the hole as the ribbon is recovered.

The ribbon was installed after the rod was pulled out of the ground. The ribbon is a laminate of SUDAN IV between a hydrophobic material and a cotton material.

(over)

SUDAN IV is a brown powder that reacts with a DNAPL, or an LNAPL, to form a red dye. The red dye causes a dramatic stain of the ribbon. With this technique one can locate the high concentrations of pooled DNAPL in the vadose zone.

The same reactive ribbon was installed for SRS at Cape Canaveral on January 19, 1999, below the water table. The ribbon was installed on a liner through the interior of the CPT rod (a 1" hole!). As the rod is withdrawn (via a FLUTe trick), the liner dilates in the hole, supporting the hole wall. After about an hour, the ribbon was recovered by inverting the liner from the hole. The result was as spectacular as the photo from the vadose zone installation. The DNAPL stains were found to correlate well with core sample results from a nearby hole.

This is a brand new application of the *FLUTe* everting liner method. Earlier, the FLUTe liners were also installed in CPT holes at SRS with 10 gas sampling ports in a 100 ft. length.

For more information on the everting liner method and the gas sampling with liners, see the *FLUTe* data sheets "Basic Function" and "Vapor/Liquid Sampling," at our web site (***www.flut.com***) or call 888-333-2433 (toll free).

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Standard Operating Procedure

For

Microwell Installation and Environmental Sampling by Site Characterization and Analysis Penetrometer System (SCAPS)

SOP No: M-0002-SWT-04

PREPARED BY:

(Author) (Date)

REVIEWED BY:

(SCAPS Manager) (Date)

(Environmental Services Coordinator) (Date)

(Quality Assurance Officer) (Date)

1.0 Scope and Application

1.1 Introduction

This standard operating procedure (SOP) is based on several technical reports and methods, which are referenced at the end of this document. This SOP describes the procedures used to monitor and sample microwells installed with the Site Characterization and Analysis Penetrometer System (SCAPS) currently deployed by the US Army Corps of Engineers Tulsa District. This SOP also discusses the techniques and methods by which soil and groundwater samples are collected as they relate to SCAPS operations.

Within the text of this document, a ***microwell*** **is defined as a small diameter monitoring well (£1 inch ID) used to monitor groundwater depth and quality. They may be permanent or temporary dependent upon project needs.**

1.2 Application

This SOP is applicable to the rapid investigation of subsurface contamination at hazardous waste sites.

1.3 Personnel and Training

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of SCAPS technology and familiar with monitoring well installation, soil boring installation, environmental sampling, and grouting techniques.

The SCAPS manager and environmental sampling coordinator will ensure all personnel are qualified and have received training relevant to the equipment and instruments currently possessed by the Investigations Section and used to support the District's SCAPS program. Additional District technical resources (chemists, industrial hygienists, geologists, etc.) will be used to support and augment SCAPS operations whenever required.

2.0 Method Summary

2.1 Introduction

This SOP describes the installation, monitoring, and sampling of microwells and soil borings by SCAPS.

The SCAPS system incorporates special penetrometers with sensors for contaminant detection and subsurface sampling equipment to map soil characteristics and contaminant distribution.

2.2 Cone Penetrometer System

Cone penetrometer testing (CPT) and standard penetrometer testing have been widely used in the geotechnical industry for determining soil strength and soil type from measurements of tip resistance and sleeve friction on an instrumented probe. The SCAPS uses a truck-mounted CPT platform to advance its chemical and geotechnical-sensing probe. The CPT platform provides a 20-ton static reaction force associated with the weight of the truck. The forward portion of the truck-mounted laboratory is the **push room**. It contains the rods, hydraulic rams, and associated system controllers. Beneath the SCAPS CPT push room is the steam manifold for the rod and probe decontamination system. The rear portion of the truck-mounted laboratory is the isolatable **data collection room** in which components of the CPT, onboard computers, and related support instruments are located.

2.3 Initial Site Survey

The site will be initially surveyed to locate underground utilities and underground obstacles to prevent damage to the SCAPS, ensure crew safety, and to prevent damage to utilities. Many sites contain a variety of underground hazards, such as telephone cables, gas lines, electrical power cables, water pipes, sanitary sewer lines, drainage pipes, and steam lines.

Once the survey has been completed, approximate locations for each planned penetration, soil boring, and microwell are determined based on such factors as proximity to suspected contaminant sources, anticipated groundwater flow patterns, suspected underground obstacles, cultural features, topography variations, and mobility limitations.

Dependent upon site conditions and field results, the SCAPS manager and technical manager will modify all penetrometer, soil boring, and microwell locations when appropriate.

2.4 "Dummy" Exploration

At the discretion of the SCAPS manager, a "dummy" tip will be advanced into the subsurface soil to probe for any unanticipated anomalies, which may hinder the intrusive exploration of the location. The "Dummy" tip contains no sensors or sampling tools that may be damaged.

2.5 Soil Classification by Cone Penetrometer Test

A series of locations will be selected to conduct soil classifications. Soil strength and type is determined by monitoring tip resistance and sleeve friction when the CPT probe is advanced through the subsurface soil.

The combination of the SCAPS's reaction mass and hydraulics can advance the probe into the ground at a rate of 1m/min in accordance with

ASTM Methods D3441 and D5778. The tip resistance is measured by means of a system of strain gauges that form an internal load cell as the cone tip is advanced. Friction developed along a floating cylindrical sleeve, just behind the cone tip, is measured similarly as the device passes through the soil. Tip penetration resistance and sleeve friction is measured independently and continuously. The point and sleeve friction load cells are independently calibrated in the field prior to cone penetrometer operation.

Soil classification is conducted on-board the SCAPS during field operations using a computer-based routine that references the strain gauge readings, the calibration curves and an empirical relationship between cone resistance and friction. The SCAPS instruments are capable of discriminating porous sands from tighter, finer-grade silts and clays.

2.6 Soil Boring Installation

For the installation of a soil boring, the SCAPS is moved into position over the selected location. Soil samples are collected using soil-sampling equipment such as the **Vertek**ä or **MOSTAP**ä sampler. These penetrometer tools are designed to recover soil samples in a configuration similar to the split spoon penetrometer where the soil is contained within a split stainless steel cylindrical sleeve. These samplers (2-inch OD by 24 inch length) have conical tips that are released at the starting depth for sampling to remain in place as the sampler cutting edge and barrel, or tube, is pushed to the final sampling depth. The samplers require that a lanyard must be pulled firmly upward at the beginning depth desired for sampling to effect tip release. The samplers retrieve a 1.5-inch diameter by 18-24 inch length (550-700 cm^3 internal volume capacity). The devices have several removable parts, all of which must be decontaminated prior to reassembly for subsequent sampling.

2.6.1 Sampling Technique

Once the soil sampler has been retracted with the desired soil-sampling interval, a field technician retrieves the sampler and opens up the cylindrical sleeve. The sampling interval is logged according to the Unified Soil Classification System (USCS) and visually evaluated for discoloration, odors, or other indications of contamination. Findings are documented in a field notebook. Clean, stainless steel utensils are used to extract the soil samples.

At a predetermined interval, an equipment blank will be collected. ASTM Type II water is poured generously over a cleaned pair of cylindrical sleeves and sampling utensils. This liquid is collected and containerized. This equipment blank will be used to monitor the decontamination procedures relating to a subsequent soil sampling event.

2.6.2 Sample Preservation, Containers, Handling, and Storage

Soil samples will be collected in appropriate containers which will be filled, preserved (when required), and chilled as soon as possible. Headspace within the container will be minimized whenever possible. The sampler will wear disposable latex gloves and will change to new gloves between each soil interval depth and location.

2.7 Microwells Installation

For the installation of a microwell, the SCAPS is moved into position over the selected location. The microwell is installed using the ***Power Punch***™ Water Sampler. In addition to the standard push rods, the ***Power Punch***™ sampler is comprised of a sacrificial drive point, sealing body, drive point holder and 0.75 inch ID polyvinyl chloride (PVC) slotted screen. The screen will be 0.75 inch ID (1.1 inch OD) schedule 40 mill slotted, precleaned, and wrapped PVC having 0.010 inch slots (10 slot). The screen length will be based upon job requirements. The sampler is attached to the push rod and advanced to the desired sampling depth. At the desired depth of placement, PVC pipe (0.75 inch ID/1.1 inch OD) is run down inside the penetrometer rods (1.875 inch OD) and connected to the existing screen and tip. During retraction of the penetrometer push rods, the sealing body is released to isolate the screened interval from the annular space above. The body is released by rotating the push rods at least one-half turn clockwise. The remaining push rods are then removed from the hole. The PVC pipe extending above the ground surface is trimmed to a height of 10 inches or less to allow the SCAPS truck to drive off of the location.

The ***Power Punch***™ sampler utilized by the District incorporates innovative direct push technology developed by GeoInsight. This tool allows the attached screen to be shielded as it is advanced through the subsurface soil, preventing damage, carry down of contaminants, and soil smearing of the screen. The tool automatically seals the screen in place and provides an annular seal so that grouting is often not necessary.

2.8 Microwells Stabilization and Measurement

Dependent upon site activities, geologic conditions, and analytical requirements, the microwells will be allowed to recover for a minimum of 30 minutes prior to measuring the water level and attempting to collect any groundwater samples. Several hours may be required for the microwells to sufficiently recover and produce an adequate groundwater sample.

Water level measurements will be taken after the microwells have been allowed to stabilize for 48 hours. Measurements will be taken after the microwell's cap has been removed and the well has stabilized for a minimum of five minutes.

Water levels will be recorded by using an electronic water level indicator capable of measuring the static water level. All meters will be properly decontaminated between each microwell location. The water level will be measured to the nearest 0.01 foot with respect to the established measuring point (notch) on the microwells. The measurement will be checked against previous water level data if available, and where an anomalous reading is indicated, remeasurement will occur until the reading is within 0.02 foot. All measurements will be recorded in a field book with indelible ink and will include the microwell number, date, time, measuring device (serial number), and field technician initials. The depth of the microwell will be measured and compared to the installation depth to determine if the well is accumulating fine-grained material.

If a hydrocarbon layer is encountered, the thickness of the layer will be measured if possible.

2.9 Groundwater Sampling

2.9.1 Purging Technique

The microwell will be sampled as soon as a sufficient volume of groundwater has been collected; as determined by measuring the water level. This will be accomplished as soon as possible, generally within 24 hours of the microwell installation. If for some reason sampling has not been conducted within the 24-hour time limit, the microwell will be purged prior to sampling.

A minimum of 3 casing volumes will be removed and the microwell will be allowed to recover. If the microwell does not adequately recover a sufficient volume of groundwater within 24 hours, the microwell will be considered to be "dry" and properly abandoned and grouted.

Purging of the microwell may be accomplished by two methods dependent upon water level depth. A peristaltic pump may be used to purge the microwells where groundwater levels do not exceed a depth of 28 feet. Small diameter disposable Teflon bailers are generally used to collect and purge groundwater at all levels. Small diameter stainless steel bailers may also be used to conduct purging activities.

Due to the generally small volume of groundwater recovered from the SCAPS installed microwells (≈500 ml), water quality measurements such as pH, conductivity, temperature, and turbidity are not routinely measured during purging activities. Such measurements may be collected when adequate groundwater recovery is present.

All purge water will be properly containerized, labeled, staged and managed in accordance with the overall project work plan.

2.9.2 Sampling Technique

As indicated in Section 2.8, sampling of the microwell will not occur until a minimum of 30 minutes has elapsed. Purging of the microwell will not be required if it is sampled within 24 hours of installation.

Groundwater samples will be collected with a Teflon or stainless steel bailer suspended from a dedicated Teflon coated monofilament line or through an in-line sample pump with inert tubing. All equipment, unless disposable or dedicated for that particular well location, will be properly decontaminated prior to sampling. Sampling equipment will be transported in sealed, clean containers, and care will be taken to avoid contamination. Non-disposable sampling equipment will be cleaned between well locations.

If a sufficient volume of groundwater is present, a sample will be collected and analyzed for various water quality parameters. At a minimum, these parameters will include pH, conductance, and temperature. Other conditions relating to odor, color, turbidity, etc. will be noted in the field book.

2.9.3 Sample Preservation, Containers, Handling, and Storage

Groundwater samples will be collected in appropriate containers which will be filled, preserved (when required), and chilled as soon as possible. The sampler will wear disposable latex gloves and will change to new gloves between each microwell location. Groundwater samples will not be filtered unless directed by the SCAPS manager or project chemist. Pre-preservation of sample containers will be performed when applicable.

2.10 Microwell Abandonment and Grouting

With regards to microwell abandonment, the ***Power Punch***™ tool utilized by the District allows the crew to disconnect and remove most of the microwell pipe, leaving the ***Power Punch***™ tip and screen in place. The excess piping is then containerized. This material will be disposed of as non-hazardous waste dependent site contamination and overall project work plan. The microwell location is then grouted.

Grouting will be performed to ensure that vertical cross contamination does not occur in the penetration, borehole, and microwell locations. Depending upon site conditions, the grouting material may be bentonite pellets or a mixture of either 40% silica flour and 60% portland cement or 5% bentonite powder and 95% portland cement. The grouting material will be extruded from the penetrometer tool during retractions or manually placed into the hole as the PVC riser pipe and /or screen is removed. Following push pipe retraction, additional grout will be added to bring the grout level to ground surface.

2.11 Decontamination

Dependent upon push depth and number of locations, a relatively small volume of decontamination fluids will be generated by SCAPS activities. Five to ten gallons of decontamination fluids will be generated for every 50 feet pushed with the CPT. As the penetrometer is retracted, a high-pressure hot water system is used to wash each rod section and remove possible contamination. The decontamination fluid is collected in a five-gallon bucket and transferred to a DOT certified steel drum or other approved container.

All equipment will be properly decontaminated prior to sampling. Sampling equipment and utensils will be transported in sealed, clean containers, and care will be taken to avoid contamination. Non-disposable sampling equipment will be cleaned between sampling locations. The decontamination process will begin with a non-phosphate detergent wash (**Liquinox**ä), followed by a series of distilled water rinses, and conclude with an air-drying step. Additional rinses with isopropyl alcohol may be required if gross contamination of the equipment is evident. Five to ten gallons of decontamination fluids will be generated every one to two days when soil samples are collected.

3.0 Method Limitations

3.1 Truck-Mounted Cone Penetrometer Access Limit

The SCAPS CPT support platform is a 20-ton Kenworth all-wheel-drive diesel powered truck. The dimensions of the truck require a minimum access width of 10 feet and a height clearance of 16 feet. Some sites, or areas of sites, might not be accessible to a vehicle the size of the SCAPS CPT truck. The access limits of the SCAPS CPT truck are similar to those for conventional drill rigs and heavy excavation equipment.

3.2 Cone Penetrometer Advancement Limits

The CPT sensors and sampling tools may be difficult to advance in subsurface lithologies containing cemented sands and clays, buried debris, gravel units, cobbles, boulders, and shallow bedrock. As with all intrusive site characterization methods, it is extremely important that all underground utilities and structures are located using reliable geophysical equipment operated by trained professionals before undertaking activities at a site. Local utility companies should be contacted for the appropriate information and approval when applicable.

3.3 Representative Groundwater Samples

The installation method does not provide the minimum 2-inch annular space between the diameter of the hole and the outside diameter of the PVC pipe, as recommended by widely followed guidelines for the construction of monitoring wells. Data generated from the analysis of groundwater samples collected from the microwells may not be accepted as being a truly representative groundwater sample. *It should be understood that the microwells are intended to provide a rapid and cost effective access to groundwater and allow a sample to be screened for the presence or absence of contamination. Formal monitoring wells may be constructed at a later time.*

4.0 Quality Assurance/Quality Control

4.1 Overview

Geotechnical and chemical data generated by field crews during the SCAPS investigation will be reviewed by personnel possessing the required skills necessary to evaluate and validate the results. A quality assurance (QA) officer will be assigned to the project to ensure that all data quality objectives for the project are adequately being met.

4.2 SCAPS CPT QA/QC

Initial system setup will require the calibration of a few components including, but not limited to, the point and sleeve friction load cells, strain gauges. Calibrations will occur whenever a different probe assembly is used.

4.3 Environmental Sampling QA/QC

The QA officer evaluates the data generated from environmental sampling activities with regards to project specific quality assurance objectives, i.e., Precision, Accuracy, Representativeness, Comparability, Completeness, and Sensitivity. Specific analytical sample types are selected to adequately address overall project QA objectives. They include:

- Quality Assurance/Quality Control Duplicate Samples - Dependent upon sample volume/recovery, quality assurance (QA) and quality control (QC) duplicate samples will be collected on a site-specific basis and in accordance with the project work plan. The QA sample is shipped to a separate laboratory other than the laboratory (field) performing the field and QC samples. Results from these samples assist in evaluating overall sampling and analysis techniques.

- Equipment (Rinsate) Blanks - One equipment blank will be collected and analyzed on a site-specific basis and in accordance with the project work plan. Equipment blanks are routinely collected whenever the same sampling equipment is used repeatedly. Results from these samples assist in evaluating decontamination procedures and equipment cross-contamination.

- Travel (Trip)/Temperature Blanks - Travel (trip) will accompany all aqueous sample shipments; specifically with those samples being collected and analyzed for volatile organics. Travel (trip) blanks are collected and analyzed to assist with evaluating cross-contamination among each volatile organic sample shipment.

  Temperature blanks will accompany all sample shipments. Temperature blanks are collected and submitted to evaluate the temperature of the sample cooler upon arrival at the laboratory.

5.0 Waste Disposal

Decontamination fluids and other investigative derived wastes (IDW) generated during SCAPS activities will be properly containerized, staged, labeled, and managed in accordance with the overall project work plan. The volume of waste will be minimized whenever applicable. Soil, liquid, and personal protective equipment (PPE) IDW will be separately containerized and segregated. The PPE will be disposed of as nonhazardous waste unless it has been grossly contaminated or is determined to be contaminated by site data.

6.0 Health and Safety

A site-specific safety and health plan will be developed for SCAPS and related activities. All field personnel will attend safety meetings scheduled by the SCAPS field manager and industrial hygiene officer.

All field personnel will follow current OSHA standards and regulations documented within USACE's EM385-1-1.

7.0 References

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STANDARD OPERATING PROCEDURE:
Installation and Development of Monitoring Wells
Phase II RI, East Gate Disposal Yard, Fort Lewis, Washington

The sonic drilling work to be performed includes drilling 19 continuous borings to varying depths up to a maximum of 120 feet and installing wells in these borings. The borings will be drilled to characterize the extent of NAPL contamination and define the subsurface geology. Soil will be logged continuously in all the boreholes by the URS field geologist and samples will be collected for analysis at designated intervals. Soil samples will be collected and analyzed. Eleven of the deep wells (120 feet bgs) will be completed as multiport wells for groundwater sampling from multiple levels. The remaining 8 monitoring wells will be completed as 2-inch wells for NAPL monitoring and sampling.

Soil Sampling

The borings will be drilled using a 6-inch-outer-diameter casing and either a solid-tube or split-tube core barrel to collect soil samples. The core barrel will be advanced ahead of the casing for sample collection to prevent cross contamination between sample intervals. Soil samples will be collected continuously from the surface to the total depth of the hole (determined in the field by the geologist). Soil samples will be vibrated out of the core barrel and into a plastic sleeve, knotted at both ends. The borings may be completed as monitoring wells to a depth to be determined by the USACE representative, in accordance to the specifications outlined below.

The drillers and geologists shall wear clean nitrile gloves during all drilling, decontamination and sampling activities. Gloves shall be changed prior to each soil sample collected and between each borehole.

Precautions shall be taken to fully contain water and soil cuttings produced during borehole drilling, sampling, backfilling, and decontamination of equipment. To minimize the potential for surface contamination, drill cuttings will be contained using 4-millimeter thick plastic sheets encircling the area adjacent to the drill flight. During drilling, borehole cuttings generated will be transferred from the plastic sheets to a staging area in EGDY with a dump truck or loader provided by the sonic contractor.

Boreholes left open after drilling will be covered with a minimum ¼-inch plywood and safety cones will be placed around the location until the borehole is backfilled. All completed holes shall be backfilled by the end of each day, in accordance with this SOP.

Monitoring Well Installation

Nineteen monitoring wells may be installed in the boreholes with a total maximum depth of approximately 120 feet for the deepest wells. Eleven of the monitoring wells possibly will be installed to the top of the Kitsap Formation (110 to 120 feet) and completed as multiport wells, with the remaining 8 wells completed as standard single-casing wells. The standard monitoring wells will be drilled using 6-inch-diameter casing. For borings advanced to the lower unit of the upper aquifer, a 10-inch casing will be advanced into the top of the intermediate aquitard. To avoid cross-contamination between the upper and lower aquifer units, the 10-inch hole will be cleaned out and the bottom sealed with bentonite. The top of this grout seal must be sounded for depth to ensure proper thickness and placement. A 6-inch casing will then be advanced into the lower unit of the upper aquifer.

Monitoring Well Construction

The standard (non-multiport) wells will be constructed with 2-inch-diameter schedule 80 PVC casing with a riser, locking well cap, and pre-packed, stainless steel, wire wrapped, well screen. The standard wells will have 10-foot screened intervals with 0.020-inch slotted PVC screen and will be prepacked with a sand filter pack consisting of clean No. 20 Monterey sand. The No. 20 Monterey sand (filter pack) will extend at least 1 foot below the screened interval and extend 3 feet above the screen interval. The sand will be placed below and above the prepacked screen using a tremie pipe. The top of the filter pack will be continuously sounded during retraction of the temporary casing by the drilling contractor to ensure that the filter pack remains within the casing during removal. A bentonite clay seal will be placed above the filter pack with a maximum thickness of 5 feet and shall not be placed within NAPL (if present). The seal will be installed using ¼-inch-diameter bentonite pellets and the minimum hydration time for the bentonite seal will be 1 hour. Halliburton Class G - 40% silica flour cement grout will be mixed with a mechanical grout mixer (progressive cavity pump) and placed from the top of the clay seal to the ground surface using a tremie pipe. Centralizers will be placed at the top and bottom of the well and every 40 feet in between. The drilling contractor shall furnish and use stainless steel centralizers for centralizers that contact the ends of the screen and PVC centralizers for centralizers that contact the mild steel riser.

The wells may be screened at a depth other than the final depth of the boring. The difference between the final depth of the boring and the bottom of the well screen may be significant and may require the placement of a silica cement grout seal below the well screen using a tremie pipe. Sufficient time (i.e., 72 hours) will be required to allow the grout to set before constructing the well. The multiport monitoring well system will be built completely above ground at the project site and inserted into the boring prior to withdrawing the temporary casing. Screened intervals will be selected by a government representative based on the boring logs.

Each multiport well shall consist of continuous, extruded polyethylene tubing and be constructed such that at least four sampling ports can each be accessed for groundwater sample collection and water level measurements. The ports shall be hydraulically separate from each other and accessible to groundwater by screens installed on site. The screen size shall be designed to prevent sand and silt from entering the well ports. Each multiport well shall be self-contained; that is, the sampling ports shall all be contained within one well stem. No “nested” wells of multiple well stems in the same borehole will be allowed. Centralizers shall be secured to the outside of the well stem every 40 feet. Static depth to groundwater in well locations varies from approximately 10 to 30 feet below ground surface.

Any tubing used in the multiport well design shall be furnished at the work site in continuous lengths to reach the required depths for sampling. Tubing lengths shall not be joined together, but instead shall be continuous lengths between the ground surface and sampling ports. All multiport well components, including but not limited to sampling ports, wire mesh screen, double valve pumps, sample tubing, PVC casing or extruded polyethylene well tubing shall be assembled in the field into a multiport well system beside the temporarily cased borehole. The multiport monitoring well shall be installed with sand filter pack and bentonite seals between discrete sampling ports.

Filter pack in the multiport wells shall consist of clean, washed, rounded to sub-rounded siliceous material free from calcareous grains or material. Organic matter, soft, friable, thin, or elongated particles are not permissible. Quantities to complete monitoring well installations shall be as specified in the field. The artificial filter pack (Nos. 10-20 and 20-40 silica sand) shall be installed around the well screen from the bottom of the screen to approximately 3 feet above the top of the well screen. A secondary filter pack consisting of a 1- to 2-foot-thick layer of washed No. 20-40 silica sand shall be placed on top of the screen filter pack material in conventional wells to prevent grout sealing materials from migrating down the well bore into the filter. The finer grained, secondary filter pack will not be required for multiport well installations.

The bentonite seal for conventional type wells (non-multiport), intended to keep grout from entering the filter pack, shall consist of hydrated, sodium montmorillonite in pellet form furnished in plastic-lined sacks or buckets from a commercial source and free of impurities that adversely impact the water quality. Bentonite pellets shall be commercially formed into approximately 3/8-inch- to ½-inch-diameter spherical or cylindrical shapes. Bentonite pellets shall contain no additives such as synthetic or organic polymers. Either pumpable, high-solids bentonite grout slurry or dry, granular bentonite made for the environmental drilling industry shall be used for bentonite seals in multiport wells. Injection of dry, granular bentonite seals will be allowed for multiport well construction when conditions allow. A 3- to 5-foot-thick bentonite plug shall be placed on top of the filter pack for conventional type (non-multiport) monitoring wells. Bentonite pellets shall be slowly poured into the annular space between the drill casing and the well riser. The drill casing shall be pulled as the bentonite is added to prevent creation of a bridge between the drive casing and the riser. Bentonite shall be added until the plug is at least 3 feet thick, as verified by repeated measurements with a sounding line. Annular grout sealant shall not be added until the bentonite plug has been allowed to hydrate at least 1 hour.

For well seals placed above the water table, potable water shall be used to hydrate the pellets. For multiport wells, injection of either pumpable, high-solids bentonite grout slurry or dry, granular bentonite shall be used for bentonite seals. The bentonite seals will be injected through a grouting tube with its discharge at the point of placement while casing is being pulled. Seals shall be placed in a method that insures minimal disturbance of the filter packed zone. Seals shall be placed between pre-determined, sand-packed sampling zones. Thus, multiport well bentonite seals will vary in thickness depending on the length of annulus between sampling zones. For multiport well bentonite seals, sufficient time shall elapse to allow for either in situ slurry or dry bentonite swelling prior to the construction of the next filter packed zone. The top of each bentonite seal must be sounded for depth to ensure proper bentonite emplacement. Multiport system design and well component materials will be dependent upon the aquifer characteristics in which the well is installed.

Monitoring Well Development

The deep monitoring wells will be developed by low-flow pumping. The shallow wells will not be developed because these are intended to be used as NAPL sampling wells, and development would cause loss of NAPL. Due to the small diameter and fragile nature of the multiport monitoring wells, development will include low-flow pumping until water quality parameters stabilize.

During development, groundwater quality parameters (pH, temperature, specific conductance, oxidation-reduction potential [ORP], dissolved oxygen, and turbidity) will be monitored. Measurements will be collected at intervals of approximately 10 to 20 minutes. When readings stabilize, purging will cease. The stabilization guidelines are three successive readings within +/- 0.1 for pH, +/- 3 percent for conductance, +/- 10 percent for temperature, turbidity, and DO, and +/- 10 mV for ORP. A turbidity reading of 10 NTUs or less is desirable. The information will be documented on a monitoring well development data sheet (Appendix B). If the indicator parameters do not stabilize, purging will cease at the discretion of the USACE.

At the end of development, the drillers will clean all sediment from the bottom of the well. The development water will be pumped into 55-gallon drums and transported to EGDY to be placed into a government-provided Baker tank. Liquid will be subsequently pumped off into the Fort Lewis sanitary sewer system after sufficient time has passed to allow solids to settle out. Wells with NAPL present will not be developed, at the discretion of the USACE representative.

Well Completion

Flushmount or steel riser completions shall be determined in the field by the USACE representative and shall depend on the site conditions. Wells will be completed using a 5-foot length of steel casing. Steel riser completions shall extend 2.5 feet above ground surface. The casing will be installed on the same day the grout is placed. A 4-foot square protective concrete pad approximately 6 inches thick and 3 inches below ground surface will be poured around the steel casing. The pad shall slope away from the casing to prevent water from pooling adjacent to the casing. A locking cover will be installed on top of the protective casing. Padlocks and survey markers will be provided by the government and will be placed on each monitoring well.

Decontamination

The drilling contractor will decontaminate all equipment that will be placed into the borehole and all equipment that may come in contact with soil samples. Equipment will be decontaminated prior to and after each boring. All decontamination water can be allowed to infiltrate on the ground surface near the borehole. The drilling contractor will provide 5-gallon buckets and three clean brushes for decontamination of the split spoon sampler. The drilling contractor will wear clean nitrile gloves during decontamination activities. Decontamination procedures for drilling equipment are as follows:

- Rinse with a pressure steam cleaner
- If visible dirt or oil is present on the equipment, wash with detergent and potable water, and rinse with pressure steam cleaner
- Air dry

The drilling contractor will decontaminate sampling equipment, including samplers and sample sleeves prior to sample collection. Decontamination procedures are as follows:

- Wash with Alconox and water solution
- Rinse with potable water
- Rinse with distilled water
- Air dry

Borehole Abandonment

Once sampling of the borehole has been completed, the drilling contractor will abandon the borehole if a monitoring well will not be installed. Halliburton Class G - 40% silica flour cement grout shall be used to abandoned the boreholes, with 7.5 to 9 gallons of water per 90-pound sack of cement. Grouting material will be mixed with a mechanical grout mixer and pumped through a tremie pipe in one continuous operation from the bottom of the interval to be sealed to the top. Boreholes will be abandoned in compliance with the state and county well abandonment requirements.

SEATTLE DISTRICT HTRW DESIGN CENTER
STANDARD OPERATING PROCEDURES

22 March 1999

US Army Corps
of Engineers
Seattle District

Table of Contents **Page**

LOW-FLOW GROUND WATER PURGING AND SAMPLING USING DEDICATED BLADDER PUMP SYSTEM

STANDARD OPERATING PROCEDURES

1.0 PURPOSE

This Standard Operating Procedure provides general information on low flow minimal draw down ground water purging and sample acquisition from a HTRW monitoring well with dedicated (left in place) bladder pump system. This SOP is intended to provide field personnel with a uniform approach to routine ground water sampling tasks using the low flow method.

2.0 SCOPE

This guideline describes equipment and method for the low flow purging and collection of ground water sample from the saturated zone. Review of these guidelines will also assist in the development and execution of a low flow purging and sampling plan that will provide meaningful and representative data.

3.0 DEFINITION

Low flow purging and sampling using dedicated bladder pumps is an EPA recommended method and is an acceptable method to use for USACE projects. The low flow purging and sampling technique induces laminar (non-turbulent) flow in the immediate vicinity of the sampling pump intake, thus drawing fresh ground water directly from the aquifer, horizontally through the well screen and into the sampling device. Low flow pumping rates are in the approximate range of 0.1 to 0.5 liter/minute. These low flow rates minimize disturbance in the aquifer, resulting in: (1)minimal production of artificial turbidity and oxidation; (2)minimal mixing of chemically distinct zones; (3)minimal loss of volatile organic compounds; and (4)collection of representative samples while minimizing purge volume.

4.0 GUIDELINES

4.1 General

Efficiency and cost-effectiveness of a sampling program will be increased by planning before starting the sampling operation. Well construction must be reviewed in order to specify the equipment and procedures to be used during purging and sampling. A table of well specifications that includes at least the well depths, casing diameters, screened intervals, recovery rates, and water level measurements is to be provided in the Project Sampling and Analysis Plan. Mobilization of equipment will be faster if accessibility of each well location is verified, the wells are accurately plotted on a site map, and the sampling order is determined in advance.

4.2 Purging, Sampling, and Monitoring Supplies and Equipment

The following is a general list of supplies and equipment that will be required when sampling monitoring wells.

- Accident Prevention Plan
- Project Sampling and Analysis Plan
- Personal protective equipment (e.g., gloves, rain gear or Tyvek-type disposable paper suits, steel toe boots, safety glasses)
- First aid kit
- Keys for well locks
- Dedicated purge and sample equipment (Well Wizard or equivalent dedicated pump with stainless steel casing and Teflon bladder, stainless steel inlet screen, Teflon-lined polyethylene twin bonded tubing with 3/8” OD sample tube and ¼” OD air line, 2” or 4” well caps with 3/8” OD discharge and ¼” OD air supply fittings and access hole for water level measurements, 3/8” OD dura-flex discharge adapter)
- In-line flow cell with multi-parameter meter that measures and displays pH, conductivity, temperature, dissolved oxygen, and oxygen-reduction potential (MicroPurge Flow Cell Model FC4000 or equivalent in-line flow cell which allows for interchanging of sensor probes).
- Pump controller (MicroPurge Smart Controller Model 400 or equivalent)
- 12 volt DC air compressor, 0.21 SFM @ 100 psi; maximum lift of 75 feet
- Oilless Air Compressor, 4.3 SCFM @ 100 psi; maximum lift of 200 feet
- Turbidity meter (LaMotte Turbidity Meter Model 2008 or equivalent)
- Photoionization detector (MicroTip Model HL-2000 or equivalent)
- Combustible gas indicator (Cannonball Biosystems. Inc. or equivalent)

- Electric water level measurement meter
- Standards and gasses for calibration (e.g., pH, conductivity, turbidity, PID, CGI)
- Pyrex measuring cup
- Stop watch
- Calculator
- Temperature and trip blanks, as specified in the SAP
- Sample preservation(e.g., deionized water, acids, pipettes, pH paper)
- Sample containers(e.g., glass or polyethylene of specific volumes)
- Sample shipment ice chest coolers
- Cold packs or ice for sample preservation in shipment coolers
- Plastic freezer bags to contain ice
- Bubble wrap plastic bags for sample containers
- Packing material to prevent sample containers from breakage during shipment
- Fiber and clear tape
- Chain-of-custody labels, record forms, custody seals, and ground water purging and sampling log sheets. Ground water purging and sampling log sheet is attached.
- Measuring tape
- Log book and indelible ink pen
- Decontamination equipment(e.g., tap and distilled water, non-phosphate soap, buckets, sponges, brushes)
- Camera and film
- Tool box
- D.O.T. approved gasoline storage container for air compressor

- Paper towels and/or rags
- Plastic sheeting (Visqueen)
- Distilled water sprayer used for decontamination
- Scissors and/or razor knife
- Trash bags
- Extra batteries and/or battery packs
- Express mail air bills

Once all the equipment is gathered and checked to determine that it is clean, properly packaged and in working order, the actual procedures for obtaining the samples must be selected. Well sampling is discussed in the next eleven sections in the order that it is performed:

1) Sample Preservation
2) Trip Blanks
3) Equipment Calibration
4) Well Condition Check and Contamination Prevention
5) Air Monitoring
6) Water Level Measurement and Monitoring
7) Initial Pump Installation
8) Low-Flow Purging
9) Sample Collection
10) After Completion of Sampling
11) Decontamination

4.3 Sample Preservation

The appropriate sample containers will be prepared in advance of actual sample collection for analytes of interest and include sample preservative where necessary. Preservatives will be added to the sample containers in a controlled setting prior to entering the field in order to reduce introducing field contaminants into the sample container while adding the preservatives. The preservatives will be transferred from the chemical bottle to the sample container using a disposable pipette. The pipette will be used for only one preservative type and then discarded after adding the specific preservative in the required group of sample containers. The pH of VOA samples will be checked by filling an extra vial with sample water and checking the pH with pH paper once per sampling event.

4.4 Trip Blanks

Trip blanks are used to assess the potential induction of contaminants from sample containers or during the transportation and storage procedures. Trip blanks are not opened in the field. Trip blanks are prepared only when VOC samples are taken and are analyzed for VOC analytes. Trip blanks will be prepared in the USACE Seattle District laboratory by filling 40 ml volatile organic analyses (VOA) vials with reagent grade water prior to commencement of field work. Trip blanks will be preserved following the same procedure as investigative samples. One trip blank will accompany each cooler containing VOC samples sent to the laboratory for analysis.

4.5 Equipment Calibration

Prior to and following each day of sampling, all sampling device and monitoring equipment will be calibrated according to manufacturer's recommendations. Calibration documentation including date, time, and the initials of the person that performed the calibration will be recorded in the logbook.

A MicroPurge   Flow Cell Model FC4000 or equivalent will be used to simultaneously measure the pH, conductivity, water temperature, dissolved oxygen (DO), and oxidation reduction potential (Eh) of the water and aqueous solutions. The pH sensor will be calibrated at 2 points. One at neutral point (pH 7 buffer) and the second at pH 4 if the sample is expected to be acidic or pH 10 if the sample is expected to be basic. The conductivity sensor should be calibrated with a standard close to the conductivity range as the water to be sampled and performed at a temperature close to 25 degrees centigrade. This will minimize temperature compensation errors. Before calibrating the DO sensor, check condition of the membrane and change it if bubbles are visible under the membrane, if significant deposits of dried KCL electrolyte are visible on the membrane or O-ring, and/or if the probe shows unstable readings or other malfunction. For DO sensor calibration follow the detailed calibration procedure found in the MicroPurge   Flow Cell Model FC4000 User Guide manual or equivalent.

A dissolved oxygen Hach limnology kit or equivalent will be used on a site-specific basis as a quality control check on the DO sensor. The temperature and Eh sensors are factory calibrated, but should be checked on a regular basis. The temperature sensor should be checked by immersing it in water at a known temperature value. The Eh sensor should be checked by immersing it in a solution with a known oxidation reduction potential value, “Zobell” solution is recommended. Temperature and Eh sensors that cannot be factory recalibrated should be replaced if readings vary more than ±10 percent.

A MicroTIP, Model HL-2000, or equivalent hand held air monitor/photoionization detector(PID) will be used to measure the total concentration of airborne photoionizable gases and vapors released from the wells. The PID will first be calibrated to zero air followed by isobutylene span gas at 100 ppm +/- 5%.

A LaMotte Turbidity Meter, Model 2008, or equivalent will be used to measure the turbidity of the ground water. Turbidity standards, AMCO Turbidity Standard 0.5 NTU or 5.0 NTU, will be used to calibrate the meter.

A combustible gas indicator(CGI), Biosystems,Inc. Cannonball, or equivalent that will respond to all combustible gases and vapors will be used when specified in the Project Sampling and Analysis Plan. The CGI will first be calibrated to zero air followed by LFL propane span gas at 52.4 %.

4.6 Well Condition Check and Contamination Prevention

Check and record the condition of the well for any damage or evidence of tampering. To prevent contamination of the surface soils and the equipment, lay out a plastic sheeting around the wellhead and place the monitoring, purging and sampling equipment on the sheeting.

4.7 Air Monitoring

Measure total organic vapors upwind from the well to obtain a background reading using a PID equipped with a 10.6 eV lamp. Unlock well and remove well cap. Measure head space with the PID. For wells installed on a landfill or sites where combustible gas may be present, also measure head space with a CGI. If measurements indicate it is not safe, take necessary precautions noted in Health and Safety Plan.

4.8 Water Level Measurement and Monitoring

An electric water level meter will be used to measure the water level in the wells before purging, during purging, and after sampling. The water level probe should be carefully lowered down the well to minimize disturbance. Check water level periodically to monitor draw down as a guide to flow rate adjustment. The goal is minimal draw down, less than 4 inches during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval and may require adjustment based on site-specific conditions.

Measure the water level to the nearest 0.01 foot. Water level will be measured from the notch located at the top of the well casing. If well casing is not notched, measurement will be taken from the north edge of the top of the well casing, and a notch will be made using a decontaminated metal file.

Well depth should be obtained from well logs prior to entering the field. If well depth measurement is required, measure depth after sampling is complete.

4.9 Initial Pump Installation

The pump intake shall be positioned in the middle of the screened interval for wells with screen lengths less than or equal to 5-feet. For wells with longer screens, the pump intake shall be placed within the most productive zone. Therefore, the geologic log for each well shall first be consulted to determine the most productive zone. If at all possible, the pump intake shall not be placed within 2-feet of the well bottom or low water level.

4.10 Low-Flow Purging

Set up air compressor, pump controller, and in-line low flow cell to manufacturer specifications.

Begin purging at rate of 0.1 to 0.5 liters/minute. The appropriate and final purge rate will be determined by monitoring ground water draw down controlled by site specific conditions. If in-line flow meters are not used, pumping rates should be determined by collecting a measured aliquot of purge water over a period of at least one minute. The discharge during purging and sampling must produce a non-pulsating flow. The water level should stabilize and ideally the pump rate should be sufficiently low to allow an equal or greater amount of water to recharge the well so little or no water level draw down is observed.

Measure and record ground water levels at least every 2 to 5 minutes until stabilization occurs. After stabilization, measure water levels at regular intervals. If significant draw down occurs, more than 4 inches, lower the speed of the pump and repeat discharge and water level measurements. Repeat until the water level stabilizes to closely match the recharge rate. Record pumping rate and any adjustments and depths to water on the purging and sampling log sheet.

Prior to and during purging, historic water quality parameter data shall be used to assist with evaluating stabilization. Any significant deviations will be recorded in the field sampling log book.

During purging, water chemistry indicator parameters will be measured continuously, every 2 to 5 minutes, until the parameters have stabilized. The water chemistry indicator parameters monitored shall include pH, temperature, conductivity, redox potential (Eh) and dissolved oxygen (DO). Turbidity shall also be measured, but shall not used as a stabilizer indicator. However, turbidity values should not exceed 10 NTU’s. The required indicator parameters to be monitored will be specified in the Project Sampling and Analysis Plan. As a guideline for stabilization, all indicator parameters should have stabilized for three successive readings. The 3 successive readings should be within +/- 0.1 for pH, +/- 3% for conductivity, +/- 10% for temperature, DO, and Eh. Eh and DO usually require the longest time for stabilization. The above stabilization guidelines are provided as estimates and will not be appropriate for use in all circumstances. The purge stabilized indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable parameter values during purging. Purging will continue until the indicator parameters have stabilized to within the specified tolerance for each parameter and graph out asymptotically. It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter particularly with respect to draw down, flow rate, and sampling device. Fifteen to 30 minutes of purging at a rate of 0.1 to 0.5 liter/minute may be required to reach stabilization. Purging will cease if the indicator parameters do not stabilize within 60 minutes of elapsed purging time.

The ground water should not be exposed to the atmosphere prior to measurement of the parameters because turbulence, degassing, aeration, heating, and depressurization can all cause significant changes in Eh, conductivity, and DO concentrations. Therefore, an in-line multi-parameter flow-through cell will be utilized when monitoring the indicator parameters.

All water produced during purging will be containerized and stored pending evaluation of acceptability for discharge or treatment.

Unless absolutely necessary, the pump will not be turned off between the purging and sampling process.

Wells installed in very low permeability formations(<0.1 L/min recharge) will require alternative purging and sampling methods. Use of the usual low flow techniques may be impractical in this type of environment, because devices to pump at such low flow rates are not readily available. The primary consideration is to avoid de-watering of the well screen and exposing the filter pack or formation in the saturated zone to atmospheric conditions. This may entail acquiring the sample with no or very little purging(volume of the tubing and pump chamber) and repeated recovery of the water. This may require that the water chemistry parameters be measured more frequently(every 1 to 2 minutes). Satisfying the usual sample volume requirements may also be a problem and some latitude will be needed on the part of the end-users. To ensure that the appropriate technique and methodology for purging and sampling collection is used, information on well construction and development is needed prior to the start of field activities. The decision on the purging and sampling collection technique and methodology to employ will be dictated by site specific conditions and objectives covered in the Project Sampling and Analysis Plan.

4.11 Sample Collection

Sampling can be initiated after the water chemistry indicator parameters have stabilized. Before collecting samples, sampling personnel will don clean, Nitrile or equivalent protective gloves. Sampling should occur in progression from least to most contaminated well if this is known. Samples will be collected directly from the end of the discharge tubing maintaining the established low flow purge rate. The sequence in which the different types of samples are collected is immaterial.

While filling the sample vial for VOC analysis, formation of air bubbles, aeration, and turbulence should be minimized by using the established low flow rate. A meniscus should be formed over the mouth of the vial to eliminate formation of air bubbles and head space prior to capping.

When pouring the sample from the discharge tubing into the sample bottle, the sample water will be poured gently down the inside of the bottle with minimal turbulence. After filling the sample container, the Teflon-lined cap will be screwed tightly to prevent the container from leaking. A sample label will be filled out and placed on the sample container as specified in the Project Sampling and Analysis Plan. The samples will be stored and shipped at 4°C. All samples will be shipped to the laboratory within 48 hours of collection.

The intent of low flow purging and sampling is to minimize disturbance in the well and thus eliminate the need for filtering samples for inorganic analyses. The unfiltered sample is meant to represent the total mobile contaminant load. However, filtering of samples collected for inorganic analyses may be recommended in some instances. The decision to filter samples will be dictated by site specific sampling objectives covered in the Project Sampling and Analysis Plan.

If filtering is performed, in-line filters will be used. The filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of one liter of ground water following purging and prior to sampling.

4.12 After Completion of Sampling

The air inlet and discharge lines shall be carefully removed from their respective well cap fittings Place protective cap on the air inlet and discharge fittings. Close and lock the well. Between all sampling locations, all sampling equipment that comes in contact with the well water(eg. water level meter, turbidity vials) will require decontamination**.** All non-dedicated supplies and equipment will be gathered and disposed of properly.

4.13 Decontamination

The water level meter and water chemistry parameter indicator sensors will be decontaminated according to the following procedures:

1. The water level meter will be hand washed with phosphate free detergent with a scrubber or sponge, then thoroughly rinsed with distilled water.

2. The parameter indicator meter probes will be rinsed with clean tap water after each measurement. No other decontamination procedures are necessary or recommended for these instrument probes and vials since they are very sensitive, and they do not contact in-situ well and sample water. After the sampling event, the flow cell chamber and sensors will be cleaned and maintained as necessary according to the care and maintenance procedures found in the MicroPurge Flow Cell Model FC4000 User Guide manual or equivalent.

End of Standard Operating Procedures

Appendix B
Standard Field Forms

Appendix B
Standard Field Forms

SCAPS Tulsa District Corps of Engineers CPT/LIF Report Form

HTRW Drilling Log

Groundwater Sampling Data Sheet

Well Development Report

EPA Region 10 Field Sample Data and Chain of Custody Sheet

Cooler Receipt Form

Daily Chemical Quality Control Report

NAPL Thickness/Sampling Form

SCAPS
Tulsa District Corps of Engineers
CPT/LIF Report Form

Push ID: ____________________ Tool ID:________ Date: ______________

Total Push Depth: ________________ Time Push Completed: __________________

Grout: ______________________________________

Comments: ____

++

Push ID: ____________________ Tool ID:________ Date: ______________

Total Push Depth: ________________ Time Push Completed: __________________

Grout: ______________________________________

Comments: ____

++

Push ID: ____________________ Tool ID:________ Date: ______________

Total Push Depth: ________________ Time Push Completed: __________________

Grout: ______________________________________

Comments: ____

++

Push ID: ____________________ Tool ID:________ Date: ______________

Total Push Depth: ________________ Time Push Completed: __________________

Grout: ______________________________________

Comments: ____

HTRW DRILLING LOG

DISTRICT

HOLE NUMBER

1 COMPANY NAME

2. DRILL SUBCONTRACTOR

SHEET OF SHEETS

3 PROJECT

4 LOCATION

5 NAME OF DRILLER

6 MANUFACTURER'S DESIGNATION OF DRILL

7 SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT

8 HOLE LOCATION

9 SURFACE ELEVATION

10 DATE STARTED

11 DATE COMPLETED

12 OVERBURDEN THICKNESS

15 DEPTH GROUNDWATER ENCOUNTERED

13. DEPTH DRILLED INTO ROCK

16 DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED

14 TOTAL DEPTH OF HOLE

17 OTHER WATER LEVEL MEASUREMENTS (SPECIFY)

18 GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19 TOTAL NUMBER OF CORE BOXES			
20 SAMPLES FOR CHEMICAL ANALYSIS	VOC	METALS	OTHER (SPECIFY)	OTHER (SPECIFY)	OTHER (SPECIFY)	21 TOTAL CORE RECOVERY %
22. DISPOSITION OF HOLE	BACKFILLED	MONITORING WELL	OTHER (SPECIFY)	23 SIGNATURE OF INSPECTOR		

LOCATION SKETCH/COMMENTS

SCALE:

PROJECT

HOLE NO

ENG FORM 5056-R, AUG 94

(Proponent: CECW-EG)

HTRW Drilling Log

HTRW DRILLING LOG (CONTINUATION SHEET)

PROJECT	INSPECTOR	HOLE NUMBER
		SHEET OF SHEETS

ELEV (a)	DEPTH (b)	DESCRIPTION OF MATERIALS (c)	FIELD SCREENING RESULTS (d)	GEOTECH SAMPLE OR CORE BOX NO (e)	ANALYTICAL SAMPLE NO (f)	BLOW COUNT (g)	REMARKS (h)

PROJECT	HOLE NO.

ENG FORM 5056A-R, AUG 94

(Proponent: CECW-EG)

GROUNDWATER SAMPLING DATA SHEET

Project Name: __________
Project/Task No.: __________
Date: __________
Weather: __________
Samplers: __________
Purge Method: __________
Sample Method: __________
Sampling Device: __________
Tubing Type: __________
Pump Intake Depth: __________
Water Disposal/quantity: __________

Sample Number: __________
Station Type: __________
Station Number: __________
Well Condition: __________
Well Diameter: __________
Screen Interval: __________
Measuring Point (MP): __________
Elevation of MP: __________
Elevation of Water: __________
Depth to bottom: __________
Depth to water: __________
Depth to NAPL: __________
NAPL thickness: __________

Field Test Kit Results:

PID: __________
DO: __________
Alkalinity: __________
Ferrous Iron: __________
Other: __________
____

Meter Information:

	Model	Calib. Date
pH:		
Eh:		
Conductivity:		
DO Meter:		
Turbidity:		
Temperature:		
Other:		

Containers:

Analysis	Type	#-Primary	#-MS/MSD

QA/QC Samples:

Duplicate: __________
Replicate: __________
MS/MSD: __________
Blank: __________

Comments:

Field Parameters	Units	0 Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes
Temperature								
pH								
Conductivity								
Eh								
DO								
Turbidity								
Time								
Water Level								
Flow Rate								

Field Parameters	Units	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Sample
Temperature								
pH								
Conductivity								
Eh								
DO								
Turbidity								
Time								
Water Level								
Flow Rate								

WELL DEVELOPMENT REPORT

Project________________ Well No.________ Depth________ Datum________
Contractor________ Rig________ Operator________ Inspector________

Date	Method	Duration	Depth	Discharge		Sediment		Remarks
				Rate	% sand	Grain size	Volume	

EPA
EPA Region 10
1200 Sixth Avenue
Seattle WA 98101

FIELD SAMPLE DATA AND CHAIN OF CUSTODY SHEET

Case No.: ____________
Project Code: ____________ Account: ____________
Name/Location ____________
(EPA Lab Only, Leave Blank for Contract Lab)
Proj. Off.: ____________ Tel.# ____________

☐ Enforcement/Custody
☐ Data Confidential
☐ Possible Toxic/Hazardous
☐ Data for STORET

Miscellaneous: ____________

Sampling Crew: ____________

Recorder: ____________
(Signature Required)

SOURCE CODE	Matrix					# CONTAINERS							LAB NUMBER			STORET STATION NUMBER	SAMPLING DATE & TIME				TRAFFIC REPORT NUMBERS		SAMPLER'S INITIALS	STATION DESCRIPTION
	Oil	Water	Sediment	Tissue	Prsrvd (Y/N)	Qt. Cubit	Gal. Cubit	16 oz.	8 oz.	120 ml.	40 ml.	Other	Yr.	Wk	Seq		Yr	Mo	Dy	Time	Org.	Inorg.		

LAB NUMBER			DEPTH	Unit	Type	COL MTD CD	QA CODE	TEMP DEG C	pH	CNDCTVTY umho/cm	COMPOSITE ONLY				
											ENDING DATE				
Yr.	Wk	Seq									Mo.	Day	Time	Type	Freq

Condition of Samples upon Receipt at Lab:

Custody Seals Intact: ☐ yes ☐ no ☐ none

CHAIN OF CUSTODY RECORD

Relinquished by: *(signature)*	Received by: *(signature)*	Date/Time
Relinquished by: *(signature)*	Received by: *(signature)*	Date/Time
Relinquished by: *(signature)*	Received by: *(signature)*	Date/Time
Relinquished by: *(signature)*	Received by Mobile Lab For Field Analysis: *(signature)*	Date/Time
Dispatched by: *(signature)* Date/Time	Received for Lab by: *(signature)*	Date/Time
Method of Shipment		

Laboratory Copy White
Project Officer Copy Yellow
Field or Office Copy Pink

COOLER RECEIPT FORM

LIMS# __________

Contractor Cooler __________
QA Lab Cooler # __________
Number of Coolers __________

PROJECT: ______________________________ DATE RECEIVED: __________________

USE OTHER SIDE OF THIS FORM TO NOTE DETAILS CONCERNING CHECK-IN PROBLEMS.

A. PRELIMINARY EXAMINATION PHASE: Date cooler was opened: ____________________

By: (print) ____________________ (sign) ____________________

1. Did cooler come with a shipping slip (air bill, etc.)?.................... YES NO

   If YES, enter carrier name & air bill number here: ____________________

2. Were custody seals on outside of cooler?.................... YES NO

   How many & where: ____________ Seal date: __________ Seal name: __________

3. Were custody seals unbroken and intact at the date and time of arrival?.................... YES NO
4. Did you screen samples for radioactivity using the Geiger Counter?.................... YES NO
5. Were custody papers sealed in a plastic bag & taped inside to the lid?.................... YES NO
6. Were custody papers filled out properly (ink, signed, etc.)?.................... YES NO
7. Did you sign custody papers in the appropriate place?.................... YES NO
8. Was project identifiable from custody papers? If YES, enter project name at top of this form. YES NO
9. If required, was enough is used? .... Type of ice: ______________ YES NO
10. Have designated person initial here to acknowledge receipt of cooler: __________ (date) __________

B. LOG-IN PHASE: Date samples were logged-in: ______________

By (print) ____________________ (sign) ____________________

11. Describe type of packing in cooler: ____________________
12. Were all bottles sealed in separate plastic bags?.................... YES NO
13. Did all bottles arrive unbroken & were labels in good condition?.................... YES NO
14. Were all bottle labels complete (ID, date, time signature, preservative, etc.)?.................... YES NO
15. Did all bottle labels agree with custody papers?.................... YES NO
16. Were correct containers used for the tests indicated?.................... YES NO
17. Were correct preservatives added to samples?.................... YES NO
18. Was a sufficient amount of sample sent for tests indicated?.................... YES NO
19. Were bubbles absent in VOA samples? If NO, list by QA#: ______________ YES NO
20. Was project manager called & status discussed? If YES, give details on the back of form. YES NO
21. Who was called? ____________________
    By whom? ____________________ (date) ____________________

DAILY CHEMICAL QUALITY CONTROL REPORT

Project Name:	
Project No.:	

Date							
Day	S	M	T	W	TH	F	S

Weather	Bright Sun	Clear	Overcast	Rain	Snow
Temp	To 32	32–50	50–70	70–85	85 up
Wind	Still	Mod.	High	Report No.	
Humidity	Dry	Mod.	Humid		

Personnel and Visitors on Site (List names and affiliations):

Equipment on Site:

Work Performed Today (Include tasks performed and progress/delays):

Safety (Include any infractions of approved safety plan or instructions from Government personnel. Specify corrective action taken):

Attached Forms (check box and describe):

☐ HTRW Drilling Log

☐ Groundwater Sampling Data Sheet

☐ Well Development Data Sheet

☐ EPA Region 9 Laboratory Analyses Required

☐ Well Development Data Sheet

☐ Field Sample Data and Chain of Custody Sheet

☐ Laboratory Data – ☐ SCAPS , ☐ FASP, ☐ Fixed

DAILY CHEMICAL QUALITY CONTROL REPORT

Project Name:	
Project No./Task No.:	**Date:**

Samples Collected (Field and QA)/Requested Analyses/Laboratories Performing Work:

Field Audit Results/Problems Encountered/Corrective Actions Taken:

Instructions to Contractors (Include names, reactions, and remarks):

By ______________________ **Title** ______________________

(Signature/Printed Name)

NAPL Thickness/Sampling Form

Well ID	Date and Time	LNAPL		LNAPL	Water		DNAPL		DNAPL	Well	Comments
		Top[a]	Bottom	Thickness	Top[a]	Bottom	Top[a]	Bottom	Thickness	Total Depth	
A-4											
A-5											
A-6											
A-8											
A-10											
DSW-1D											
DSW-4B											
DSW-4C											
DSW-4D											
DSW-4E											
DSW-5B											
DSW-6B											
DSW-6C											
OFS-4D											
OFS-4E											
ONS-1B											
ONS-1C											
ONS-2A											

[a] All measurements are in feet below ground surface for flush mounted wells or feet below top casing for wells with casing stickup above ground surface.

PART II

QUALITY ASSURANCE PROJECT PLAN

TABLE OF CONTENTS

Tables

Appendices

ASTM	American Society for Testing and Materials
bgs	below ground surface
CGI	combustible gas indicator
cm	centimeter
CPT	cone penetrometer testing
CSM	conceptual site model
DCE	dichloroethene
DNAPL	dense nonaqueous-phase liquid
DQO	data quality objectives
DSITMS	direct sampling ion trap mass spectrometer
EGDY	East Gate Disposal Yard
EPA	United States Environmental Protection Agency
FLUTe	Flexible Liner Underground Technologies
FSP	Field Sampling Plan
GPR	ground-penetrating radar
GPS	Global Positioning System
LCSs	laboratory control samples
LIF	laser-induced fluorescence
LIMS	Laboratory Information Management System
LNAPL	light nonaqueous-phase liquid
MDLs	method detection limits
µg/L	microgram per liter
µmol/L	micromol per liter
mg/kg	milligrams per kilogram
MIP	membrane interface probe
mL/min	milliliter per minute
mm	millimeter
MQLs	method quantitation limits
MRLs	method reporting limits
MS/MSD	matrix spike/matrix spike duplicate
NAPL	nonaqueous-phase liquid
NWTPH–Dx	Northwest Total Petroleum Hydrocarbons–Diesel Extended
ORP	oxidation-reduction potential
PAHs	polycyclic aromatic hydrocarbons
PCE	tetrachloroethene
PE	performance evaluation
PID	photoionization detector
POL	petroleum, oil, and lubricant
ppm	parts per million
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
RPD	relative percent difference
SAP	Sampling and Analysis Plan
SCAPS	Site Characterization and Analysis Penetrometer System

SOP	standard operating procedures
SVOCs	semivolatile organic compounds
TCE	trichloroethene
TPH	total petroleum hydrocarbon
USACE	United States Army Corps of Engineers
VOCs	volatile organic compounds

This Quality Assurance Project Plan (QAPP), in conjunction with the Field Sampling Plan (FSP), composes the Sampling and Analysis Plan (SAP), which is an integral part of the Management Plan for the East Gate Disposal Yard (EGDY) Phase II Remedial Investigation (RI) field exploration. The purpose of the SAP is to ensure production of high-quality data that meet project objectives and requirements and accurately characterize measurement parameters. The SAP provides protocols for collecting samples, measuring and controlling data, and documenting field and laboratory methods so that the data are technically and legally defensible. The SAP was prepared in accordance with guidelines set forth by the U.S. Army Corps of Engineers (USACE) requirements (USACE 2001 and 1998).

The SAP has two major components: Part I - the Field Sampling Plan (FSP) and Part II - the Quality Assurance Project Plan (QAPP). The FSP presents the detailed scope of work associated with field activities (e.g., sampling types, sampling locations) and specifies the procedures to be used for sampling and other field operations. The QAPP describes the analytical data quality objectives, field and laboratory analytical procedures, quality assurance/quality control (QA/QC) procedures, and data quality evaluation criteria.

Sampling and analysis procedures for the field exploration are designed to satisfy the data quality objectives (DQOs) identified in Section 6 of the Work Plan. This plan presents the analytical methods and associated QA/QC procedures selected to meet the DQOs.

The primary objective of this field exploration is to collect data required to better define the extent of trichloroethene (TCE) and nonaqueous-phase liquid (NAPL) contamination, which will be evaluated and integrated into the EGDY conceptual site model (CSM).

A dynamic investigation approach with a toolbox of sampling and analytical options has been developed for this investigation. Each investigation approach is based on the need to locate and characterize very high levels of contamination and to aid in the design of a method for successfully removing NAPL from the subsurface. The overall project DQOs are as follows:

- DQO 1 – Obtain data required for design of a thermal remedial action for NAPL source area treatment
- DQO 2 – Obtain data required to complete an evaluation of options for optimization of the existing pump and treat system
- DQO 3 – Obtain data required to complete an evaluation of reactive barrier wall placement options
- DQO 4 – Provide analytical results that can be used to segregate and classify investigation-derived waste as solid, hazardous, or dangerous waste according to Resource Conservation and Recovery Act (RCRA) and Washington state Dangerous Waste Regulations
- DQO 5 – Ensure that the turnaround time for the field-generated data supports the real-time decision making needs of the dynamic work plan

2.1 CHEMICALS OF CONCERN

EGDY is the source for widespread TCE contamination at the Fort Lewis Logistics Center. The source of two TCE-contaminated groundwater plumes is believed to be liquid waste containing mixtures of petroleum hydrocarbons and solvents. Previous activities at the site indicate that three distinct product types have been observed at the site:

- Product Type A – Heavy, viscous, dark brown waste oil with TCE
- Product Type B – Light, iridescent oil
- Product Type C – Pure TCE

Chemical and physical testing of these observed product types, plus any additional product types observed during this investigation, will be performed to identify specific chemicals of potential concern associated with these products (e.g., polycyclic aromatic hydrocarbons [PAHs], vinyl chloride, noncarcinogenic total petroleum hydrocarbons [TPH] fractions).

2.2 DATA COLLECTION APPROACH

A dynamic sampling and analysis process was developed to generate data to meet project objectives. A logical chain of reasoning will be followed so that the data gathered support the conclusions made by the technical staff. This investigation allows for changes in the number of locations/samples as the investigation progresses. Results from the early stages will be evaluated and incorporated in refining the CSM prior to additional data collection. A more detailed description of the sampling rationale and project DQOs can be found in Section 6.2 of the Work Plan.

Site information will be gathered and data gaps filled by using a toolbox of sampling and analytical options:

- Geophysics – ground-penetrating radar (GPR) and/or electrical resistivity imaging
- Drilling – sonic drilling techniques and monitoring well installation
- On-site physical and chemical measurements – Site Characterization and Analysis Penetrometer System (SCAPS), cone penetrometer testing (CPT), GeoVIS soil video imaging, laser-induced fluorescence (LIF), membrane interface probe (MIP) with direct sampling ion trap mass spectrometer (DSITMS), Flexible Liner Underground Technologies (FLUTe) ribbon samplers
- Groundwater elevation measurements
- Soil, groundwater, and NAPL sampling
- Off-site analytical laboratory analysis – soil, groundwater, and/or NAPL chemical and physical testing
- Field monitoring – air, groundwater, and NAPL measurements
- Surveying – Global Positioning System (GPS) and traditional survey

All measurements will be made according to standard operating procedures (SOPs) documented in the SAP. Field sampling SOPs are included in Appendix A to the FSP. Laboratory analysis SOPs are included in Appendix A to this QAPP. This section describes the approach toward data generation in the field and off site, and describes sources of uncertainty and how uncertainty will be managed. The quality control program associated with this approach and documented in this QAPP has been developed to address these uncertainties.

2.2.1 Geophysics

GPR is used to characterize with high definition the surface topography of the intermediate aquitard (30 to 40 feet below ground surface [bgs]) and other less continuous shallow aquitards. Electrical resistivity imaging (including induced polarization) is used to characterize the definition of deeper stratigraphic units. These methods would allow the technical team to indirectly determine the aquitard thickness, composition, continuity, lateral extent, and physical/hydrogeologic properties. These methods provide highly defined data about the aquitard characteristics, they are non-invasive, and the results are immediate. This would allow the technical team the ability to change the sampling scope and add information to the CSM.

If these geophysical tools will be used in the RI, a separate management plan will be developed specifically for the geophysical investigation.

2.2.2 Field Measurements

Chemical field measurement results will be used to assess site conditions for worker health and safety (e.g., volatile organic compounds [VOCs]), measure the stability of groundwater conditions prior to sample collection, determine the extent of NAPL in soil (e.g., SCAPS LIF, FLUTe and GeoVIS), determine the extent of TCE in groundwater (e.g., SCAPS MIP/DSITMS), and determine geologic/hydrogeologic properties of soil (e.g., SCAPS CPT).

Methods and equipment have been selected to give rapid assessments of site conditions and therefore have a higher degree of uncertainty than more rigorous methods. The inherent uncertainty of these methods is acceptable for this project because the rapid assessment allows for immediate assessment of site conditions and a greater number of measurements (e.g., SCAPS CPT, LIF, and MIP). The SCAPS MIP/DSITMS instrument reporting limits (100 to 200 micrograms per liter [µg/L] for TCE) are higher than the risk-based screening level of 5 µg/L. Reporting limits (sensitivity) are limited by the MIP delivery system and the dissolved phase concentration indicative of NAPL. The estimated reporting limit for the DSITMS is 2 µg/L, which is lower than the risk-based screening level of 5 µg/L. This uncertainty in concentration is acceptable for this project because it allows the identification of presence or absence of VOCs at the site. A greater number of measurements allows for more representative sampling throughout the site and can compensate for the inherent variability in the measurement methods and contaminant distribution heterogeneity. Field measurements will be evaluated immediately in the field by the technical team who will make decisions on subsequent sampling locations, measurements tools, and site conditions.

2.2.3 SCAPS Laboratory

The SCAPS laboratory will analyze water samples collected from new sonic-installed multichamber wells, SCAPS Power Punch™ microwells, and surface water for VOCs using direct sampling with DSITMS. These lower reporting limits and rapid assessment for VOCs will allow a greater number of measurements, more representative sampling throughout the site, and definition of the extent of the groundwater plume. Results for VOCs will be evaluated immediately in the field by the technical team who will make decisions on subsequent sampling locations to ensure that the extent of the TCE groundwater plume is adequately evaluated.

2.2.4 Off-site Fixed Laboratories

Two off-site fixed laboratories will analyze soil, groundwater, and NAPL samples for physical and/or chemical characteristics. Project laboratories and analytes are listed in Table 2-1. Rapid turnaround analysis will be required only for soil and groundwater samples. Results will be evaluated as soon as they become available by the technical team who will make decisions on subsequent sampling locations to ensure that the extent of different fuel types present at the site is identified. Preliminary soil results will be reported on a wet weight basis. This uncertainty is acceptable because results will be evaluated qualitatively to define the extent of different fuel types present at the site. Dry weight results will be reported with final data packages. All other fixed laboratory analyses will be performed with routine turnaround times because results are not needed immediately to define the extent of contamination. Methods and laboratories were selected that could provide data to support design needs of the thermal treatment systems. Associated quality controls are sufficient to support decisions based on these results.

Fixed laboratory analytical results will be used to confirm field measurements and define the nature and extent of contamination across the site. Fixed laboratory results for analyses using the Northwest Total Petroleum Hydrocarbons–Diesel Extended (NWTPH–Dx) method will also be used identify different petroleum products. Chromatograms generated for site samples will be compared to chromatograms generated by the project laboratory for numerous known fuel types (fuels chromatogram library) and probable fuel types identified.

2.2.5 Surveying

The horizontal coordinates for all SCAPS sampling locations will be determined by either referencing a aerial photograph or base map or through the use of a Trimble global positioning system (GPS). The GPS will not be mounted on the SCAPS rig. When aerial photographs or base maps of the work site are available with a coordinate grid overlay and sufficient ground reference points are present, the sampling locations may be measured with reference to the ground points with those measurements transferred to the photograph or map. The grid overlay will then be used to calculate the coordinates of the sampling location.

A differential GPS may be employed to obtain horizontal coordinates. Data collection will be performed when a position dilution of precision (PDOP) of less than 5.0 is measured. A minimum of 40 measurements at each sampling location will be collected to determine the horizontal coordinates.

Vertical coordinates will be determined using either an existing topographic map or a precision optical level.

2.3 ANALYTICAL METHODS

Analytical methods were selected to provide data to support project objectives. Analytical methods to be performed for the field exploration are described in Section 5. Laboratories performing these methods are listed in Table 2-1. Laboratory SOPs are included as Appendix A.

2.4 ANALYTICAL METHOD DETECTION LIMITS, QUANTITATION LIMITS, AND REPORTING LIMITS

Sensitivity requirements for all methods and matrices are driven by the DQOs. Specific requirements by method and matrix are presented in Table 2-2, followed by the definitions for method detection limits (MDLs) method, quantitation limits (MQLs), and method reporting limits (MRLs).

2.4.1 Method Detection Limit

The MDL is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is determined from analysis of a sample in a given matrix containing the analyte (Appendix B of 40 CFR 136).

2.4.2 Method Quantitation Limit

The MQL represents the value for which the laboratory has demonstrated the ability to reliably quantitate target analytes within a prescribed performance criteria for the method performed. Operationally, it is equivalent to the concentration of the lowest calibration standard in the initial calibration curve.

2.4.3 Method Reporting Limit

The MRL is a threshold value below which the laboratory reports a result of nondetected. It may be based on project-specific concentrations of concern, regulatory action levels, or sensitivity capability of method and instrument. The MRLs are adjusted based on the sample matrix and any necessary sample dilutions. Operationally, it is equivalent to the MQL adjusted based on the sample matrix and any necessary dilutions. Routine laboratory MRLs for all target analytes are listed in Appendix B.

Table 2-1
PROJECT LABORATORIES

LABORATORY	ANALYTE	MATRIX	ADDRESS AND CONTACT
SCAPS Team	VOCs[a]	Water	1645 S. 101st E. Ave. Tulsa, OK 74128 Contacts: Eddie Mattioda Chris Kennedy Phone: (918) 669-7445
	Stratigraphy TPH NAPL extent	Soil	
Sound Analytical Services, Inc.	VOCs	Water	5755 8th Street East Tacoma, WA 98424 Contact: Dawn Werner Phone: (253) 922-2310 Fax: (253) 922-5047
	VOCs SVOCs TPH–Dx	Soil/product	
PTS Laboratories, Inc.	Grain size Permeability Density Porosity Cation exchange capacity Total organic carbon	Soil	8100 Secura Way Santa Fe Springs, CA 90670 Contact: Richard Young Phone: (562)907-3607 Fax: (562) 907-3610
	Oil/water interfacial tension Density/viscosity Boiling point distribution	Product	

Notes:

[a] Target analyte list includes trichloroethene, cis-1,2-dichloroethene, vinyl chloride, and tetrachloroethene

Table 2-2
SENSITIVITY REQUIREMENTS

ANALYTE	MATRIX	SENSITIVITY DRIVER
TPH by LIF (SCAPS)	Soil	Technology limitations and site-specific factors. Threshold values (reporting limits) will be determined in the field.
TPH–Dx by GC/FID (fixed laboratory)	Soil	Less than LIF threshold value
TPH–Dx by GC/FID (fixed laboratory)	NAPL	Concentration determined by dilution
SVOCs (fixed laboratory)	Soil	Engineering design requirements
SVOCs (fixed laboratory)	NAPL	Concentration determined by dilution
VOCs by MIP/DSITMS and direct ITMS	Groundwater, surface water	MCLs
VOCs (fixed laboratory)	Soil	Engineering design requirements
VOCs (fixed laboratory)	Groundwater	MCLs
VOCs (fixed laboratory)	NAPL	Concentration determined by dilution
NAPL w/ FLUTe ribbon sampler	Soil	Technology limitations. Presence or absence of NAPL will be determined in the field.
NAPL w/ GeoVIS	Soil	Technology limitations. Presence or absence of NAPL will be determined in the field.
Other analyses	Soil, groundwater, NAPL	Engineering design requirements

Notes:

GC/FID	gas chromatograph/flame ionization detector
MCLs	maximum contaminant levels
TPH–DX	total petroleum hydrocarbons – diesel extended

This section describes field measurement procedures, sample handling, and coordination procedures between the sampling team and analytical laboratories. Detailed sampling procedures are discussed in the FSP.

3.1 FIELD MEASUREMENT METHODS

Measurements to be collected during field activities include air screening for VOCs, soil stratigraphy, NAPL screening, and groundwater quality parameters.

3.1.1 Air Monitoring for Health and Safety

Air monitoring using a photoionization detector (PID) and a combustible gas indicator (CGI) will be used to evaluate health and safety conditions during drilling and other field activities when warranted. All meters used will be calibrated daily according to manufacturers' instructions. Specific monitoring requirements are discussed in the Site Safety and Health Plan.

3.1.2 Groundwater Field Measurements

Groundwater will be monitored during sampling for specific conductance, pH, temperature, oxidation-reduction potential (ORP), dissolved oxygen, and turbidity using a water quality meter with flow-through chamber. The instrument will be used and calibrated daily according to the manufacturer's instructions.

3.1.3 SCAPS CPT, LIF, MIP/DSITMS, GeoVIS, and FLUTe Ribbon Samplers

The SCAPS will be equipped with a CPT that measures tip penetration and sleeve friction that can be used to provide simultaneous and continuous geotechnical and stratigraphic information. Additionally, the SCAPS will be equipped with an LIF sensor that can be used to define the horizontal and vertical extent of the petroleum hydrocarbon plume. The MIP with DSITMS can be used to define the horizontal and vertical extent of the TCE plume in groundwater. The MIP can be used to collect direct, in situ VOC measurements. Also, the SCAPS rig can be used to collect groundwater samples (using a PowerPunch™ sampler) that can be analyzed in the SCAPS laboratory using DSITMS. Surface water samples also can be analyzed using DSITMS. The SCAPS rig will also be equipped with a GeoVIS system and FLUTe ribbon samplers. The GeoVIS system collects images gathered by a video camera focused out of a port on the side of a standard push probe. The images can be used to determine the extent of NAPL in the subsurface. The FLUTe ribbon sampler is an everting, air-driven liner with absorbent materials that will change color when in contact with NAPL. After the ribbon has been extracted from a push location, NAPL intervals can be mapped by the technical team. At the end of each penetration by the SCAPS, sensor data will be plotted as a function of depth and archived. Brief descriptions of each of these sensors are included below. The SOPs for the SCAPS LIF, MIP/DSITMS, FLUTe ribbon samplers, GeoVIS, and the groundwater sampling equipment are included in Appendix A. Confirmation soil and water samples will be collected and analyzed at an off-site laboratory (see Section 4.1.5).

3.1.3.1 Soil Classification Using Geotechnical Sensors

The SCAPS geotechnical sensors will be used to provide simultaneous and continuous geotechnical and stratigraphic information. The SCAPS probe will be operated to collect subsurface stratigraphy data in accordance with procedures described in American Society for Testing and Materials (ASTM) Method D3441.

3.1.3.2 Hydrocarbon Presence Using LIF

The LIF sensor can detect the presence of hydrocarbons in the bulk soil matrix throughout the vadose zone, capillary fringe, and saturated zones. The SCAPS will be used to collect a continuous record of possible contaminant locations and more complete delineation of the area of contamination. The SCAPS LIF system is capable of providing information on contaminant distribution of POL compounds. Since the SCAPS fluorescence intensity is generally proportional to in situ concentration, SCAPS LIF data can be used to effectively delineate not only the presence, but also the relative concentration, of contaminants. This proportional feature of the SCAPS LIF data can be used to pinpoint the zones of highest contaminant concentration and screen the variation in concentration across the site. Additionally, LIF wavelengths profiles provide information on contaminant types. These results will be evaluated along with NWTPH–Dx chromatograms to determine fuel product types.

The SCAPS LIF uses a nitrogen laser as the ultraviolet excitation source. The N2 laser has a wavelength of 337 manometers and pulses at a rate of 10 times per second. This wavelength will excite aromatic compounds with three or more rings as well as some two-ring compounds. Fluorescence intensity is generally proportional to in situ hydrocarbon concentration. The SCAPS LIF sensor provides spatial resolution of 4 centimeters (cm) when driven at 1 meter/minute.

The SCAPS LIF sensor response is checked using an aqueous solution of Rhodamine 6G (10 micromols per liter [µmol/L]) before and after each penetration event to monitor LIF system response and document any system drift.

The linear range for the LIF is approximately 100 milligrams per kilogram (mg/kg) to 50,000 mg/kg measured as TPH. The site-specific fluorescence threshold will be determined by comparing SCAPS POL sensor LIF response to soil analyses for TPH–Dx and PAH. The fluorescence threshold is the quantitative limit that the fluorescence intensity must exceed in order to qualify as a detection.

Non-linearity of LIF response tends to occur at concentrations greater than 10,000 mg/kg. Sample intervals with LIF fluorescence response above this level will be targeted for off-site TPH–Dx and PAH analyses of soil samples. In sandy soils, the non-linearity occurs at lower concentrations than in clay-rich soils, possibly due to self-adsorption or saturation.

Verification soil samples will be collected at depths of interest, including areas of strong, medium, low, and no fluorescence response, and analyzed for TPH–Dx at the off-site laboratory as well as aboveground with the SCAPS/LIF. Aboveground LIF measurements will be made to assess comparability of in situ LIF and off-site TPH–Dx results. LIF and TPH–Dx results should be in agreement on detect and nondetect for a minimum of 80 percent of the samples, with a false negative rate of less than 5 percent. In addition, verification soil samples will be collected from areas of different soil types and fluorescence emission spectra. Soil verification samples will be collected concurrently with the LIF field effort, and will be used to assist with interpretation of the three-dimensional map of fluorescence response.

The LIF is subject to interference that can make data reduction complicated, and limit the real-time nature of data analyses and decisionmaking. Moisture in soil and fluorescing compounds or minerals (e.g., carbonates) may affect the LIF readings and influence performance statistics. The LIF sensitivity to POL generally increases with greater soil moisture content. LIF sensitivity generally increases with increased grain size.

The potential presence of fluorescence emission from nontarget (nonhydrocarbon) analytes within the soil matrix must also be considered when assessing LIF data. Because the LIF sensor collects full spectral information it is almost always possible to discriminate between hydrocarbon and non-hydrocarbon fluorescence by analyzing the spectral features associated with the data. The SCAPS LIF sensor system uses a multichannel detection scheme to capture a complete fluorescence emission spectrum at each point along the push. Suspected nontarget fluorescence emission based on spectral response will be investigated by obtaining a soil sample at the appropriate depth and analyzing this sample for TPH–Dx. The LIF response will be considered nontarget fluorescence if the TPH–Dx indicates a nondetect. Once the nontarget fluorescence has been confirmed using TPH–Dx, the emission spectra will be used to differentiate nontarget fluorescence in subsequent penetrations.

3.1.3.3 Volatile Contaminant Presence using MIP/DSITMS

The MIP sensor can detect the presence of VOCs in the bulk soil matrix throughout the vadose zone, capillary fringe, and saturated zones. However, there appears to be a matrix-moisture content effect for vadose soils. The SCAPS will be used to collect a continuous record of possible contaminant locations and more complete delineation of the area of contamination. The SCAPS MIP/DSITMS system is capable of providing information on contaminant distribution of VOCs. The target analytes for DSITMS analysis are TCE, dichloroethene (DCE), tetrachloroethene (PCE), and vinyl chloride. The MIP/DSITMS is composed of the MIP, a metal/teflon composite membrane that samples VOCs in situ and the DSITMS that identifies and quantifies the VOCs. Since the MIP/DSITMS is capable of multiple, discreet VOC measurements in a single penetration, the MIP/DSITMS data can be used to effectively delineate not only the presence of VOCs, but the also the concentration of the compounds. This feature of the SCAPS MIP/DSITMS data can be used to pinpoint the zones of highest contaminant concentration and screen the variation in concentration across the site.

The MIP is a permeable membrane device used to detect volatile contaminants as it is driven to depth in soil or other unconsolidated materials. A thin film membrane is impregnated into a stainless steel screen on the face of the probe. This membrane is heated to 100 to 120 degrees Celsius leading to quick diffusion of VOC contaminants across the membrane into the helium carrier gas, which flushes the back of the membrane and transports the contaminants to the aboveground DSITMS. The DSITMS is composed of a quadropole ion-trap mass spectrometer, a capillary interface, and a variety of sample inlets for use with gas (air and soil gas), soil, and water. The capillary interface limits flow into the DSITMS to 0.1 to 1.0 milliliter per minute (mL/min), which is compatible with both electron impact and chemical ionization sources. Direct injection of groundwater and surface water samples into the DSITMS is also possible.

The MIP/DSITMS is calibrated daily. Once calibration is achieved, calibration standards are analyzed twice a day during the direct sampling method, and once after each penetration is completed. A blank sample is analyzed for background subtraction to ensure there is no carryover in the transfer line, any time samples having greater than 500 parts per million (ppm) of VOC contamination are analyzed, and between analyses of samples from different sources. During the MIP/DSITMS, a system blank will be performed before and after each set of in situ measurements. Sample results with concentrations greater than the highest calibration standard will be verified by analyzing additional standards with concentrations at or above the sample concentration.

The linear range of the MIP/DSITMS is 500 ppm. Soil with TCE concentrations greater than 500 ppm can saturate the MIP, which would cause the system to be inoperable while it is being flushed out.

Validation data indicated that the system provides quantitative estimates of subsurface contamination distribution; however, there appears to be a matrix moisture-content effect for vadose soils. The MIP/DSITMS will be used as a high-level field screening technique to rapidly delineate the distribution of VOC contamination in groundwater. Verification samples will be collected to include a range of contaminant concentrations and will be analyzed by the analytical laboratory by U.S. Environmental Protection Agency (EPA) SW-846 Method 8260B (USEPA 1994a).

3.1.3.4 NAPL Extent Using GeoVIS

The GeoVIS soil video imaging system is integrated into a CPT probe. Soil in contact with the side of the probe is imaged through a sapphire window and lens system with a miniature color video camera as the probe is pushed into the ground. The soil is illuminated with an array of white light-emitting diodes located in the probe. The video signal from the camera is returned to the surface where it is displayed in real-time on a video monitor, recorded on a video cassette recorder, and/or captured digitally with a frame grabber installed in a microcomputer system. In its current configuration, the system images an area that is 2 millimeters (mm) by 2.5 mm, which provides a magnification factor of approximately 100x when viewed on a standard 13-inch monitor.

3.1.3.5 NAPL Extent Using FLUTe Ribbon Sampler

The FLUTe system consists of an impermeable flexible liner and an exterior covering on the liner that reacts with NAPL to form a bright red dye stain on a white background. The liner/cover system can be emplaced via several push rod methods. The pressurized liner forces the reactive cover tightly against the hole wall. The reactive cover is recovered from the hole by inverting/peeling the liner from the hole. In this manner, the cover does not touch the hole wall anywhere else as it is removed. The cover can then be examined for the presence and extent of layers, and even globules, of NAPL in the subsurface. This technique of installation and removal of the reactive covering through the interior of push rods provides a relatively inexpensive method for mapping of light nonaqueous-phase liquid (LNAPL) and dense nonaqueous-phase liquid (DNAPL) in the source region.

The liner installation method can be applied to the many driven casing “drilling” methods. The same method is employed, regardless of the casing diameter, to allow the casing to be withdrawn without excessive drag of the liner on the casing. The rods are pushed to the full depth of interest. The liner with its reactive covering is inserted into the interior hole in the rods to the full depth. The rods are then filled with air. The rods are raised one rod section at a time to expose the hole wall. The liner is pressurized with a charge of air to hold the hole open and to anchor the liner in the hole. More air is added to the interior of the liner as the rods are pulled. Once the rods are fully removed, the hole is supported and sealed by the air-filled liner. The covering is pressed against the hole wall for approximately 1 hour and then the liner is inverted (peeled inside out) from the hole. The covering is therefore interior to the inverted liner. The covering is then peeled from the interior of the liner to reveal the stained map of the distribution of NAPL in the subsurface.

3.2 FIELD MEASUREMENT INSTRUMENT CALIBRATION PROCEDURES

The calibration and general maintenance of field instruments will be the responsibility of the URS Field Investigation Manager or the SCAPS leader. Field instruments requiring calibration include:

- PID
- Groundwater quality meter
- CGI
- SCAPS CPT and LIF
- MIP/DSITMS

All calibration procedures and measurements will be performed in accordance with manufacturers’ specifications and standard operating procedures. Field instruments will be checked and calibrated prior to their use on site, and batteries will be charged and checked daily where applicable. Instrument calibrations will be performed at the beginning of each work day and checked and recalibrated if necessary through the course of the day according to manufacturers’ specifications or if deemed necessary by sampling personnel. Special attention will be given to instruments that may drift with change in ambient temperature.

Equipment that fails calibration and/or becomes otherwise inoperable during the field investigation will be removed from service and segregated to prevent inadvertent use. Such equipment will be properly tagged to indicate that it should not be used until repaired. Equipment that cannot be repaired or recalibrated will be replaced.

All documentation pertinent to the calibration and/or maintenance of field equipment will be maintained in an active field logbook. Logbook entries regarding the status of field equipment will contain, at a minimum the following information:

- Date and time of calibration
- Name of person conducting calibration
- Type and identification of equipment being serviced (make, model and serial number)
- Reference standard used for calibration (such as pH of buffer solutions)

- Calibration and/or maintenance procedure used
- Other pertinent information

3.3 SAMPLE HANDLING, CONTAINERS, PRESERVATION, AND HOLDING TIMES

Sample containers, preservation, and holding times are summarized by matrix in the FSP (in Tables 4-6 to 4-10). Soil and water samples will be collected in glass or plastic containers purchased for the project. NAPL samples will be collected in glass containers. The containers will have screw-type lids to assure adequate sealing of the bottles. Lids of the containers will have Teflon inserts to prevent sample reaction with the lid and to improve the quality of the seal.

Commercially available pre-cleaned jars will be used and the USACE will maintain a record of certification from the supplier. The bottle shipment documentation will record batch numbers for the bottles. With this documentation, bottles can be traced to the supplier and bottle wash analysis results can be reviewed. The bottle wash documentation will be archived by the supplier for a period of 5 years.

Sample preservation will be performed in the field. Sample preservation procedures are used to maintain the character of analytes as sampled (i.e., representative concentrations and/or speciation in situ) during storage and shipment. Regardless of the nature of the sample, absolute stability for all constituents cannot be achieved. Preservation techniques, such as pH control and refrigeration, may retard physiochemical and biochemical changes. As a general rule, analyzing the sample as soon as possible is the best way to minimize physicochemical and biochemical changes.

All samples will be placed in the appropriate sample container and refrigerated (on ice in a cooler or in a refrigerator in the field office) immediately upon sample collection. The samples will be transferred to the mobile field laboratory and contract laboratories as soon as possible and using chain of custody procedures as described in the FSP. Upon receipt at the contract laboratories, a cooler receipt form will be filled out to document sample condition. The laboratories will meet all specified holding times and should make every effort to prepare and analyze the samples immediately after they are received.

3.4 COORDINATION WITH ANALYTICAL LABORATORIES

Team members will work closely with the laboratories (mobile and fixed) to ensure that samples are handled and analyzed following procedures described in this QAPP. A schedule of field work and sampling will be established approximately 2 weeks prior to commencement of field work. Each day that samples are hand delivered or shipped to the laboratories, a designated team member will notify the laboratories to confirm that samples have been sent.

The laboratories will contact the URS Project Manager or Project Chemist as soon as possible and no later than 24 hours after it is suspected that re-analysis of a sample by the laboratory is unable to determine a result due to matrix interference.

Field QC and laboratory QC samples will be employed to evaluate data quality. Quality control samples are controlled samples introduced into the analysis stream whose results are used to review data quality and to calculate the accuracy and precision of the chemical analysis program. The purpose of each type of QC sample, collection and analysis frequency, and evaluation criteria are described in this section. Collection and analysis frequency are summarized in Tables 4-1 through 4-4. Laboratory control limits are listed in Appendix C.

QC procedures for both the mobile field laboratory and the fixed laboratories' analyses will be consistent with the requirements described in the laboratories' protocols and methods. These requirements are defined in SOPs as part of the laboratory's QA program plan. Methods for establishing the quality of laboratory measurements and sample results will generally conform with EPA Contract Laboratory Program scope of work or EPA SW-846 (USEPA 1994a) QC requirements and quality criteria (when applicable). All QC measurements and data assessment for this project will be conducted on samples from and within batches of samples from this project alone; in other words, no "other project" samples will be used with samples from this project for assessment of data quality.

4.1 FIELD QUALITY CONTROL SAMPLES

Field QC checks are accomplished through the analysis of controlled samples that are introduced to the laboratory from the field. Rinsate and field blanks, field duplicates, matrix spike/matrix spike duplicate (MS/MSD), and performance evaluation (PE) samples will be collected and submitted to the mobile field laboratory and/or the fixed laboratories, where applicable, to provide a means of assessing the quality of data resulting from the field sampling program. Field QC samples will be selected by the sampling team and designated on the chain of custody form as appropriate.

4.1.1 Rinsate and Field Blanks

Rinsate blanks are collected to determine the potential for cross-contamination of samples during collection. Rinsate blanks will be collected and analyzed at the rate of 5 percent if utilizing non-dedicated sampling equipment. If dedicated or disposable sampling equipment is utilized, field blanks will be collected instead. Rinsate blanks will consist of store-bought distilled water collected from the final rinse of sampling equipment after the decontamination procedures described in Section 3.9 of the FSP. Blank sample collection methods and frequency are described in the FSP. Field blanks will consist of store-bought distilled water transferred directly into sample containers in the field.

All rinsate or field blanks will be submitted blind to the laboratory, with sample numbers that are indistinguishable from primary samples. Quality control criteria and corrective actions are the same as for method blanks (Section 4.2.2). Blank samples will be analyzed for the same parameters as the associated field samples.

4.1.2 Field Duplicates

Field duplicate samples will be used to check for sampling reproducibility. Field duplicates will be collected from locations with suspected high contamination levels. Field duplicates will be submitted at a frequency of 10 percent of the field samples for every analytical method. Field duplicate samples will be submitted from locations having significant concentrations of target analytes as determined by results of field screening. Control limits for field duplicate precision are 30 percent relative percent difference (RPD) for aqueous samples and 50 percent RPD for soil and NAPL samples.

Field duplicates will be submitted blind to the laboratories, with sample numbers that are indistinguishable from primary samples. Quality control criteria for field duplicates and calculation and reporting of the RPD are described in Section 7.1.

4.1.3 Matrix Spike/Matrix Spike Duplicates

MS/MSDs are used to assess sample matrix interferences and analytical errors, as well as to measure the accuracy and precision of the analysis. The MS/MSDs will be collected and analyzed at a rate of 5 percent of the field samples for each off-site chemical laboratory and SCAPS laboratory analytical method or at least one for each analytical batch, whichever frequency is greater. Known concentrations of analytes are added to environmental samples; the MS or MSD is then processed through the entire analytical procedure and the recovery of the analytes calculated. Results are expressed as percent recovery of the known spiked amount (and RPD for MS/MSD pairs).

Because MS/MSD samples measure the matrix interference of a specific matrix, only MS/MSD samples from this investigation will be analyzed, and not samples from other projects. The MS/MSD samples will be analyzed for the same parameters as the associated field samples in the same QC analytical batch.

Additionally, MS/MSD samples should not be collected from locations with potentially high concentrations of target analytes that may mask the added MS/MSD compounds. Because of the high concentrations of target analytes, MS/MSD samples will not be submitted with NAPL samples.

4.1.4 Performance Evaluation Samples

Ten water PE samples will be submitted to the SCAPS laboratory and Sound Analytical Services, Inc., to evaluate the accuracy of the VOC analyses. PE samples will be submitted blind for chemical analysis. The PE samples will be spiked by the commercial supplier with the site chemicals of concern at concentrations consistent with those previously observed in groundwater at the site. One PE sample will be analyzed the first day of laboratory analysis. The PE sample results will be immediately compared to the vendor’s documented acceptable control limits by URS. Sample analysis will not continue until the laboratory has met certified PE sample acceptance limits and approval has been obtained from USACE. Assuming criteria have been met, a second sample of that matrix will be analyzed at random the same week, with the remaining PE samples submitted blind to the laboratory at regular intervals through the remaining analysis schedule.

The PE material will be from commercial sources. The PE supplier will fill pre-cleaned sample bottles with the PE material. Fictitious sample identification numbers will be assigned in the field as described in Section 5.2 of the FSP.

4.1.5 Confirmation Analyses

Verification soil and/or water samples will be collected at selected depths. Visual evaluation of selected soil samples for NAPL contamination will be compared against LIF data. Sample intervals representative of different soil types, different emission spectra, and different emission intensity will be selected based on SCAPS LIF and geotechnical sensor measurements. The SCAPS will be used to obtain verification soil and/or water samples from some of these locations for off-site laboratory analyses of total petroleum Hydrocarbons–Diesel extended (TPH–Dx), VOCs, and semivolatile organic compounds (SVOCs) to control and assist with understanding uncertainty, bias, and interference associated with DSITMS, MIP/DSITMS, and LIF analyses. A specific percentage of samples will not be selected; rather these samples will be selected in the field by the technical team to assist in data interpretation. All analyses will be conducted within a 48-hour turnaround time. Soil data will be used for on-site validation and calibration of the fluorescence response obtained by the SCAPS LIF sensor. This data will assist with determining the relationship between LIF response and TPH and PAH concentration over the range of site soil and contaminant types. The relationship between LIF signal, TPH–Dx, and PAH soil data will be evaluated by the technical team. The SCAPS LIF data will be used to define the boundary of the NAPL and petroleum, oil, and lubricant (POL) contamination above the site specific threshold concentration (reporting limit).

4.2 LABORATORY QUALITY CONTROL SAMPLES

Laboratory QC checks are accomplished through analyzing initial and continuing calibration samples, method blanks, surrogate spikes, laboratory control samples (LCSs), and laboratory duplicate samples. Not all of these QC samples will be required for all methods. Typically, these samples are not required for methods other than EPA SW-846, methods such as ASTM methods. Method-specific QC samples are described in the laboratory SOPs.

4.2.1 Initial and Continuing Calibration Samples

Laboratory instrument calibration requirements are summarized in Tables 4-2 through 4-5, and are discussed in Section 6.

4.2.2 Method Blanks

Method blanks are used to check for laboratory contamination and instrument bias. Laboratory method blanks will be analyzed at a minimum frequency of 5 percent or one per analytical batch for all chemical parameter groups.

QC criteria require that no contaminants be detected in the blank(s) above the MQL. If a chemical is detected, the action taken will follow the laboratory SOPs as modified. Blank samples will be analyzed for the same parameters as the associated field samples.

4.2.3 Surrogate Spikes

Accuracy of an analytical measurement is evaluated by using surrogate spikes. Surrogate compounds are compounds not expected to be found in environmental samples; however, they are chemically similar to several compounds analyzed in the methods and behave similarly in extracting solvents. Samples for organics analysis will be spiked with surrogate compounds consistent with the requirements described in the laboratory SOPs.

Percent recovery of surrogates is calculated concurrently with the analytes of interest, using the equation in Section 7.2. Since sample characteristics will affect the percent recovery, the percent recovery is a measure of accuracy of the overall analytical method on each individual sample.

4.2.4 Laboratory Control Samples

LCSs are used to monitor the laboratory's day-to-day performance of routine analytical methods, independent of matrix effects. The LCSs are prepared by spiking reagent water or silica sand with standard solutions prepared independently of those used in establishing instrument calibration. The LCSs are extracted and analyzed with each batch of samples. Results are compared on a per-batch basis to established control limits and are used to evaluate laboratory performance for precision and accuracy. Laboratory control samples may also be used to identify any background interference or contamination of the analytical system that may lead to the reporting of elevated concentration levels or false positive measurements.

4.2.5 Laboratory Duplicate Samples

Precision of the analytical system is evaluated by using laboratory duplicates. Laboratory duplicates are two portions of a single homogeneous sample analyzed for the same parameter. Laboratory duplicates will be prepared and analyzed with project samples as listed in Tables 4-2 through 4-5.

Table 4-1
FIELD QUALITY CONTROL SAMPLE COLLECTION SUMMARY— SOIL, NAPL, AND GROUNDWATER

SAMPLE TYPE	LABORATORY	FREQUENCY
Rinsate/field blanks	Fixed, SCAPS (ITMS)	5 percent
Field duplicates	Fixed, SCAPS (ITMS)	10 percent of all samples
MS/MSD (or laboratory duplicates)	Fixed, SCAPS (ITMS)	5 percent of all samples or as specified in SOP
Performance evaluation samples	Fixed, SCAPS (ITMS)	See discussion above

Notes:

ITMS	ion trap mass spectrometer
MS/MSD	matrix spike/matrix spike duplicate
SCAPS	Site Characterization and Analysis Penetrometer System
SOP	standard operating procedure

Table 4-2
SCAPS LABORATORY QUALITY CONTROL SAMPLE SUMMARY— GROUNDWATER AND SURFACE WATER

ANALYTE	BACKGROUND CORRECTION BLANKS	SYSTEM BLANK CHECK	MASS AXIS CALIBRATION	INITIAL CALIBRATION	CALIBRATION CHECK STANDARDS	PERFORMANCE EVALUATION CHECK STANDARDS
MIP/DSITMS	After samples with >500 ppm VOC and between samples from different sources		At startup and daily	3-pt		
DSITMS	After samples with >500 ppm VOC and between samples from different sources		At startup and daily	5-pt		
MIP		Before and after each set of in situ measurements			After each penetration	Daily at startup and end of each day
DS		NA			2/day	Daily at startup and end of each day

Notes:

DS	direct sampling
DSITMS	direct sampling ion trap mass spectrometer
MIP	membrane interface probe
VOC	volatile organic compound

Table 4-3

FIXED LABORATORY QUALITY CONTROL SAMPLE SUMMARY—SOIL

ANALYTE	METHOD REFERENCE	METHOD BLANKS[a]	MS/MSD (PERCENT)[b]	LABORATORY CONTROL SAMPLE (BLANK SPIKE)[a]	SURROGATE	INITIAL CALIBRATION	INITIAL CALIBRATION VERIFICATION	CONTINUING CALIBRATION STANDARD[c]
VOCs	SW-846 8260B	1/batch	5	1/batch	All samples	5-pt	1/batch	After every 12 hours
TPH–Dx	NWTPH-Dx	1/batch	5	5 percent	All samples	5-pt	1/batch	After every 12 hours
SVOCs	SW-846 8270C	1/batch	5	1/batch	All samples	3-pt	1/batch	After every 10 samples
Grain size	ASTM D422/D4464	NA	5[c]	NA	NA	NA	NA	NA
Effective porosity	API RP40	NA	NA	NA	NA	NA	NA	NA
Permeability	ASTM D5084	NA	NA	NA	NA	NA	NA	NA
Total organic carbon	SW-846 9060	1/batch	5	1/batch	NA	NA	NA	NA
Cation exchange capacity	SW-846 9081	1/batch	5	1/batch	NA	1-pt	Standard and blank with every batch	Standard and blank after every 10 samples
Bulk density	ASTM D2937	NA	5[c]	NA	NA	NA	NA	NA

[a] Batch is equivalent to 20 or fewer samples prepared and analyzed together with common QC samples.

[b] MS/MSD for organics; MS/lab duplicate for inorganics

[c] Laboratory duplicate only

Notes:

NA - not applicable

TAT - turnaround time

Table 4-4
FIXED LABORATORY QUALITY CONTROL SAMPLE SUMMARY—NAPL

ANALYTE	METHOD REFERENCE	METHOD BLANKS[a]	MS/MSD (PERCENT)	LABORATORY CONTROL SAMPLE (BLANK SPIKE)[a]	SURROGATE	INITIAL CALIBRATION	INITIAL CALIBRATION VERIFICATION	CONTINUING CALIBRATION STANDARD[b]
VOCs	SW-846 8260B	1/batch	NA	1/batch	All samples	5-pt	1/batch	After every 10 samples
SVOCs	SW-846 8270C	1/batch	NA	5 percent	All samples	5-pt	1/batch	After every 10 samples
TPH–Dx	NW-TPH-Dx	1/batch	NA	1/batch	All samples	5-pt	1/batch	After every 10 samples
Oil/water interfacial tension	ASTM D971	NA	NA	NA	NA	NA	NA	NA
Density/viscosity	ASTM D445/D1481	NA	NA	NA	NA	NA	NA	NA
Boiling point distribution	ASTM D86	NA	NA	NA	NA	NA	NA	NA

[a] Batch is equivalent to 20 or fewer samples prepared and analyzed together with common QC samples.
[b] Continuing calibration blank samples are analyzed immediately after continuing calibration standards.

Note:
NA - not applicable

Table 4-5
FIXED LABORATORY QUALITY CONTROL SAMPLE SUMMARY—GROUNDWATER

ANALYTE	METHOD REFERENCE	METHOD BLANKS[a]	MS/MSD (PERCENT)	LABORATORY CONTROL SAMPLE (BLANK SPIKE)[a]	SURROGATE	INITIAL CALIBRATION	INITIAL CALIBRATION VERIFICATION[a]	CONTINUING CALIBRATION STANDARD AND BLANK[b]
VOCs	SW-846 8260B	1/batch	5	1/batch	All samples	3-pt	1/batch	After every 12 hours

[a] Batch is equivalent to 20 or fewer samples prepared and analyzed together with common QC samples.
[b] Continuing calibration blank samples are analyzed immediately after continuing calibration standards.

This section describes the analytical procedures to be used for analytical laboratory measurements. The analytical methods and associated QA/QC procedures were selected based on consideration of the DQOs. The analytical methods, calibration procedures, and QC measurements and criteria are based on current analytical protocols in the following:

- EPA SW-846 test methods for evaluation of solid waste (U.S. EPA 1994a)
- American Society for Testing and Materials (ASTM annual updates)
- *Methods for the Chemical Analysis of Water and Wastes* (U.S. EPA 1979)
- Laboratory-specific SOPs

Laboratory method summaries, including reference and preservation, extraction, cleanup and instrumentation, are included in Tables 5-1 through 5-4. Laboratory-specific SOPs are included in Appendix A. Project-specific modifications to these methods are discussed below.

Laboratory QA will be implemented and maintained as described in this plan and according to the laboratories' QA plans and SOPs. Quality control samples are described in Section 4 of this QAPP. Analytical method target analytes, routine reporting limits, and control limits are listed in Appendices B and C.

The methods selected are sufficient to meet the project DQOs. While a best effort will be made to achieve the project DQOs, there may be cases in which it is not possible to meet the specified goals. Any limitation in data quality due to analytical problems (e.g., elevated detection limits due to highly contaminated samples) will be identified within 48 hours and brought to the attention of the USACE technical team. In addition, this information will be discussed in the data evaluation report.

5.1 NONAQUEOUS-PHASE ANALYTICAL APPROACH

The laboratory will prepare NAPL samples according to the following:

- VOCs by EPA SW-846 Method 8260B: If the product sample is soluble in methanol, then 0.1 gram of the sample is weighed out and analyzed. If the product sample is not soluble in methanol, then 7 to 10 grams of the sample are weighed out and extracted with 10 milliliters of methanol.
- SVOCs by EPA SW-846 Method 8270C: 1 gram of the sample is weighed out and diluted to 10 milliliters.
- TPH-Dx by NWTPH-Dx: 0.1 gram of the sample is weighted and diluted to 10 milliliters.

Table 5-1

SCAPS LABORATORY METHOD SUMMARY—GROUNDWATER AND SURFACE WATER

ANALYTE	METHOD REFERENCE	PRESERVATION METHOD	EXTRACTION METHOD	CLEANUP METHOD	INSTRUMENT/ DETECTOR
VOCs-MIP/DSITMS	SCAPS SOP	NA	Membrane Interface Probe	NA	Ion Trap Mass Spectrometer
VOCs-DSITMS	SCAPS SOP	None	Direct Sparging	NA	Ion Trap Mass Spectrometer

Notes:
NA – not applicable

Table 5-2

FIXED LABORATORY METHOD SUMMARY—SOIL

ANALYTE	METHOD REFERENCE	PRESERVATION METHOD	EXTRACTION METHOD	CLEANUP METHOD	INSTRUMENT/ DETECTOR
VOCs	SW-846 5035/8260B	4 ± 2 °C	5030	NA	GC/MS
SVOCs	SW-846 8270C	4 ± 2 °C	Sonication	GPC	GC/MS
TPH-diesel	NWTPH–Dx	4 ± 2 °C	3550B	NA	GC/FID
Grain size	ASTM D422/D4464	None	NA	NA	NA
Permeability (hydraulic conductivity)	ASTM D5084	None	NA	NA	Flexible wall permeameter
Density	ASTM D2937	None	NA	NA	NA
Porosity	API RP40	None	Toluene	None	NA
Cation exchange capacity	SW-846 9081	None	Sodium acetate	NA	Atomic absorption
Total organic carbon	SW-846 9060	4 ± 2 °C	Dean-Stark	None	Titration with Fe SO$_4$

Notes:
NA - not applicable

Table 5-3

FIXED LABORATORY METHOD SUMMARY—NAPL

ANALYTE	METHOD REFERENCE	PRESERVATION METHOD	EXTRACTION METHOD	CLEANUP METHOD	INSTRUMENT/ DETECTOR
VOCs	SW-846 8260B	4 ± 2 °C	5030	NA	GC/MS
SVOCs	SW-846 8270C	4 ± 2 °C	NA	GPC	GC/MS
TPH-diesel	NWTPH–Dx	4 ± 2 °C	3550B	NA	GC/FID
Oil/water interfacial tension	ASTM D971	Refrigeration	NA	NA	Central Scientific Direct Reading Tensiometer
Viscosity/density	ASTM D445/D1481	Refrigeration	NA	NA	Canon Crossarm Viscometer
Boiling point distribution/distillation	ASTM D86	Refrigeration	NA	NA	Thermometer

Notes:
GC/FID - gas chromatograph/flame ionization detector
GC/MS - gas chromatograph/mass spectrometer
GPC - gel permeation chromatography
NA - not applicable

Table 5-4

FIXED LABORATORY METHOD SUMMARY—GROUNDWATER

ANALYTE	METHOD REFERENCE	PRESERVATION METHOD	EXTRACTION METHOD	CLEANUP METHOD	INSTRUMENT/ DETECTOR
VOCs	SW-846 8260B	HCl acid to pH <2 4 ± 2 °C	NA	NA	GC/MS

Notes:
GC/MS - gas chromatograph/mass spectrometer
NA - not applicable

Analytical instrument calibration and maintenance will be conducted in accordance with the QC requirements identified in each laboratory SOP and QA plan, and the manufacturers' instructions. General requirements are discussed below.

6.1 STANDARD SOLUTIONS

A critical element in the generation of quality data is the purity/quality and traceability of the standard solutions and reagents used in the analytical operations. To ensure the highest purity possible, all primary reference standards and standard solutions will be obtained from a reliable commercial source. The laboratories will maintain a written record of the supplier, lot number, purity/concentration, receipt/preparation date, preparer's name, method of preparation, expiration date, and all other pertinent information for all standards, standard solutions, and individual standard preparation logs.

Standard solutions will be validated prior to use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard solution using another standard solution prepared at a different time or obtained from a different source. Stock and working standard solutions will be checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change of concentration. Care will be exercised in the proper storage and handling of standard solutions, and all containers will be labeled as to compound, concentration, solvent, expiration date, and preparation data (initials of preparer/date of preparation). Reagents will be examined for purity by subjecting an aliquot or subsample to the corresponding analytical method as well.

6.2 BALANCES

Analytical balances will be calibrated annually according to manufacturers' instructions and have a calibration check before each use by laboratory personnel. Balance calibration shall be documented in appropriate hard-bound log books with pre-numbered pages.

6.3 REFRIGERATORS

All refrigerators will be monitored for proper temperature by measuring and recording internal temperatures on a daily basis. At a minimum, thermometers used for these measurements will be calibrated annually, according to manufacturers' instructions.

6.4 WATER SUPPLY SYSTEM

The project laboratories will maintain an appropriate water supply system that is capable of furnishing ASTM Type II polished water to the various analytical areas.

6.5 LABORATORY INSTRUMENTS

As stated in EPA SW-846 (USEPA 1994a) and applicable laboratory SOPs, calibration of all analytical instrumentation is required to ensure that the analytical system is operating correctly and functioning at the sensitivity required to meet project-specific DQOs. Each instrument will be calibrated with standard solutions appropriate to the instrument and analytical method, in accordance with the methodology specified and at the QC frequency specified in the project laboratory SOPs.

The calibration and maintenance history of the project laboratory instrumentation is an important aspect of the project's overall QA/QC program. As such, all initial and continuing calibration procedures will be implemented by trained personnel following the manufacturer's instructions and in accordance with applicable EPA protocols to ensure the equipment is functioning within the tolerances established by the manufacturer and the method-specific analytical requirements.

The DQOs for the EGDY Phase II RI field exploration are designed to ensure that the accuracy and precision of the data will be sufficient that the data will be useful for identifying the source of, evaluating the potential for natural attenuation of, and designing in situ treatment methods for NAPL and TCE at the site.

The data quality parameters presented in this section are precision, accuracy (bias), representativeness, comparability, completeness, and sensitivity. Project-specific control limits for these parameters are presented in Appendix C. Required QA/QC sample frequency and calibration requirements are summarized for all laboratory analyses in Tables 4-1 through 4-4.

7.1 PRECISION

Precision is defined as the degree of agreement between or among independent, similar, or repeated measures. Precision is expressed in terms of analytical variability. For this project, analytical variability will be measured as the RPD or coefficient of variation between analytical lab duplicates and between the MS and MSD analyses. Monitoring variability will be measured by analysis of blind field duplicate samples.

Precision will be calculated as the RPD as follows:

$$\%RPD_i = \frac{2\left|O_i - D_i\right|}{\left(O_i + D_i\right)} \times 100\%$$

where:

$\%RPD_i$ = Relative percent difference for compound i

O_i = Value of compound i in original sample

D_i = Value of compound i in duplicate sample

The resultant RPD will be compared to acceptance criteria and deviations from specified limits reported. If the objective criteria are not met, the laboratory will supply a justification of why the acceptability limits were exceeded and implement the appropriate corrective actions. The RPD will be reviewed during data quality review, and deviations from the specified limits will be noted and the effect on reported data commented upon by the data reviewer.

7.2 ACCURACY

Accuracy is the amount of agreement between a measured value and the true value. It will be measured as the percent recovery of MS/MSD, organic surrogate compounds, and PE samples. Additional potential bias will be quantitated by the analysis of blank samples (e.g., method and rinsate blanks).

Accuracy shall be calculated as percent recovery of analytes as follows:

$$\%R_i = \left(Y_i \div X_i\right) \times 100\%$$

where:

$\%R_i$ = percent recovery for compound i

Y_i = measured analyte concentration in sample i
(measured - original sample concentration)

X_i = known analyte concentration in sample i

The resultant percent recoveries will be compared to acceptance criteria and deviations from specified limits will be reported. If the objective criteria are not met, the laboratory will supply a justification of why the acceptability limits were exceeded and implement the appropriate corrective actions. Percent recoveries will be reviewed during data quality review, and deviations from the specified limits will be noted and the effect on reported data commented upon by the data reviewer.

7.3 REPRESENTATIVENESS

Representativeness is the degree to which sample results represent the system under study. This component is generally considered during the design phase of a program. This program will use the results of all analyses to evaluate the data in terms of its intended use. Site locations for sampling are placed using a biased approach to maximize the likelihood of locating and identifying site contamination, if present. Areas of apparent contamination have been selected for determination of potential impacts from past activities.

7.4 COMPARABILITY

Comparability is the degree to which data from one data set on study can be compared with data from other similar analytical methods, studies, reference values (such as background), reference materials, and screening values. This goal will be achieved through using standard techniques to collect and analyze representative samples and reporting analytical results in appropriate units. Comparability will be evaluated during data quality assurance review (see Section 10). Specifically, comparability between TPH results reported from LIF and NWTPH–Dx methods, and between VOC reported from MIP/DSITMS, DSITMS, and EPA SW-846 8260B will be evaluated.

7.5 COMPLETENESS

Completeness for usable data is defined as the percentage of usable data out of the total amount of data generated. Because the number of samples that will be collected to measure each parameter exceeds that required for the analysis, approximately 100 percent completeness is anticipated. When feasible, the amount of sample collected will be sufficient to reanalyze the sample, should the initial results not meet QC requirements. Less than 100 percent completeness could result if sufficient chemical contamination exists to require sample dilutions, resulting in an increase in the project-required detection/quantitation limits for some parameters. Highly contaminated environments can also be sufficiently heterogeneous to prevent the achievement of specified precision and accuracy criteria. The target goal for completeness shall be 98 percent for all data. Completeness for quality data shall be 95 percent for each individual analytical method. Quality data are data obtained in a sample batch for which all QC criteria were met. Completeness will be calculated as follows:

$$\%C = \frac{A}{I} x100\%$$

where:

$\%C$ = Percent completeness (analytical)

A = Actual number of samples collected/valid analyses obtained

I = Intended number of samples/analyses requested

Nonvalid data (i.e., data qualified as "R" rejected) will be identified during the QA review (Section 10.3).

7.6 SENSITIVITY

The sensitivity of the analytical methods (i.e., method detection limits) identified for this project is sufficient to allow comparison of project results to decision criteria. Analytical method reporting limits for all requested analytes are listed in Appendix B.

Field and laboratory instrumentation will be examined and tested prior to being put into service and will be maintained according to the manufacturers' instructions. Sampling personnel will maintain a supply of typical maintenance replacement items available in the field to help prevent downtime because of equipment malfunctions. Examples of typical equipment maintenance items may include but not be limited to filters, tubing, fittings, sample containers, and calibration standards.

8.1 FIELD INSTRUMENTS

The following equipment or instruments, if utilized, will be serviced before the project is initiated and at regular intervals during the project as required by the manufacturer's instructions:

- Water quality meter
- PID
- CGI

Manufacturers' instructions will be followed for any additional equipment that is required for the project.

8.2 LABORATORY INSTRUMENTS

All laboratory instruments will be maintained as specified in the project laboratories' QA plans and according to manufacturers' instructions.

The ultimate responsibility for maintaining quality throughout the field exploration of the EGDY site rests with the USACE and URS Project Managers. The day-to-day responsibility for ensuring the quality of field and laboratory data rests with the USACE technical team, URS Field Investigation Managers, the Project QA/QC Officer, and the laboratory program administrators.

Any nonconformances with the established QC procedures will be expeditiously identified and controlled. Where procedures are not in compliance with the established protocol, corrective actions will be taken immediately. Subsequent work that depends on the nonconforming activity will not be performed until the identified nonconformance is corrected.

9.1 FIELD CORRECTIVE ACTION

The SCAPS manager, URS Field Investigation Manager, and the on-site USACE technical team representative will review the procedures being implemented in the field for consistency with the established protocols. Sample collection, preservation, labeling, etc., will be checked for completeness. Where procedures are not strictly in compliance with the established protocol, the deviations will be field documented and reported to the Project QA/QC Officer. Corrective actions will be defined by the USACE technical team and documented as appropriate. Upon implementation of the corrective action, the Project QA/QC Officer will be provided with a written memo documenting field implementation, and will then review it and provide a copy to the USACE technical team. The memo will become part of the field exploration project file.

9.2 LABORATORY CORRECTIVE ACTION

The laboratory QA data reviewer will review the data generated to ensure that all QC samples have been run as specified in the protocol. Recoveries of LCSs, surrogates, MS samples for consistency with method accuracy, RPD for laboratory duplicate, and MSD samples for consistency with method precision, will be evaluated against the control limits listed in Appendix C.

Laboratory personnel will be alerted that corrective actions are necessary if any of the following occur:

- The QC data are outside the warning or acceptance windows established for precision and accuracy. The laboratory project manager will contact the laboratory QA manager to discuss out-of-control limit data sets. If the analyses cannot produce data sets that are within control limits, a USACE Project Technical Leader will be notified within 48 hours of any analysis that fails to meet the data quality objectives specified in this QAPP.
- Blanks contain contaminants at concentrations above the levels specified in the laboratory QA plan for any target compound.
- Undesirable trends are detected in matrix spike or LCS recoveries, RPD between MSDs, or surrogates recoveries.
- Unusual changes in detection limits are observed.
- Deficiencies are detected by the laboratory QA manager during internal or external audits, or from the results of performance evaluation samples.

If any nonconformances in analytical methodologies or quality control sample results are identified by the analyst, corrective actions will be implemented immediately. Specific corrective actions are outlined in each method laboratory SOP. Corrective action procedures will be handled initially at the bench level by the analyst, who will review the preparation or extraction procedure for possible errors, check the instrument calibration, spike and calibration mixes, instrument sensitivity, etc. The analyst will immediately notify his/her supervisor of the identified problem and the investigation which is being conducted. If the problem persists or cannot be identified, the matter will be referred to the laboratory supervisor and laboratory QA manager for further investigation. Once the problem has been resolved, full documentation of the corrective action procedure will be filed by the laboratory QA manager, and if data are affected, the USACE technical team will be provided a corrective action memo for inclusion in the project file.

Corrective action may include, but will not be limited to the following:

- Reanalyzing suspect samples if holding time criteria permit
- Resampling and analyzing new samples
- Retrieving the archived sample for analysis
- Evaluating and amending sampling and/or analytical procedures (with USACE consultation)
- Accepting data with an acknowledged level of uncertainty (with USACE consultation)
- Recalibrating analytical instruments
- Evaluating and attempting to identify limitations of the data

Data deemed unacceptable following the implementation of the required corrective action measures will not be accepted by the USACE technical team and followup corrective actions will be explored.

9.3 CORRECTIVE ACTIONS FOLLOWING DATA EVALUATION

The Project QA/QC Officer will review the field and laboratory data generated for this project to ensure that all project quality assurance objectives are met. If any nonconformances are found in the field procedures, sample collection procedures, field documentation procedures, laboratory analytical and documentation procedures, and data evaluation and quality review procedures, the impact of those nonconformances on the overall project QA objectives will be assessed. Appropriate actions, including resampling and reanalysis, may be recommended to the USACE Project Manager so that the project objectives can be accomplished.

The chemical data reduction and review process for this project will include data generation, reduction, and QA review:

- URS, SCAPS, and USACE technical team representatives will perform limited data quality reviews of preliminary field and laboratory data prior to uploading these data to eRoom.
- Project laboratories will conduct data reduction and data quality review (see Section 10.1)
- URS will conduct an independent data quality review upon receipt of data packages from the laboratories (see Section 10.2).
- URS will prepare a final quality control summary report after the field work and final analyses have been completed (see Section 10.3).

10.1 DATA REDUCTION, REVIEW, AND DELIVERABLES BY PROJECT LABORATORIES

10.1.1 Data Reduction Procedure

10.1.1.1 Fixed Laboratories Data Reduction Procedures

The fixed laboratories will perform in-house analytical data reduction under the direction of the laboratory QA manager. Data reduction will be conducted as follows:

- Raw data produced by the analyst will be processed and reviewed for attainment of QC criteria as outlined in this SAP and/or established EPA methods, for overall reasonableness, and for transcription or calculation errors.
- After the data have been entered into the Laboratory Information Management System (LIMS), a computerized report will be generated and sent to the laboratory QA data reviewer.
- Rapid turnaround data will be reported within 48 hours of sample receipt by the laboratory. Preliminary results prior to formal in-house review or re-analysis are acceptable.
- The laboratory QA data reviewer will decide whether any sample reanalysis is required and the laboratory project manager will discuss reanalysis with the Project QA/QC Officer as soon as possible. If corrective actions have been taken and data still do not meet project QA requirements, a USACE technical team representative will be notified by the Project QA/QC Officer within 48 hours of the corrective action.
- Upon acceptance of the preliminary reports by the laboratory QA data reviewer, final reports will be generated. Final data reports will be available within 30 calendar days of sample submittal.

Laboratory data reduction procedures will be those specified in EPA SW-846 (USEPA 1994a) and those described in the laboratory SOPs. The data reduction steps will be documented, signed, and dated by the analyst.

10.1.1.2 Laboratory Qualifiers

Laboratory qualifiers as described and defined in the laboratory QA plans will include:

- Concentration below required reporting limit
- Estimated concentration due to poor spike recovery
- Concentrations of the chemical also found in laboratory blank
- Other sample-specific qualifiers necessary to describe QC conditions

10.1.1.3 Laboratory Recordkeeping

The laboratories will maintain detailed procedures for laboratory recordkeeping in order to support the validity of all analytical work. Each data report package submitted to URS will contain the laboratory's written certification that the requested analytical method was run and that all QA/QC checks were performed. The laboratory program administrator will provide URS with QC reports of its external audits if appropriate, which will become part of the central project files.

10.1.2 In-house Laboratory Data Review by Fixed Laboratories

The laboratory review will be conducted by a laboratory QA reviewer who has the initial responsibility for the correctness and completeness of the data. The laboratory QA reviewer will evaluate the quality of the work based on an established set of laboratory guidelines and this QAPP to ensure that:

- Sample preparation information is correct and complete
- Analysis information is correct and complete
- Appropriate procedures have been followed
- Analytical results are correct and complete
- QC sample results are within appropriate QC limits
- Laboratory blanks are within appropriate QC limits
- Special sample preparation and analytical requirements have been met
- Documentation is complete (all anomalies in the preparation and analysis have been documented; holding times are documented)

10.1.3 Data Deliverables

To ensure that project data are sufficient to meet both qualitative and quantitative DQOs, laboratory data deliverables permitting a data quality assessment are required. Laboratory deliverables will be sufficient to permit a limited quality review of precision, accuracy, and adherence to the method SOP. The SCAPS team will conduct quality reviews on the data collected using SCAPS techniques. URS will conduct quality reviews on the data obtained from fixed laboratories (Section 10.2).

Information provided will be sufficient to review the data with respect to:

- Holding times and conditions
- Detection/quantitation limits
- Initial and continuing calibration
- Surrogate recoveries
- Laboratory duplicates and MS/MSDs
- Precision and accuracy
- Representativeness
- Comparability
- Completeness

10.1.4 SCAPS Deliverables

For SCAPS LIF results for soil TPH, MIP/DSITMS for groundwater VOCs, CPT results for geotechnical data, FLUTe ribbon NAPL data, and GeoVIS NAPL imaging daily deliverables will include the following:

- Summary table with push identification, total push depth, push type, push start time, brief comments
- Field data form (either text or scanned) with push information such as push identification, total push depth, and comments regarding stratigraphy or LIF response (anomalous intervals, peak wavelength, possible contaminant identification)
- Graphical file of scanned field results for each push; this form contains graphical representation of cone resistance, sleeve friction, soil classification, fluorescence intensity, and wavelength at peak
- Graphical file of the map view of the site, showing push locations and cultural features (roads, buildings, etc.)
- Graphical file of the orthographic view with stratigraphy
- Graphical file of the orthographic view with LIF counts
- Graphical file of a three-dimensional view with iso-surface of LIF counts
- GMS support files needed to operate GMS (for example, bor, .map, .mat, .img, .mat, and .sol files); these files could be zipped together and packaged when transferred
- SCAPS raw data files generated by the SCAPS during each push
- FLUTe ribbon photograph
- GeoVIS video tape or photograph

The graphical files will be placed on the Webserver and the GMS files will go onto an ftp site.

For MIP/DSITMS results reported by the SCAPS team, the laboratory will prepare and retain full analytical and associated QC documentation. The SCAPS laboratory will report the data as an analytical batch of 20 or fewer samples, along with associated QC reporting data. The analytical results will be submitted to USACE via hard copy and electronic files. The formats for electronic deliverables are to be determined.

The laboratory will provide the following hard copy information regarding MIP/DSITMS sample results for each analytical data package submitted:

- Date received, extracted, and analyzed
- Sample identification
- Matrix type
- Identification and concentration
- Dilution values for analyses
- Reporting limits for undetected analytes
- Initial and continuing calibration results
- LCS recoveries
- Laboratory duplicate RPD
- Method blank results

10.1.5 Fixed Laboratories Deliverables

To ensure that project chemical data are sufficient to meet both qualitative and quantitative DQOs, laboratory data deliverables that will permit a data quality assessment are required.

The laboratory will prepare and retain full analytical and associated QC documentation. The laboratory will report the data as an analytical batch of 20 or fewer samples, along with associated QC reporting data. The final analytical data will be provided in complete Contract Laboratory Program (CLP)-type deliverable data format (all results).

The analytical results will be submitted to URS via hard copy and electronic files. The formats for electronic deliverables are included in Appendix D.

The laboratory will provide the following hard copy information for each analytical data package submitted for the EGDY site field exploration project:

- The cover sheet will list the samples included in the report, provide narrative comments describing problems encountered in analysis, and identify any analyses not meeting quality control criteria, including holding times.
- Chain of custody forms and cooler receipt forms will be provided.
- Tabulated results will be provided with inorganic and organic compounds identified and quantified, and reporting limits for all analytes shown. All analytes will be reported for each

sample as a detected concentration or as not detected above the specific limits of quantitation, which must be stated. All soil samples will be reported on a dry-weight basis with percent moisture also reported. The laboratory will also report dilution factors, date of extraction, extraction batch number, date of analysis, and analytical batch number for each sample. Tentatively identified compounds will not be reported.

- Analytical results will be provided for QC sample spikes, laboratory duplicates, initial and continuing calibration verifications of standards and laboratory blanks, standard procedural blanks, LCSs, surrogates, laboratory reference materials, and detection limit check samples.
- Raw data system printouts (or legible photocopies) will be provided that identify date of reported analysis, analyst, parameters analyzed, calibration curves, calibration verifications, method blanks, any reported sample dilutions, cleanup logs, laboratory duplicates, spikes, control samples, sample spiking levels, preparation/extraction logs, run logs, and chromatograms.
- Chromatograms will be labeled with analyte peaks, internal standards, and surrogate standards where applicable.
- Mass calibration and mass and spectral tuning will be reported for gas chromatography/mass spectroscopy (GC/MS) analyses.

The narrative accompanying the data package will include the identification of samples not meeting total QC criteria as specified in this SAP, and/or the laboratory QA plans, and cautions regarding nonquantitative use or unusability due to out-of-control QC results. Data reduction and QC review steps will be documented, signed, and dated by an authorized representative.

10.2 INDEPENDENT DATA QUALITY REVIEW BY URS

The second level of review will be performed by URS (or designee) and will include a review of laboratory performance criteria and sample-specific criteria. One hundred percent of fixed laboratories' data will be reviewed. Additionally, URS will determine whether the DQOs have been met, and will calculate the data completeness for the project. The data quality review will be performed according to *EPA Region 9 RCRA Corrective Action Program Data Review Guidance Manual* (USEPA 1996).

Full data validation will also be performed on 10 percent of all data according to EPA functional guidelines (USEPA 1994b). Sample data groups will be selected by the USACE after receipt of all final data packages and following the initial data quality review.

Data quality review is a process to determine if the data meet project-specific DQOs. The data quality review will include verification of the following:

- Compliance with the QAPP
- Proper sample collection and handling procedures
- Holding times

- Field QC results
- Instrument calibration verification
- Laboratory blank analysis
- Detection limits
- Laboratory duplicates
- MS/MSD percent recoveries and RPDs
- Surrogate percent recoveries
- Data completeness and format
- Data qualifiers assigned by the laboratories

Qualifiers will be added to data during the review as necessary. Qualifiers applied to the data as a result of the independent review will be limited to:

U	The analyte was analyzed for but was not detected above the reporting limit.
J	The analyte was positively identified; the associated numerical value is an estimate of the concentration of the analyte in the sample.
UJ	The analyte was not detected above the sample reporting limit. However, the reporting limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.
R	The sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.

Results of the QA review and/or validation will be included in a data quality review report that will provide a basis for meaningful interpretation of the data quality and evaluate the need for corrective actions and/or comprehensive data validation. This report will be used to generate the quality control summary report.

10.3 QUALITY CONTROL SUMMARY REPORT BY URS

After the field work and the final analyses have been completed and reviewed, a final quality control summary report will be prepared by the Project QA/QC Officer. The report will summarize the QA and audit information, indicating any corrective actions taken and the overall results of SAP compliance. The Project QA/QC Officer, in coordination with the laboratory's QA manager or qualified designee, will prepare the final summary that will be included in the central project file and incorporated as part of the final field exploration report.

The QC summary report will provide a basis for meaningful interpretation of the data quality and evaluate the need for corrective actions and/or additional comprehensive data validation. Analytical data will be qualified by reviewing the laboratory's standard analytical QC such as laboratory blanks, duplicates, LCSs, PE samples, MS/MSDs, and surrogate recoveries. The data quality review will involve checking the laboratory data package against criteria established in the QAPP. The data will be considered valid if they meet the criteria established in this QAPP for the following elements:

- Accuracy
- Precision
- Completeness
- Representativeness
- Comparability

The QC summary report will include evaluation of sampling documentation/representativeness, technical holding time, instrument calibration and tuning, field and laboratory blank sample analyses, method QC sample results, field duplicates, compound identification and quantitation, elevated reporting limits, and a summary of qualified data.

Performance and systems audits may be conducted to determine whether:

- The QA program has been documented in accordance with specified requirements
- The documented program has been implemented
- Any nonconformances were identified and corrective action or identified deficiencies was implemented

The URS Project QA/QC Officer will be responsible for initiating audits, selecting the audit team, and overseeing audit implementation. The URS Project QA/QC Officer is responsible for supervising and checking that samples are collected and handled in accordance with this management plan and that documentation of work is adequate and complete. The URS Project QA/QC Officer also is responsible for overseeing that the project performance satisfies the QA objectives as set forth in this QAPP.

Reports and technical correspondence will be peer reviewed by qualified individuals before being finalized.

11.1 PERFORMANCE AUDITS

Performance audits are utilized to quantitatively evaluate the accuracy of measurement data through the use of PE samples and blind check samples. Independent commercial PE samples will be submitted to the laboratories with the field samples for VOC analysis. The PE samples will be used to monitor the quality of the laboratory data instead of submitting split samples to a fixed analytical laboratory. This allows correction of problems in the field before analytical activities are complete.

All PE samples will be introduced blind to the analytical process. The performance audit will be conducted by URS and approved by a USACE Project Technical Leader.

11.2 SYSTEMS AUDITS

Systems audits of the field and laboratory procedures may be conducted during this project. Field audits will be conducted if the USACE Project Technical Leaders or Project QA/QC Officer identifies the need. Systems audits of the laboratory will be performed annually and when the laboratory QA manager identifies the need, which may be throughout this project. An additional systems audit may be requested by the Project QA/QC Officer, if warranted. The frequency of on-site audits will depend on the type of interaction and communications the Project QA/QC Officer experiences with the laboratory staff, and on the frequency of observations of noncompliance with QC criteria and SOPs.

The laboratory QA manager will regularly conduct the following internal audits:

- Technical audit including reviews of calibration and equipment monitoring records, laboratory logbooks, maintenance records, and instrument control charts
- Data quality audit reviews, including all aspects of data collection, reporting and review
- Management system audits verifying that management and supervisory staff are effectively implementing and monitoring all QC activities necessary to support the laboratory QA program

External laboratory reviews are conducted by various government agencies and clients, such as the EPA CLP, U.S. Naval Energy and Environmental Support Activity, and the USACE Hazardous Waste Remedial Actions Program.

11.3 AUDIT PROCEDURE

This section provides requirements and guidance for performing internal and external audits to verify compliance with the elements of the SAP.

The USACE and URS Project Managers, the USACE Project Technical Leaders and, if appropriate, other audited entities (e.g., Field Investigation Managers, laboratory supervisors) will be notified by the Project QA/QC Officer of an audit a reasonable time before the audit is performed. This notification will be in writing and will include information such as the general scope and schedule of the audit, and the name of the audit team leader.

A pre-audit conference will be conducted at the audit site with the appropriate manager or designated representative (e.g., Field Investigation Manager, laboratory supervisor). The purpose of the conference will be to confirm the audit scope, present the audit plan, discuss the audit sequence, and plan for the post-audit conference.

The audit is then implemented by the audit team. Selected elements of the SAP will be audited to the depth necessary to evaluate the effectiveness of implementation. Checklists prepared by the audit team and approved by the Project QA/QC Officer will be sufficiently detailed to document major audit components. Conditions requiring immediate corrective action will be reported immediately to the Project QA/QC Officer.

At the conclusion of the audit, a post-audit conference will be held with the Field Investigation Managers or laboratory supervisors, or their designated representative, to present audit findings and clarify any misunderstandings. A list of audit findings will be concisely stated by the audit team leader. The findings will be acknowledged by signature of a USACE Project Technical Leader or designated representative upon completion of the post-audit conferences.

An audit report will be prepared by the audit team leader and signed by the Project QA/QC Officer. The report will include the following:

- Description of the audit scope
- Identification of the audit team
- List of persons contacted during pre-audit, audit, and post-audit activities
- A summary of audit results, including an evaluation statement regarding the effectiveness of the SAP elements which were audited
- Details of findings and program deficiencies
- Recommendations for corrective actions to the Project QA/QC Officer, with a copy to the USACE and URS Project Managers, the USACE Project Technical Leaders, and others as appropriate

11.4 AUDIT RESPONSE

The USACE or URS Project Manager or designated representative will respond to the audit report within 7 days of receipt. The response will clearly state the corrective action for each finding, including action to prevent recurrence and the date the corrective action will be completed.

11.5 FOLLOW-UP ACTION

Followup action will be performed by the Project QA/QC Officer or designated representative to:

- Evaluate the adequacy of the Project Manager’s response
- Evaluate that corrective action is identified and scheduled for each finding
- Confirm that corrective action is accomplished as scheduled

Followup action may be accomplished through written communications, re-audit, or other appropriate means. When all corrective actions have been verified, a memo will be sent to the USACE Project Manager signifying the satisfactory closeout of the audit.

11.6 AUDIT RECORDS

Original records generated for all audits will be retained in the central project files. Records will include audit reports, written replies, the record of completion of corrective actions, and documents associated with the conduct of audits that support audit findings and corrective actions as appropriate.

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Appendix A

Standard Operating Procedures

CONTENTS

Site Characterization and Analysis Penetrometer System/Laser-Induced Fluorescence (SCAPS/LIF)

SCAPS Membrane Interface Probe with Direct Sampling Ion Trap Mass Spectroscopy (MIP/DSITMS)

Flexible Liner Underground Technologies (FLUTe) Ribbon Sampler

Sound Analytical Services, Inc. – Semivolatile Petroleum Products Method for Soil and Water by NWTPH–Dx Modified

Sound Analytical Services, Inc. – Semivolatile Organic Compound (Base/Neutrals and Acids) Analysis by GC/MS, Method 8270C

Sound Analytical Services, Inc. – Method 8260B Modified: Volatile Organic Compound Analysis using Finnigan Mat INCOS50 GC/MS

Sound Analytical Services, Inc. – Method 8260B Modified: Volatile Organic Compound Analysis by Finnigan Mat ITS-40 GC/MS

PTS Laboratories – Method 9060 Total Organic Carbon (TOC)

PTS Laboratories – Interfacial Tension of Oil Against Water by the Ring Method – ASTM D971

PTS Laboratories – Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity) – ASTM D445

PTS Laboratories – Density and Relative Density (Specific Gravity) of Viscous Material by Lipkin Bicapillary Pycnometer – ASTM D1481

PTS Laboratories – Porosity – API RP40

PTS Laboratories – Dry or Native Bulk Density – ASTM D2937

PTS Laboratories – Manual Distillation of Petroleum Products – ASTM D86

PTS Laboratories – Particle Size by Mechanical Sieve – ASTM D422M-63

PTS Laboratories – Particle Size by Laser Light Scattering – ASTM D4464M-85

PTS Laboratories – Hydraulic Conductivity and Permeability to Water (Methods ASTM D5084, EPA 9100, and API RP40)

PTS Laboratories – Cation Exchange Capacity – EPA 9081

Standard Operating Procedure

For

Site Characterization and Analysis Penetrometer System/Laser Induced Fluorescence (SCAPS/LIF)

SOP No: M-0003-SWT-03

PREPARED BY: ____________________
(Author) (Date)

REVIEWED BY: ____________________
(SCAPS Manager) (Date)

____
(Quality Assurance Officer) (Date)

1.0 Scope and Application

1.1 Introduction

This standard operating procedure (SOP) is based on several technical reports and methods, which are referenced at the end of this document. This SOP describes the procedures used to conduct a subsurface ***in-situ*** petroleum hydrocarbon investigation with the Site Characterization and Analysis Penetrometer System and Laser Induced Fluorescence technique (SCAPS/LIF) currently deployed by the US Army Corps of Engineers Tulsa District.

1.2 Application

This SOP is applicable to the rapid investigation of subsurface petroleum hydrocarbon contamination at hazardous waste sites.

1.3 Personnel and Training

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of SCAPS technology and familiar with cone penetrometer testing, soil boring installation, grouting techniques, and laser-induced fluorescence.

The SCAPS manager will ensure all personnel are qualified and have received training relevant to the equipment and instruments currently possessed by the Investigations Section and used to support the District's SCAPS program. Additional District technical resources (chemists, industrial hygienists, geologists, etc.) will be used to support and enhance SCAPS operations whenever required.

2.0 Method Summary

2.1 Introduction

This SOP describes the process by which a subsurface ***in-situ*** petroleum hydrocarbon investigation will be conducted with SCAPS/LIF system.

The SCAPS system incorporates surface geophysical methods, surveying and mapping methods, special penetrometers with sensors for contaminant detection, and subsurface sampling equipment to map soil characteristics and contaminant distribution.

2.2 Cone Penetrometer System

Cone penetrometer testing (CPT) and standard penetrometer testing have been widely used in the geotechnical industry for determining soil strength and soil type from measurements of tip resistance and sleeve friction on an instrumented probe. The SCAPS uses a truck-mounted CPT platform to advance its chemical and geotechnical-sensing probe. The CPT platform provides a 20-ton static reaction force associated with the weight of the truck. The forward portion of the truck-mounted laboratory is the **push room**. It contains the rods, hydraulic rams, and associated system controllers. Underneath the SCAPS CPT push room is the steam manifold for the rod and probe decontamination system. The rear portion of the truck-mounted laboratory is the isolatable **data collection room** in which components of the CPT, onboard computers, and related support instruments are located.

2.3 Initial Site Survey

The site will be initially surveyed to locate underground utilities and underground obstacles to prevent damage to the SCAPS, ensure crew safety, and to prevent damage to utilities. Many sites contain a variety of underground anomalies, such as telephone cables, gas lines, electrical power cables, water pipes, sanitary sewer lines, drainage pipes, and steam lines.

Once the survey has been completed, approximate locations for each planned penetration are determined based on such factors as proximity to suspected contaminant sources, anticipated groundwater flow patterns, suspected underground obstacles, cultural features, topography variations, and mobility limitations.

Dependent upon site conditions and field results, the SCAPS manager and technical manager will modify all penetrometer locations when appropriate.

2.4 "Dummy" Exploration

At the discretion of the SCAPS manager, a "dummy" tip will be advanced into the subsurface soil to probe for any unanticipated anomalies, which may hinder the intrusive exploration of the location. The "Dummy" tip contains no sensors or sampling tools that may be damaged.

2.5 Soil Classification by Cone Penetrometer Test

A series of locations will be selected to conduct soil classifications. Soil strength and type is determined by monitoring tip resistance and sleeve friction when the CPT probe is advanced through the subsurface soil.

The combination of the SCAPS's reaction mass and hydraulics can advance the probe into the ground at a rate of 1m/min in accordance with ASTM Methods D3441 and D5778. The tip resistance is measured by means of a system of strain gauges that form an internal load cell as the cone tip is advanced. Friction developed along a floating cylindrical sleeve, just behind the cone tip, is measured similarly as the device passes through the soil. Tip penetration resistance and sleeve friction is measured independently and continuously. The point and sleeve friction load cells are independently calibrated in the field prior to cone penetrometer operation.

Soil classification is conducted on-board the SCAPS during field operations using a computer-based routine that references the strain gauge readings, the calibration curves and an empirical relationship between cone resistance and friction. The SCAPS instruments are capable of discriminating porous sands from tighter, finer-grade silts and clays.

2.6 Laser-Induced Fluorescence (LIF)

A series of locations will be selected to conduct an ***in-situ*** analysis for petroleum hydrocarbon contamination. The District's SCAPS supports a Laser-Induced Fluorescence (LIF) Sensor and Support System operated in accordance with ASTM Method D6187, except when noted otherwise within this SOP.

The SCAPS/LIF method provides data on the in-situ distribution of petroleum hydrocarbons based on the fluorescence response induced in the polycyclic aromatic hydrocarbon (PAH) compounds that are components of petroleum hydrocarbons. PAHs in petroleum products are induced to fluorescence by excitation with ultra-violet (UV) light. The method provides a "detect/non-detect" field screening capability relative to a detection limit derived for a specific fuel product on a site-specific soil matrix. The SCAPS LIF is primarily used, as a field screening, qualitative method but can be semi-quantitative at concentrations within two orders of magnitude of its detection limit for fluorescent petroleum hydrocarbons.

The LIF system uses a pulsed nitrogen laser (**PTI ™ 2300**) with an optical multichannel analyzer (**EG&G™ Model 1460**) and photodiode array detector (**EG&G™ Model 1421**) to make fluorescence measurements via optical fibers. These fibers are integrated with the penetrometer probe and umbilical of the SCAPS. The measurement is made through a sapphire window on the probe.

Fluorescence emission spectra are collected once per second as the probe is advanced into the subsurface soil. An on-board computer is used to generate real-time depth plots of fluorescent intensity at the spectral peak, wavelength of spectral peak, sleeve friction and tip resistance, and soil type characteristics as interpreted from the strain gauge data. The fluorescent intensity in the spectral window is plotted as a function of depth in real time as the probe is pushed into the soil.

2.7 Borehole Abandonment and Grouting

Grouting will be performed to ensure that vertical cross contamination does not occur in the penetration and borehole locations. To accomplish this a silica flour cement mixture will either be automatically pumped into the hole as the penetrometer probe/sensor is retracted or manually placed into the open borehole.

2.8 Decontamination

Dependent upon push depth and number of locations, a small volume of decontamination fluids is generated by at each location. As the penetrometer/probe is retracted, a high pressure hot water/steam-cleaning system is used to wash each rod section and remove possible contamination. The decontamination fluid is collected in a five-gallon bucket from under the truck and transferred to a DOT certified steel drum or other approved container.

3.0 Method Limitations

3.1 Truck-Mounted Cone Penetrometer Access Limit

The SCAPS CPT support platform is a 20-ton freightliner all-wheel-drive diesel powered truck. The dimensions of the truck require a minimum access width of 10 feet and a height clearance of 16 feet. Some sites, or areas of sites, might not be accessible to a vehicle the size of the SCAPS CPT truck. The access limits of the SCAPS CPT truck are similar to those for conventional drill rigs and heavy excavation equipment.

3.2 Cone Penetrometer Advancement Limits

The CPT sensors and sampling tools may be difficult to advance in subsurface lithologies containing cemented sands and clays, buried debris, gravel units, cobbles, boulders, and shallow bedrock. As with all intrusive site characterization methods, it is extremely important that all underground utilities and structures is located using reliable geophysical equipment operated by trained professionals before undertaking activities at a site. Local utility companies should be contacted for the appropriate information and approval when applicable.

3.3 Response to Different Petroleum Hydrocarbons

The relative response of SCAPS LIF sensor depends on the specific analyte being measured. The instrument’s sensitivity to different hydrocarbon compounds can vary by as much as two orders of magnitude.

3.4 Matrix Effects

The in-situ fluorescence response of the LIF sensor to hydrocarbon compounds is also sensitive to variations in the soil matrix. Matrix properties that affect LIF sensitivity include soil grain size, mineralogy, moisture content, and surface area. Each of these factors influences the relative amount of analyte that is adsorbed on or absorbed into the soil. Only the relative fraction of analyte that is optically accessible at the window of the probe can contribute to the fluorescence signal.

3.5 Spectral Interferences

The SCAPS LIF sensor is sensitive to any material that fluoresces when excited with ultraviolet wavelengths of light. Although intended to specifically target petroleum hydrocarbons, the excitation energy produced by the LIF system's laser may cause other naturally occurring substances to fluoresce as well.

4.0 Quality Assurance/Quality Control

4.1 Overview

Geotechnical and chemical data generated by field crews during the SCAPS investigation will be reviewed by personnel possessing the required skills necessary to evaluate and validate the results. A quality assurance officer will be assigned to the project to ensure that all data quality objectives for the project are adequately being met.

4.2 SCAPS CPT QA/QC

Initial system setup will require the calibration of a few components including, but not limited to, the point and sleeve friction load cells, strain gauges. Calibrations will occur whenever a different probe assembly is used.

4.3 SCAPS LIF QA/QC

Initial system setup will require the calibration of a number of components including, but not limited to, the laser, the detector, strain gauges.

An evaluation of the sensitivity of the LIF sensor and contamination encountered at the site is completed by collecting a number of confirmation soil samples from various depths, and either analyzing these samples on-site or at an analytical laboratory. The field or laboratory analytical tests should adequately characterize the soil sample for the presence of petroleum hydrocarbon contaminants, especially polyaromatic hydrocarbons. Acceptable methods include, but are not limited to, EPA method 418.1, modified 8015, modified 8270.

Due to the nature of the ***in-situ*** measurement, duplicate samples cannot be measured by LIF. Soil heterogeneity and variation in contaminant distribution can be significant over short distances both horizontally and vertically. A number of soil samples will be collected at various depths and locations such that equal numbers of nondetects and detects relating to the LIF readings can be adequately analyzed and evaluated.

5.0 Waste Disposal

Decontamination fluids and other investigative derived wastes (IDW) generated during SCAPS activities will be properly containerized, staged, labeled, and managed in accordance with the project work plan. The volume of waste will be minimized whenever applicable. Soil, liquid, and personal protective equipment (PPE) IDW will be separately containerized and segregated. The PPE will be disposed of as nonhazardous waste unless it has been grossly contaminated or is determined to be contaminated by on-site field data.

6.0 Health and Safety

A site-specific safety and health plan will be developed for SCAPS and related SCAPS activities. All field personnel will attend safety meetings scheduled by SCAPS field manager and industrial hygiene officer.

All field personnel will follow current OSHA standards and regulations documented within USACE's EM385-1-1.

7.0 References

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U.S. Army Corps of Engineers, (1996). "Cone Penetrometer Grouting Evaluation." Technical Report GL-96-33, Waterways Experiment Station, Vicksburg, MS

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American Society for Testing and Materials (ASTM). (1997). “Standard Practice for Cone Penetrometer Technology Characterization of Petroleum Contaminated Sites with Nitrogen Laser-Induced Fluorescence”. Designation D6187-97. Philadelphia, PA

American Society for Testing and Materials (ASTM). (1998). “Standard Test Method for Mechanical Cone Penetrometer Tests in Soil”. Designation D3441-98. Philadelphia, PA

Standard Operating Procedure

For

Membrane Interface Probe and Direct Sampling Ion Trap Mass Spectrometer

SOP No: M-0005-SWT-01

PREPARED BY:

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(Author) (Date)

REVIEWED BY:

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(Technical Manager) (Date)

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(Project Chemist) (Date)

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(Quality Assurance Officer) (Date)

1.0 Scope and Application

1.1 Introduction

This standard operating procedure (SOP) describes the procedures used to identify and determine the concentration of volatile organic compounds (VOCs) in the subsurface environment using the Membrane Interface Probe/Direct Sampling Ion Trap Mass Spectrometer (MIP/DSITMS) system coupled with direct push techniques.

1.2 Application

This SOP is applicable to all locations where direct push techniques can be employed. The DSITMS technique may be used to examine individual groundwater samples properly containerized in 40ml vials. The MIP/DSITMS technique is only applicable to characterizing VOCs in the vadose and saturated zones.

1.3 Personnel and Training

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of mass spectrometers and familiar with general analytical chemistry techniques, sample extraction procedures, and waste management practices.

The project chemist will ensure all personnel are qualified and have received training relevant to the equipment and instruments currently possessed by the HTRW Design Branch and used to support the District's field analytical program.

2.0 Method Summary

2.1 Introduction

Samples may be introduced into the Ion Trap Mass Spectrometer (ITMS) by one of two methods:

<u>Direct Sampling/Vial Sparging</u>: One of the more common techniques which allows the analyst to introduce a sample by directly sparging a vial containing a groundwater sample with helium and analyzing the effluent vapor with the DSITMS.

<u>Membrane Interface Probe</u>: This in situ technique allows the analyst to vertically profile a subsurface location for the presence of VOCs. The MIP/DSITMS is comprised of the MIP, a metal/teflon composite membrane that samples VOCs in situ and the DSITMS that identifies and quantifies the VOCs. The MIP/DSITMS is capable of multiple, discreet VOC measurements in a single penetration, sampling depths/resolution are determined on a site-specific basis.

The MIP is a permeable membrane device used to detect volatile contaminants as it is driven to depth in soil or other unconsolidated materials. A thin film membrane is impregnated into a stainless steel screen on the face of the probe. This membrane is heated to 100 - 120 degrees Celsius leading to quick diffusion of VOC contaminants across the membrane into the He carrier gas which flushes the back of the membrane and transports the contaminants to the above ground DSITMS.

2.2 Background Information

Geoprobe Systems, Inc. (www.georprobesystems.com) developed the MIP. The MIP/DSITMS has been used by U.S. Army Waterways Experiment Station with a standard geophysical cone penetrometer truck (CPT) capable of advancing direct push sampling tools but has also been deployed using other vehicles capable of advancing direct push tools (Geoprobe, Earth Probe, etc.).

3.0 Method Limitations and Potential Interferences

Direct Sampling Ion Trap Mass Spectrometry is a method for the quantitative measurement, continuous real-time monitoring, and quantitative and qualitative preliminary screening of VOCs in water, soil, and air (Wise et al, 1997). It is applicable to the determination of VOCs in batch samples taken to the laboratory and to on-site measurement and monitoring. It is best suited for the routine quantitative monitoring of sampling locations characterized once using standard gas chromatography mass spectrometry methods, for analyzing samples for the presence of VOCs, and for support of site characterization and remediation activities requiring the analysis of large numbers of samples in a short period of time or requiring on-line continuous monitoring. It is applicable to the qualitative and quantitative analysis of unknown (previously uncharacterized) samples provided that the absence of interferences can be documented. This procedure is not applicable if results are required for individual positional isomers (e.g.; ortho, meta, para-xylenes) or individual geometric isomers (e.g., cis/trans ethenes) unless unique operating conditions are developed and demonstrated which make it possible. Isomer distribution must be determined at least once using gas chromatography or gas chromatography mass spectrometry methods.

The DSITMS demonstrates the capability of meeting the precision and accuracy QC performance criteria establish for water analysis by EPA Method 624 (40 CFR Part 136).

Validation data collected for in situ MIP/DSITMS data in saturated soils as compared to data for samples collected by US EPA sampling Method 5035 and analysis Method 8260 indicate that the system provides quantitative estimates of subsurface contamination distribution.

4.0 Health and Safety

The toxicity or carcinogenicity of chemicals used in this procedure has not been precisely defined. Each chemical will be treated as a potential health hazard, and exposure to these chemicals will be minimized whenever possible. The project chemist will be responsible for maintaining awareness of OSHA regulations regarding safe handling and disposal of chemicals.

All USACE personnel will follow current safety and health requirements published by OSHA and stated within USACE's EM385-1-1 Manual. Material safety data sheets will be kept on-site regarding all reagents. Emergency numbers and a hospital route will be openly displayed near the work area.

5.0 Sample Preservation and Handling

The MIP/DSITMS technique requires no sample handling other than the collection of soil and groundwater samples necessary to meet project quality assurance and quality control objectives. During the direct sampling/vial sparging method, the DSITMS requires the collection and containerization of groundwater samples prior to analysis.

Groundwater samples will be collected in 40ml certified vials (amber or clear) with teflon liners. Samples may either be preserved (with hydrochloric acid) or unpreserved prior to analysis. Preserved samples shall be analyzed within 14 days. Unpreserved samples may be analyzed within 7 days.

The collection of soil samples will follow the procedures set forth in SW846 Method 5035 and generally will be collected in tared and prepreserved 40ml certified vials (amber or clear) with teflon liners. Samples may either be preserved with methanol or sodium bisulfate dependent upon the required quantitation limits or headspace readings from field instruments. Preserved samples shall be analyzed within 14 days. An alternative to the prepreservation of vials is to use the Encore sampler, which requires preservation by the laboratory within 48 hours.

6.0 Quality Assurance/Quality Control

6.1 Mass Axis Calibration

Mass axis calibration of the DSITMS should be ran initially at start up and checked daily using an acceptable calibration compound such as perflourotributylamine (PFTBA). Refer to the manufactures recommendation for frequency. Record the results of mass axis calibration for future reference.

6.2 Background Subtraction

A blank sample should be run for background subtraction, to ensure there is no carryover in the transfer line, any time samples are run having > 500 ppm of VOC contamination, and between analysis of samples from different sources. During the MIP/DSITMS, a system blank check should be performed before and after each set of in situ measurements.

6.3 Calibration Curve

A calibration curve should be developed using laboratory prepared standards of known concentrations bracketing the expected contaminant concentrations for a particular site.

Once calibration is achieved, analyze calibration check standards a minimum of twice a day during the direct sampling method and once after each penetration is completed while using the MIP/DSITMS. Corrective action is required whenever the calibration factor (slope of calibration curve) varies by > 2 standard deviations from the mean value developed during calibration (see 3.) and subsequent analyses of calibration check standards. Corrective actions include, but are not limited to, system leak checking, evaluation of current calibration standard relative to the Performance Evaluation Check Standard (PECS; see 6.4 below) and/or complete recalibration.

Operating conditions used to generate the calibration curve should not be changed during sample analysis. Critical operating parameters that affect system sensitivity are carrier gas flow rate of the MIP, membrane temperature and DSITMS set points for electron multiplier voltage (EM), ionization time (IT) and filament current.

6.4 Performance Evaluation Check Standards

Performance Evaluation Check Standards (externally prepared) should be run daily at startup and at the conclusion of each day. Corrective action is required whenever the PECS results are significantly different from the true value (i.e. results do not fall within 2 standard deviations of the historic mean value developed for the analytical system).

6.5 Verification Sampling

The MIP/DSITMS system is intended to be used as a high-level field screening technique to rapidly delineate the distribution of VOC contaminants in the subsurface. The direct sampling/vial sparging method is more amenable to low level concentrations. The data collected can be used to accurately place a minimum number of conventional sampling points (soil bores and/or monitoring wells) for site characterization and monitoring. Verification sampling and off site analysis by US EPA Method 8260 will be performed on a site-specific basis and in accordance with the project work plan to confirm the results obtained using the DSITMS.

Select locations and depths for verification sampling to include a range of contaminant concentrations from non-detect to the maximum concentrations detected DSITMS. Obtain soil for verification samples of the MIP/DSITMS by using direct push soil sampler advanced to depth using the CPT at locations offset no greater than 1 to 1.5 ft horizontally from the MIP push location. Soil cores obtained for verification sampling should be subsampled using US EPA Method 5035 (i.e. subsamples placed immediately into tarred vials containing 5 mL methanol, or the Encore sampler). Note that clay subsamples that do not readily break up in the methanol when shaken should be manually broken into smaller pieces using a stainless steel spatula until the sample is completely submerged by the methanol. If soil remains above the surface of the methanol, the VOC contaminants will escape the extract and partition into the headspace of the vial causing erroneously low concentrations during analysis. Verification samples for the direct sampling/vial sparging technique should be collected in 40 ml vials as described in section 5.0. Verification samples should be place on ice until shipped to the off site laboratory for analysis by US EPA Method 8260.

7.0 Procedure

The steps listed in the following sections outline the general procedure for operating the MIP/DSITMS. Operation of the DSITMS alone to characterize individual groundwater samples is performed in accordance with Section 7.2 below and as outlined in Draft EPA Method 8265. Additional procedures are followed in accordance with operating instructions provided by the manufacturer and software designer.

7.1 Membrane Interface Probe

7.1.1 Set flow rate of He to MIP module between 80-120 mL/minute (do not exceed 18 psi back pressure). This will cause the helium carrier gas to flow out of the membrane.
7.1.2 Interface MIP carrier gas return line to inlet of heated (100 ^{o}C) DSITMS interface.
7.1.3 Using the MIP controller, heat the membrane of the MIP to 120 ^{o}C and acquire 3-minute background data file using the DSITMS.
7.1.4 Cool MIP to < 40 ^{o}C using air or with the aid of deionized water, place calibration jig around membrane, simultaneously add clean sand and water (refer to sec. 7.3.3). Acquire 3-minute soil background data file using DSITMS. Repeat three times for establishment of baseline.

7.2 Direct Sampling Ion Trap Mass Spectrometer

7.2.1 Check DSITMS heater temperature, adjust if necessary per instrument manufactures instructions (normally between 150 – 200 ^{o}C).
7.2.2 Check carrier gas flow rate, adjust if necessary.
7.2.3 Check critical DSITMS parameters: EM voltage, filament current and IT, adjust if necessary per instrument manufactures instructions.
7.2.4 Calibrate the DSITMS mass axis according to the manufactures' instruction. Print a hard copy of the mass axis calibration and archive.

7.2.5 Analyze a middle to low concentration calibration standard to access system sensitivity (see details of calibration standard analysis in **Quantitative Calibration of MIP/DSITMS sensor** below). Adjust DSITMS operating parameters as needed to achieve desired sensitivity.

7.3 Quantitative Calibration of MIP/DSITMS Sensor

7.3.1 Prepare stock standard solutions for analytes of interest by weighing neat (99%) VOC analytes into a 10-mL vol. flask containing approximately 7-8 mL methanol. Be careful to ensure that the neat analyte is dropped directly into the methanol and does not touch the unwetted glass surface of the vol. flask. Prepare stock solutions in the concentration ranges of 1-5 mg/mL. Multiple analyte mixtures in a single stock solution are acceptable as long as no analytes yielding identical m/z are mixed (see **Inferences**). Details of VOC stock solution preparation can be found in US EPA Method 8260. Alternatives to the preparation of stock solutions can be made based on volume measurements rather than weight.

7.3.2 Prepare aqueous dilutions of the calibration standards using the equation $C_1V_1 = C_2V_2$ in reagent water by filling a 1 liter graduated cylinder with water and injecting a measured volume of the methanol stock solution to obtain the desired aqueous concentration (Note: Be sure units are the same). For the purpose of vial sparging, 40 ml vials will be used. A gas tight syringe should be used for this dilution (rinse thoroughly with methanol after use). It is important to inject the methanol solution **below** the water surface in the graduated cylinder/vial and gently stir to mix the aqueous standard dilution. Vigorous shaking of the standard dilution will cause low, erratic response during subsequent analysis. A list of initial calibration concentrations is reported in Section 7.10 of this SOP for both the MIP/DSITMS and DSITMS.

7.3.3 During the MIP/DSITMS, insure that the MIP heater is turned off and the membrane is < 40 C. Place calibration jig on MIP with the membrane section in the middle of the jig. Using an aqueous standard prepared as described in 7.3.2, gently pour standard and sand at constant rates into the calibration jig. Simultaneously turn on MIP heater and begin DSITMS data acquisition. For the direct sampling/vial sparging method, immediately place the vial on the sparging apparatus and begin acquisition while sparging.

7.3.4 Analyze at a minimum of three different concentrations of dilutions in duplicate covering the desired concentration range. Make dilutions, one at a time as described in 7.3.2 and **analyze immediately**. Do not batch the preparation of dilutions in water as VOCs defuse out of the water in a short period of time.

7.3.5 Analyze calibration standards at various intervals, such as when problems operating instrument occur, or whenever sample concentrations vary widely and at least once after every penetration during the MIP/DSITMS and twice a day during the direct sampling/vial sparging method.

7.3.6 Analyze a PECS at least once each day of operation when using the MIP/DSITMS and twice a day when using the direct sampling/vial sparging method or after each 20 sample analyses. Keep a continuing graphical or tabular record of daily calibration check standards and PECS for determination of system performance. Take corrective action whenever calibration standards or PECS results do not meet QC criteria.

7.4 Analytical Procedure for MIP/DSITMS

7.4.1 Analyze blank water/sand sample before each penetration.

7.4.2 Prepare DSITMS data acquisition files for all planned sampling depths before penetration begins. Record data file names and sampling depths in the field-sampling logbook.

7.4.3 In moderately contaminated areas, insure the MIP membrane <40 ^{o}C. Push the MIP to the first sampling depth. Continuous heating of the membrane is preferred when high dissolved phase or free-phase Non Aqueous Phase Liquid (NAPL) is encountered.

7.4.4 Begin data acquisition as soon as depth is achieved (generally a 3 minute acquisition).

7.4.5 Once acquisition is complete, turn off membrane heater and prepare the next DSITMS acquisition file before advancing to the next sampling depth.

7.4.6 Repeat 7.4.2 through 7.4.5 for each sampling depth during penetration.

7.4.7 Analyze a system blank and at least one calibration check standard after retraction of MIP from penetration. Check system response of both the blank and standard to insure no contaminant carryover and continuing calibration.

7.4.8 PECS will be run at the frequency stated in section 7.3.6.

7.5 Calculate Results

7.5.1 Determine relevant m/z values to quantify specific analytes of interest.

7.5.2 Plot selected ion profiles for m/z of each analyte.

7.5.3 Integrate area for relevant m/z values over a consistent number of scans (typically 50 to 100 scans). Actual sample integration intervals should **always** be the same number of scans as that used for calibration data quantification. Print and save integrated data file.

7.5.4 Use response factor determined from calibration curve for each analyte to calculate the concentration of analyte present in the sample.

7.5.5 Depending on the manufacturer of the ITMS, software for automation of calibration and sample data reduction may be available. Otherwise, manual integration using the DSITMS software and common spreadsheet means can be used for calculation of results.

7.6 Method Performance

7.6.1 Accuracy and Precision

The DSITMS has been shown to be capable of meeting the precision and accuracy QC performance criteria establish for water analysis by EPA Method 624 (40 CFR Part 136).

Validation data collected for in situ MIP/DSITMS data in saturated soils and compared to data for samples collected by US EPA sampling Method 5035 and analysis Method 8260 indicate that the system provides quantitative estimates of subsurface contamination distribution. However, there appears to be a matrix moisture-content effect for vadose soils.

7.6.2 Detection Limits

Limit of detection (LOD) calculations are conducted using the U.S. EPA method proscribed in SW 846 (U.S. EPA 1995). This method involves n replicate measurements of a low but detectable analyte concentration, estimation of analytical system noise as the variance of the n replicate measurements and calculation of LOD using the equation:

$$\mathrm{LOD} = t_{n-1,\ \alpha/s}\ S \qquad \text{(Equation 1)}$$

where, $t_{n-1,,\ \alpha/s}$ is the student t value for n replicates at the 95% confidence level and S estimate of the standard deviation. For n values between 5 and 9, the $t_{n-1,\ /s}$ ranges between 2.78 and 2.23, respectively. Measurements for LOD calculations are made using the entire MIP/DSITMS sensing system, therefore measuring the expected system performance in the direct push well. Typical LOD values calculated for data obtained in actual field operations are on the order of 100 to 200 ug/L (as water).

7.6.3 Time Considerations

Absolute time required for a single iteration of pushing to multiple sampling depths and making a number of MIP/DSITMS measurements is dependent on the total depth and sampling resolution desired. Each DSITMS analysis requires 3 minutes to complete. Estimates of time required for a single complete iteration range from one hour for penetrations < 25 ft with up to ten discrete DSITMS measurements to approximately 3 hours for penetrations up to 150 ft with up to 25 discrete DSITMS measurements.

7.7 Critical Parameters and Troubleshooting

7.7.1 MIP/DSITMS

The MIP carrier gas flow rate and system response (i.e. slope of calibration curves) are linked. If the flow is change, re-calibration may be needed. The MIP operating temperature is critical to sensitivity and reproducibility. The membrane is impermeable to VOCs at temperatures less than 100 C. Recommended operating temperature for the MIP is 120 ^oC.

The transfer line may become contaminated whenever highly contaminated soil and groundwater are analyzed (> 500 ppm). If the analyte transfer line becomes contaminated with VOCs disconnect the analyte transfer line and the He supply line at the DSITMS inlet. Using a reducing union, back flush 1/8" analyte transfer line with 1/16" He supply line. Back flush for approximately 20 minutes, check the condition of the transfer line by reconnecting to the DSITMS inlet and analyzing system performance blank (air or water). Repeat back flush as necessary.

Closely monitor the calibration check standards and PECS as data is collected throughout the day. If a change is noted in the calibration check standard response, immediately analyze a PECS. If the PECS meets QC limits (see **Quality Control)**, remake the standard stock solution as specified in **Quantitative Calibration of MIP/DSITMS VOC Sensor (section 7.3)**. If the response of the PECS changes while the calibration check standard response meets QC limits, open a new vial of PECS and analyze. If the check standard and PECS both fail to meet QC limits, the problem is likely with the DSITMS or a leak in the MIP/DSITMS membrane or gas carrier line. Leak check MIP membrane, if applicable. If no leak is found and the response factors for both the check standard and PECS are low compared to QC limits, try adjusting the EM voltage upward to regain acceptable response. Periodic upward adjustment of the EM over its life is common.

7.7.2 DSITMS

In addition to the details listed in Section 7.7.1 it should be noted that directly purging water into the DSITMS entrains significant water vapor and the life span of an EM in DSITMS is shorter than that of a conventional gas chromatograph/mass spectrometer system. The analyst should ensure to leave adequate space between the lip and neck of the 40ml vial when individual analyses are performed on the DSITMS during the direct sampling/vial sparging method.

7.8 Reagents

The following reagents are required:

Helium, 99.9999% purity
Methanol, purge and trap grade
Milli-Q or equivalent Water (ASTM Type II Reagent Water)
Neat Volatile Materials, 99% purity for standards preparation or purchased
Pre-made stock solutions
Externally prepared performance evaluation check standard solutions

7.9 Apparatus

The following apparatus are required:

Cone penetrometer truck with direct push well capability (American Standard Testing Methods, 1995 Annual book of ASTM standards. 04.08 (D-3441), American Society for Testing and Materials, Philadelphia).

Direct Sampling Ion Trap Mass Spectrometer (Finnigan Magnum/ITMS 40 or Varian Saturn; retrofitted with direct sampling inlet; wise et al, 1997).
Membrane Interface Probe and controller (Geoprobe Systems, Inc.)
Gas-Tight Syringes (10uL to 10 mL)
250 mL Volumetric flasks
10 mL volumetric flasks
1 L graduated cylinder
4-10 mL screw cap vials with teflon lined caps
Flow Meter (digital type preferred)
40 mL vials for direct sampling
Silica sand for MIP
Calibration jig for MIP
Leak detector for Helium gas
Uninterrupted Power Supply (UPS) - Preferred

7.10 Initial Calibration Concentrations

The following series of calibration standards may be created to produce an initial calibration curve for the project. Individual standards may be added or removed to enhance the calibration curve and satisfy project-specific data quality objectives.

MIP/DSITMS (water)

100 ppb	200 ppb	500 ppb	1000 ppb	5000 ppb

DSITMS (water)

2.5 ppb	5.0 ppb	50 ppb	500 ppb	1000 ppb

8.0 Waste Disposal

All waste will be disposed of by a local certified disposal company (i.e., **SafetyKleenä)** and will be managed in accordance with the project work plan. All waste will be properly containerized, labeled, staged, and managed. Soil and liquid wastes will be containerized separately. Personal protective equipment (PPE) will be disposed of as non-hazardous waste, unless otherwise noted within the project work plan.

9.0 References

(1) Garner, W.Y., "Good Laboratory Practice Standards, Applications for Field and Laboratory Studies", American Chemical Society, (1992)

(2) Davis, W. M., M. B. Wise, J. S. Furey, and C. V. Thompson, "Rapid Detection of Volatile Organic Compounds in Groundwater by *In Situ* Purge and Direct-Sampling Ion-Trap Mass Spectrometry," *Field Analytical Chemistry and Technology* 2(2):89-96, 1998

(3) Davis, W.M., J.S. Furey and B. Porter, 1998b, "Field Screening of VOCs in Ground Water using the Hydrosparge VOC Sensor" *in press* in Current Protocols in Field Analytical Chemistry, V. Lopez-Avila, ed.; J. Wiley and Sons, Inc., New York, NY.

(4) Davis, W. M. and Costanza, J., "Rapid Detection of Volatile Organic Compounds in the Subsurface by Membrane Introduction into a Direct Sampling Ion Trap Mass Spectrometer," *August 2000*

(5) Environmental Security Technology Certification Program, "Cost and Performance Report for SCAPS Hydrosparge VOC Sensor", July 1999, available at http://www.estcp.org/technical_documents.htm

(6) T. Christy, United States Patent Number 5,639,956, Permeable Membrane Soil Probe, June 17, 1997.

(7) M. B. Wise, C. V. Thompson, R. Merriweather, and M. Guerin, “Review of Direct MS Analysis of Environmental Samples”, *Field Analytical Chemistry and Technology*, 1(5):251-276, 1997

(8) EPA. 1995. "Test Methods for Evaluating Solid Waste; Physical/Chemical Methods, SW-846 Third Edition" Washington, DC.

(9) M. Wise, M. Guerin, R. Merriweather, C. Thompson, and W. Davis, “Draft Method 8265, Direct Sampling Ion Trap Mass Spectrometery for the Measurement of Volatile Organic Compounds in Water, Soil, and Air,” Submitted to Environmental Protection Agency Methods Workgroup by Oak Ridge National Laboratory, June 1997.

Flexible Liner Underground Technologies, Ltd. Co.

The subtle approach to the geosciences

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505-455-1300, or ckmist @ aol.com

Description of *NAPL FLUTe* system

The system once emplaced:

This system consists of an impermeable flexible liner and an exterior covering on the liner which reacts with pure product (e.g., NAPL and DNAPL) to form a bright red dye stain on a white background. The liner/cover system can be emplaced via several push rod methods. The pressurized liner forces the reactive cover tightly against the hole wall. The reactive cover is recovered from the hole by inverting/peeling the liner from the hole. In this manner, the cover does not touch the hole wall anywhere else as it is removed. The cover can then be examined for the presence and extent of layers, and even globules, of NAPL in the subsurface. This technique of installation and removal of the reactive covering through the interior of push rods provides a relatively inexpensive method for mapping of NAPLs and DNAPLs in the source region.

The installation technique

This liner installation method can be applied to the many driven casing "drilling" methods. The same trick is employed regardless of the casing diameter to allow the casing to be withdrawn without excessive drag of the liner on the casing. As the casing/rods are withdrawn, the liner is dilated against the hole wall at high pressure to support the hole wall against collapse and to seal the hole against vertical flow.

Experience:

This installation technique was first developed for the installation of color reactive liners for the mapping of NAPL layers in sediments. The technique has been employed at Savannah River Site, NC, Cape Canaveral, FL, Paducah, KY, and Murdock, NB. Only the Murdock site (6 three port wells to 80 ft.) included miniwells in cone penetrometer holes. The rest had liners installed via cone penetrometer rods for color mapping by inversion of the liner from the hole (see the *Mini FLUTe* description for water well installations).

Procedure:

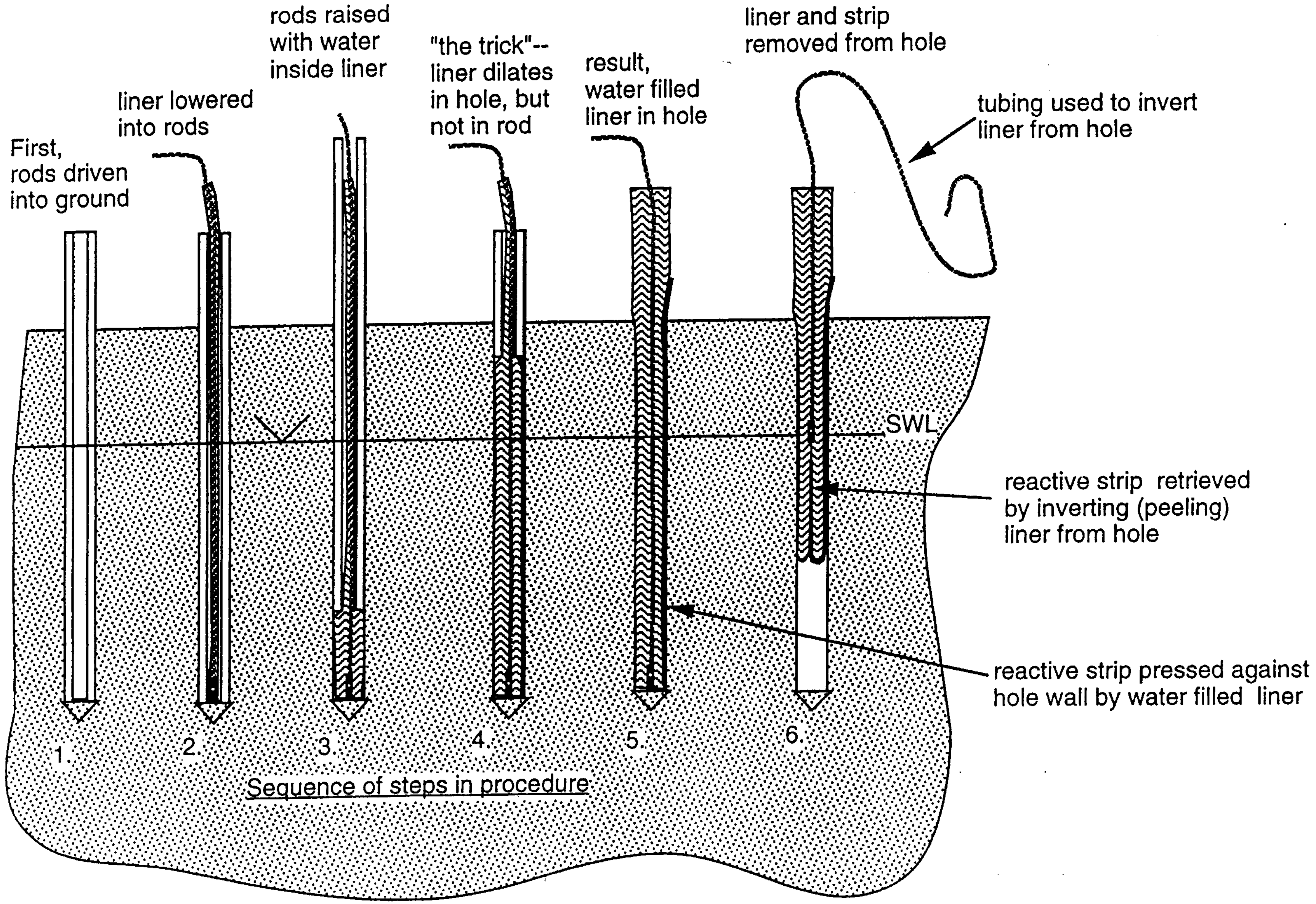
The procedure is illustrated in the attached drawing. The rods are pushed to the full depth of interest. The liner with its reactive covering is inserted into the interior hole in the rods to the full depth. The rods are then filled with water. The rods are raised by one rod section to expose the hole wall. The liner is pressurized with a charge of water to hold the hole open and to anchor the liner in the hole. More water is added to the interior of the liner as the rods are pulled. Once the rods are fully removed, the hole is supported and sealed by the water filled liner. The covering is pressed against the hole wall for an hour, or so, and then the liner is inverted (peeled inside out) from the hole. The covering is therefore interior to the inverted liner. The covering is then peeled from the interior of the liner to reveal the stained map of the distribution of NAPLs in the subsurface.

The liner can be reused to install another reactive covering in another pushed hole.

For information on this technique, call toll free 888-333-2433.

Note: This technique is a proprietary method devised by Flexible Liner Underground Technologies, Ltd. Co. of Santa Fe, NM. Several patents are pending on the method and hardware for several kinds of applications.

NAPL FLUTe method of installing color reactive liners in a punched hole pat. pend.



This technique allows mapping of NAPL/DNAPL layers in punched holes

For details,
phone: 888-333-2433

Mapping of DNAPL locations just became much easier!

The Westinghouse group at the Savannah River Site (SRS) installed a ribbon manufactured by Flexible Liner Underground Technologies (*FLUTe*) in a cone penetrometer hole, let it sit for an hour, and recovered the ribbon shown below. The red dye marks were spectacular in the regions of high DNAPL concentrations. The white ribbon was installed against the wall of a 1.4" hole with a *FLUTe* everting liner deployed from a small pressure canister. The ribbon was recovered by inverting the liner from the hole. The inverting liner surrounds the ribbon and prevents any other contact with the hole as the ribbon is recovered.

The ribbon was installed after the rod was pulled out of the ground. The ribbon is a laminate of SUDAN IV between a hydrophobic material and a cotton material.

(over)

SUDAN IV is a brown powder that reacts with a DNAPL, or an LNAPL, to form a red dye. The red dye causes a dramatic stain of the ribbon. With this technique one can locate the high concentrations of pooled DNAPL in the vadose zone.

The same reactive ribbon was installed for SRS at Cape Canaveral on January 19, 1999, below the water table. The ribbon was installed on a liner through the interior of the CPT rod (a 1" hole!). As the rod is withdrawn (via a FLUTe trick), the liner dilates in the hole, supporting the hole wall. After about an hour, the ribbon was recovered by inverting the liner from the hole. The result was as spectacular as the photo from the vadose zone installation. The DNAPL stains were found to correlate well with core sample results from a nearby hole.

This is a brand new application of the *FLUTe* everting liner method. Earlier, the FLUTe liners were also installed in CPT holes at SRS with 10 gas sampling ports in a 100 ft. length.

For more information on the everting liner method and the gas sampling with liners, see the *FLUTe* data sheets "Basic Function" and "Vapor/Liquid Sampling," at our web site (***www.flut.com***) or call 888-333-2433 (toll free).

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SOP NO.: 0339.3
DATE: February 26, 2001
AUTHOR: RBF
PAGE 1 OF 12

TITLE: Semivolatile Petroleum Products Method for Soil and Water by NWTPH-Dx Modified

Approved By: ______________________ 03/21/2001
Department Manager Date

Approved By: Lila A Transue 3-21-01
Quality Assurance Director Date

Copy No.: 005

Issued To: K. Carpenter

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1 SCOPE AND APPLICATION

1.1 This SOP delineates the procedure for the identification and quantitation of semivolatile petroleum products using the WSDOE NWTPH-Dx method. This method is applicable to both soils and waters. Waters may be collected in either 1-liter or 125-mL sample jars.

2 REFERENCES

2.1 Total Petroleum Hydrocarbons, Analytical Methods for Soil and Water, WSDOE, Guidance for Remediation of Releases from Underground Storage Tanks, Appendix L, April, 1992, WTPH-D Diesel in Soil.

2.2 Total Petroleum Hydrocarbons, Analytical Methods for Soil and Water, WSDOE, Guidance for Remediation of Releases from Underground Storage Tanks, Appendix L, April, 1992, WTPH-D Diesel in Water.

2.3 Analytical Methods for Petroleum Hydrocarbons, WSDOE, Toxics Cleanup Program and the Ecology Environmental Laboratory, Publication No. ECY 97-602, June 1997.

2.4 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Methods 3510C, 3550B, 3540C, 3580A, 8000B, and 8015B.

3 ASSOCIATED SOPS

3.1 0010.3, Use and Maintenance of Laboratory Glassware.
3.2 0014.7, Use and Maintenance of Laboratory Balances.
3.3 0160.7, Determination of Sample Dry Weight.
3.4 0301.3, Liquid-Liquid Extraction, EPA Method 3510C.
3.5 0334.3, High Temperature Sonication Extraction Procedure, EPA Method 3550B Modified.

3.6 0387.2, Maintenance of Varian 3300/3400 and HP 5890/6890 GCs with FIDs.
3.7 0326.1, Hydrocarbon Identification Method for Soil and Water by NWTPH-HCID Modified.
3.8 0335.2, Petroleum Fuel Hydrocarbon Analysis by EPA SW-846 Method 8015B Modified.
3.9 0349.5, Extractable Fuels Screening by GC-FID.
3.10 0611.5, Organic Standard Solution Recordkeeping.
3.11 0504.6, Client Contact Recordkeeping.
3.12 0600.5, Quality Control Charting and Establishing Method Warning and Action Limits.
3.13 0617.3, Initial Demonstration of Capability for Analytical Methods.

4 DEFINITIONS

4.1 WSDOE = Washington State Department of Ecology.
4.2 NWTPH-Dx = Northwest Total Petroleum Hydrocarbon - Diesel Extended.
4.3 GC = Gas Chromatograph.
4.4 FID = Flame Ionization Detector.
4.5 K-D = Kuderna Danish.
4.6 MS = Mass Spectrometry.
4.7 AED = Atomic Emission Detector.
4.8 BS/BSD = Blank Spike/Blank Spike Duplicate.
4.9 MS/MSD = Matrix Spike/Matrix Spike Duplicate.
4.10 RPD = Relative Percent Difference.
4,11 SPE = Solid Phase Extraction.
4.12 ICV = Initial Calibration Verification.
4.13 CCV = Continuing Calibration Verification.

5 PROCEDURE

5.1 SUMMARY. This method is used to identify, by pattern matching ("fingerprinting"), and quantitate semivolatile petroleum products. These products include kerosene, jet fuels, diesel oils, fuel oils, lubricating oils, hydraulic fluids, mineral oils and insulating oils such as transformer oils. Soil samples are weighed, dried, surrogate is added and extracted with methylene chloride. Water samples (1-liter or 100-mL volume) are acidified, surrogate is added and extracted with methylene chloride. Extracts are then concentrated and an aliquot of sample is analyzed by GC-FID. The hydrocarbons are quantitated against diesel (nC10-nC24) and motor oil (>nC24-nC36) standards (default) used for calibration and identified by pattern matching to the calibration standard or appropriate library spectra.

5.2 INTERFERENCES

5.2.1 Solvents, reagents, glassware, and other equipment coming in contact with the extract may yield interferences.

5.2.2 Non-petroleum hydrocarbons (non-polar) will also be extracted using this procedure. Hydrocarbons eluting in the ranges described above for fuel hydrocarbons will be detected and reported as false positives. All semi-volatile results must be reported; atypical results should be qualified appropriately.

5.2.3 Phthalate esters are found in many materials commonly found in the laboratory. In particular, plastics should be avoided because phthalates are routinely used as plasticizers and are easily extracted from the plastic materials.

5.3 SAMPLE HANDLING, PRESERVATION, AND HOLDING TIME REQUIREMENTS.

5.3.1 Water samples may be collected in 1-liter or 125 mL amber glass bottles. Soil samples are typically collected in 4-oz. or 8-oz. glass jars. All sample containers must have Teflon-lined caps.
5.3.2 All samples shall be stored at 4°C +/- 2°C after collection. Water samples should be preserved with 1+1 HCl to a pH of ≤ 2.
5.3.3 Holding time, from the date of sampling to extraction, is 14 days for soil and 7 days for water. Holding time from extraction to analysis is 40 days.

5.4 EQUIPMENT

5.4.1 Gas Chromatograph, Hewlett Packard 6890 or equivalent w/wo autosampler equipped with a capillary split/splitless injector and an FID.
5.4.2 Chromatographic column: DB-1, 30 meters x 0.32 mm ID x 0.25 um film thickness (J & W Scientific) or equivalent.
5.4.3 Data acquisition system: Hewlett Packard ChemStation or equivalent.
5.4.4 Analytical Balance, accurate to at least 0.0001g.
5.4.5 Ultrasonic bath type sonicator (Peak output = 1230 watts, frequency = 42kHz).
5.4.6 Ultrasonic horn sonicator, macro-tipped, equipped with a timer and tuner.
5.4.7 Volumetric Flasks, 10 mL, 25 mL, 50 mL, 100 mL, 250 mL, Class A, ground glass stoppered.
5.4.8 K-D flasks, 250 mL.
5.4.9 Concentrator Tubes, 10 mL.
5.4.10 Snyder Columns, 3-ball, 24/40 ground glass joint.
5.4.11 Scintillation vials with Teflon-lined screw caps.
5.4.12 Drying oven.
5.4.13 Filter funnels.
5.4.14 Filter paper, Whatman #4 or equivalent.
5.4.15 Glass standard vials with screw caps and Teflon-lined septum.
5.4.16 Autosampler vials, 1.5 mL, crimp top or equivalent.
5.4.17 20 mL scintillation vials, with Teflon-lined lids or equivalent.
5.4.18 2000 mL or 200 mL separatory funnel, Teflon or equivalent.
5.4.19 250 mL beaker.
5.4.20 Centrifuge.
5.4.21 Pasteur pipette, disposable.

5.5 REAGENTS/STANDARDS

5.5.1 Methylene Chloride (CH_2Cl_2), analytical reagent grade or equivalent.

5.5.2 Sodium sulfate, anhydrous powder, reagent grade or equivalent.

5.5.3 Sulfuric acid, concentrated, trace metals grade or equivalent.

5.5.4 Silica gel, 100/200 mesh, Baker Analyzed Reagent grade or equivalent - Before use, activate for at least 16 hours at 130°C in a shallow tray.

5.5.5 Petroleum product standards, Accustandard FUEL-SET, 20 mg/mL in CH_2Cl_2 or equivalent.

5.5.6 Surrogate Stock Standard. Approximately 0.5 g (weighed to the nearest 0.0001 g) of 1-Chlorooctane (99%, Aldrich) and o-Terphenyl (99%, Aldrich) are diluted to a final volume of 250 mL with acetone, providing a stock spiking solution of approximately 2,000 mg/L.

5.5.7 Reference/Stock Standards. Prepare individual petroleum product reference/stock standards; kerosene, JP-5, diesel #2, transformer oil, motor oil, and bunker crude fuel oil.

- 5.5.7.1 Add 5 to 10 drops or the pure petroleum product to a tarred 10 mL volumetric flask. Record the weight to the nearest 0.0001g and bring to volume in methylene chloride, stopper and mix by inverting several times. Calculate the concentration of the standard using the equation below.
  - 5.5.7.1.1 Stock Conc., ug/ml = $\frac{\text{(final wt. mg)-(tare wt. mg)}}{\text{10 mL}} \times \frac{\text{1,000 ug}}{\text{mg}}$
  - 5.5.7.1.2 These standards are also used to ensure the proper identification of petroleum products by chromatographic pattern matching.
- 5.5.7.2 The use of commercially available standards is an acceptable alternative to the above procedure.

5.5.8 Calibration Working Standards. Using the stock standards, prepare calibration working standards for the identified petroleum product(s) to be quantitated. Serially dilute the reference/stock standard(s) to prepare calibration curve(s). Calibration standards must, at a minimum, provide a minimum 5 (five) point calibration curve, include a sufficiently low standard to provide necessary detection limits, and define a linear working range of the instrument. A mid-range calibration standard should also be prepared for calibration curve verification.

- 5.5.8.1 In order to be acceptable, each calibration curve must have a linear correlation coefficient (r) of at least 0.990 and none of the standards may vary from their true value by more than +/- 15%. #2 diesel oil and motor oil are the default petroleum product for reporting purposes.

5.5.9 Retention Time Window Standard. The retention time standard contains toluene, nC_{10}-nC_{25}, nC_{32}, and nC_{36}, each at approximately 100 ug/mL. This is used to establish retention time windows for the quantitation of, #2 diesel and motor oils (defaults petroleum product). Other individual alkanes may be added to the standard as requested by product or client.

5.5.10 ERA Quality Control Standard, or equivalent.

5.5.11 Diesel Spiking Solution. Approximately 12.5g of #2 diesel fuel (from a source differing from that of the reference/stock diesel standard) is weighed into a

250 mL volumetric flask, weight recorded, and diluted to volume with acetone. The concentration should be approximately 50,000 ug/mL. The spike amount will be 100 uL, yielding a final sample concentration of 1000 ug/mL.

5.5.12 Motor Oil Spiking Solution. Approximately 12.5 g of motor oil (from a source differing from that of the reference/stock diesel standard, usually 20/50W Valvoline) is weighed into a 250 mL volumetric flask, weight recorded, and diluted to volume with methylene chloride. The concentration should be approximately 50,000 ug/mL. The spike amount will be 100 uL, yielding a final sample concentration of 1000 ug/mL.

5.5.13 Other spiking solutions may be made following the procedure outlined in 5.5.11 and 5.5.12 using different petroleum products. #2 diesel and motor oil will be the default spiked products if sample contaminant is unknown.

5.5.14 Internal Standard Solution, 5a-androstane, purchased at a concentration of 2000 ug/mL.

5.6 CALIBRATION

5.6.1 The gas chromatograph is set up as follows:

Injector: 280°C
Detector: 300°C

5.6.1.1 Oven ramping profile: Initial column temperature is set to 45°C and held for 2.5 minutes, ramped to 320°C at 20°C per minute and held for 7 minutes. *Note: if the sample extracts are extremely discolored, the final hold time of the column may be extended to prevent carryover and excessive baseline rise.*

5.6.1.2 The FID is allowed to stabilize at manufacturers recommended makeup and carrier gas flows prior to analysis.

5.6.2 Standard and surrogate solutions are allowed to come to room temperature prior to use.

5.6.3 A daily outside (second source) diesel and motor oil QC check standard is analyzed every 24 hours or with each sequence of samples whichever is greater.

5.7 SAMPLE PREPARATION

5.7.1 Check that daily balance calibration has been performed.

5.7.2 Water Extraction

5.7.2.1 Allow the samples to come to room temperature. Mix the sample well by inverting the bottle several times. Check the pH of the sample to ensure that it is <2. If not, acidify the sample with 1+1 HCl until the sample pH <2. Decant 1-liter samples into 2-liter separatory funnels, or 100 mL samples into 200 mL separatory funnels. Add 100 uL of surrogate solution to 1-Liter samples, or 10 uL of surrogate solution to 100 mL samples.

5.7.2.2 Add 60 mL of methylene chloride to 1-liter sample jar (or 10 mL of methylene chloride to 125-mL sample jar), cap and shake vigorously for a few seconds to wash off any hydrocarbons adhering to the side of the jar. Add this solvent to the separatory funnel, cap and shake vigorously, venting frequently, for at least 2 minutes.

5.7.2.3 After the two phases have separated, drain the solvent through filter paper and methylene chloride pre-rinsed sodium sulfate, into a K-D apparatus.

5.7.2.4 Repeat the extraction twice more using 60 mL (or 10 mL) of methylene chloride each time and add these extracts to the K-D.

5.7.2.5 Rinse the filter paper and tip of the separatory funnel with 5-10 mL of methylene chloride into the K-D. Pre-wet a Snyder column with 1-2 mL of methylene chloride, assemble the K-D apparatus and concentrate the extract to 1-3 mL on a hot water bath. Allow the apparatus to cool, disassemble it, rinsing the joints with 1-2 mL of methylene chloride. For samples with an original volume of 1-liter, dilute the extract to a final volume of 5.0 mL and store in a Teflon-lined screw-capped scintillation vial. For samples with an original volume of 100 mLs, reduce the extract to a final volume of 0.5 mL and store in an autosampler vial. Store the extract vials in a refrigerator at 4C ± 2C.

5.7.2.6 For 0.5 mL extracts, proceed to section 5.7.2.7. For 5 mL extracts, transfer 1.0 mL of the extract to a separate autosampler vial prior to analysis. Add 10 uL of internal standard solution to the vial, and store at 4C until analysis.

5.7.2.7 For 0.5 mL extracts, add 5 uL of internal standard solution to the vial, and store at 4C until analysis.

5.7.2.8 Along with each sample set, extract and analyze at least one duplicate sample per 10 or fewer samples (10%), if adequate sample volume is provided, and, for each extraction batch, at least one method blank and blank spike/blank spike duplicate. If requested, a matrix spike/matrix spike duplicate may also be extracted. Spiking of surrogates, extraction and analyses of the QC samples will be conducted identically to the regular samples with the exception that reverse osmosis water will be used for the method blank and BS/BSD.

5.7.2.9 If an extract is extremely discolored or forms a precipitate, a dilution may be performed prior to analysis.

5.7.2.10Record all pertinent data in the diesel extraction logbook including QC batch identifier, date extracted, extraction analyst initials, solvent lot number, sample volume, surrogate amount, final volume, and standard numbers for all surrogate and matrix spikes.

5.7.3 Soil Extraction Note that the alternate use of soxhlet extraction (SAS SOP 0367.2) or sonication extraction (SAS SOP 0334.3) may be appropriate for some samples.

5.7.3.1 Weigh approximately 10 grams of soil into a solid into a solid Teflon-lined cap VOA vial, recording the weight to the nearest 0.0001g, Add approximately 5-10 grams of anhydrous sodium sulfate to the vial. Additional sodium sulfate may be required for nonporous (e.g., clay samples) or wet samples. Add 100 uL of surrogate stock and 10 mL of methylene chloride. *NOTE: 20 mL may be required if the sample is extremely wet and takes up more than average volume in the VOA vial.* Mix the sample by shaking or use of an automatic vortex mixer. The sample should be free flowing sandy texture. NOTE: Mixing of the sample inside the VOA vial with a spatula may score the glass and result in possible vial explosion in the sonicator bath.

5.7.3.2 Heat the ultrasonic bath by turning the heater on. Mark the solvent level on each vial with a felt tip permanent marker. When bath temperature is at approximately 60 – 70°C, placed the samples in the bath and sonicate for 30 minutes.

5.7.3.3 When sonication is complete, remove the vials from the bath and allow to cool to room temperature. Cooling may be facilitated by placing samples in a cold water bath. Samples may require centrifugation if the soil/sodium sulfate mixture has expanded.

5.7.3.4 If 10 mLs of methylene chloride were used for extraction, transfer 1.0 mL of each extract to a Teflon-lined autosampler vial. If a 20 mL volume of methylene chloride was used for extraction, concentrate a 2.0 mL aliquot of each extract to 1.0 mL and transfer to a Teflon-lined autosampler vial. Add 10 uL of internal standard solution to each vial. Store the vials at 4 ± 2C until ready for analysis. Note: if the sample extracts are extremely discolored, the concentration step may not be required. Add the internal standard to a 1 mL aliquot of the discolored extract into a separate autosampler vial and add 10 uL to the aliquot, and store at 4 ± 2C until ready for analysis.

5.7.3.5 Along with each sample set, extract and analyze at least one duplicate per set of 10 or fewer samples (10% frequency). For each extraction batch, at least one method blank and blank spike/blank spike duplicate are extracted and analyzed. Matrix spike/matrix spike duplicate analyses are performed as requested by the Client if sufficient sample volume is available. Spiking of surrogates, extraction and analyses of the QC samples will be conducted identically to the regular samples with the exception that no soil is added to the method blank or BS/BSD.

5.7.3.6 If an extract is extremely discolored or forms a precipitate, a dilution may be performed prior to analysis.

5.7.3.7 Record all pertinent data in the diesel extraction logbook including QC batch identifier, date extracted, extraction analyst initials, solvent lot number, sample volume, surrogate amount, final volume, and standard numbers for all surrogate and matrix spikes.

5.7.3.8 Percent Solids

5.7.3.8.1The percent solids (dry weight) of an approximately 10 gram portion of the sample is determined for use in calculating the final concentration of the sample. Follow procedures outline in SAS SOP 0160.7.

5.7.4 Sample Cleanup In those cases where samples contain a significant amount of naturally occurring non-petroleum organics, e.g. leaf litter, beauty bark, etc., which may contribute biogenic interferences, the following cleanup technique may be employed.

5.7.4.1 Add approximately 1 mL of concentrated sulfuric acid to the extract vial, cap tightly and shake or vortex the sample for a minimum of 1 minute. ***Caution:*** *Because sulfuric acid produces a highly exothermic reaction with water and other polar materials, extreme care should be exercised with its use.*

5.7.4.2 Allow the two phases to separate. Centrifugation may facilitate this process. Additional sulfuric acid cleanup steps may be needed. Using a disposable Pasteur pipette, transfer the methylene chloride phase (top) to a methylene chloride pre-rinsed silica gel SPE tube and allow it to elute into another scintillation vial. Store the sample extract in a refrigerator until analysis. Granular silica gel may also be used in place of the SPE tube.

5.7.4.3 **Note:** It has been noted that some petroleum products, i.e. heavy oils such as #6 fuel oil or bunker crude may experience a concentration loss of between 10 and 20 percent when subjected to this cleanup technique. This loss appears to be primarily associated with the removal of petroleum compounds which contain sulfur. To account for this loss when analyzing samples that have subjected to the cleanup procedure in preparation for heavy fuel oil determination, the analyst must use standards which have undergone the cleanup technique to calibrate the GC.

5.8 ANALYSIS AND IDENTIFICATION

5.8.1 Prior to analysis of any samples or QC samples, the analyst must prepare and analyze a mid-range calibration check standard (CCV) to insure that the instrument is functioning correctly and that the calibration is still valid. The value obtained for this analysis must not vary from the known value by more than +/- 15%. If the value falls outside this range, then a second mid-range calibration check standard (CCV) should be analyzed. If the analysis of the second check standard fails to meet the acceptance criteria, then the instrument must be recalibrated prior to analysis of any samples.

5.8.2 A typical analysis sequence consists of the following:

5.8.2.1 Retention time window standard
5.8.2.2 Mid-range calibration check standard (CCV).
5.8.2.3 ERA Diesel standard/second source Motor Oil standard (ICV).
5.8.2.4 Method blank and blank spike(s).
5.8.2.5 10 samples (or less).
5.8.2.6 Mid-range calibration check standard (CCV).

5.8.3 The analyst shall use #2 diesel and motor oil as the default product for reporting purposes when no petroleum products were identified in any initial screening or when type(s) of petroleum products are unknown prior to analysis.

5.8.4 Extracts stored in scintillation vials area transferred to 1.5 mL autosampler vials.

5.8.5 Extracts are analyzed by injection of 1 uL on the GC by an autosampler. **Note:** The use of GC/MS or GC/AED may be substituted for GC/FID as long as all other method parameters are met.

5.8.6 A mid-range calibration standard is analyzed after every 10 samples or at the end of a sample analysis sequence.

5.8.7 If NWTPH-HCID has not been previously performed on the samples and/or the type of petroleum present is unknown, the analyst may prescreen the samples to determine the petroleum product.

5.8.8 The observed petroleum product shall be determined by pattern matching with standard(s) analyzed the same day. chromatograms used for this "fingerprinting" should be normalized to approximately 90% of full scale for the largest component of the particular petroleum product observed.

5.8.9 When reporting results, terms such as "diesel range" or "motor oil range", or derivations of them, should only be used when the analyst is unable to identify the petroleum product(s) present. Motor oils, hydraulic fluids and similar petroleum products which consist primarily of an unresolved chromatographic envelope of compounds originating at, or extending beyond tetracosane (nC_{24}), may be reported using the collective term "lube oil" unless specific identification is possible. Heavy fuel oils, e.g. fuel oil #6 or Bunker Crude, which contain diesel range components as well as a lube oil range may be reported using the collective term, "heavy fuel oil", unless specific identification is possible. These products should not be confused with mixtures of #2 diesel and lube oils. **Note:** Actual identification of the grade or type of lube oil and/or heavy oil may require equipment and techniques beyond the scope of this method.

5.8.10 The retention time windows for integration must be adjusted to incorporate the majority of the components or petroleum product(s) identified in the samples. If specific product identification can not be made, the analyst must quantitate the samples with the calibration curve for the petroleum product that most closely resembles that of the samples. The default petroleum products for this method are #2 diesel and motor oil. In all cases, the selected retention time windows used for quantitation must, at a minimum, include any unresolved envelope or compounds as well as all discrete component peaks with an area greater than or equal to 10% of the largest peak. These compounds must be integrated to the baseline as a group.

5.8.11 For those surrogate compounds which elute within retention time ranges used for petroleum product integration, the analyst must subtract the area of the surrogate from the total area to yield a corrected area of the petroleum product.

5.8.12 At the discretion of the analyst, the range of components included in the integration may be adjusted in order to minimized the potential contribution of an co-eluting fractions arising from the presence of multiple petroleum products. Any change in the integration range must be reflected in the integration of the calibration standards.

5.8.13 For the default petroleum products, #2 diesel and motor oil, the calibration standard area of the components from dodecane (nC_{12}) and tetracosane (nC_{24}) (#2 diesel) and from tetracosane (nC_{24}) to hexatriacontane (nC_{36}) (motor oil) are integrated to the baseline as a group. The data system will automatically remove any surrogate areas which elute within the retention time windows. The samples are integrated in the same manner and the areas compared.

5.9 CALCULATIONS

The following calculations are used for quantitation of sample results:

$$\text{sample conc., mg/L} = \frac{\underline{(\text{area count*response factor}^1) * \text{extract volume}}}{(\text{volume inj., uL})*\text{sample volume, mL})}$$

$$\text{sample conc., mg/kg} = \frac{\underline{(\text{area count*response factor}^1) * \text{extract volume}}}{(\text{volume inj., uL})*\text{sample weight, g})*(\%\text{solids})}$$

1 = ng injected/area count

5.10 QUALITY CONTROL

5.10.1 Duplicate analyses are run every 10 samples or every batch, whichever is more frequent. For water samples, a duplicate is run whenever adequate sample volume is provided.

5.10.2 A method blank for each matrix is extracted and run every 20 samples, whichever is more frequent.

5.10.3 Mid-range calibration check standards (CCV) are run every 10 samples or every batch, whichever is more frequent.

5.10.4 A BS/BSD with diesel and motor oil is analyzed with every analytical batch. If the blank spike/blank spike duplicate results are outside QC criteria, the batch must be reextracted if sufficient sample volume is available.

5.10.5 Soil matrix spike and matrix spike duplicates are extracted and analyzed as requested every 20 samples or every batch, whichever is more frequent. Water matrix spikes are analyzed when requested when adequate sample volume is received from the client.

5.10.6 The ERA diesel check standard must be within ranges provided by the manufacturer or analysis cannot proceed. The motor oil ICV must be within +/- 15% of true value or analysis cannot proceed. System maintenance or recalibration should be performed if reanalysis does not yield acceptable results.

5.11 PRECISION AND ACCURACY

5.11.1 Accuracy is evaluated based on blank spike and matrix spike recoveries. Blank spike recovery limits are calculated semiannually based on control chart data. The current limits are provided in Table 1. Matrix spike recovery limits are 50% and 150%.

5.11.2 Accuracy is also evaluated based on surrogate recoveries. The recovery of the surrogate should be between 50% and 150% and must be reported with the results. If the recovery of the surrogate is not able to be obtained due to a high level of petroleum contamination, then this fact needs to be reported with the data.

5.11.3 Precision is evaluated based on BS/BSD and MS/MSD RPD and duplicate RPD. BS/BSD limits are calculated semiannually based on control chart data. The current limits are provided in Table 1. Duplicate and MS/MSD RPD limits are ≤ 35%. If criteria is not met, sample matrix interference must be demonstrated and the sample qualified accordingly.

5.12 REPORTING LIMITS

5.12.1 Soils: Jet fuels through #2 diesel 25 mg/kg, lube and heavy fuel oils approximately 50 mg/kg.

5.12.2 Waters: Jet fuels through #2 diesel 0.25 mg/L, lube and heavy fuel oils approximately 0.50 mg/L.

5.13 MODIFICATIONS TO PUBLISHED METHODOLOGY

5.13.1 Reporting limits for soil is 13 mg/kg instead of 25 for petroleum products in the elution range of jet fuels through #2 diesel. For petroleum products eluting after #2 diesel, e.g. motor oils, hydraulic fluids, and heavy fuel oils, the reporting limits is approximately 50 mg/kg for soil as opposed to 100 mg/kg.

5.13.2 Working surrogate standards are prepared in conjunction with the motor oil calibration standards.

5.13.3 Final sample extract volume is 5.0 mL instead of 10 mL.

5.13.4 Silica gel SPE tubes are used instead of silica gel 100/200 mesh.

5.13.5 A full liter of water or 100 mL of water is extracted instead of 400 mL.

5.13.6 Both #2 diesel and motor oil are used as default petroleum products when product is unknown or not identified.

6 HEALTH AND SAFETY/SPECIAL CONSIDERATIONS

6.1 Gloves and safety goggles should be worn during sample preparation and extraction.

6.2 All extractions should be performed in a hood.

7 NONCONFORMANCE AND CORRECTIVE ACTION

7.1 If any non-matrix related QA/QC parameters are not met, a reextraction and reanalysis should be performed, if adequate sample is available.

7.2 Any nonconformance encountered during sample preparation (e.g., insufficient sample volume or matrix-specific problems) should be documented in a nonconformance memorandum and appropriate corrective action taken.

7.3 If the mid-range calibration standard falls outside +/- 15% of the true value, all samples associated with the standard (back in the queue to the last valid standard) are re-analyzed. If a persistent problem exists, and is not resolved by re-analysis, routine instrument maintenance should be performed following the procedure outlined in SAS SOP 0387.2.

8 RECORDS MANAGEMENT/DOCUMENTATION

8.1 Each extraction batch identifier and appropriate QA/QC should be recorded in extraction logbooks. Date and signature should accompany the recorded information.

8.2 Extraction logbooks are archived with the QC department when completed for permanent storage.

8.3 If client contact is required, a Client Contact Record is completed and maintained in the master file.

8.4 If nonconformance is observed during sample extraction, a nonconformance memorandum is completed; the memorandum is placed in the file, and a copy of the memorandum is given to the QA director.

9 WASTE MANAGEMENT AND POLLUTION PREVENTION

9.1 All laboratory waste must be handled in accordance with SAS SOP 0036.5.

9.2 All laboratory procedures must comply with the policies set forth in SAS's Pollution Prevention Plan.

Table 1
Blank Spike Acceptance Limits for NWTPH-Dx
Expiration Date: 8/5/01

Parameter	% Recovery, Water	RPD, Water	% Recovery, Soil	RPD, Soil
#2 Diesel	65 – 140	≤ 24	67 – 139	≤ 22
Motor Oil	59 – 127	≤ 27	62 – 120	≤ 25

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SOP NO.: 0313.6
DATE: December 19, 2000
AUTHOR: BH
PAGE 1 OF 11

TITLE: Semivolatile Organic Compound (Base/Neutrals and Acids) Analysis by GC/MS, Method 8270C

Approved By: Brent Hepner 03/21/2001
Department Manager Date

Approved By: Lila A Transue 3-21-01
Quality Assurance Director Date

Copy No.: 010

Issued To: K. Carpenter

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1. SCOPE AND APPLICATION
   1.1. This SOP is used to determine the concentration of semivolatile organic compounds in extracts prepared from all types of solid waste matrices, soils, sediments, and aqueous samples. Direct injection of a sample may be used in limited applications.
   1.2. This method can be used to quantify most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted without derivatization as sharp peaks from a gas chromatographic fused silica capillary column coated with a slightly polar silicone. Such compounds include polynuclear aromatic hydrocarbons, chlorinated hydrocarbons and pesticides, phthalate esters, organophosphate esters, nitrosamines, aromatic nitro compounds, and phenols, including nitrophenols. This method routinely provides qualitative and quantitative identification for the target analytes to the practical quantitation limits provided in Table 1.

2. REFERENCES
   2.1. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition, Method 8270C.

3. ASSOCIATED SOPS
   3.1. 0002.6, Internal Sample Transfer and Chain of Custody.
   3.2. 0010.3, Use and Maintenance of Laboratory Glassware.
   3.3. 0611.5, Organic Standard Solution Recordkeeping.
   3.4. 0301.3, Liquid Liquid Extraction, EPA Method 3510C.
   3.5. 0302.5, Sonication Extraction Procedure, EPA Method 3550B.
   3.6. 0367.2, Soxhlet Extraction, EPA Method 3540C.

3.7. 0334.3, High Temperature Sonication Extraction Procedure, EPA Method 3550B Modified.
3.8. 0344.1, Semivolatile Organic Standard Solution Preparation.
3.9. 0342.2, Gel Permeation Chromatography Extract Cleanup Procedure.
3.10. 0160.7, Determination of Sample Dry Weight/Total Percent Solids.

4. DEFINITIONS

4.1. BNAs = Base/Neutrals and Acidic Semivolatile Organic Compounds.
4.2. GC = Gas Chromatograph.
4.3. MS = Mass Spectrometer.
4.4. PQL = Practical Quantitation Limit.
4.5. MDL = Method Detection Limit.
4.6. GPC = Gel Permeation Chromatography.
4.7. PAHs = Polynuclear Aromatic Hydrocarbons.
4.8. DFTPP = Decafluorotriphenylphosphine.
4.9. SPCC = System Performance Check Compounds.
4.10. CCC = Calibration Check Compounds.
4.11. RPD = Relative Percent Difference.
4.12. SOP = Standard Operating Procedure.

5. PROCEDURE

5.1. SUMMARY. A measured volume of sample, typically 1 L for aqueous samples and 15 grams for solid samples, is extracted with methylene chloride. Aqueous samples are extracted at a pH greater than 11.0 and again at a pH less than 2.0 using a separatory funnel, as described in SAS SOP 0301.3. Solid samples are extracted following the sonication procedures described in SAS SOP 0302.5, or by soxhlet procedures, as described in SAS SOP 0367.2 or 0334.3. The methylene chloride extract is dried and concentrated (typically) to a volume of 10.0 mL. Qualitative identification of the parameters in the extract is performed using the retention time and the relative abundance of two or more characteristic masses (m/z). Quantitative analysis is performed using internal standard techniques with one or more characteristic m/z.

5.2. INTERFERENCES

5.2.1. Method interferences may be caused by contaminants in solvents, reagents, glassware, and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the chromatograms. All of these materials are routinely demonstrated to be free from interferences under the conditions of the analysis by the analysis of method blanks.

5.2.2. Glassware must be scrupulously cleaned, following procedures described in SAS SOP 0010.3, Use and Maintenance of Laboratory Glassware.

5.2.3. The use of high purity reagents and solvents helps to minimize interference problems.

5.2.4. Matrix interferences may be caused by contaminants that are co-extracted from the sample. The extent of matrix interferences will vary considerably from source to source, depending upon the nature of the sample. Solid samples may be subjected to GPC cleanup as described in SOP 0342.2, and aqueous samples may also be GPC'd.

5.3 SAMPLE HANDLING, PRESERVATION, AND HOLDING TIME REQUIREMENTS.

5.3.1 It is recommended that aqueous samples be collected in 1L amber glass bottles. Duplicate volumes should be provided for reanalysis or QC analysis.

5.3.2 Samples are stored at $4^{o}C \pm 2^{o}C$. Holding time for extraction of aqueous samples is 7 days from the date sampled. Holding time for extraction of solid samples is 14 days from the date sampled. Holding time for analysis of extracts is 40 days from date of extraction.

5.3.3 If residual chlorine is present in an aqueous sample, the sample should be preserved at the time of collection with 80 mg of sodium thiosulfate per liter of sample.

5.4 EQUIPMENT

5.4.1 GC/MS System (ITS40): Varian 3400 GC; 0.25mm id, 30m, 0.1 u film thickness DB-5 capillary column; Finnigan ITS 40; Finnigan Automatic Vial Sampler; Finnigan Magnum Software Data System; and, a 65,000 compound NIST Spectral Library.

5.4.2 Separatory Funnel-2L, with Teflon stopcock.

5.4.3 Concentrator tube, Kuderna-Danish-10 mL, graduated.

5.4.4 Evaporative flask, Kuderna-Danish-500 mL. Attach to concentrator tube with clips.

5.4.5 Snyder columns, Kuderna-Danish-Three-ball macro.

5.4.6 Glass vials-10 to 15 mL, with Teflon-lined screw caps.

5.4.7 Autosampler vials, 1.5 mL, with Teflon-lined screw caps.

5.4.8 Boiling chips, approximately 10/40 mesh, certified clean.

5.4.9 Water bath.

5.4.10 Heated ultrasonic water bath.

5.4.11 Analytical balance, capable of accurately weighing 0.0001 g.

5.4.12 Glass powder funnel.

5.4.13 Whatman filter paper, Qualitative grade.

5.5 REAGENTS/STANDARDS

5.5.1 Initial calibration stock solution, 200 ng/uL, prepared as described in SOP 0344.1.

5.5.2 Working calibration standards (ITS40), 2.5, 1.0, 0.5, 0.1, 0.05, and 0.01 ug/mL, prepared as described in SAS SOP 0344.1.

5.5.3 Ultra Scientific CLP-300 Base/Neutrals matrix and blank spiking solution, 100 ug/mL.

5.5.4 Ultra Scientific CLP-400 Acids matrix and blank spiking solution, 100 ug/mL.

5.5.5 Semivolatile continuing calibration check stock standard, 100 ng/uL, prepared as described in SAS SOP 0344.1.

5.5.6 Semivolatile continuing calibration check working standard, 1.0 ng/uL, prepared as described in SAS SOP 0344.1.

5.5.7 Semivolatile surrogate standard, 100 ng/uL, prepared as described in SAS SOP 0344.1.

5.5.8 Internal standard solution, 100 ng/uL, prepared as described in SAS SOP 0344.1.

5.5.9 Tuning standard solution (DFTPP, pentachlorophenol, benzidine, and 4,4'-DDT), all at a concentration of 2.5 ng/uL, purchased from Chem Service.

5.5.10 Helium, ultrapure grade.

5.5.11 Sodium sulfate, anhydrous, granular, Tracepur or equivalent grade (suitable for environmental residue analysis).

5.6 INSTRUMENT CALIBRATION

5.6.1 Instrument operating conditions are included in this SOP as Attachment 1.

5.6.2 Tuning

5.6.2.1 A MS tuning compound (DFTPP) is analyzed every twelve hours during instrument operation, prior to analysis of standards, samples, or QC samples. Method tuning criteria must be met before sample analysis can proceed.

5.6.2.2 Tuning Procedure: 1.0 uL of a 2.5 ng/uL solution of decafluorotriphenylphosphine (DFTPP) must be analyzed in a scanning mode of 40 - 450 m/z. The tuning solution must also contain 4,4'-DDT, Pentachlorophenol, and Benzidine at concentrations of 2.5 ng/uL.

5.6.2.3 DFTPP Tuning Criteria:

Mass	Ion Abundance Criteria
51	10 - 80% of base peak
68	< 2% of mass 69
70	< 2% of mass 69
127	10 - 80% of base peak
197	< 2% of mass 198
198	Base peak or > 50% of 442
199	5 - 9% of mass 198
275	10 - 60% of base peak
365	> 1% of base peak
441	Present, but less than mass 443
442	Base peak or > 50% of mass 198
443	15 - 24% of mass 442

5.6.2.4 Column performance and Injector Inertness Criteria:

- o Benzidine tailing factor of ≤ 3.0.
- o Pentachlorophenol tailing factor of ≤ 5.0.
- o Degradation of 4,4'-DDT to 4,4'-DDE and 4,4'-DDD $\leq 20\%$.

5.6.3 Initial Calibration

5.6.3.1 10 uL of internal standard solution is added to all calibration standards, QC samples, and samples prior to analysis. The autosampler injects 4 uL standard and extract volumes into the instrument for analysis.

5.6.3.2 The system is operated under a valid Initial Calibration. The initial calibration is a six point curve, established to meet QC criteria established for Method 8270C.

5.6.4 Continuing Calibration

5.6.4.1 If the initial calibration was not performed the same day as analysis, a continuing calibration is performed, using the 1.0 (ITS40) ug/mL standard. The continuing calibration must meet QC criteria established for Method 8270C.

5.6.5 Prior to analysis of samples, associated batch QC is analyzed in the following order: a method blank, a matrix spike (MS) sample, and a matrix spike duplicate (MSD) sample, and/or a blank spike (BS) and a blank spike duplicate (BSD).

5.7 SAMPLE PREPARATION

5.7.1 100 uL of surrogate standard solution is added to the weighed solid sample or to the liquid sample volume.

5.7.2 100 uL of base/neutral matrix spike standard solution and 100 uL of acid matrix spike solution is added to the sample volume chosen for matrix spike and matrix spike duplicate analysis. A blank spike/blank spike duplicate analysis can be performed if insufficient sample volume/quantity is not available for matrix spike and matrix spike duplicate analysis, or if additional method monitoring is desired.

5.7.3 Extract water samples following procedures described in SAS SOP 0301.3, Liquid Liquid Extraction. Extract solid samples following procedures described in SAS SOP 0302.5 or 0334.2, Sonication Extraction; alternatively, solid samples may be extracted following procedures described in SAS SOP 0367.2, Soxhlet extraction.

5.7.4 Sample extracts are dried by pouring the extract through a filter paper cone filled with sodium sulfate that has been pre-wet with methylene chloride.

5.7.5 The sample extract (or a portion of the extract) may be cleaned up using GPC following procedures described in SAS SOP 0342.2.

5.7.6 Concentrate the extract to 10.0 mL.

5.8 SAMPLE ANALYSIS

5.8.1 Analyte identification is achieved in accordance with Method 8270C (Section 7.6).

5.8.2 Analyte quantitation is achieved based on the initial calibration in accordance with Method 8270C (Section 7.6).

5.9 CALCULATIONS

5.9.1 Instrument software calculates the concentration of the analyte in the final extract in ug/L. This result is used in the following equations:

5.9.2 Water: $$\text{Conc., (ug/L)} = \frac{[\text{extract conc., ug/L}] \times [\text{final extract vol., mL}] \times [\text{dil. factor}]}{[\text{sample volume, mL}]}$$

5.9.3 Soil: $$\text{Conc., (ug/kg)} = \frac{[\text{extract conc., ug/L}] \times [\text{final extract vol., mL}] \times [\text{dil. factor}]}{[\text{sample weight, g}] \times [\text{\%solids}]}$$

5.10 QUALITY CONTROL

5.10.1 Instrument Quality Control

5.10.1.1 Tuning is performed every 12 hours of instrument operation. Tuning criteria must be met before analysis can begin.

5.10.1.2 The initial calibration standards QC criteria established for Methods 8270C must be met before sample analysis can begin (%RSD ≤ 30, minimum RRF >0.05 for SPCC compounds). If the curve fails the %RSD criteria, the following actions may be performed: rerun the curve; reoptimize the system and rerun the curve; or, prepare new standards and rerun the curve.

5.10.1.3 The continuing calibration standard must meet QC criteria before sample analysis can begin (%D < 30 for CCC compounds, 0.05 minimum RF). If the calibration fails the %D criteria, the following actions may be performed: rerun the standard; prepare a new standard; or, perform a new initial calibration.

5.10.1.4 Continuing calibration internal standard areas must meet QC criteria of -50% to +200% of the initial calibration internal standard area recoveries.

5.10.2 Analytical Quality Control

5.10.2.1 The method blank should be free of target compounds. If low level contamination is present, it must be below the PQL for the target analyte, except for common laboratory solvents and phthalate esters, which can be allowed up to 5 times the sample PQL.

5.10.2.2 Quality control limits for surrogate recoveries are determined from control charting of surrogate recoveries. Current limits are included in Table 2. Samples with surrogates outside recovery ranges are typically reanalyzed to verify a matrix effect. If the method blank has surrogate recoveries outside established limits, the batch must be reanalyzed, if sufficient sample volume is available. If the BS/BSDs have surrogate recoveries outside established limits, the batch must be reanalyzed, if sufficient sample volume is available.

5.10.2.3 Soil matrix spike and matrix spike duplicates are extracted and analyzed every 20 samples or every batch, whichever is greater. Soil MS/MSD %Rs and RPDs must be within laboratory QC limits, or matrix interference established (usually by sample re-extraction re-analysis). Water matrix spikes are analyzed when adequate sample is received from the client; otherwise, a blank spike/blank spike duplicate (BS/BSD) is performed for the batch. If BS/BSD RPD is outside laboratory QC criteria, the batch must be reextracted if sufficient sample volumes are available. Advisory quality control limits for blank spikes and matrix spikes are determined from control charting of blank spike/blank spike duplicate recoveries and RPDs. Current limits are included in Table 2.

5.10.2.4 MDL studies are performed annually; the MDL results are maintained by the QA/QC Department.

5.10.2.5 Control limits for surrogate recoveries blank spike/blank spike duplicate recoveries (%R) and RPDs are calculated and updated twice yearly.

5.11 PRECISION AND ACCURACY

5.11.1 Precision is evaluated by BS/BSD RPD, or, if matrix effects and/or interferences are not an issue, by MS/MSD RPD. Note that RPD outliers in the case of MS/MSD analyses may be due to matrix interferences and/or effects.

5.11.2 BS/BSD samples must meet RPD criteria, or the batch is reanalyzed. The criteria are advisory for MS/MSD samples. If the corresponding BS/BSD samples meet criteria, any MS/MSD outliers may be considered a matrix effect, and the analyst may flag the results accordingly.

5.11.3 Accuracy is evaluated by surrogate recoveries and BS/BSD percent recoveries summarized in Table 2. MS/MSD percent recoveries are evaluated for accuracy, but may be biased due to potential matrix interferences.

5.11.4 BS/BSD samples must meet %R criteria, or the batch is reanalyzed. The criteria is advisory for MS/MSD samples; if the corresponding BS/BSD samples meet criteria, any MS/MSD outliers may be considered a matrix effect, and the results flagged accordingly by the analyst.

5.12PQLs

5.12.1 PQLs are listed in Table 1.

5.13MODIFICATIONS TO PUBLISHED METHOD

5.13.1 None.

6.0 HEALTH AND SAFETY/SPECIAL CONSIDERATIONS

6.1 The following analytes have been tentatively classified as known or suspected, human or mammalian carcinogens: benzo (a) anthracene, benzidine, 3,3'dichlorobenzidine, benzo (a) pyrene, alpha-BHC, beta-BHC, gamma-BHC, delta-BHC, dibenz (a,h)-anthracene, N-nitrosodimethylamine, 4,4'-DDT, and polychlorinated biphenyl compounds. Primary standards of these toxic compounds should be prepared in hood. A NIOSH/MESA approved toxic gas respirator should be worn when handling high concentrations of these toxic compounds.

7.0 NONCONFORMANCE AND CORRECTIVE ACTION

7.1. Any nonconformance encountered during sample preparation (e.g., insufficient sample volume, multiphase, or matrix-specific problems) should be documented in a nonconformance memorandum and appropriate corrective action taken.

8.0 RECORDS MANAGEMENT/DOCUMENTATION

8.1. Each batch identifier and appropriate QA/QC should be recorded in the preparation logbook. Calibration standard lot identifiers (as described in SAS SOP 0611.5) are also recorded in the preparation logbook.

8.2. Logbooks are archived with the QC department when completed for permanent storage.

8.3. If client contact is required, a Client Contact Record is completed and maintained in the master file.

8.4. MS data is archived to magnetic tape on a routine basis.

9.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

9.1. All laboratory waste must be handled in accordance with SAS SOP 0036.5.

9.2. All laboratory procedures must comply with the policies set forth in SAS's Pollution Prevention Plan.

Table 1. EPA Method 8270 Compounds and PQLs

Compound	Water PQL ug/L	Soil PQL ug/kg
Phenol	0.5	100
bis(2-Chloroethyl)ether	1.5	100
2-Chlorophenol	0.5	100
1,3-Dichlorobenzene	0.5	100
1,4-Dichlorobenzene	0.5	100
Benzyl Alcohol	0.5	100
1,2-Dichlorobenzene	0.5	100
2-Methylphenol	0.5	100
bis(2-Chloroisopropyl)ether	0.5	100
3- & 4-Methylphenol	0.5	100
N-nitroso-di-n-propylamine	0.5	100
Hexachloroethane	0.5	100
Nitrobenzene	0.5	100
Isophorone	0.5	100
2-Nitrophenol	0.5	100
2,4-Dimethylphenol	0.5	100
Benzoic Acid	0.5	100
bis(2-Chloroethoxy)methane	0.5	100
2,4-Dichlorophenol	0.5	100
1,2,4-Trichlorobenzene	0.5	100
Naphthalene	0.1	20
4-Chloroaniline	0.5	100
Hexachlorobutadiene	0.5	100
4-Chloro-3-methylphenol	0.5	100
2-Methylnaphthalene	0.1	20
Hexachlorocyclopentadiene	0.5	100
2,4,6-Trichlorophenol	0.5	100
2,4,5-Trichlorophenol	0.5	100
2-Chloronaphthalene	0.1	20
2-Nitroaniline	0.5	100
Dimethylphthalate	0.5	100
Acenaphthylene	0.1	20
2,6-Dinitrotoluene	0.5	100
3-Nitroaniline	0.5	100
Acenaphthene	0.1	20
2,4-Dinitrophenol	0.5	100
4-Nitrophenol	0.5	100
Dibenzofuran	0.5	100
2,4-Dinitrotoluene	0.5	100
Diethylphthalate	1	100

Table 1, Continued. **EPA Method 8270 Compounds and PQLs**

Compound	**Water PQL ug/L**	**Soil PQL ug/kg**
4-Chlorophenylphenylether	0.5	100
Fluorene	0.1	20
4-Nitroaniline	0.5	100
4,6-Dinitro-2-methylphenol	0.5	100
N-Nitrosodiphenylamine	0.1	100
4-Bromophenylphenylether	0.5	100
Hexachlorobenzene	0.5	100
Pentachlorophenol	0.5	100
Phenanthrene	0.1	20
Anthracene	0.1	20
Di-n-butylphthalate	1	200
Fluoranthene	0.1	20
Pyrene	0.1	20
Butylbenzylphthalate	10	100
3,3'-Dichlorobenzidine	5	100
Benzo(a)anthracene	0.1	20
Chrysene	0.1	20
bis(2-Ethylhexyl)phthalate	10	100
Di-n-octylphthalate	0.5	100
Benzo(b)fluoranthene	0.1	20
Benzo(k)fluoranthene	0.1	20
Benzo(a)pyrene	0.1	20
Indeno(1,2,3-cd)pyrene	0.1	20
Dibenz(a,h)anthracene	0.1	20
Benzo(g,h,i)perylene	0.1	20
Carbazole	0.5	100
N-nitrosodimethylamine	0.5	100
Pyridine	0.5	100
Benzidine	0.5	200
1,2-Diphenylhydrazine	0.5	100
Tetrachlorophenols	0.5	100
Aniline	2	1000
Cyclohexanone	2	200
2-Nitropropane	2	100
2-Ethoxyethanol	2	100

Table 2. **Quality Control Limits, Semivolatile Organics by USEPA Method 8270C**

Matrix : Water
Expires: 06/08/2001

Blank and Matrix Spike Recovery

1,2,4-Trichlorobenzene	42 - 114%	=<30% RPD
1,4-Dichlorobenzene	39 - 114%	=<35% RPD
2,4-Dinitrotoluene	50 - 132%	=<31% RPD
2-Chlorophenol	44 - 119%	=<33% RPD
4-Chloro-3-methylphenol	45 - 141%	=<33% RPD
4-Nitrophenol	17 - 83%	=<39% RPD
Acenaphthene	48 - 114%	=<32% RPD
N-nitroso-di-n-propylamine	30 - 130%	=<28% RPD
Pentachlorophenol	24 - 154%	=<38% RPD
Phenol	15 - 82%	=<38% RPD
Pyrene	46 - 127%	=<32% RPD

Surrogate Recovery

2 - Fluorobiphenyl	56 - 127%
2 - Fluorophenol	34 - 109%
2,4,6 - Tribromophenol	55 - 156%
Nitrobenzene - d5	52 - 149%
p - Terphenyl - d14	43 - 145%
Phenol - d5	19 - 105%

Matrix : Soil
Expires: 06/08/2001

Blank and Matrix Spike Recovery

1,2,4-Trichlorobenzene	48 - 140%	=<30% RPD
1,4-Dichlorobenzene	53 - 131%	=<33% RPD
2,4-Dinitrotoluene	51 - 140%	=<33% RPD
2-Chlorophenol	58 - 123%	=<32% RPD
4-Chloro-3-methylphenol	50 - 150%	=<32% RPD
4-Nitrophenol	36 - 130%	=<41% RPD
Acenaphthene	54 - 128%	=<32% RPD
N-nitroso-di-n-propylamine	43 - 130%	=<35% RPD
Pentachlorophenol	21 - 144%	=<41% RPD
Phenol	45 - 128%	=<36% RPD
Pyrene	45 - 145%	=<34% RPD

Surrogate Recovery

2 - Fluorobiphenyl	55 - 137%
2 - Fluorophenol	57 - 146%
2,4,6 - Tribromophenol	35 - 146%
Nitrobenzene - d5	56 - 145%
p - Terphenyl - d14	45 - 134%
Phenol - d5	54 - 140%

Table 2, Continued. **Quality Control Limits, Semivolatile Organics by USEPA Method 8270C**

Matrix : TCLP Leachate
Expires: 06/08/2001

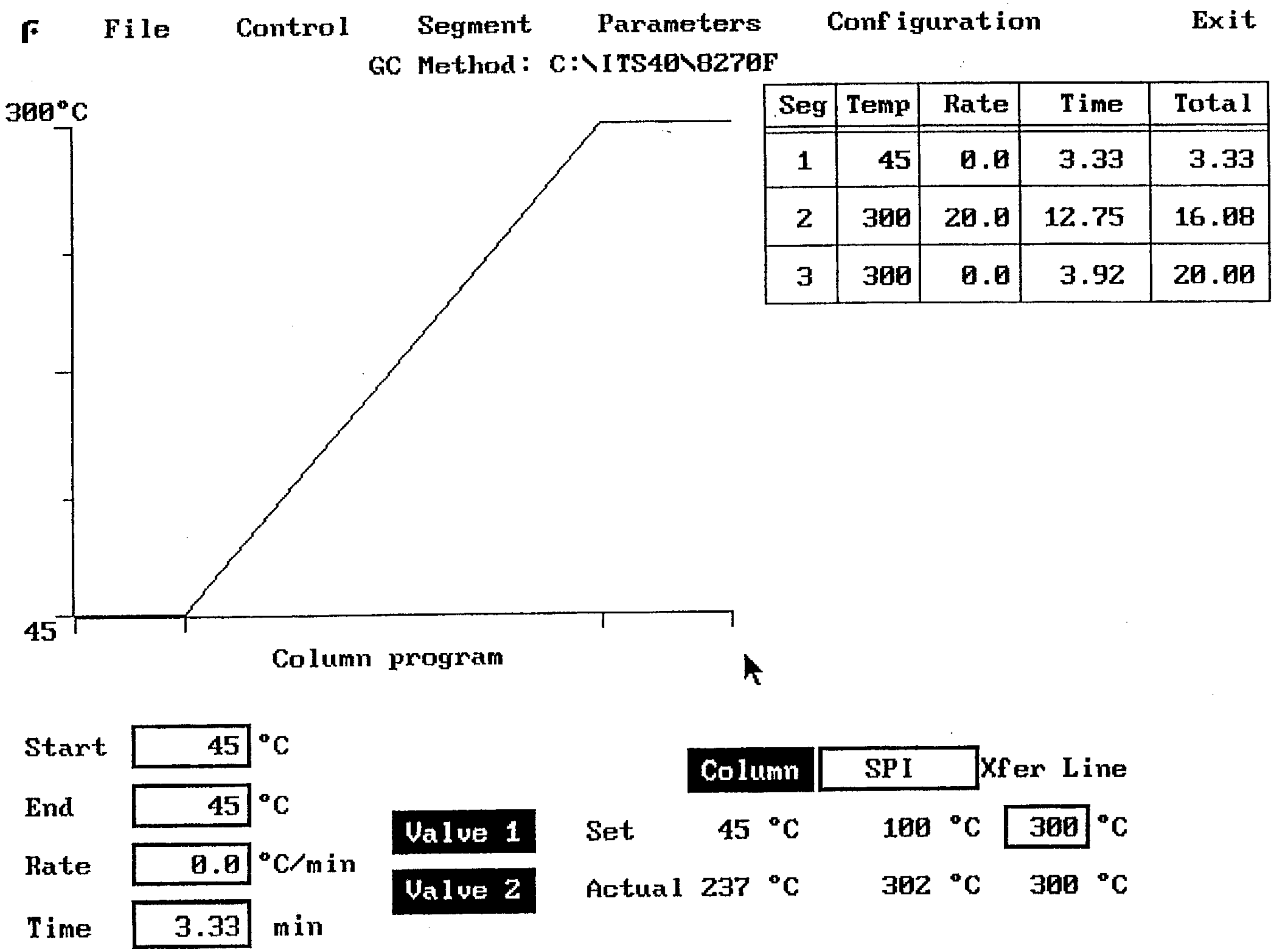
Blank and Matrix Spike Recovery

1,4-Dichlorobenzene	41 - 123%	=<26% RPD
2,4,5-Trichlorophenol	51 - 148%	=<30% RPD
2,4,6-Trichlorophenol	44 - 138%	=<33% RPD
2,4-Dinitrotoluene	48 - 141%	=<31% RPD
2-Methylphenol	32 - 141%	=<35% RPD
3- & 4-Methylphenol	34 - 152%	=<37% RPD
Hexachlorobenzene	36 - 137%	=<23% RPD
Hexachlorobutadiene	39 - 128%	=<36% RPD
Hexachloroethane	35 - 145%	=<32% RPD
Nitrobenzene	42 - 158%	=<33% RPD
Pentachlorophenol	17 - 167%	=<36% RPD
Pyridine	10 - 133%	=<47% RPD

Surrogate Recovery

2 - Fluorobiphenyl	61 - 138%
2 - Fluorophenol	23 - 152%
2,4,6 - Tribromophenol	59 - 147%
Nitrobenzene - d5	45 - 166%
p - Terphenyl - d14	34 - 150%
Phenol - d5	34 - 130%

ATTACHMENT 1



GC Method: C:\ITS40\8270F

Seg	Temp	Rate	Time	Total
1	45	0.0	3.33	3.33
2	300	20.0	12.75	16.08
3	300	0.0	3.92	20.00

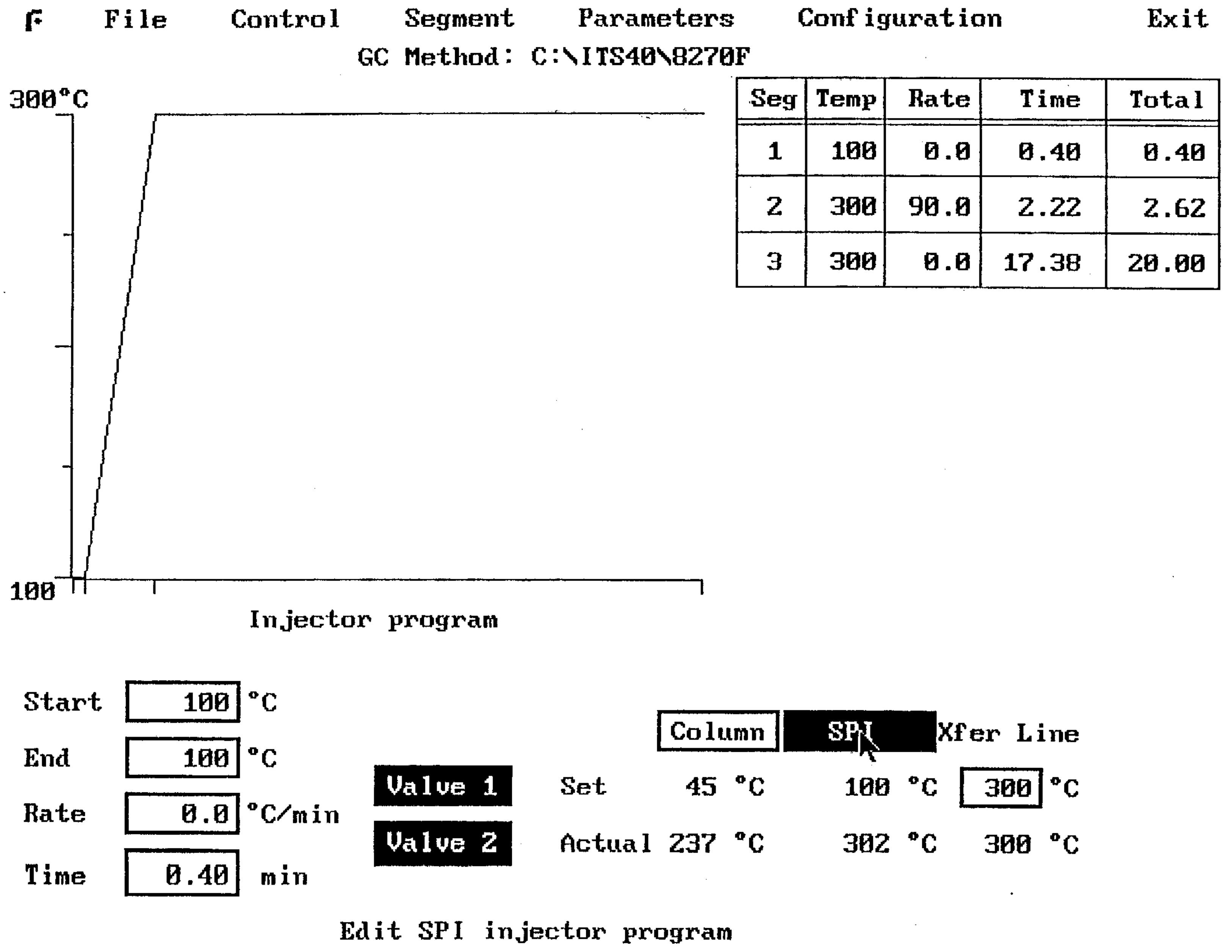
Start 45 °C

End 45 °C

Rate 0.0 °C/min

Time 3.33 min

	Column	SPI	Xfer Line
Set	45 °C	100 °C	300 °C
Actual	237 °C	302 °C	300 °C



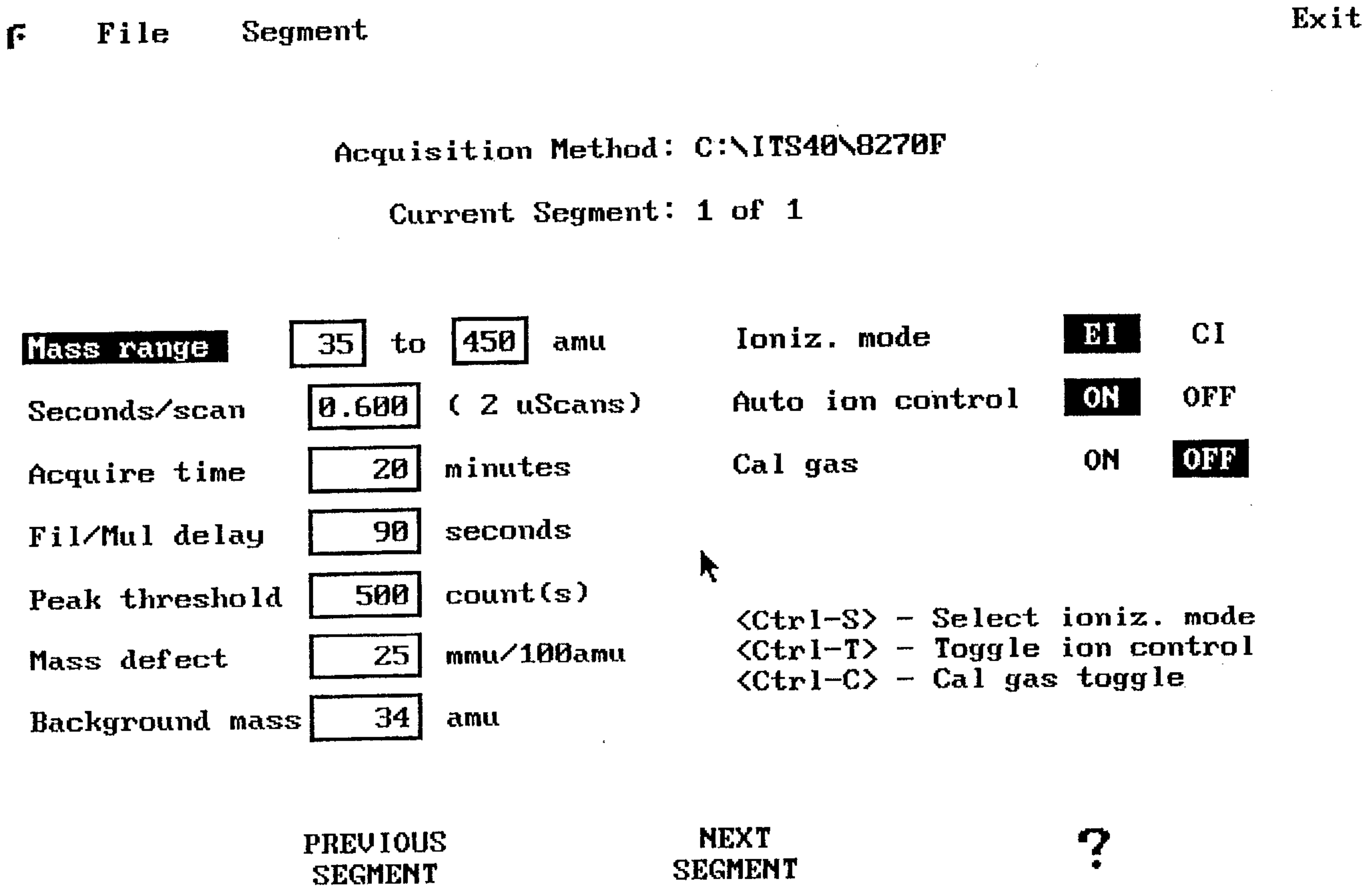
GC Method: C:\ITS40\8270F

Seg	Temp	Rate	Time	Total
1	100	0.0	0.40	0.40
2	300	90.0	2.22	2.62
3	300	0.0	17.38	20.00

Start 100 °C
End 100 °C
Rate 0.0 °C/min
Time 0.40 min

	Column	SPI	Xfer Line
Set	45 °C	100 °C	300 °C
Actual	237 °C	302 °C	300 °C

Edit SPI injector program



Acquisition Method: C:\ITS40\8270F

Current Segment: 1 of 1

Mass range 35 to 450 amu

Seconds/scan 0.600 (2 uScans)

Acquire time 20 minutes

Fil/Mul delay 90 seconds

Peak threshold 500 count(s)

Mass defect 25 mmu/100amu

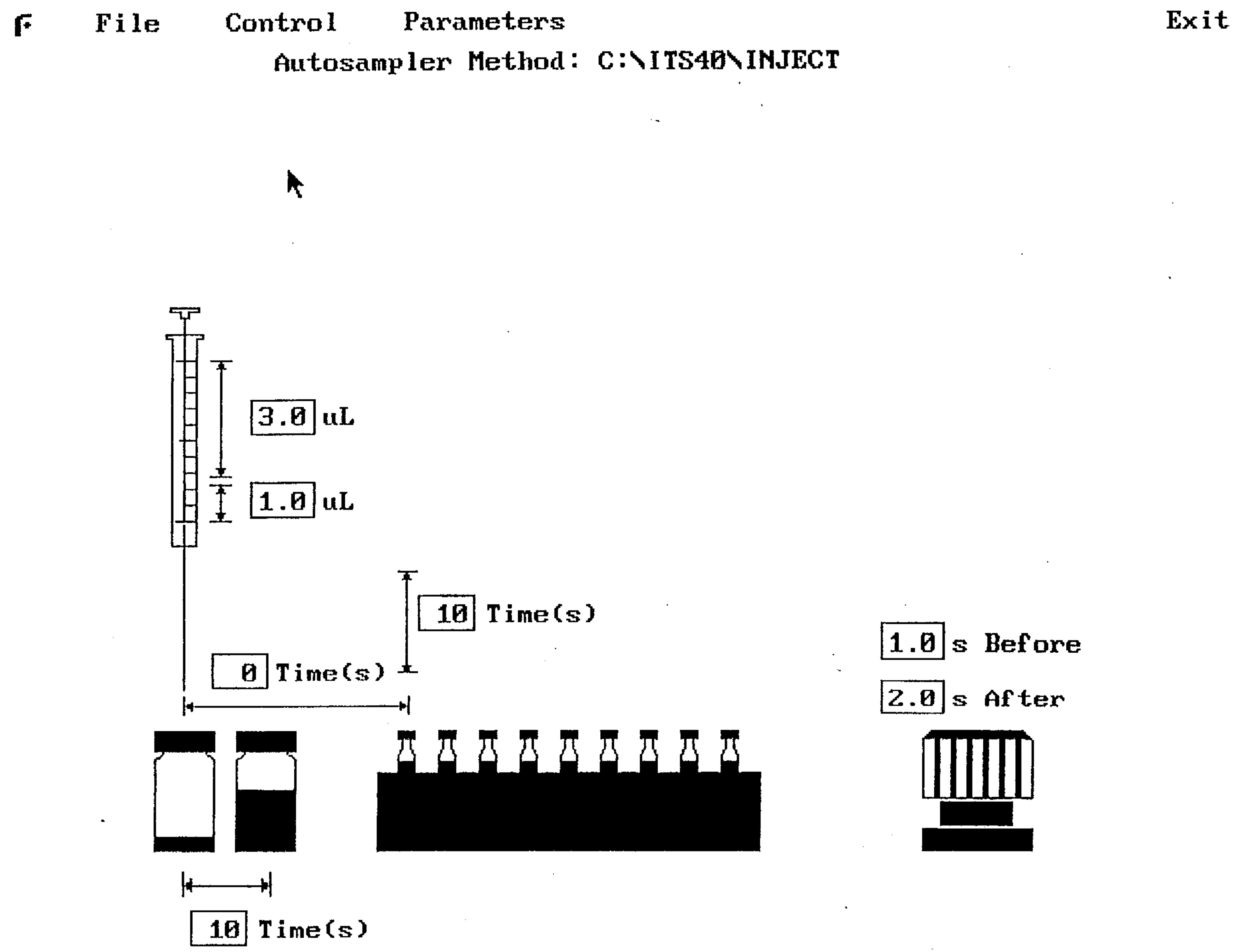
Background mass 34 amu

Ioniz. mode [✓ EI] CI

Auto ion control [✓ ON] OFF

Cal gas ON [✓ OFF]

<Ctrl-S> - Select ioniz. mode
<Ctrl-T> - Toggle ion control
<Ctrl-C> - Cal gas toggle



Autosampler Method: C:\ITS40\INJECT

3.0 uL

1.0 uL

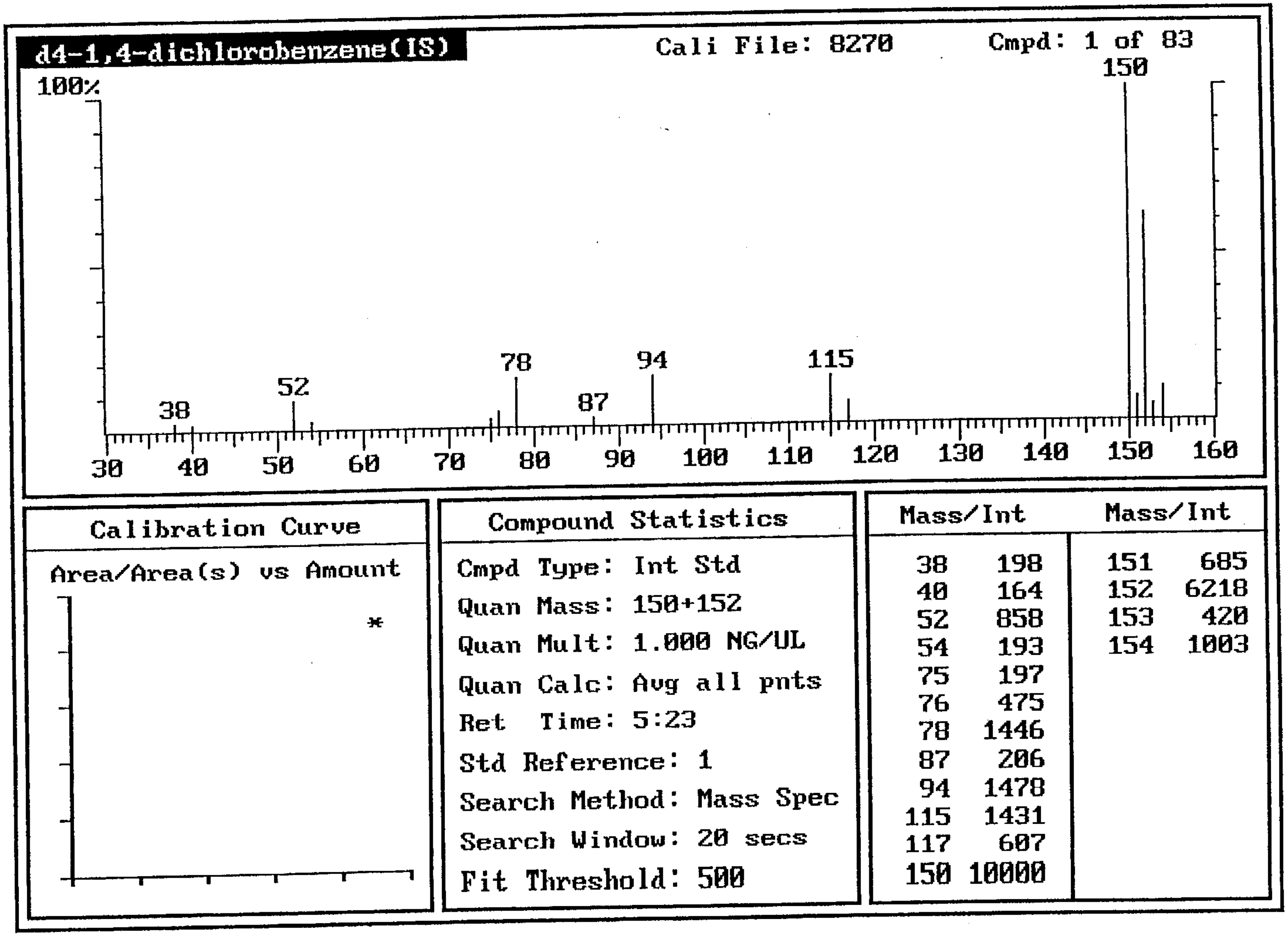
10 Time(s)

0 Time(s)

1.0 s Before

2.0 s After

10 Time(s)



Compound Statistics

Cmpd Type: Int Std

Quan Mass: 150+152

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 5:23

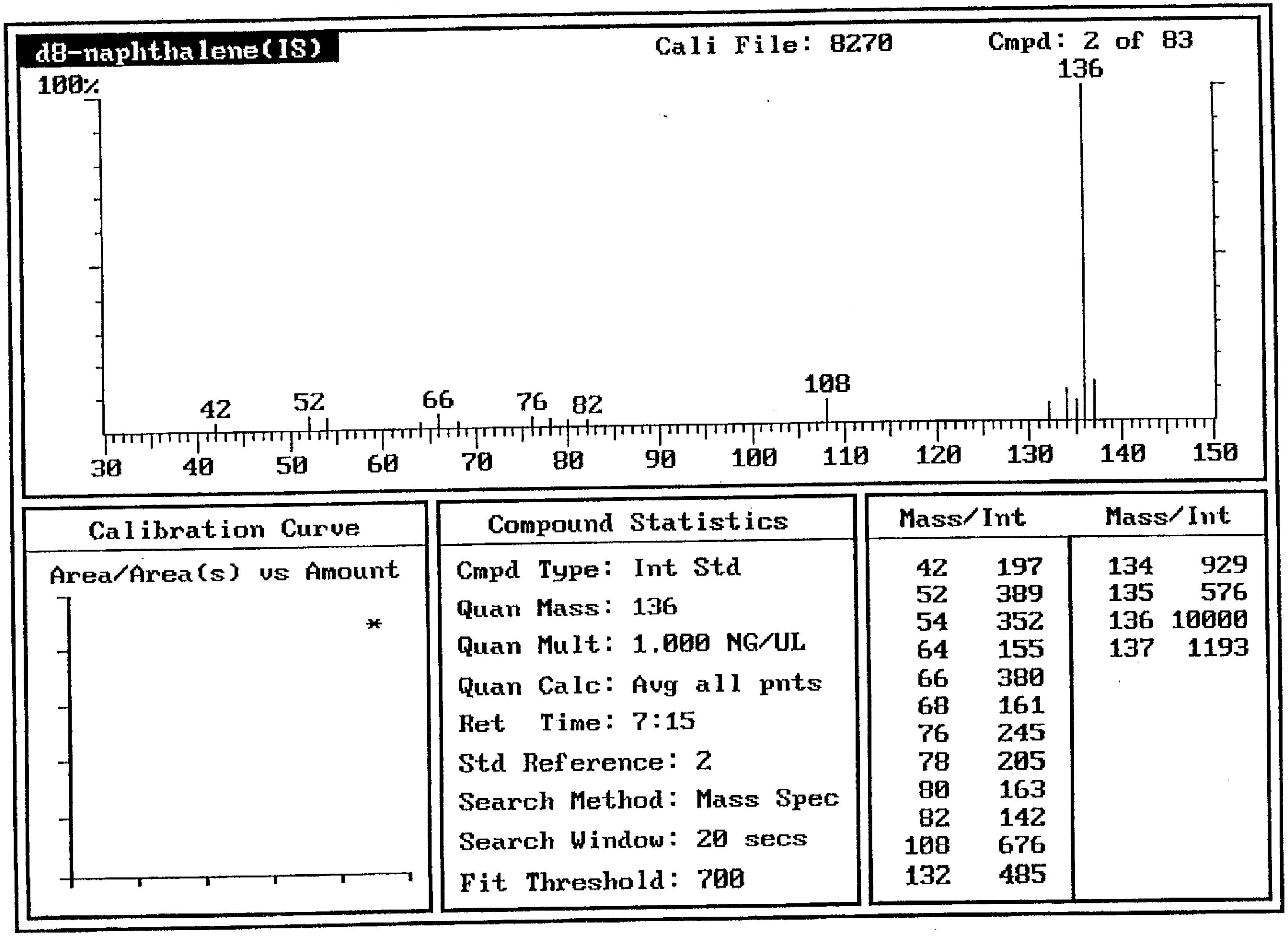
Std Reference: 1

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 500

Mass/Int		Mass/Int	
38	198	151	685
40	164	152	6218
52	858	153	420
54	193	154	1003
75	197		
76	475		
78	1446		
87	206		
94	1478		
115	1431		
117	607		
150	10000		



d8-naphthalene(IS)

Cali File: 8270

Cmpd: 2 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Int Std

Quan Mass: 136

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 7:15

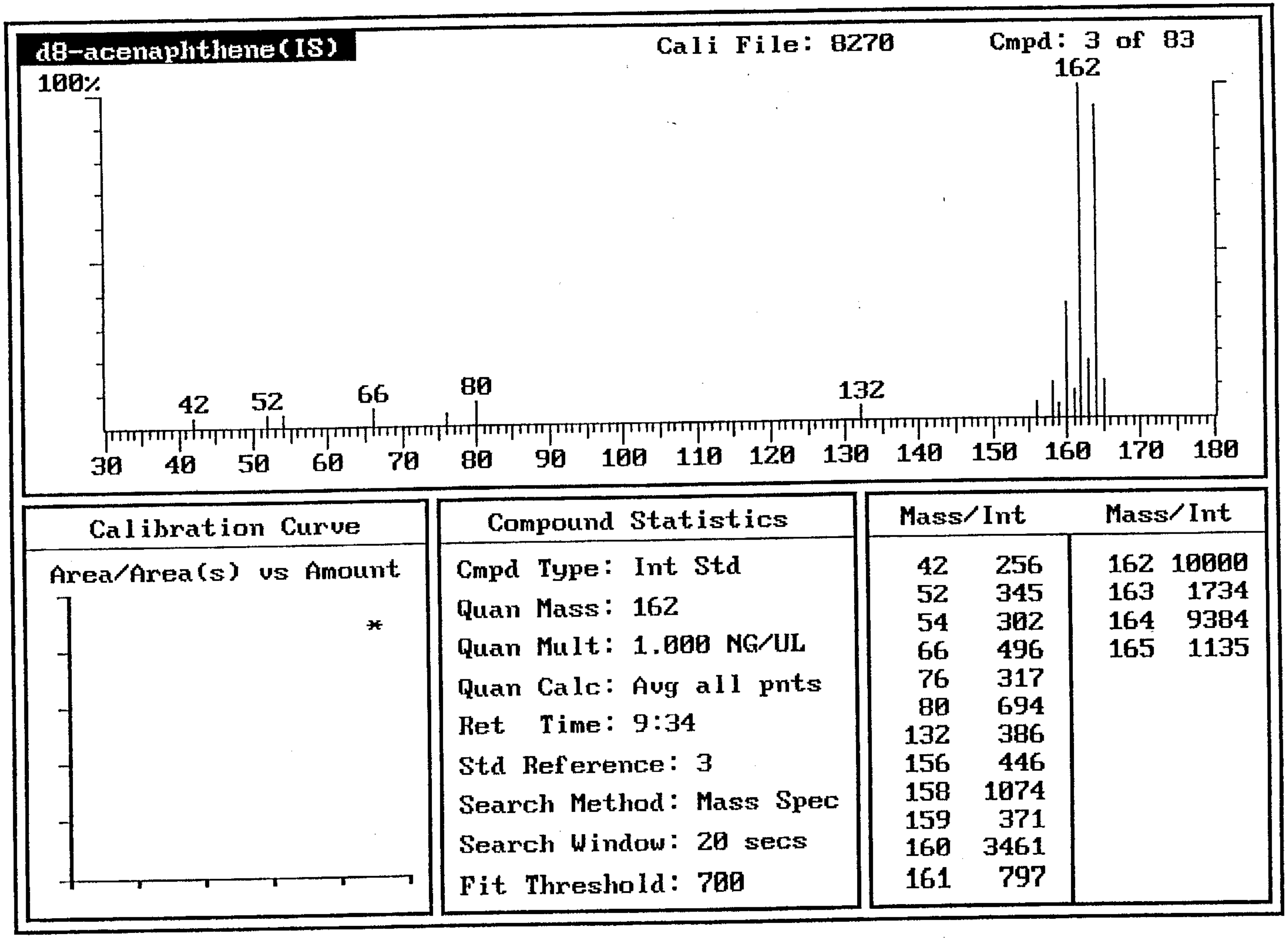
Std Reference: 2

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 700

Mass/Int		Mass/Int	
42	197	134	929
52	389	135	576
54	352	136	10000
64	155	137	1193
66	380		
68	161		
76	245		
78	205		
80	163		
82	142		
108	676		
132	485		



d8-acenaphthene(IS) Cali File: 8270 Cmpd: 3 of 83

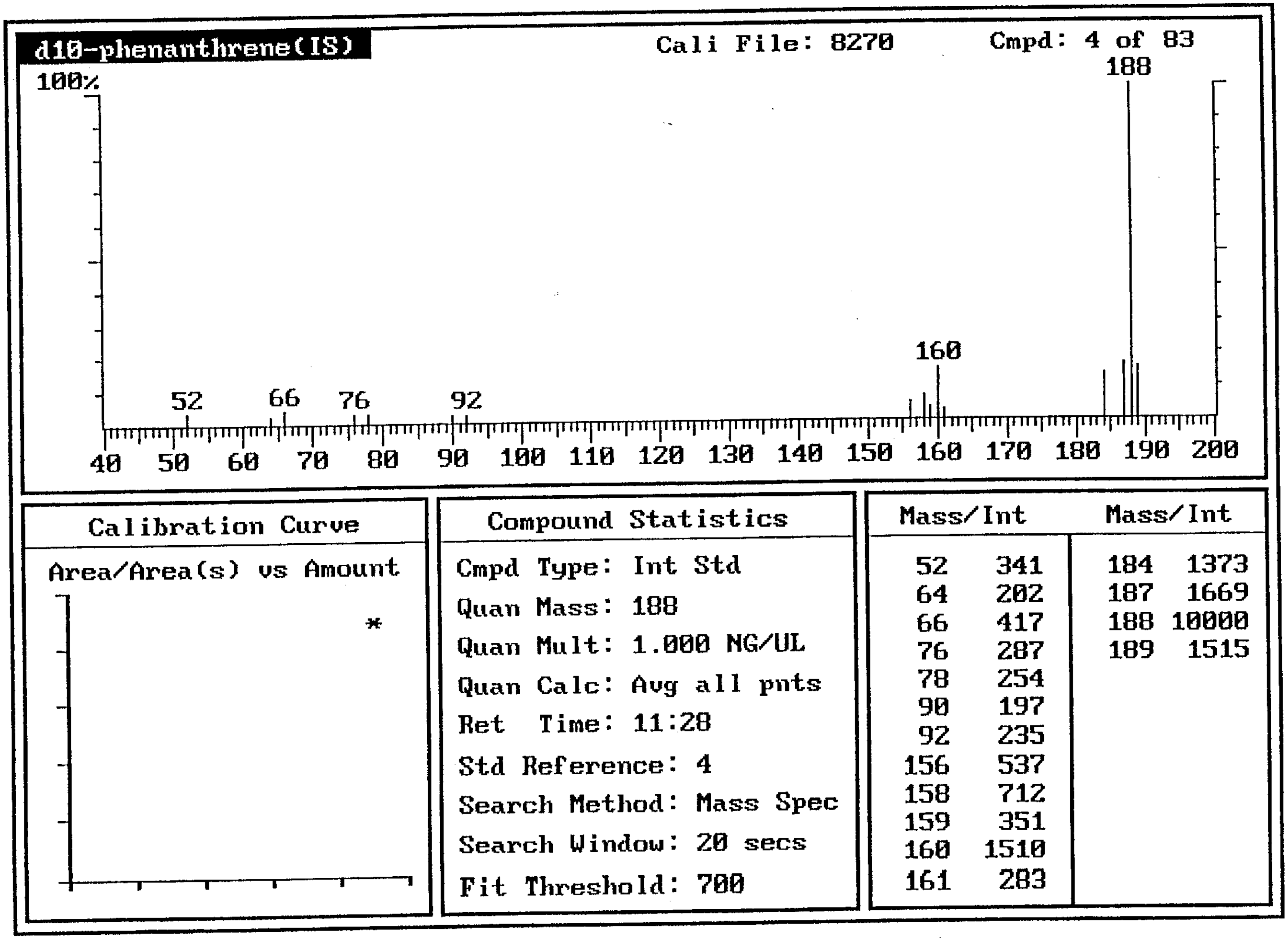
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Int Std
Quan Mass: 162
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:34
Std Reference: 3
Search Method: Mass Spec
Search Window: 20 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
42	256	162	10000
52	345	163	1734
54	302	164	9384
66	496	165	1135
76	317		
80	694		
132	386		
156	446		
158	1074		
159	371		
160	3461		
161	797		



d10-phenanthrene(IS) Cali File: 8270 Cmpd: 4 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Int Std

Quan Mass: 188

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 11:28

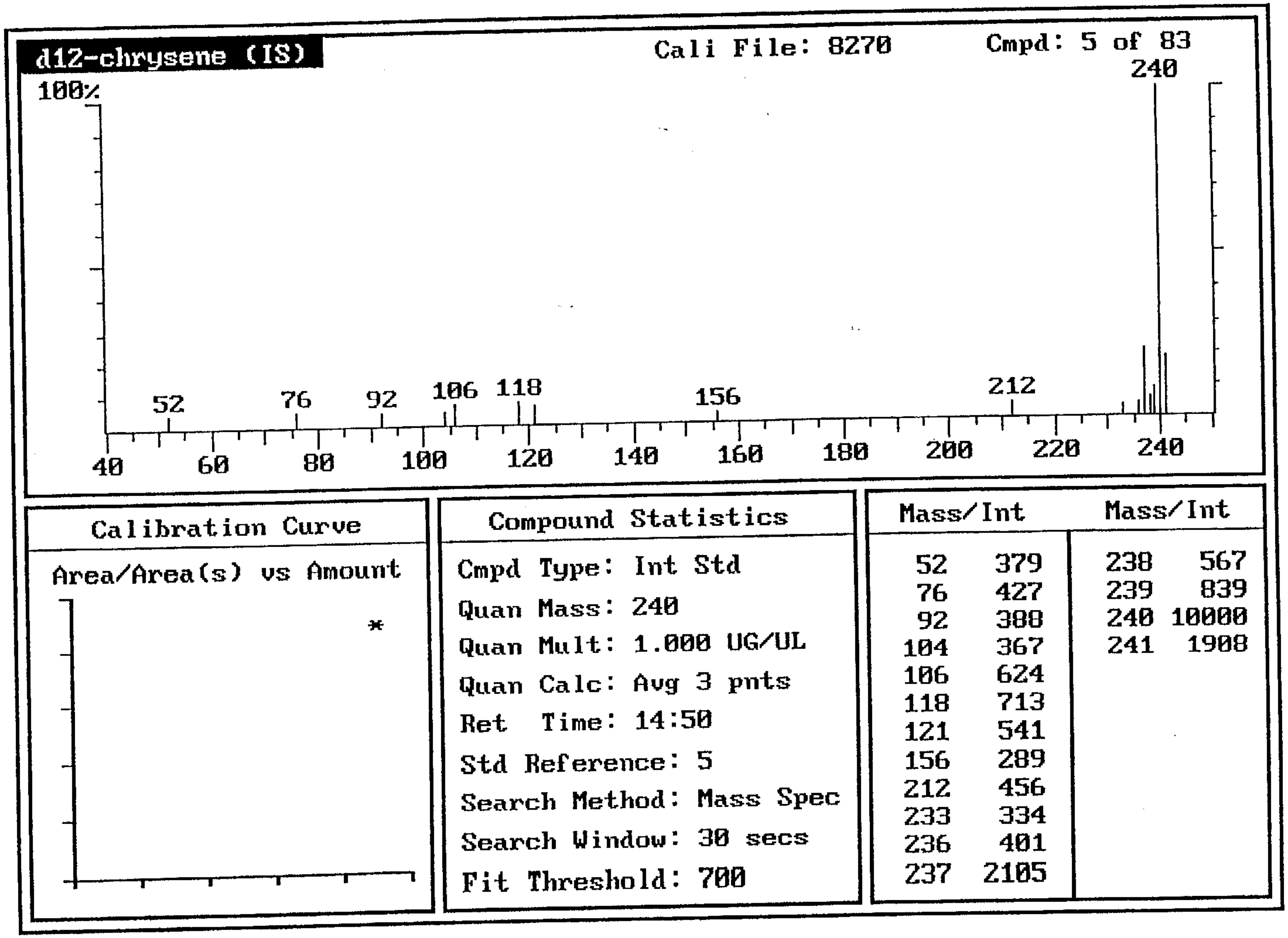
Std Reference: 4

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 700

Mass/Int		Mass/Int	
52	341	184	1373
64	202	187	1669
66	417	188	10000
76	287	189	1515
78	254		
90	197		
92	235		
156	537		
158	712		
159	351		
160	1510		
161	283		



d12-chrysene (IS)

Cali File: 8270

Cmpd: 5 of 83

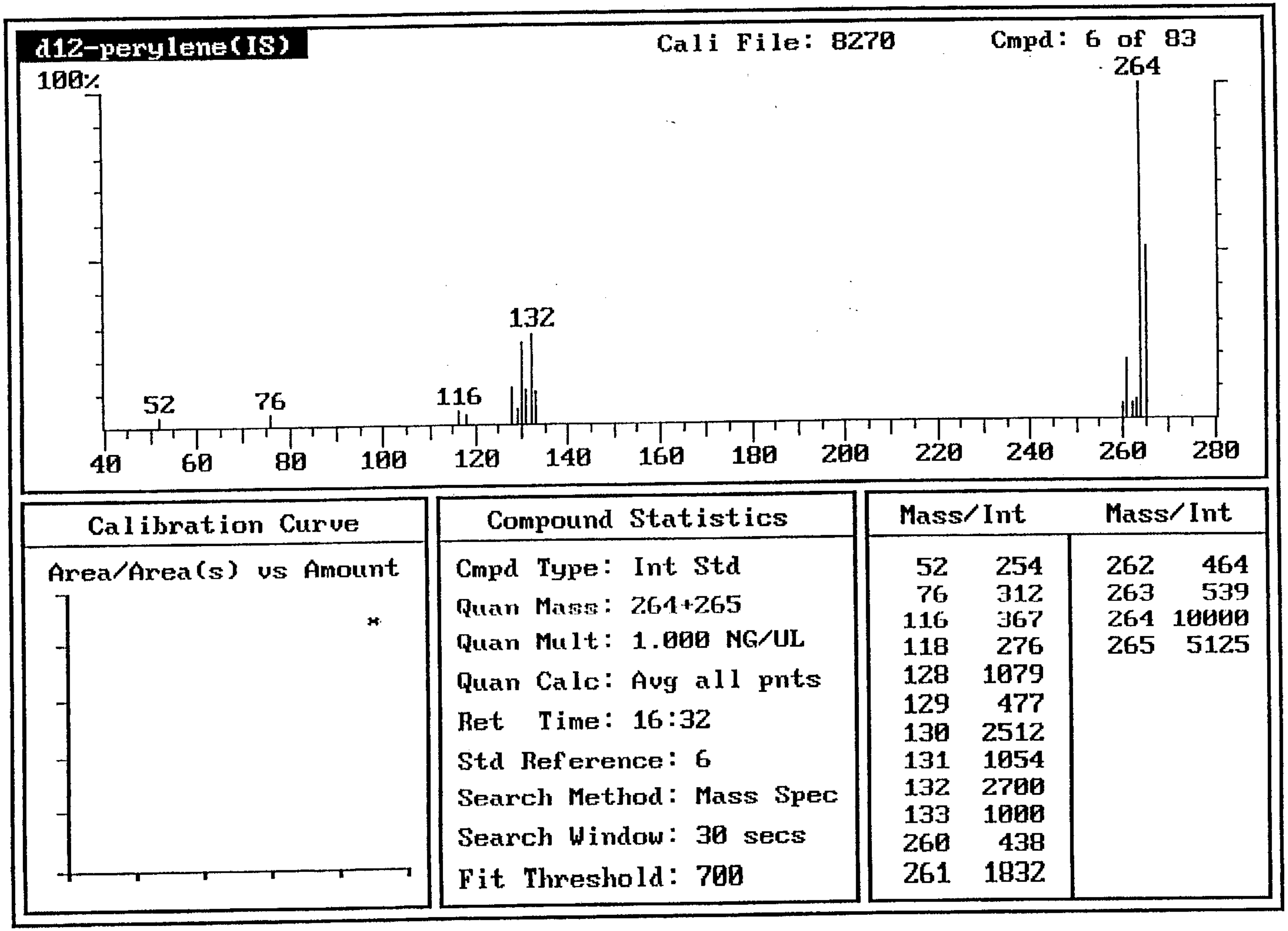
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Int Std
Quan Mass: 240
Quan Mult: 1.000 UG/UL
Quan Calc: Avg 3 pnts
Ret Time: 14:50
Std Reference: 5
Search Method: Mass Spec
Search Window: 30 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
52	379	238	567
76	427	239	839
92	388	240	10000
104	367	241	1908
106	624		
118	713		
121	541		
156	289		
212	456		
233	334		
236	401		
237	2105		



d12-perylene(IS) Cali File: 8270 Cmpd: 6 of 83

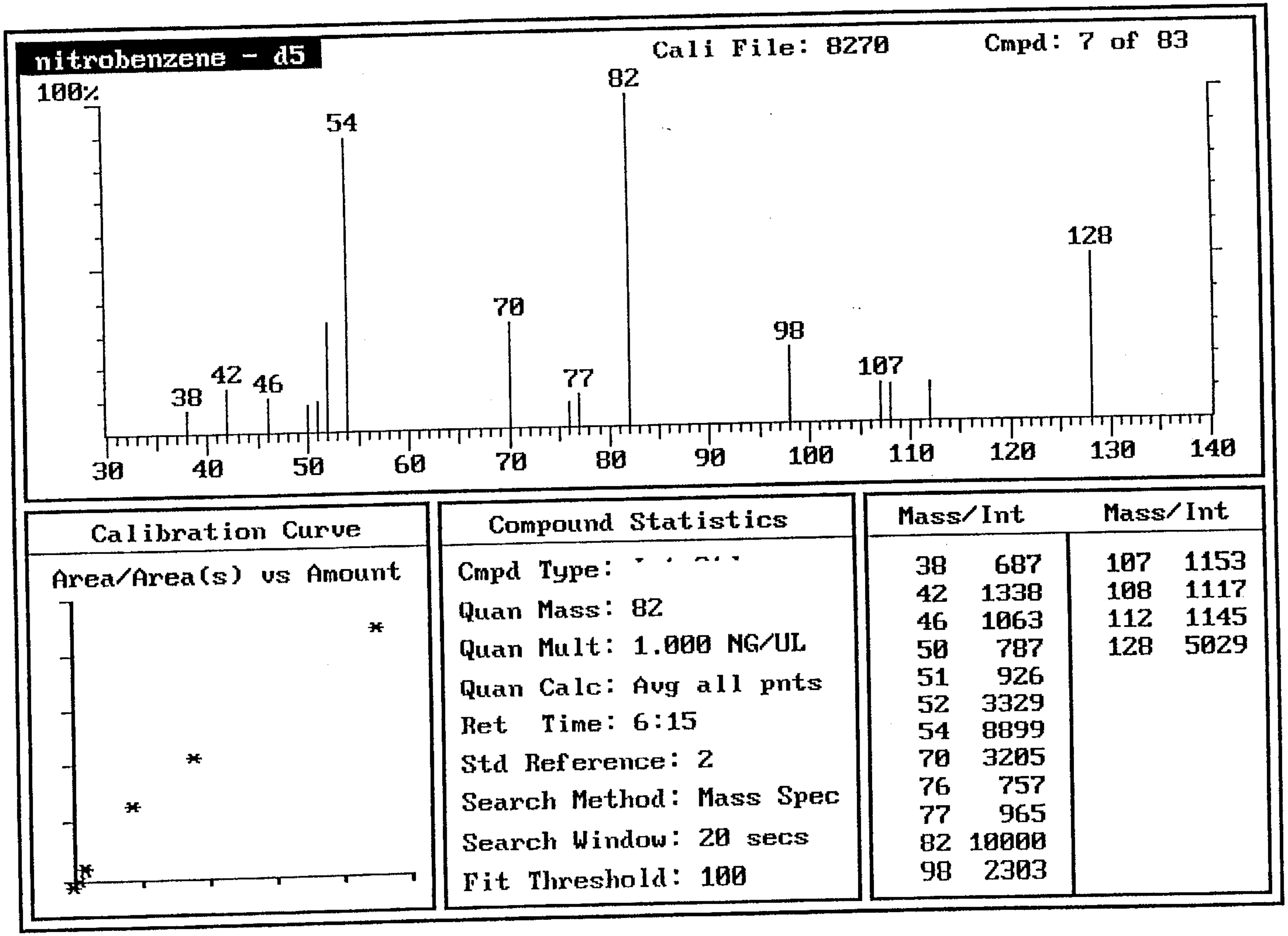
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Int Std
Quan Mass: 264+265
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 16:32
Std Reference: 6
Search Method: Mass Spec
Search Window: 30 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
52	254	262	464
76	312	263	539
116	367	264	10000
118	276	265	5125
128	1079		
129	477		
130	2512		
131	1054		
132	2700		
133	1000		
260	438		
261	1832		



nitrobenzene - d5

Cali File: 8270

Cmpd: 7 of 83

Calibration Curve

Compound Statistics

Cmpd Type: [illegible]

Quan Mass: 82

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 6:15

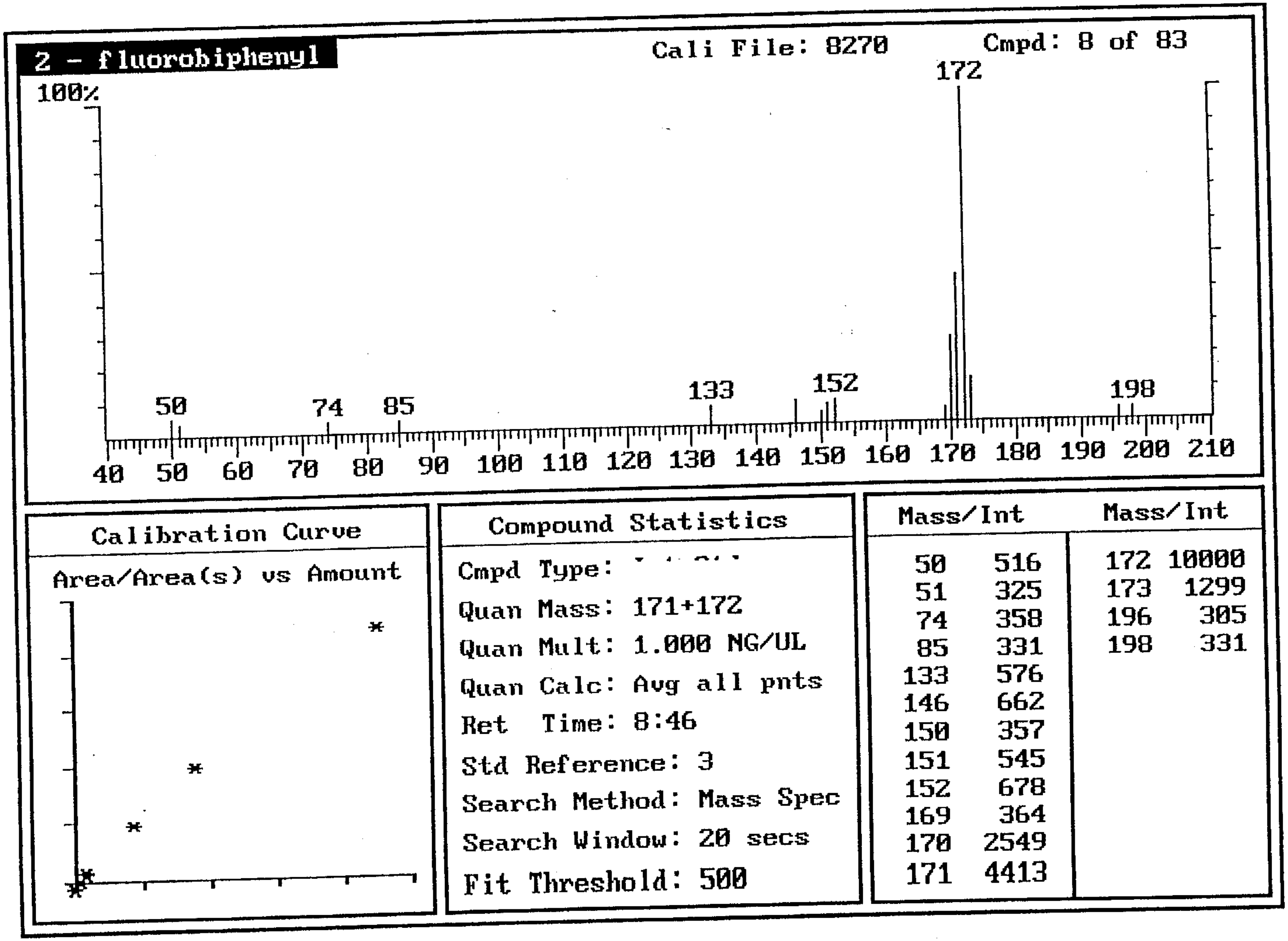
Std Reference: 2

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 100

Mass/Int		Mass/Int	
38	687	107	1153
42	1338	108	1117
46	1063	112	1145
50	787	128	5029
51	926		
52	3329		
54	8899		
70	3205		
76	757		
77	965		
82	10000		
98	2303		



2 - fluorobiphenyl

Cali File: 8270

Cmpd: 8 of 83

Compound Statistics

Cmpd Type: [illegible]

Quan Mass: 171+172

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 8:46

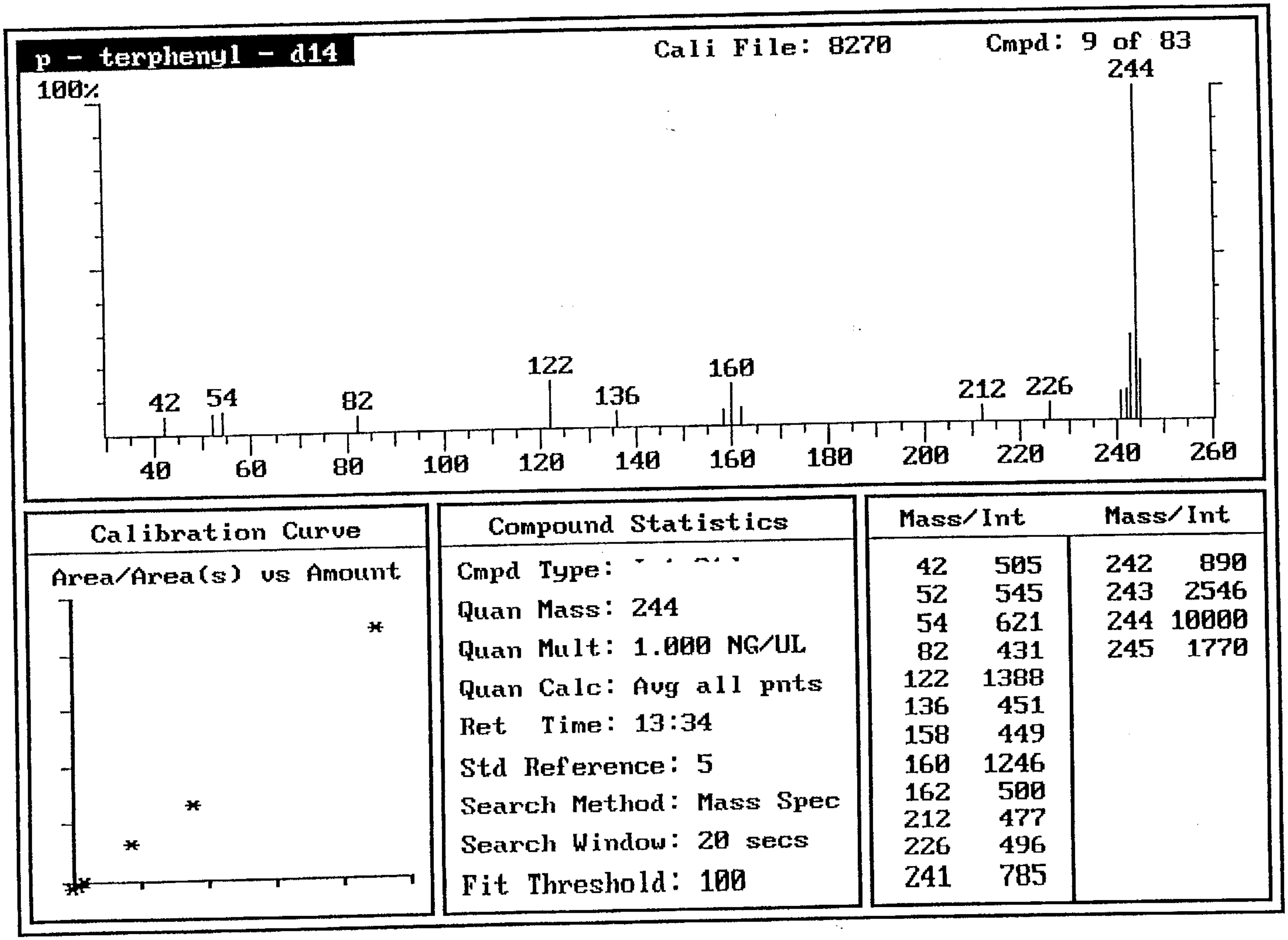
Std Reference: 3

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 500

Mass/Int		Mass/Int	
50	516	172	10000
51	325	173	1299
74	358	196	305
85	331	198	331
133	576		
146	662		
150	357		
151	545		
152	678		
169	364		
170	2549		
171	4413		



p - terphenyl - d14

Cali File: 8270

Cmpd: 9 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: [illegible]

Quan Mass: 244

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 13:34

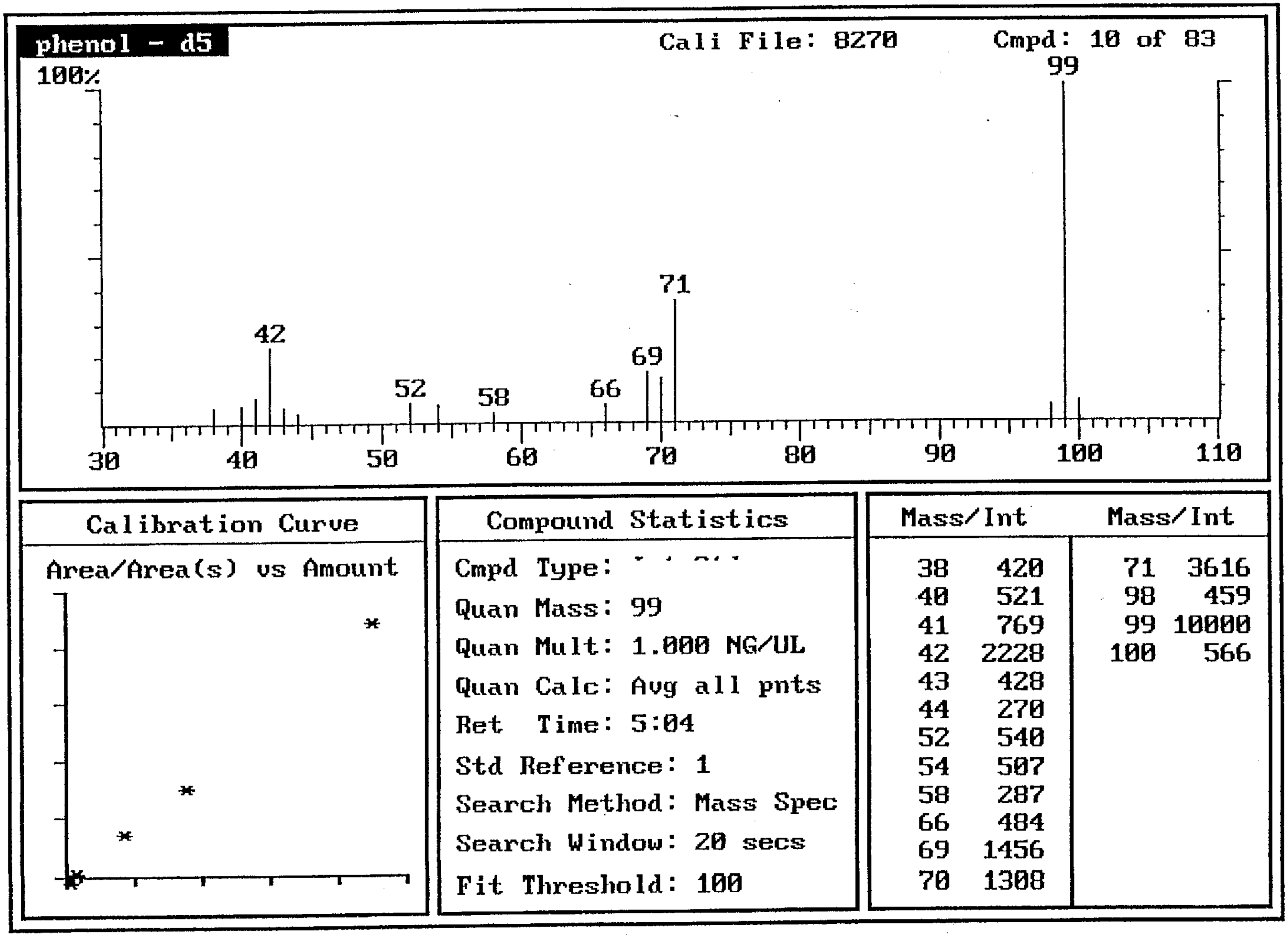
Std Reference: 5

Search Method: Mass Spec

Search Window: 20 secs

Fit Threshold: 100

Mass/Int		Mass/Int	
42	505	242	890
52	545	243	2546
54	621	244	10000
82	431	245	1770
122	1388		
136	451		
158	449		
160	1246		
162	500		
212	477		
226	496		
241	785		



phenol - d5

Cali File: 8270

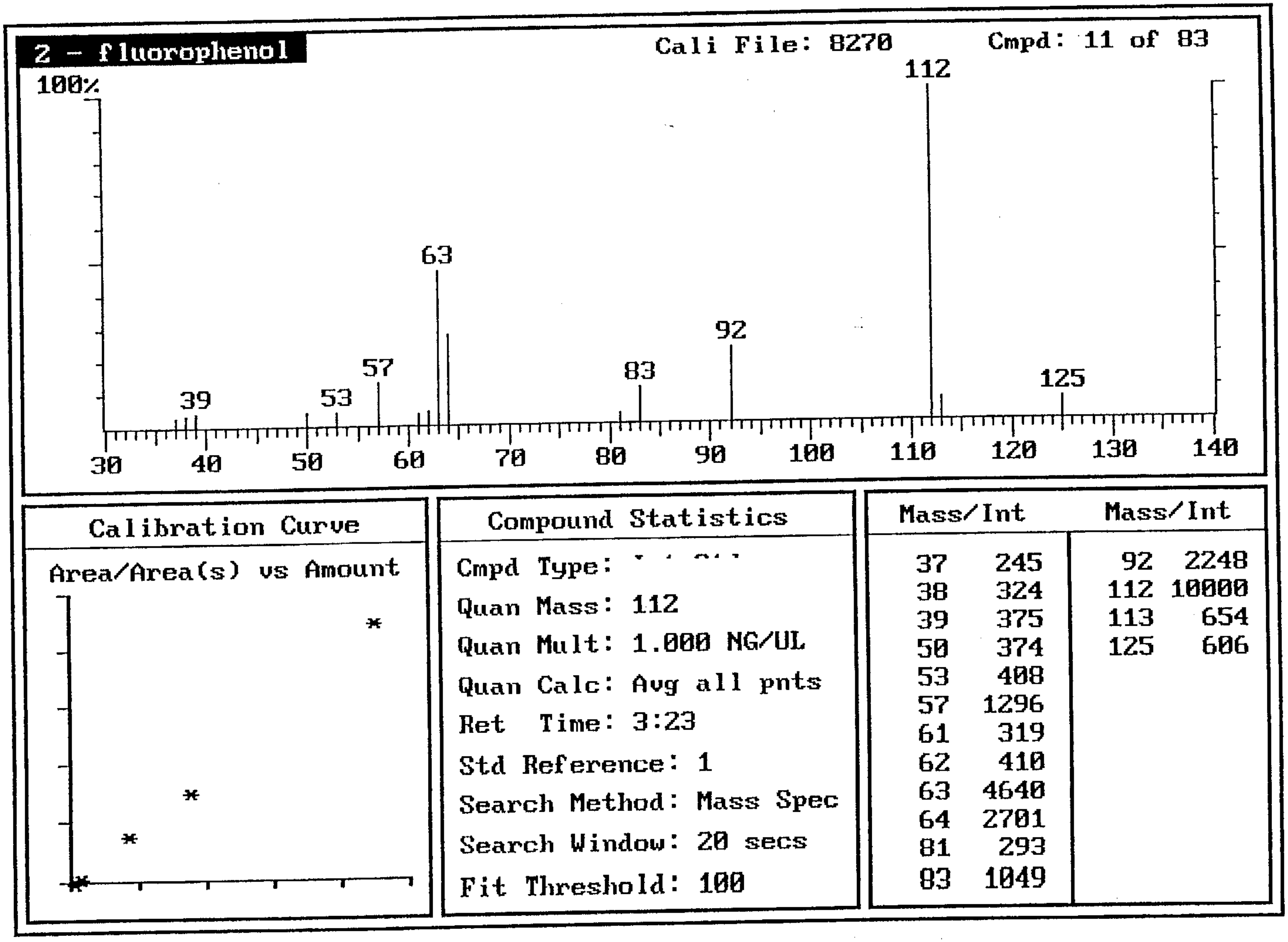
Cmpd: 10 of 83

Calibration Curve

Compound Statistics

Cmpd Type: [illegible]
Quan Mass: 99
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:04
Std Reference: 1
Search Method: Mass Spec
Search Window: 20 secs
Fit Threshold: 100

Mass/Int		Mass/Int	
38	420	71	3616
40	521	98	459
41	769	99	10000
42	2228	100	566
43	428		
44	270		
52	540		
54	507		
58	287		
66	484		
69	1456		
70	1308		



2 - fluorophenol

Cali File: 8270

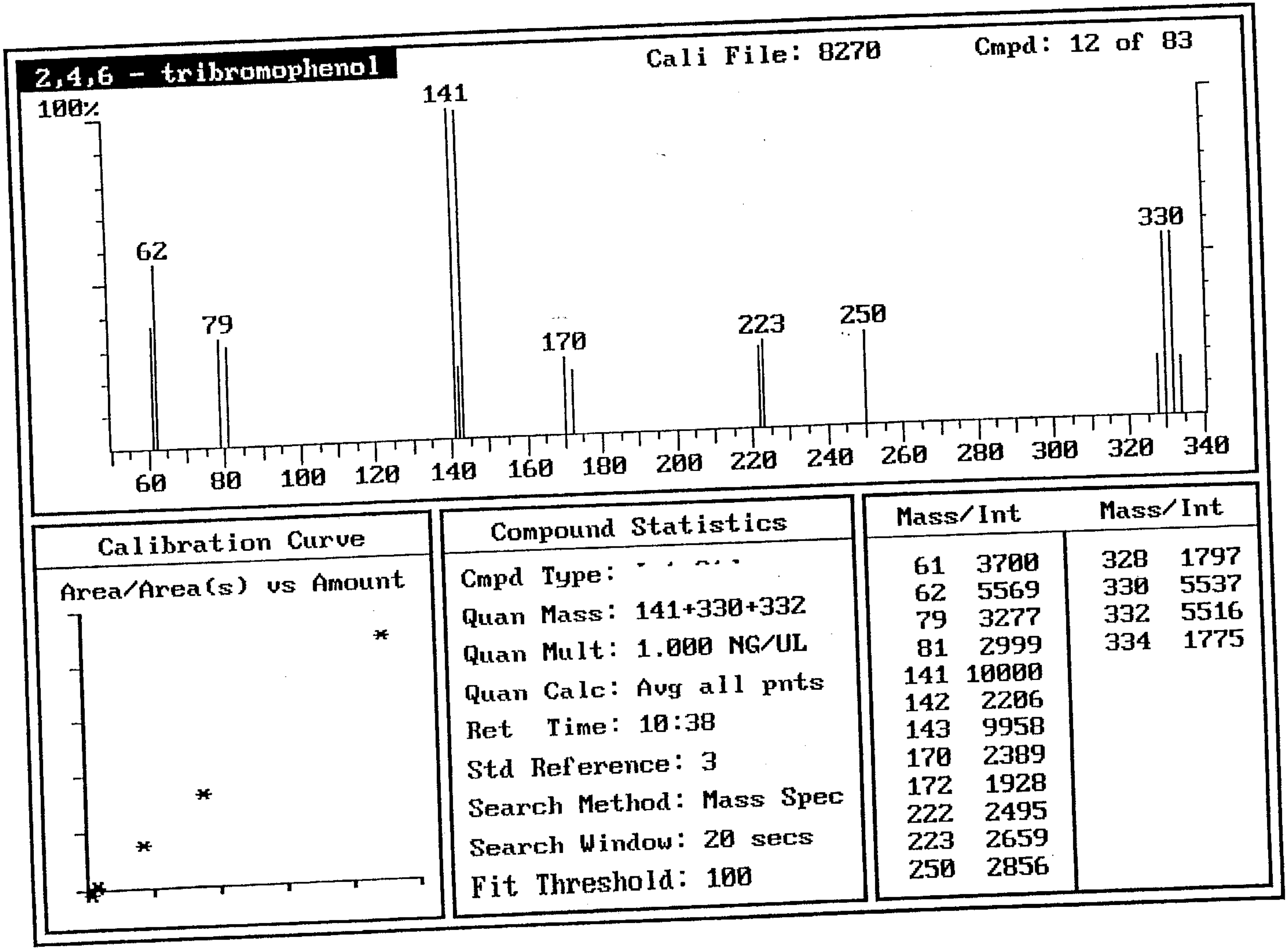
Cmpd: 11 of 83

Calibration Curve

Compound Statistics

Cmpd Type: [illegible]
Quan Mass: 112
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 3:23
Std Reference: 1
Search Method: Mass Spec
Search Window: 20 secs
Fit Threshold: 100

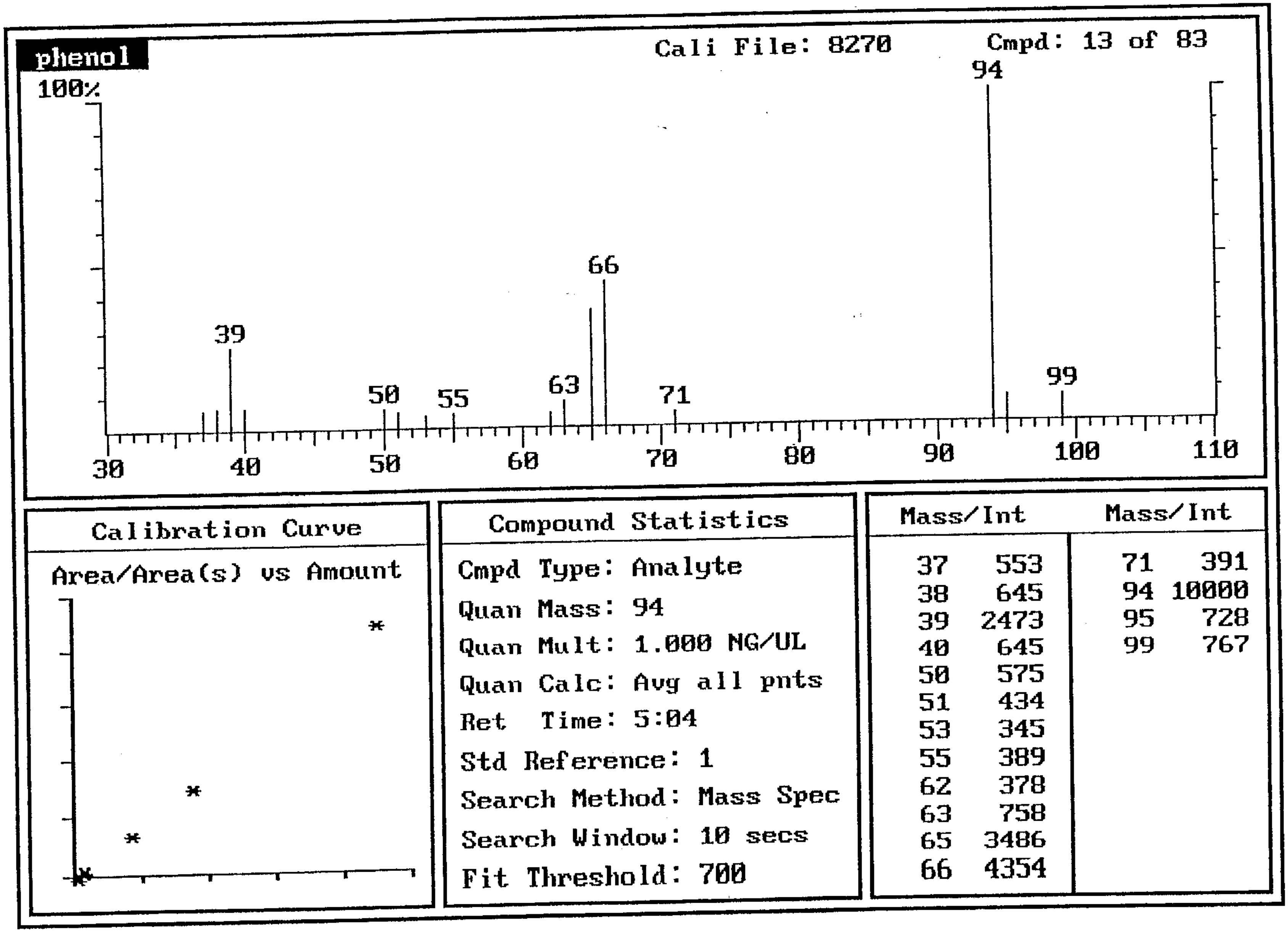
Mass/Int		Mass/Int	
37	245	92	2248
38	324	112	10000
39	375	113	654
50	374	125	606
53	408		
57	1296		
61	319		
62	410		
63	4640		
64	2701		
81	293		
83	1049		



Compound Statistics

Cmpd Type: [illegible]
Quan Mass: 141+330+332
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:38
Std Reference: 3
Search Method: Mass Spec
Search Window: 20 secs
Fit Threshold: 100

Mass/Int		Mass/Int	
61	3700	328	1797
62	5569	330	5537
79	3277	332	5516
81	2999	334	1775
141	10000		
142	2206		
143	9958		
170	2389		
172	1928		
222	2495		
223	2659		
250	2856		



phenol

Cali File: 8270

Cmpd: 13 of 83

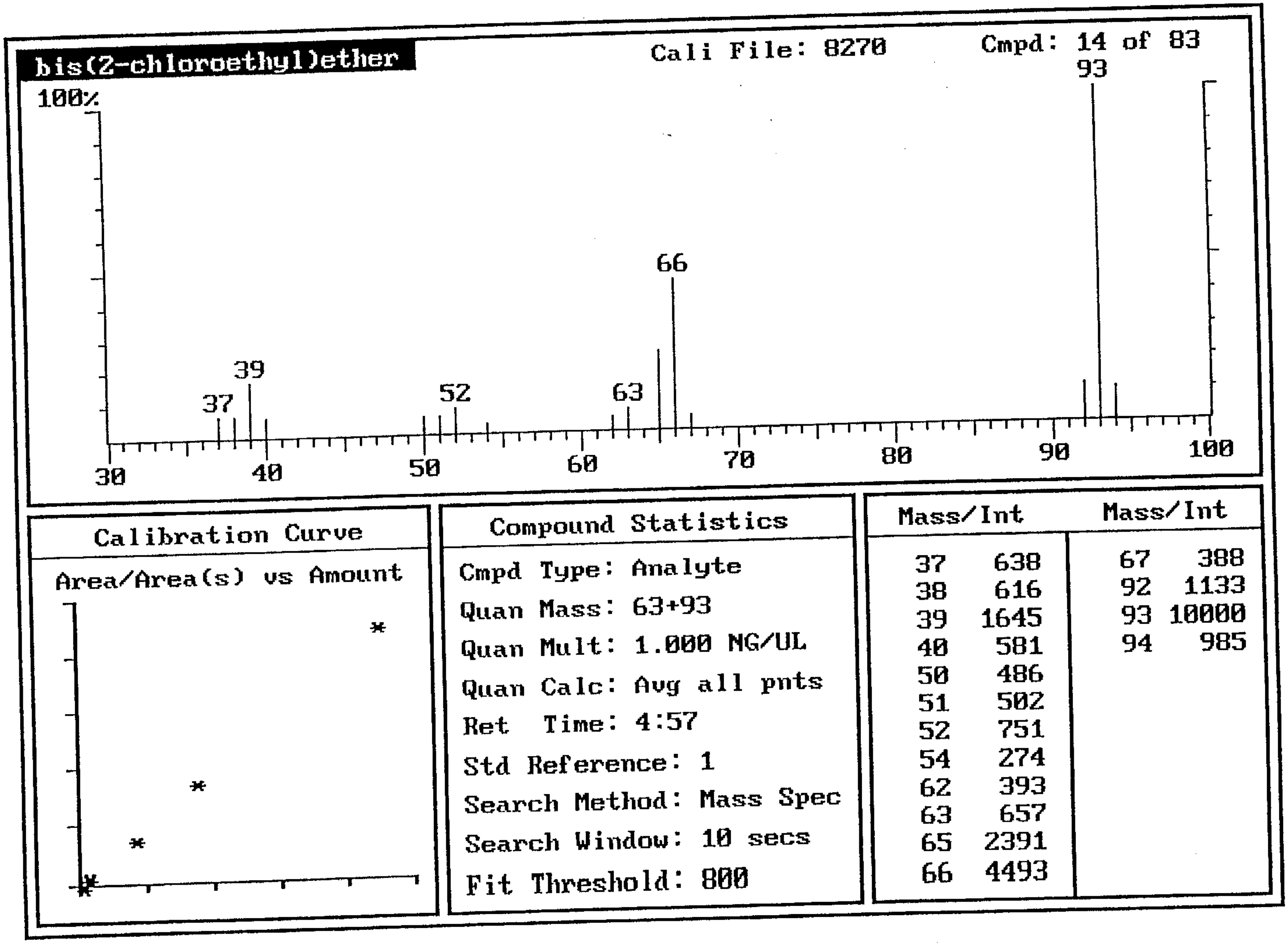
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 94
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:04
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
37	553	71	391
38	645	94	10000
39	2473	95	728
40	645	99	767
50	575		
51	434		
53	345		
55	389		
62	378		
63	758		
65	3486		
66	4354		



bis(2-chloroethyl)ether

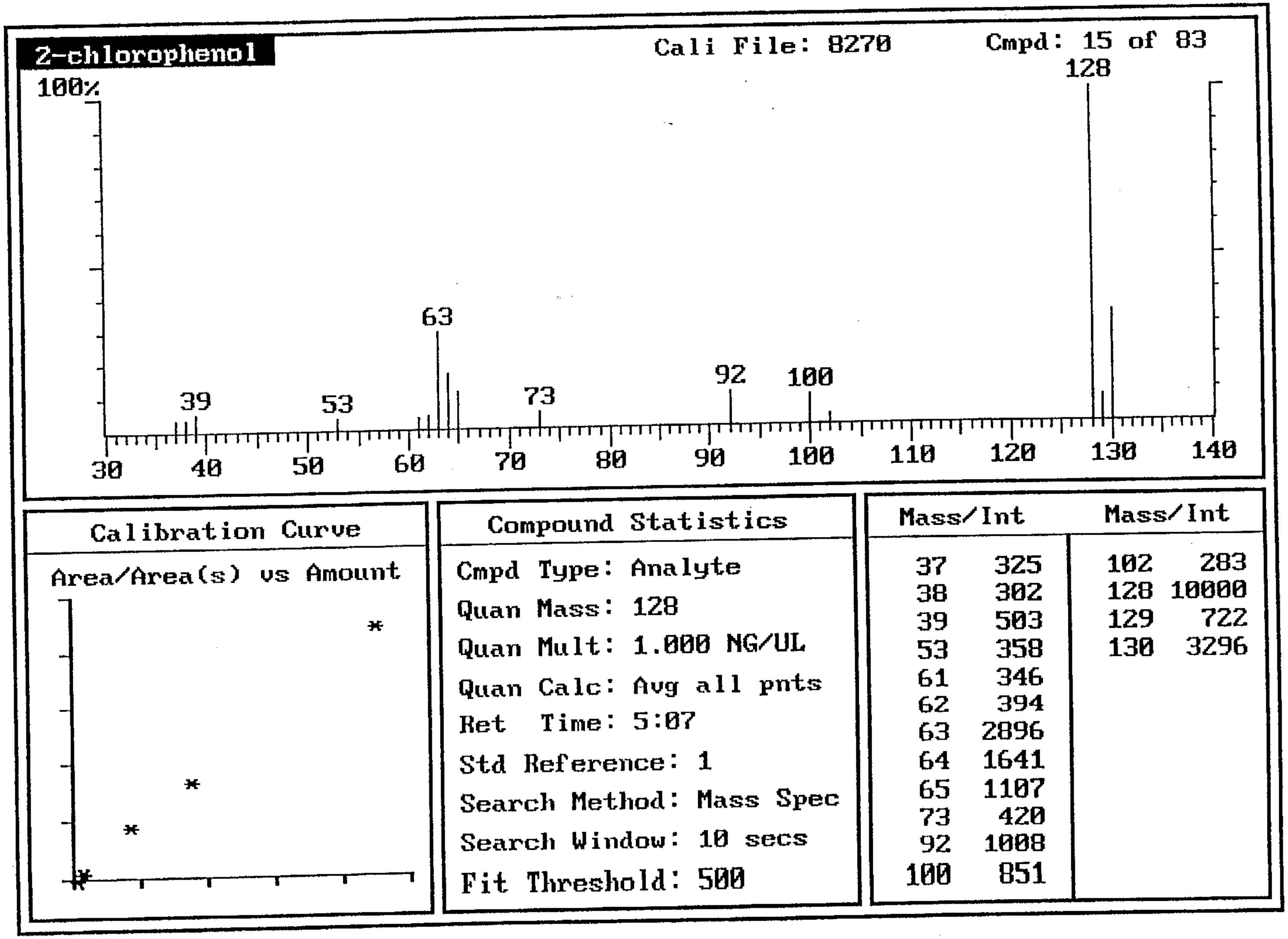
Cali File: 8270

Cmpd: 14 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 63+93
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 4:57
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass	Int	Mass	Int
37	638	67	388
38	616	92	1133
39	1645	93	10000
40	581	94	985
50	486		
51	502		
52	751		
54	274		
62	393		
63	657		
65	2391		
66	4493		



2-chlorophenol

Cali File: 8270

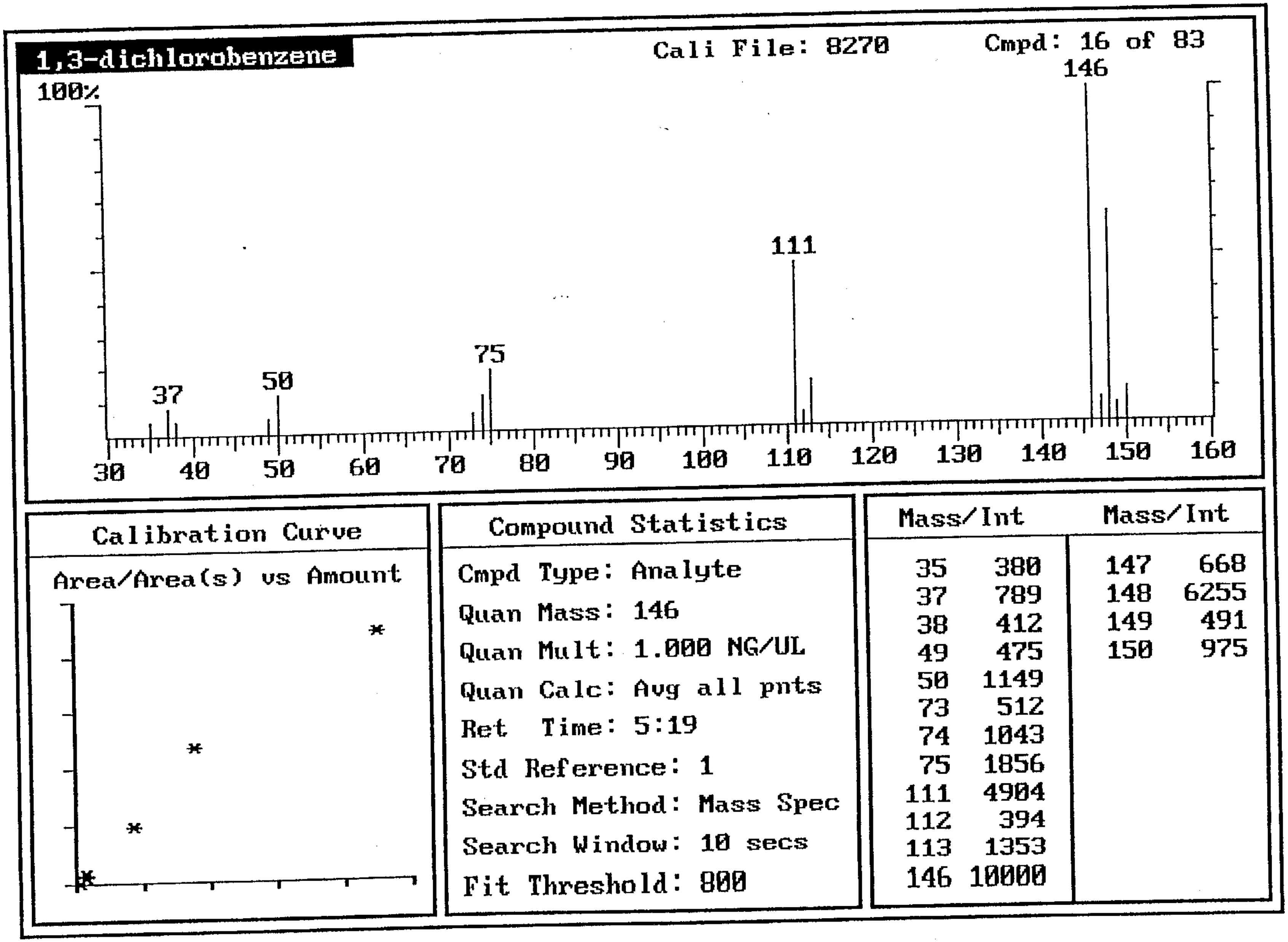
Cmpd: 15 of 83

Calibration Curve

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 128
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:07
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 500

Mass/Int		Mass/Int	
37	325	102	283
38	302	128	10000
39	503	129	722
53	358	130	3296
61	346		
62	394		
63	2896		
64	1641		
65	1107		
73	420		
92	1008		
100	851		



1,3-dichlorobenzene

Cali File: 8270

Cmpd: 16 of 83

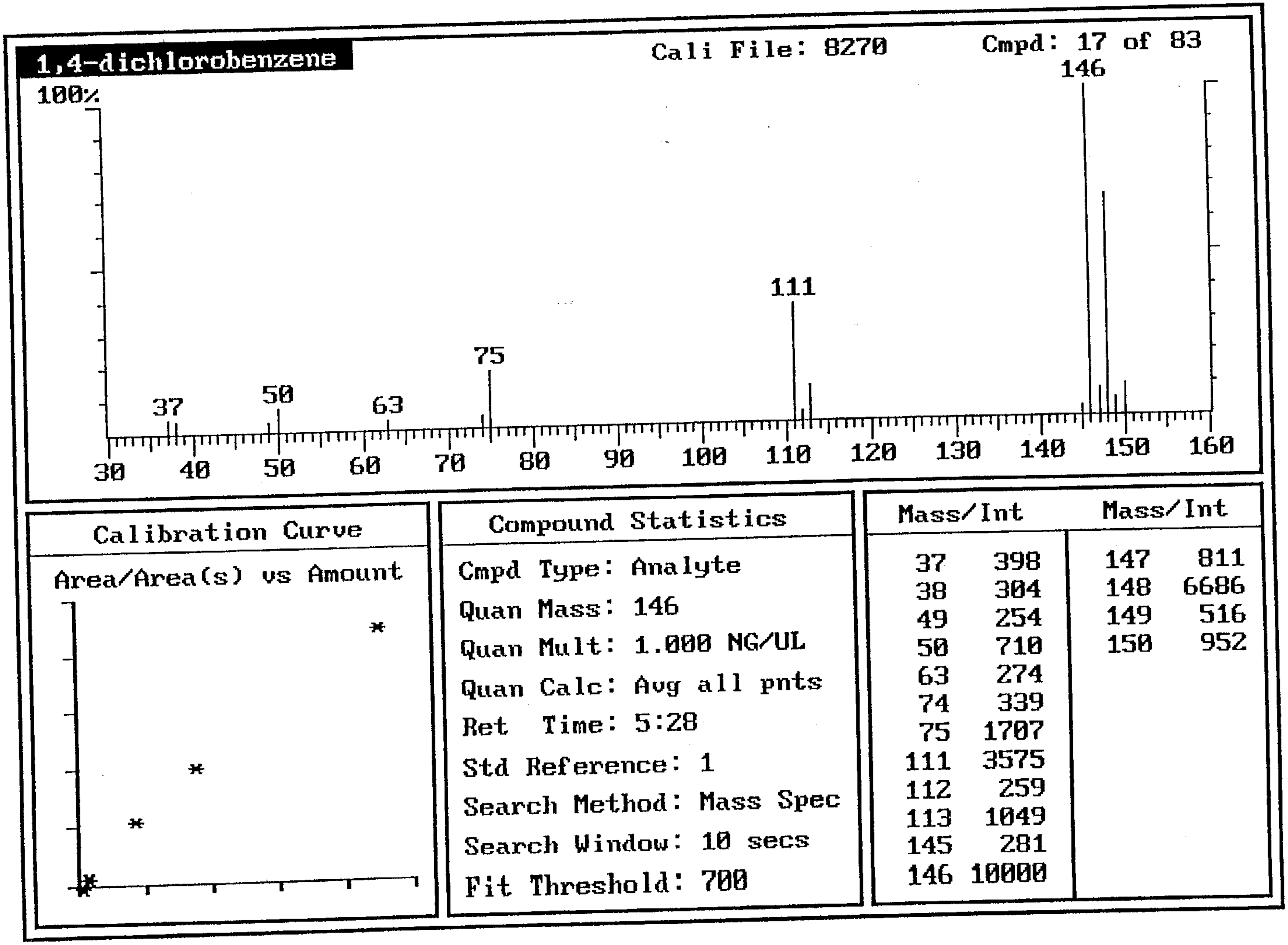
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 146
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:19
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
35	380	147	668
37	789	148	6255
38	412	149	491
49	475	150	975
50	1149		
73	512		
74	1043		
75	1856		
111	4904		
112	394		
113	1353		
146	10000		



1,4-dichlorobenzene

Cali File: 8270

Cmpd: 17 of 83

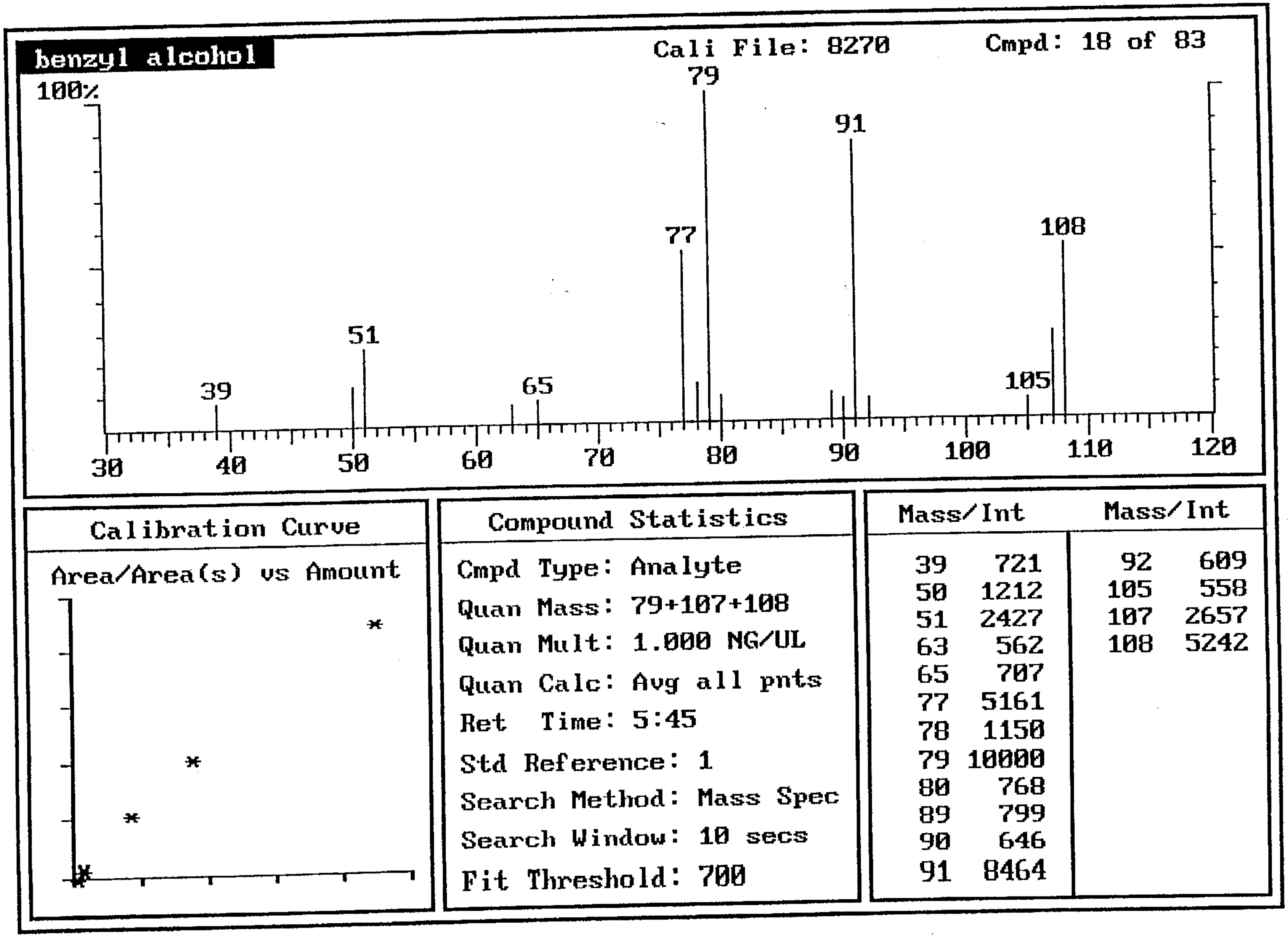
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 146
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:28
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
37	398	147	811
38	304	148	6686
49	254	149	516
50	710	150	952
63	274		
74	339		
75	1707		
111	3575		
112	259		
113	1049		
145	281		
146	10000		



benzyl alcohol

Cali File: 8270

Cmpd: 18 of 83

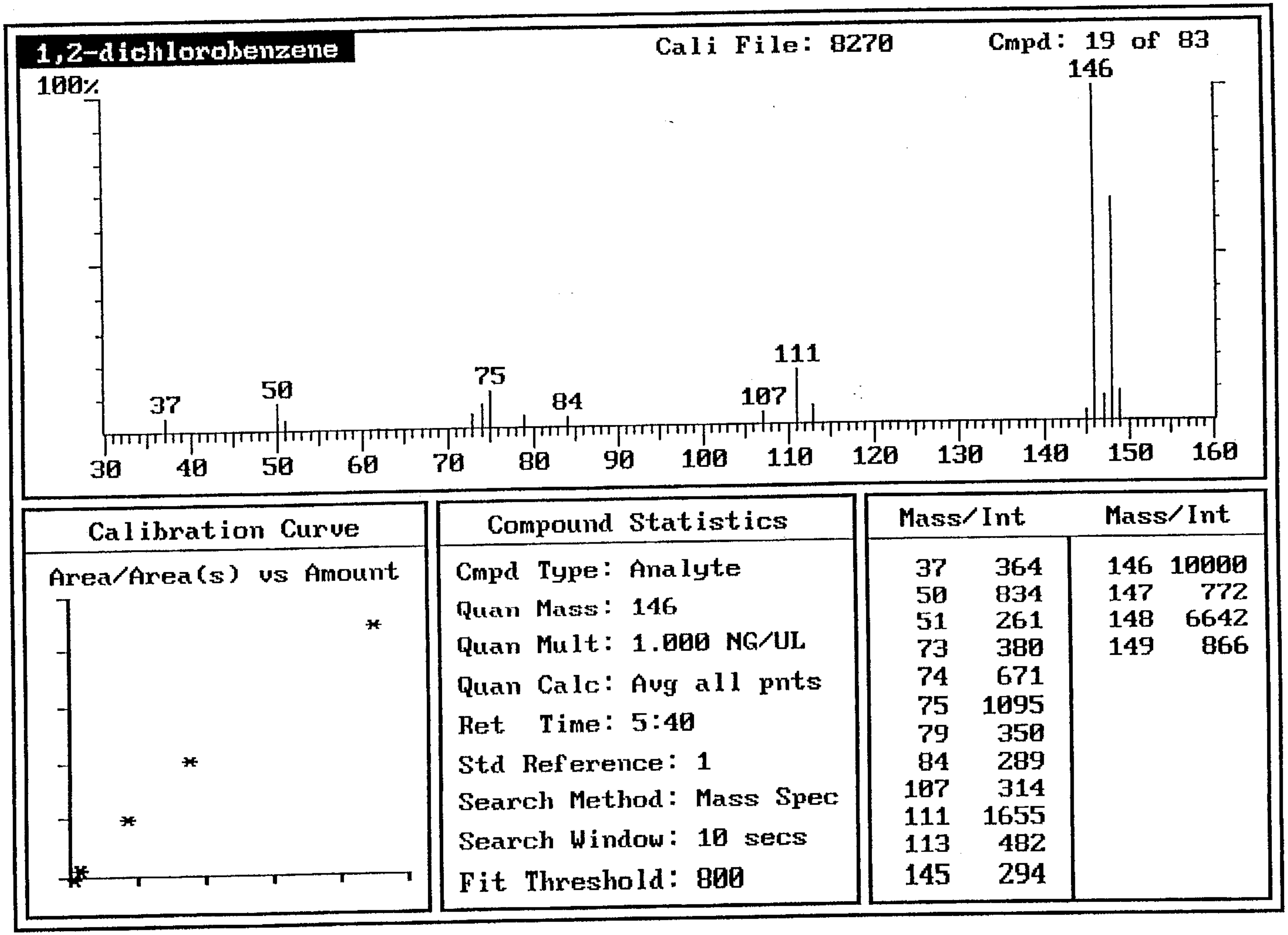
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 79+107+108
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:45
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
39	721	92	609
50	1212	105	558
51	2427	107	2657
63	562	108	5242
65	707		
77	5161		
78	1150		
79	10000		
80	768		
89	799		
90	646		
91	8464		



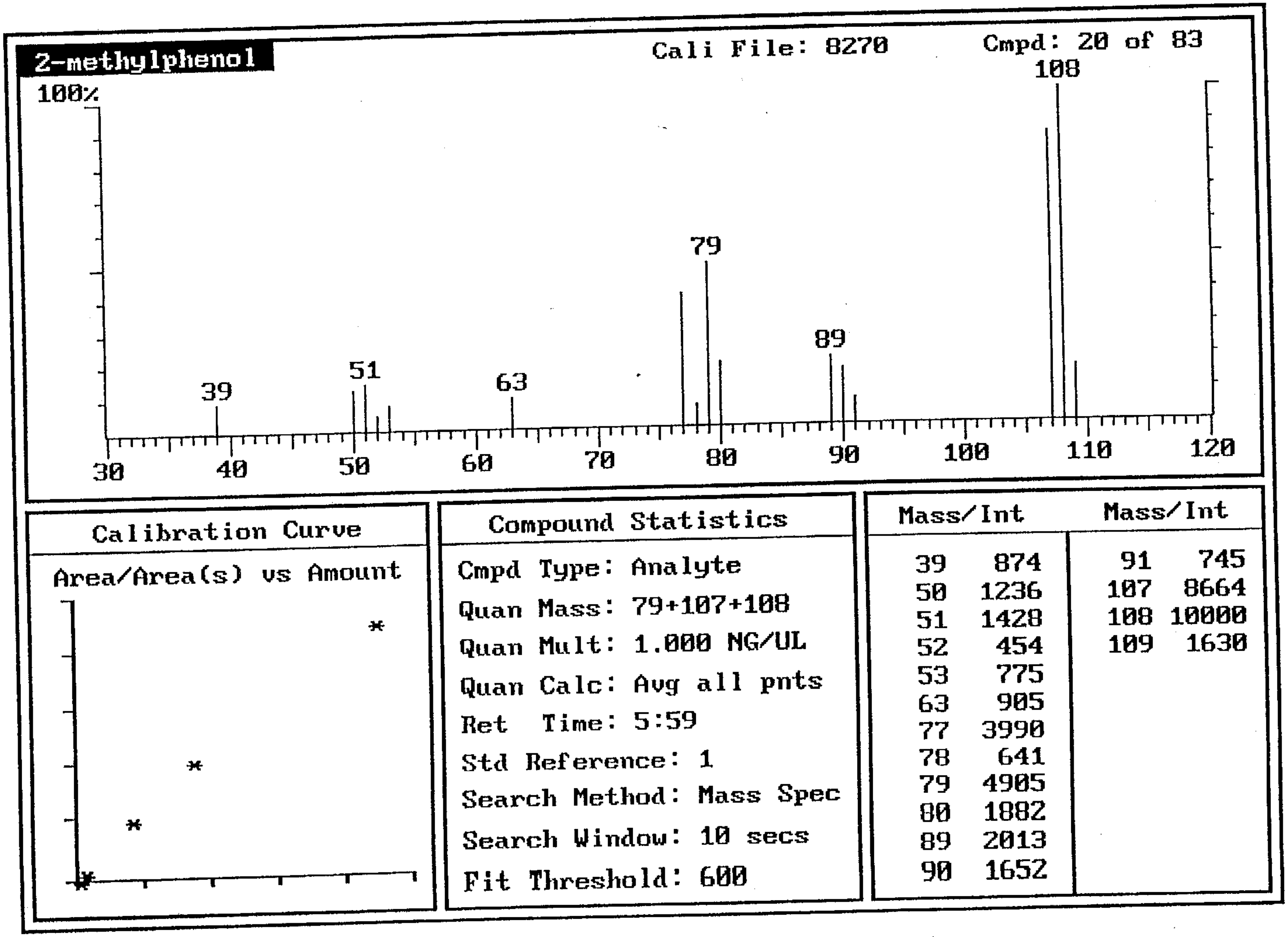
1,2-dichlorobenzene Cali File: 8270 Cmpd: 19 of 83

Calibration Curve

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 146
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:40
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
37	364	146	10000
50	834	147	772
51	261	148	6642
73	380	149	866
74	671		
75	1095		
79	350		
84	289		
107	314		
111	1655		
113	482		
145	294		



2-methylphenol Cali File: 8270 Cmpd: 20 of 83

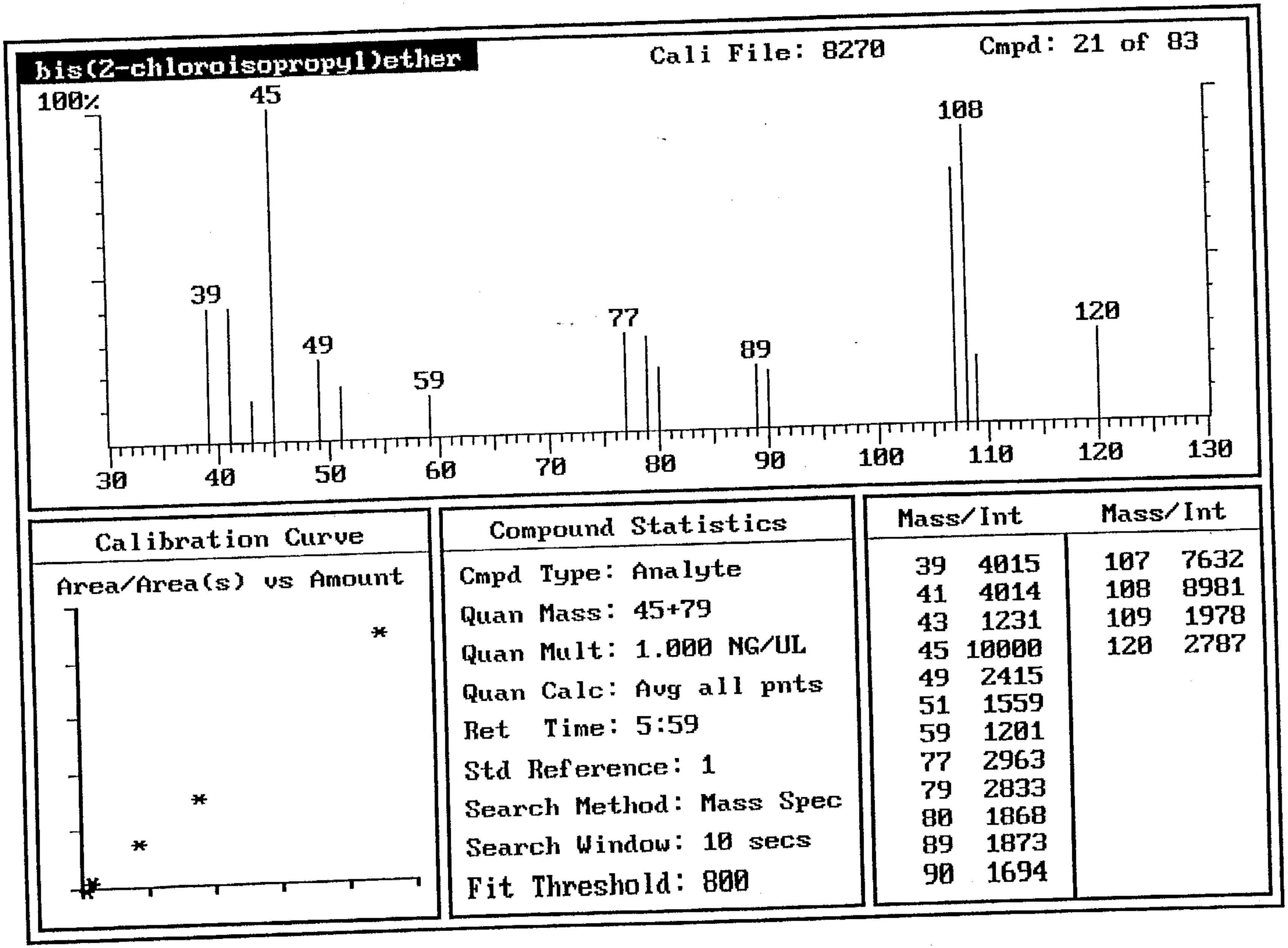
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 79+107+108
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:59
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 600

Mass/Int		Mass/Int	
39	874	91	745
50	1236	107	8664
51	1428	108	10000
52	454	109	1630
53	775		
63	905		
77	3990		
78	641		
79	4905		
80	1882		
89	2013		
90	1652		



bis(2-chloroisopropyl)ether Cali File: 8270 Cmpd: 21 of 83

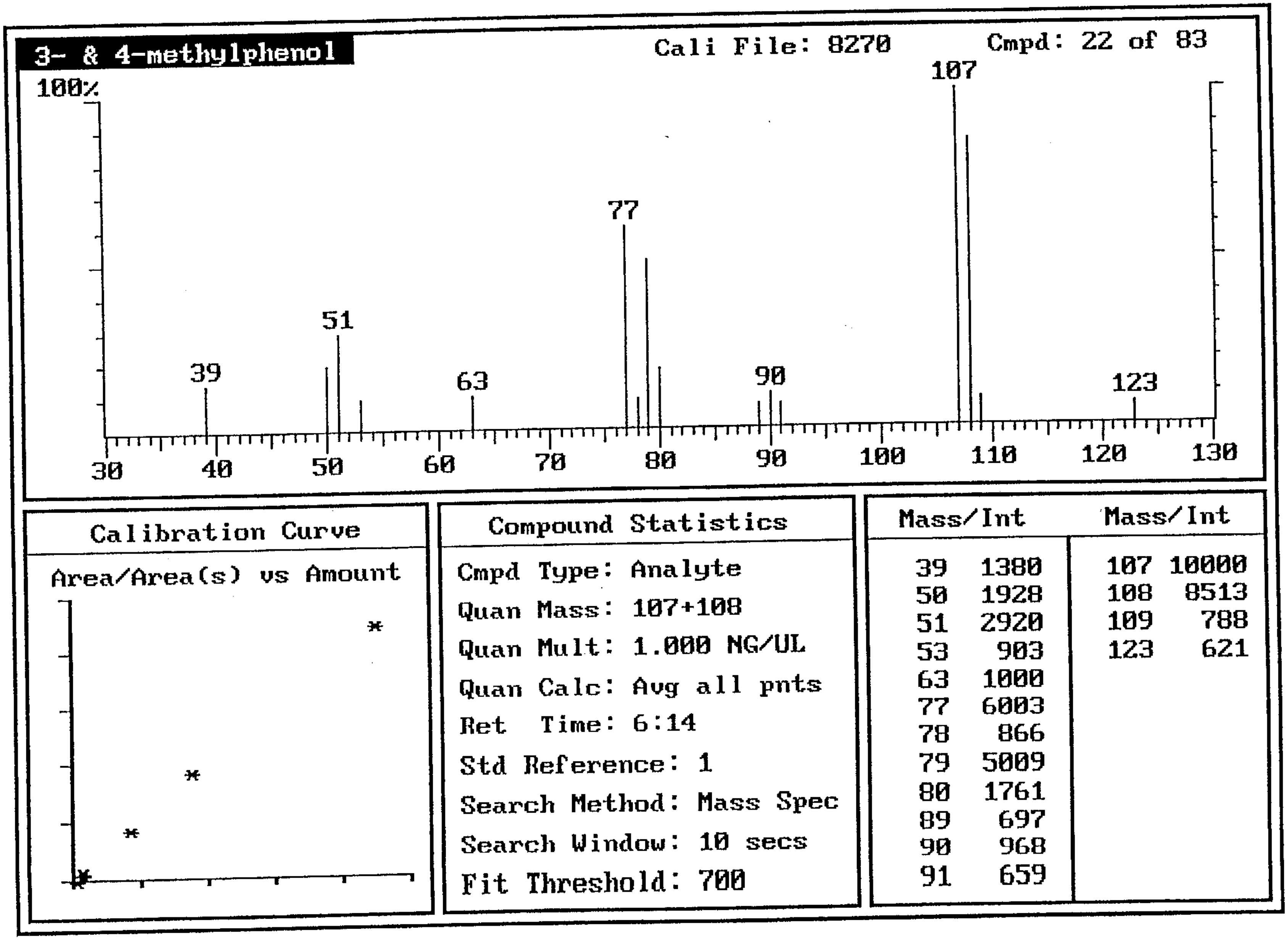
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 45+79
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 5:59
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	4015	107	7632
41	4014	108	8981
43	1231	109	1978
45	10000	120	2787
49	2415		
51	1559		
59	1201		
77	2963		
79	2833		
80	1868		
89	1873		
90	1694		



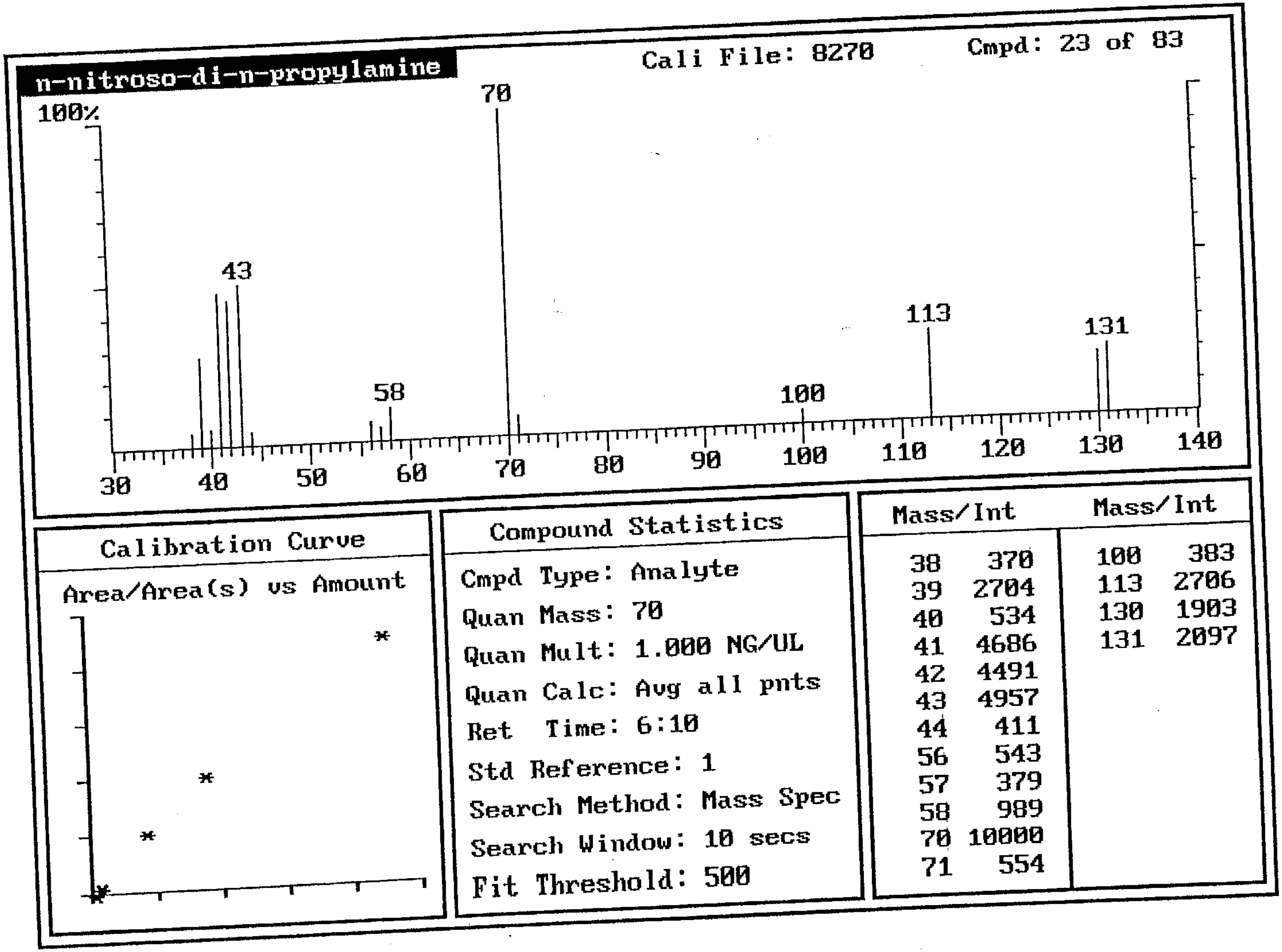
```
3- & 4-methylphenol              Cali File: 8270     Cmpd: 22 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 107+108
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret  Time: 6:14
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

 Mass/Int        Mass/Int

 39   1380       107  10000
 50   1928       108   8513
 51   2920       109    788
 53    903       123    621
 63   1000
 77   6003
 78    866
 79   5009
 80   1761
 89    697
 90    968
 91    659
```



n-nitroso-di-n-propylamine

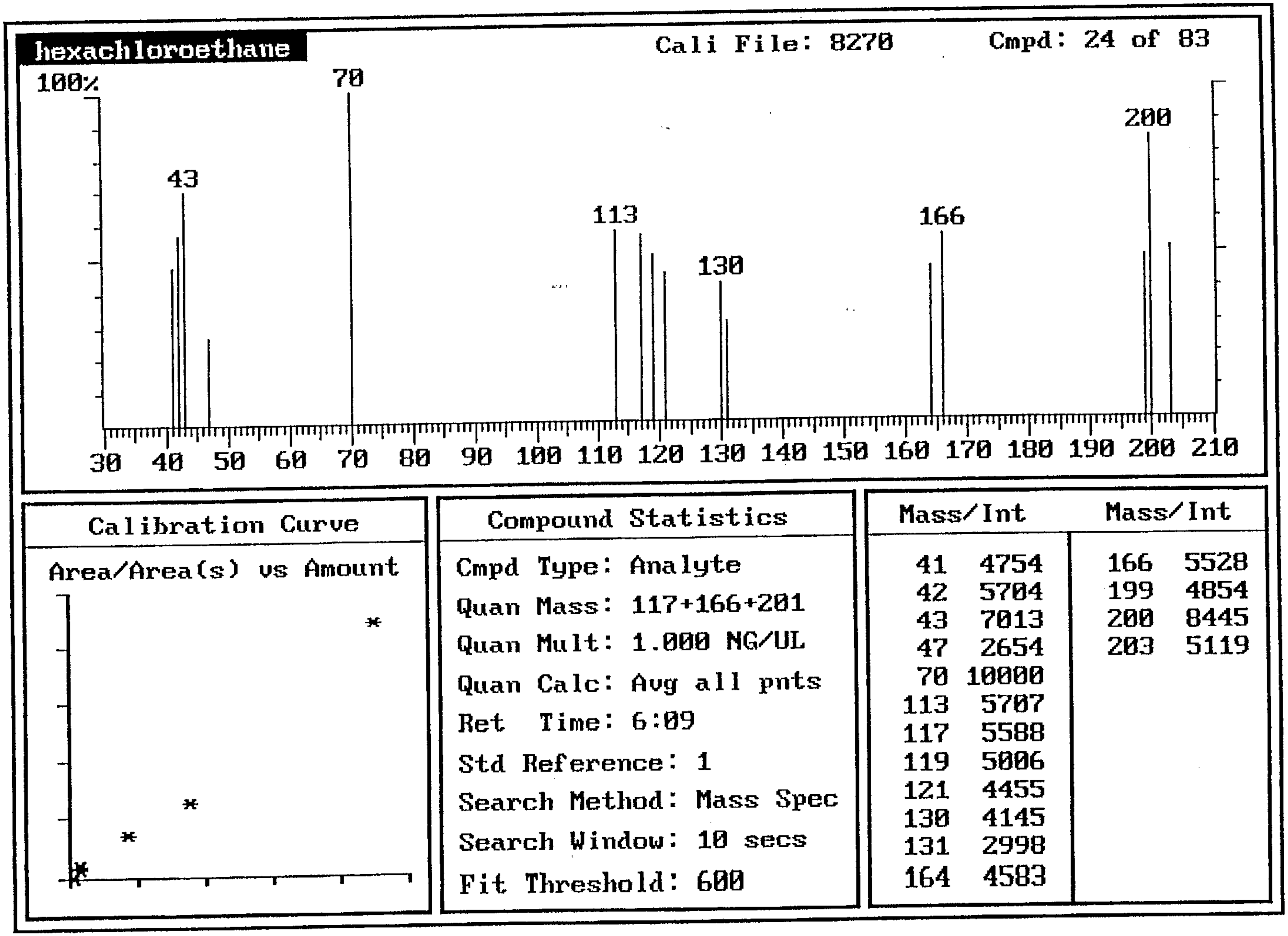
Cali File: 8270

Cmpd: 23 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 70
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:10
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 500

Mass/Int		Mass/Int	
38	370	100	383
39	2704	113	2706
40	534	130	1903
41	4686	131	2097
42	4491		
43	4957		
44	411		
56	543		
57	379		
58	989		
70	10000		
71	554		

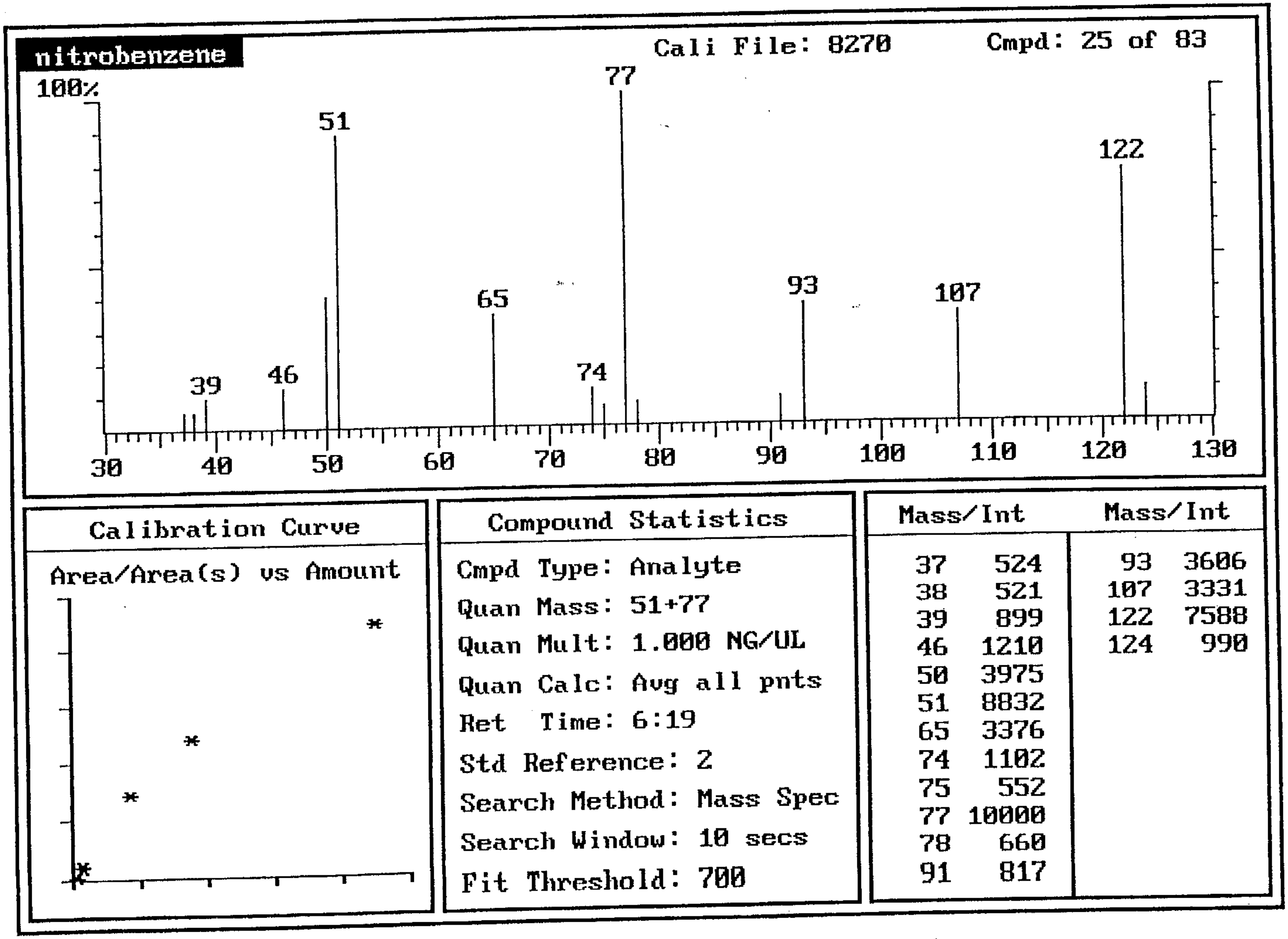


hexachloroethane Cali File: 8270 Cmpd: 24 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 117+166+201
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:09
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 600

Mass/Int		Mass/Int	
41	4754	166	5528
42	5704	199	4854
43	7013	200	8445
47	2654	203	5119
70	10000		
113	5707		
117	5588		
119	5006		
121	4455		
130	4145		
131	2998		
164	4583		



nitrobenzene

Cali File: 8270

Cmpd: 25 of 83

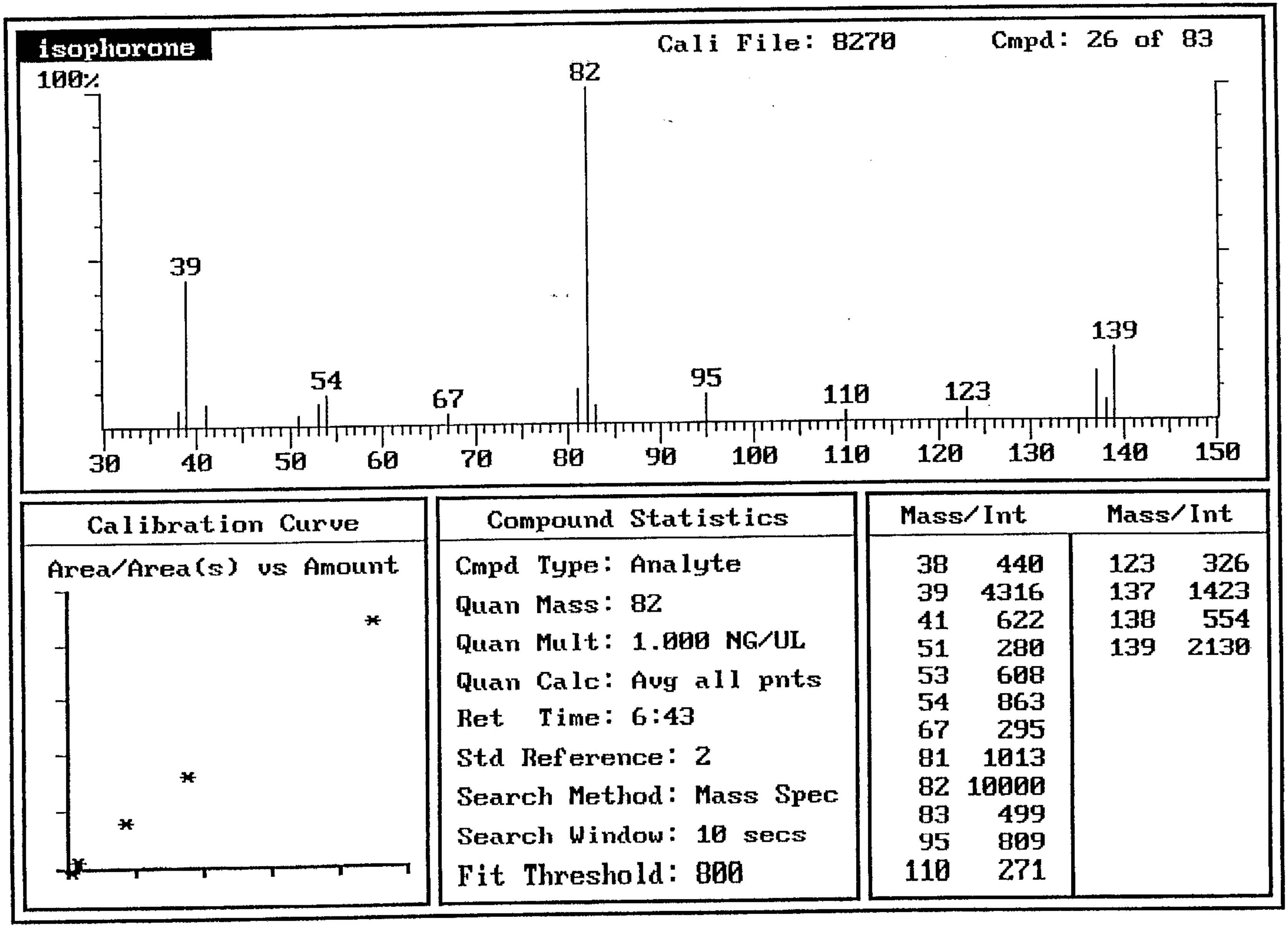
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 51+77
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:19
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
37	524	93	3606
38	521	107	3331
39	899	122	7588
46	1210	124	990
50	3975		
51	8832		
65	3376		
74	1102		
75	552		
77	10000		
78	660		
91	817		



isophorone

Cali File: 8270

Cmpd: 26 of 83

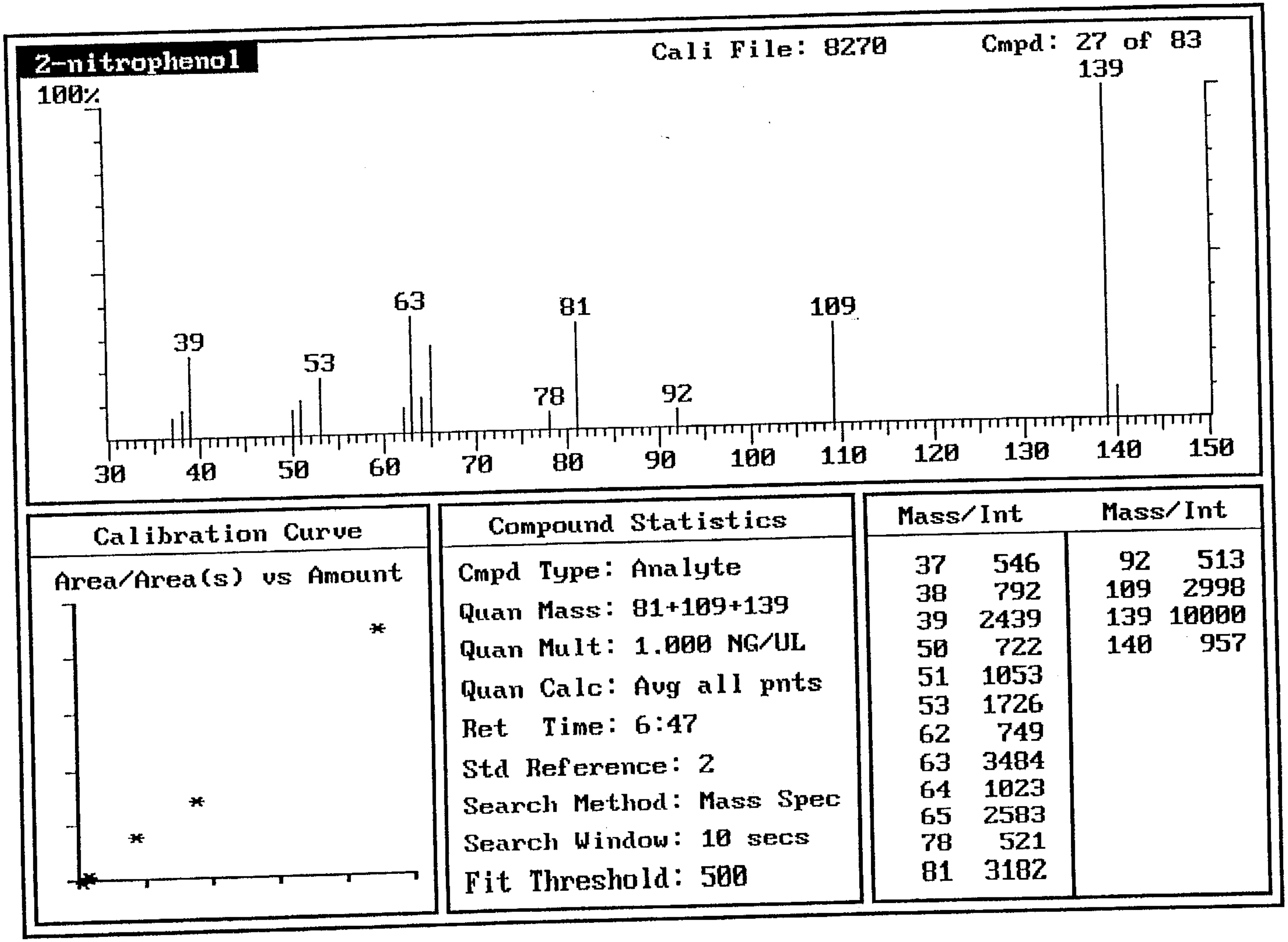
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 82
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:43
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
38	440	123	326
39	4316	137	1423
41	622	138	554
51	280	139	2130
53	608		
54	863		
67	295		
81	1013		
82	10000		
83	499		
95	809		
110	271		



2-nitrophenol

Cali File: 8270

Cmpd: 27 of 83

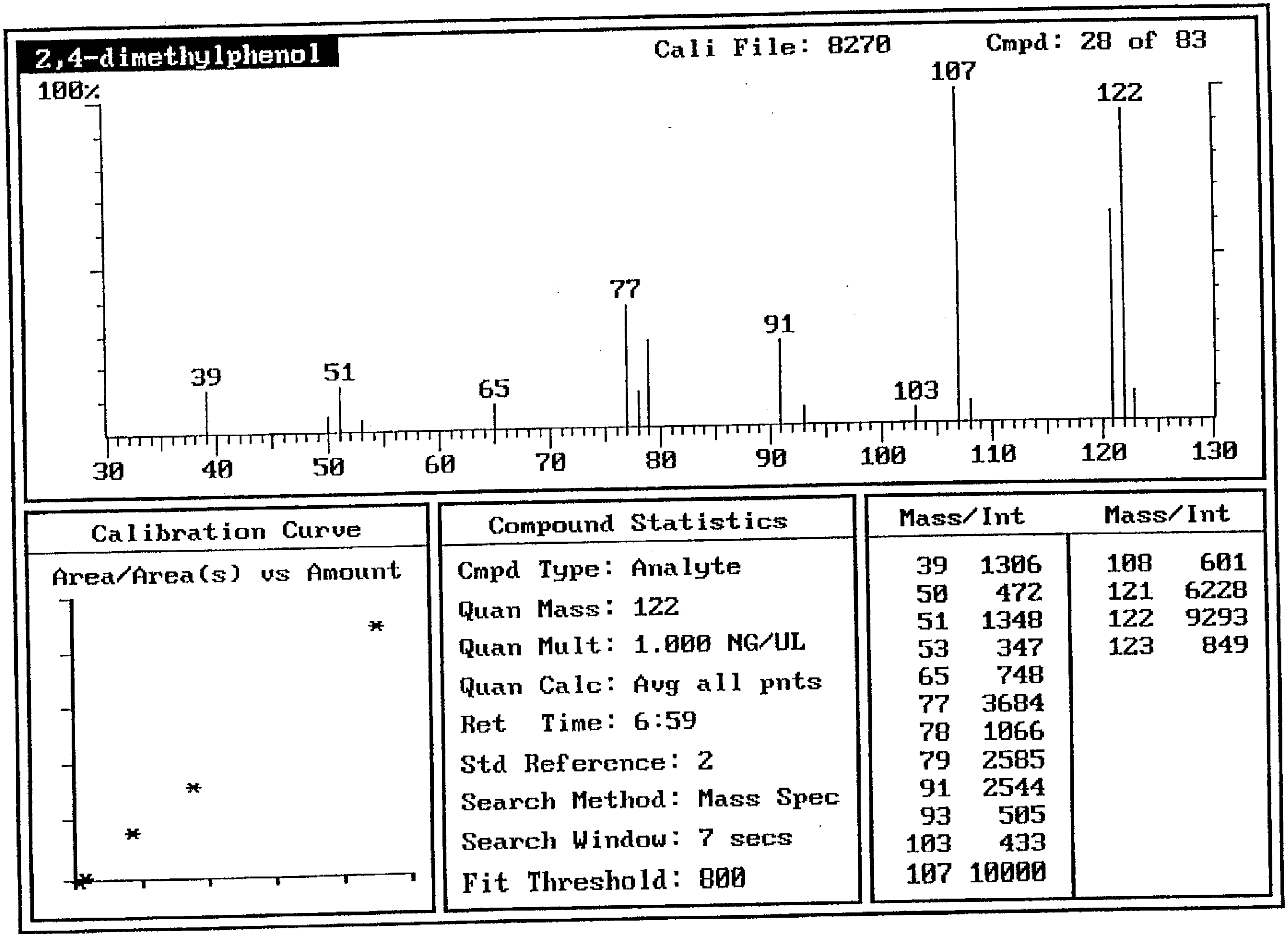
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 81+109+139
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:47
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 500

Mass/Int		Mass/Int	
37	546	92	513
38	792	109	2998
39	2439	139	10000
50	722	140	957
51	1053		
53	1726		
62	749		
63	3484		
64	1023		
65	2583		
78	521		
81	3182		



2,4-dimethylphenol

Cali File: 8270

Cmpd: 28 of 83

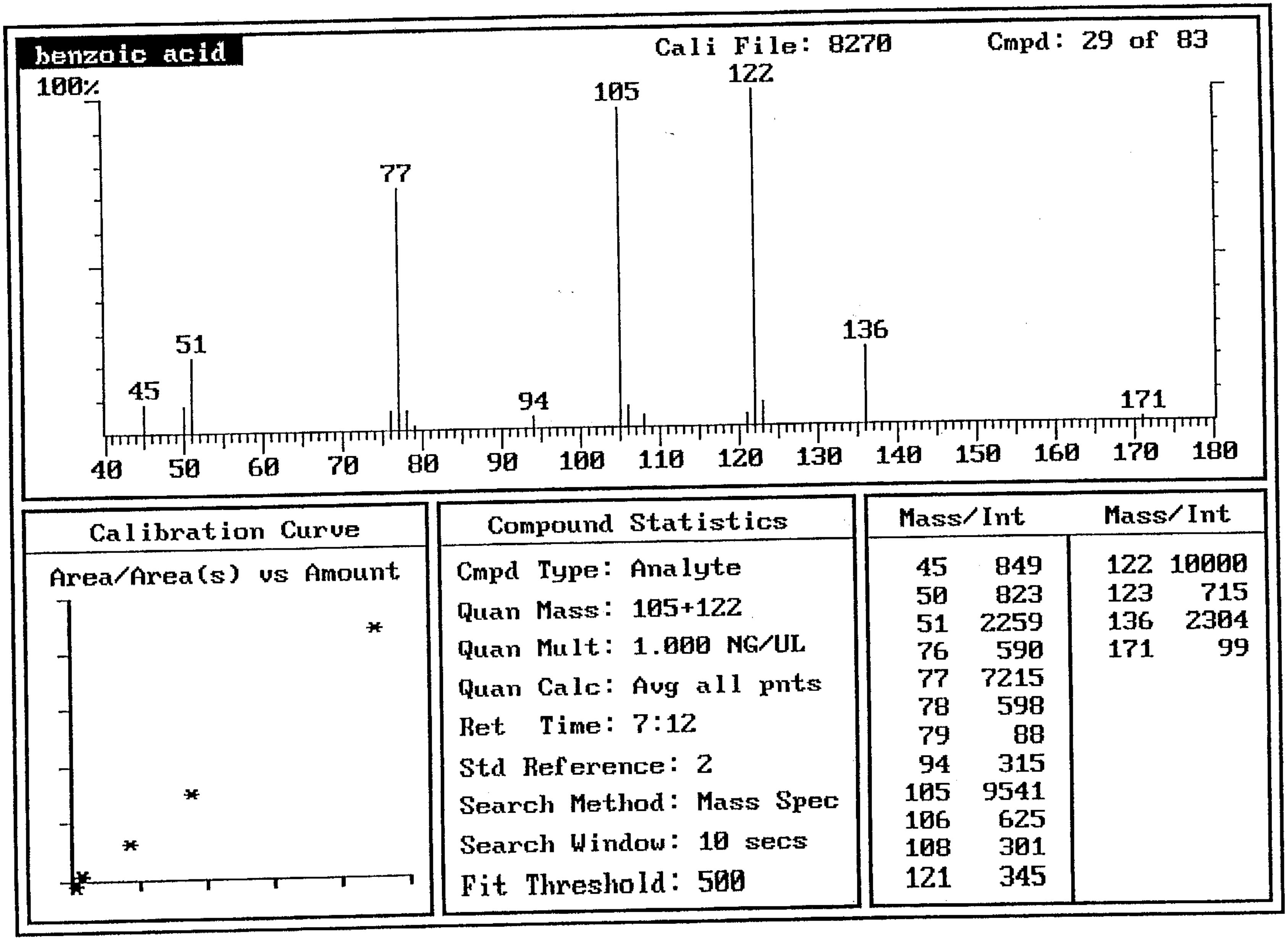
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 122
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 6:59
Std Reference: 2
Search Method: Mass Spec
Search Window: 7 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	1306	108	601
50	472	121	6228
51	1348	122	9293
53	347	123	849
65	748		
77	3684		
78	1066		
79	2585		
91	2544		
93	505		
103	433		
107	10000		



benzoic acid

Cali File: 8270

Cmpd: 29 of 83

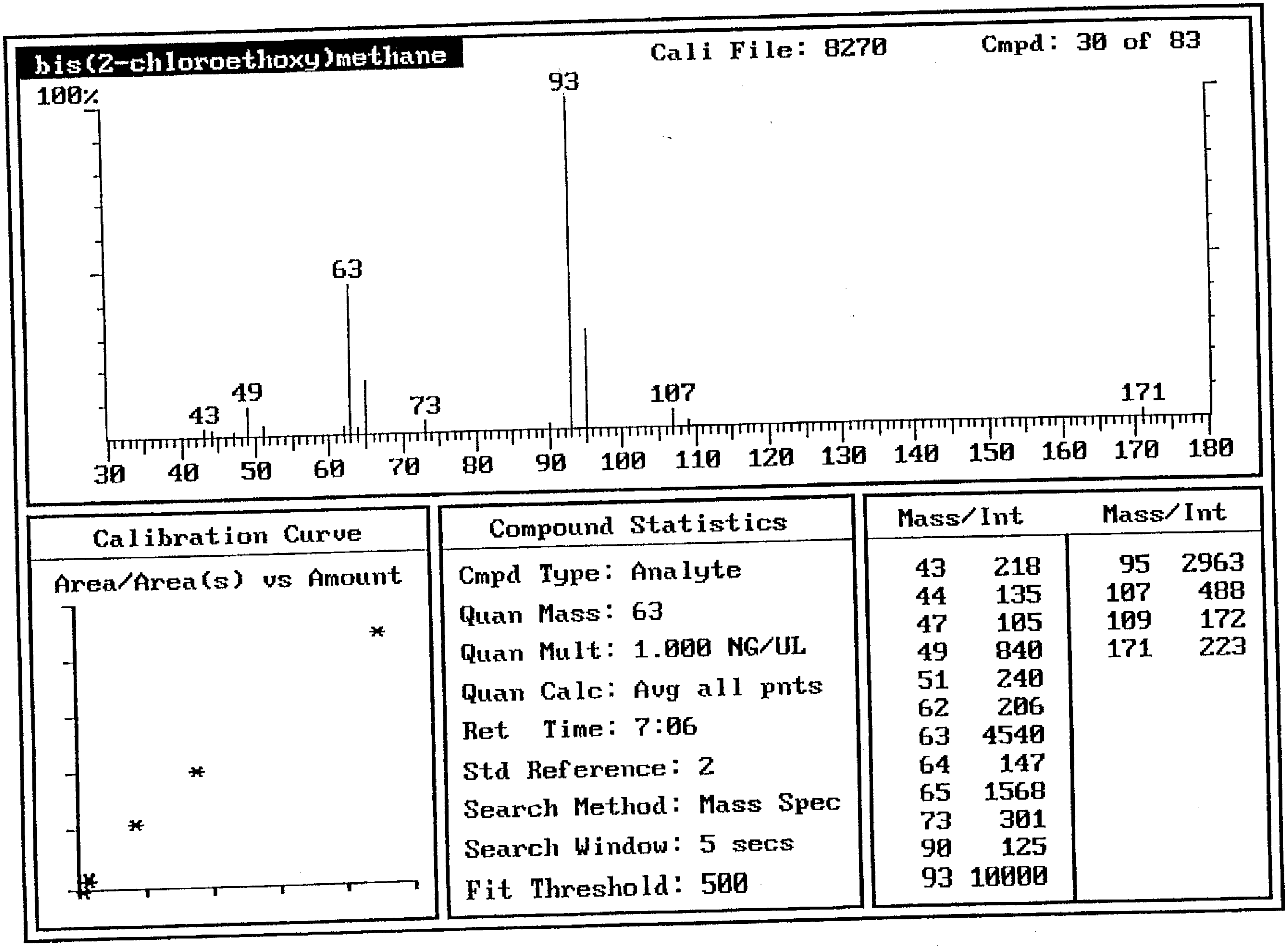
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 105+122
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:12
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 500

Mass/Int		Mass/Int	
45	849	122	10000
50	823	123	715
51	2259	136	2304
76	590	171	99
77	7215		
78	598		
79	88		
94	315		
105	9541		
106	625		
108	301		
121	345		



bis(2-chloroethoxy)methane

Cali File: 8270

Cmpd: 30 of 83

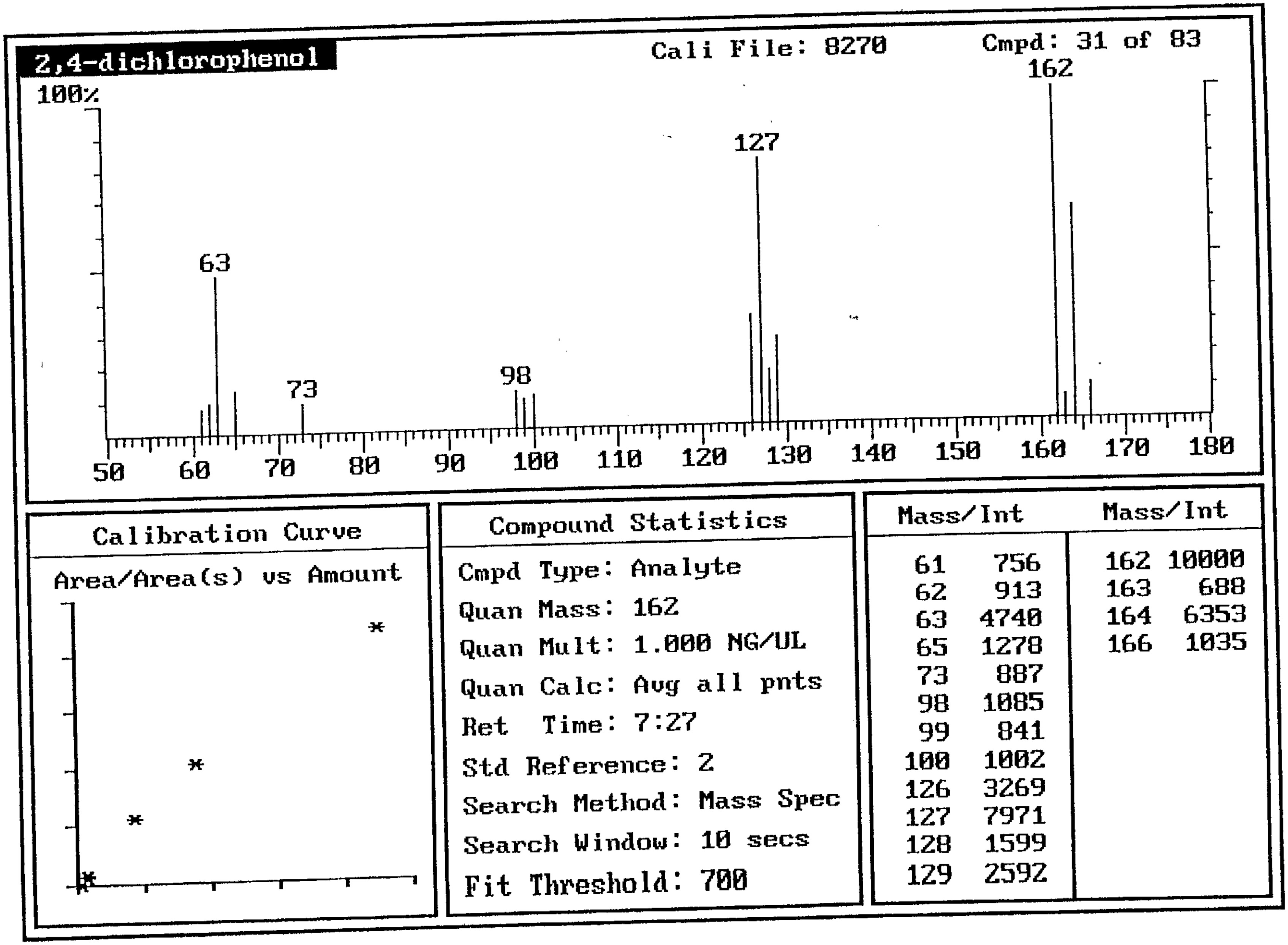
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 63
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:06
Std Reference: 2
Search Method: Mass Spec
Search Window: 5 secs
Fit Threshold: 500

Mass/Int		Mass/Int	
43	218	95	2963
44	135	107	488
47	105	109	172
49	840	171	223
51	240		
62	206		
63	4540		
64	147		
65	1568		
73	301		
90	125		
93	10000		



2,4-dichlorophenol

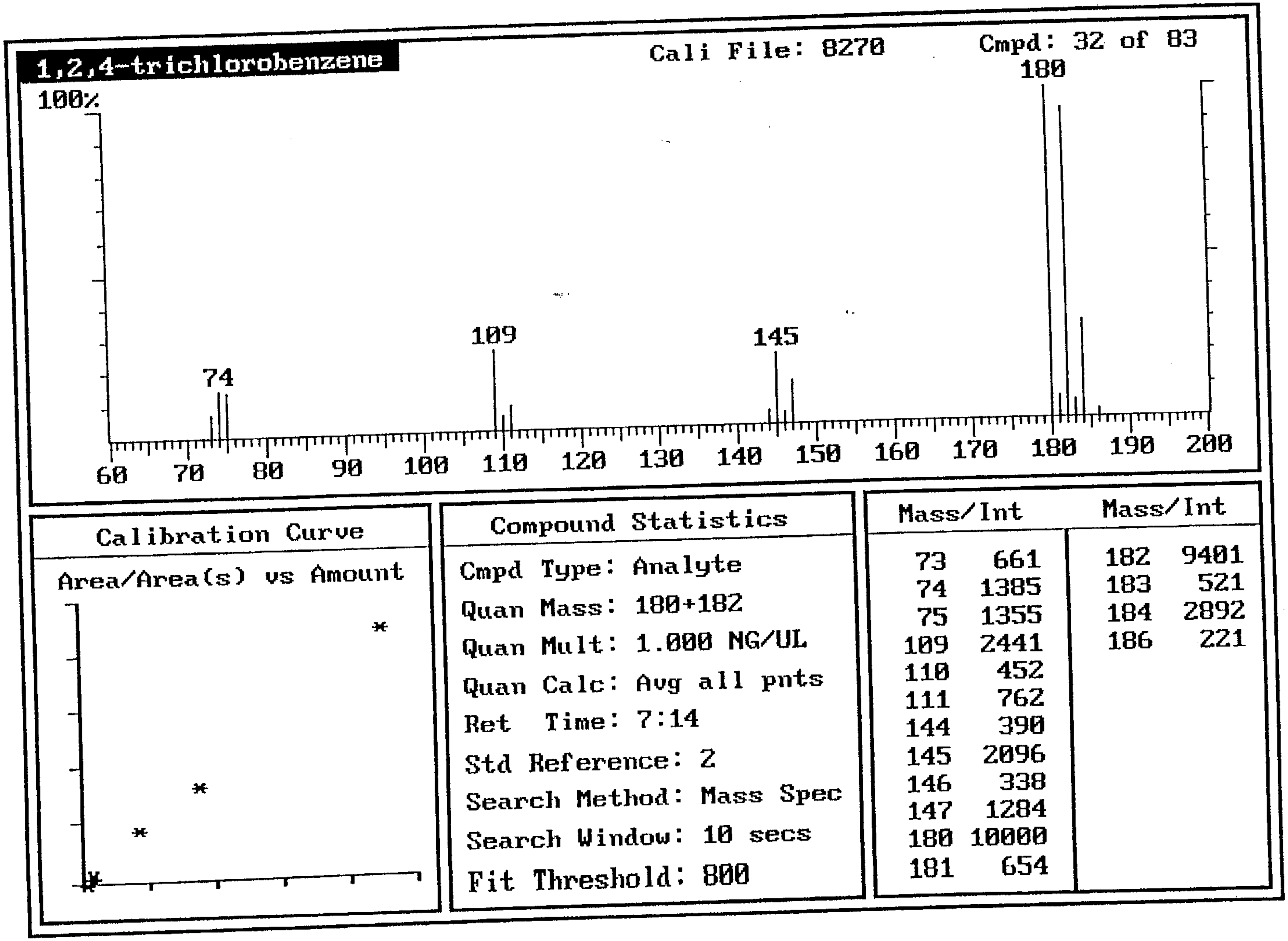
Cali File: 8270

Cmpd: 31 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 162
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:27
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
61	756	162	10000
62	913	163	688
63	4740	164	6353
65	1278	166	1035
73	887		
98	1085		
99	841		
100	1002		
126	3269		
127	7971		
128	1599		
129	2592		



1,2,4-trichlorobenzene Cali File: 8270 Cmpd: 32 of 83

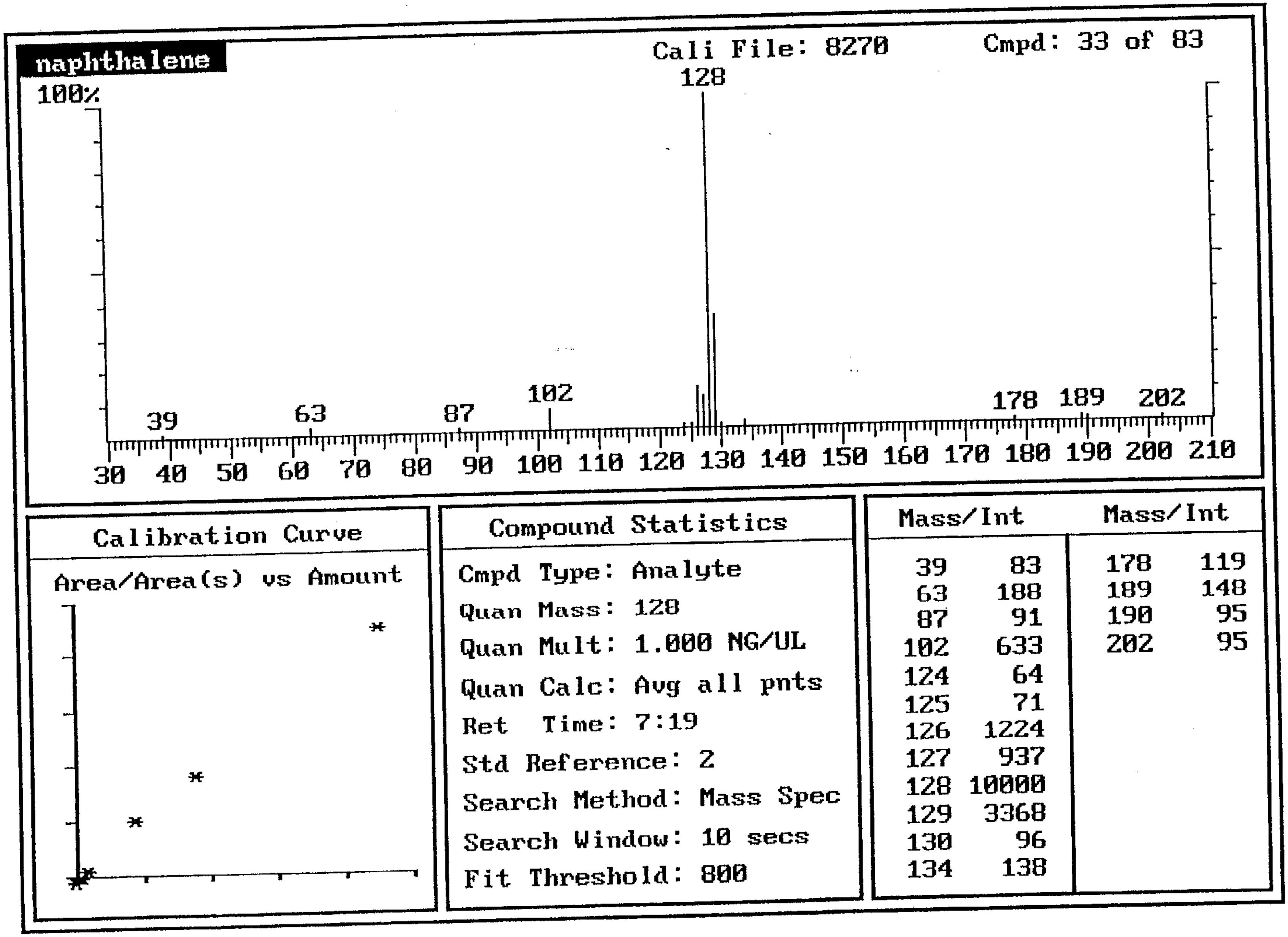
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 180+182
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:14
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
73	661	182	9401
74	1385	183	521
75	1355	184	2892
109	2441	186	221
110	452		
111	762		
144	390		
145	2096		
146	338		
147	1284		
180	10000		
181	654		



Cali File: 8270

Cmpd: 33 of 83

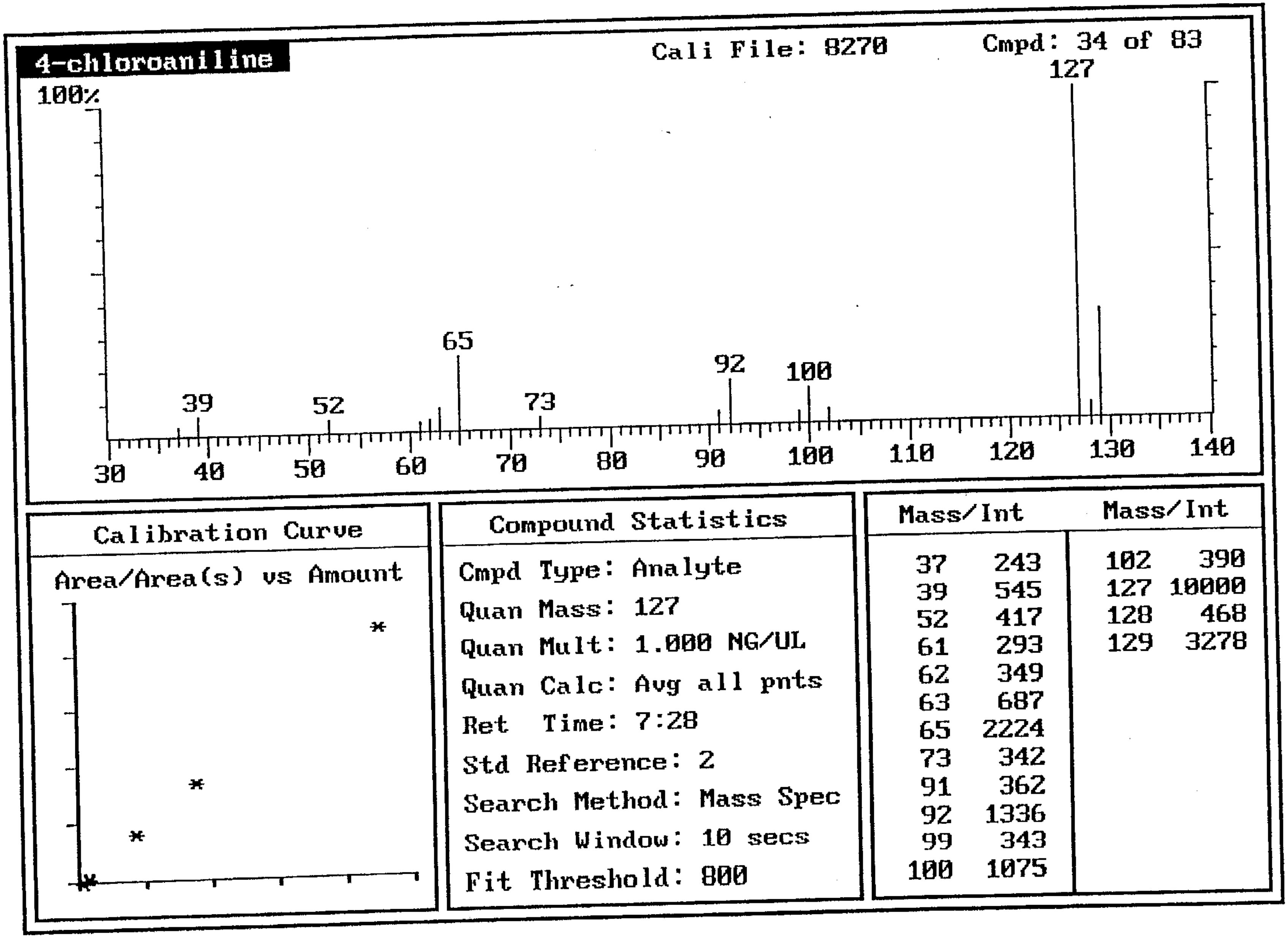
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 128
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:19
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	83	178	119
63	188	189	148
87	91	190	95
102	633	202	95
124	64		
125	71		
126	1224		
127	937		
128	10000		
129	3368		
130	96		
134	138		



4-chloroaniline Cali File: 8270 Cmpd: 34 of 83

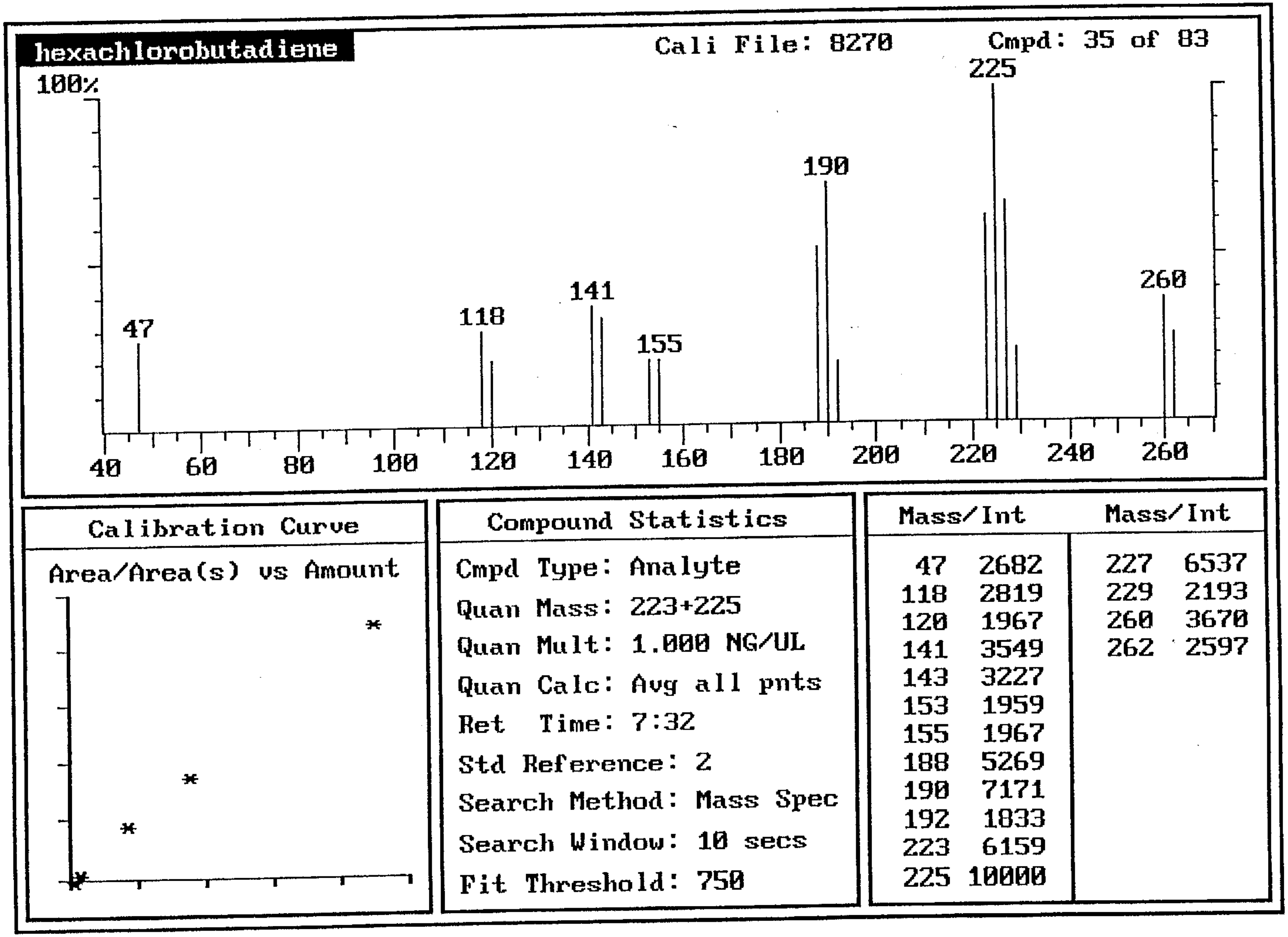
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 127
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:28
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
37	243	102	390
39	545	127	10000
52	417	128	468
61	293	129	3278
62	349		
63	687		
65	2224		
73	342		
91	362		
92	1336		
99	343		
100	1075		



hexachlorobutadiene Cali File: 8270 Cmpd: 35 of 83

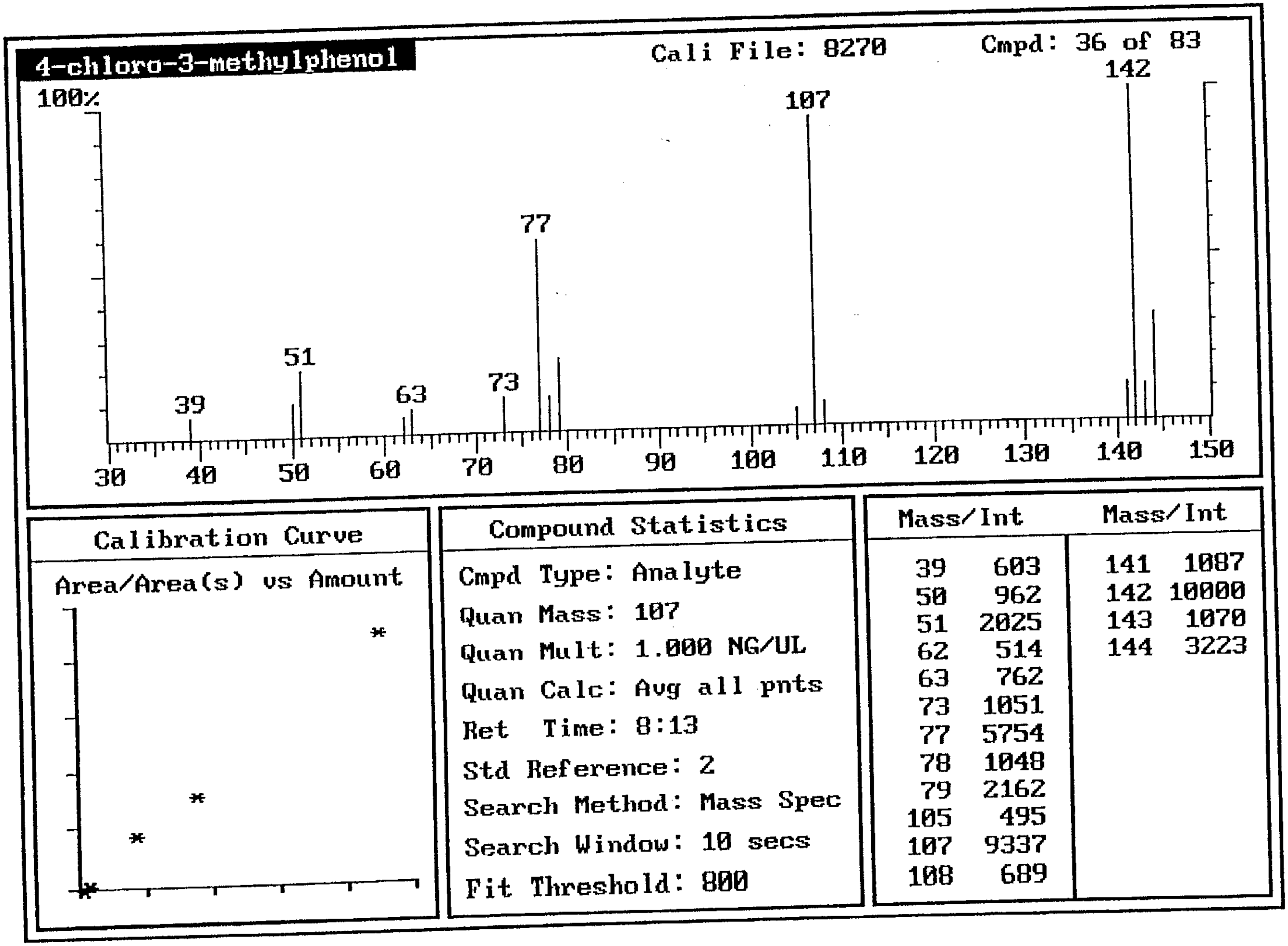
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 223+225
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 7:32
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 750

Mass/Int		Mass/Int	
47	2682	227	6537
118	2819	229	2193
120	1967	260	3670
141	3549	262	2597
143	3227		
153	1959		
155	1967		
188	5269		
190	7171		
192	1833		
223	6159		
225	10000		



4-chloro-3-methylphenol

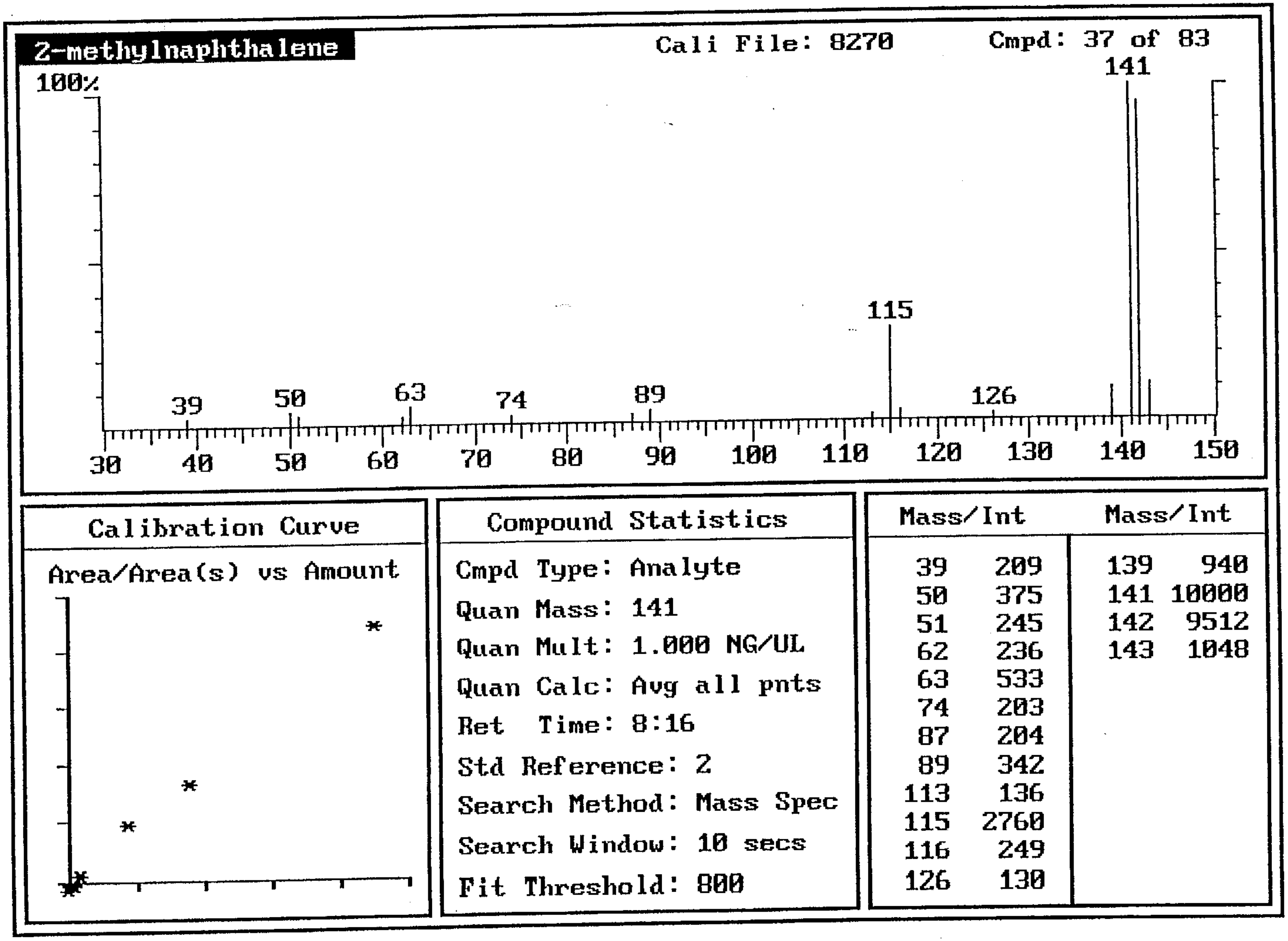
Cali File: 8270

Cmpd: 36 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 107
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 8:13
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	603	141	1087
50	962	142	10000
51	2025	143	1070
62	514	144	3223
63	762		
73	1051		
77	5754		
78	1048		
79	2162		
105	495		
107	9337		
108	689		



2-methylnaphthalene Cali File: 8270 Cmpd: 37 of 83

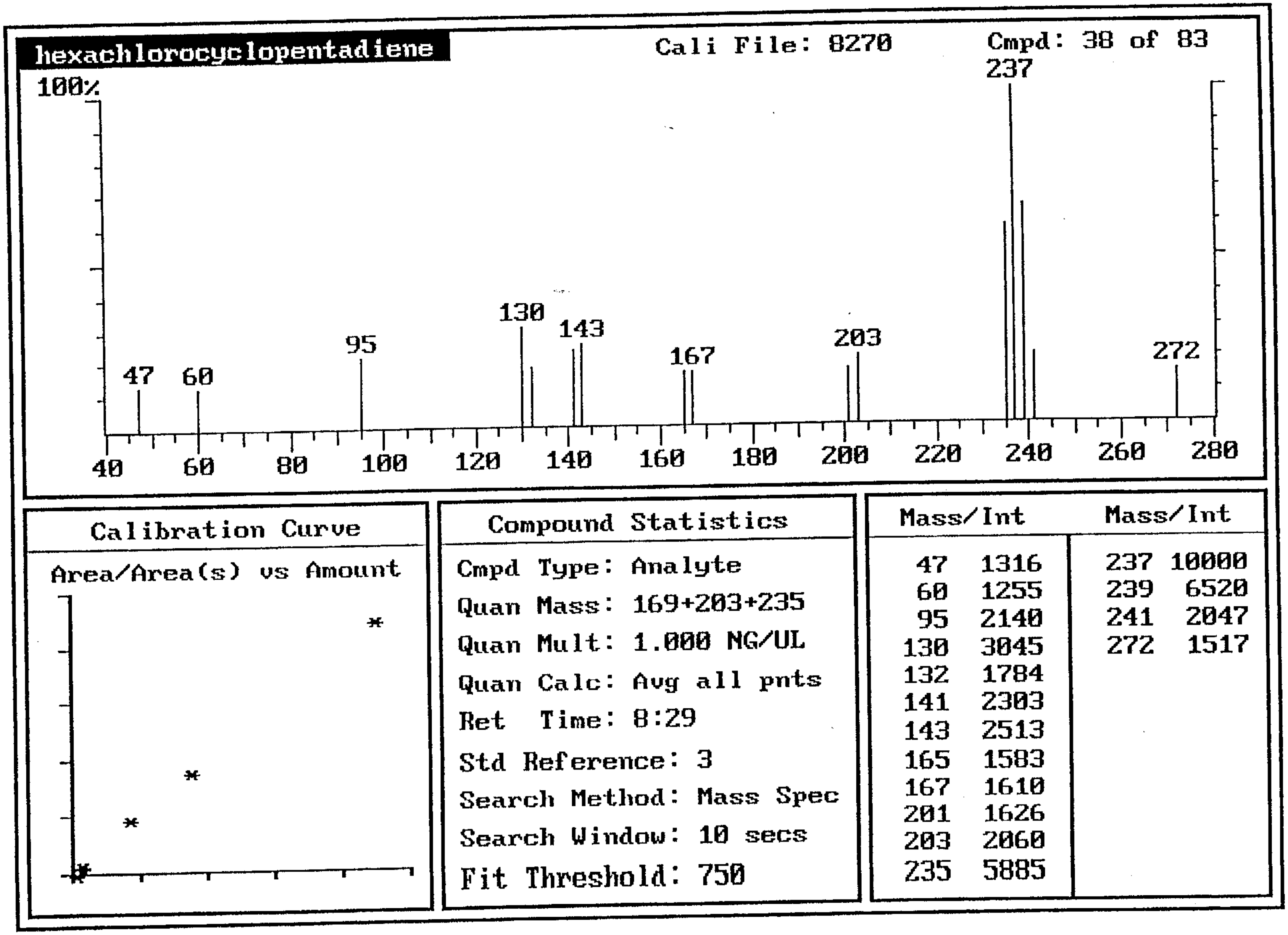
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 141
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 8:16
Std Reference: 2
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	209	139	940
50	375	141	10000
51	245	142	9512
62	236	143	1048
63	533		
74	203		
87	204		
89	342		
113	136		
115	2760		
116	249		
126	130		



hexachlorocyclopentadiene Cali File: 8270 Cmpd: 38 of 83

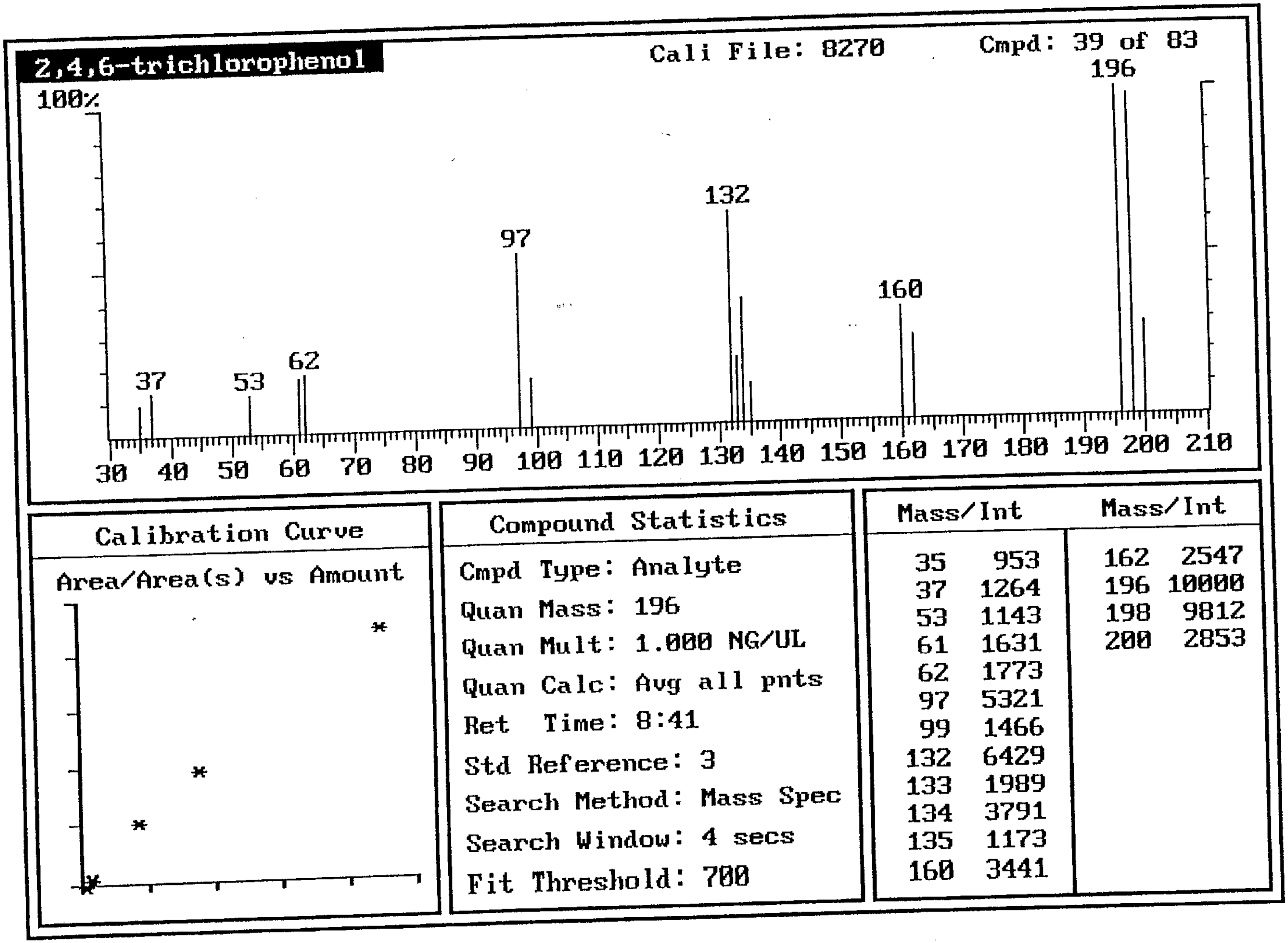
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 169+203+235
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 8:29
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 750

Mass/Int		Mass/Int	
47	1316	237	10000
60	1255	239	6520
95	2140	241	2047
130	3045	272	1517
132	1784		
141	2303		
143	2513		
165	1583		
167	1610		
201	1626		
203	2060		
235	5885		



2,4,6-trichlorophenol

Cali File: 8270

Cmpd: 39 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 196

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 8:41

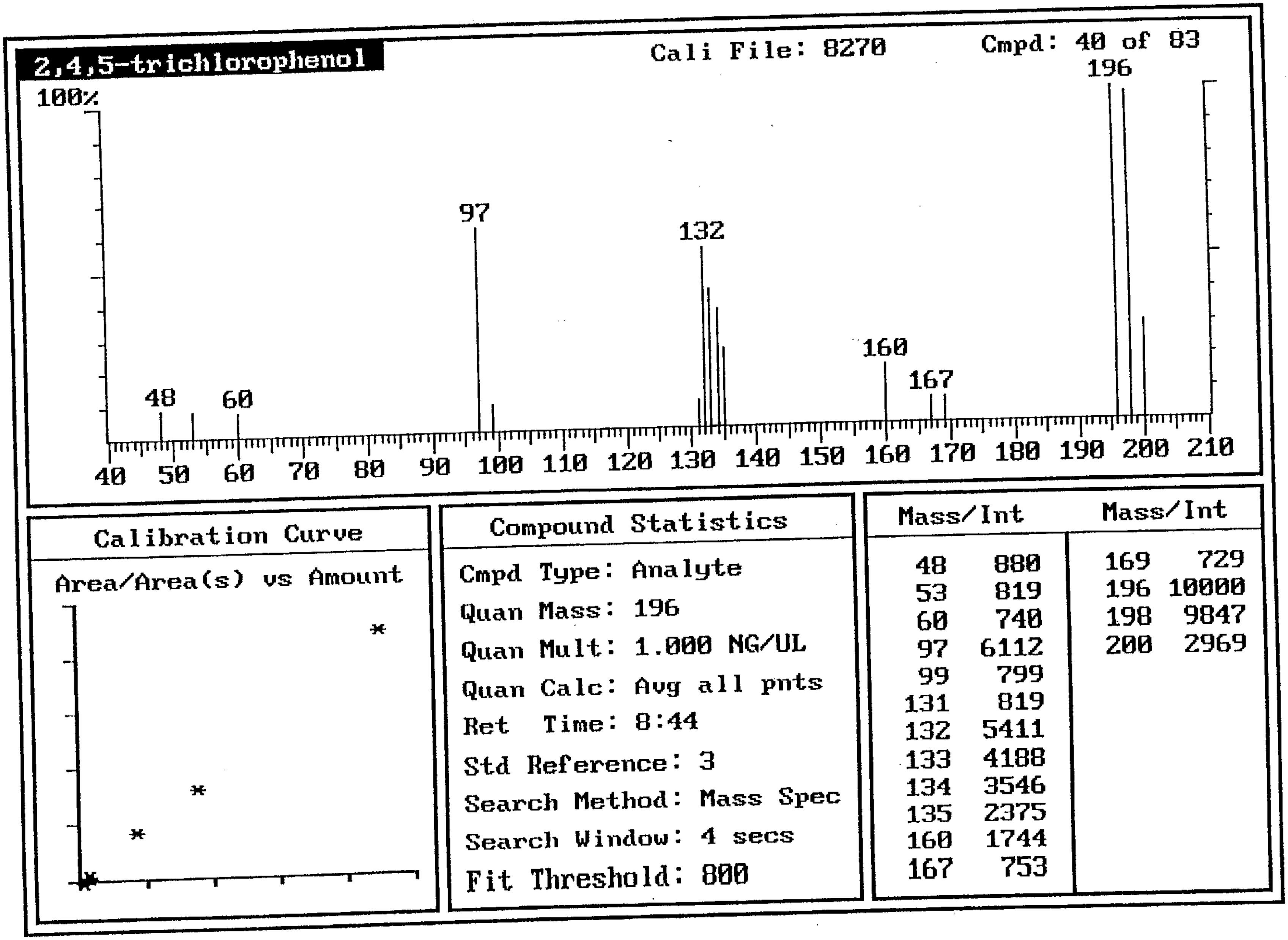
Std Reference: 3

Search Method: Mass Spec

Search Window: 4 secs

Fit Threshold: 700

Mass/Int		Mass/Int	
35	953	162	2547
37	1264	196	10000
53	1143	198	9812
61	1631	200	2853
62	1773		
97	5321		
99	1466		
132	6429		
133	1989		
134	3791		
135	1173		
160	3441		



2,4,5-trichlorophenol

Cali File: 8270

Cmpd: 40 of 83

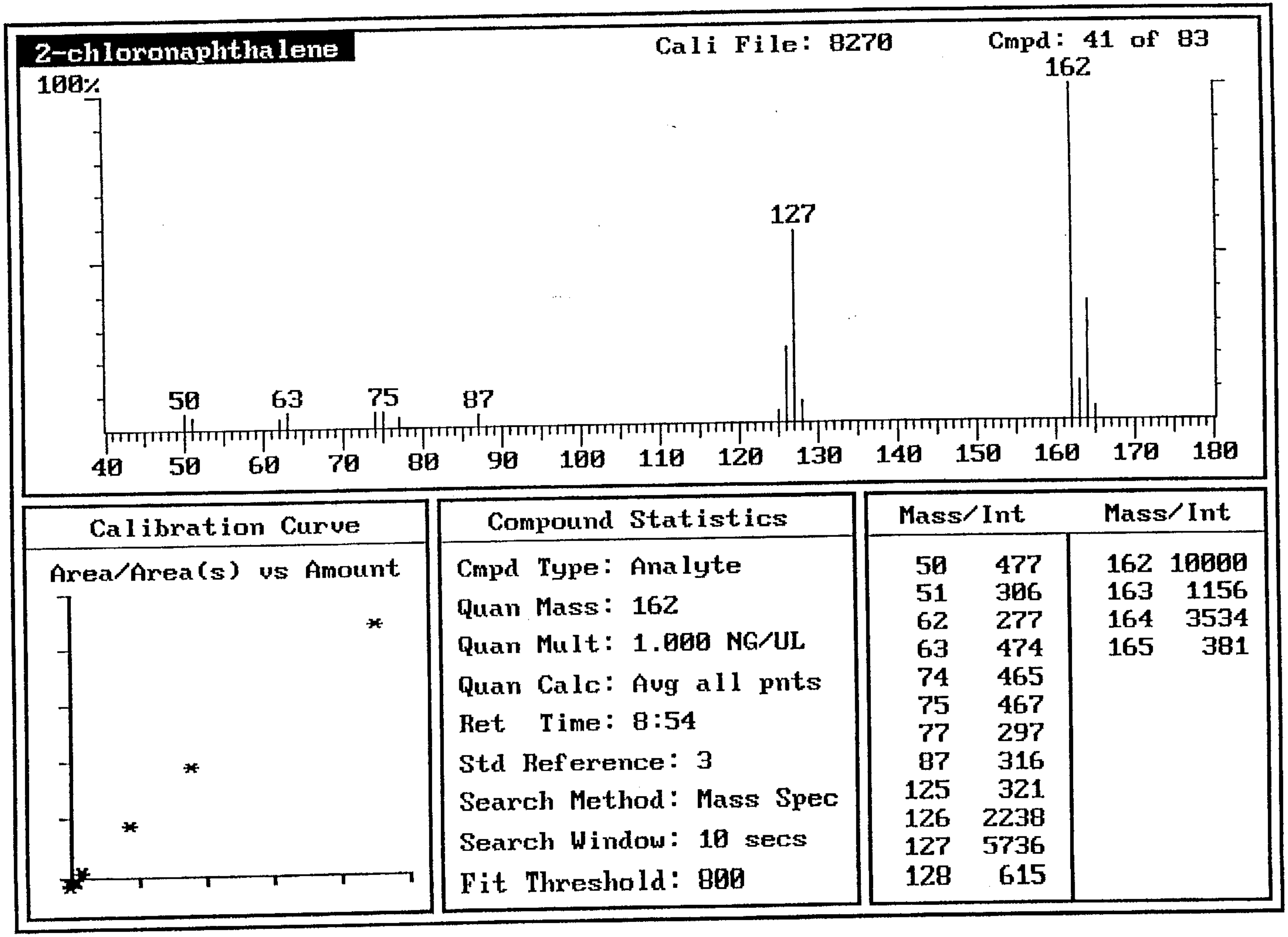
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 196
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 8:44
Std Reference: 3
Search Method: Mass Spec
Search Window: 4 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
48	880	169	729
53	819	196	10000
60	740	198	9847
97	6112	200	2969
99	799		
131	819		
132	5411		
133	4188		
134	3546		
135	2375		
160	1744		
167	753		

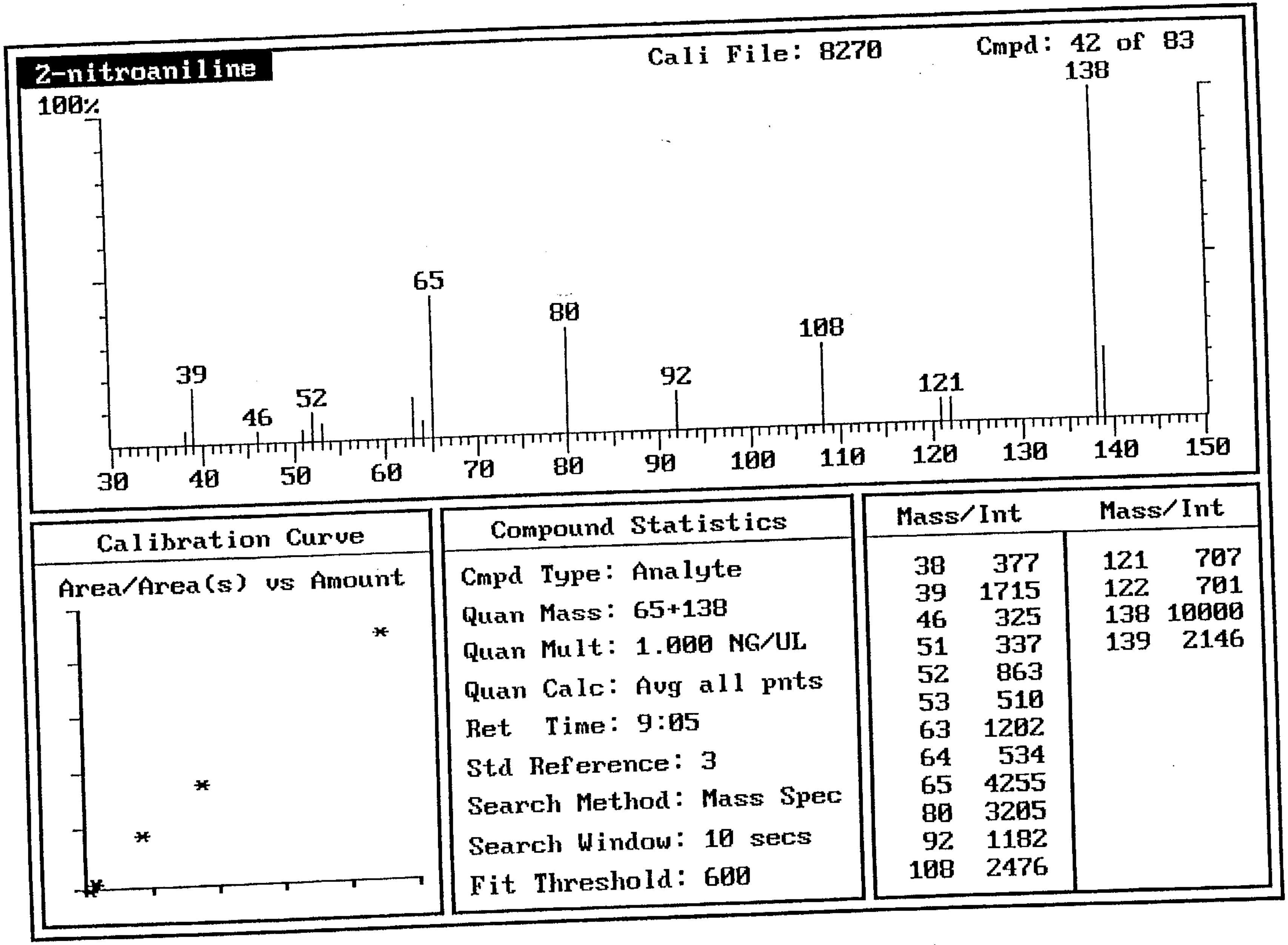


2-chloronaphthalene Cali File: 8270 Cmpd: 41 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 162
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 8:54
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	477	162	10000
51	306	163	1156
62	277	164	3534
63	474	165	381
74	465		
75	467		
77	297		
87	316		
125	321		
126	2238		
127	5736		
128	615		



2-nitroaniline

Cali File: 8270

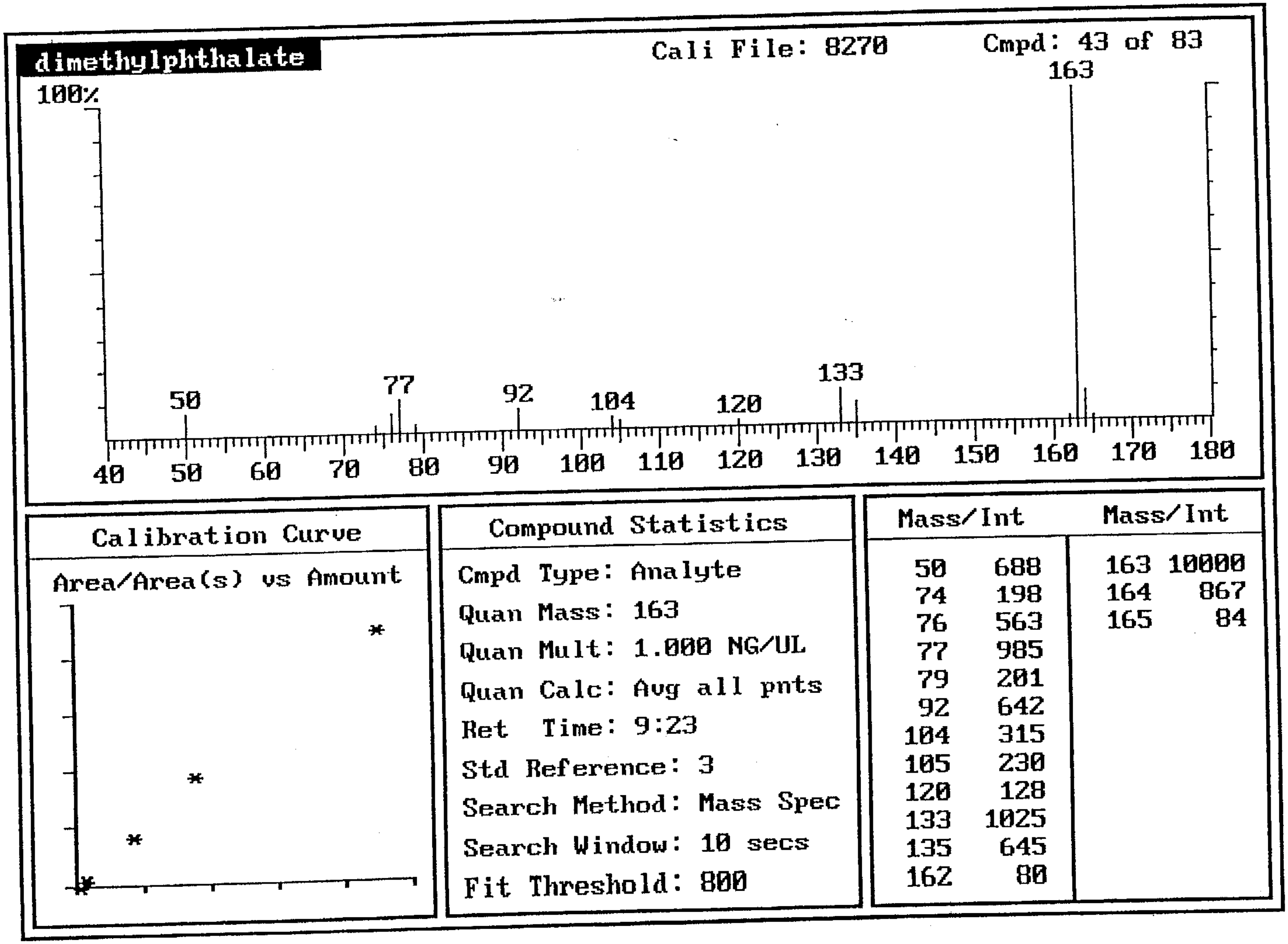
Cmpd: 42 of 83

Calibration Curve

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 65+138
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:05
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 600

Mass/Int		Mass/Int	
38	377	121	707
39	1715	122	701
46	325	138	10000
51	337	139	2146
52	863		
53	510		
63	1202		
64	534		
65	4255		
80	3205		
92	1182		
108	2476		



dimethylphthalate

Cali File: 8270

Cmpd: 43 of 83

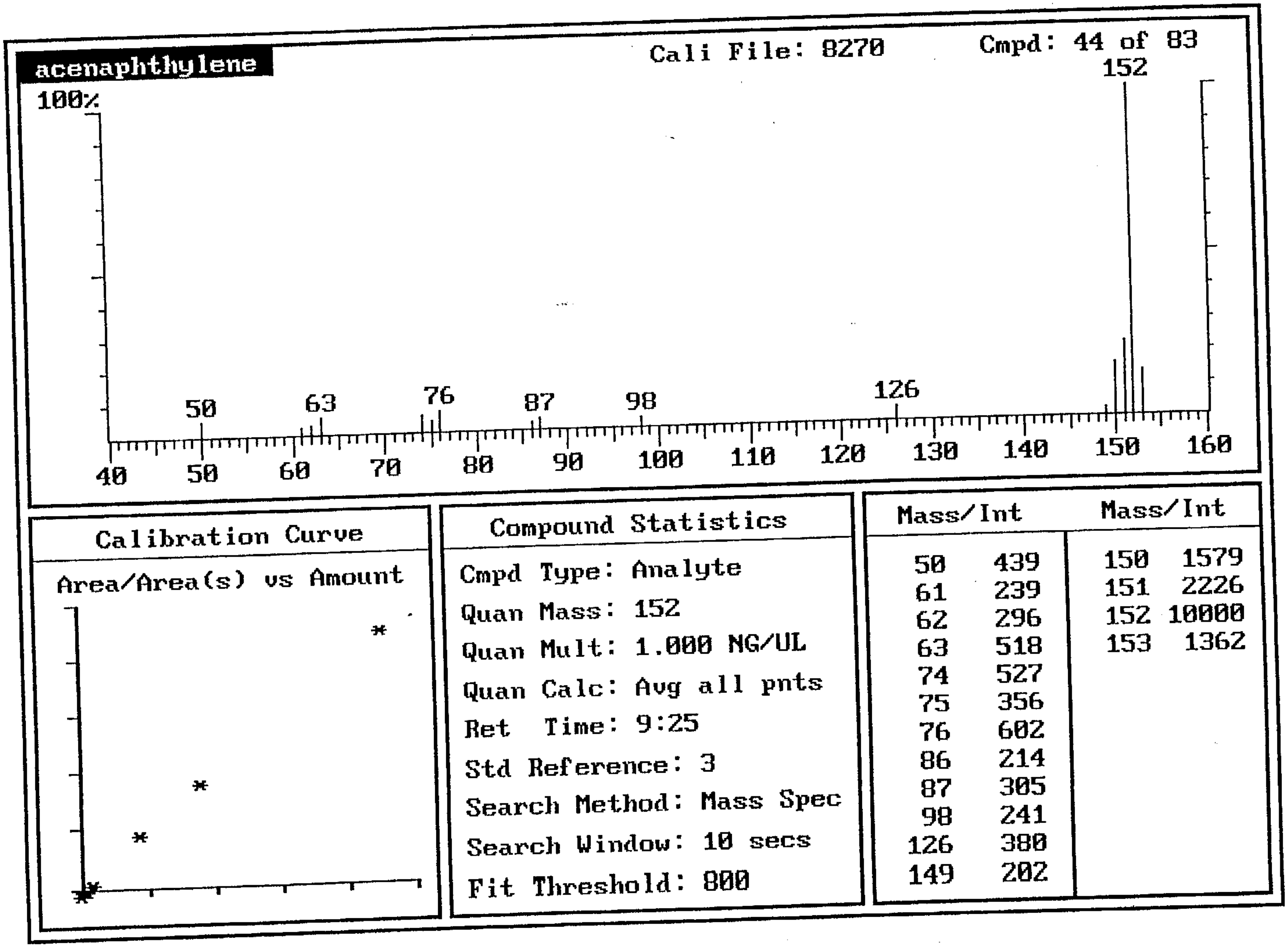
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 163
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:23
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	688	163	10000
74	198	164	867
76	563	165	84
77	985		
79	201		
92	642		
104	315		
105	230		
120	128		
133	1025		
135	645		
162	80		



acenaphthylene

Cali File: 8270

Cmpd: 44 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 152

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 9:25

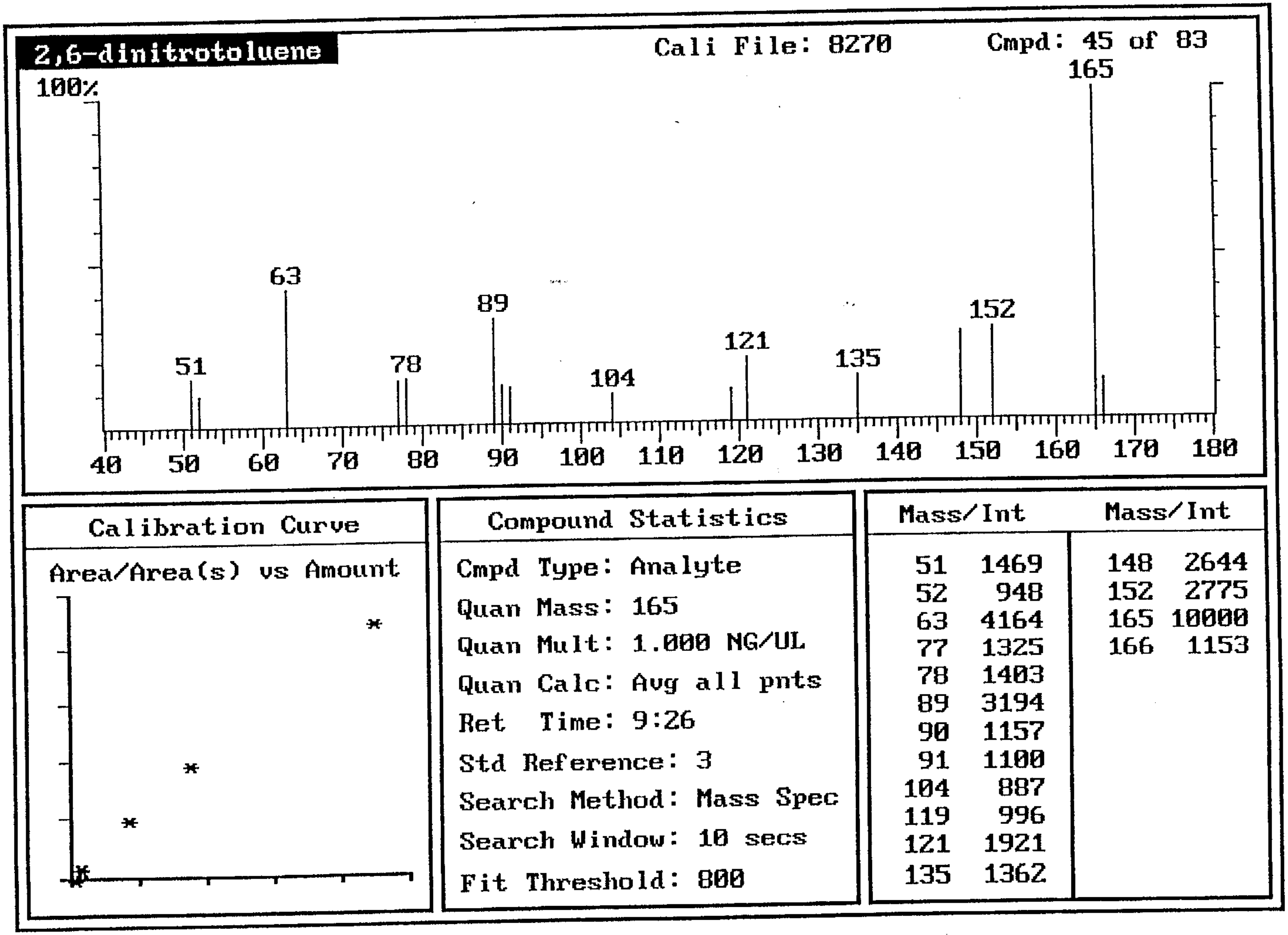
Std Reference: 3

Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 800

Mass/Int		Mass/Int	
50	439	150	1579
61	239	151	2226
62	296	152	10000
63	518	153	1362
74	527		
75	356		
76	602		
86	214		
87	305		
98	241		
126	380		
149	202		



2,6-dinitrotoluene

Cali File: 8270

Cmpd: 45 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 165

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 9:26

Std Reference: 3

Search Method: Mass Spec

Search Window: 10 secs

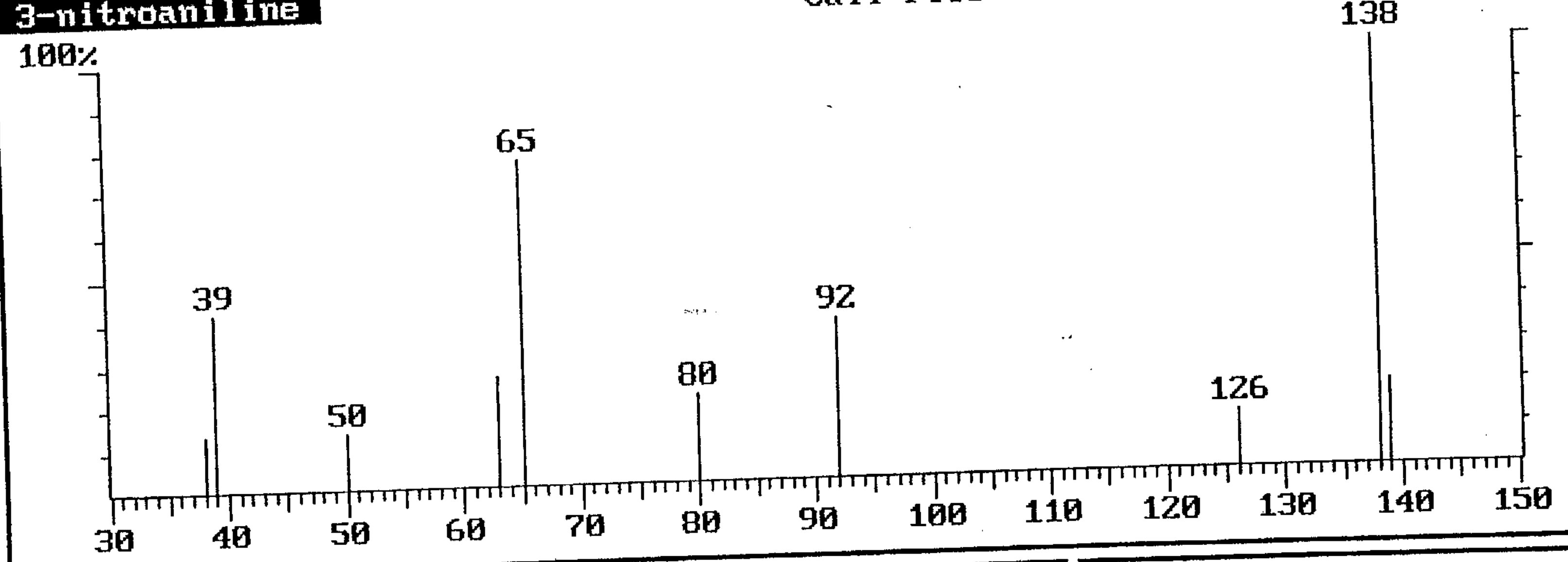
Fit Threshold: 800

Mass/Int		Mass/Int	
51	1469	148	2644
52	948	152	2775
63	4164	165	10000
77	1325	166	1153
78	1403		
89	3194		
90	1157		
91	1100		
104	887		
119	996		
121	1921		
135	1362		

3-nitroaniline

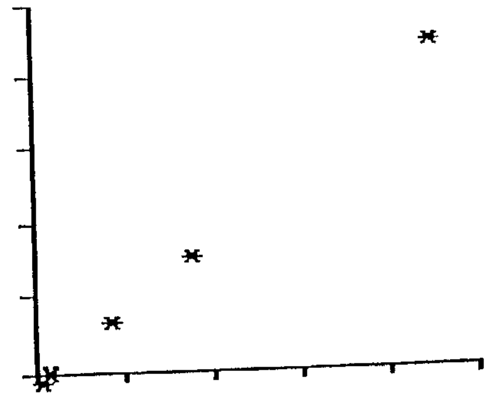
Cali File: 8270

Cmpd: 46 of 83



Calibration Curve

Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte

Quan Mass: 138

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 9:38

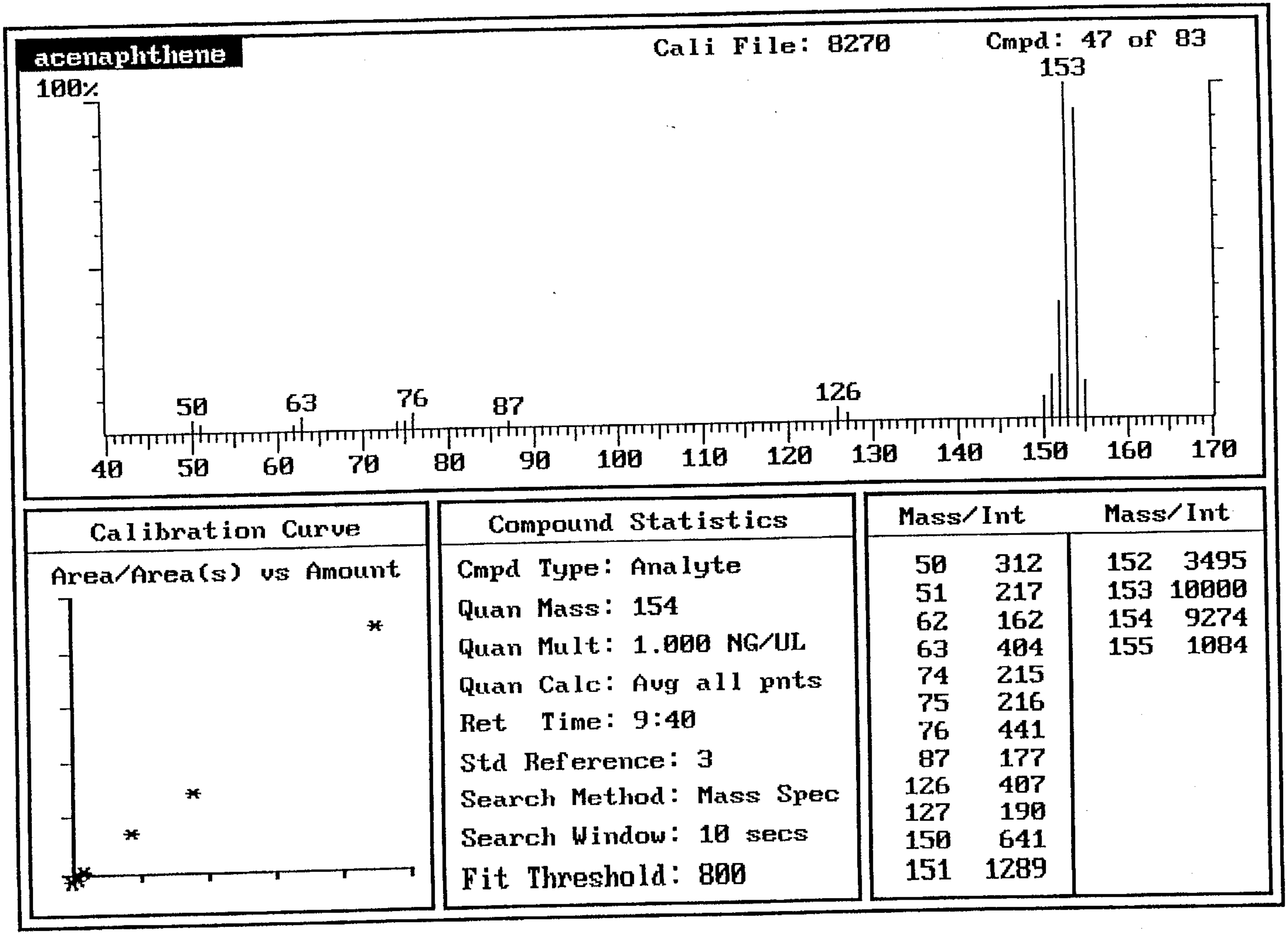
Std Reference: 3

Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 800

Mass/Int		Mass/Int
38	466	
39	1455	
50	462	
63	920	
65	2663	
80	728	
92	1308	
126	468	
138	3494	
139	691	



acenaphthene   Cali File: 8270   Cmpd: 47 of 83

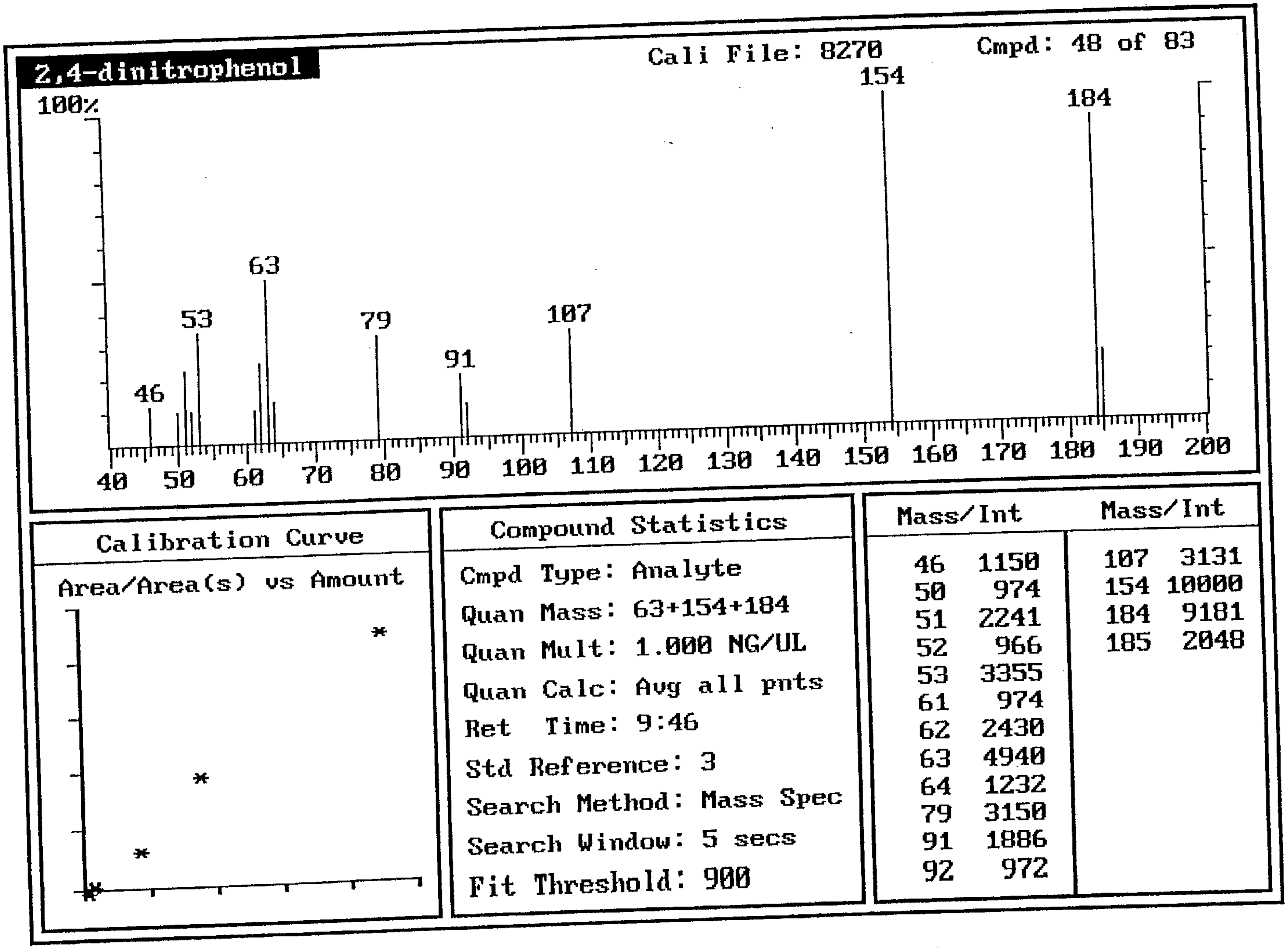
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 154
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:40
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	312	152	3495
51	217	153	10000
62	162	154	9274
63	404	155	1084
74	215		
75	216		
76	441		
87	177		
126	407		
127	190		
150	641		
151	1289		



2,4-dinitrophenol

Cali File: 8270 Cmpd: 48 of 83

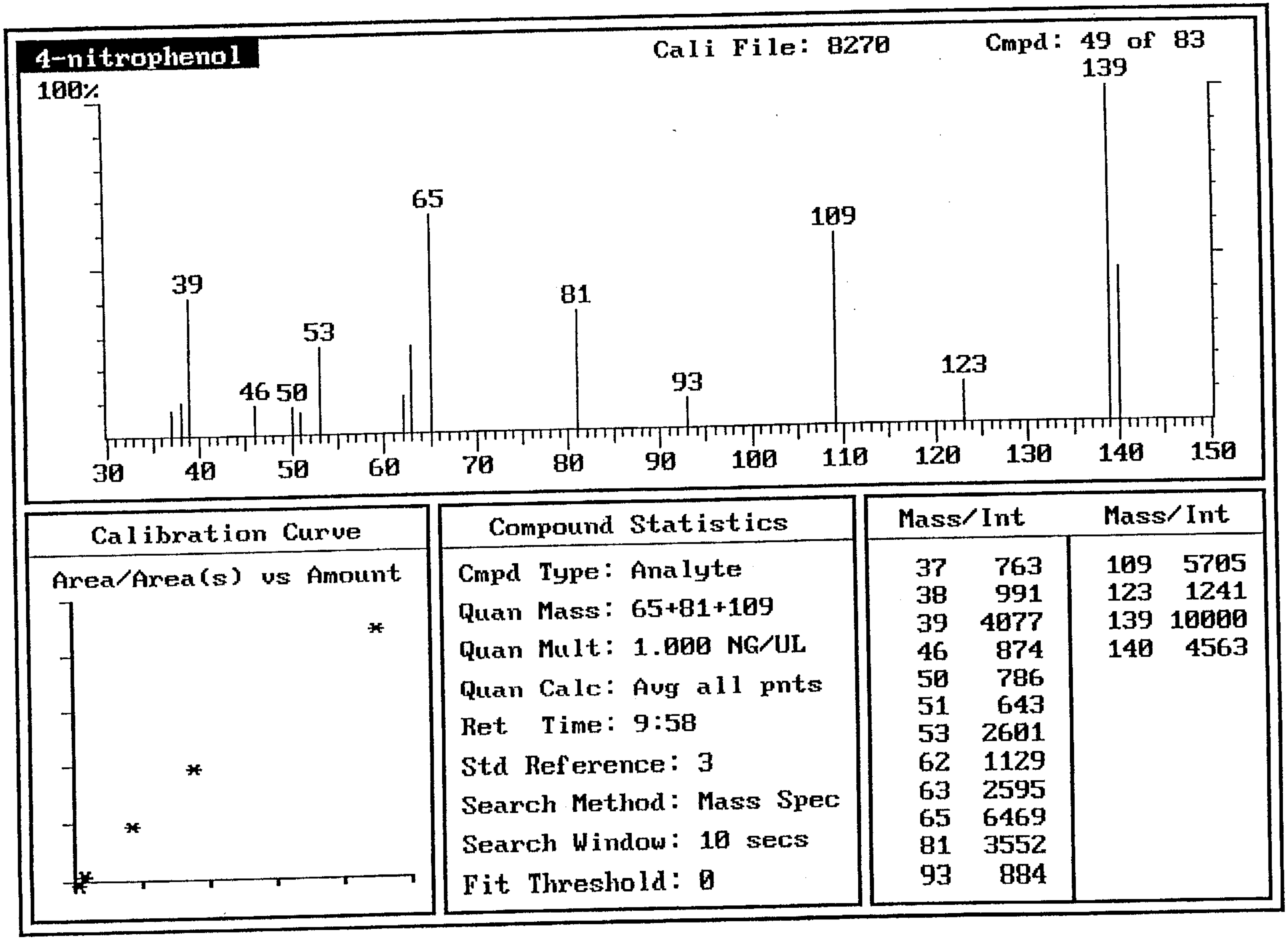
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 63+154+184
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:46
Std Reference: 3
Search Method: Mass Spec
Search Window: 5 secs
Fit Threshold: 900

Mass/Int		Mass/Int	
46	1150	107	3131
50	974	154	10000
51	2241	184	9181
52	966	185	2048
53	3355		
61	974		
62	2430		
63	4940		
64	1232		
79	3150		
91	1886		
92	972		



4-nitrophenol

Cali File: 8270

Cmpd: 49 of 83

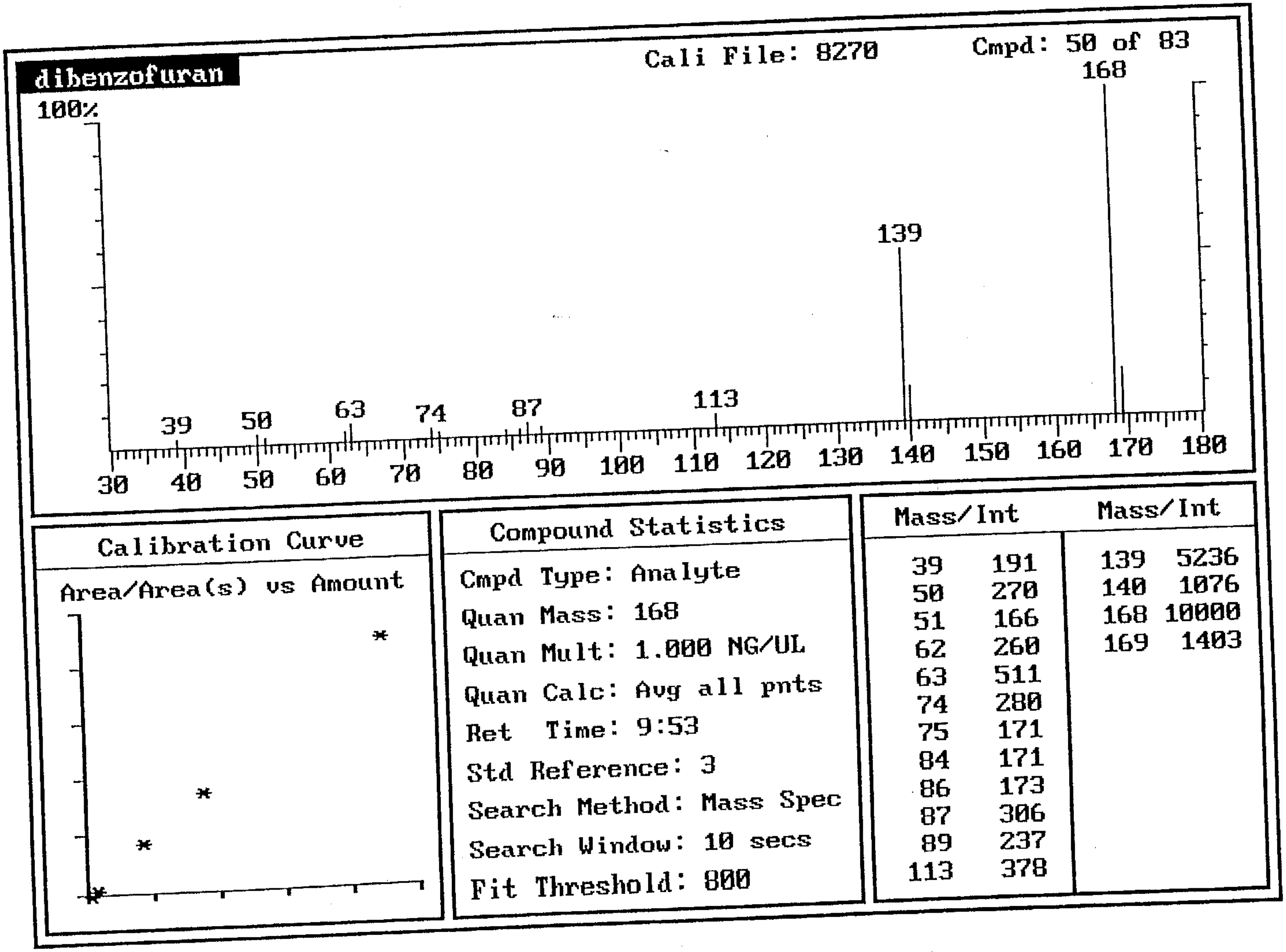
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 65+81+109
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:58
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 0

Mass/Int		Mass/Int	
37	763	109	5705
38	991	123	1241
39	4077	139	10000
46	874	140	4563
50	786		
51	643		
53	2601		
62	1129		
63	2595		
65	6469		
81	3552		
93	884		



dibenzofuran

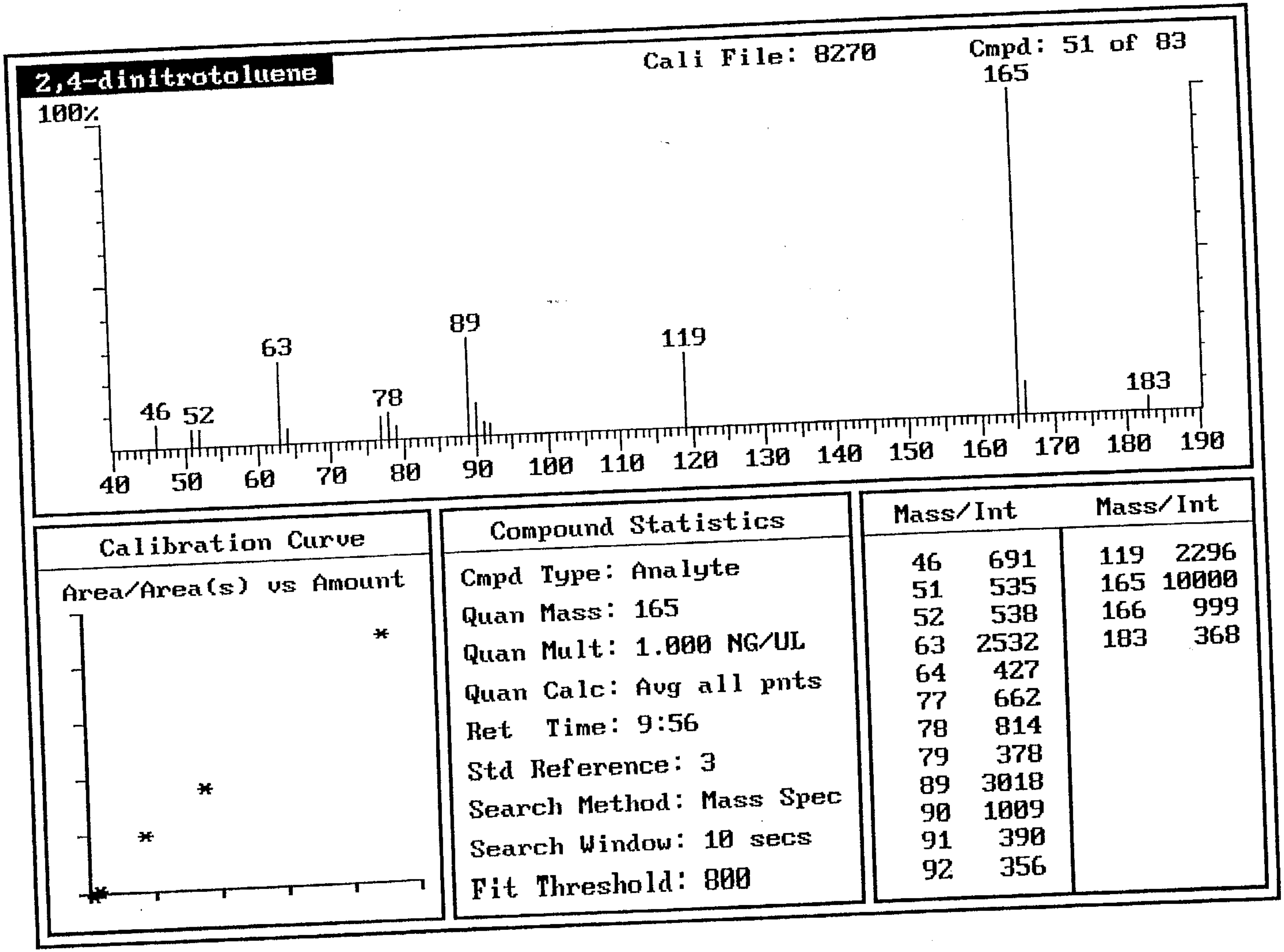
Cali File: 8270

Cmpd: 50 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 168
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:53
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	191	139	5236
50	270	140	1076
51	166	168	10000
62	260	169	1403
63	511		
74	280		
75	171		
84	171		
86	173		
87	306		
89	237		
113	378		



2,4-dinitrotoluene

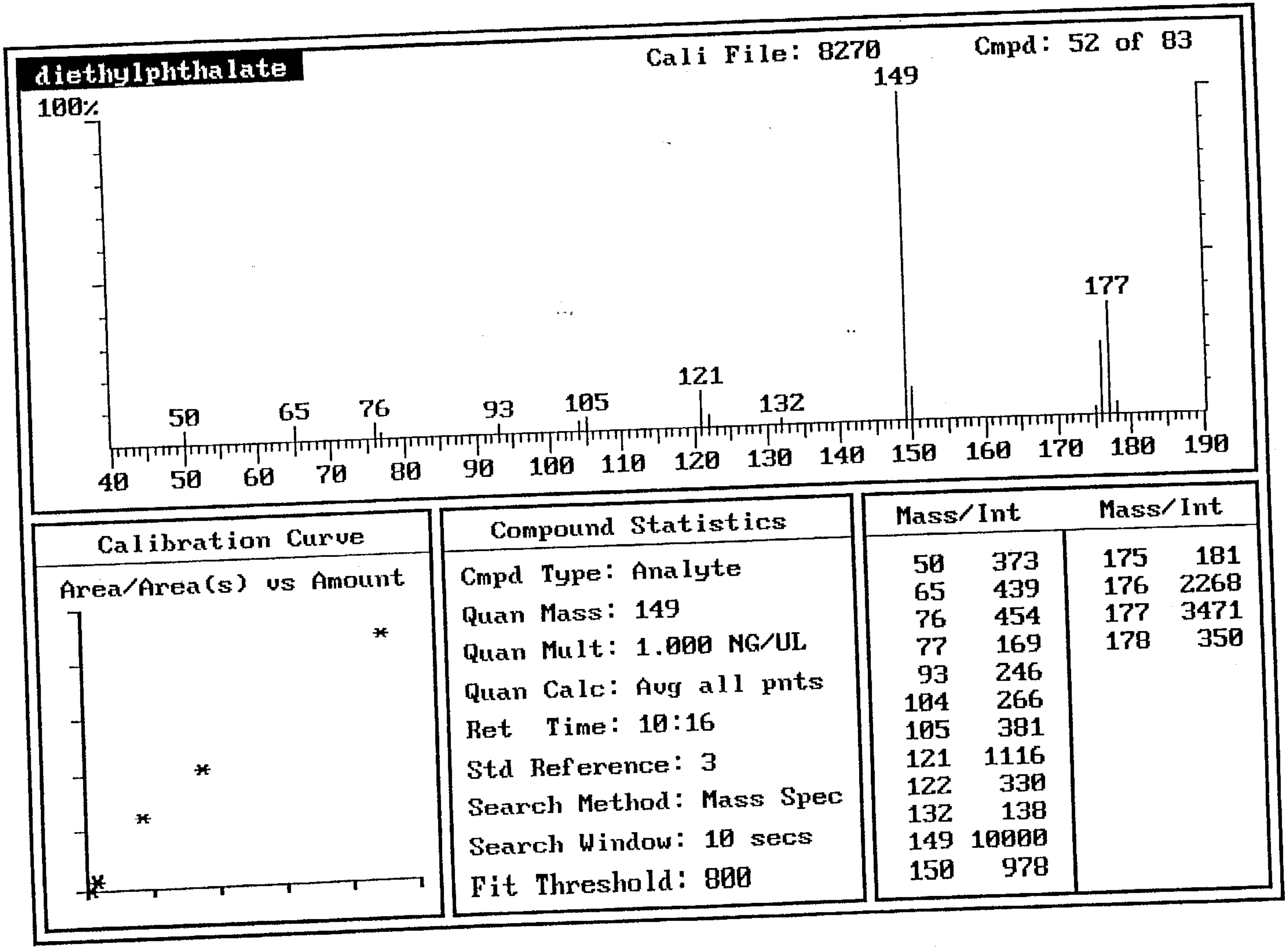
Cali File: 8270

Cmpd: 51 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 165
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:56
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
46	691	119	2296
51	535	165	10000
52	538	166	999
63	2532	183	368
64	427		
77	662		
78	814		
79	378		
89	3018		
90	1009		
91	390		
92	356		



diethylphthalate

Cali File: 8270

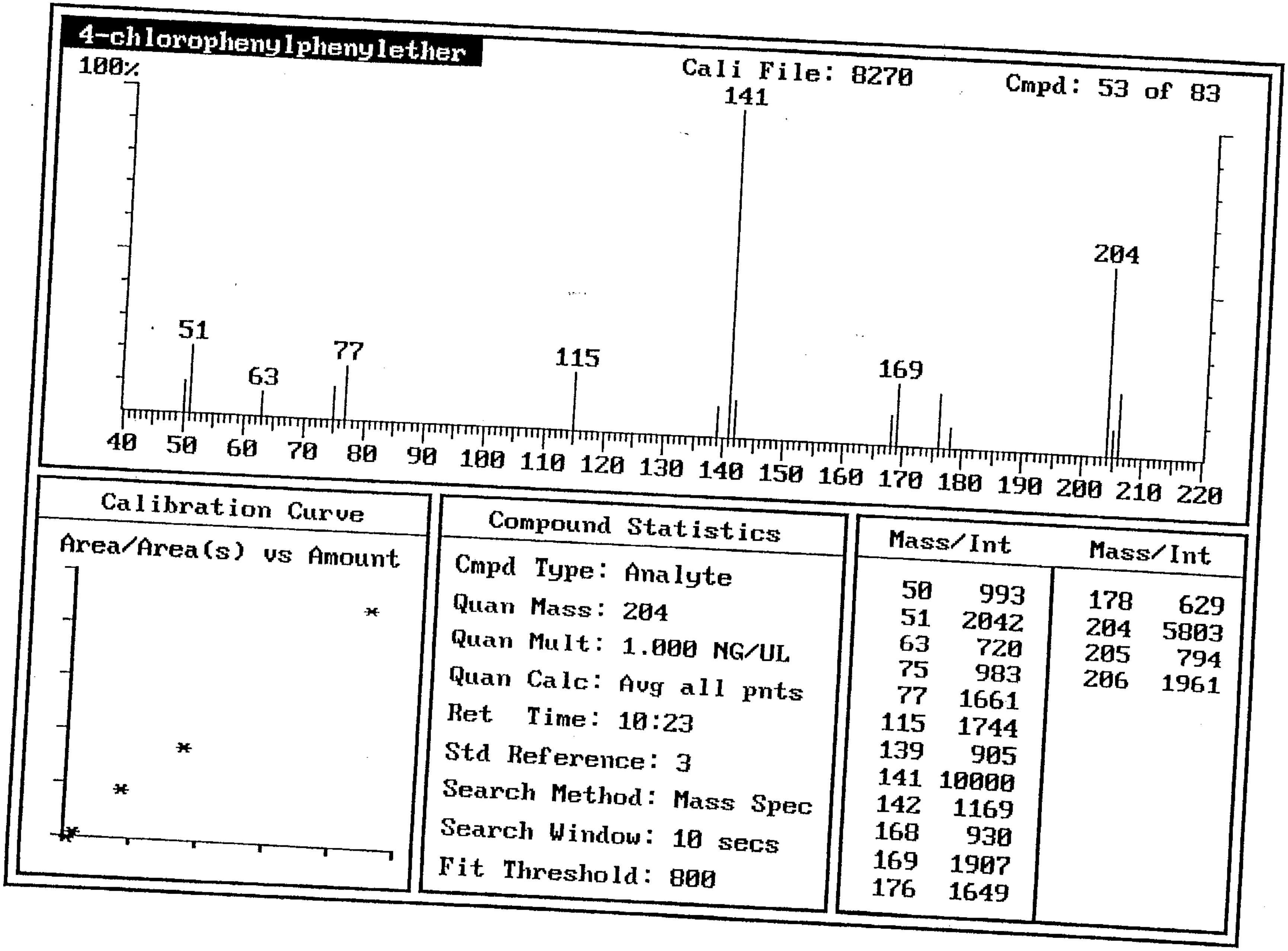
Cmpd: 52 of 83

Calibration Curve

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 149
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:16
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	373	175	181
65	439	176	2268
76	454	177	3471
77	169	178	350
93	246		
104	266		
105	381		
121	1116		
122	330		
132	138		
149	10000		
150	978		



4-chlorophenylphenylether

Cali File: 8270

Cmpd: 53 of 83

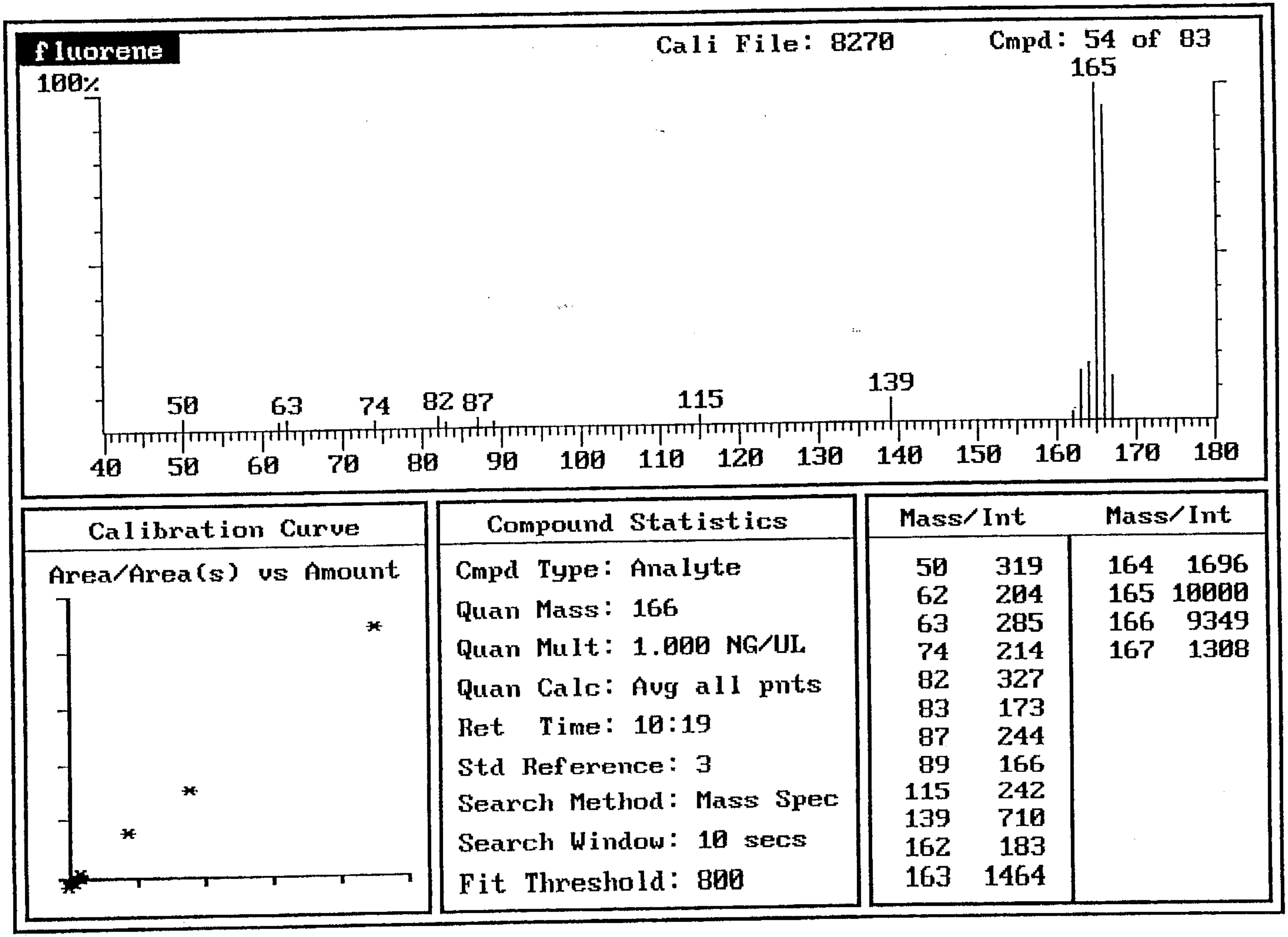
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 204
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:23
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	993	178	629
51	2042	204	5803
63	720	205	794
75	983	206	1961
77	1661		
115	1744		
139	905		
141	10000		
142	1169		
168	930		
169	1907		
176	1649		



fluorene

Cali File: 8270

Cmpd: 54 of 83

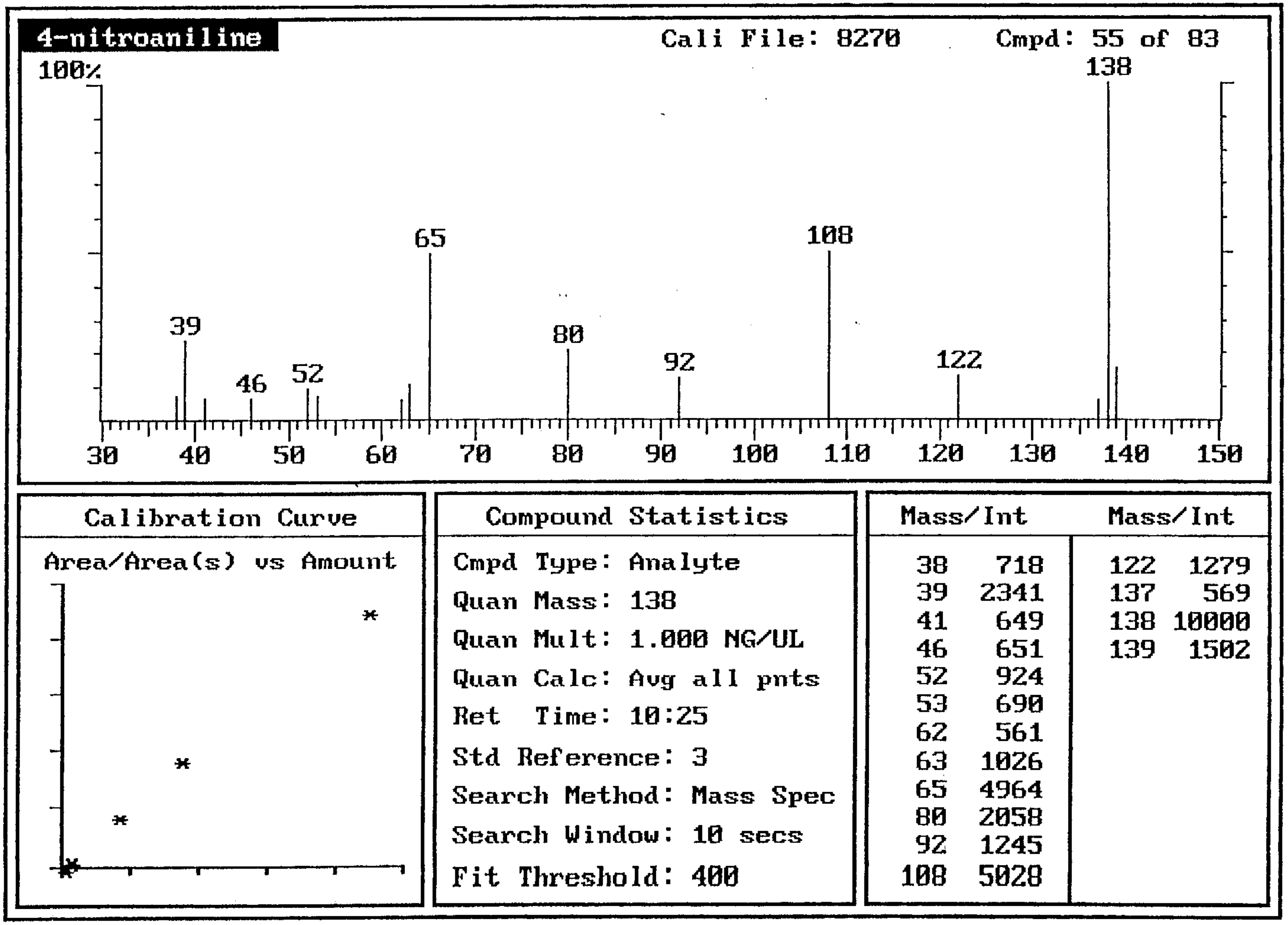
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 166
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:19
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	319	164	1696
62	204	165	10000
63	285	166	9349
74	214	167	1308
82	327		
83	173		
87	244		
89	166		
115	242		
139	710		
162	183		
163	1464		



4-nitroaniline Cali File: 8270 Cmpd: 55 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 138

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 10:25

Std Reference: 3

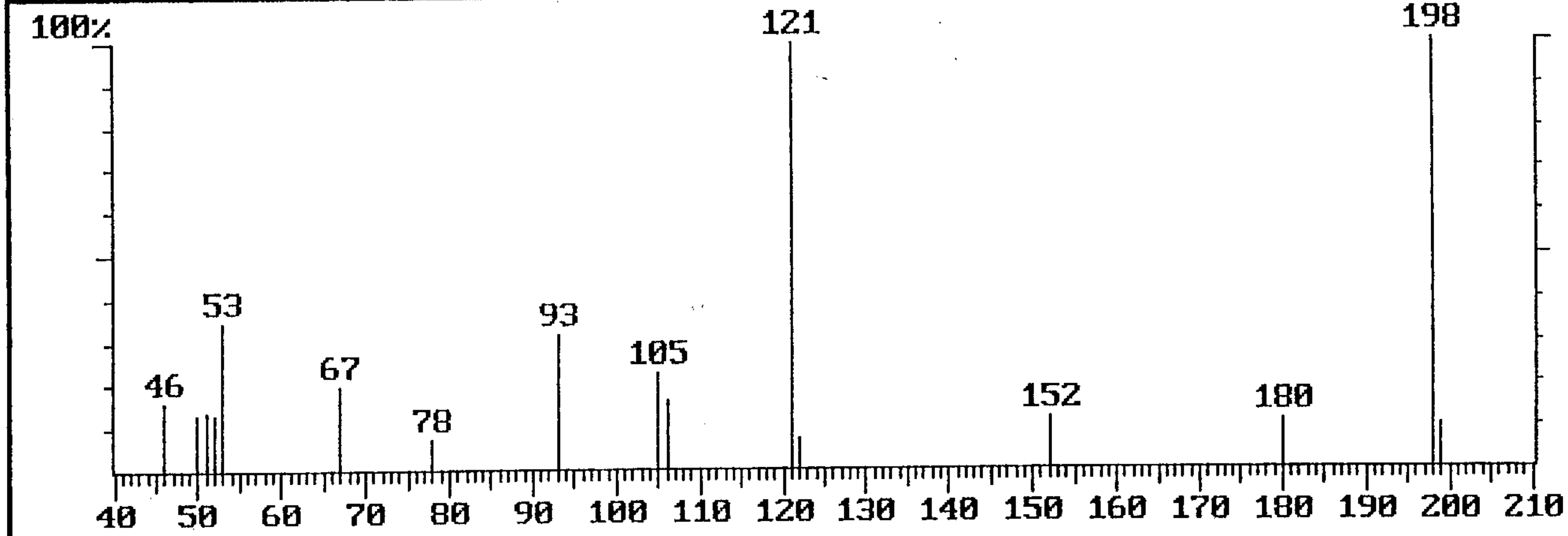
Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 400

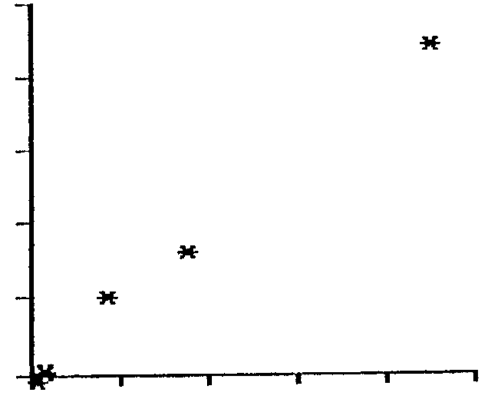
Mass/Int		Mass/Int	
38	718	122	1279
39	2341	137	569
41	649	138	10000
46	651	139	1502
52	924		
53	690		
62	561		
63	1026		
65	4964		
80	2058		
92	1245		
108	5028		

4,6-dinitro-2-methylphenol Cali File: 8270 Cmpd: 56 of 83



Calibration Curve

Area/Area(s) vs Amount

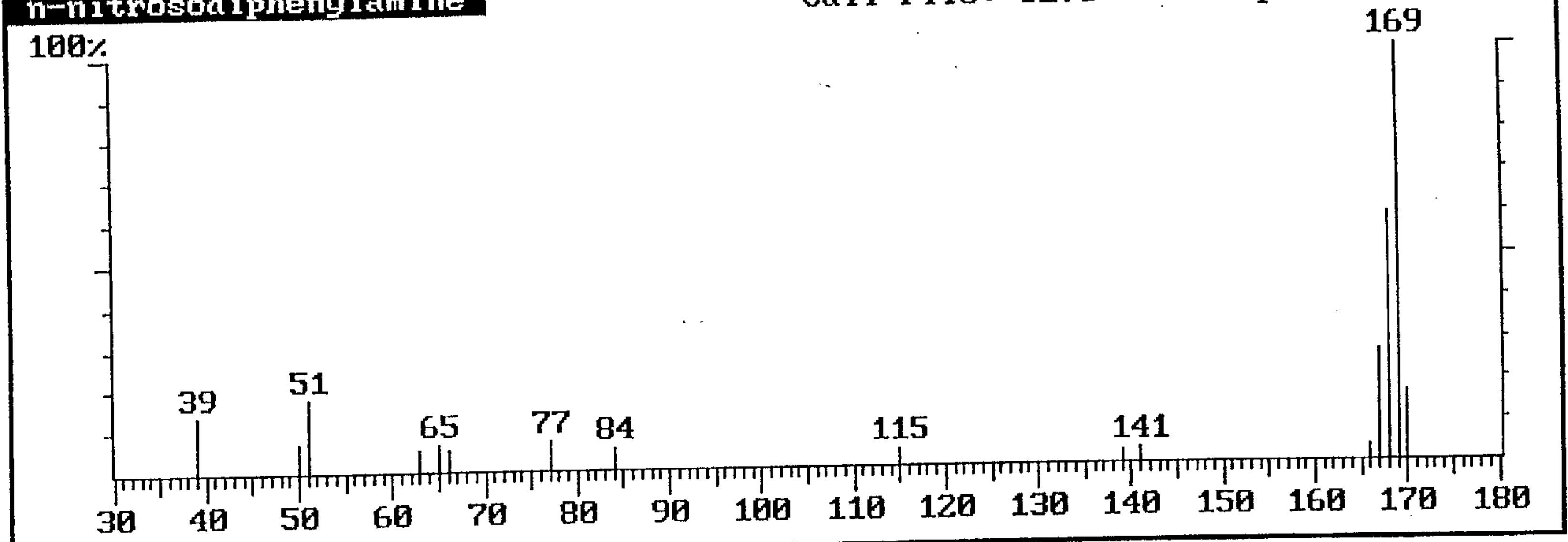


Compound Statistics

Cmpd Type: Analyte
Quan Mass: 121
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:28
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

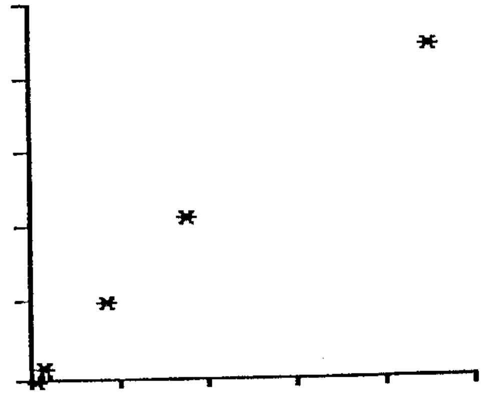
Mass/Int		Mass/Int	
46	1561	152	1169
50	1282	180	1116
51	1364	198	10000
52	1314	199	972
53	3457		
67	1917		
78	706		
93	3167		
105	2221		
106	1567		
121	9958		
122	697		

n-nitrosodiphenylamine Cali File: 8270 Cmpd: 57 of 83



Calibration Curve

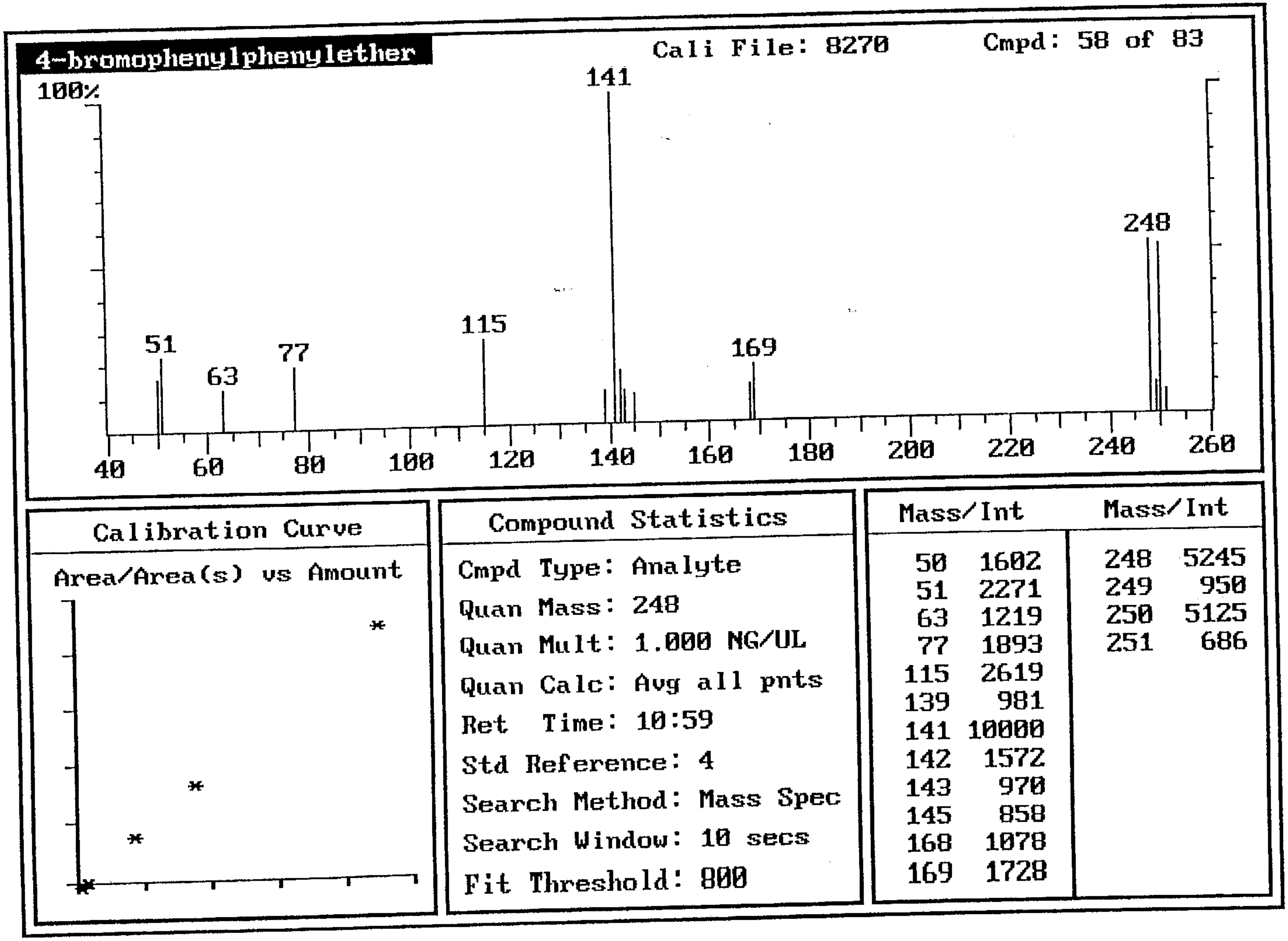
Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte
Quan Mass: 169
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:33
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	1370	167	2640
50	694	168	5960
51	1739	169	10000
63	486	170	1626
65	651		
66	490		
77	716		
84	514		
115	398		
139	265		
141	335		
166	308		



4-bromophenylphenylether Cali File: 8270 Cmpd: 58 of 83

Calibration Curve

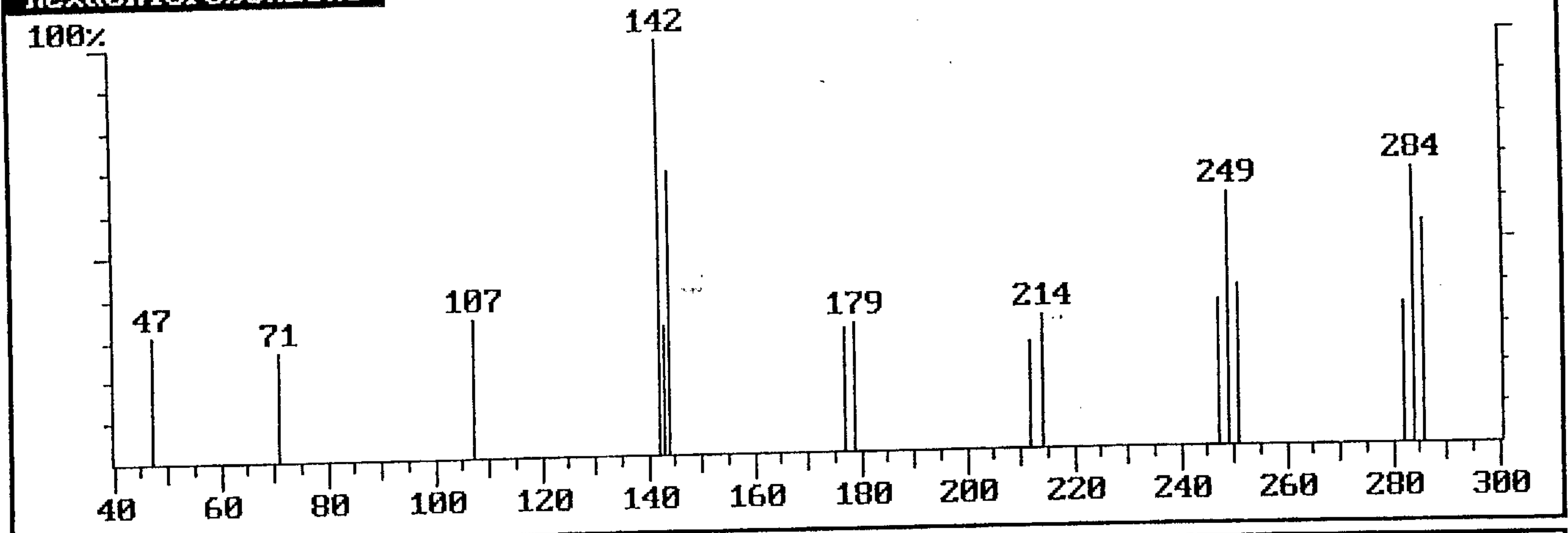
Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 248
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:59
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

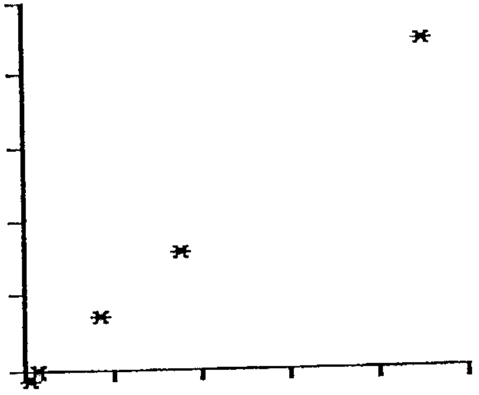
Mass/Int		Mass/Int	
50	1602	248	5245
51	2271	249	950
63	1219	250	5125
77	1893	251	686
115	2619		
139	981		
141	10000		
142	1572		
143	970		
145	858		
168	1078		
169	1728		

hexachlorobenzene Cali File: 8270 Cmpd: 59 of 83



Calibration Curve

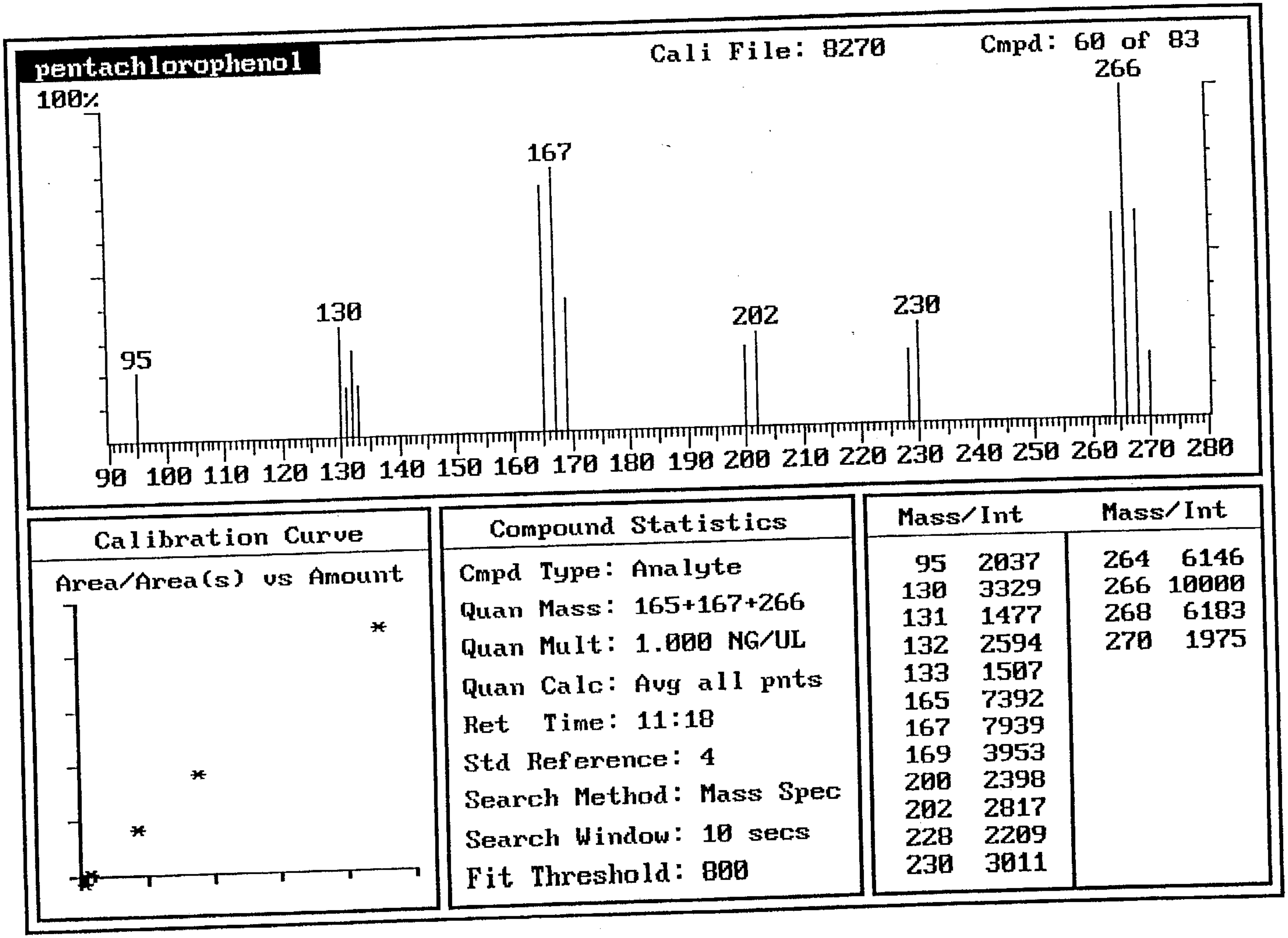
Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte
Quan Mass: 284
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 11:01
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 600

Mass/Int		Mass/Int	
47	3055	251	3923
71	2673	282	3414
107	3377	284	6700
142	10000	286	5397
143	3169		
144	6854		
177	3041		
179	3116		
212	2586		
214	3245		
247	3581		
249	6158		



pentachlorophenol

Cali File: 8270

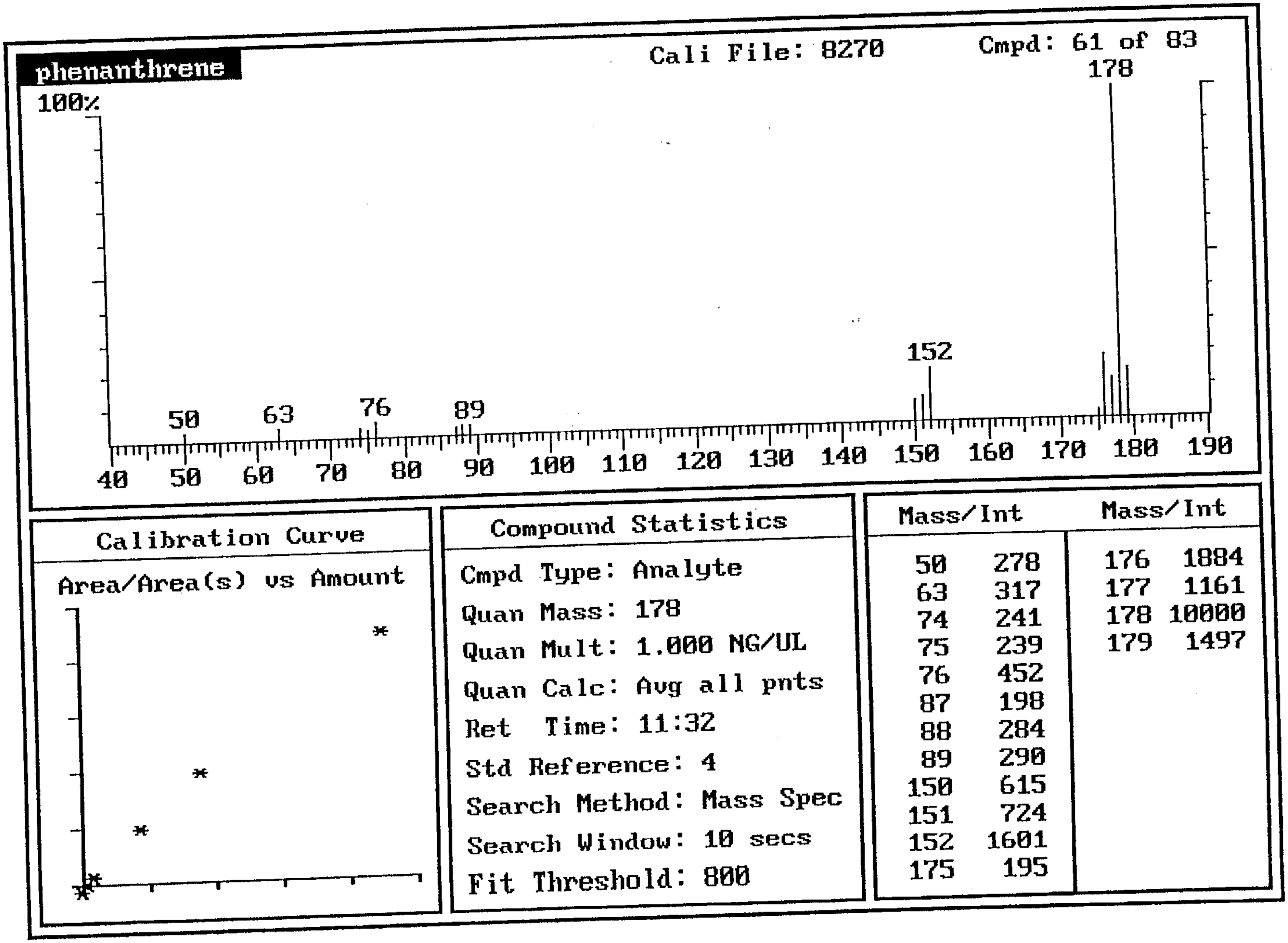
Cmpd: 60 of 83

Calibration Curve

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 165+167+266
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 11:18
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
95	2037	264	6146
130	3329	266	10000
131	1477	268	6183
132	2594	270	1975
133	1507		
165	7392		
167	7939		
169	3953		
200	2398		
202	2817		
228	2209		
230	3011		


phenanthrene

Cali File: 8270

Cmpd: 61 of 83

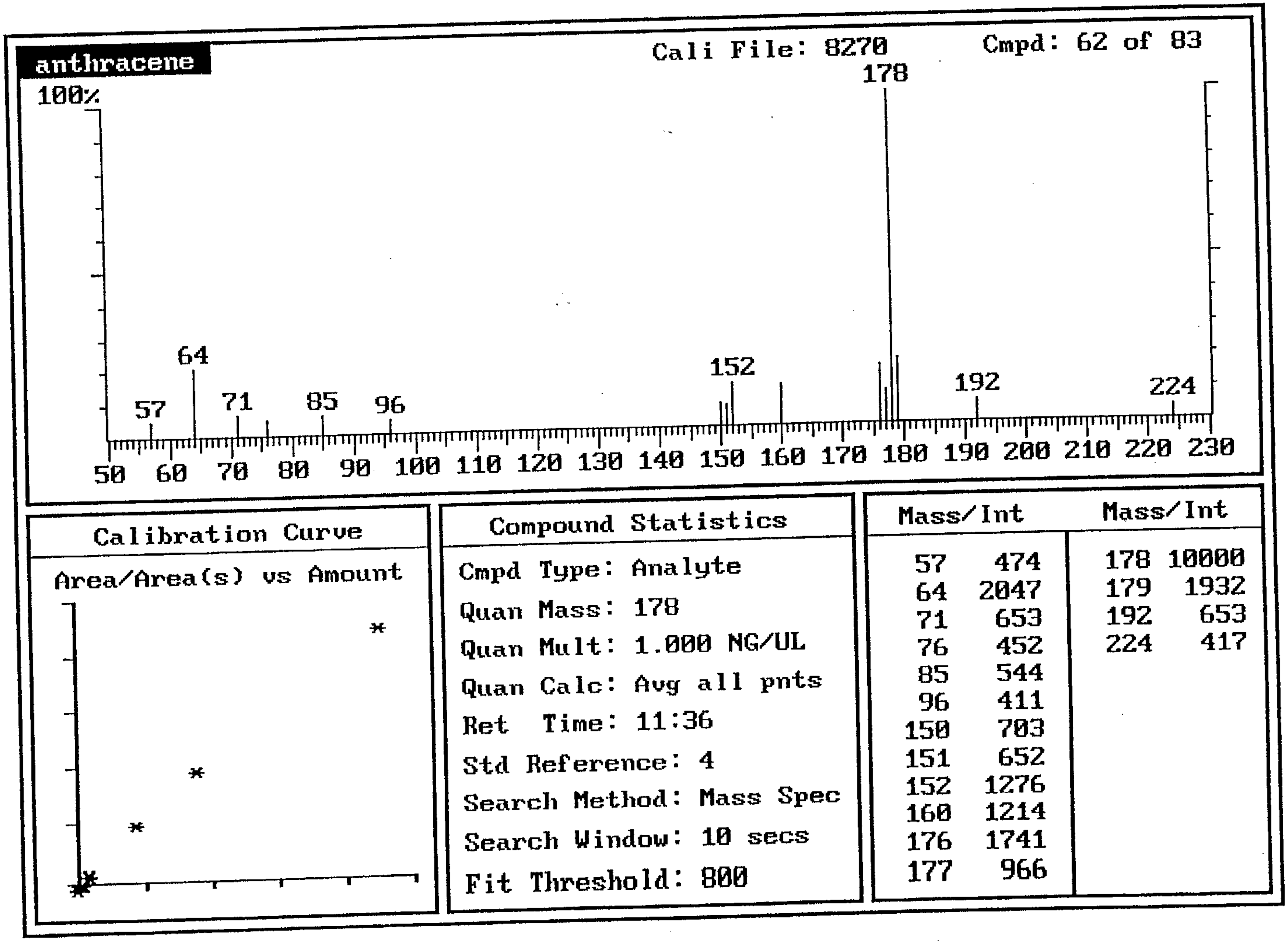
Calibration Curve

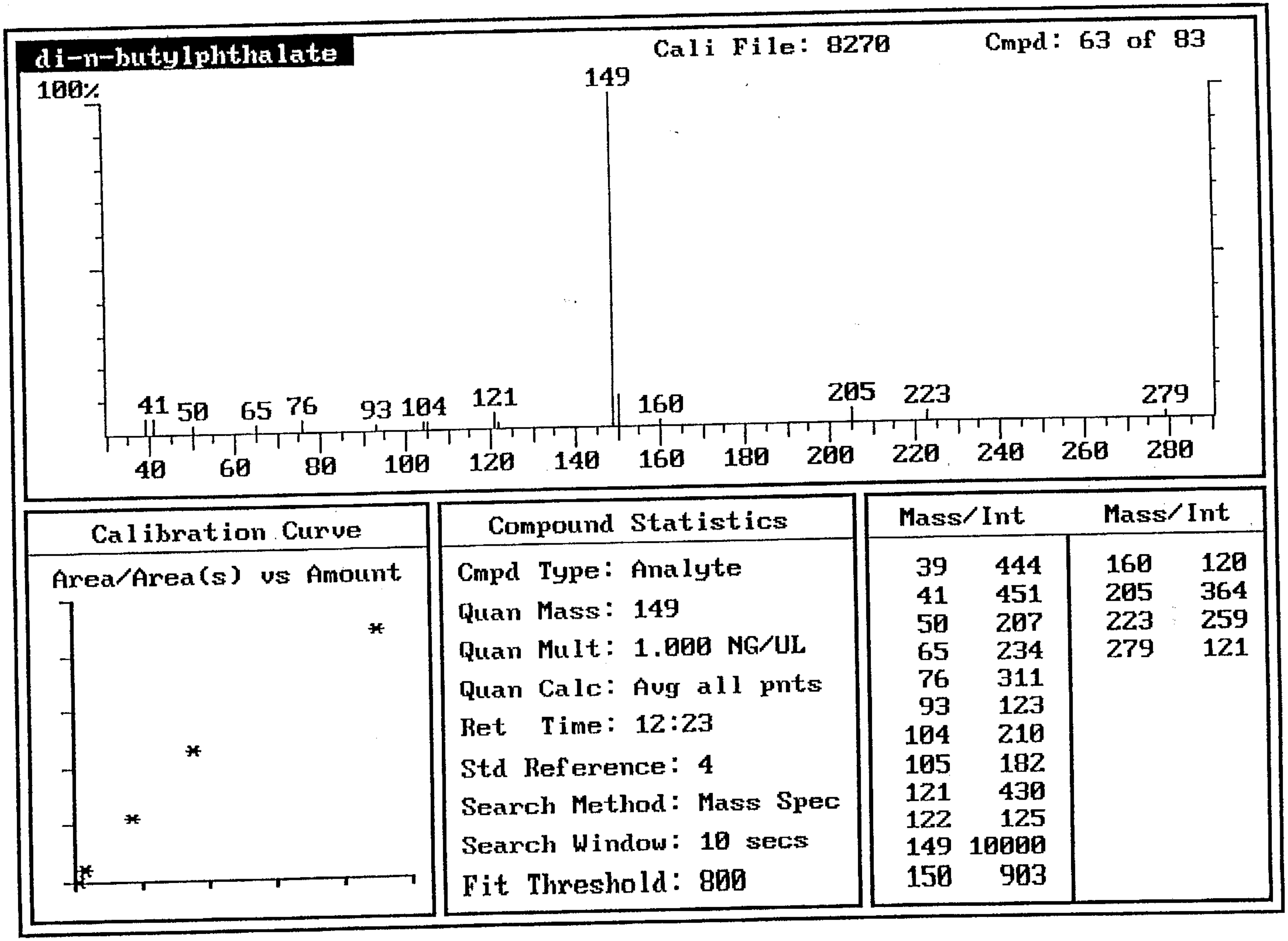
Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 178
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 11:32
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	278	176	1884
63	317	177	1161
74	241	178	10000
75	239	179	1497
76	452		
87	198		
88	284		
89	290		
150	615		
151	724		
152	1601		
175	195		





di-n-butylphthalate

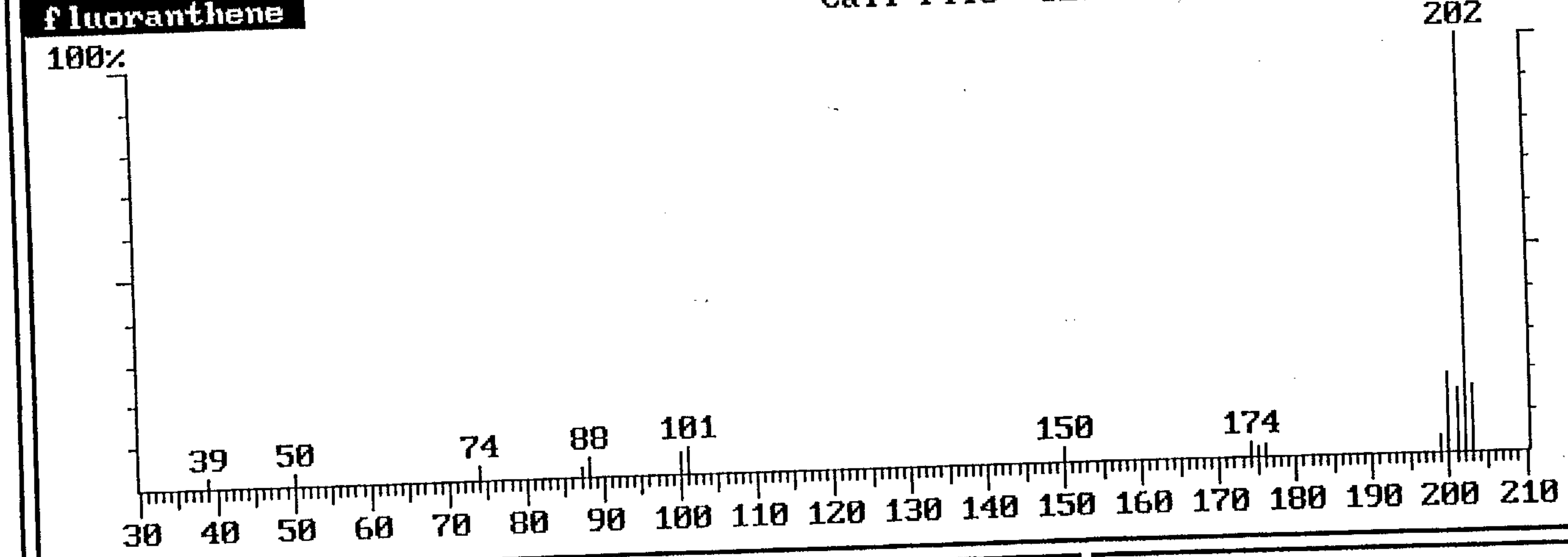
Cali File: 8270

Cmpd: 63 of 83

Cmpd Type: Analyte
Quan Mass: 149
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 12:23
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

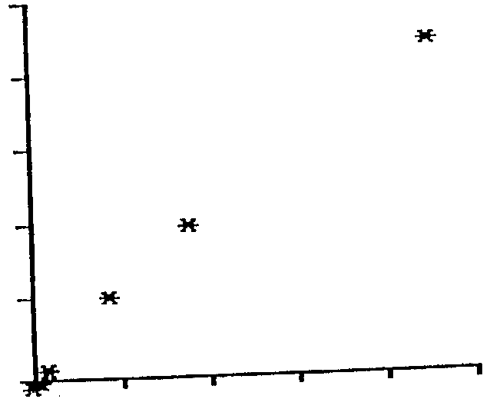
Mass/Int		Mass/Int	
39	444	160	120
41	451	205	364
50	207	223	259
65	234	279	121
76	311		
93	123		
104	210		
105	182		
121	430		
122	125		
149	10000		
150	903		

fluoranthene Cali File: 8270 Cmpd: 64 of 83



Calibration Curve

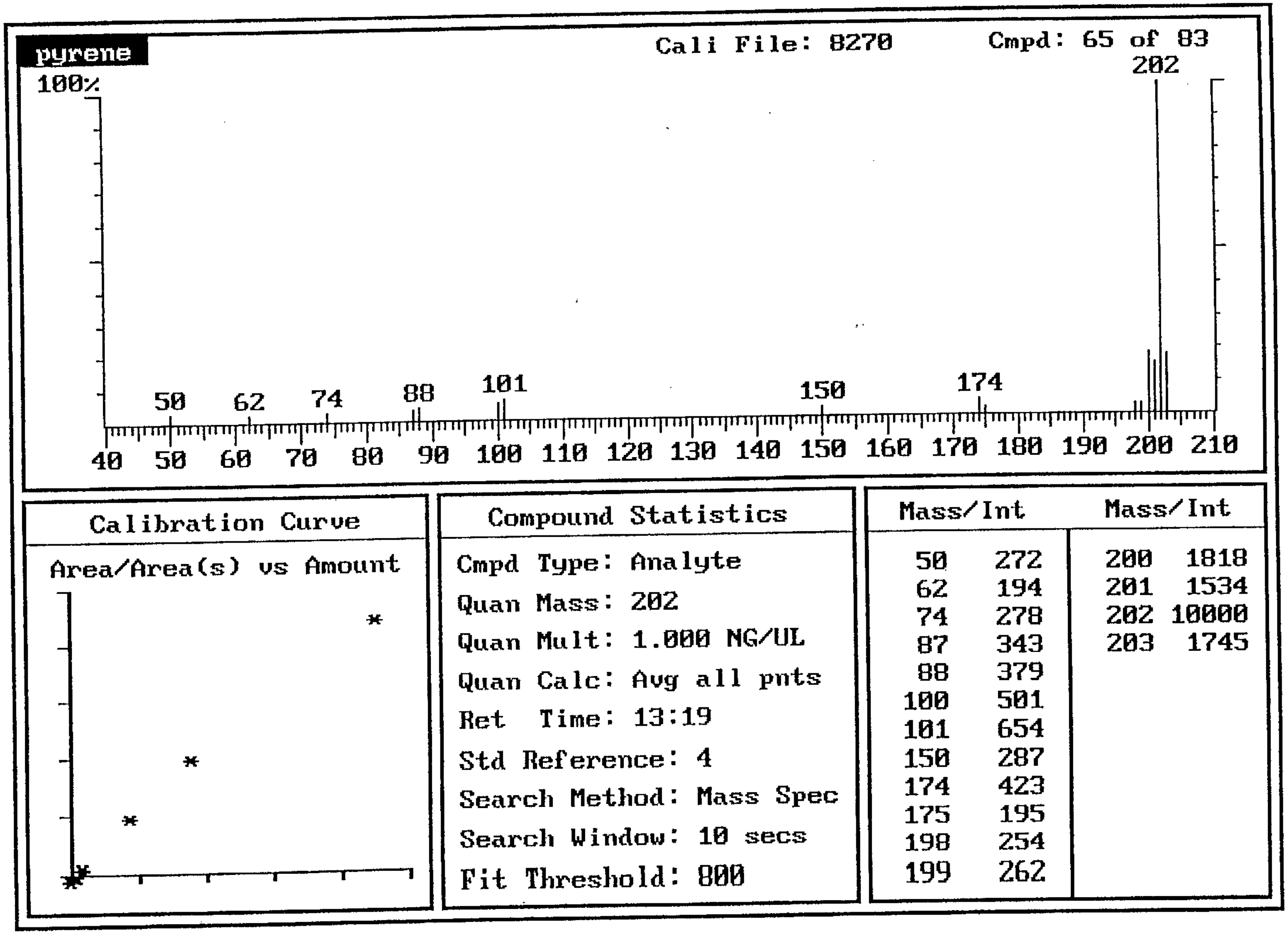
Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte
Quan Mass: 202
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 13:03
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	209	200	1890
50	242	201	1535
74	308	202	10000
87	229	203	1591
88	433		
100	492		
101	632		
150	341		
174	329		
175	215		
176	261		
199	374		



pyrene Cali File: 8270 Cmpd: 65 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 202

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 13:19

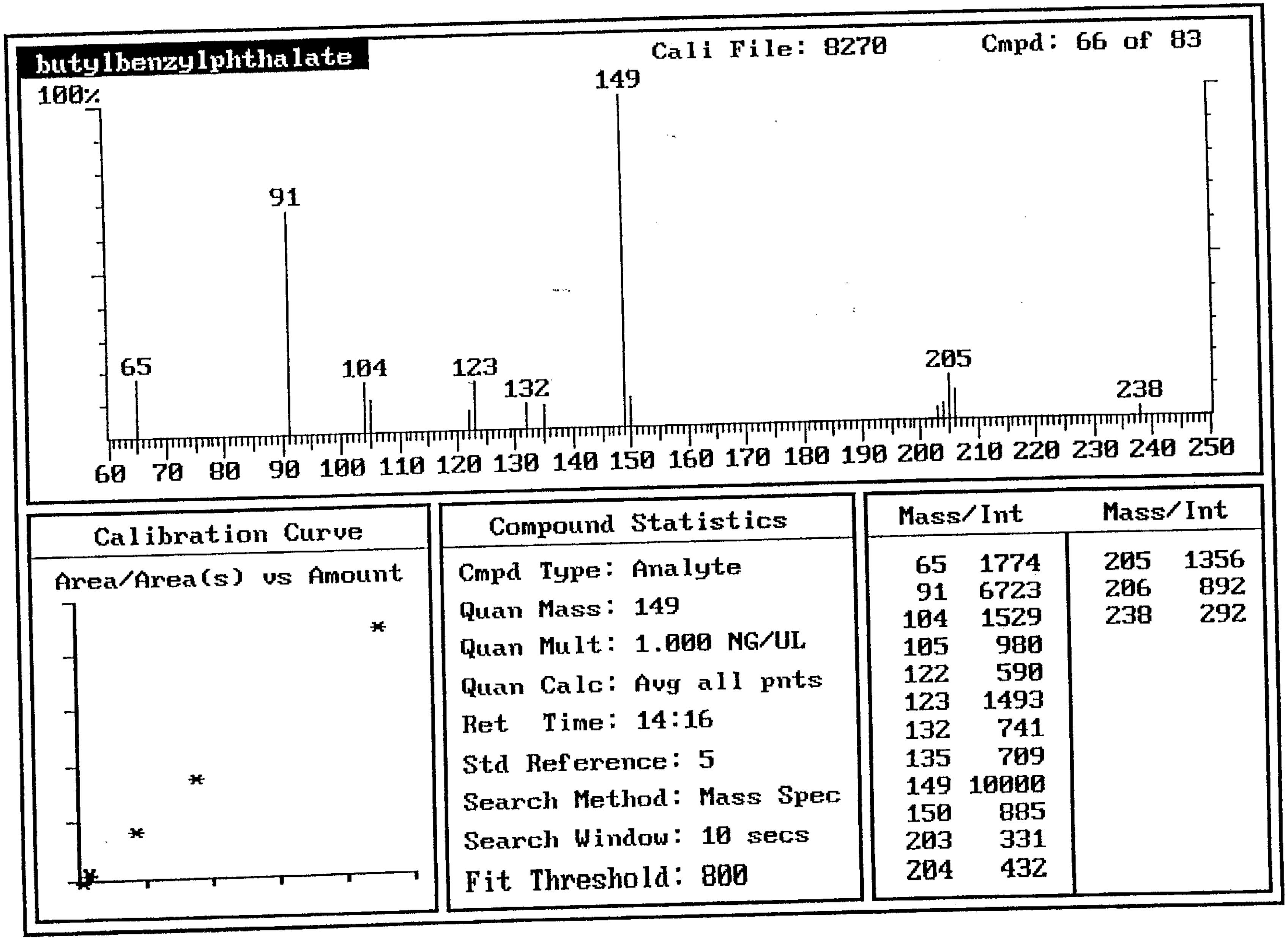
Std Reference: 4

Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 800

Mass/Int		Mass/Int	
50	272	200	1818
62	194	201	1534
74	278	202	10000
87	343	203	1745
88	379		
100	501		
101	654		
150	287		
174	423		
175	195		
198	254		
199	262		



butylbenzylphthalate

Cali File: 8270

Cmpd: 66 of 83

Calibration Curve

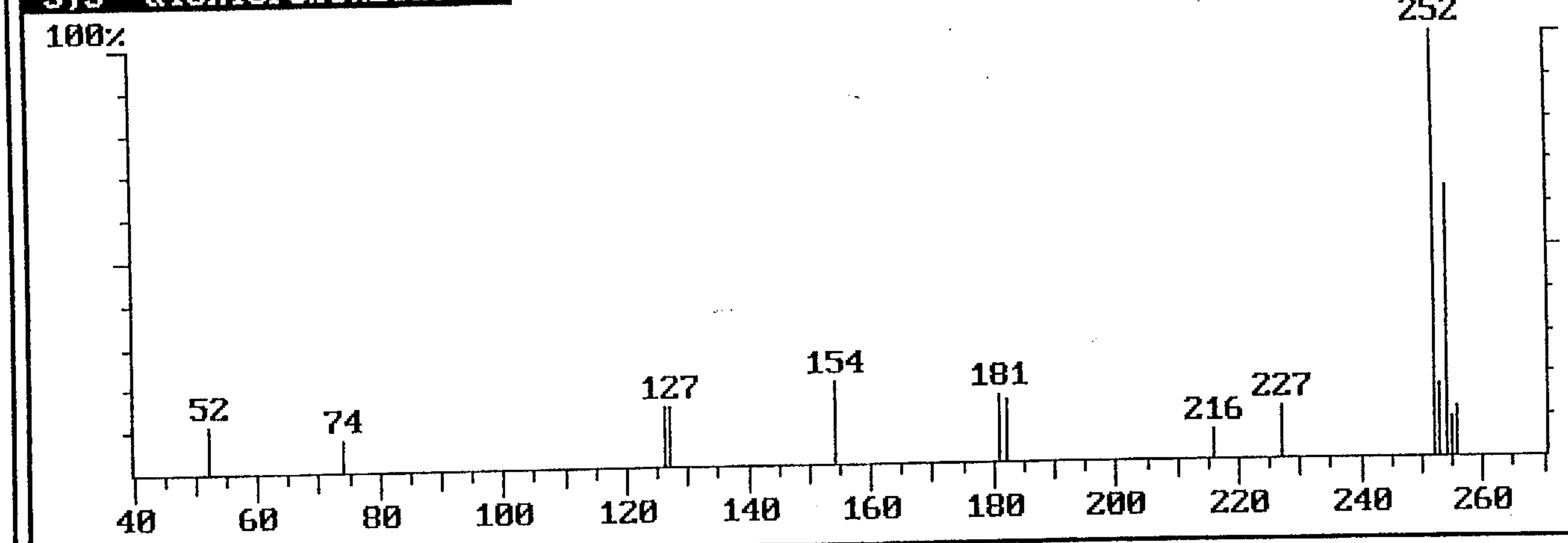
Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 149
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 14:16
Std Reference: 5
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

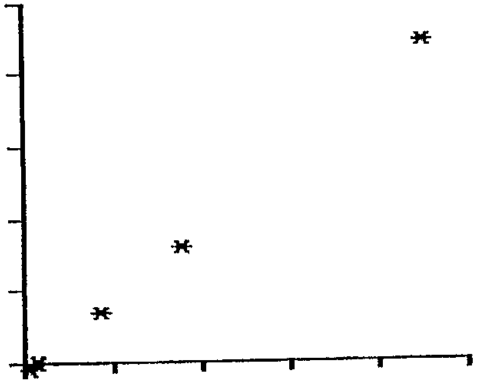
Mass/Int		Mass/Int	
65	1774	205	1356
91	6723	206	892
104	1529	238	292
105	980		
122	590		
123	1493		
132	741		
135	709		
149	10000		
150	885		
203	331		
204	432		

3,3'-dichlorobenzidine Cali File: 8270 Cmpd: 67 of 83



Calibration Curve

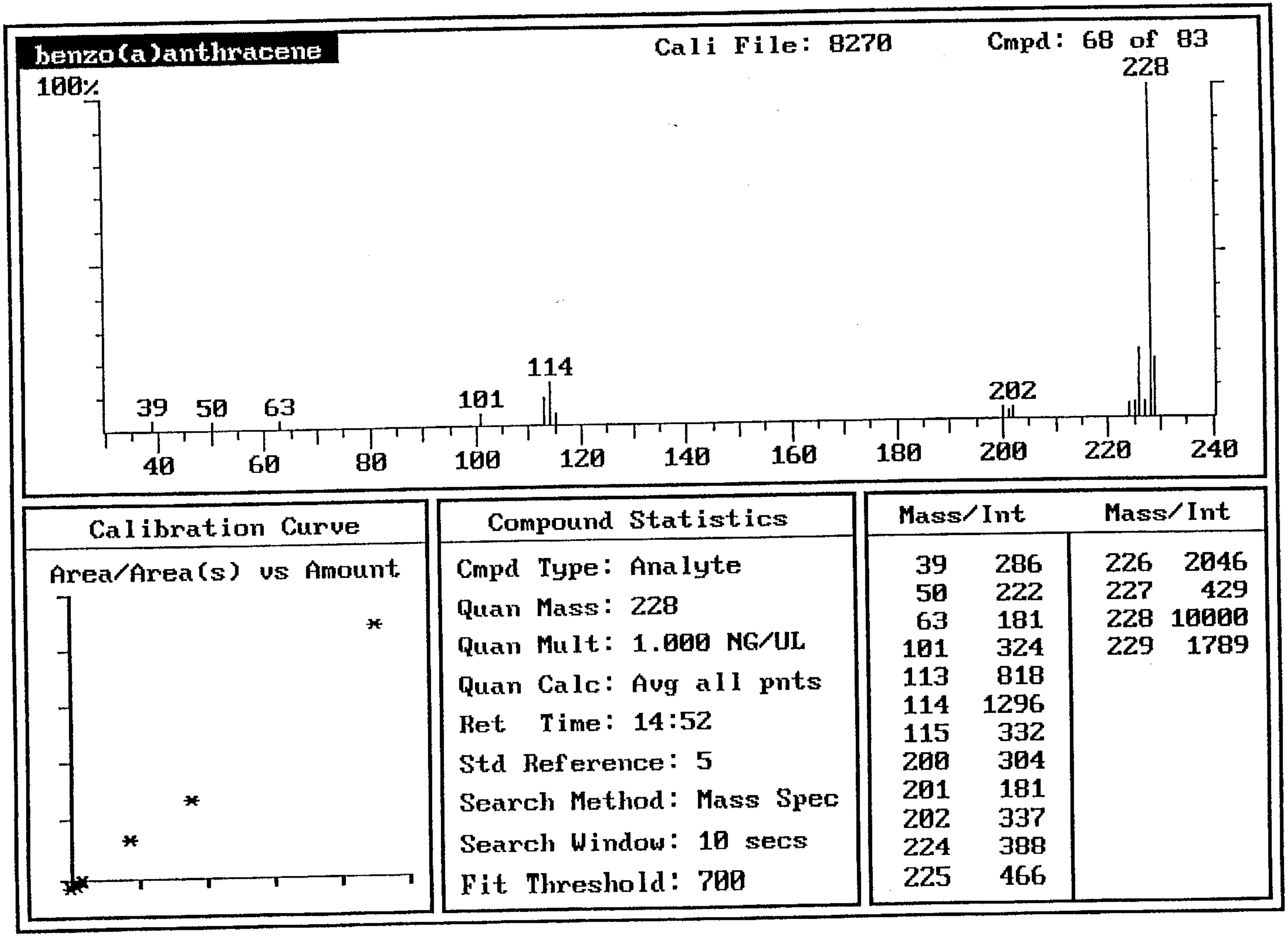
Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte
Quan Mass: 252+254
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 14:54
Std Reference: 5
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 600

Mass/Int		Mass/Int	
52	1081	255	942
74	758	256	1150
126	1401		
127	1431		
154	1959		
181	1600		
182	1455		
216	673		
227	1218		
252	10000		
253	1711		
254	6389		



benzo(a)anthracene

Cali File: 8270

Cmpd: 68 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 228

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 14:52

Std Reference: 5

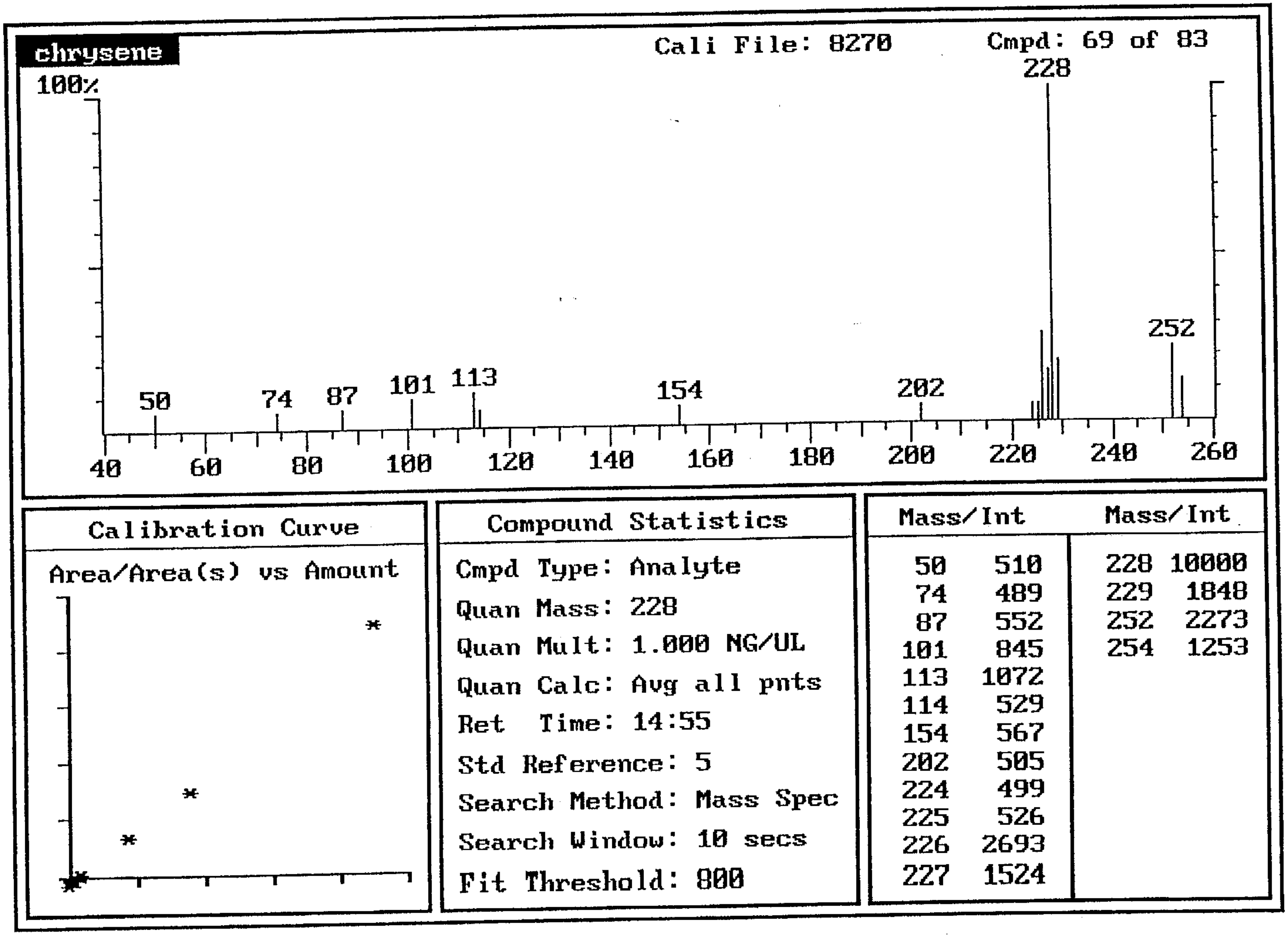
Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 700

Mass/Int	
39	286
50	222
63	181
101	324
113	818
114	1296
115	332
200	304
201	181
202	337
224	388
225	466

Mass/Int	
226	2046
227	429
228	10000
229	1789



chrysene   Cali File: 8270   Cmpd: 69 of 83

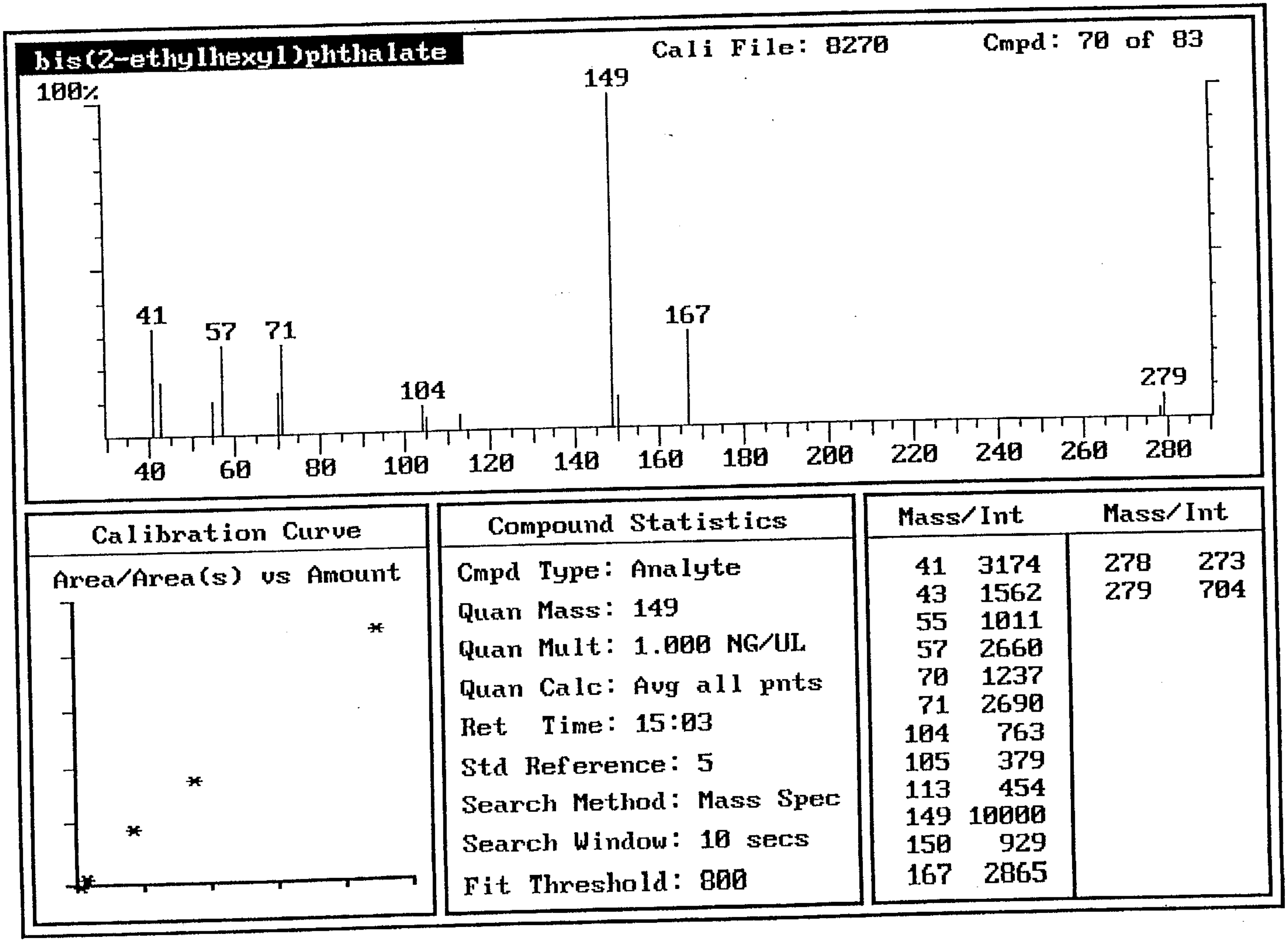
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 228
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 14:55
Std Reference: 5
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	510	228	10000
74	489	229	1848
87	552	252	2273
101	845	254	1253
113	1072		
114	529		
154	567		
202	505		
224	499		
225	526		
226	2693		
227	1524		



bis(2-ethylhexyl)phthalate

Cali File: 8270

Cmpd: 70 of 83

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 149

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 15:03

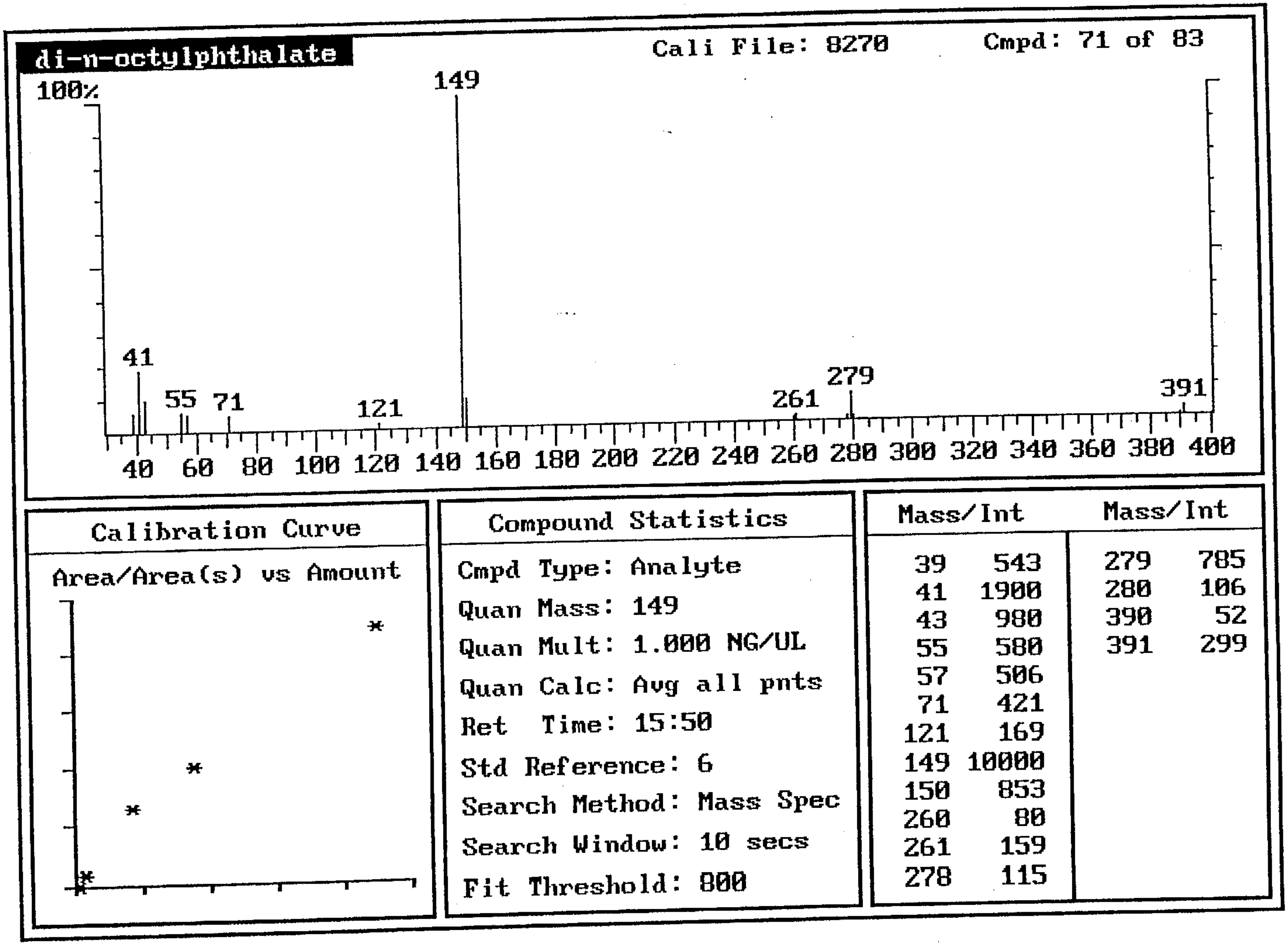
Std Reference: 5

Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 800

Mass/Int		Mass/Int	
41	3174	278	273
43	1562	279	704
55	1011		
57	2660		
70	1237		
71	2690		
104	763		
105	379		
113	454		
149	10000		
150	929		
167	2865		



di-n-octylphthalate Cali File: 8270 Cmpd: 71 of 83

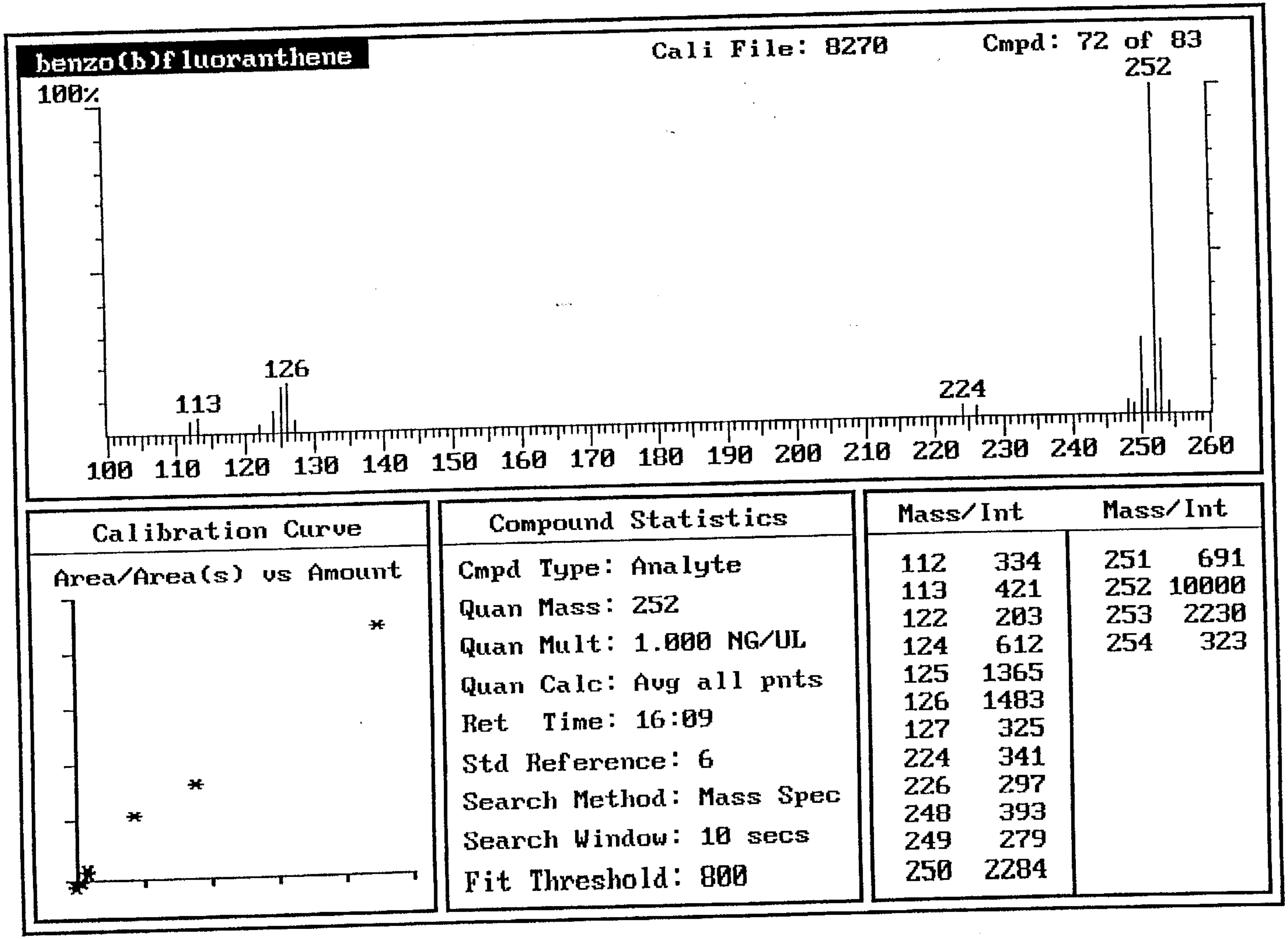
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 149
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 15:50
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
39	543	279	785
41	1900	280	106
43	980	390	52
55	580	391	299
57	506		
71	421		
121	169		
149	10000		
150	853		
260	80		
261	159		
278	115		



benzo(b)fluoranthene

Cali File: 8270

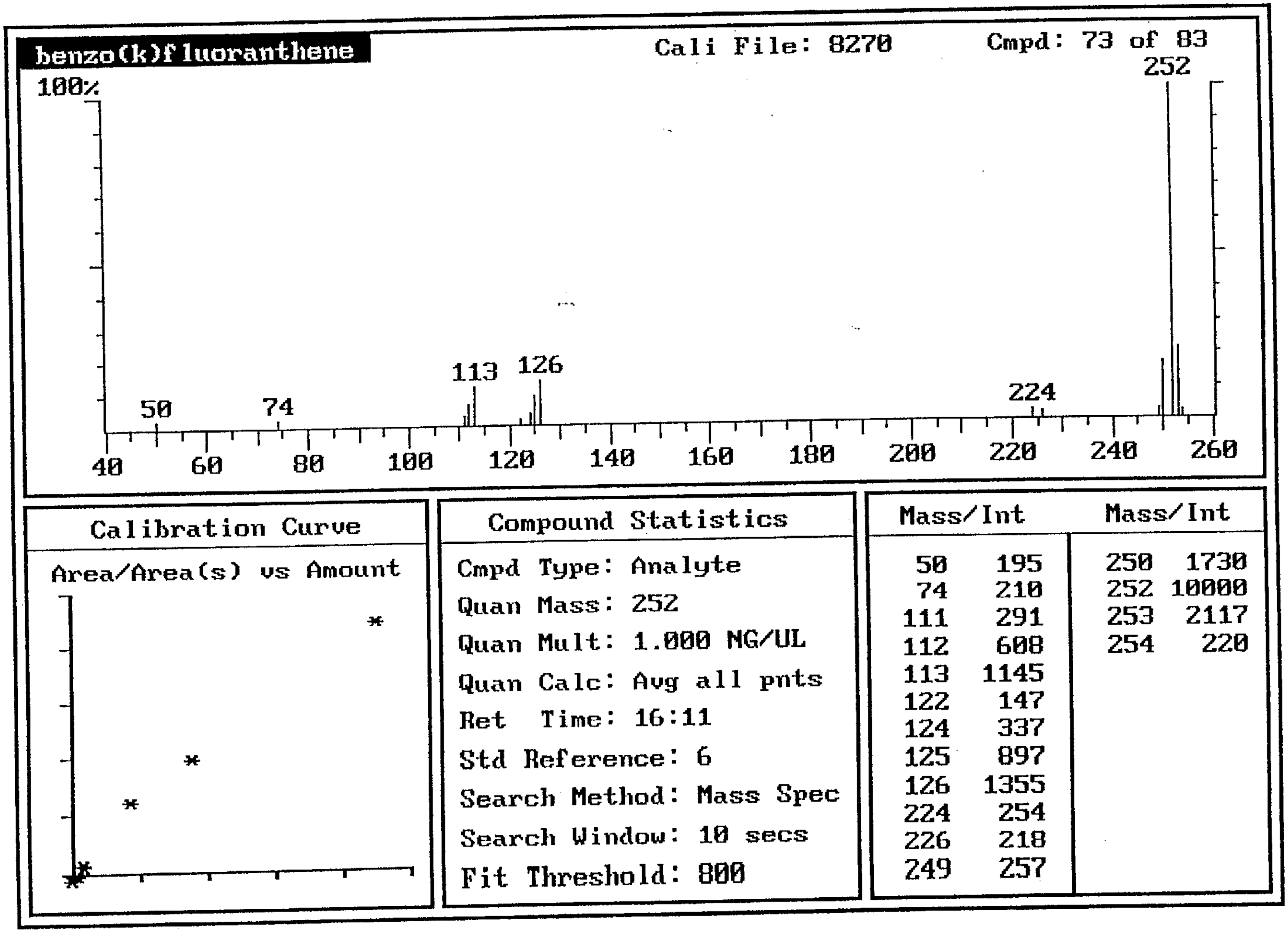
Cmpd: 72 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 252
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 16:09
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass	Int
112	334
113	421
122	203
124	612
125	1365
126	1483
127	325
224	341
226	297
248	393
249	279
250	2284

Mass	Int
251	691
252	10000
253	2230
254	323



benzo(k)fluoranthene Cali File: 8270 Cmpd: 73 of 83

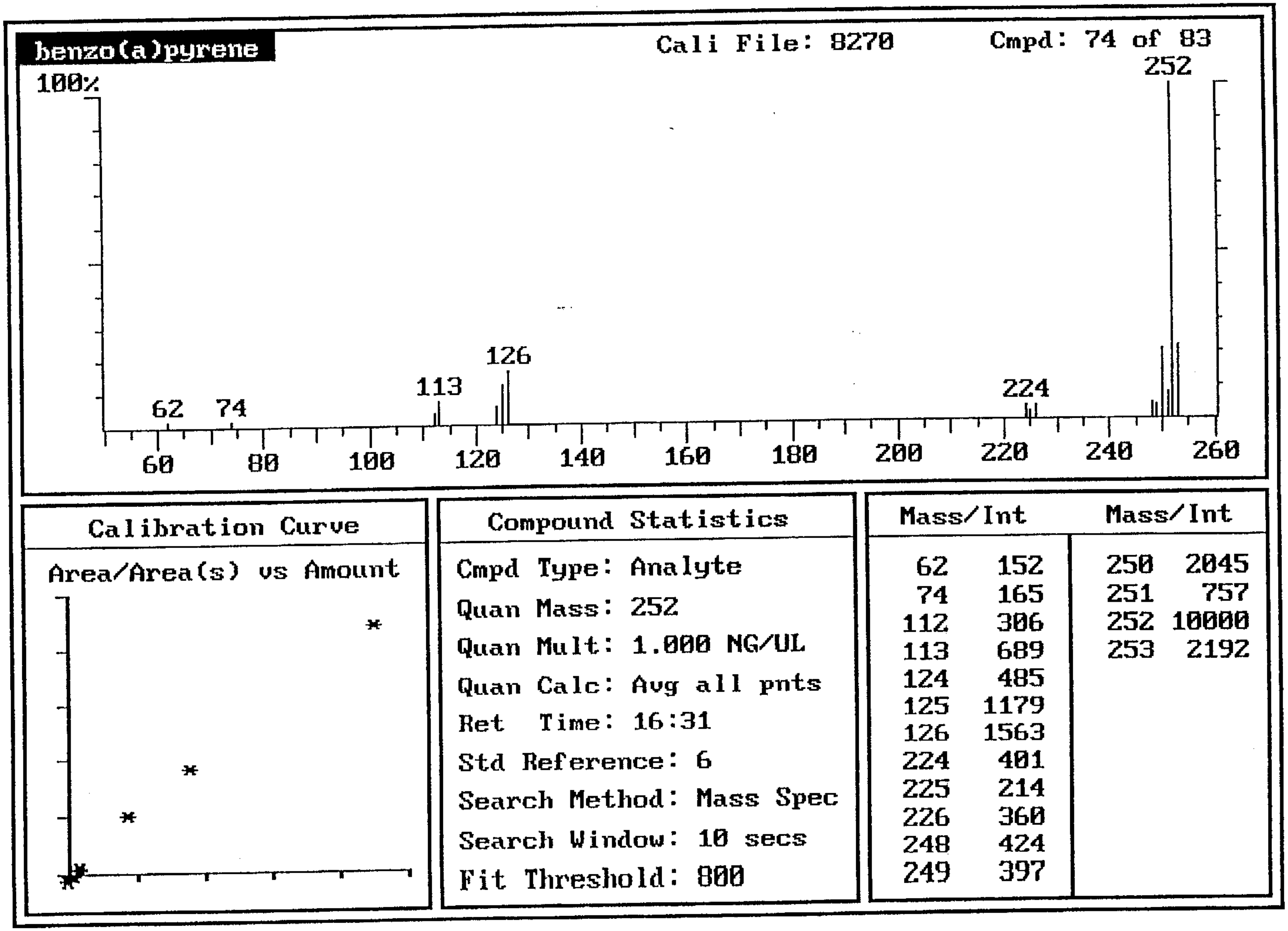
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 252
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 16:11
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	195	250	1730
74	210	252	10000
111	291	253	2117
112	608	254	220
113	1145		
122	147		
124	337		
125	897		
126	1355		
224	254		
226	218		
249	257		



benzo(a)pyrene

Cali File: 8270

Cmpd: 74 of 83

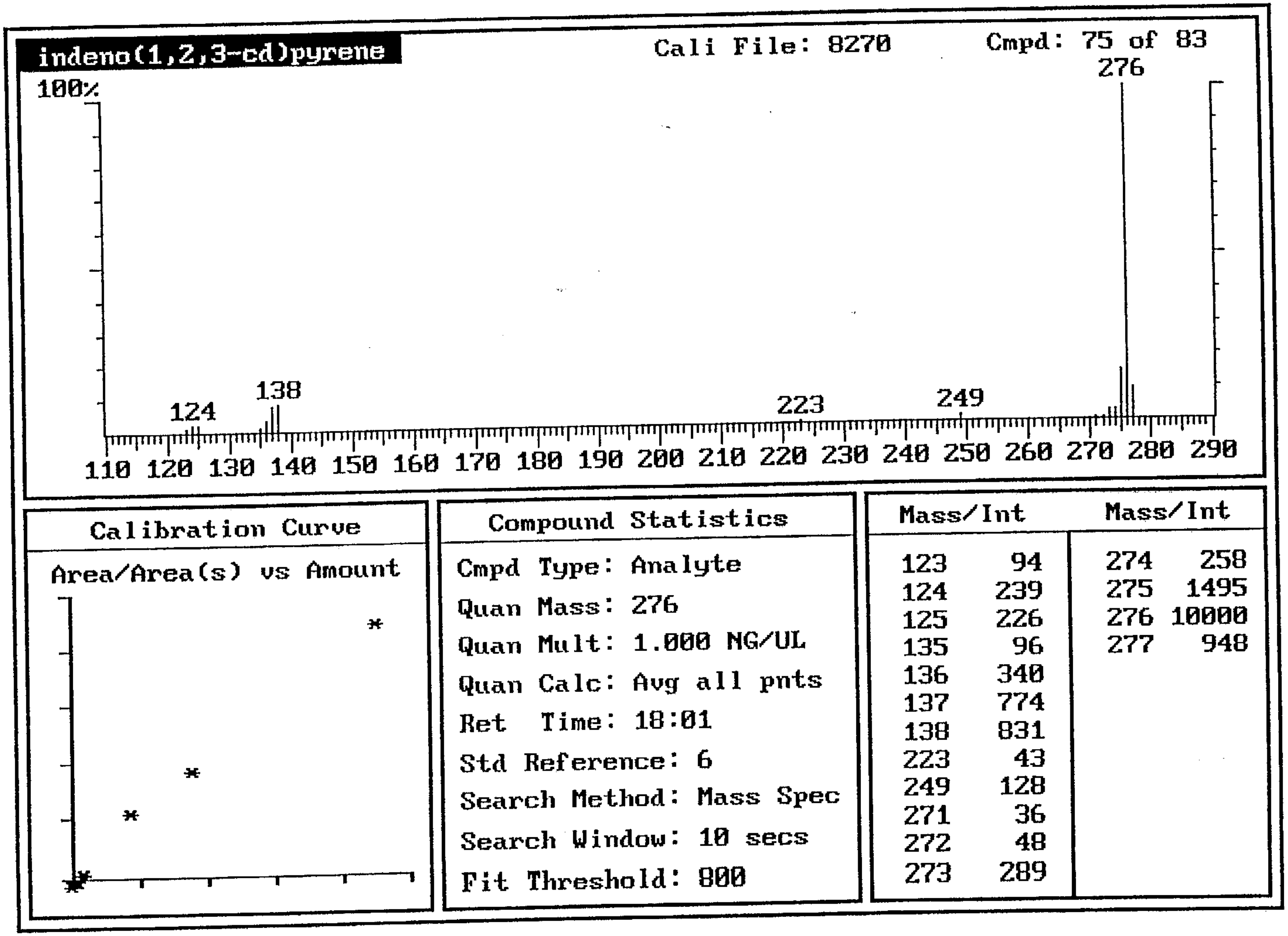
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 252
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 16:31
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
62	152	250	2045
74	165	251	757
112	306	252	10000
113	689	253	2192
124	485		
125	1179		
126	1563		
224	401		
225	214		
226	360		
248	424		
249	397		



indeno(1,2,3-cd)pyrene Cali File: 8270 Cmpd: 75 of 83

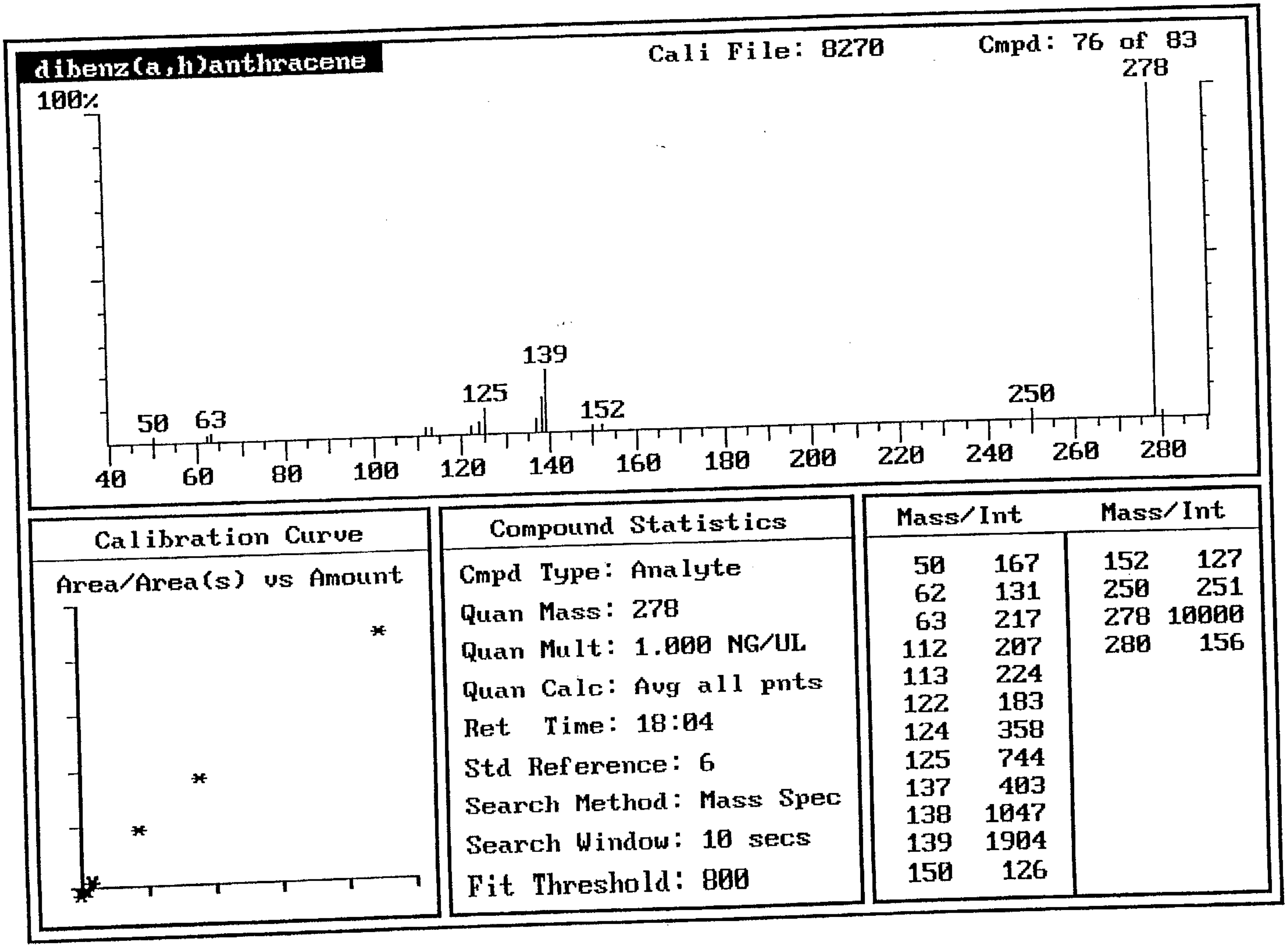
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 276
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 18:01
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
123	94	274	258
124	239	275	1495
125	226	276	10000
135	96	277	948
136	340		
137	774		
138	831		
223	43		
249	128		
271	36		
272	48		
273	289		



dibenz(a,h)anthracene

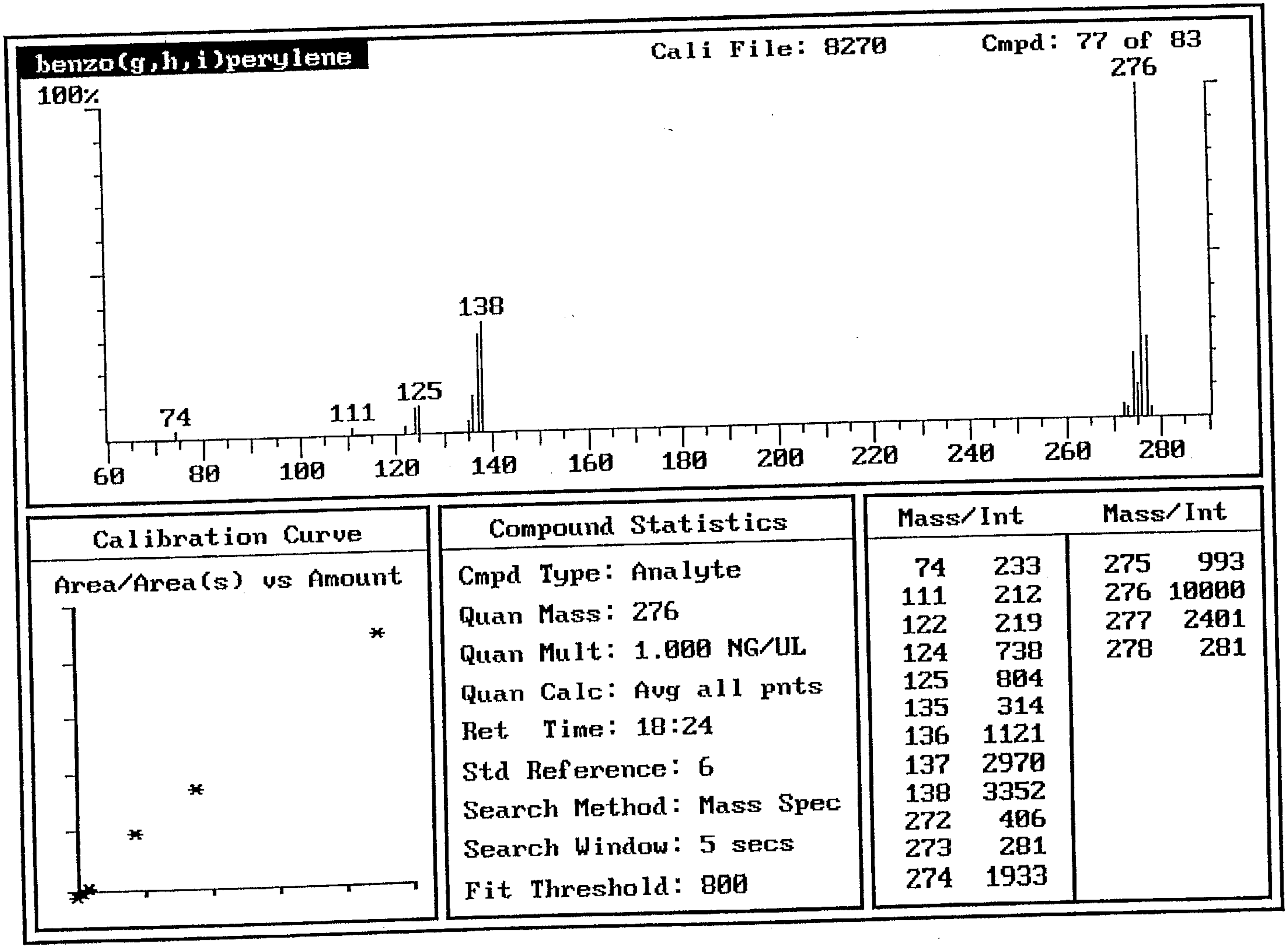
Cali File: 8270

Cmpd: 76 of 83

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 278
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 18:04
Std Reference: 6
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
50	167	152	127
62	131	250	251
63	217	278	10000
112	207	280	156
113	224		
122	183		
124	358		
125	744		
137	403		
138	1047		
139	1904		
150	126		



benzo(g,h,i)perylene

Cali File: 8270

Cmpd: 77 of 83

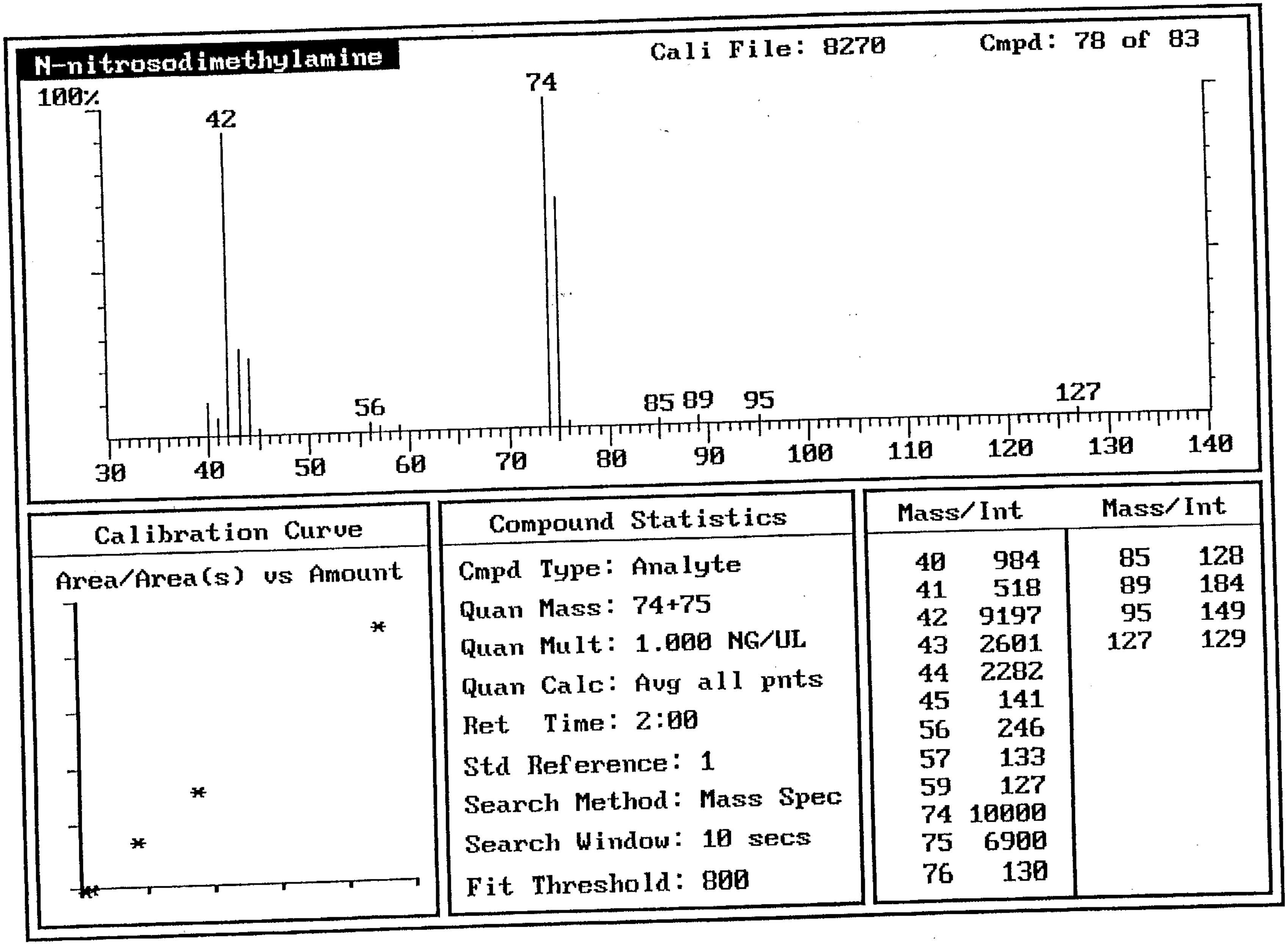
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 276
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 18:24
Std Reference: 6
Search Method: Mass Spec
Search Window: 5 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
74	233	275	993
111	212	276	10000
122	219	277	2401
124	738	278	281
125	804		
135	314		
136	1121		
137	2970		
138	3352		
272	406		
273	281		
274	1933		



N-nitrosodimethylamine

Cali File: 8270

Cmpd: 78 of 83

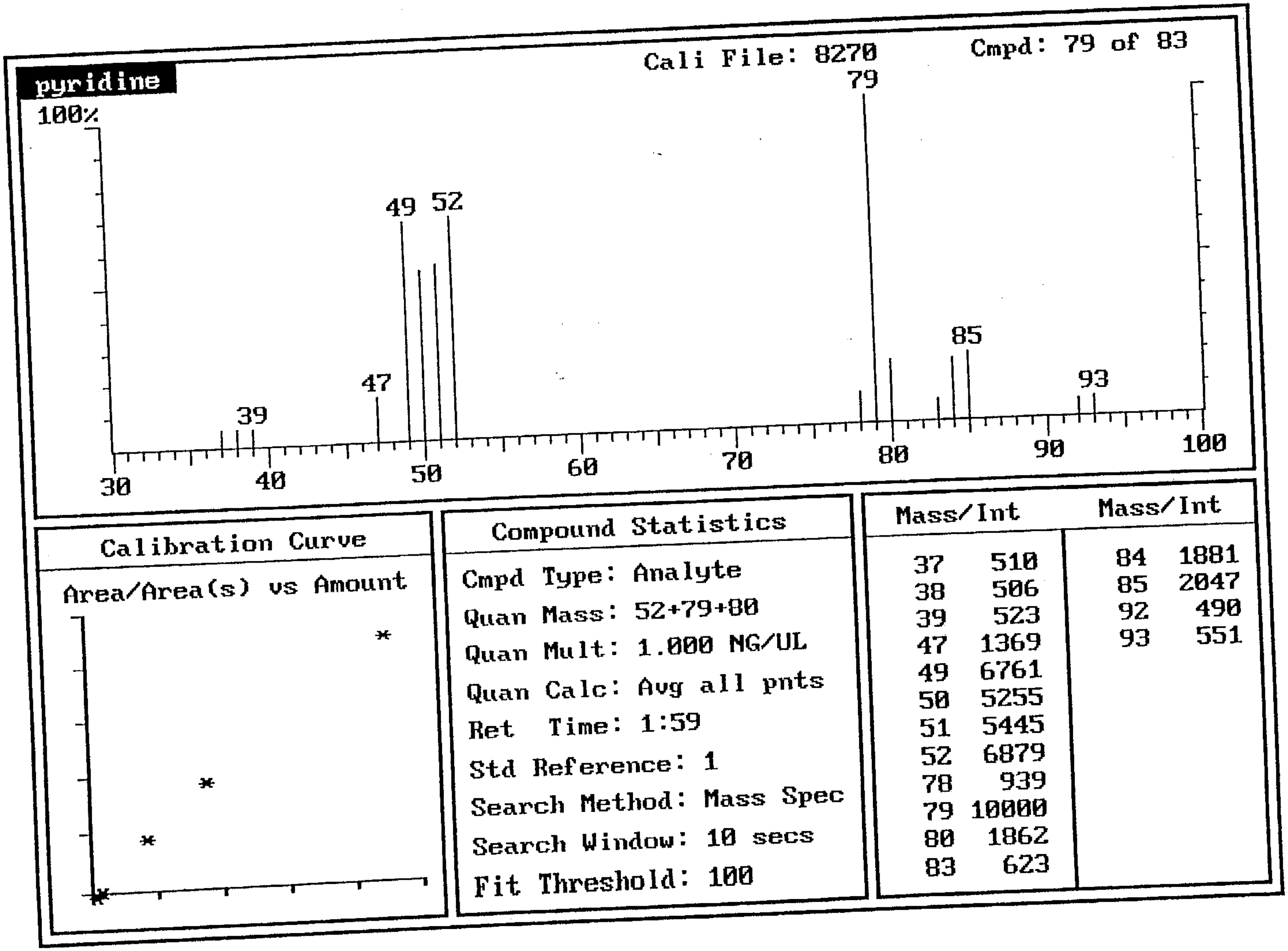
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 74+75
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 2:00
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
40	984	85	128
41	518	89	184
42	9197	95	149
43	2601	127	129
44	2282		
45	141		
56	246		
57	133		
59	127		
74	10000		
75	6900		
76	130		



pyridine

Cali File: 8270 Cmpd: 79 of 83

Calibration Curve

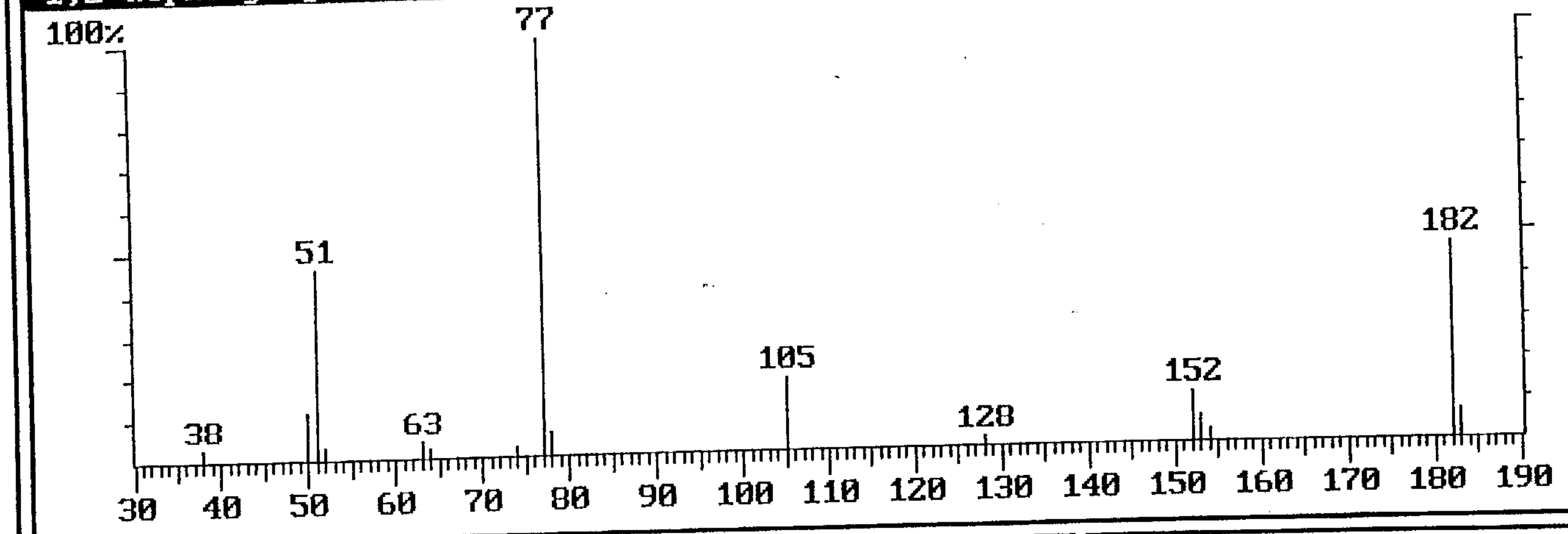
Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 52+79+80
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 1:59
Std Reference: 1
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 100

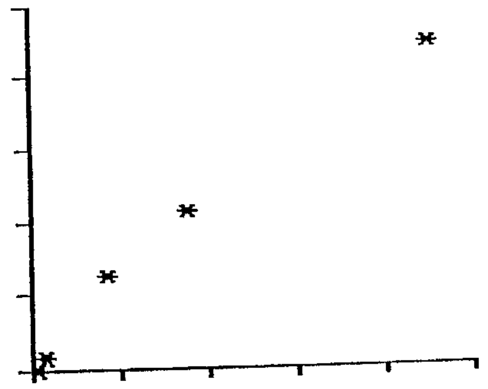
Mass/Int		Mass/Int	
37	510	84	1881
38	506	85	2047
39	523	92	490
47	1369	93	551
49	6761		
50	5255		
51	5445		
52	6879		
78	939		
79	10000		
80	1862		
83	623		

1,2-diphenylhydrazine Cali File: 8270 Cmpd: 80 of 83



Calibration Curve

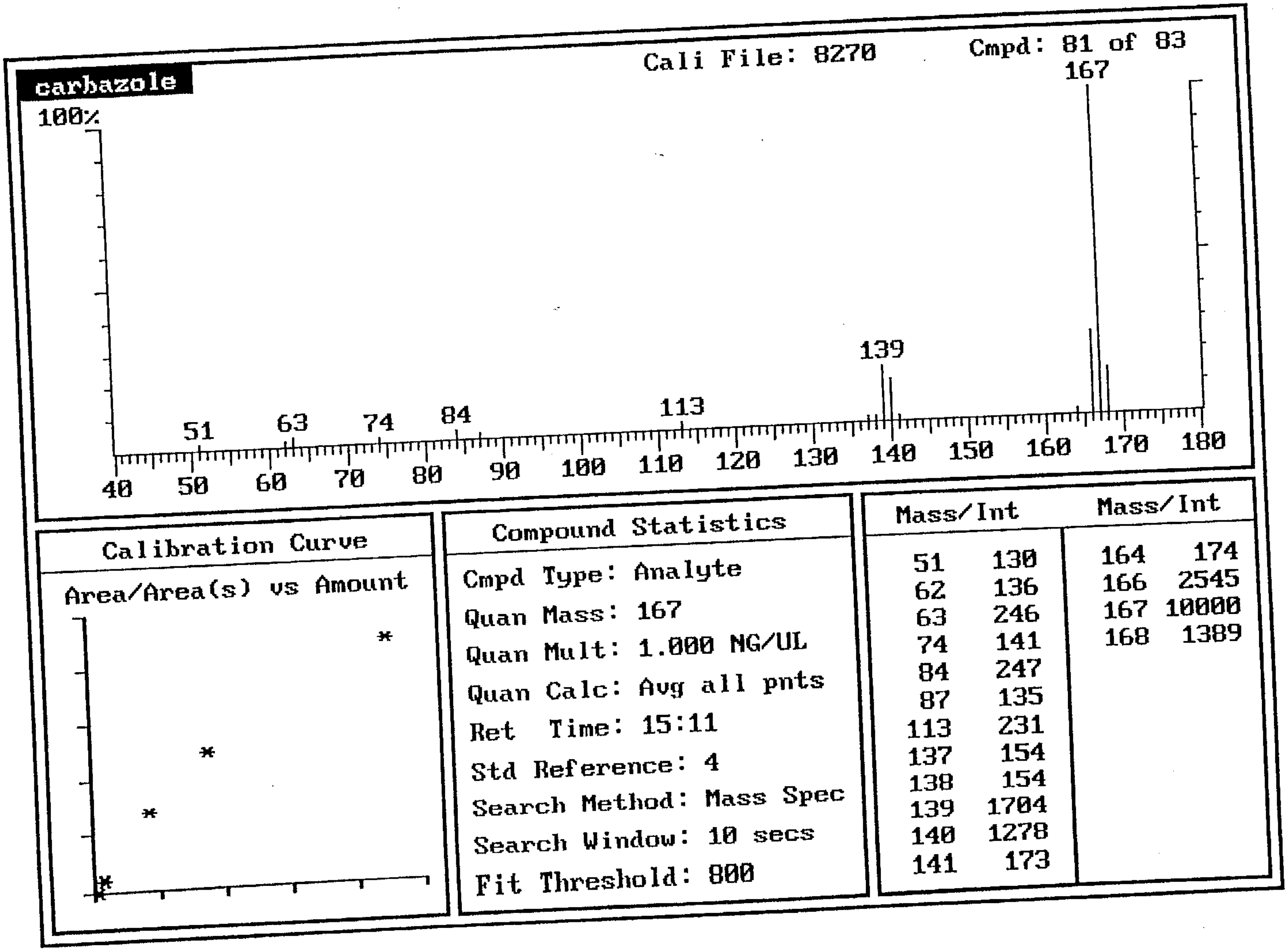
Area/Area(s) vs Amount



Compound Statistics

Cmpd Type: Analyte
Quan Mass: 77
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:40
Std Reference: 4
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
38	250	153	609
50	1166	154	256
51	4585	182	4696
52	275	183	675
63	367		
64	189		
74	217		
77	10000		
78	587		
105	1755		
128	214		
152	1230		



carbazole

Cali File: 8270

Cmpd: 81 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte

Quan Mass: 167

Quan Mult: 1.000 NG/UL

Quan Calc: Avg all pnts

Ret Time: 15:11

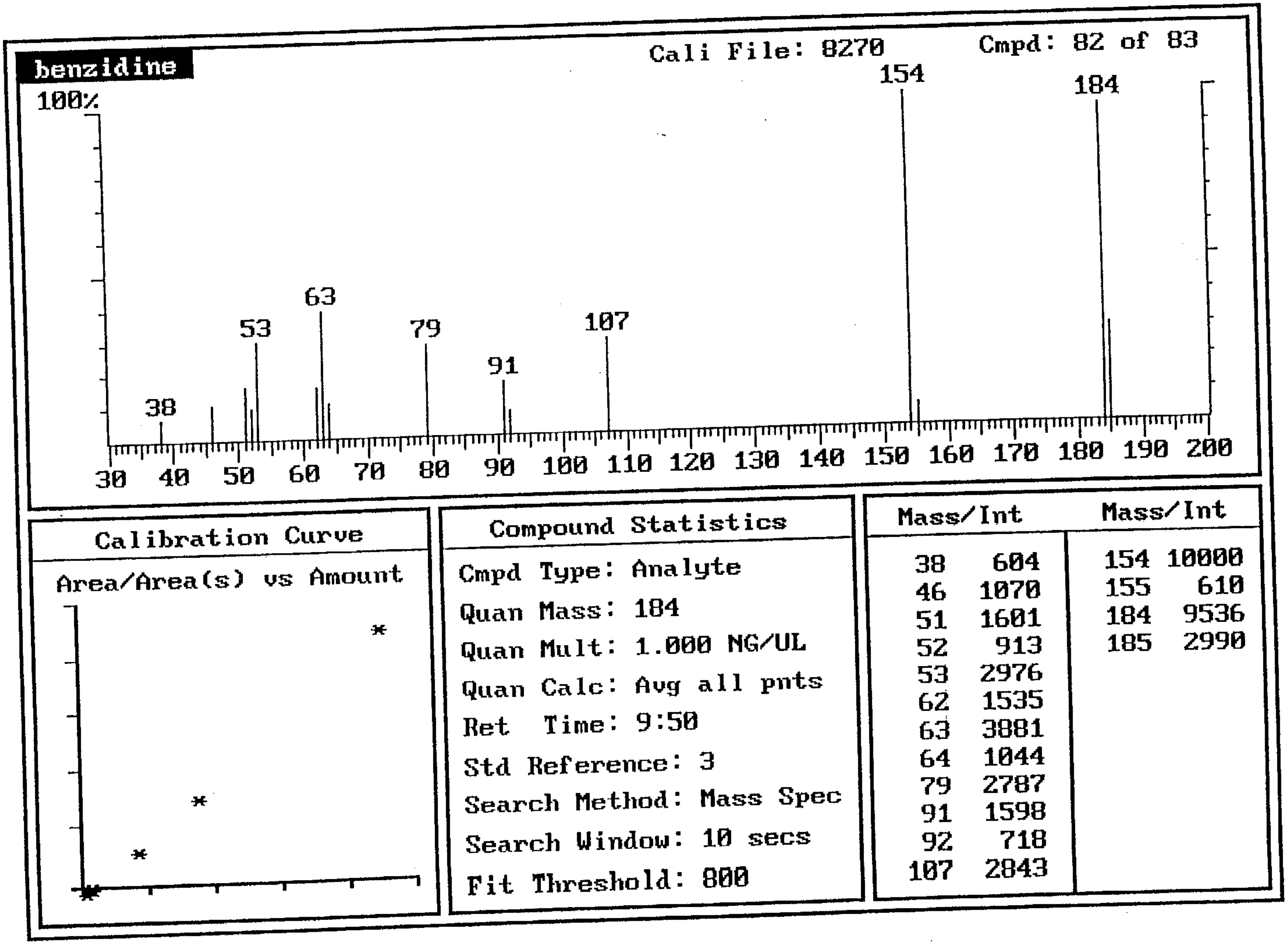
Std Reference: 4

Search Method: Mass Spec

Search Window: 10 secs

Fit Threshold: 800

Mass/Int		Mass/Int	
51	130	164	174
62	136	166	2545
63	246	167	10000
74	141	168	1389
84	247		
87	135		
113	231		
137	154		
138	154		
139	1704		
140	1278		
141	173		



benzidine

Cali File: 8270

Cmpd: 82 of 83

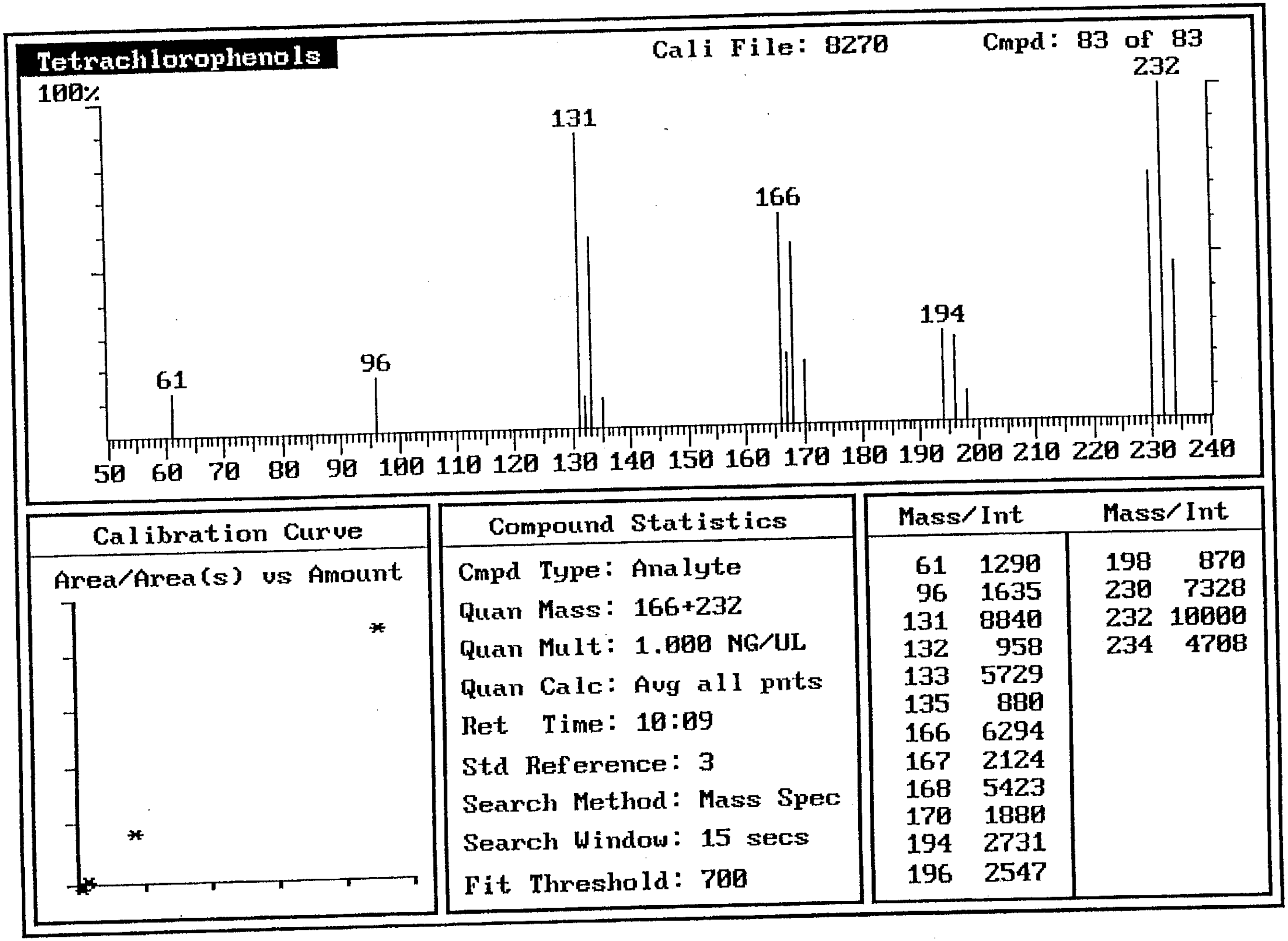
Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 184
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 9:50
Std Reference: 3
Search Method: Mass Spec
Search Window: 10 secs
Fit Threshold: 800

Mass/Int		Mass/Int	
38	604	154	10000
46	1070	155	610
51	1601	184	9536
52	913	185	2990
53	2976		
62	1535		
63	3881		
64	1044		
79	2787		
91	1598		
92	718		
107	2843		



Tetrachlorophenols

Cali File: 8270

Cmpd: 83 of 83

Calibration Curve

Area/Area(s) vs Amount

Compound Statistics

Cmpd Type: Analyte
Quan Mass: 166+232
Quan Mult: 1.000 NG/UL
Quan Calc: Avg all pnts
Ret Time: 10:09
Std Reference: 3
Search Method: Mass Spec
Search Window: 15 secs
Fit Threshold: 700

Mass/Int		Mass/Int	
61	1290	198	870
96	1635	230	7328
131	8840	232	10000
132	958	234	4708
133	5729		
135	880		
166	6294		
167	2124		
168	5423		
170	1880		
194	2731		
196	2547		

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SOP NO.: 0311.5
DATE: October 30, 2000
AUTHOR: FRZ
PAGE 1 OF 21

TITLE: Method 8260B Modified: Volatile Organic Compound Analysis using Finnigan Mat INCOS50 GC/MS

Approved By: ____________ Department Manager — 3/21/2001 Date

Approved By: ____________ Quality Assurance Director — 3-21-01 Date

Copy No.: 009

Issued To: K. Carpenter

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1. SCOPE AND APPLICATION

1.1. This SOP is used to determine the concentration of volatile organic compounds in aqueous, soil, or organic matrices. This method can be used to measure organic compounds that have boiling points below 200 C, insoluble or slightly soluble in water, and can elute from a capillary GC column in a Gaussian peak profile. However, for some target compounds, the quantitation limits are determined by purging efficiency and/or instrument response. Such compounds include low molecular weight halogenated hydrocarbons, aromatics, ketones, acetates, acrylates, ethers, and sulfides.

1.2. Analytes that are affected by any of the limitation stated above will be reflected in their corresponding detection limits and/or response factors.

1.3. The target compound list and associated reporting limits are provided in Table 1.

2. REFERENCES

2.1. Test Methods for Evaluating Solid Waste: SW-846, methods 8000B, 5030B, and 8260B.
2.2. Tekmar LSC 3000 Users Manual.
2.3. Finnigan MAT Incos50 Operator's Manual.
2.4. Varian Archon Autosampler Users Manual.

3. ASSOCIATED STANDARD OPERATING PROCEDURES

3.1. 0002.6, Internal Sample Transfer and Chain of Custody.
3.2. 0003.7, Sample Data Processing.
3.3. 0004.6, Preparation of Trip Blanks.

3.4. 0005.6, Sample Storage and Security.
3.5. 0010.3, Use and Maintenance of Laboratory Glassware.
3.6. 0012.7, Use and Maintenance of Laboratory Refrigerators.
3.7. 0016.4, Use and Maintenance of Automatic Dispensing Pipets.
3.8. 0029.6, Sample Handling Procedure for Drinking Water Samples.
3.9. 0030.5, Verification of Quality of Materials Used in the Laboratory.
3.10. 0032.5, SAS Sample Documentation.
3.11. 0314.0, Purge and Trap Volatile Organic Extraction, EPA SW-846 Method 5030B.
3.12. 0327.1, Instrument Maintenance for GC/MS Analysis System.
3.13. 0504.6, Client Contact Record keeping.
3.14. 0513.5, Data Reporting for Drinking Water Analysis.
3.15. 0521.1, Electronic Archiving Procedures.
3.16. 0600.5, Quality Control Charting and Establishing Method Warning and Action Limits.
3.17. 0605.4, Archiving Laboratory Logbooks
3.18. 0610.3, Laboratory Corrective Action Procedures.
3.19. 0612.3, Volatile Organic Standard Solution Record keeping.

4. DEFINITIONS

4.1. BFB = Bromofluorobenzene.
4.2. CCAL = continuing calibration standard.
4.3. Gases = Dichlorodifluoromethane, chloromethane, vinyl chloride, bromomethane, chloroethane, and trichlorofluoromethane.
4.4. non-Gases = Standard 54 component VOC mixture: See Attachment 2.
4.5. GC = gas chromatograph.
4.6. ICAL = initial calibration.
4.7. LCS = laboratory control sample i.e. secondary source standard.
4.8. LFB = laboratory fortified blank..
4.9. MDL = method detection limit.
4.10. PQL = Practical Quantitation Limit.
4.11. RPD = relative percent difference.
4.12. SOP = standard operating procedure.
4.13. TIC = tentatively identified compound.
4.14. VOA = Volatile Organic Analyte.
4.15. PPB = Parts per Billion.
4.16. VOC = Volatile Organic Compounds.

5. PROCEDURE

5.1. SUMMARY.

5.1.1. An automated purge and trap analysis system is utilized that employs analytical equipment designed to operate using 44 mL VOA vials. Therefore, before any sample can be analyzed, aqueous or otherwise, it must be prepared in such a way that the final sample for analysis is contained in a 44 mL VOA vial. Non-aqueous samples like oils, solids, and products CANNOT be sampled and analyzed in 44 mL VOA vials but must first be extracted in methanol and diluted to volume with DI H2O prior to analysis.

5.1.2. A 5 ml sample aliquot is automatically transfer from the VOA vial to a purge vessel at ambient temperature and purged with an inert gas(helium), collecting all purgeable analytes onto a organic trap. The trap is then heated and backflushed with an inert gas (helium) to desorb the compounds onto the capillary GC column. The GC temperature is increased at a specific rate thereby separating the analytes from the column by boiling point difference. As the analytes elute, they are introduced into the mass spectrometer via a jet separator and detected using the Finnigan MAT Incos50 Quadrupole detector. Identification of target analytes is accomplished by comparing their mass spectra with that of the NIST library spectra. Analyte quantitation is established by comparing the response of the quantitation ion to a multi-point internal standard calibration curve for that ion.

5.2. INTERFERENCE

5.2.1. A trip blank is prepared from reagent water at the time of sample collection and carried through all the handling, storage and analytical procedures to verify samples are not contaminated during shipment and storage.

5.2.2. Methylene chloride contamination is minimized by isolating the volatile samples from the general laboratory.

5.2.3. Carry over is reduced by analyzing rinse blanks after contaminated samples. Samples analyzed immediately after a sample with a high level of contamination may be reanalyzed if the analyst deems the data suspect.

5.3. SAMPLE HANDLING, PRESERVATION, AND HOLDING TIME REQUIREMENTS

5.3.1. Samples must be submitted to the laboratory in 44 ml VOA vials with Teflon-lined caps. Aqueous sample volumes can contain headspace no larger than 5 mm in diameter (a small pea). Samples must be preserved with concentrated hydrochloric acid to a pH of less than two. Ascorbic acid preservation is required if free chlorine is present. However, it is the responsibility of the sampler, not the laboratory, to test for and treat appropriately any free chlorine that is detected.

5.3.2. Soil and non-aqueous samples submitted for 5030 must be contained in glass jars with Teflon lined caps and as little headspace as possible; 5035 samples must be contained in pre-weighed glass jars with Teflon lined caps and containing the known volume of methanol.

5.3.3. Soil samples submitted for 5035 low soil analysis must be contained in 44 mL VOA vials containing 5 mL of NaHSO4 preserved deionized water.

5.3.4. All samples must be analyzed within 14 days of sampling.

5.4. EQUIPMENT

5.4.1. Varian Archon 2000 Autosampler.

5.4.2. Tekmar 3000 Thermal Desorption Unit.
5.4.3. Varian 3400 GC.
5.4.4. DB-624 GC capillary column, 75 meters, 3 micrometer film thickness, 0.54 micrometer inner diameter.
5.4.5. Finnigan MAT Incos50 Quadrupole mass spectrometer.
5.4.6. Finnigan MAT Magnum Data System with NIST Library.
5.4.7. Barnstead B-Pure Water Purification System.
5.4.8. Supelco Type K Sorbent Trap.

5.5. REAGENTS AND STANDARDS
5.5.1. Methanol, purge and trap grade.
5.5.2. <u>Stock Standards</u>
5.5.2.1. <u>ICAL Standards</u>
5.5.2.1.1. The **gases** are purchased as a mixture at 200 ug/mL and are A2LA/ISO-9001 Certified.
5.5.2.1.2. The **non-gases** are purchased as a mixture at 2000 ug/mL and are A2LA/ISO-9001 Certified.
5.5.2.1.3. A 10,000 ppm **ketones stock** standard is prepared by combining and diluting the following amounts of neat materials with 35 milliliters of methanol: 441 uL of 2-butanone, 441 uL of acetone, 441 uL of 2-hexanone, and 441 uL of 4-methyl-2-pentanone.
5.5.2.1.4. A 10,000 ppm **carbon disulfide** stock standard is prepared by diluting 280 uL of the neat material to 35 milliliters with methanol.
5.5.2.1.5. A 10,000 ppm **vinyl acetate** stock standard is prepared by diluting 378 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.6. A 10,000 ppm **2-chloroethyl vinyl** ether stock standard is prepared by diluting 336 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.7. A 10,000 ppm **1,3,5-trichlorobenzene** stock standard is prepared by diluting 350 mg of the neat material with 35 milliliters of methanol.
5.5.2.1.8. A 10,000 ppm **hexane** stock standard is prepared by diluting 539 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.9. A 10,000 ppm **tetrahydrofuran** stock standard is prepared by diluting 392 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.10. A 10,000 ppm **benzyl chloride** stock standard is prepared by diluting 322 uL of neat material with 35 milliliters of methanol.
5.5.2.1.11. A 10,000 ppm **1,1,2-trichlorotrifluoroethane** stock standard is prepared by diluting 224 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.12. A 10,000 ppm **Iodomethane** stock standard is prepared by diluting 154 uL of the neat material with 35 milliliters of methanol.
5.5.2.1.13. A 10,000 ppm **trans-1,4-dichloro-2-butene** stock standard is prepared by diluting 301 uL of the neat material with 35 milliliters of methanol.

- 5.5.2.1.14. A 10,000 ppm **cis-1,4-dichloro-2-butene** stock standard is prepared by diluting 308 uL of the neat material with 35 milliliters of methanol.
- 5.5.2.1.15. A 10,000 ppm **F-List stock** standard is prepared by diluting 392 uL of neat ethyl acetate and 497 uL of diethyl ether with 35 milliliters of methanol.
- 5.5.2.1.16. A 1000 ppm **acrolein/acrylonitrile** standard is purchased as a mixture.
- 5.5.2.1.17. A 2000 ppm **toluene** standard; purchased as a single component solution.
- 5.5.2.1.18. 2000 ppm **TCLP mix**; purchased as a mixture.
- 5.5.2.1.19. 200 ppm **TCLP Spike**; prepared in 5.0 milliliters of methanol as described below:
  - 5.5.2.1.19.1. **Toluene**, 1000 uL of 2000 ppm stock.
  - 5.5.2.1.19.2. **TCLP mixture**, 1000 uL of 2000 ppm stock.
- 5.5.2.1.20. A 10,000 ppm **1,4-dioxane** stock standard is prepared by diluting 343 uL of neat material with 35 milliliters of methanol.
- 5.5.2.1.21. A 10,000 ppm **methyl tert-butyl ether** stock standard is prepared by diluting 476 uL of neat material with 35 milliliters of methanol.
- 5.5.2.1.22. A 10,000 ppm **methacrylonitrile** stock standard is prepared by diluting 441 uL of neat material with 35 milliliters of methanol.
- 5.5.2.1.23. A 10,000 ppm **cyclohexane** stock standard is prepared by diluting 455 uL of neat material with 35 milliliters of methanol.

5.5.2.2. <u>LCS Standards</u>

- 5.5.2.2.1. The **gases** are purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.
- 5.5.2.2.2. The **non-gases** are purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.
- 5.5.2.2.3. The **additions** solution is purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.
- 5.5.2.2.4. The **acrolein/acrylonitrile** solution is purchased as a mixture from an alternate source as the ICAL standards at 1000 ug/mL.
- 5.5.2.2.5. The 25 ppm **gases** are prepared by diluting 250 uL of the 200 ppm LCS gases to 2 mL with methanol.
- 5.5.2.2.6. The 25 ppm **non-gases** are prepared by diluting 250 uL of the 200 ppm LCS non-gases to 2 mL with methanol.
- 5.5.2.2.7. The 25 ppm **additions** are prepared by diluting 250 uL of the 200 ppm LCS additions to 2 mL with methanol.

5.5.2.3. <u>Tuning Standards</u>

- 5.5.2.3.1. Tuning is performed off the BFB added in the Internal Standard/ Surrogate during sample transfer and purge.

5.5.2.4. <u>Internal Standards and Surrogate Standards</u>

- 5.5.2.4.1. The following internal standard and surrogate compounds are purchased neat: Pentafluorobenzene, 1,4-Dichlorobenzene-d4, Chlorobenzene-d5, 1,4-Difluorobenzene, Dibromofluoromethane, Toluene-d8, 4-Bromofluorobenzene, Fluorobenzene, and Ethylbenzene-d10.

5.5.2.4.2. A 10,000 ug/mL Internal Standard and Surrogate Mixture is prepared by diluting 165 uL of Pentafluorobenzene, 225 uL of 1,4-Difluorobenzene, 159 uL of Chlorobenzene-d5, 250 mg of 1,4-Dichlorobenzene-d4, 103 uL of Dibromofluoromethane, 265 uL of Toluene-d8, 157 uL of Bromofluorobenzene, 244 uL of Fluorobenzene, and 263 uL of Ethylbenzene-d10 to 25 mL with methanol.

5.5.3. <u>Working Standards</u>

- 5.5.3.1. <u>ICAL Standards for Water Analysis:</u>
  - 5.5.3.1.1. 200 ppm **Gases**; purchased as a mixture at 200 ug/mL and are A2LA/ISO-9001 Certified.
  - 5.5.3.1.2. 200 ppm **non-Gases**; prepared by diluting the following to 30 milliliters with methanol:
    - 5.5.3.1.2.1. **Carbon disulfide**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.2. **trans-1,4-Dichloro-2-butene**, 3000 uL of 10,000 ppm stock.
    - 5.5.3.1.2.3. **Iodomethane**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.4. **Benzyl chloride**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.5. **Vinyl acetate**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.6. **1,1,2-Trichlorotrifluoroethane**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.7. **VOC components**, 3000 uL of 2000 ppm stock.
    - 5.5.3.1.2.8. **1,3,5-Trichlorobenzene**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.9. **Hexane**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.2.10. **Tetrahydrofuran**, 3000 uL of 10,000 ppm stock.
    - 5.5.3.1.2.11. **cis-1,4-Dichloro-2-butene**, 3000 uL of 10,000 ppm stock.
  - 5.5.3.1.3. 200 ppm Additions; dilute the following to 30 mL with methanol:
    - 5.5.3.1.3.1. **Ketone mixture**, 3000 uL of 10,000 ppm stock.
    - 5.5.3.1.3.2. **F-list**, 3000 uL of 10,000 ppm stock.
    - 5.5.3.1.3.3. **2-Chloroethylvinyl ether**, 3000 uL of 10,000 ppm stock.
    - 5.5.3.1.3.4. **Methyl tert-butyl ether**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.3.5. **Cyclohexane**, 600 uL of 10,000 ppm stock.
    - 5.5.3.1.3.6. **n-Butanol**, 741 uL of the neat solution.
    - 5.5.3.1.3.7. **iso-Butanol**, 716 uL of the neat solution.
    - 5.5.3.1.3.8. **1,4-Dioxane**, 580 uL of the neat solution.
  - 5.5.3.1.4. 1000 ppm **acrolein/acrylonitrile**; purchase as a mixture.
  - 5.5.3.1.5. 200 ppm **TCLP Spike**; prepared in 10 milliliters of methanol as described below:
    - 5.5.3.1.5.1. **Toluene**, 1000 uL of 2000 ppm stock.
    - 5.5.3.1.5.2. **TCLP mixture**, 1000 uL of 2000 ppm stock.
    - 5.5.3.1.5.3. 250 ppm **Internal standard/Surrogate**, 5875 uL of 10,000 ppm stock diluted to 235 milliliters with methanol.

5.5.3.2. ICAL Standards for Low Soil Analysis:

  5.5.3.2.1. 200 ppm **Gases**; prepared by diluting 250 uL of 200 ppm ICAL gases stock to 2.0 mL with methanol.

  5.5.3.2.2. 200 ppm **non-Gases**; prepared by diluting the following to 4.0 milliliters with methanol:

    5.5.3.2.2.1. **Carbon disulfide**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.2. **trans-1,4-Dichloro-2-butene**, 50 uL of 10,000 ppm stock.
    5.5.3.2.2.3. **Iodomethane**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.4. **Benzyl chloride**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.5. **1,1,2-Trichlorotrifluoroethane**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.6. **VOC components**, 50 uL of 2000 ppm stock.
    5.5.3.2.2.7. **1,3,5-Trichlorobenzene**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.8. **Hexane**, 10 uL of 10,000 ppm stock.
    5.5.3.2.2.9. **Tetrahydrofuran**, 50 uL of 10,000 ppm stock.
    5.5.3.2.2.10. **cis-1,4-Dichloro-2-butene**, 50 uL of 10,000 ppm stock.

  5.5.3.2.3. 200 ppm Additions; dilute the following to 4.0 mL with methanol:

    5.5.3.2.3.1. **Ketone mixture**, 50 uL of 10,000 ppm stock.
    5.5.3.2.3.2. **Vinyl acetate**, 10 uL of 10,000 ppm stock.
    5.5.3.2.3.3. **2-Chloroethyl vinyl ether**, 50 uL of 10,000 ppm stock.
    5.5.3.2.3.4. **Methyl tert-butyl ether**, 10 uL of 10,000 ppm stock.
    5.5.3.2.3.5. **Cyclohexane**, 10 uL of 10,000 ppm stock.
    5.5.3.2.3.6. **Acrolein/Acrylonitrile,** 500 uL of purchased 10000 ppm mixture.
    5.5.3.2.3.7. 25 ppm **TCLP Spike**; prepared by diluting 250 uL of 200 ppm TCLP/Matrix Spike in 2.0 milliliters of methanol.

5.5.4. Calibration standards for Aqueous and Low Soil:

  5.5.4.1. Initial calibration standards: 10, 20, 50, 100, 150, and 200, ug/L(ug/Kg), diluted from working standard.

  5.5.4.2. Continuing calibration standards: 50 ug/L (ug/Kg) diluted from working standards.

  5.5.4.3. Laboratory Control Sample: 50 ug/L (ug/Kg) diluted from stock standards.

5.5.5. Matrix and blank spiking solution: 50 ug/L (ug/Kg) diluted from LCS working standard.

5.5.6. Instrument Standards

  5.5.6.1. A 10 ug/L ICAL standard is prepared by adding 2.2 microliters of gases, non-gases, additions, and 0.22 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.

  5.5.6.2. A 20 ug/L ICAL standard is prepared by adding 4.4 microliters of gases, non-gases, additions, and 0.44 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.

  5.5.6.3. A 50 ug/L ICAL standard is prepared by adding 11 microliters of gases, non-gases, additions, and 1.1 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.

- 5.5.6.4. A 100 ug/L ICAL standard is prepared by adding 22 microliters of gases, non-gases, additions, and 2.2 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.
- 5.5.6.5. A 150 ug/L ICAL standard is prepared by adding 33 microliters of gases, non-gases, additions, and 3.3 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.
- 5.5.6.6. A 200 ug/L ICAL standard is prepared by adding 44 microliters of gases, non-gases, additions, and 4.4 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.
- 5.5.6.7. A 5000 ug/L Ketones ICAL standard is prepared by adding 22 microliters of 10,000 ppm ketones stock standard to 44 mL of deionized water.
- 5.5.6.8. A 50 ug/L CCAL standard is prepared by adding 11 microliters of gases, non-gases, additions, and 1.1 uL Acrolein/Acrylonitrile ICAL working standards to 44 mL of deionized water.
- 5.5.6.9. A 50 ug/L LCS standard is prepared by adding 11 microliters of LCS gases, LCS non-gases, LCS additions, and LCS Acrolein/Acrylonitrile working standards to 44 mL of deionized water.
- 5.5.6.10. A 10 ug/Kg ICAL standard is prepared by adding 2.0 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.11. A 20 ug/Kg ICAL standard is prepared by adding 4.0 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.12. A 50 ug/Kg ICAL standard is prepared by adding 10 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.13. A 100 ug/Kg ICAL standard is prepared by adding 20 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.14. A 150 ug/Kg ICAL standard is prepared by adding 30 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.15. A 200 ug/Kg ICAL standard is prepared by adding 40 microliters of gases, non-gases, and additions, ICAL working standards to 5 mL of deionized water w/ stir bar.
- 5.5.6.16. A 50 ug/Kg LCS standard is prepared by adding 10 microliters of the LCS gases, LCS non-gases, and LCS additions working standards to 5 mL of deionized water w/ stir bar.

5.5.7. Helium, ultrapure grade.

5.5.8. Liquid carbon dioxide.

5.6. INSTRUMENT CALIBRATION

5.6.1. Tuning.

5.6.1.1. The MS is tuned using BFB before any analysis begins. Tunes may be purged or injected directly into the GC. A valid tune provides for 12 hours of instrument operation from the time of injection. The following is the criteria for a valid tune:

Mass	**Criteria**
50	8 to 40% of mass 95
75	30 to 66% of mass 95
95	Base peak, 100% relative abundance
96	5 to 9% of mass 174
173	Less than 2% of mass 174
174	50.0 - 120% of mass 174
175	4 to 9% of mass 174
176	Greater than 93% but less than 101% of mass 174
177	5 to 9% of mass 176

5.6.2. Operating Conditions

5.6.2.1. The typical operating conditions for the Archon Autosampler are:

Sample type <water>
Sample Volume: 5 mL
Dilution fact: no
Rinse Volume: 3 - 6
# of rinses: 0 - 3
Standard 1: Dependent
Standard 2: Dependent
S.Preheat stir: no
Stir: no
W.Stir time(m): 0.00
W. Settle time: 0.00
Syringe flushes: 0 - 3

Preheat: yes
Preheat temp: 40 - 80
Preheat time: 0
Purge time (m): 0
Desorb time (m): 1- 6.0
Oper.ModeRemode
Cycle Timer: 0
Aux. Timer: 0
Link to method: Dependent

5.6.2.2. The Tekmar 3000 operating conditions generally are:

Trap Temperature: 30 – 60 °C
Purge Time: 8.0 – 12.0 minutes
5 *Dry Purge Time:* 0.0 – 6.0 minutes
Desorb Preheat Temperature: 200 - 240 °C
Desorb: 200 - 240 °C for 4 - 6 minutes
Bake: 200 - 300 °C for 4 - 6 minutes
Valve Temperature: 100 - 150 °C
Transfer Line Temperature: 100 - 150 °C

5.6.2.3. GC operating conditions generally are:

Jet separator temperature:	200 - 225 °C
Injector temperature:	200 - 220 °C
Column head pressure:	25 - 35 psi
Initial column temperature:	30 °C, hold for 5.0 minutes
Temperature program:	30 °C to 152 °C at 8.0 °C/minute, hold for 0.0 minutes, 152 °C to 202 °C at 16 °C/minute, hold for 0.63 minutes.

5.6.3. Initial Calibration.

5.6.3.1. An initial calibration curve is established using a minimum of five points each point containing all the target analytes, 4 internal standards, and 5 surrogates. The calibration standards are at concentrations of 10, 20, 50, 100 and 200 ug/L (ug/Kg). More calibration points may be added at the analyst's discretion to improve quantitation of one or more individual analytes.

5.6.3.2. Using the nearest internal standard, a response factor (RF) and average RF for the entire calibration range is calculated for each Analyte. The relative standard deviation (RSD) of the response factors is calculated for each compound.

5.6.3.3. Before the calibration curve can be deemed valid it must first meet the following criteria:

5.6.3.3.1. The RSD for the CCC Compounds Vinyl chloride, 1,1-Dichloroethene, Chloroform, 1,2-Dichloropropane, Toluene, and Ethylbenzene must be equal to or less than 30 percent.

5.6.3.3.2. The average RF for the SPCC Compounds must be greater than or equal to 0.1 for Chloromethane, 1,1-Dichloroethane, and Bromoform and greater than or equal to 0.3 for Chlorobenzene and 1,1,2,2-Tetrachloroethane.

5.6.3.3.3. The relative retention times of each compound should agree within 0.06 relative retention time units.

5.6.3.4. With the conditions of section 5.5.3.3 satisfied, one and only one of the following quantitation models must be applied to each target analyte:

5.6.3.4.1. An RSD equal to or less than 15% (30% for gases and poor purging compounds).

5.6.3.4.2. A linear regression (not forced through the origin) when the percent RSD is greater than 15 percent and the correlation coefficient for a linear plot of concentration vs. response is 0.990 or greater.

5.6.3.4.3. A quadratic regression (not forced through the origin) when sections 5.6.3.4.1 and 5.6.3.4.2 do not apply, requiring the curve to be continuous, continuously differential and monotonic over the calibration range, and the number of calibration standards is equal to or greater than six. The coefficient of the determination must be equal to or greater than 0.99.

5.6.3.5. If the conditions of section 5.6.3.3 are satisfied, an alternate quantitation method using average of response factors for ALL target analytes can be applied if the mean of the average of response factors for the entire compound list is equal to or less than 15 percent, with no target analyte RSD value above 30%.

5.6.4. Continuing Calibration.

5.6.4.1. Before analysis begins, the calibration is verified immediately after the instrument has been tuned by analyzing a CCAL standard. The CCAL standard is quantitated using the initial calibration. In order for the CCAL to be valid, the CCC Compounds must have a percent drift of less than 20 percent and the SPCC Compounds must meet the minimum average RF required in 5.6.3.3.2. If the CCAL standard fails these criteria, a second CCAL standard is analyzed. If the CCAL fails again, the instrument is recalibrated, or the data is documented in a nonconformance memo. The recovery of all other compounds is at the analyst discretion.

5.7. . SAMPLE PREPARATION

5.7.1. ***Soil Extraction:***

5.7.1.1. *Method 5035 preserved in the lab*: A sample aliquot (approximately 10 g) is placed into a scintillation vial and the exact weight recorded. 10 mL of methanol is added. The sample is homogenized via a vortex mixer then placed in the shaker table for 15 minutes. The sample is centrifuged to remove soil particulate matter from the extract. An 1100 uL aliquot of methanol extract is added to 44 mL of ASTM Type II water contained in an appropriately labeled VOA vial. To prepare the blank spike (LCS) and blank spike (LCS) duplicate proceed as stated above, adding 100 uL of the 200 ppm LCS stock standards to 10 mL of methanol. To prepare the matrix spike/matrix spike duplicate, add 100 uL of the 200 ppm LCS stock standards to pre-weighed soil sample aliquots prior to extracting with 10 mL of methanol. A method blank is prepared by adding 1100 uL of extracting methanol to 44 mL of ASTM Type II water.

5.7.1.2. *Method 5035 Methanol Preserved in the field*: The sample jar is first weighed and the sample weight determined by subtracting the tare weight. An 1100 uL aliquot of methanol extract is added to 44 mL of ASTM Type II water contained in an appropriately labeled VOA vial. To prepare the blank spike (LCS) and blank spike (LCS) duplicate proceed as stated above, adding 11 uL of the 200 ppm LCS stock standards to 44 mL of ASTM Type II water containing 1100 uL of methanol. To prepare the post matrix spike/post matrix spike duplicate, add 11 uL of the 200 ppm LCS stock standards to each of the two additional samples prepared as described at the beginning of 1.1.1.2. A method blank is prepared by adding 1100 uL of methanol to 44 mL of ASTM Type II water.

5.7.1.3. *Method 5035 **NaHSO4** Preserved*: Each sample VOA vial is first weighed and the sample weight determined by subtracting the tare weight. The samples are then analyzed as received using the soil analysis option of the Archon 2000 autosampler. A post matrix spike/post matrix spike duplicate is not applicable. A duplicate sample analysis is the only QC check sample appropriate for this method, when sufficient sample VOA vials have been provided. A method blank is prepared by adding 5 ml of ASTM Type II water preserved w/ NaHSO4 to a 44 mL VOA vial w/ stir bar.

5.7.1.4. If the water solution becomes cloudy upon addition of the soil extract, a higher dilution may be required and is prepared at this time.

5.7.2. ***Water Extraction***:

5.7.2.1. All aqueous samples will be analyzed as received. If available, samples may be screened by analyzing a spare VOA. Dilutions of the sample are made in multiples of 2, 5, 10, 20, 50, or 100.

5.7.3. ***TCLP Extraction***:

5.7.3.1. Prepare a method blank by adding exactly 2200 uL of TCLP extract solution in 44 mL of DI water contained in a VOA vial and seal; 1 per batch of 20.

5.7.3.2. Prepare a blank spike by adding exactly 2200 uL of TCLP extract solution and 11 uL of TCLP spike mix to 44 mL DI of water contained in a VOA vial and seal; 1 set per batch of 20.

5.7.3.3. For each sample, remove a 2200 uL aliquot from the TCLP extract and dispense the total volume into 44 mL of DI water contained in a VOA vial. Seal and check for any significant headspace. If a large headspace is observed, discard the contents of the VOA vial and begin again. For highly contaminated sample, all subsequent dilution's of that extract can be made at this time.

5.7.3.4. Prepare a duplicate sample by dispensing a 2200 uL aliquot from the TCLP extract into 44 mL of DI water contained in a VOA vial; 1 per batch of 20.

5.7.3.5. Prepare a post matrix spike for any specified sample by dispensing a 2200 uL aliquot from the TCLP extract and 11 uL of the TCLP spike mix into 44 mL of DI water contained in a VOA vial; 1 per batch of 20.

5.7.3.6. Place all the sample dilutions including Q.C. samples in a VOA rack and store in the refrigerator until analysis.

5.8. SAMPLE ANALYSIS

5.8.1. Samples are loaded into the autosampler with associated QC and the instrument sequence initiated. Data is automatically collected by the data system.

5.8.2. Results are printed and then manually entered into spreadsheets by the analyst.

5.8.3. The analyst reviews all results reported before transferring the results to the project file.

5.8.4. The analyst verifies the pH of all submitted VOA samples after analysis and records the value(s) on the sample worksheet; the pH should be less than two.

5.9. CALCULATIONS

5.9.1. To calculate analyte concentration in a sample analyzed via 5035, due as follows: Result (ug/Kg) = 100 x (quan value (ug/L) x dilution x extract volume (mL)) / (sample wt. (g) x percent solids).

5.9.2. To calculate analyte concentration in a sample analyzed via 5035 ***NaHSO4 Preserved***, due as follows: Result (ug/Kg) = 100 x (quan value (ug/Kg) x 5) / (sample wt. (g) x percent solids).

5.9.3. To calculate analyte concentration in a sample analyzed via TCLP, due as follows: Result (mg/L) = quan value (ug/L) x dilution / 1000.

5.9.4. To calculate analyte concentration in a sample analyzed via Water extraction, due as follows: Result (ug/L) = quan value (ug/L) x dilution.

5.10. QUALITY CONTROL

5.10.1. The instrument must be operated under a valid tune and ICAL, as described in Sections 5.6.1 and 5.6.3.

5.10.2. Continuing calibration verification standards are analyzed under the criteria described in Section 5.6.4.

5.10.3. A method blank is analyzed with every batch of 20 samples (not including QC) and should be free of target compounds above the respective PQLs.

5.10.4. An LCS and LCS duplicate, both containing most if not all reported analytes, are analyzed with every batch of 20 samples (not including QC). A duplicate and/or matrix spike is performed upon client request when sufficient sample volume has been provided.

5.10.4.1. When insufficient sample is available to analyze a matrix duplicate and/or matrix spike, the LCS and LCS duplicate will be substituted and reported as the blank spike/blank spike duplicate.

5.10.4.2. If sufficient sample has been provided, a sample duplicate and sample matrix spike or matrix spike and matrix spike duplicate will be performed at the analysts discretion. Matrix spikes are prepared by adding the same LCS standards and amounts used to prepare the LCS/LCS duplicate samples. **Note:** Do to the impractical task of spiking, charting, and controlling all target analytes, a subset consisting of the five compounds required by EPA method 8260B section 5.13 will be reported unless specified in writing by the client.

5.10.4.3. Some target analytes present in the calibration curve may not be present and/or detectable in the LCS standard. These analytes will not have LCS precision and accuracy data available and will therefore be evaluated based on their recovery in the CCAL.

5.10.5. One microliter of the 250 ppm Internal standard / Surrogate mix is added automatically to each 10 mL aliquot during sample transfer.

5.10.6. Internal standard areas for CCAL standards must meet the criteria of 50 to 200 percent of the last initial calibration internal standard area recoveries.

5.10.7. Sample surrogate recoveries must be within the following ranges of +/- 3 sigma standard deviation calculated from blank, blank spike, LCS, and sample data and Shell document default limits. Current limits are:

Surrogate	Recovery Limit (water)	Recovery Limit (soil)	Recovery Limit (soil-low)
Dibromofluoro-methane	85 – 117	81 – 113	75 – 125
Fluorobenzene	81 – 120	75 – 112	80 – 111
Toluene-d8	92 – 114	81 – 125	78 – 119
Ethylbenzene-d10	91 – 108	86 – 121	80 – 116
Bromofluorobenzene	83 – 110	80 – 113	77 – 121

Control limits are updated semiannually as sufficient data becomes available. Samples with any surrogate outside recovery ranges are reanalyzed when sufficient sample volume is available. When a surrogate recovery is outside established limits in a method blank, the analytical batch is reanalyzed when sufficient sample volume is available.

5.10.8. A method detection limits study for each target compound is performed on an annual basis.

5.10.9. Control limits for surrogates and LCS samples are updated bi-annually. Current limits are listed in Table 2.

5.11. PRECISION AND ACCURACY

5.11.1. Accuracy is evaluated based on LCS and LCS duplicate recoveries. Accuracy is also evaluated via surrogate recoveries. See section 5.10.7.

5.11.2. Precision is evaluated based on LCS and LCS duplicate RPD data of a select 12 target compounds whose physical and chemical properties best represent an across the spectrum measure of total analyte performance.

5.12. REPORTING LIMITS

5.12.1. The reporting limit is 1000 ug/L for n-butyl alcohol, iso-butyl alcohol, 1,4-dioxane, 50 ug/L for tetrahydrofuran, 2-chloroethyl vinyl ether, acrolein, acrylonitrile, cis 1,4-dichloro-2-butene and trans 1,4-dichloro-2-butene, 20 ug/L for m,p-xylenes, and 10 ug/L for all other analytes.

5.13. MODIFICATIONS TO PUBLISHED METHODS

5.13.1. Tune criteria is modified to reflect tune parameters as stated in SW-846 Data Validation for Volatile Organics Analysis.

5.13.2. Sound Analytical Services recognizes that not all clients request the exact same compound list for 8260B analysis and therefore, in some cases, does not spike the LCS/LCS (BS/BSD duplicate) duplicate with every compound listed in the method.

5.13.3. If during a CCAL analysis a CCC compound is outside the 20 percent drift criteria, the calibration may still be considered valid under analysts discretion if the following is true:

5.13.3.1. The percent drift for the CCC in question is greater than 20 percent relative to the I-CAL value AND

5.13.3.2. The CCC compound in all of the associated samples is quantitated as non detect.

5.13.4. Analytes are reported to the MDL as estimated (J) and not ND when detected below the lowest calibration standard as specified in method 8000B, section 7.4.

6. HEALTH AND SAFETY/SPECIAL CONSIDERATIONS

6.1. Many compounds on the 8260 list are hazardous and carcinogenic. Please consult MSDS before preparing any standards.

7. NONCONFORMANCE AND CORRECTIVE ACTION

7.1. If batch QA/QC parameters are not met, all samples within the batch are reanalyzed, if adequate sample is available.

7.2. Nonconformance's encountered during sample analysis is documented by the analyst.

8. RECORDS MANAGEMENT AND DOCUMENTATION

8.1. The analyst provides the completed data package to the designated peer reviewer for peer review and signature.

8.2. Nonconformance documentation is filed in the master file. A copy is provided to the QA Director for review.

8.3. All samples analyzed are recorded in a sample run logbook.

8.4. Any instrument maintenance or repair is noted in the instrument maintenance logbook.

8.5. All data is archived to magnetic tape.

8.6. Logbooks are archived with the QC Department when completed for permanent storage. All records will be in a controlled area with limited access.

8.7. If client contact is required, a Client Contact Record is completed and maintained in the master file.

9. WASTE MANAGEMENT AND POLLUTION PREVENTION

9.1. All laboratory waste must be handled in accordance with SAS SOP 0036.5.

9.2. All laboratory procedures must comply with the policies set forth in SAS's Pollution Prevention Plan.

Table 1. EPA Method 8260B Compounds and PQLs for the Incos 50.

VOC Compound	**PQL Water ug/L**	**PQL Low Soil ug/kg**	**PQL Med. Soil ug/kg**
Dichlorodifluoromethane	10	10	400
Chloromethane	10	10	400
Vinyl chloride	10	10	400
Bromomethane	10	10	400
Chloroethane	10	10	400
Trichlorofluoromethane	10	10	400
1,1-Dichloroethene	10	10	400
1,1,2-Trichlorotrifluoroethane	10	10	400
Acrolein	50	50	2000
Carbon disulfide	10	10	400
Acetone	50	50	2000
Iodomethane	10	10	400
Methylene chloride	10	10	400
methyl tert-butyl ether	10	10	400
trans-1,2-Dichloroethene	10	10	400
Acrylonitrile	50	50	2000
Hexane	10	10	400
1,1-Dichloroethane	10	10	400
Vinyl acetate	10	10	400
2,2-Dichloropropane	10	10	400
2-Butanone	50	50	2000
cis-1,2-Dichloroethene	10	10	400
Tetrahydrofuran	50	50	2000
Bromochloromethane	10	10	400
Chloroform	10	10	400
1,1,1-Trichloroethane	10	10	400
Carbon Tetrachloride	10	10	400
1,1-Dichloropropene	10	10	400
Benzene	10	10	400
1,2-Dichloroethane	10	10	400
Trichloroethene	10	10	400
1,2-Dichloropropane	10	10	400
1,4-Dioxane	1000	1000	40000
Dibromomethane	10	10	400
Bromodichloromethane	10	10	400
2-Chloroethyl vinyl ether	50	50	2000
cis-1,3-Dichloropropene	10	10	400
4-Methyl-2-pentanone	50	50	2000
Toluene	10	10	400
trans-1,3-Dichloropropene	10	10	400
1,1,2-Trichloroethane	10	10	400

Table 1, Continued. EPA Method 8260B Compounds and PQLs for the Incos 50.

VOC Compound	PQL Water ug/L	PQL Low Soil ug/kg	PQL Med. Soil ug/kg
Tetrachloroethene	10	10	400
1,3-Dichloropropane	10	10	400
2-Hexanone	50	50	2000
Dibromochloromethane	10	10	400
1,2-Dibromoethane	10	10	400
Chlorobenzene	10	10	400
Ethylbenzene	10	10	400
1,1,1,2-Tetrachloroethane	10	10	400
m,p-Xylene	20	20	800
o-Xylene	10	10	400
Styrene	10	10	400
Bromoform	10	10	400
Isopropylbenzene	10	10	400
cis-1,4-Dichloro-2-butene	50	50	2000
Bromobenzene	10	10	400
n-Propylbenzene	10	10	400
1,1,2,2-Tetrachloroethane	10	10	400
trans-1,4-Dichloro-2-butene	50	50	2000
1,2,3-Trichloropropane	10	10	400
2-Chlorotoluene	10	10	400
1,3,5-Trimethylbenzene	10	10	400
4-Chlorotoluene	10	10	400
t-Butylbenzene	10	10	400
1,2,4-Trimethylbenzene	10	10	400
sec-Butylbenzene	10	10	400
1,3-Dichlorobenzene	10	10	400
4-Isopropyltoluene	10	10	400
1,4-Dichlorobenzene	10	10	400
Benzyl chloride	10	10	400
n-Butylbenzene	10	10	400
1,2-Dichlorobenzene	10	10	400
1,2-Dibromo-3-chloropropane	10	10	400
1,3,5-Trichlorobenzene	10	10	400
1,2,4-Trichlorobenzene	10	10	400
Hexachlorobutadiene	10	10	400
Naphthalene	10	10	400
1,2,3-Trichlorobenzene	10	10	400
Hexachloroethane	10	10	400
Ethyl ether	10	10	400
Ethyl acetate	10	10	400
iso-Butyl alcohol	1000	1000	40000
n-Butyl alcohol	1000	1000	40000
Cyclohexane	10	10	400

Table 2. Quality Control Limits.

Volatile Organics List by USEPA Method 5030B/8260B Modified

Analysis Method : 8260B
Matrix : Leachate
Preparation Method : 1311 / SW5030B
Medium -INCOS 50- Level
Expires: 12/15/2000

Blank Spike Recovery	
1,1-Dichloroethene	69 - 149%
1,2-Dichloroethane	62 - 142%
1,4-Dichlorobenzene	60 - 140%
2-Butanone	16 - 115%
Benzene	64 - 134%
Carbon Tetrachloride	61 - 149%
Chlorobenzene	58 - 134%
Chloroform	65 - 140%
Tetrachloroethene	57 - 137%
Toluene	60 - 140%
Trichloroethene	71 - 126%
Vinyl chloride	67 - 159%
Matrix Spike Recovery	
1,1-Dichloroethene	69 - 149%
1,2-Dichloroethane	62 - 142%
1,4-Dichlorobenzene	60 - 140%
2-Butanone	16 - 115%
Benzene	64 - 134%
Carbon Tetrachloride	61 - 149%
Chlorobenzene	58 - 134%
Chloroform	65 - 140%
Tetrachloroethene	57 - 137%
Toluene	60 - 140%
Trichloroethene	71 - 126%
Vinyl chloride	67 - 159%
Surrogate Recovery	
Bromofluorobenzene	78 - 115%
Dibromofluoromethane	88 - 120%
Ethylbenzene-d10	83 - 125%
Fluorobenzene	75 - 121%
Toluene-D8	75 - 125%

Table 2, Continued. Quality Control Limits.

Volatile Organics by USEPA Method 5035/8260B Modified

Analysis Method : 8260B
Matrix : Soil, Low Level
Preparation Method : SW5035 Mod.
Low -Incos 50- Level
Expires: 06/15/2000

Blank Spike Recovery		
1,1-Dichloroethene	75 - 125%	=<20% RPD
1,2-Dichloroethane	75 - 125%	=<19% RPD
1,4-Dichlorobenzene	75 - 125%	=<18% RPD
2-Butanone	60 - 140%	=<45% RPD
Benzene	75 - 125%	=<16% RPD
Carbon Tetrachloride	75 - 125%	=<23% RPD
Chlorobenzene	76 - 125%	=<15% RPD
Chloroform	75 - 125%	=<16% RPD
Ethylbenzene	82 - 125%	=<11% RPD
m,p-Xylene	83 - 125%	=<11% RPD
o-Xylene	82 - 125%	=<12% RPD
Tetrachloroethene	75 - 125%	=<17% RPD
Toluene	78 - 125%	=<15% RPD
Trichloroethene	76 - 125%	=<15% RPD
Vinyl chloride	75 - 125%	=<31% RPD
Matrix Spike Recovery		
1,1-Dichloroethene	75 - 125%	=<20% RPD
1,2-Dichloroethane	75 - 125%	=<19% RPD
1,4-Dichlorobenzene	75 - 125%	=<18% RPD
2-Butanone	60 - 140%	=<45% RPD
Benzene	75 - 125%	=<16% RPD
Carbon Tetrachloride	75 - 125%	=<23% RPD
Chlorobenzene	76 - 125%	=<15% RPD
Chloroform	75 - 125%	=<16% RPD
Ethylbenzene	82 - 125%	=<11% RPD
m,p-Xylene	83 - 125%	=<11% RPD
o-Xylene	82 - 125%	=<12% RPD
Tetrachloroethene	75 - 125%	=<17% RPD
Toluene	78 - 125%	=<15% RPD
Trichloroethene	76 - 125%	=<15% RPD
Vinyl chloride	75 - 125%	=<31% RPD
Surrogate Recovery		
Bromofluorobenzene	77 - 121%	
Dibromofluoromethane	75 - 125%	
Ethylbenzene-d10	80 - 116%	
Fluorobenzene	80 - 111%	
Toluene-D8	78 - 119%	

Table 2, Continued. Quality Control Limits.

Volatile Organics by USEPA Method 5035/8260B Modified

Analysis Method : 8260B
Matrix : Soil, Medium Level
Preparation Method : SW5035 Mod.
Medium -Incos 50- Level
Expires: 12/15/2000

Blank Spike Recovery		
1,1-Dichloroethene	75 - 125%	=<17% RPD
1,2-Dichloroethane	75 - 125%	=<25% RPD
1,4-Dichlorobenzene	75 - 125%	=<25% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	74 - 124%	=<11% RPD
Carbon tetrachloride	75 - 125%	=<25% RPD
Chlorobenzene	75 - 125%	=<10% RPD
Chloroform	75 - 125%	=<25% RPD
Ethylbenzene	75 - 125%	=<25% RPD
m,p-Xylene	75 - 125%	=<25% RPD
o-Xylene	75 - 125%	=<25% RPD
Tetrachloroethene	75 - 122%	=<20% RPD
Toluene	77 - 125%	=<12% RPD
Trichloroethene	76 - 120%	=<9.9% RPD
Vinyl Chloride	75 - 125%	=<25% RPD
Matrix Spike Recovery		
1,1-Dichloroethene	75 - 125%	=<17% RPD
1,2-Dichloroethane	75 - 125%	=<25% RPD
1,4-Dichlorobenzene	75 - 125%	=<25% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	74 - 124%	=<11% RPD
Carbon tetrachloride	75 - 125%	=<25% RPD
Chlorobenzene	75 - 125%	=<10% RPD
Chloroform	75 - 125%	=<25% RPD
Ethylbenzene	75 - 125%	=<25% RPD
m,p-Xylene	75 - 125%	=<25% RPD
o-Xylene	75 - 125%	=<25% RPD
Tetrachloroethene	70 - 130%	=<20% RPD
Toluene	77 - 125%	=<12% RPD
Trichloroethene	76 - 125%	=<9.9% RPD
Vinyl Chloride	75 - 125%	=<25% RPD
Surrogate Recovery		
Bromofluorobenzene	80 - 113%	
Dibromofluoromethane	81 - 113%	
Ethylbenzene-d10	86 - 121%	
Fluorobenzene	75 - 112%	
Toluene-D8	81 - 125%	

Table 2, Continued. Quality Control Limits.

Volatile Organics by USEPA Method 5030B/8260B Modified

Analysis Method : 8260B
Matrix : Water
Preparation Method : SW5030B
Medium -INCOS 50- Level
Expires: 12/15/2000

Blank Spike Recovery		
1,1-Dichloroethene	80 - 120%	=<14% RPD
1,2-Dichloroethane	81 - 120%	=<12% RPD
1,4-Dichlorobenzene	81 - 120%	=<17% RPD
2-Butanone	60 - 140%	=<40% RPD
Benzene	80 - 120%	=<12% RPD
Carbon Tetrachloride	88 - 120%	=<13% RPD
Chlorobenzene	80 - 120%	=<15% RPD
Chloroform	90 - 120%	=<11% RPD
Ethylbenzene	80 - 120%	=<25% RPD
m,p-Xylene	80 - 120%	=<25% RPD
o-Xylene	80 - 120%	=<25% RPD
Tetrachloroethene	80 - 120%	=<17% RPD
Toluene	84 - 120%	=<16% RPD
Trichloroethene	82 - 120%	=<16% RPD
Vinyl chloride	80 - 120%	=<10% RPD
Matrix Spike Recovery		
1,1-Dichloroethene	80 - 120%	=<14% RPD
1,2-Dichloroethane	81 - 120%	=<12% RPD
1,4-Dichlorobenzene	81 - 120%	=<17% RPD
2-Butanone	60 - 140%	=<40% RPD
Benzene	80 - 120%	=<12% RPD
Carbon Tetrachloride	88 - 120%	=<13% RPD
Chlorobenzene	80 - 120%	=<15% RPD
Chloroform	90 - 120%	=<11% RPD
Ethylbenzene	80 - 120%	=<25% RPD
m,p-Xylene	80 - 120%	=<25% RPD
o-Xylene	80 - 120%	=<25% RPD
Tetrachloroethene	80 - 120%	=<17% RPD
Toluene	84 - 120%	=<16% RPD
Trichloroethene	70 - 130%	=<16% RPD
Vinyl chloride	80 - 120%	=<10% RPD
Surrogate Recovery		
Bromofluorobenzene	83 - 110%	
Dibromofluoromethane	85 - 117%	
Ethylbenzene-d10	91 - 108%	
Fluorobenzene	81 - 120%	
Toluene-D8	92 - 114%	

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SOP NO.: 0312.5
DATE: October 19, 2000
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PAGE 1 OF 21

TITLE: Method 8260B Modified: Volatile Organic Compound Analysis by Finnigan Mat ITS-40 GC/MS

Approved By: Julie R Zborowski — Department Manager — Date: 3/21/2001

Approved By: Lela A Transue — Quality Assurance Director — Date: 3-21-01

Copy No.: 010

Issued To: K. Carpenter

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1. SCOPE AND APPLICATION
   1.1. This SOP is used to determine the concentration of volatile organic compounds in aqueous, soil, leachate, and organic matrices. This method can be used to measure organic compounds that have boiling points below 200 C, insoluble or slightly soluble in water, and can elute from a capillary GC column in a Gaussian peak profile. However, for some target compounds, the quantitation limits are determined by purging efficiency and/or instrument response. Such compounds include low molecular weight halogenated hydrocarbons, aromatics, ketones, acetates, acrylates, ethers, and sulfides.
   1.2. Ion Trap technology though excellent for increased sensitivity does have its drawbacks. The most significant being methanol interference and/or reactions with many early eluting target analytes, making medium level soil extraction unusable by this method. In addition, some target analytes such as Acrolein Vinyl acetate, Ketones, trans-1,4-Dichloro-2-butene, and many others do not respond well due to intermolecular interactions within the Ion Trap itself.
   1.3. Analytes that are affected by any of the limitation stated above will be reflected in their corresponding detection limits and/or response factors
   1.4. The target compound list and associated reporting limits are provided in Table 1.

2. REFERENCES
   2.1. Test Methods for Evaluating Solid Waste: SW-846, methods 8000B, 5030B, 8260B.
   2.2. Tekmar LSC 3000 Users Manual.
   2.3. Finnigan MAT ITS-40 Operator's Manual.

2.4. Varian Archon 2000 Autosampler Users Manual

3. ASSOCIATED STANDARD OPERATING PROCEDURES
    3.1. 0002.6, Internal Sample Transfer and Chain of Custody.
    3.2. 0003.7, Sample Data Processing.
    3.3. 0004.6, Preparation of Trip Blanks.
    3.4. 0005.6, Sample Storage and Security.
    3.5. 0010.3, Use and Maintenance of Laboratory Glassware.
    3.6. 0012.7, Use and Maintenance of Laboratory Refrigerators.
    3.7. 0016.4, Use and Maintenance of Automatic Dispensing Pipets.
    3.8. 0029.6, Sample Handling Procedure for Drinking Water Samples.
    3.9. 0030.5, Verification of Quality of Materials Used in the Laboratory.
    3.10. 0032.5, SAS Sample Documentation.
    3.11. 0303.1, Purge and Trap Volatile Organic Extraction, EPA SW-846 Method 5030B.
    3.12. 0327.1, Instrument Maintenance for GC/MS Analysis System.
    3.13. 0504.6, Client Contact Record keeping.
    3.14. 0513.5, Data Reporting for Drinking Water Analysis.
    3.15. 0521.1, Electronic Archiving Procedures.
    3.16. 0600.5, Quality Control Charting and Establishing Method Warning and Action Limits.
    3.17. 0605.4, Archiving Laboratory Logbooks
    3.18. 0610.3, Laboratory Corrective Action Procedures.
    3.19. 0612.3, Volatile Organic Standard Solution Record keeping.

4. DEFINITIONS
    4.1. BFB = Bromofluorobenzene.
    4.2. CCAL = continuing calibration standard.
    4.3. Gases = Dichlorodifluoromethane, Chloromethane, Vinyl chloride, Bromomethane, Chloroethane, and Trichlorofluoromethane.
    4.4. non-Gases = Standard 54 component VOC mixture.
    4.5. GC = gas chromatograph.
    4.6. ICAL = initial calibration.
    4.7. LCS = laboratory control sample i.e. secondary source standard.
    4.8. LFB = laboratory fortified blank.
    4.9. MDL = method detection limit.
    4.10. PQL = Practical Quantitation Limit.
    4.11. RPD = relative percent difference.
    4.12. SOP = standard operating procedure.
    4.13. TIC = tentatively identified compound.
    4.14. VOA = Volatile Organic Analyte.
    4.15. PPM = Parts per Million
    4.16. PPB = Parts per Billion
    4.17. VOC = Volatile Organic Compounds

5. PROCEDURE

5.1. SUMMARY.

5.1.1. An automated purge and trap analysis system is utilized, and employs analytical equipment designed to operate using 44 mL VOA vials. Therefore, before any sample can be analyzed, aqueous or otherwise, it must be prepared in such a way that the final sample for analysis is contained in a 44 mL VOA vial. Non-aqueous samples like oils, solids, and products CANNOT be sampled and analyzed in 44 mL VOA vials but must first be extracted in methanol and diluted to volume with DI H2O prior to analysis.

5.1.2. 10 mL sample aliquot is automatically transferred from the VOA vial to a purge vessel at ambient temperature and purged with an inert gas (helium), collecting all purgeable analytes onto an organic trap. The trap is then heated and back flushed with an inert gas (helium) to desorb the compounds onto the capillary GC column. The GC temperature is increased at a specific rate thereby separating the analytes from the column by boiling point difference. As the analytes elute, they are introduced into the mass spectrometer via a jet separator and detected using the Finnigan MAT ITS-40 Ion Trap detector. Identification of target analytes is accomplished by comparing their mass spectra with that of the NIST library spectra. Analyte quantitation is established by comparing the response of the quantitation ion to a multi-point internal standard calibration curve for that ion.

5.2. INTERFERENCE

5.2.1. A trip blank may be prepared from reagent water at the time of sample collection and carried through all the handling, storage and analytical procedures to verify samples are not contaminated during shipment and storage

5.2.2. Methylene chloride contamination is minimized by isolating the volatile samples from the general laboratory.

5.2.3. Carry over is reduced by analyzing rinse blanks after contaminated samples. Samples analyzed immediately after a sample with a high level of contamination may be reanalyzed if the analyst deems the data suspect.

5.3. SAMPLE HANDLING, PRESERVATION, AND HOLDING TIME REQUIREMENTS

5.3.1. Samples must be submitted to the laboratory in 44 ml VOA vials with Teflon-lined caps. Aqueous sample volumes can contain headspace no larger than 5 mm in diameter (a small pea). Samples must be preserved with concentrated hydrochloric acid to a pH of less than two. Ascorbic acid preservation is required if free chlorine is present. However, it is the responsibility of the sampler, not the laboratory, to test for and treat appropriately any free chlorine that is detected.

5.3.2. Soil and non-aqueous samples submitted for 5030 must be contained in glass jars with Teflon lined caps and as little headspace as possible; 5035 samples must be contained in pre-weighed glass jars with Teflon lined caps and containing the known volume of methanol.

5.3.3. Soil samples submitted for 5035 low soil analysis must be contained in 44 mL VOA vials containing 5 mL of NaHSO4 preserved deionized water.

5.3.4. All samples must be analyzed within 14 days of sampling.

5.4. EQUIPMENT

5.4.1. Varian Archon 2000 Autosampler with refrigeration unit.

5.4.2. Tekmar 3000 Thermal Desorption Unit with cryocooling capability.

5.4.3. Varian 3400 GC.

5.4.4. DB-624 GC capillary column, 75 meters, 3 micrometer film thickness, 0.54 micrometer inner diameter with a 15 meters post column: DB-Wax capillary, 3 micrometers film thickness, 0.54 micrometer inner diameter

5.4.5. Finnigan MAT ITS-40 Ion Trap mass spectrometer.

5.4.6. Finnigan MAT Magnum Data System with NIST Library.

5.4.7. Barnstead B-Pure Water Purification System.

5.4.8. Supelco Type K Organic Trap.

5.5. REAGENTS AND STANDARDS

5.5.1. Methanol, purge and trap grade.

5.5.2. <u>Stock Standards</u>

5.5.2.1. <u>ICAL Standards</u>

5.5.2.1.1. The **gases** are purchased as a mixture at 200 ug/mL and are A2LA/ISO-9001 Certified.

5.5.2.1.2. The **non-gases** are purchased as a mixture at 2000 ug/mL and are A2LA/ISO-9001 Certified.

5.5.2.1.3. A 10,000 ppm **ketones stock** standard is prepared by combining and diluting the following amounts of neat materials with 35 milliliters of methanol: 441 uL of 2-butanone, 441 uL of acetone, 441 uL of 2-hexanone, and 441 uL of 4-methyl-2-pentanone.

5.5.2.1.4. A 10,000 ppm **carbon disulfide** stock standard is prepared by diluting 280 uL of the neat material to 35 milliliters with methanol.

5.5.2.1.5. A 10,000 ppm **vinyl acetate** stock standard is prepared by diluting 378 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.6. A 10,000 ppm **2-chloroethyl vinyl** ether stock standard is prepared by diluting 336 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.7. A 10,000 ppm **1,3,5-trichlorobenzene** stock standard is prepared by diluting 350 mg of the neat material with 35 milliliters of methanol.

5.5.2.1.8. A 10,000 ppm **hexane** stock standard is prepared by diluting 539 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.9. A 10,000 ppm **tetrahydrofuran** stock standard is prepared by diluting 392 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.10. A 10,000 ppm **benzyl chloride** stock standard is prepared by diluting 322 uL of neat material with 35 milliliters of methanol.

5.5.2.1.11. A 10,000 ppm **1,1,2-trichlorotrifluoroethane** stock standard is prepared by diluting 224 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.12. A 10,000 ppm **Iodomethane** stock standard is prepared by diluting 154 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.13. A 10,000 ppm **trans-1,4-dichloro-2-butene** stock standard is prepared by diluting 301 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.14. A 10,000 ppm **cis-1,4-dichloro-2-butene** stock standard is prepared by diluting 308 uL of the neat material with 35 milliliters of methanol.

5.5.2.1.15. A 10,000 ppm **F-List stock** standard is prepared by diluting 392 uL of neat ethyl acetate and 497 uL of diethyl ether with 35 milliliters of methanol.

5.5.2.1.16. A 1000 ppm **acrolein/acrylonitrile** standard is purchased as a mixture.

5.5.2.1.17. 2000 ppm **toluene**; purchased as a single component solution.

5.5.2.1.18. 2000 ppm **TCLP mix**; purchased as a mixture.

5.5.2.1.19. 200 ppm **TCLP Spike**; prepared in 5.0 milliliters of methanol as described below:

5.5.2.1.19.1. **Toluene**, 1000 uL of 2000 ppm stock.

5.5.2.1.19.2. **TCLP mixture**, 1000 uL of 2000 ppm stock.

5.5.2.1.20. A 10,000 ppm **1,4-dioxane** stock standard is prepared by diluting 343 uL of neat material with 35 milliliters of methanol.

5.5.2.1.21. A 10,000 ppm **methyl tert-butyl ether** stock standard is prepared by diluting 476 uL of neat material with 35 milliliters of methanol.

5.5.2.1.22. A 10,000 ppm **methacrylonitrile** stock standard is prepared by diluting 441 uL of neat material with 35 milliliters of methanol.

5.5.2.1.23. A 10,000 ppm **cyclohexane** stock standard is prepared by diluting 455 uL of neat material with 35 milliliters of methanol.

5.5.2.2. <u>LCS Standards</u>

5.5.2.2.1. The **gases** are purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.

5.5.2.2.2. The **non-gases** are purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.

5.5.2.2.3. The **additions** solution is purchased as a mixture from an alternate source as the ICAL standards at 200 ug/mL.

5.5.2.2.4. The **acrolein/acrylonitrile** solution is purchased as a mixture from an alternate source as the ICAL standards at 1000 ug/mL.

5.5.2.3. <u>Tuning Standards</u>

5.5.2.3.1. Tuning is performed off the BFB added in the Internal Standard/Surrogate during sample transfer and purge.

5.5.2.4. <u>Internal Standards and Surrogate Standards</u>

5.5.2.4.1. The following internal standard and surrogate compounds are purchased neat: **Pentafluorobenzene, 1,4-Dichlorobenzene-d4, Chlorobenzene-d5, 1,4-Difluorobenzene, Dibromofluoromethane, Toluene-d8, 4-Bromofluorobenzene, Fluorobenzene, and Ethylbenzene-d10**.

5.5.2.4.2. A 10,000 ug/mL Internal Standard and Surrogate Mixture is prepared by diluting 165 uL of Pentafluorobenzene, 225 uL of 1,4-Difluorobenzene, 159 uL of Chlorobenzene-d5, 250 mg of 1,4-Dichlorobenzene-d4, 103 uL of Dibromofluoromethane, 265 uL of Toluene-d8, 157 uL of Bromofluorobenzene, 244 uL of Fluorobenzene, and 263 uL of Ethylbenzene-d10 to 25 mL with methanol.

5.5.3. Working Standards

5.5.3.1. ICAL Standards

5.5.3.1.1. 4.0 ppm **non-Gases**; prepared by diluting the following to 35 milliliters with methanol:

- 5.5.3.1.1.1. **Carbon disulfide**, 14 uL of 10,000 ppm stock.
- 5.5.3.1.1.2. **trans-1,4-dichloro-2-butene**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.1.3. **Iodomethane**, 14 uL of 2.4 ppm stock.
- 5.5.3.1.1.4. **VOC components**, 70 uL of 2000 ppm stock.
- 5.5.3.1.1.5. **1,3,5-Trichlorobenzene**, 14 uL of 10,000 ppm stock.
- 5.5.3.1.1.6. **cis-1,4-dichloro-2-butene**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.1.7. **Benzyl chloride**, 14 uL of 10,000 ppm stock.
- 5.5.3.1.1.8. **1,1,2-Trichlorotrifluoroethane**, 14 uL of 10,000 ppm stock.
- 5.5.3.1.1.9. **Tetrahydrofuran**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.1.10. **Hexane**, 14 uL of 10,000 ppm stock.

5.5.3.1.2. 4.0 ppm **Gases + Additions**; prepared by diluting the following to 35 milliliters with methanol:

- 5.5.3.1.2.1. **VOC Gases** mix, 700 uL of 200 ppm stock.
- 5.5.3.1.2.2. **2-Chloroethylvinyl ether**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.2.3. **Acrolein/acrylonitrile**, 700 uL of 1000 ppm stock.
- 5.5.3.1.2.4. **Ketones**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.2.5. **Methacrylonitrile**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.2.6. **1,4-Dioxane**, 140 uL of 10,000 ppm stock.
- 5.5.3.1.2.7. **Methyl tert-butyl ether**, 14 uL of 10,000 ppm stock.
- 5.5.3.1.2.8. **Vinyl Acetate**, 70 uL of 10,000 ppm stock.
- 5.5.3.1.2.9. **Cyclohexane**, 70 uL of 10,000 ppm stock.

5.5.3.1.3. 12.5 ppm **Internal standard/Surrogate**, 295 uL of 10,000 ppm stock diluted to 235 milliliters of methanol.

5.5.3.1.4. 4.0 ppm **LCS non-gases**, 40 uL of 200 ppm LCS non-gases stock diluted to 2.0 mL with methanol.

5.5.3.1.5. 4.0 ppm **LCS gases**, 40 uL of 200 ppm LCS gases stock diluted to 2.0 mL with methanol.

5.5.3.1.6. 4.0 ppm **LCS additions**, 40 uL of 200 ppm LCS additions stock diluted to 2.0 mL with methanol.

5.5.3.1.7. 4.0 ppm **TCLP Spike**, 40 uL of 200 ppm TCLP Spike stock diluted to 2.0 mL with methanol.

5.5.4. Calibration standards for Aqueous and Low Soil:

5.5.4.1. Initial calibration standards: 0.4, 1.0, 2.0, 5.0, 10 ug/L (0.4, 0.8, 2.0, 5.0, 10 ug/Kg for low soils), diluted from working standard. More points may be employed at the analysts' discretion.

5.5.4.2. Continuing calibration standards: 1.0 ug/L (2.0 ug/Kg for low soils) diluted from working standards.

5.5.4.3. Laboratory Control Sample: 1.0 ug/L (2.0 ug/Kg for low soils) diluted from stock standards.

5.5.5. Instrument Standards

5.5.5.1. A 0.4 ug/L ICAL standard is prepared by adding 4.4 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.2. A 1.0 ug/L ICAL standard is prepared by adding 11 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.3. A 2.0 ug/L ICAL standard is prepared by adding 22 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.4. A 5.0 ug/L ICAL standard is prepared by adding 55 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.5. A 10 ug/L ICAL standard is prepared by adding 110 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.6. A 1.0 ug/L CCAL standard is prepared by adding 11 microliters of gases + additions and non-gases ICAL working standards to 44 mL of deionized water.

5.5.5.7. A 1.0 ug/L LCS standard is prepared by adding 11 microliters of LCS gases, LCS non-gases, and LCS additions working standards to 44 mL of deionized water.

5.5.5.8. A 0.4 ug/Kg ICAL standard is prepared by adding 0.5 microliters of gases + additions and non-gases ICAL working standards to 5 g of deionized water w/ stir bar.

5.5.5.9. A 0.8 ug/Kg ICAL standard is prepared by adding 1.0 microliters of gases + additions and non-gases ICAL working standards to 5 g of deionized water w/ stir bar.

5.5.5.10. A 2.0 ug/Kg ICAL standard is prepared by adding 2.5 microliters of gases + additions and non-gases ICAL working standards to 5 g of deionized water w/ stir bar.

5.5.5.11. A 5.0 ug/Kg ICAL standard is prepared by adding 6.25 microliters of gases + additions and non-gases ICAL working standards to 5 g of deionized water w/ stir bar.

5.5.5.12. A 10 ug/Kg ICAL standard is prepared by adding 12.5 microliters of gases + additions and non-gases ICAL working standards to 5 g of deionized water w/ stir bar.

5.5.5.13. A 2.0 ug/Kg ICAL standard is prepared by adding 2.5 microliters of LCS gases, LCS additions, and LCS non-gases working standards to 5 g of deionized water w/ stir bar.

5.5.6. Helium, ultrapure grade.

5.5.7. Liquid carbon dioxide.

5.6. INSTRUMENT CALIBRATION

5.6.1. Tuning

5.6.1.1. The MS is tuned using BFB before any analysis begins. Tunes may be purged or injected directly into the GC. A valid tune provides for 12 hours of instrument operation from the time of injection. The following is the criteria for a valid tune:

Mass	**Criteria**
50	8 to 40% of mass 95
75	30 to 66% of mass 95
95	Base peak, 100% relative abundance
96	5 to 9% of mass 174
173	Less than 2% of mass 174
174	50.0 - 120% of mass 174
175	4 to 9% of mass 174
176	Greater than 93% but less than 101% of mass 174
177	5 to 9% of mass 176

5.6.2. Instrument Conditions

5.6.2.1. The operating conditions for the Varian Archon methods are, but not limited to the following:

Sample type <soil>
Sample volume: 10 mL
Dilution fact : no
Rinse volume : 3
# of rinses : 0
Standard 1 : Dependent
Standard 2 : Dependent
S.Preheat stir : no
Stir : yes
W.Stir time(m) : 0.00
W.Settle time : 0.00
Syringe flushes : 0

Preheat : yes
Preheat temp : 30
Preheat time : 0
Purge time (m) : 8.0
Desorb time(m) : 6.0
Oper.ModeRemode
Cycle Timer : 0
Aux. Timer : 0
Link to method : Dependent

Sample type <water>
Sample volume: 10 mL
Dilution fact : Dependent
Rinse volume : 3
# of rinses : 3

Preheat : yes
Preheat temp : 80
Preheat time : 0
Purge time (m) : 0.0

Standard 1 : Dependent
Standard 2 : Dependent
S.Preheat stir : no
Stir : no
W.Stir time(m) : 0.00
W.Settle time : 0.00
Syringe flushes : 1

Desorb time(m) : 1.0
Oper.ModeRemode
Cycle Timer : 0
Aux. Timer : 0
Link to method : Dependent

5.6.2.2. The Tekmar 3000 operating conditions are, but not limited to the following:

Trap Temperature	40 degrees Celsius
Purge Time	8.0 minutes
Dry Purge Time	4.0 minute
Desorb Preheat Temperature	220 degrees Celsius
Desorb	220 degrees Celsius for 6 minutes
Bake	240degrees Celsius for 5 minutes
Valve Temperature	120 degrees Celsius
Transfer Line Temperature	120 degrees Celsius

5.6.2.3. The GC operating conditions are:

Ion Trap Tempurature	200 degrees Celcius.
Jet separator temperature:	220 degrees Celsius.
Injector temperature:	220 degrees Celsius.
Column head pressure:	20 psi
Initial column temperature:	20 degrees Celsius hold for 6.0 minutes
Temperature program:	20 to 200 degrees Celsius at 13 degrees/minute, hold for 5.16 minutes.

5.6.3. INITIAL CALIBRATION.

5.6.3.1. An initial calibration curve is established using a minimum of five points with each point containing all the target analytes, 4 internal standards, and 5 surrogates. The calibration standard concentrations are 0.4, 1.0, 2.0, 5.0 and 10 ug/L (0.4, 0.8, 2.0, 5.0, 10 ug/Kg for low soils). More calibration points may be added at the analyst's discretion to improve quantitation of one or more individual analytes.

5.6.3.2. Using the nearest internal standard, a response factor (RF) and average RF for the entire calibration range is calculated for each Analyte. The relative standard deviation (RSD) of the response factors is calculated for each compound.

5.6.3.3. Before the calibration curve can be deemed valid, it must first meet the following criteria:

5.6.3.3.1. The RSD for the CCC Compounds Vinyl chloride, 1,1-Dichloroethene, Chloroform, 1,2-Dichloropropane, Toluene, and Ethylbenzene must be equal to or less than 30 percent.

5.6.3.3.2. The average RF for the SPCC Compounds must be greater than or equal to 0.1 for Chloromethane, 1,1-Dichloroethane, and Bromoform and greater than or equal to 0.3 for Chlorobenzene and 1,1,2,2-Tetrachloroethane.

5.6.3.3.3. The relative retention times of each compound should agree within 0.06 relative retention time units.

5.6.3.4. With the conditions of section 5.6.3.3 satisfied, one and only one of the following quantitation models must be applied to each target analyte:

5.6.3.4.1. An RSD equal to or less than 15% (30% for gases and poor purging compounds).

5.6.3.4.2. A linear regression (not forced through the origin) when the percent RSD is greater than 15 percent and the correlation coefficient for a linear plot of concentration vs. response is 0.990 or greater.

5.6.3.4.3. A quadratic regression (not forced through the origin) when sections 5.6.3.4.1 and 5.6.3.4.2 do not apply, requiring the curve to be continuous, continuously differential and monotonic over the calibration range, and the number of calibration standards is equal to or greater than six. The coefficient of the determination must be equal to or greater than 0.99.

5.6.3.5. If the conditions of section 5.6.3.3 are satisfied, an alternate quantitation method using average of response factors for ALL target analytes can be applied if the mean of the average of response factors for the entire compound list is equal to or less than 15 percent, with no target analyte RSD value above 30%.

5.6.4. CONTINUING CALIBRATION

5.6.4.1. The calibration is verified immediately after the instrument has been tuned by analyzing a CCAL standard. The CCAL standard is quantitated using the initial calibration. In order for the CCAL to be valid, the CCC Compounds must have a percent drift of less than 20 percent and the SPCC Compounds must meet the minimum average RF required in the ICAL. If the CCAL standard fails these criteria then either a second CCAL standard is analyzed, the instrument is recalibrated, or the data is documented in a nonconformance memo. The recovery of all other compounds is at analyst discretion.

5.7. SAMPLE PREPARATION

5.7.1. ***Soil Extraction:***

5.7.1.1. _Method 5030_: A sample aliquot (approximately 10 g) is placed into a scintillation vial and the exact weight recorded. 10 mL of methanol is added. The sample is homogenized via a vortex mixer then placed in the shaker table for 15 minutes. The sample is centrifuged to remove soil particulate matter from the extract. An 44 uL aliquot of methanol extract is added to 44 mL of ASTM Type II water contained in an appropriately labeled VOA vial. To prepare the blank spike (LCS) and blank spike (LCS) duplicate proceed as stated above, adding 100 uL of the 200 ppm LCS stock standards to 10 mL of methanol. To prepare the matrix spike/matrix spike duplicate, add 100 uL of the 200 ppm LCS stock standards to pre-weighed soil sample aliquots prior to extracting with 10 mL of methanol. A method blank is prepared by adding 44 uL of extracting methanol to 44 mL of ASTM Type II water.

5.7.1.2. *Method 5035 Methanol Preserved*: The sample jar is first weighed and the sample weight determined by subtracting the tare weight. A 44 uL aliquot of methanol extract is added to 44 mL of ASTM Type II water contained in an appropriately labeled VOA vial. To prepare the blank spike (LCS) and blank spike (LCS) duplicate proceed as stated above, adding 100 uL of the 200 ppm LCS stock standards to 10 mL of methanol. To prepare the post matrix spike/post matrix spike duplicate, add 11 uL of the 200 ppm LCS stock standards to each of the two additional samples prepared as described at the beginning of 5.18.1.2. A method blank is prepared by adding 44 uL of methanol to 44 mL of ASTM Type II water.

5.7.1.3. *Method 5035 NaHSO4 Preserved*: Each sample VOA vial is first weighed and the sample weight determined by subtracting the tare weight. The samples are then analyzed as received using the soil analysis option of the Archon 2000 autosampler. A post matrix spike/post matrix spike duplicate is not applicable. A duplicate sample analysis is the only QC check sample appropriate for this method, when sufficient sample VOA vials have been provided. A method blank is prepared by adding 5 ml of ASTM Type II water to a 44 mL VOA vial w/ stir bar.

5.7.1.4. If the water solution becomes cloudy upon addition of the soil extract, a higher dilution may be required and is prepared at this time.

5.7.2. ***Water Extraction***:

5.7.2.1. All aqueous samples will be analyzed as received. If available, samples may be screened by analyzing a spare VOA. Dilutions of the sample are made in multiples of 2, 5, 10, 20, 50, or 100.

5.7.3. ***TCLP Extraction***:

5.7.3.1. Prepare a method blank by adding exactly 110 uL of TCLP extract solution in 44 mL of DI water contained in a VOA vial and seal; 1 per batch of 20.

5.7.3.2. Prepare a blank spike by adding exactly 110 uL of TCLP extract solution and 11 uL of TCLP spike mix to 44 mL DI of water contained in a VOA vial and seal; 1 set per batch of 20.

5.7.3.3. For each sample, remove a 110 uL aliquot from the TCLP extract and dispense the total volume into 44 mL of DI water contained in a VOA vial. Seal and check for any significant headspace. If a large headspace is observed, discard the contents of the VOA vial and begin again. For highly contaminated sample, all subsequent dilution's of that extract can be made at this time.

5.7.3.4. Prepare a duplicate sample by dispensing a 110 uL aliquot from the TCLP extract into 44 mL of DI water contained in a VOA vial; 1 per batch of 20.

5.7.3.5. Prepare a post matrix spike for any specified sample by dispensing a 110 uL aliquot from the TCLP extract and 11 uL of the TCLP spike mix into 44 mL of DI water contained in a VOA vial; 1 per batch of 20.

5.7.3.6. Place all the sample dilutions including Q.C. samples in a VOA rack and store in the refrigerator until analysis.

5.8. SAMPLE ANALYSIS

5.8.1. Samples are loaded into the autosampler with associated QC and the instrument sequence initiated. Data is automatically collected by the data system.

5.8.2. Results are printed and then manually entered into spreadsheets by the analyst.

5.8.3. The analyst reviews all results reported before transferring the results to the project file.

5.8.4. The analyst verifies the pH of all submitted VOA samples after analysis and records the value(s) on the sample worksheet; the pH should be less than two.

5.9. CALCULATIONS

5.9.1. To calculate analyte concentration in a sample analyzed via 5035, due as follows: Result (ug/Kg) = 100 x (quan value (ug/L) x dilution x extract volume (mL)) / (sample wt. (g) x percent solids).

5.9.2. To calculate analyte concentration in a sample analyzed via 5035 ***<u>NaHSO4 Preserved</u>***, due as follows: Result (ug/Kg) = 100 x (quan value (ug/Kg) x 5) / (sample wt. (g) x percent solids).

5.9.3. To calculate analyte concentration in a sample analyzed via TCLP, due as follows: Result (mg/L) = quan value (ug/L) x dilution / 1000.

5.9.4. To calculate analyte concentration in a sample analyzed via Water extraction, due as follows: Result (ug/L) = quan value (ug/L) x dilution.

5.10. QUALITY CONTROL

5.10.1. The instrument must be operated under a valid tune and ICAL, as described in Sections 5.6.1 and 5.6.3.

5.10.2. Continuing calibration verification standards are analyzed under the criteria described in Section 5.6.4.

5.10.3. A method blank is analyzed with every batch of 20 samples (not including QC) and should be free of target compounds above there respective PQLs.

5.10.4. An LCS and LCS duplicate, both containing most if not all reported analytes, are analyzed with every batch of 20 samples (not including QC). A duplicate and/or matrix spike is performed upon client request when sufficient sample volume has been provided.

5.10.4.1. An LCS and LCS duplicate sample is analyzed per analytical batch of 20 samples (not including QC samples).

5.10.4.2. When insufficient sample is available to analyze a matrix duplicate and/or matrix spike, the LCS and LCS duplicate will be substituted and reported as the blank spike/blank spike duplicate.

5.10.4.3. If sufficient sample has been provided, a sample duplicate and sample matrix spike or matrix spike and matrix spike duplicate will be performed at the analysts discretion. Matrix spikes are prepared by adding the same LCS standards and amounts used to prepare the LCS/LCS duplicate samples. **Note:** Do to the impractical task of spiking, charting, and controlling all target analytes, a subset consisting of the five compounds required by EPA method 8260B section 5.13 will be reported unless specified in writing by the client.

5.10.4.4. Some target analytes present in the calibration curve may not be present and/or detectable in the LCS standard. These analytes will not have LCS precision and accuracy data available and will therefore be evaluated based on their recovery in the CCAL.

5.10.5. One microliter of the 12.5 ppm Internal standard / Surrogate mix is added automatically to each 10 mL aliquot during sample transfer.

5.10.6. Internal standard areas for CCAL standards must meet the criteria of 50 to 200 percent of the last continuing calibration internal standard area recoveries.

5.10.7. Sample surrogate recoveries must be within the following ranges of +/- 3 sigma standard deviation calculated from blank, blank spike, LCS, and sample data and Shell document default limits:

Surrogate:	Recovery Limit(water)	Recovery Limit(soil)	Recovery Limit(soil-low)
Dibromo-fluoromethane	84 - 115	81 – 113	75 - 123
Fluorobenzene	82 – 108	75 – 112	85 - 110
Toluene-d8	95 – 106	81 – 125	78 - 112
Ethylbenzene-d10	90 - 111	86 – 121	75 - 118
Bromofluorobenzene	81 – 113	80 – 113	75 - 124

Samples with any surrogate outside recovery ranges are reanalyzed when sufficient sample volume is available. When a surrogate recovery is outside established limits in a method blank, the analytical batch is reanalyzed when sufficient sample volume is available.

5.10.8. A method detection limits study for each target compound is performed on an annual basis.

5.10.9. Control limits for surrogates and LCS samples are updated bi-annually. Current limits are listed in Table 2.

5.11. PRECISION AND ACCURACY

5.11.1. Accuracy is evaluated based on LCS and LCS duplicate recoveries. Accuracy is also evaluated via surrogate recoveries. See section 5.10.7.

5.11.2. Precision is evaluated based on LCS and LCS duplicate RPD data of a select 12 target compounds whose physical and chemical properties best represent an across the spectrum measure of total analyte performance.

5.12. REPORTING LIMITS

5.12.1. The reporting limit is 2.0 ug/L for the ketones, 2-chloroethyl vinyl ether, acrylonitrile, acrolein, trans-1,4-dichloro-2-butene, cis-1,4-dichloro-2-butene, tetrahydrofuran, methacrylonitrile, and vinyl acetate; 0.8 ug/L for m,p-xylenes; 4.0 ug/L for 1,4-dioxane; and 0.4 ug/L for all other analytes. Reporting limits may vary according to client specific requests but are ultimately subject to instrument detection limits.

5.13. MODIFICATIONS TO PUBLISHED METHOD

5.13.1. Tune criteria is modified to reflect tune parameters as stated in SW-846 Data Validation for Volatile Organics Analysis.

5.13.2. Sound Analytical Services recognizes that not all clients request the exact same compound list for 8260B analysis and therefore, in some cases, does not spike the LCS/LCS (BS/BSD duplicate) duplicate with every compound listed in the method.

5.13.3. If during a CCAL analysis a CCC compound is outside the 20 percent drift criteria, the calibration may still be considered valid under analysts discretion if the following is true:

  5.13.3.1. The percent drift for the CCC in question is greater than 20 percent relative to the I-CAL value AND

  5.13.3.2. The CCC compound in all of the associated samples is quantitated as non-detect.

5.13.4. Analytes are reported to the MDL as estimated (J) and not ND when detected below the lowest calibration standard as specified in method 8000B, section 7.4.

6. HEALTH AND SAFETY/SPECIAL CONSIDERATIONS

6.1. Many compounds on the 8260B list are hazardous and carcinogenic. Please consult MSDS before preparing any standards.

7. NONCONFORMANCE AND CORRECTIVE ACTION

7.1. If batch QA/QC parameters are not met, all samples within the batch are reanalyzed, if adequate sample is available.

7.2. Any nonconformance encountered during sample analysis is documented by the analyst.

8. RECORDS MANAGEMENT AND DOCUMENTATION

8.1. The analyst provides the completed data package to the designated peer reviewer for peer review and signature.

8.2. Nonconformance documentation is filed in the master file. A copy is provided to the QA Director for review.

8.3. All samples analyzed are recorded in a sample run logbook.

8.4. Any instrument maintenance or repair is noted in the instrument maintenance logbook.

8.5. All data is archived to magnetic tape.

8.6. Logbooks are archived with the QC Department when completed for permanent storage.

8.7. All records will be in a controlled area with limited access.

8.8. If client contact is required, a Client Contact Record is completed and maintained in the master file.

9. WASTE MANAGEMENT AND POLLUTION PREVENTION

9.1. All laboratory waste must be handled in accordance with SAS SOP 0036.5.

9.2. All laboratory procedures must comply with the policies set forth in SAS's Pollution Prevention Plan.

Table 1. EPA Method 8260B Compounds and PQLs.

VOC Compound	PQL Water ug/L	PQL Low Soil ug/kg	PQL Med. Soil ug/kg
Dichlorodifluoromethane	0.4	0.4	400
Chloromethane	0.4	0.4	400
Vinyl chloride	0.4	0.4	400
Bromomethane	0.4	0.4	400
Chloroethane	0.4	0.4	400
Trichlorofluoromethane	0.4	0.4	400
1,1-Dichloroethene	0.4	0.4	400
1,1,2-Trichlorotrifluoroethane	0.4	0.4	400
Acrolein	2	2	2000
Carbon disulfide	0.4	0.4	400
Acetone	2	2	2000
Iodomethane	0.4	0.4	400
Methylene chloride	0.4	0.4	400
methyl tert-butyl ether	0.4	0.4	400
trans-1,2-Dichloroethene	0.4	0.4	400
Acrylonitrile	2	2	2000
Hexane	0.4	0.4	400
1,1-Dichloroethane	0.4	0.4	400
Vinyl acetate	2	2	2000
2,2-Dichloropropane	0.4	0.4	400
2-Butanone	2	2	2000
cis-1,2-Dichloroethene	0.4	0.4	400
Tetrahydrofuran	2	2	2000
Bromochloromethane	0.4	0.4	400
Methacrylonitrile	2	2	2000
Chloroform	0.4	0.4	400
1,1,1-Trichloroethane	0.4	0.4	400
Carbon Tetrachloride	0.4	0.4	400
1,1-Dichloropropene	0.4	0.4	400
Benzene	0.4	0.4	400
1,2-Dichloroethane	0.4	0.4	400
Trichloroethene	0.4	0.4	400
1,2-Dichloropropane	0.4	0.4	400
1,4-Dioxane	4	4	4000
Dibromomethane	0.4	0.4	400
Bromodichloromethane	0.4	0.4	400
2-Chloroethyl vinyl ether	2	2	2000
cis-1,3-Dichloropropene	0.4	0.4	400
4-Methyl-2-pentanone	2	2	2000
Toluene	0.4	0.4	400
trans-1,3-Dichloropropene	0.4	0.4	400
1,1,2-Trichloroethane	0.4	0.4	400

Table 1, Continued. EPA Method 8260B Compounds and PQLs.

VOC Compound	PQL Water ug/L	PQL Low Soil ug/kg	PQL Med. Soil ug/kg
Tetrachloroethene	0.4	0.4	400
1,3-Dichloropropane	0.4	0.4	400
2-Hexanone	2	2	2000
Dibromochloromethane	0.4	0.4	400
1,2-Dibromoethane	0.4	0.4	400
Chlorobenzene	0.4	0.4	400
Ethylbenzene	0.4	0.4	400
1,1,1,2-Tetrachloroethane	0.4	0.4	400
m,p-Xylene	0.8	0.8	800
o-Xylene	0.4	0.4	400
Styrene	0.4	0.4	400
Bromoform	0.4	0.4	400
Isopropylbenzene	0.4	0.4	400
cis-1,4-Dichloro-2-butene	2	2	2000
Bromobenzene	0.4	0.4	400
n-Propylbenzene	0.4	0.4	400
1,1,2,2-Tetrachloroethane	0.4	0.4	400
trans-1,4-Dichloro-2-butene	2	2	2000
1,2,3-Trichloropropane	0.4	0.4	400
2-Chlorotoluene	0.4	0.4	400
1,3,5-Trimethylbenzene	0.4	0.4	400
4-Chlorotoluene	0.4	0.4	400
t-Butylbenzene	0.4	0.4	400
1,2,4-Trimethylbenzene	0.4	0.4	400
sec-Butylbenzene	0.4	0.4	400
1,3-Dichlorobenzene	0.4	0.4	400
4-Isopropyltoluene	0.4	0.4	400
1,4-Dichlorobenzene	0.4	0.4	400
Benzyl chloride	0.4	0.4	400
n-Butylbenzene	0.4	0.4	400
1,2-Dichlorobenzene	0.4	0.4	400
1,2-Dibromo-3-chloropropane	0.4	0.4	400
1,3,5-Trichlorobenzene	0.4	0.4	400
1,2,4-Trichlorobenzene	0.4	0.4	400
Hexachlorobutadiene	0.4	0.4	400
Naphthalene	0.4	0.4	400
1,2,3-Trichlorobenzene	0.4	0.4	400
Hexachloroethane	0.4	0.4	400
Ethyl ether	0.4	0.4	400
Ethyl acetate	0.4	0.4	400
iso-Butyl alcohol	40	40	40000
n-Butyl alcohol	40	40	40000
Cyclohexane	0.4	0.4	400

Table 2. Quality Control Limits.

Volatile Organics by USEPA Method 5035/8260B Modified

Analysis Method : 8260B
Matrix : Soil
Preparation Method : SW5035 Mod.
Low -ITS 40- Level
Expires: 12/15/2000

Blank Spike Recovery

1,1-Dichloroethene	75 - 125%	=<19% RPD
1,2-Dichloroethane	75 - 125%	=<18% RPD
1,4-Dichlorobenzene	75 - 125%	=<17% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	75 - 125%	=<17% RPD
Carbon Tetrachloride	75 - 125%	=<20% RPD
Chlorobenzene	75 - 125%	=<18% RPD
Chloroform	76 - 119%	=<19% RPD
Ethylbenzene	76 - 125%	=<18% RPD
m,p-Xylene	75 - 125%	=<18% RPD
o-Xylene	75 - 125%	=<20% RPD
Tetrachloroethene	75 - 125%	=<24% RPD
Toluene	78 - 125%	=<19% RPD
Trichloroethene	76 - 125%	=<19% RPD
Vinyl chloride	75 - 125%	=<19% RPD

Matrix Spike Recovery

1,1-Dichloroethene	75 - 125%	=<19% RPD
1,2-Dichloroethane	75 - 125%	=<18% RPD
1,4-Dichlorobenzene	75 - 125%	=<17% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	75 - 125%	=<17% RPD
Carbon Tetrachloride	75 - 125%	=<20% RPD
Chlorobenzene	75 - 125%	=<18% RPD
Chloroform	76 - 119%	=<19% RPD
Ethylbenzene	76 - 125%	=<18% RPD
m,p-Xylene	75 - 125%	=<18% RPD
o-Xylene	75 - 125%	=<20% RPD
Tetrachloroethene	75 - 125%	=<24% RPD
Toluene	78 - 125%	=<19% RPD
Trichloroethene	76 - 125%	=<19% RPD
Vinyl chloride	75 - 125%	=<19% RPD

Surrogate Recovery

Bromofluorobenzene	75 - 124%
Dibromofluoromethane	75 - 123%
Ethylbenzene-d10	75 - 118%
Fluorobenzene	85 - 110%
Toluene-d8	78 - 112%

Table 2, Continued. Quality Control Limits.

Volatile Organics List by USEPA Method 5030B/8260B Modified

Analysis Method : 8260B
Matrix : Leachate
Preparation Method : 1311 / SW5030B
Medium -ITS-40- Level
Expires: 12/15/2000

Blank Spike Recovery

1,1-Dichloroethene	60 - 150%
1,2-Dichloroethane	62 - 132%
1,4-Dichlorobenzene	60 - 140%
2-Butanone	33 - 148%
Benzene	63 - 128%
Carbon Tetrachloride	55 - 135%
Chlorobenzene	64 - 122%
Chloroform	57 - 133%
Tetrachloroethene	64 - 123%
Toluene	60 - 140%
Trichloroethene	60 - 123%
Vinyl chloride	44 - 132%

Matrix Spike Recovery

1,1-Dichloroethene	60 - 150%
1,2-Dichloroethane	62 - 132%
1,4-Dichlorobenzene	60 - 140%
2-Butanone	33 - 148%
Benzene	63 - 128%
Carbon Tetrachloride	55 - 135%
Chlorobenzene	64 - 122%
Chloroform	57 - 133%
Tetrachloroethene	64 - 123%
Toluene	60 - 140%
Trichloroethene	60 - 123%
Vinyl chloride	44 - 132%

Surrogate Recovery

Bromofluorobenzene	79 - 114%
Dibromofluoromethane	83 - 116%
Ethylbenzene-d10	91 - 111%
Fluorobenzene	75 - 112%
Toluene-D8	73 - 121%

Table 2, Continued. Quality Control Limits.

Volatile Organics by USEPA Method 5030B/8260B Modified

Analysis Method : 8260B
Matrix : Water
Preparation Method : SW5030B
Low -ITS-40- Level
Expires: 12/15/2000

Blank Spike Recovery

1,1-Dichloroethene	80 - 120%	=<13% RPD
1,2-Dichloroethane	80 - 120%	=<18% RPD
1,4-Dichlorobenzene	80 - 120%	=<20% RPD
2-Butanone	60 - 140%	=<40% RPD
Benzene	80 - 117%	=<13% RPD
Carbon Tetrachloride	80 - 120%	=<20% RPD
Chlorobenzene	80 - 120%	=<15% RPD
Chloroform	80 - 120%	=<15% RPD
Ethylbenzene	80 - 120%	=<25% RPD
m,p-Xylene	80 - 120%	=<15% RPD
o-Xylene	80 - 120%	=<14% RPD
Tetrachloroethene	80 - 120%	=<13% RPD
Toluene	80 - 120%	=<14% RPD
Trichloroethene	80 - 119%	=<14% RPD
Vinyl chloride	80 - 120%	=<20% RPD

Matrix Spike Recovery

1,1-Dichloroethene	80 - 120%	=<13% RPD
1,2-Dichloroethane	80 - 120%	=<18% RPD
1,4-Dichlorobenzene	80 - 120%	=<20% RPD
2-Butanone	60 - 140%	=<40% RPD
Benzene	80 - 117%	=<13% RPD
Carbon Tetrachloride	80 - 120%	=<20% RPD
Chlorobenzene	80 - 120%	=<15% RPD
Chloroform	80 - 120%	=<15% RPD
Ethylbenzene	80 - 120%	=<25% RPD
m,p-Xylene	80 - 120%	=<15% RPD
o-Xylene	80 - 120%	=<14% RPD
Tetrachloroethene	80 - 120%	=<13% RPD
Toluene	80 - 120%	=<14% RPD
Trichloroethene	80 - 119%	=<14% RPD
Vinyl chloride	80 - 120%	=<20% RPD

Surrogate Recovery

Bromofluorobenzene	81 - 113%
Dibromofluoromethane	84 - 115%
Ethylbenzene-d10	90 - 111%
Fluorobenzene	82 - 108%
Toluene-D8	95 - 106%

Table 2, Continued. Quality Control Limits.

Volatile Organics by USEPA Method 5035/8260B Modified

Analysis Method : 8260B
Matrix : Soil
Preparation Method : SW5035 Mod.
Medium -ITS-40- Level
Expires: 12/15/2000

Blank Spike Recovery		
1,1-Dichloroethene	77 - 125%	=<17% RPD
1,2-Dichloroethane	75 - 113%	=<25% RPD
1,4-Dichlorobenzene	75 - 106%	=<25% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	75 - 116%	=<24% RPD
Carbon tetrachloride	75 - 125%	=<25% RPD
Chlorobenzene	75 - 117%	=<22% RPD
Chloroform	75 - 119%	=<25% RPD
Ethylbenzene	75 - 125%	=<25% RPD
m,p-Xylene	75 - 125%	=<25% RPD
o-Xylene	75 - 125%	=<25% RPD
Tetrachloroethene	75 - 103%	=<25% RPD
Toluene	75 - 119%	=<20% RPD
Trichloroethene	75 - 119%	=<30% RPD
Vinyl Chloride	75 - 119%	=<25% RPD
Matrix Spike Recovery		
1,1-Dichloroethene	77 - 125%	=<17% RPD
1,2-Dichloroethane	75 - 125%	=<25% RPD
1,4-Dichlorobenzene	75 - 106%	=<25% RPD
2-Butanone	60 - 140%	=<25% RPD
Benzene	75 - 116%	=<24% RPD
Carbon tetrachloride	75 - 125%	=<25% RPD
Chlorobenzene	75 - 117%	=<22% RPD
Chloroform	75 - 119%	=<25% RPD
Ethylbenzene	75 - 125%	=<25% RPD
m,p-Xylene	75 - 125%	=<25% RPD
o-Xylene	75 - 125%	=<25% RPD
Tetrachloroethene	75 - 103%	=<25% RPD
Toluene	75 - 119%	=<20% RPD
Trichloroethene	75 - 119%	=<30% RPD
Vinyl Chloride	75 - 119%	=<25% RPD
Surrogate Recovery		
Bromofluorobenzene	80 - 113%	
Dibromofluoromethane	81 - 113%	
Ethylbenzene-d10	86 - 121%	
Fluorobenzene	75 - 112%	
Toluene-D8	81 - 125%	

METHOD 9060

TOTAL ORGANIC CARBON

1.0 SCOPE AND APPLICATION

1.1 Method 9060 is used to determine the concentration of organic carbon in ground water, surface and saline waters, and domestic and industrial wastes. Some restrictions are noted in Sections 2.0 and 3.0.

1.2 Method 9060 is most applicable to measurement of organic carbon above 1 mg/L.

2.0 SUMMARY OF METHOD

2.1 Organic carbon is measured using a carbonaceous analyzer. This instrument converts the organic carbon in a sample to carbon dioxide (CO_2) by either catalytic combustion or wet chemical oxidation. The CO_2 formed is then either measured directly by an infrared detector or converted to methane (CH_4) and measured by a flame ionization detector. The amount of CO_2 or CH_4 in a sample is directly proportional to the concentration of carbonaceous material in the sample.

2.2 Carbonaceous analyzers are capable of measuring all forms of carbon in a sample. However, because of various properties of carbon-containing compounds in liquid samples, the manner of preliminary sample treatment as well as the instrument settings will determine which forms of carbon are actually measured. The forms of carbon that can be measured by Method 9060 are:

1. Soluble, nonvolatile organic carbon: e.g., natural sugars.
2. Soluble, volatile organic carbon: e.g., mercaptans, alkanes, low molecular weight alcohols.
3. Insoluble, partially volatile carbon: e.g., low molecular weight oils.
4. Insoluble, particulate carbonaceous materials: e.g., cellulose fibers.
5. Soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter: e.g., oily matter adsorbed on silt particles.

2.3 Carbonate and bicarbonate are inorganic forms of carbon and must be separated from the total organic carbon value. Depending on the instrument manufacturer's instructions, this separation can be accomplished by either a simple mathematical subtraction, or by removing the carbonate and bicarbonate by converting them to CO_2 with degassing prior to analysis.

3.0 INTERFERENCES

3.1 Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be removed or accounted for in the final calculation.

3.2 This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a microliter-type syringe or pipet. The openings of the syringe or pipet limit the maximum size of particle which may be included in the sample.

3.3 Removal of carbonate and bicarbonate by acidification and purging with nitrogen, or other inert gas, can result in the loss of volatile organic substances.

4.0 APPARATUS AND MATERIALS

4.1 Apparatus for blending or homogenizing samples: Generally, a Waring-type blender is satisfactory.

4.2 Apparatus for total and dissolved organic carbon:

4.2.1 Several companies manufacture analyzers for measuring carbonaceous material in liquid samples. The most appropriate system should be selected based on consideration of the types of samples to be analyzed, the expected concentration range, and the forms of carbon to be measured.

4.2.2 No specific analyzer is recommended as superior. If the technique of chemical oxidation is used, the laboratory must be certain that the instrument is capable of achieving good carbon recoveries in samples containing particulates.

5.0 REAGENTS

5.1 ASTM Type II water (ASTM D1193): Water should be monitored for impurities, and should be boiled and cooled to remove CO_2.

5.2 Potassium hydrogen phthalate, stock solution, 1,000 mg/L carbon: Dissolve 0.2128 g of potassium hydrogen phthalate (primary standard grade) in Type II water and dilute to 100.0 mL.

NOTE: Sodium oxalate and acetic acid are not recommended as stock solutions.

5.3 Potassium hydrogen phthalate, standard solutions: Prepare standard solutions from the stock solution by dilution with Type II water.

5.4 Carbonate-bicarbonate, stock solution, 1,000 mg/L carbon: Weigh 0.3500 g of sodium bicarbonate and 0.4418 g of sodium carbonate and transfer both to the same 100-mL volumetric flask. Dissolve with Type II water.

5.5 Carbonate-bicarbonate, standard solution: Prepare a series of standards similar to Step 5.3.
NOTE: This standard is not required by some instruments.

5.6 Blank solution: Use the same Type II water as was used to prepare the standard solutions.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples must be collected using a sampling plan that addresses the considerations discussed in Chapter Nine of this manual.

6.2 Sampling and storage of samples in glass bottles is preferable. Sampling and storage in plastic bottles such as conventional polyethylene and cubitainers is permissible if it is established that the containers do not contribute contaminating organics to the samples.
NOTE: A brief study performed in the EPA Laboratory indicated that Type II water stored in new, 1-qt cubitainers did not show any increase in organic carbon after 2 weeks' exposure.

6.3 Because of the possibility of oxidation or bacterial decomposition of some components of aqueous samples, the time between sample collection and the start of analysis should be minimized. Also, samples should be kept cool (4°C) and protected from sunlight and atmospheric oxygen.

6.4 In instances where analysis cannot be performed within 2 hr from time of sampling, the sample is acidified ($pH \leq 2$) with HCl or H_2SO_4.

7.0 PROCEDURE

7.1 Homogenize the sample in a blender.
NOTE: To avoid erroneously high results, inorganic carbon must be accounted for. The preferred method is to measure total carbon and inorganic carbon and to obtain the organic carbon by subtraction. If this is not possible, follow Steps 7.2 and 7.3 prior to analysis; however, volatile organic carbon may be lost.

7.2 Lower the pH of the sample to 2.

7.3 Purge the sample with nitrogen for 10 min.

7.4 Follow instrument manufacturer's instructions for calibration, procedure, and calculations.

7.5 For calibration of the instrument, a series of standards should be used that encompasses the expected concentration range of the samples.

7.6 Quadruplicate analysis is required. Report both the average and the range.

8.0 QUALITY CONTROL

8.1 All quality control data should be maintained and available for easy reference or inspection.

8.2 Employ a minimum of one blank per sample batch to determine if contamination or any memory effects are occurring.

8.3 Verify calibration with an independently prepared check standard every 15 samples.

8.4 Run one spike duplicate sample for every 10 samples. A duplicate sample is a sample brought through the whole sample preparation and analytical process.

9.0 METHOD PERFORMANCE

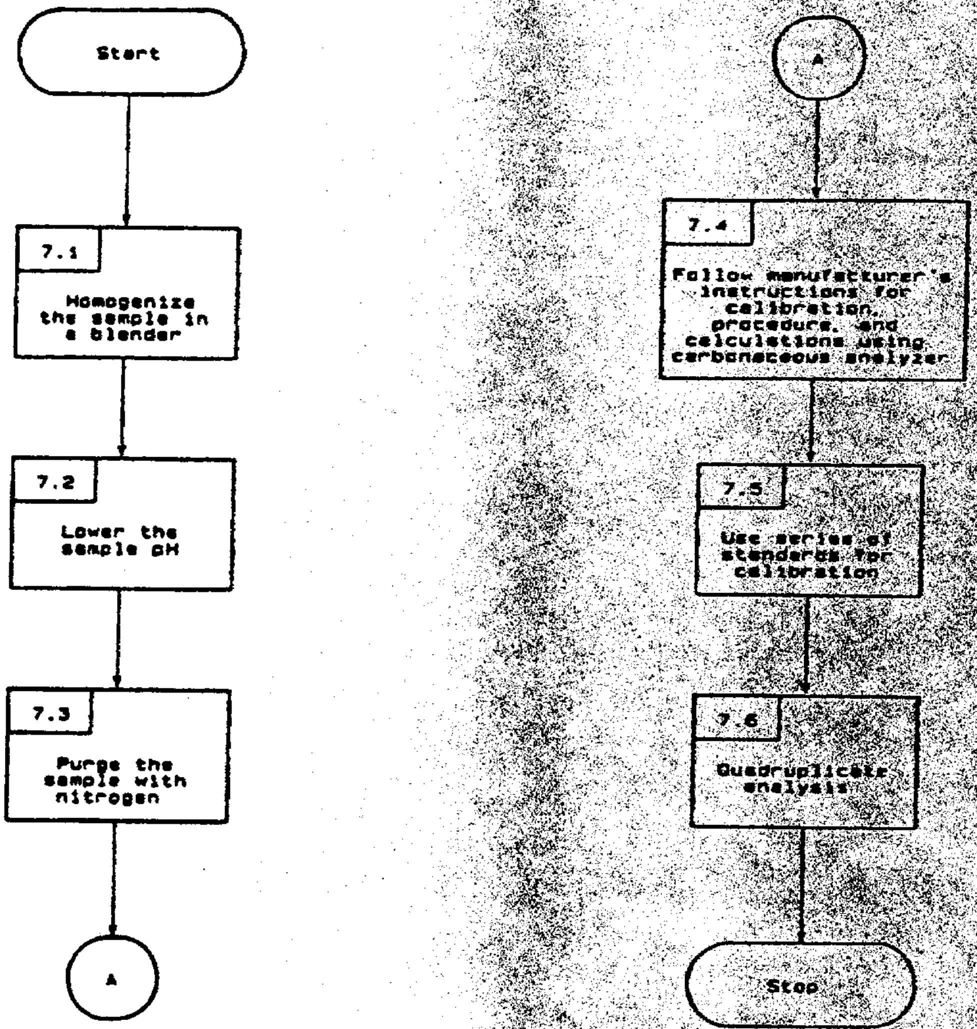
9.1 Precision and accuracy data are available in Method 415.1 of Methods for Chemical Analysis of Water and Wastes.

10.0 REFERENCES

1. Annual Book of ASTM Standards, Part 31, "Water," Standard D 2574-79, p. 469 (1976).

2. Standard Methods for the Examination of Water and Wastewater, 14th ed., p. 532, Method 505 (1975).

METHOD 9060
TOTAL ORGANIC CARBON



Designation: D 971 – 82

An American National Standard

Standard Test Method for
INTERFACIAL TENSION OF OIL AGAINST WATER BY THE RING METHOD[1]

This standard is issued under the fixed designation D 971; 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.

1. Scope

1.1 This method covers the measurement of, under nonequilibrium conditions, the interfacial tension of mineral oils[2] against water.

2. Summary of Method

2.1 *Interfacial Tension* is determined by measuring the force necessary to detach a planar ring of platinum wire from the surface of the liquid of higher surface tension, that is, upward from the water-oil interface. To calculate the interfacial tension, the force so measured is corrected by an empirically determined factor which depends upon the force applied, the densities of both oil and water, and the dimensions of the ring. Measurements are made under rigidly standardized nonequilibrium conditions in which the measurement is completed within 1 min after formation of the interface.

3. Significance and Use

3.1 This method has been shown by practice to give a reliable indication of the presence of hydrophilic compounds.

4. Apparatus (Figs. 1 and 2)

4.1 *Tensiometer*[3] with a torsion wire to apply the force to lift the ring; the torsion wire is attached to a scale graduated in millinewtons per metre.

4.2 *Ring* of fine platinum wire in a nearly true circle of 4 or 6-cm circumference welded to a suitable stirrup made of the same wire. It is necessary to know, to three significant figures, the circumference of each ring, and the ratio of the diameter of the ring to the diameter of the wire of which it is made.

4.3 *Sample Container*[4]—Glass beaker or cylindrical vessel having a minimum diameter of 45 mm.

5. Preparation of Apparatus

5.1 Clean all glassware by removing any residual oil with petroleum naphtha followed by several washes with methyl ethyl ketone and water and immersion in a hot cleaning solution of chromic acid. (**Warning**—Petroleum naphtha and methyl ethyl ketone are flammable and harmful if inhaled. Chromic acid can cause severe burns and requires extreme care. See Annex A1.1 and A1.2 for precautions in using these materials.) Rinse thoroughly with tap water and then with distilled water. Unless it is to be used immediately, drain the sample container in an inverted position over a clean cloth.

5.2 Clean the platinum ring by rinsing it in petroleum naphtha followed by rinsing in methyl ethyl ketone. (**Warning**—See Annex A1.3.) Then heat the ring in the oxidizing portion of a gas flame.

6. Calibration of Apparatus

6.1 Calibrate the tensiometer against known weights and adjust its zero point according to

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[1] This method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.

Current edition approved Aug. 27, 1982. Published October 1982. Originally published as D 971 – 48 T. Last previous edition D 971 – 50 (1977).

[2] Statements defining this test and its significance when applied to electrical insulating oils of mineral origin will be found in ASTM Method and Specifications D 177, Testing Electrical Insulating Oils of Petroleum Origin, *1982 Annual Book of ASTM Standards*, Part 40.

[3] Tensiometers that use the Du Nouy principle for measuring interfacial and surface tension should be used.

[4] Plasticizers used in the manufacture of tubing and containers can be detrimental to the quality of distilled water.

the procedure of its manufacturer. Make certain that all portions of the ring are in the same horizontal plane.

7. Sample

7.1 Filter the sample through a 150-mm diameter, unwashed filter paper of medium porosity, using fresh paper for each 25-mL portion of oil. Determine the density of the filtered oil to the nearest 0.001 g/mL at 25°C.

8. Procedure

8.1 Introduce 50 to 75 mL of distilled water at a temperature of 25 ± 1°C to a freshly cleaned sample container and place it on the adjustable platform of the tensiometer. Clean the platinum ring (5.2) and suspend it from the tensiometer. Raise the adjusting platform until the ring is immersed in the water to a depth not exceeding 6 mm in the center of the sample container as determined by visual observation.

8.2 Slowly lower the platform, increasing the torque of the ring system by maintaining the torsion arm in the zero position. As the film of water adhering to the ring approaches the breaking point, proceed slowly with adjustment to assure that the moving system will be in the zero position when rupture occurs. Using the scale reading at which this occurs, calculate the tension of the water sample as described in Section 9 using the value 0.997 for the difference of density of water and air $(D - d)$; a value of 71 to 72 mN/m should be obtained. When low values are found, possibly due to improper adjustment of the tensiometer or improperly cleaned apparatus, make readjustments; clean the sample container with hot chromic acid cleaning solution, rinse, and repeat the measurement. If a low value is still obtained, further purify the distilled water (for instance, by redistilling from an alkaline solution of potassium permanganate).

8.3 Return the tensiometer scale to zero and raise the adjustable platform until the ring is immersed to a depth of about 5 mm in the distilled water. Pour the filtered oil, previously brought to a temperature of 25 ± 1°C on the water to a depth of about 10 mm. Take care that the ring does not touch the oil-water interface. If a ring with a short stirrup is used, keep the oil level below the top of the stirrup to prevent bridging. If this is not possible, break the bridge with a suitable clean, sharp instrument as soon as possible after withdrawing the stirrup from the oil.

8.4 Allow the oil-water interface to age for 30 ± 1 s, then slowly lower the platform, increasing the torque of the ring system by maintaining the torsion arm in the zero position. As the water adhering to the ring approaches the breaking point, proceed slowly with adjustment to assure that the moving parts will be in zero position when rupture occurs. Time these operations so that, as nearly as possible, 30 s are required to draw the ring through the interface. Proceed very slowly as the breaking point is approached, since the break is usually sluggish and too rapid movement may result in a high reading. Complete the entire operation, from the time of pouring the oil into the sample container until the film ruptures, in about 1 min. Record the scale reading at which the ring breaks free from the interface.

9. Calculation

9.1 Calculate the interfacial tension of the sample by means of the following equation;

$$\text{Interfacial tension, mN/m} = P \times F$$

where:

P = scale reading when film ruptures, mN/m (Note), and

F = factor converting scale reading in mN/m to interfacial tension obtained as described in 9.2.

NOTE—If the scale is not graduated in millinewtons per metre, or if either the ring or the platinum wire are of different diameters than those for which the scale is graduated, correct the scale readings to millinewtons per metre for the particular ring used.

9.2 Using the value of diameter ratio, R/r, specified by the manufacturer for the rings used, prepare a graph[5] of correction factors, F, by means of the following equation; the graph should cover even increments of $P/D - d$ from 0 to 800 and should give correction factors to three digits:

$$F = 0.7250 + \sqrt{\frac{1.452P}{C^2(D - d)} + 0.04534 - \frac{1.679}{R/r}}$$

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[5] For a description of procedure, see Zuidema and Waters, *Industrial and Engineering Chemistry*, Analytical Edition, IENAA, Vol 13, 1941, p. 312.

where:

P = scale reading, mN/m,
C = circumference of ring, mm,
D = density of water at 25°C, g/mL,
d = density of sample at 25°C, g/mL,
R = radius of ring, mm, and
r = radius of wire of ring, mm.

10. Precision

10.1 Results should not differ from the mean by more than the following amounts:

10.1.1 *Repeatability* (same operator and apparatus)— 2 % of mean.

10.1.2 *Reproducibility* (different operators and apparatus)—5 % of mean.

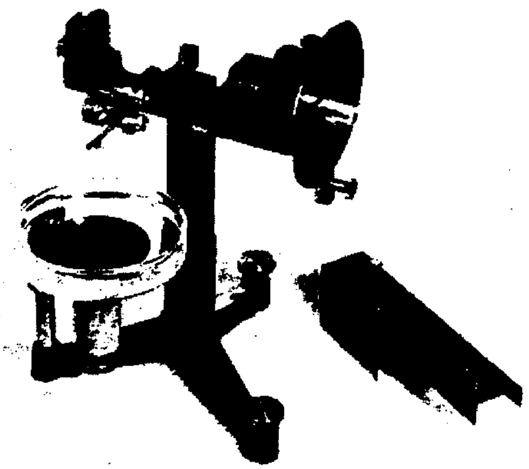

FIG. 1 Tensiometer

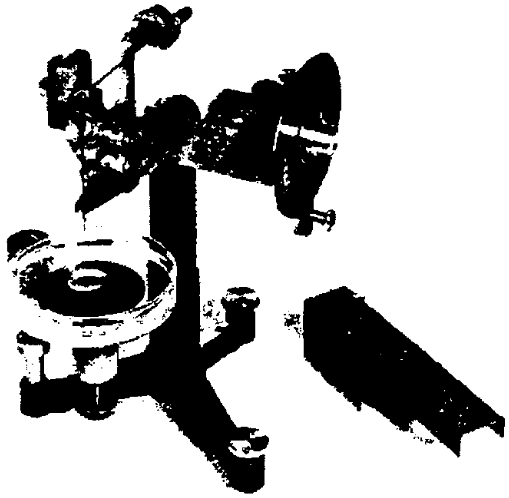

FIG. 2 Interfacial Tensiometer

ANNEX

(MANDATORY INFORMATION)

A1. PRECAUTIONARY STATEMENTS

A1.1 Petroleum Naphtha

Tag Closed Flash Point over 100°F. **Caution**—Combustible. Vapor harmful.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

Tag Closed Cup Flash Point 20 to 100°F. **Warning**—Flammable. Harmful if inhaled.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid prolonged breathing of vapor or spray mist.
Avoid prolonged or repeated skin contact.

A1.2 Methyl Ethyl Ketone

Warning—Flammable.

Keep away from heat, sparks, and open flame.
Keep container closed.
Use only with adequate ventilation.
Avoid prolonged breathing of vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A1.3 Chromic Acid (Cleaning Solution)

Danger—Causes severe burns. A recognized carcinogen.

Strong oxidizer, contact with other material may cause fire. Hygroscopic.

Do not get in eyes, on skin, or on clothing.
Avoid breathing vapor or mist.
Keep container closed.
Use with adequate ventilation.
Do not take internally.
Wash thoroughly after handling.

Designation: D 445 – 83

Designation: 71/79

An American National Standard
Deutsche Norm DIN 51 550
British Standard 4708

Standard Test Method for
KINEMATIC VISCOSITY OF TRANSPARENT AND OPAQUE LIQUIDS (AND THE CALCULATION OF DYNAMIC VISCOSITY)[1]

This standard is issued under the fixed designation D 445; 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 is also a standard of the Institute of Petroleum issued under the fixed designation IP 71. The final number indicates the year of last revision.

This method was adopted as a joint ASTM-IP standard in 1964.

This method has been adopted for use by government agencies to replace Method 305.6 of Federal Test Method Standard No. 791b.

1. Scope

1.1 This test method covers the determination of the kinematic viscosity of liquid petroleum products (Note 1), both transparent and opaque, by measuring the time for a volume of liquid to flow under gravity through a calibrated glass capillary viscometer. The dynamic viscosity can be obtained by multiplying the measured kinematic viscosity by the density of the liquid.

Note 1—For the measurement of the viscosity of bitumens, see also Test Method D 2170, and Test Method D 2171/IP 222.

1.2 This test method is intended for application to liquids for which the shear stress and shear rates are proportional (Newtonian flow, Note 2).

Note 2—The method depends on the behavior of the sample, and ideally the coefficient of viscosity should be independent of the rate of shear (this is commonly called Newtonian flow behavior). If, however, the coefficient of viscosity varies significantly with the rate of shear, different results may be obtained from viscometers of different capillary diameters.

1.3 *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.*

2. Applicable Documents

2.1 *ASTM Standards:*

D 446 Specifications and Operating Instructions for Glass Capillary Kinematic Viscometers[2]

D 2170 Test Method for Kinematic Viscosity of Asphalts (Bitumens)[3]

D 2171 Test Method for Viscosity of Asphalts by Vacuum Capillary Viscometer[3]

E 1 Specification for ASTM Thermometers[4]

E 77 Method for Verification and Calibration of Liquid-in-Glass Thermometers[5]

3. Definitions

3.1 *kinematic viscosity*—a measure of the resistive flow of a fluid under gravity, the pressure head being proportional to the density, ρ, of the fluid; for gravity flow under a given hydrostatic head, the pressure head of a liquid is proportional

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[1] This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.07 on Flow Properties.

Current edition approved Oct. 28, 1983. Published January 1984. Originally published as D 445 – 37 T. Last previous edition D 445 – 82.

In the IP, this test method is under the jurisdiction of the Standardization Committee.

[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 04.03.

[4] *Annual Book of ASTM Standards*, Vol 03.04 and 05.01.

[5] *Annual Book of ASTM Standards*, Vol 14.01.

to its density, ρ. For any particular viscometer, the time of flow of a fixed volume of fluid is directly proportional to its kinematic viscosity, $\nu = \eta/\rho$, where η is the dynamic viscosity coefficient. The kinematic viscosity coefficient has the dimension L^2/T, where L is a length, and T is a time. The cgs unit of kinematic viscosity is one centimetre squared per second and is called one stokes (symbol St). The SI unit of kinematic viscosity is one metre squared per second and is equivalent to 10^4 St. Frequently, the centistokes (symbol cSt) is used (1 cSt = 10^{-2} St).

3.2 *density*—the mass per unit volume of the fluid. The dimension of density is M/L^3, where M is a mass. The cgs unit of density (ρ) is one gram per cubic centimetre, and the SI unit of density is one kilogram per cubic metre.

3.3 *dynamic viscosity* (coefficient of)—the ratio between the applied shear stress and rate of shear. This coefficient, η, is thus a measure of the resistance to flow of the fluid; it is commonly called the viscosity of the liquid. The dimension of the coefficient of dynamic viscosity is $M/LT = FT/L^2$ depending on whether the dimension of viscosity is based on the M-L-T system or the F-L-T system (where F represents a force). The cgs unit of dynamic viscosity is one gram per centimetre per second = one dyne-second per centimetre squared and is called one poise (symbol P). The SI unit of dynamic viscosity is one newton-second per metre squared and is equivalent to 10 P. Frequently, the centipoise (symbol cP) is used (1 cP = 10^{-2} P).

NOTE 3—Dynamic viscosity also denotes a frequency-dependent quantity in which shear stress and shear rate have a sinusoidal time dependence; it is hoped that this dual use of the same term will not be confusing.

4. Summary of Method

4.1 The time is measured in seconds for a fixed volume of liquid to flow under gravity through the capillary of a calibrated viscometer under a reproducible driving head and at a closely controlled temperature. The kinematic viscosity is the product of the measured flow time and the calibration constant of the viscometer.

5. Significance and Use

5.1 Many petroleum products, as well as non-petroleum materials, are used as lubricants for bearings, gears, compressor cylinders, hydraulic equipment, etc. The proper operation of the equipment depends upon the proper kinematic viscosity or viscosity (sometimes called dynamic viscosity) of the liquid. Thus, the accurate measurement of kinematic viscosity and viscosity is essential to many product specifications.

5.2 The kinematic viscosity of many petroleum fuels is important for their proper use, for example, flow of fuels through pipe lines, injection nozzles and orifices, and the determination of the temperature range for proper operation of the fuel in burners.

6. Apparatus

6.1 *Viscometers* of the glass capillary type, calibrated and capable of measuring kinematic viscosity within the limits of precision given in Section 12, are acceptable. Viscometers listed in Table 1 meet these requirements.

6.1.1 Automated assemblies that measure kinematic viscosity within the limits of precision given in Section 11 are acceptable alternatives; kinematic viscosities less than 10 cSt and flow times less than 200 s may require a kinetic energy correction (see Specifications D 446).

6.2 *Viscometer Holders* to enable the viscometer to be suspended in a similar position as when calibrated. The proper alignment of vertical parts may be confirmed by using a plumb line.

6.3 *Viscometer Thermostat and Bath*—Any transparent liquid or vapor bath may be used, provided that it is of sufficient depth that at no time during the measurement will any portion of the sample in the viscometer be less than 20 mm below the surface of the bath liquid or less than 20 mm above the bottom of the bath.

6.3.1 The temperature control must be such that for the range from 15 to 100°C (60 to 212°F) the temperature of the bath medium does not vary by more than 0.01°C (0.02°F) over the length of the viscometers, or between the position of each viscometer, or at the location of the thermometer. For temperatures outside this range, the variation must not exceed 0.03°C (0.05°F).

6.4 *Temperature-Measuring Device*—Standardized liquid-in-glass thermometers (Table 2) of an accuracy after correction of 0.02°C (0.04°F) can be used, or any other thermometric device of equal accuracy. If standardized liquid-in-glass thermometers are used, it is recommended (but not required) that two thermometers be used; they must agree within 0.04°C (0.07°F).

6.5 *Timing Device*—Any timing device may be used provided that the readings can be taken with a discrimination of 0.2 s or better, and that it has an accuracy within ±0.07 % when tested over intervals of 15 min.

6.5.1 Electrical timing devices may be used if the current frequency is controlled to an accuracy of 0.05 % or better. Alternating currents, as provided by some public power systems, are intermittently rather than continuously controlled. When used to actuate electrical timing devices, such control can cause large errors in viscosity flow measurements.

7. Calibration

7.1 *Viscometers*—Use only calibrated viscometers with constants measured and provided to the nearest 0.1 % of their value.

7.2 *Thermometers*—Routine liquid-in-glass thermometers should be checked to the nearest 0.01°C (0.02°F) by direct comparison with a suitable calibrated thermometer.

7.2.1 Kinematic viscosity test thermometers shall be standardized at total immersion which means immersion to the top of the mercury column, with the remainder of the stem and the expansion chamber at the top of the thermometer exposed to room temperature. Do not submerge the expansion bulb at the top of the thermometer.

7.2.2 It is essential that the ice point of standardized thermometers be determined periodically and that the official corrections be adjusted to conform to the change in ice point.

7.3 *Timers*—Standard time signals available in some countries may be used for checking accuracy of timing devices.

7.4 *Viscosity Standards*[6] (Table 3)—These may be used as confirmatory checks on the procedure in the laboratory. If the measured kinematic viscosity does not agree within ±0.35 % of the certified value, each step in the procedure should be rechecked, including thermometer and viscometer calibration, to locate the source of error. It must be appreciated that a correct result obtained on a standard oil does not preclude the possibility of a counterbalancing combination of the possible sources of error.

7.4.1 *Viscosity Oil Standards*, ASTM, having the approximate kinematic viscosity shown in Table 3 are available.[5] Certified kinematic viscosity values are compared by annual cooperative tests by a number of laboratories. The current values are supplied with each portion.

8. Procedure for Kinematic Viscosity

8.1 The specific details of operation vary for the different types of viscometers listed in Table 1. In all cases, however, proceed in accordance with 8.2 through 8.6.

8.2 Maintain the bath at the test temperature within the limits given in 6.3.1. Apply the necessary corrections, if any, to all thermometer readings.

8.2.1 Ascertain that the ice point of the thermometer has been determined recently and the corrections, if any, applied to the calibration values. The possible change in the ice point reading of new thermometers may require a check every week.

8.2.2 Select a clean dry, calibrated viscometer having a range covering the estimated viscosity (that is, a wide capillary for a very viscous liquid and a narrower capillary for a more fluid liquid). The flow time should not be less than 200 s.

8.2.3 When the temperature of the test is below the dew point, fit loosely packed drying tubes onto the open ends of the viscometer to prevent water condensation. Drying tubes must fit the design of the viscometer and not restrict the flow of the sample under test by pressures created in the instrument. At temperatures below 0°C (32°F), it may be advisable to charge the sample into the viscometer at ambient temperature; allow the viscometer to cool to bath temperature, keeping the sample in the working capillary to prevent slight accumulation of frost on the walls of the capillary.

8.2.4 Viscometers used for silicone fluids, fluorocarbons, and other liquids which are difficult to remove by the use of a cleaning agent, should be reserved for the exclusive use of those fluids except when calibrating. Subject such viscometers to calibration checks at frequent intervals.

8.3 Charge the viscometer in the manner dictated by the design of the instrument, this operation being in conformity with that employed when the instrument was calibrated. Should the sample contain solid particles, filter during charging thru a No. 200 (75-μm) sieve.

8.3.1 With certain products which exhibit

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[6] The ASTM Viscosity Oil Standards are available in 1-pt containers. Purchase orders should be addressed to the Cannon Instrument Co., P. O. Box 16, State College, PA. 16801. Shipment will be made as specified or by best means.

"gel-like" behavior, take care that measurements are made at sufficiently high temperatures for such materials to flow freely so that similar results will be obtained in viscometers of different capillary diameters.

8.3.2 The viscosity of steam-refined cylinder oils, black lubricating oils, residual fuel oils, and similar waxy products can be affected by the previous thermal history. Follow the preheating procedure given below to obtain uniform results for viscosities below 95°C (200°F).

8.3.2.1 To obtain a representative sample, heat in the original container to about 50°C (122°F) with stirring and shaking. Probe the bottom of the container with a rod to be certain that all waxy materials are in solution. Pour 100 mL into a 125-mL conical flask. Stopper loosely with a cork or rubber stopper. Immerse the flask in a bath of boiling water for 30 min. Mix well, remove the sample from the bath and strain it through a No. 200 (75-µm) screen directly into the viscometer already in the thermostated bath. Complete the viscosity test within 1 h after preheating.

8.4 Allow the charged viscometer to remain in the bath long enough to reach the test temperature. Because this time will vary for the different instruments and for different temperatures, establish a safe temperature equilibrium time by trial (30 min should be sufficient). Where design of the viscometer requires it, adjust the volume of the test sample after the sample has reached temperature equilibrium. One bath is often used to accommodate several viscometers. Never add or withdraw a viscometer while any other viscometer is in use for measuring a flow time.

8.5 Use suction (if the sample contains no volatile constituents) or pressure to adjust the head level of the test sample to a position in the capillary arm of the instrument about 5 mm ahead of the first timing mark. With the sample flowing freely measure in seconds, to within 0.2 s (see 6.5), the time required for the meniscus to pass from the first timing mark to the second. If this flow time is less than the specified minimum (see 8.2.2), select a viscometer with a capillary of smaller diameter and repeat the operation.

8.5.1 For modified Ostwald and suspended-level types, repeat the procedure described in 8.5 to make a second measurement of the flow time. For reverse flow viscometers use the same or another viscometer and begin at 8.3 to make the second measurement.

8.6 If two measurements agree within 0.2 %, use the average for calculating the reported kinematic viscosity. For reverse-flow types, flow times should agree within 0.35 %. If these agreements are not obtained, reject the test results.

9. Procedure for Dynamic Viscosity

9.1 Determine the kinematic viscosity as described in Section 8.

9.2 Determine the density of the sample, to the nearest ~~0.001~~ g/cm^3 at the same temperature as the viscosity, in accordance with any applicable method.

10. Cleaning of Viscometer

10.1 Between successive determinations, clean the viscometer thoroughly by several rinsings with an appropriate solvent completely miscible with the sample, followed by a completely volatile solvent. Dry the tube by passing a slow stream of filtered dry air through the viscometer for 2 min or until the last trace of solvent is removed.

10.2 Periodically clean the instrument with chromic acid to remove organic deposits, rinse thoroughly with distilled water and acetone, and dry with clean dry air. Inorganic deposits may be removed by hydrochloric acid treatment before use of cleaning acid, particularly if barium salts are suspected.

11. Calculations and Report

11.1 Calculate the kinematic viscosity, ν, from the measured flow time, t, and the instrument constant, C, by means of the following equation:

$$\nu = Ct$$

where:

ν = kinematic viscosity, cSt,
C = calibration constant of the viscometer, cSt/s, and
t = flow time, s.

11.2 Calculate the dynamic viscosity, η, from the calculated kinematic viscosity, ν, and the density, ρ, by means of the following equation:

$$\eta = \rho \nu$$

where:

η = dynamic viscosity, cP,
ρ = density, g/cm^3, (Note 4) at the same temperature used for measuring the flow time t, and
ν = kinematic viscosity, cSt.

11.3 Report test results for both the kinematic and dynamic viscosity rounded to the nearest one part per thousand of the value measured or calculated, respectively.

NOTE 4—It is permissible to use density valves calculated in grams per millilitre units as being numerically equivalent to those in grams per cubic centimetre units.

12. Precision

12.1 The precision of this test method as obtained by statistical examination of interlaboratory test results for clean, transparent oils tested over the range from 15 to 100°C (59 to 212°F) is as follows:

12.2 *Repeatability*—The difference between successive test results, obtained by the same apparatus under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of this test method, exceed 0.35 % of their mean only in one case in twenty. Differences greater than this should be considered suspect.

12.3 *Reproducibility*—The difference between two single and independent test results, obtained by different operators working in different laboratories on identical test material would, in the long run, in normal and correct operation of this test method, exceed 0.70 % of their mean only in one case in twenty. Differences greater than this should be considered suspect.

12.4 The precision data[7] in 12.2 and 12.3 were obtained using five mineral oils covering the kinematic viscosity range from 3 to 1200 cSt at temperatures from 38 and 99°C.

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[7] Available from ASTM Headquarters, 1916 Race St., Phila., PA 19103, by requesting RR:D01-1132.

TABLE 1 Viscometer Types

Viscometer Identification	Range, cSt[A]
A. Ostwald Types for Transparent Liquids:	
1. Cannon Fenske Routine[C]	0.5[B] to 20 000
2. Zeitfuchs[C]	0.6 to 3 000
3. SIL[C]	0.6 to 10 000
4. Cannon-Manning Semimicro[C]	0.4 to 20 000
5. BS/IP U-tube[D]	0.9[B] to 10 000
6. BS/IP U-tube Miniature[D]	0.2 to 100
7. Pinkevitch	0.6[B] to 17 000
B. Suspended-Level Types for Transparent Liquids:	
1. Ubbelohde[C]	0.3[B] to 100 000
2. FitzSimons[C]	0.6 to 1 200
3. Atlantic[C]	0.75[B] to 5 000
4. Cannon-Ubbelohde, Cannon-Ubbelohde Dilution[C]	0.5[B] to 100 000
5. Cannon-Ubbelohde Semimicro[C]	0.4 to 20 000
6. BS/IP Suspended Level[D]	3.5[B] to 100 000
7. BS/IP Suspended level, Shortened Form[D]	1.05[B] to 10 000
8. BS/IP Miniature Suspended Level[D]	0.6 to 3 000
C. Reverse-Flow Types for Transparent and Opaque Liquids:	
1. Zeitfuchs Cross-Arm[C]	0.6 to 100 000
2. Cannon-Fenske Opaque[C]	0.4 to 20 000
3. Lantz-Zeitfuchs[C]	60 to 100 000
4. BS/IP U-tube Reverse Flow[D]	0.6 to 300 000

[A] Each range quoted requires a series of viscometers. To avoid the necessity of making a kinetic energy correction, these viscometers are designed for a flow time in excess of 200 s except where noted.

[B] In each of these series, the minimum flow time for the viscometers with the lowest constant exceeds 200 s.

[C] Specifications and operating instructions for these viscometers have been assembled in Method D 2515.

[D] Specifications for these are given in Appendixes to IP 71.

TABLE 2 Kinematic Viscosity Test Thermometers[A]

Test Temperature[B] Scale Error[B]		Thermometer Number	
°F	°C	ASTM[C]	IP[D]
−65	−53.9	74F	69F, C
−60 to −35	−51 to −35	43F	65F, C
−40	−40	73F, C	68F, C
0	−17.8	72F	67F, C
32	0		33F, C
68 and 70	20 and 21.1	44F, C	29F, C
77	25	45F, C	30F, C
86	30	118F, C	
100	37.8	28F	31F, C
	40	120C	
122	50	46F, C	66F, C
130	54.4	29F	34F, C
140	60	47F, C	35F, C
180	82.2	48F	90F, C
200	93.3		36F, C
210 and 212	98.9 and 100	30F	32F, C
	100	121C	
275	135	110F, C	
	−20		99C
	80		100C
	40	120C	92C

[A] The smallest graduation of the Fahrenheit thermometers is 0.1°F and for the Celsius thermometers is 0.05°C except for ASTM 43F and IP 65F for which it is 0.2°F.

[B] Scale error for the Fahrenheit thermometers is not to exceed ±0.2°F (except for ASTM 110F which is ±0.3°F): for the Celsius thermometers it is ±0.1°C. These scale errors are required to apply only at the given test temperature.

[C] Complete construction detail is given in Specification E 1.

[D] Complete construction detail is given in Part I of IP Standards for Petroleum and Its Products.

TABLE 3 Values of the Several ASTM Viscosity Oil Standards

Viscosity Standard Conforming to ASTM Standards[A]	Approximate Kinematic Viscosity, cSt								
	At −53.89°C (−65°F)	At −40°C (−40°F)	At 20°C (68°F)	At 25°C (77°F)	At 37.78°C (100°F)	At 40°C (104°F)	At 50°C (122°F)	At 98.89°C (210°F)	At 100°C (212°F)
S-3	300	80	4.6	4.0	3.0	2.9		1.2	1.2
S-6			11	8.9	6.0	5.7		1.8	1.8
S-20			44	34	20	18		4.0	3.9
S-60			170	120	60	54		7.4	7.2
S-200			640	450	200	180		17	17
S-600			2400	1600	600	520	280	33	32
S-2000			8700	5600	2000	1700		78	75
S-8000			37 000	23 000	8000	6700			
S-30 000				81 000	27 000	23 000	11 000		

[A] The actual values for the standards listed above are established and annually reaffirmed by cooperative tests. In 1971, tests were made using 15 different types of viscometer in 26 laboratories located in 9 countries.

APPENDIX

(Nonmandatory Information)

X1. ICE POINT DETERMINATION

X1.1 To achieve an accuracy of ±0.02°C for calibrated kinematic viscosity thermometers, it is required that a check at the ice point be made. It is recommended that the interval of checking be every six months: for a new thermometer, check monthly for the first six months.

X1.2 A detailed procedure for the measurement of the ice point is described in Method E 77. The suggestions in the following sections of this appendix are given specifically for the mercury-in-glass "kinematic viscosity" thermometers described in Table 2, and may not apply to other thermometers.

X1.2.1 The ice point reading of kinematic viscosity thermometers shall be taken 5 min after being at test temperature for not less than 3 min. The ice point reading shall be expressed to the nearest 0.01°C or 0.02°F.

X1.2.2 Select clear pieces of ice, preferably made from pure water. Discard any cloudy or unsound portions. Rinse the ice with distilled water and shave or crush into small pieces, avoiding direct contact with the hands or any chemically unclean objects. Fill the Dewar vessel with the crushed ice and add sufficient distilled and preferably precooled water to form a slush, but not enough to float the ice. Insert the thermometer, packing the ice gently about the stem, to a depth sufficient to cover the 0°C (32°F) graduation. As the ice melts, drain off some of the water and add more crushed ice.

X1.2.3 Raise the thermometer a few millimetres after at least 3 min have elapsed, tap the stem gently, and observe the reading. Successive readings taken at least 1 min apart should agree within one tenth of a division.

X1.2.4 Alternatively, some of the ice may be heaped around the stem above the ice point and a deep narrow channel formed to permit observation of the meniscus which is thus kept well below the general level of the ice. Observations may then be made as described above without, however, raising the thermometer.

X1.2.5 Record the readings and compare with previous readings. If the readings are found to be higher or lower than the reading corresponding to a previous calibration, readings at all other temperatures will be correspondingly increased or decreased.

Designation: D 1481 – 81

An American National Standard

Standard Test Method for
DENSITY AND RELATIVE DENSITY (SPECIFIC GRAVITY) OF VISCOUS MATERIALS BY LIPKIN BICAPILLARY PYCNOMETER[1]

This standard is issued under the fixed designation D 1481; 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.

1. Scope

1.1 This method covers the determination of the density of oils more viscous than 15 cSt at 20°C (mm^2/s), and of viscous oils and melted waxes at elevated temperatures, but not at temperatures at which the sample would have a vapor pressure of 100 mm Hg (13 kPa) or above.

NOTE 1—To determine the densities of less viscous liquids at 20 or 25°C use Method D 941, or Method D 1217.

1.2 This method provides a calculation procedure for converting density to relative density (specific gravity).

2. Applicable Documents

2.1 *ASTM Standards:*

D 941 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Lipkin Bicapillary Pycnometer[2]

D 1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer[2]

D 1250 Petroleum Measurement Tables[2]

3. Summary of Method[3]

3.1 The liquid is drawin into the bicapillary pycnometer through the removable siphon arm and adjusted to volume at the temperature of test, in such a manner that there is practically no drainage in the unfilled tubing. After equilibration at the test temperature, liquid levels are read and the pycnometer is removed from the thermostated bath, cooled to room temperature, and weighed. Density or relative density (specific gravity), as desired, is then calculated from the volume at the test temperature and the weight of the sample. The effect of air buoyancy is included in the calculations.

4. Significance and Use

4.1 Density is a fundamental physical property which can be used in conjunction with other properties to characterize both the light and heavy fractions of petroleum and to access the quality of crude oils.

4.2 Determination of the density or relative density of petroleum and its products is necessary for the conversion of measured volumes to volumes at the standard temperatures of 15°C or 60°F.

4.3 The determination of densities at the elevated temperatures of 40 and 100°C is particularly useful in providing the data needed for the conversion of kinematic viscosities in centistokes (mm^2/s) to the corresponding dynamic viscosities in centipoises (mPa·s).

5. Definitions

5.1 *density*—the weight in a vacuum (that is, the mass) of a unit volume of the material at any given temperature.

5.2 *relative density* (*specific gravity*)—the ratio of the mass (weight in a vacuum) of a given volume of material at a temperature, t_1, to the

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[1] This method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants.

Current edition approved Aug. 28, 1981. Published October 1981. Originally published as D 1481 – 57 T. Last previous edition D 1481 – 62 (1976).

[2] *Annual book of ASTM Standards*, Vol 05.01.

[3] For a more complete discussion of this procedure see Lipkin, M. R., Mills, I. W., Martin, C. C., and Harvey, W. T., *Analytical Chemistry*, ANCHA, Vol 21, 1949, p. 504.

mass of an equal volume of water at a reference temperature, t_2; or the ratio of the density of the material at t_1 to the density of water at t_2.

6. Apparatus

6.1 *Pycnometer*—A side-arm type of pycnometer conforming to the dimensions given in Fig. 1 and made of borosilicate glass. The weight shall not exceed 35 g without the side arm.

6.2 *Rack*—A rack to use in filling the pycnometer (see Fig. 2).

6.3 *Constant-Temperature Oven*—An oven for use in filling the pycnometer. Any oven capable of holding the filling rack, and of maintaining a temperature of approximately 100°C, may be used.

6.4 *Constant-Temperature Bath*—A mixture of water and glycerin, or oil bath having a depth of at least 305 mm (12 in.) and provided with heating, stirring, and thermostating devices adequate to maintain desired temperatures in the range from 20 to 100°C with an accuracy of ±0.01°C.

6.5 *Bath Thermometers*—Thermometers graduated in 0.1°C subdivisions and standardized for the range of use to the nearest 0.01°C (ASTM Saybolt Viscosity Thermometers 17C to 22C are recommended). For most hydrocarbons the density coefficient is about 0.0008 units/° C, and therefore a temperature error of ±0.013°C would cause an error of ±0.00001 in density.

6.6 *Pycnometer Holder*—A holder, as shown in Fig. 3, is recommended for supporting the pycnometer in the bath. A single clamp device may be used.

6.7 *Balance*—A balance able to reproduce weighings within 0.1 mg when carrying a load of 35 g or less on each pan. The balance shall be located in a room shielded from drafts and fumes and in which the temperature changes between related weighings (empty and filled pycnometer) do not cause a significant change in the ratio of the balance arms. Otherwise, weighings shall be made by the substitution method in which the calibrated weights and pycnometer are alternatively weighed on the same balance pan. The same balance shall be used for all related weighings.

6.8 *Weights*—Weights shall be used whose relative values are known to the nearest 0.05 mg or better. The same set of weights shall be used for the calibration of the pycnometer and the determination of the densities, or the sets of weights shall be calibrated relative to each other.

7. Preparation of Apparatus

7.1 Thoroughly clean the pycnometer and side arm with hot chromic acid cleaning solution (**Danger**—Causes severe burns. A recognized carcinogen. See Annex A1.1) Chromic acid solution is the most effective cleaning agent. However, surfactant cleaning fluids have also been used successfully. Rinse well with distilled water; and dry at 105 to 110°C for at least 1 h, preferably with a slow current of filtered air passing through the pycnometer. Cleaning shall be done in this manner whenever the pycnometer is to be calibrated or whenever liquid fails to drain cleanly from the walls of the pycnometer or its capillary. Ordinarily, the pycnometer may be cleaned between determinations by washing with a suitable solvent, such as isopentane or benzene, and vacuum drying. If acetone is used as the wash liquid, the pycnometer should then be rinsed with isopentane or benzene. **Danger**—Extremely flammable. See Annex A1.2, A1.3. Benzene is a poison, carcinogen. See Annex A1.4.

8. Calibration of Pycnometer

8.1 Weigh the clean, dry pycnometer (without the side arm) to the nearest 0.1 mg, and record the weight.

8.2 Fill the pycnometer with freshly boiled distilled water. This may be conveniently done by placing the pycnometer in the holder with the side arm dipping into a sample cup containing water. Allow the pycnometer to fill by siphoning. Break the siphon by removing the side arm when the liquid level in the bulb arm of the pycnometer reaches 6 on the scale.

8.3 Remove the side arm which was used to fill the pycnometer and remove excess liquid from the capillary tip by wiping with a small piece of absorbent paper.

8.4 Place the pycnometer in the holder in the constant-temperature bath at temperature t with the liquid level in the capillaries below the liquid level in the bath. When the liquid level has reached equilibrium (not less than 15 min), read the scale to the nearest 0.2 small division at the liquid level in each arm. After

5 min read the liquid level again. If the sum of the scale readings in each reading differs by more than ±0.04, repeat readings at 5-min intervals. When readings are constant, record.

8.5 Remove the pycnometer from the bath and allow it to come to room temperature. Rinse the outer surface with distilled water, with acetone, then with redistilled benzene, and dry thoroughly with a chemically clean lint-free cloth, slightly damp with water (Note 2). Allow to stand a few minutes, and then weigh to nearest 0.1 mg.

NOTE 2—In atmospheres of low humidity (60 % or lower) drying the pycnometer by rubbing with dry cotton cloth will induce static charges equivalent to a loss of about 1 mg or more in the weight of the pycnometer. This charge may not be completely dissipated in less than ½ h, and can be detected by touching the pycnometer to the wire hook on the balance and then drawing it away slowly. If the pycnometer exhibits an attraction for the wire hook, it may be considered to have a static charge.

8.6 Repeat the above, but break the siphon when water has reached the 3 mark in the bulb arm, and in the next experiment at the 0 mark in the bulb arm. Obtain the apparent volume for each filling by dividing the weight of water held by the pycnometer in each experiment by the density of water at the calibration temperature t. Calibration shall be made at 20°C, 40°C, and 50°C. Prepare a calibration curve for 20°C by plotting the sum of the two scale readings *versus* the apparent volume at 20°C. If the curve is not a straight line, and future checks do not correct it, discard the pycnometer. The line shall not be more than 0.0002 mL/unit from any one determined point.

8.7 Corresponding calibration curves shall be made for 40°C and 50°C. These calibration curves are checked using the following equation:

$$V_2 = V_1(1 + ct)$$

where:

V_2 = apparent volume at test temperature,
V_1 = apparent volume at 20°C, and
c = cubical coefficient of expansion of borosilicate glass (9.9×10^{-6}/°C).

The calculated and determined curves at 40°C and 50°C should check to within ±0.0002 mL/unit at all points. The calibration curves for higher temperatures shall be obtained by calculation.

9. Procedure

9.1 Weigh the clean, dry pycnometer, without the side arm, to 0.1 mg and record the weight.

9.2 Place a 10-mL sample beaker in the wooden rack (Fig. 2). Before attaching the side arm to the pycnometer, drain a few drops of sample through the side arm to wet the inside surface and reduce the chance of trapping air bubbles in the capillary during the filling operation. Place the side arm on the pycnometer, and place the assembly on the rack with the side arm dipping into the sample beaker as shown in Fig. 4.

9.3 In filling the pycnometer with very viscous oils or high-melting waxes, place the whole filling assembly in a hot-air oven to facilitate filling. An oven at approximately 100 °C is usually hot enough for this purpose.

9.4 Apply gentle suction to the bulb arm of the pycnometer to start the siphoning action. The suction must be gentle to avoid the formation of bubbles. After siphoning is started allow filling by siphoning to continue until the liquid level in the bulb arm ceases to rise. Then remove the pycnometer from the rack and place in the thermostated bath, in the same tilted position, until the oil ceases to contract. At this point, place the pycnometer in an upright position, and allow the liquid level in the bulb arm to reach the upper portion of the calibrated capillary, but not above 6.4. Stop siphoning by removing the side arm.

NOTE 3—With viscous oils it will reduce drainage errors to fill to the 6.0 to 6.4 mark, and it may be necessary to apply a little suction to the long arm during cooling to prevent the meniscus in the bulb arm from falling. Maintain the meniscus at about the same level in the long arm throughout the whole determination.

9.5 After removing the side-arm cap from the short arm of the pycnometer, wipe the tip and ground joint of the pycnometer, and adjust it to an upright position in the thermostated bath. The bath liquid level shall be above the 6 mark on the pycnometer and below the ground glass tip of the pycnometer.

9.6 Allow 15 min for equilibrium to be obtained. After the stated 15-min time for coming to equilibrium, read the meniscus levels in both arms of the pycnometer to the nearest 0.2 of the smallest scale division. Wait 5 min and check readings. If the sum of the readings at the two different times do not agree to within ±0.04, repeat at 5-min intervals until checks are obtained. Record the sum of these readings and also record the corresponding apparent volume from the calibration curve for the same temperature.

NOTE 4—The final level of oil in the pycnometer should not be more than 5 mm below the tip of the ground glass end of the pycnometer, and the level in the long (bulb) side of the pycnometer should be no lower than it has been at any time during the procedure. With these precautions drainage error (which is important with very viscous samples) is entirely eliminated.

9.7 Remove the pycnometer from the bath and tilt it so that the liquid moves down in the short arm and up in the bulb arm. Clean and dry the outside of the pycnometer as described in the calibration procedure (Section 8). Allow to come to balance room temperature. Weigh to the nearest 0.1 mg. Subtract the weight of empty pycnometer, without the side arm, to get the weight of sample.

10. Calculation

10.1 Calculate the density of the sample, corrected to vacuum, by the following equation:

$$\text{Density in vacuum, } d_t, \text{ g/mL} = (W/V) + C$$

where:

W = weight of sample in air, g,
V = apparent volume, mL, and
C = vacuum correction, obtained from Table 1.

10.2 Calculate the relative density (specific gravity) of the sample at t_1/t_2 by dividing the density, as calculated in 10.1, by the density of water at the reference temperature, t_2, as obtained from Table 2. Relative density (specific gravity) at t_1/15.56°C (t/60°F where t is expressed in degrees Fahrenheit) can be changed to the conventional 15.56/15.56°C (60/60°F) relative density (specific gravity) by use of the appropriate Table 23 in Standard D 1250, provided that the glass expansion factor has been excluded.

10.3 In reporting density, give the test temperature and the units (for example, density at 40°C = x.xxxx g/mL). In reporting relative density (specific gravity) give both the test temperature and the reference temperature, but no units (for example, relative density (specific gravity), 40°C/15.56°C = x.xxxx). Carry out all calculations to five figures, and round off the final results to four figures.

11. Precision

11.1 The precision of the method as obtained by statistical examination of interlaboratory test results is as follows:

11.1.1 *Repeatability*—The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

Pycnometer Volume, mL	Repeatability, g/mL
10	0.00015

11.1.2 *Reproducibility*—The difference between two single and independent results, obtained by different operators working in different laboratories on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following value only in one case in twenty:

Pycnometer Volume, mL	Reproducibility, g/mL
10	0.00035

NOTE 5—If pycnometers of other than 10 mL in volume are used, this precision statement may not apply.

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POROSITY DETERMINATION
API RP40

STANDARD OPERATING PROCEDURE

1) Weigh dry plug sample to 0.01gm.

2) Saturate using toluene.

3) Weigh saturated plug to 0.01gm

4) Weigh saturated plug submerged in toluene to 0.01gm

5) Calculate plug properties.

   a) Pore volume: (saturated weight - dry weight) / (density of saturant)
   b) Bulk volume: (saturated weight - immersed weight) / (density of saturant)
   c) Grain volume: (dry weight - immersed weight) / (density of immersion liquid)
   d) Porosity: (bulk volume - grain volume) / (bulk volume)

Blank Acceptance Range: 0.1 porosity units
Standard Acceptance Range: 98-102%

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Dry or Native Bulk Density - ASTM D2937

STANDARD OPERATING PROCEDURE

Dry Density

1) Using calipers, determine the diameter and Length of the ring sample in centimeters. Calculate the bulk volume of the sample using the formula:

   Area = d^2 x 0.7854
   Length x Area = Bulk Volume in cubic centimeters

2) Weight sample in ring and dry in oven a t 110°C for 24 hours or until weight stabilizes.
3) Weigh dry sample, remove soil form the ring and weigh empty ring.
4) Subtract ring weight from dry weight of sample and ring, divide result by the calipered bulk volume.
5) Report bulk density to the nearest 0.01 g/cc

Native Density

1) Using calipers, determine the diameter and Length of the ring sample in centimeters. Calculate the bulk volume of the sample using the formula:

   Area = d^2 x 0.7854
   Length x Area = Bulk Volume in cubic centimeters

2) Weight samples in ring, remove soil from the ring and weigh empty ring.
3) Subtract ring weight from native weight of sample and ring, divide result by the calipered bulk volume

Analyze one sample per batch using helium porosimetry. Acceptance range is 90-110% of original value.

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MANUAL DISTILLATION of PETROLEUM PRODUCTS
ASTM D86

STANDARD OPERATING PROCEDURE

1) Cool sample and condenser bath to between 55 and 65 °F.

2) Add 100 ml of sample to the distillation flask making sure not to introduce sample into the vapor tube.

3) Insert thermometer with stopper into the boiling flask with the Hg collection bulb even with the bottom of the vapor tube joint.

4) With the graduated cylinder covered and placed under the delivery spout, apply heat to the boiling flask.

5) Continue heating noting the initial boiling point (IBP) and recording the temperature at each 5% of sample recovered until 95% of the sample is recovered.

6) Calculate the percent of sample lost:

   100 – recovered – residual = Sample lost, %

Toluene Standard Acceptance Range: Boiling point, ± 3 °F

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Particle Size by Mechanical Sieve - ASTM D422M-63

Scope

Particle size distribution of sediments is determined by using a set of standard square-mesh, woven-wire cloth which conform to ASTM E-11 in conjunction with an Ro-Tap mechanical shaker unit.

Weighed particles can range from 0.25 to 0.0012 inches and are determined as the fraction of each sample is collected and weighed in each standard sieve. The complete set of sieves is:

U.S. Sieve Number	Opening, inches	Opening, mm	Phi of Screen
¼	0.25	6.351	-2.67
4	0.1873	4.757	-2.25
6	0.1324	3.364	-1.75
10	0.0787	2.000	-1.00
14	0.0557	1.414	-0.50
18	0.0394	1.000	0.00
25	0.0278	0.707	0.50
35	0.0197	0.500	1.00
40	0.0166	0.420	1.25
45	0.0139	0.354	1.50
60	0.0098	0.250	2.00
80	0.0070	0.177	2.50
120	0.0049	0.125	3.00
200	0.0029	0.074	3.75
270	0.0021	0.053	4.25
400	0.0015	0.037	4.75

Method Summary

The soil sample is dried and gently disaggregrated using a wooden mortar and pestle. Samples that contain heavy hydrocarbons are extracted by Dean-Stark distillation (API RP40) using either toluene or a chloroform-methanol azeotrope as the solvent prior to disaggregation. A representative portion of the sample, 50-1000 gms, is introduced into the U.S. Standard Sieve number 1/4 and is continuously shaken on the Ro-Tap shaker unit for a period of no less than 20 minutes and no greater than 30 minutes. Weights of the sample retained on each standard sieve number are recorded.

Quality Control

Calibration is determined by standards created by PTS Laboratories, Inc. by multiple size separation runs. Each screen is inspected prior to use for signs of excessive wear, distortion of the wire cloth or other aberrations. Sieves suspected of having a flaw are replaced and given to the laboratory supervisor for

Particle Size by Mechanical Sieve - ASTM D422M-63

microscopic inspection, after which they are either tested with standards, repaired or discarded. Duplicate samples are run for each batch of twenty samples and blind mixes of standards are run weekly. Duplicate sample acceptance ranges are 80-120 %, blind sample acceptance ranges are 90-110%.

Reporting

Data is reported in tabular and graphical formats corresponding to the ASTM/USCS Classification system and can be presented in an EDD format. Statistical data of mean, median, standard deviation, sorting, skewness and kurtosis are included.

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Particle Size by Laser Light Scattering - ASTM D4464M-85

Scope

Particle size distribution of sediments is determined by using laser light diffraction to measure the amount and patterns of light scattered by a particle's surface. This is done using laser light with a 750 nm wavelength, a Fourier lens focusing system and an array of 126 detectors. Light is diffracted around a particle at angles inversely proportional to the size of the particle; the smaller the particle the larger the angle of diffraction.

Measured particles can range from 0.4-2000 µm and are determined as the sample, dispersed in a transport fluid, is circulated through the analyzer. Extended range analyses, 0.4 - >2000 µm is accomplished by combining the >2000 µm fraction from screen sieving with the <2000 µm fraction from light scattering.

The procedure is a modification of ASTM D4464-85 (reapproved in 1991) to measure the particle size of catalytic material. The modification is that the procedure has been extended to include the measurement of unconsolidated soils and sediments. The procedure is in current use by the USGS, City of Los Angeles, University of Florida and major petroleum companies. Local, state and federal regulatory agencies have recognized the method as an alternative to ASTM D422 (hydrometer) and the pipette method.

Method Summary

For soils the sample is dried and gently disaggregated using a wooden mortar and pestle. Samples that contain heavy hydrocarbons are extracted by Dean-Stark distillation (API RP40) using either toluene or a chloroform-methanol azeotrope as the solvent prior to disaggregation. A representative portion of the sample, 5-10 gms, is introduced into the fluid module of the analyzer and is continuously circulated through the laser beam. Water samples are introduced directly into the fluid module. The circulation fluid is filtered to 0.2 µm and contains a dispersant to prevent coagulation along with an internal sonification unit to further separate the particles.

The laser beam passes through the sample cell where the suspended particles scatter the incident light. Fourier optics collect the diffracted light and focus it on to three sets of detectors, one for low-angle scattering, the second for mid-angle scattering and the third for high-angle scattering. The composite, time-averaged diffraction pattern is measured by 126 detectors placed at angles to ~35° from the optical axis. Sizes are computed by the Fraunhofer Model for Light Scattering and summed into normal ASTM, USCS or Wentworth distribution classifications for 0.4-2000 µm.

Quality Control

Calibration is determined by the optical design. Therefore, no calibration is required. All necessary adjustments are made by measuring electrical offsets and aligning the laser beam. Quality control samples of traceable diameter are run at regular intervals or as required on a project basis. Repeatability is <1% about the mean size (repeat runs of the same sample).

Reporting

Data is reported in tabular and graphical formats corresponding to the ASTM/USCS Classification system and can be presented in an EDD format. Statistical data of mean, median, standard deviation, sorting, skewness and kurtosis are included.

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SOP: HYDRAULIC CONDUCTIVITY and PERMEABILITY TO WATER

Method(s): ASTM D5084, EPA 9100, and API RP40

Scope: Method(s) cover procedures to determine hydraulic conductivity and/or permeability of sediments using a flexible wall permeameter. Method can be modified for fluids other than water and to meet site/material specific requirements.

Procedure:

I. Sample Selection
   A. Shelby Tube - Extrusion Method
      1. Transfer labels from caps to tube and note direction for top and bottom.
      2. Extrude core from the tube in the same direction it entered on to the receiving tray.
      3. Record slough, voids and any visual disturbance that may be present. Option: if requested photograph core under white and/or UV light for documentation.
      4. From a representative section obtain a sample using the Soft Sediment Coring Tool (SSCT) of required dimensions. Vertical samples should be perpendicular to visible bedding and horizontal samples parallel to visible bedding.
      5. Obtain representative material for moisture content and particle size distribution (PSD) if requested.
      6. Package sample using Teflon™ tape and 200 mesh end screens.
      7. Record sample dimensions and package weights.
   B. Shelby Tube - Slab Method
      1. Transfer labels from caps to opposite sides of the tube and note direction for top and bottom.
      2. Place tube in horizontal band saw carriage and adjust height to cut tube longitudinally into 1/3 (slab) and 2/3 (bulk) sections.
      3. Preserve slab section for photography and core description.
      4. From the bulk section obtain a sample using the Soft Sediment Coring Tool (SSCT) of required dimensions. Vertical samples should be perpendicular to visible bedding and horizontal samples parallel to visible bedding.
      5. Obtain representative material for moisture content and particle size distribution (PSD) if requested.
      6. Package sample using Teflon™ tape and 200 mesh end screens.
      7. Record sample dimensions and package weights.
   C. Other Sleeve Types
      1. Obtain samples using SSCT of required dimensions as dictated by sleeve size. Vertical samples should be parallel to the sleeves longitudinal axis and horizontal samples perpendicular to the longitudinal axis.
      2. Obtain representative material for moisture content and particle size distribution (PSD) if requested.
      3. Package sample using Teflon™ tape and 200 mesh end screens.
      4. Record sample dimensions and package weights.
   D. Remolded Samples
      1. Not recommended. Check with Laboratory Director if requested.

II. Sample Preparation and Test Measurements

A. Saturation

1. Place sample in the saturation vessel and maintain a high vacuum for a time duration as dictated by sample type. Sands = 4 Hrs, Silts/Clays = 8 Hrs.
2. Introduce pre-filtered (0.45 micron), de-aired water (or other fluid as requested) to completely submerge the sample.
3. Continue evacuation for 30 to 60 minutes.
4. Slowly remove the vacuum to atmospheric pressure.
5. Increase pressure on the surrounding liquid as required by sample type and maintain for 4 hours.
6. Slowly reduce pressure to atmospheric.
7. Keep samples submerged under liquid until mounting in permeameter cell.

B. Sample Set-up

1. Open vacuum valve on cell to expand sleeve.
2. Flow water through injection lines and lower sample support to remove entrained air.
3. Place sample on lower support and insert into cell. This should be done quickly to minimize desaturation of the sample.
4. Insert pin lock.
5. Close vacuum valve, open vent valve to bring sleeve pressure to atmospheric pressure, close vent valve, open sleeve pressure valve and increase confining pressure to 1.0 psi.
6. Flow water through downstream lines and upper sample support to remove entrained air.
7. Initiate flow through the sample.
8. Increase backpressure and injection pressure while maintaining a net stress of 1.0 psi on the sample. Continue flow to saturate sample. Net stress can not exceed consolidation pressure required by the client.
9. Check for saturation by closing injection valve, reducing backpressure to 0 psi and applying a slight pressure to the downstream burette. A sample is saturated when there is no appreciable movement of water in the burette other than a flattening of the meniscus. Specific jobs may require B-value calculations.

C. Consolidation

1. Increase the confining stress to the required consolidation pressure.
2. Monitor pore water production to stability to verify consolidation is complete.
3. If required monitor sample length change.

D. Permeability Measurement

1. Using constant head pressure increase gradient across sample as requested by client.
2. If gradient is not specified, use D5084 Sec. 8.5.1 as a guide.
3. Monitor inflow and outflow volumes for stability. Ratio of 0.75 - 1.25 is considered stable.
4. Record pressure drop across sample and flow rate for a minimum of 4 consecutive measurements.
5. Permeability is considered stable if measurements show <25% variance.
6. Reduce pore and confining pressure to 0 psi and remove sample from the cell.
7. Record length, diameter and final weight.

E. Report

1. As a minimum report:
   a. Sample identifying information
   b. Dry unit weight
   c. Native moisture content
   d. Confining stress
   e. Permeability in millidarcy
   f. Hydraulic conductivity in cm/sec
   g. Actual gradient
   h. Fluid used
2. Optional data:

a. Complete petrophysical properties
b. Sample photographs
c. Additional data as requested

The above is a basic procedure for determining hydraulic conductivity and may be modified for site specific and/or sample specific requirements. Deviations shall not be made without prior approval of the District Manager and/or QA/QC Manager.

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CATION EXCHANGE CAPACITY
SODIUM ACETATE METHOD
EPA 9081

STANDARD OPERATING PROCEDURE

1) Weigh 4-6 grams (4 for fine-medium grain, 6 for coarse grain) of representative soil and transfer to centrifuge tube.

2) Add 33 ml of 1.0 N NaOAc solution and cap the tube. Place tube in shaker unit and shake at a setting of 2 for 5 minutes. Centrifuge until the supernatant is clear. Decant the liquid. Repeat three times.

3) Add 33 ml of 99% isopropyl alcohol and cap the tube. Place tube in shaker unit and shake at a setting of 2 for 5 minutes. Centrifuge until the supernatant is clear. Decant the liquid. Repeat two times.

4) Add 33 ml of NaOAc solution and cap the tube. Place tube in shaker unit and shake at a setting of 2 for 5 minutes. Centrifuge until the supernatant is clear. Decant the liquid into a 100 ml flask. Repeat two times.

5) Add ammonium acetate until the fluid volume in the flask equals 100 ml.
6) Determine Na concentration of diluted wash fluid.

Blank Acceptance Range: <5mg/l
Standard Acceptance Range: 80-120%

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Appendix B

Laboratory Reporting Limits

Table B-1
SCAPS LABORATORY REPORTING LIMITS—SOIL

Analyte	Method Reference	Reporting Limit
TPH by Fluorescence	ASTM D 6187 (SCAPS SOP)	Determined in the field

Table B-2
SCAPS LABORATORY REPORTING LIMITS—GROUNDWATER

Analyte	Method Reference	Reporting Limit (mg/L)
VOCs by ITMS	SW-846 8265	2.5

Table B-3
FIXED LABORATORY REPORTING LIMITS—SOIL

Analyte	Method Reference	Laboratory	Reporting Limit (mg/kg)
VOC	**SW-846 5035 / 8260B**	**Sound Analytical Services, Inc.**	
1,1,1,2-Tetrachloroethane			400
1,1,1-Trichloroethane			400
1,1,2,2-Tetrachloroethane			400
1,1,2-Trichloroethane			400
1,1,2-Trichlorotrifluoroethane			400
1,1-Dechloroethane			400
1,1-Dichloroethene			400
1,1-Dichloropropene			400
1,2,3-Trichlorobenzene			400
1,2,3-Trichloropropane			400
1,2,4-Trichlorobenzene			400
1,2,4-Trimethylbenzene			400
1,2-Dibromo-3-chloropropane			400
1,2-Dibromoethane			400
1,2-Dichlorobenzene			400
1,2-Dichloroethane			400
1,2-Dichloropropane			400
1,3,5-Trichlorobenzene			400
1,3,5-Trimethylbenzene			400
1,3-Dichlorobenzene			400
1,3-Dichloropropane			400
1,4-Dichlorobenzene			400
1,4-Dioxane			4000
2,2-Dichloropropane			400
2-Butanone			2000
2-Chloroethyl Vinyl Ether			2000
2-Chlorotoluene			400
2-Hexanone			2000
4-Chlorotoluene			400
4-Isopropyltoluene			400
4-Methyl-2-pentanone			2000
Acetone			2000
Acrylonitrile			2000
Benzene			400

Analyte	Method Reference	Laboratory	Reporting Limit (mg/kg)
Benzyl Chloride			400
Bromobenzene			400
Bromochloromethane			400
Bromodichloromethane			400
Bromoform			400
Bromomethane			400
Carbon Disulfide			400
Carbon Tetrachloride			400
Chlorobenzene			400
Chloroethane			400
Chloroform			400
Chloromethane			400
cis-1,2-Dichloroethene			400
cis-1,3-Dichloropropene			400
cis-1,4-Dichloro-2-butene			2000
Dibromochloromethane			400
Dibromomethane			400
Dichlorodifluoromethane			400
Ethyl Acetate			400
Ethyl Ether			400
Ethylbenzene			400
Hexachlorobutadiene			400
Hexane			400
Iodomethane			400
m,p-Xylenes			800
Methylene Chloride			400
Naphthalene			400
n-Butylbenzene			400
n-Propylbenzene			400
o-Xylene			400
sec-Butylbenzene			400
Styrene			400
t-Butylbenzene			400
methyl tert-butyl ether			400
Tetrachloroethene			400
Tetrahydrofuran			2000
Toluene			400
trans-1,2-Dichloroethene			400
trans-1,3-Dichloropropene			400
trans-1,4-Dichloro-2-butene			2000
Trichloroethene			400
Trichlorofluoromethane			400
Vinyl Acetate			400
Vinyl Chloride			400
SVOC	**SW-846 8270C**	**Sound Analytical Services, Inc.**	
1,2,4-Trichlorobenzene			100
1,2-Dichlorobenzene			100
1,2-Diphenylhydrazine			100
1,3-Dichlorobenzene			100
1,4-Dichlorobenzene			100

Analyte	Method Reference	Laboratory	Reporting Limit (mg/kg)
2,4,5-Trichlorophenol			100
2,4,6-Trichlorphenol			100
2,4-Dichlorophenol			100
2,4-Dimethylphenol			100
2,4-Dinitrophenol			100
2,4-Dinitrotoluene			100
2,6-Dinitrotoluene			100
2-Chloronaphthalene			20
2-Chlorophenol			100
2-Ethoxyethanol			100
2-Methylnaphthalene			20
2-Methylphenol			100
2-Nitroaniline			100
2-Nitrophenol			100
2-Nitropropane			100
3- & 4- Methylphenol			100
3,3'-Dichlorobenzidine			100
3-Nitroaniline			100
4,6-Dinitro-2-methylphenol			100
4-Bromophenylphenylether			100
4-Chloro-3-methylphenol			100
4-Chloroaniline			100
4-Chlorophenylphenylether			100
4-Nitroaniline			100
4-Nitrophenol			100
Acenaphthene			20
Acenaphthylene			20
Aniline			1000
Anthracene			20
Benzidine			200
Benzo(a)anthracene			20
Benzo(a)pyrene			20
Benzo(b)fluoranthene			20
Benzo(g,h,i)perylene			20
Benzo(k)fluoranthene			20
Benzoic Acid			100
Benzyl Alcohol			100
bis(2-Chlorethoxy)methane			100
bis(2-Chloroethyl)ether			100
bis(2-Chloroisopropyl)ether			100
bis(2-Ethylhexyl)phthalate			100
Butylbenzylphthalate			100
Carbazole			100
Chrysene			20
Cyclohexanone			200
Dibenz(a,h)anthracene			20
Dibenzofuran			100
Diethylphthalate			100
Dimethylphthalate			100
Di-n-butylphthalate			100

Analyte	Method Reference	Laboratory	Reporting Limit (μg/kg)
Di-n-octylphthalate			100
Fluoranthene			20
Fluorene			20
Hexachlorobenzene			100
Hexachlorobutadiene			100
Hexachlorocyclopentadiene			100
Hexachloroethane			100
Indeno(1,2,3-cd)pyrene			20
Isophorone			100
Naphthalene			20
Nitrobenzene			100
N-nitrosodimethylamine			100
N-nitroso-di-n-propylamine			100
N-Nitrosodiphenylamine			100
Pentachlorophenol			100
Phenanthrene			20
Phenol			100
Pyrene			20
Pyridene			100
Tetrachlorophenols			100
TPH	**NWTPH–Dx**	**Sound Analytical Services, Inc.**	
#2 Diesel			20 mg/kg
Motor Oil			40 mg/kg
Diesel (>nC12-nC24)			20 mg/kg
Motor Oil (C24-C36)			40 mg/kg
Conventionals			
Grain Size	ASTM D422M-63	PTS Laboratories	NA
Permeability (Hydraulic Conductivity)	PTS SOP	PTS Laboratories	NA
Density	ASTM D2937	PTS Laboratories	NA
Porosity	PTS SOP (APR RP40)	PTS Laboratories	0.1 porosity units
Cation Exchange Capacity	SW-846 9081	PTS Laboratories	5 mg/L
Total Organic Carbon	SW-846 9060	PTS Laboratories	1 mg/L

Notes:
mg/kg - milligrams per kilogram
TAT - turn-around time

Table B-4
FIXED LABORATORY REPORTING LIMITS—NAPL

Analyte	Method Reference	Laboratory	Reporting Limits
VOCs	SW-846 8260B	Sound Analytical Services, Inc.	Determined by dilution
SVOCs	SW-846 8270C	Sound Analytical Services, Inc.	Determined by dilution
TPH–Dx	NWTPH–Dx	Sound Analytical Services, Inc.	Determined by dilution
Oil/Water Interfacial Tension	ASTM D971-82	PTS Laboratories, Inc.	NA
Viscosity/Density	ASTM D445-83	PTS Laboratories, Inc.	NA
Boiling Point Distribution/ Distillation	ASTM D86	PTS Laboratories, Inc.	NA

Table B-5
FIXED LABORATORY REPORTING LIMITS—GROUNDWATER

Analyte	Method Reference	Laboratory	Reporting Limit (µg/L)
VOC	**SW-846 8260B**	**Sound Analytical Services, Inc.**	
1,1,1-Trichloroethane			0.4
1,1,2,2-Tetrachloroethane			0.4
1,1,2-Trichloroethane			0.4
1,1,2-Trichlorotrifluoroethane			0.4
1,1-Dechloroethane			0.4
1,1-Dichloroethene			0.4
1,2-Dichloroethane			0.4
1,2-Dichloropropane			0.4
2-Butanone			2
2-Chloroethyl Vinyl Ether			2
2-Hexanone			2
4-Methyl-2-pentanone			2
Acetone			2
Benzene			0.4
Bromodichloromethane			0.4
Bromoform			0.4
Bromomethane			0.4
Carbon Disulfide			0.4
Carbon Tetrachloride			0.4
Chlorobenzene			0.4
Chloroethane			0.4
Chloroform			0.4
Chloromethane			0.4
cis-1,2-Dichloroethene			0.4
cis-1,3-Dichloropropene			0.4
Dibromochloromethane			0.4
Ethylbenzene			0.4
m,p-Xylenes			0.4
Methylene Chloride			0.4
o-Xylene			0.4
Styrene			0.4
Tetrachloroethene			0.4
Toluene			0.4
trans-1,2-Dichloroethene			0.4
trans-1,3-Dichloropropene			0.4
Trichloroethene			0.4
Trichlorofluoromethane			0.4
Vinyl Acetate			0.4
Vinyl Chloride			0.4

Notes:
µg/L - micrograms per liter

Appendix C

Laboratory Control Limits

Table C-1
SCAPS LABORATORY CONTROL LIMITS—SOIL

Analyte	Method Reference	Control Limits
TPH by Fluorescence	ASTM D 6187 (SCAPS SOP)	NA

Table C-2
SCAPS LABORATORY CONTROL LIMITS—GROUNDWATER

Analyte	Method Reference	Control Limits
VOCs by ITMS	SCAPS SOP	PECS: within 2 std dev of historic mean Calibration std: within 2 std dev of mean established during calibration

Table C-3
FIXED LABORATORY CONTROL LIMITS—SOIL

ANALYTE	METHOD REFERENCE	LABORATORY	CONTROL LIMITS
TPH–Dx	NWTPH–Dx	Sound Analytical Services, Inc.	Surrogate, MS %R: 50-150% Duplicate RPD: 50 Diesel BS: 67-139%, <22% RPD Motor Oil BS: 62-120%, <25% RPD
VOC	SW-846 8260B	Sound Analytical Services, Inc.	BS/MS: 1,1-Dichloroethene: 75-125%, <21%RPD 1,2-Dichloroethane: 75-125%, <18%RPD 1,4-Dichlorobenzene: 75-125%, <24%RPD 2-Butanone: 60-140%, <34%RPD Benzene: 75-125%, <17%RPD Carbon Tetrachloride: 75-125%, <22%RPD Chlorobenzene: 75-125%, <17%RPD Chloroform: 75-125%, <21%RPD Ethylbenzene: 76-125%, <26%RPD m,p-Xylene: 78-125%, <30%RPD o-Xylene: 77-125%, <21%RPD Tetrachloroethene: 75-118%, <17%RPD Toluene: 75-125%, <16%RPD Trichloroethene: 75-125%, <18%RPD Vinyl Chloride: 75-125%, <19%RPD Surrogates: Bromofluorobenzene: 89-109% Dibromofluoromethane: 82-112% Ethylbenzene-d10: 89-110% Fluorobenzene: 86-112% Toluene-d8: 91-108%
SVOC	SW-846 8270C	Sound Analytical Services, Inc.	BS/MS: 1,2,4-Trichlorobenzene: 48-140%, <30%RPD 1,4-Dichlorobenzene: 53-131%, <33%RPD 2,4-Dinitrotoluene: 51-140%, <33%RPD 2-Chlorophenol: 58-123%, <32%RPD 4-Chloro-3-methylphenol: 50-150%, <32%RPD 4-Nitrophenol: 36-130%, <41%RPD Acenaphthene: 54-128%, <32%RPD N-nitroso-di-n-propylamine: 43-130%, <35%RPD Pentachlorophenol: 21-144%, <41%RPD Phenol: 45-128%, <36%RPD Pyrene: 45-145%, <34%RPD Surrogates: 2-Fluorobiphenyl: 53-137% 2-Fluorophenol: 57-146% 2,4,6-Tribromophenol: 35-146% Nitrobenzene-d5: 56-145% p-Terphenyl-d14: 45-134% Phenol-d5: 54-140%

ANALYTE	METHOD REFERENCE	LABORATORY	CONTROL LIMITS
Grain Size	ASTM D422M-63	PTS Laboratories, Inc.	RPD: 20
Permeability (Hydraulic Conductivity)	PTS SOP	PTS Laboratories, Inc.	NA
Density	ASTM D2937	PTS Laboratories, Inc.	Standard Acceptance Range: 90-110%
Cation Exchange Capacity	SW-846 9081	PTS Laboratories, Inc.	Standard Acceptance Range: 80-120%
Porosity	PTS SOP (APR RP40)	PTS Laboratories, Inc.	Standard Acceptance Range: 98-102%
Total Organic Carbon	SW-846 9060	PTS Laboratories, Inc.	MS %R: ±5% Duplicate RPD: 20

Table C-4
FIXED LABORATORY CONTROL LIMITS—NAPL

Analyte	Method Reference	Laboratory	Control Limits
TPH–Dx	NWTPH–Dx	Sound Analytical Services, Inc.	LCS: 80-120%; CV:10
SVOC	SW-846 8270C	Sound Analytical Services, Inc.	LCS: 80-120%; CV:10
VOCs	SW-846 8260B	Sound Analytical Services, Inc.	Surrogate: 50-150% RPD : 40
Viscosity/Density	ASTM D445-83	PTS Laboratories, Inc.	CV: 01
Boiling Point Distribution/ Distillation (ASTM D86)	ASTM D86	PTS Laboratories, Inc.	Toluene Standard Acceptance Range: Boiling Point, ± 3 °F
Oil/Water Interfacial Tension	ASTM D971-82	PTS Laboratories, Inc.	NA

Note:
CV - coefficient of variation

Table C-5
FIXED LABORATORY CONTROL LIMITS—GROUNDWATER

Analyte	Method Reference	Laboratory	Control Limits
VOC	SW-846 8260B	Sound Analytical Services, Inc.	BS/MS: 1,1-Dichloroethene: 80-120%, <11%RPD 1,2-Dichloroethane: 80-120%, <16%RPD 1,4-Dichlorobenzene: 80-120%, <20%RPD 2-Butanone: 60-140%, <36%RPD Benzene: 80-119%, <12%RPD Carbon Tetrachloride: 80-120%, <12%RPD Chlorobenzene: 80-120%, <12%RPD Chloroform: 80-120%, <12%RPD Ethylbenzene: 80-120%, <13%RPD m,p-Xylene: 80-120%, <14%RPD o-Xylene: 80-120%, <13%RPD Tetrachloroethene: 80-120%, <12%RPD Toluene: 80-120%, <12%RPD Trichloroethene: 80-118%, <12%RPD Vinyl Chloride: 80-120%, <15%RPD
			Surrogates: Bromofluorobenzene: 86-110% Dibromofluoromethane: 83-114% Ethylbenzene-d10: 87-108% Fluorobenzene: 84-114% Toluene-d8: 91-107%

Appendix D

Electronic Data Deliverable Formats

The left column contains the column headings. The spreadsheet column headings should look just like the left column. The right column contains a brief description of the type of information that should go into the columns. The laboratory electronic files should be a text file (comma or tab delimited).

Site	Site name or project name
Location	Site location
LabName	Lab name
SDG	SDG
SampleID	Client sample ID
QAQCType	QAQC type like MS, duplicate, or blank
Matrix	Sample matrix
LabSampleID	Laboratory sample ID
RunNumber	Run number
ExtractMethod	Extraction method
AnalysisMethod	Analysis method number (i.e., EPA number)
Filter	This field is yes or no and only for water samples
DateSampled	Date Sampled
DateReceived	Date laboratory received the samples
DateExtracted	Date extracted
DateAnalyzed	Date analyzed
PercentSolids	Percent solids
PercentMoisture	Percent moisture (can fill out either the solids or the moisture column)
CAS	CAS number
Analyte	Analyte name
Result	Result (no text)
LabQual	Laboratory qualifier
ReportLimit	Reporting Limit
Units	Units
Dilution	Dilution
Surrogate	yes or no
Basis	dry or wet
SpikeAmount	Spike concentration for MS, LCS or surrogates
Recovery	spike percent recovery for MS, LCS, or surrogates
RPD	Relative percent difference for dups or MS/MSDs
LowerLimit	Lower control limit for MS, LCS, or surrogates
UpperLimit	Upper control limit for MS, LCS, or surrogates
RPDlimit	RPD control limits for dups or MS/MSDs
MethodDesc	Name of the analytical method

FINAL

SITE SAFETY AND HEALTH PLAN

PHASE II REMEDIAL INVESTIGATION

East Gate Disposal Yard and Logistics Center
Fort Lewis, Washington

Prepared for

U.S. Army Corps of Engineers
Seattle District
4735 East Marginal Way South
Seattle, Washington 98134

July 11, 2001

URS

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Seattle, Washington 98101-1616
(206) 438-2700
53-F0074209

TABLE OF CONTENTS

TABLE OF CONTENTS

Tables

Figures

Appendices

Project Identification and Approvals

Project Name:	Phase II Remedial Investigation, East Gate Disposal Yard, Fort Lewis Logistics Center, Fort Lewis, Washington
Project Number:	53F0074209.00
Business Unit:	Seattle, Washington
Contract Manager:	Dave Haddock
Delivery Order Manager:	Janette Rau
Date of Issue:	April 20, 2001
Effective Dates:	July to October 2001

Approvals:

Delivery Order Manager
Janette Rau

Date 7/16/01

Heather a Boge

Health and Safety Representative
Heather Boge

Date 7/24/01

T Reinhardt

Regional Health and Safety Manager
Tim Reinhardt, CIH

Date 7/24/01

Site Safety and Health Plan Compliance Agreement

I, the undersigned, have received a copy of the Site Safety and Health Plan for the remedial investigation project at the East Gate Disposal Yard, Fort Lewis, Washington. I have been briefed on the plan and understand it, and agree to comply with all of the health and safety requirements established by the plan. I understand that I may be prohibited from continuing work on the project for failing to comply.

I have ____ have not ____ (check one) been briefed by a project safety authority on the health and safety requirements of the project.

Project Number: ______________________________

Project Title: ______________________________

Date of Plan: ______________________________

Print Name: ______________________________

Signature: ______________________________

Firm: ______________________________

Date: ______________________________

ANSI	American National Standards Institute
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHSA	Corporate Health and Safety Administrator (URS)
CPR	cardiopulmonary resuscitation
dBA	decibels
DCE	cis-1,2-dichloroethene
EGDY	East Gate Disposal Yard
EOD	Explosives and Ordnance Disposal
HAZCOM	Hazard Communication Standard
HEPA	high-efficiency particulate air
HSO	Health and Safety Officer
IDW	investigation-derived waste
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
msl	mean sea level
NAPL	nonaqueous-phase liquid
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PCE	tetrachloroethene
PEL	permissible exposure level
PID	photoionization detector
POL	petroleum, oil, and lubricants
PPE	personal protective equipment
ppm	parts per million
RHSM	Regional Health and Safety Manager (URS)
RI	remedial investigation
SCAPS	Site Characterization and Analysis Penetrometer System
SMS	safety management standard
SPF	sun protection factor
SSC	Site Safety Coordinator
SSHP	Site Safety and Health Plan
SSO	Site Safety Officer
TCA	1,1,1-trichloroethane
TCE	trichloroethene
TPH	total petroleum hydrocarbons
URS	URS Group, Inc. (formerly Woodward-Clyde)
USACE	United States Army Corps of Engineers
UXO	unexploded ordnance
VOC	volatile organic compound

This Site Safety and Health Plan (SSHP) establishes guidelines and requirements for maintaining safe and healthy working conditions during the remedial investigation (RI) at Landfill 2, also known as the East Gate Disposal Yard (EGDY), at the Fort Lewis Logistics Center, Fort Lewis, Washington. All field personnel who are directly employed by or subcontracted to URS are required to read and understand this SSHP. URS and subcontractor personnel assigned field tasks at the site must agree to abide by the SSHP by signing the attached compliance agreement form. In addition, on-site employees and subcontractors must comply with the URS Corporate Health and Safety Program and the most recent edition of the U.S. Army Corps of Engineers (USACE), *Safety and Health Requirements Manual*, EM 385-1-1 (USACE 1996).

Health and safety guidelines and requirements are based on a review of available information concerning hazards expected to exist at the work site. The SSHP delineates health and safety procedures and equipment required to minimize the potential for injuries due to safety and physical hazards, biological hazards, and injuries due to occupational exposure to hazardous chemicals. If any hazards not anticipated by this plan are encountered in the field, the Site Safety Officer must stop work so that appropriate modification of the SSHP can be made. The SSHP may be modified by the Project Manager, the business unit Health and Safety Officer (HSO), and the Regional Health and Safety Manager (RHSM). Modifications to the SSHP must be approved by all three parties.

This plan follows the applicable requirements of 29 Code of Federal Regulations (CFR) 1910.120 Occupational Safety and Health Administration (OSHA) and the USACE *Safety and Health Elements for HTRW and EOW Documents*, ER 385-1-92 (USACE 2000). This SSHP follows the sequence of requirements described in ER 385-1-92.

1.1 SITE LOCATION AND HISTORY

EGDY was used from approximately 1946 through at least 1971 as a disposal site for liquid and solid wastes. Trenches were used for the disposal of trichloroethene (TCE) and petroleum, oil, and lubricants (POL) from equipment cleaning and degreasing activities conducted at the Fort Lewis Mount Rainier Ordnance Depot (now included in the Logistics Center). Past disposal practices at the EGDY have been identified as a likely source of present-day TCE groundwater contamination.

TCE was used as a degreasing agent at this facility until the mid-1970s, when its use was replaced with 1,1,1-trichloroethane (TCA). Waste TCE was disposed at several locations with waste oils. Trenches were excavated in the yard and on adjacent land southwest of the yard. The trenches reportedly received liquid TCE and POL from cleaning and degreasing operations, and solid waste (including drums that contained these wastes).

In 1985, the U.S. Army identified traces of TCE in several monitoring wells installed in the unconfined aquifer beneath the Logistics Center. A limited site investigation was performed in 1986 under the Department of Defense Installation Restoration Program, and a remedial investigation in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) began in 1987. The 1990 CERCLA record of decision for the Logistics Center specified that a pump-and-treat system be installed to prevent further migration of the plume. This system began operations in August 1995.

Currently the USACE is conducting drum removal operations at the EGDY. Hundreds of drums and other containers have been removed so far from former disposal trenches identified during a 1995 investigation. Many of the drums contain product consisting of mixtures of TCE and POL.

Land surface elevations at EGDY range from 270 to 280 feet above mean sea level (msl). Site topography is mostly flat or gently sloping. Site vegetation consists of thickets of Scotch-broom, grasses, and blackberry, interspersed with forested areas of Douglas fir, cottonwood, and alder.

1.2 SITE CONTAMINATION INFORMATION

The contaminant plume emanating from EGDY is over 2 miles long, between 3,000 to 4,000 feet wide, and 60 to 80 feet thick. The results of the 1986 remedial investigation and subsequent investigations by URS showed that groundwater in the shallow Vashon Drift Aquifer is contaminated principally with TCE. TCE concentrations in a few wells located within and just downgradient of EGDY have been as high as 1×10^6 micrograms per liter (µg/L). Other chemicals of concern include vinyl chloride, cis-1,2-dichloroethene (DCE), tetrachloroethene (PCE), and TCA.

Maximum soil concentrations detected during the Phase I expanded site investigation sampling for TCE, DCE, and total petroleum hydrocarbons (TPH) are 3,400 milligrams per kilogram (mg/kg), 370 mg/kg, and 45,000 mg/kg, respectively. Several chlorinated pesticides and polychlorinated biphenyls (PCBs) were detected in samples at concentrations typically below 0.060 mg/kg.

Although all of the soil sampling conducted in the EGDY study area during the remedial investigation and confirmational soil sampling was focused on likely areas of soil contamination, the results for chlorinated volatile organic compounds (VOCs) are quite variable. Only a few measurements are above 1 mg/kg, and many are in the 0.001 to 0.010 mg/kg range. This suggests either very localized disposal zones or small amounts of residual TCE in the unsaturated zone. In borings where TCE was detected at greater than 1 mg/kg, the highest concentrations occur in the upper 4 feet of the soil. Materials encountered in the test pits excavated during the confirmational soil sampling consisted of charred metallic debris, engine parts, crushed and rusted paint cans and buckets, crushed 55-gallon drums, glass bottles, and ceramic debris (hospital china).

Results of the Phase I expanded site investigation conducted in 1995 and the drum removal currently being conducted indicate that nonaqueous-phase liquid is present at the EGDY.

The Phase II RI activities are being performed to further characterize chemical contaminants in the soils and groundwater. The following sections describe field tasks associated with field work to be performed at EGDY. An activity hazard analysis for each task is also provided in this section.

2.1 SITE PREPARATION

A temporary road to access drill locations will be required. URS will provide oversight of road construction activities. A small dozer and front end loader will be used to accomplish this task.

2.2 SOIL BORINGS

Twenty-four soil borings will be drilled for soil sampling, describing the lithology of the site, and installing groundwater monitoring wells. URS will provide oversight of drilling activities.

All borings will be drilled using sonic drilling equipment. Sonic drilling employs an inertially activated drill head that generates high-frequency sinusoidal vibrations in a drill string to produce a cutting action at the bit face. This cutting action forces a continuous core of the formation into the drill string. Due to the forces developed by the resonance head and the uniform outer diameter of the drill string, excess formation material removed by the cutting face of the bit is forced back into the borehole wall, eliminating the production of cuttings during the drilling process. A geologist will log the soil cuttings and collect soil samples. Any excess soil will be disposed of as investigation-derived waste (IDW).

In addition, Site Characterization and Analysis Penetrometer System (SCAPS) testing on soil will be performed by USACE, Tulsa District. All USACE personnel will follow current safety and health requirements published by OSHA and stated with USACE's EM 385-1-1 Manual, as stated in the USACE standard operating procedure (SOP No: M-0005-SWT-01). A copy of USACE's Safety Manual will be on site during field activities. The USACE, Tulsa District Health and Safety Plan is attached (Appendix B).

2.3 MONITORING WELL INSTALLATION, DEVELOPMENT, AND SAMPLING

Monitoring wells will be installed in 19 soil borings drilled in the study area. The wells will be constructed up to a depth of approximately 120 feet below ground surface (bgs).

After monitoring wells have been constructed, the wells will be developed and sampled. A WaTerra hand pump or other low-flow, minimal drawdown technique will be used for groundwater purging and sampling. A bailer or passive skimmer will be used to collect nonaqueous-phase liquid (NAPL). All water removed from the wells during development will be disposed of as IDW.

2.4 PHYSICAL AND SAFETY HAZARDS

This section discusses the physical and safety hazards associated with activities at the site. An Activity Hazard Analysis is included in Section 2.5. Chemical exposure hazards are discussed in Section 2.6. Procedures for minimizing the chance of injury due to the hazards are briefly described in this section and detailed information is included in URS' Safety Management Standards (SMSs) included in

Appendix A. The procedures will be discussed in the initial site health and safety meeting and during daily safety meetings.

2.4.1 Slip, Trip, and Fall Hazards

Slip, trip, and fall hazards are generally present at any work site. These hazards are compounded by wet or sloped surfaces, and surfaces composed of unstable materials (loose soil, vegetation, etc.). Drilling activities present a significant hazard for slip, trips, and falls due to the presence of hoses, tools, and other obstructions in the work area. Site workers shall anticipate and correct, as practical, situations where these hazards exist. Keeping a work area free of unnecessary clutter greatly reduces the likelihood of an injury. Wearing supportive footwear with heavy soles in good condition can also reduce slip, trip and fall hazards. Additional information is provided in SMS 21, Housekeeping.

2.4.2 Lifting Hazards

Improper lifting techniques can cause injuries to the back or other portions of the musculo-skeletal system. The following actions will reduce the risk of lifting injuries:

- Use handcarts, dollies, or other lifting and moving equipment to move objects too heavy to comfortably lift.
- Always lift with the legs, keeping the back straight. Avoid twisting the back while lifting, take small steps, and use your feet to pivot.
- Get assistance or use the proper equipment if there is any question about your ability to lift the load properly.

Additional information is provided in SMS 45, Back Injury Prevention.

2.4.3 Eye Injury Hazards

Well development and sampling can produce a hazard of eye injury due to splashing of contaminated groundwater. Small particles from soil movement and drilling may also cause eye injuries. Suitable eye protection must be worn at any time when an eye injury hazard exists. Protective eyewear required for the various site activities is listed in Section 5.2. An American National Standards Institute (ANSI)-approved portable eyewash station will be available at the work site.

2.4.4 Heavy Equipment

Heavy equipment will be used during site preparation, drilling, and SCAPS testing. The URS oversight employee(s) should be familiar with proper operation of heavy equipment (i.e., drilling and steam cleaning equipment). Problems should be brought to the attention of the Site Safety Officer (SSO) and documented in the field logbook. URS personnel will observe the following precautions whenever heavy equipment is in use:

- Personal protective equipment (PPE) such as steel-toed shoes, safety glasses or goggles, and hard hats must be worn whenever working around drill rigs or heavy equipment.

- Traffic safety vests are required for URS personnel working near mobile heavy equipment, or in areas of high vehicle traffic.
- All non-essential personnel will be kept out of the work area.
- Each URS vehicle near the construction area will have a first aid kit and a fire extinguisher available. All URS personnel working near the site will know the location of these items and ensure that these items are properly maintained.

Additional information is provided in SMS 19, Heavy Equipment Operations.

2.4.5 Buried Utilities and Other Buried Hazards

It is unlikely but possible that unknown buried utility lines (electrical, communications, sewer and water supply, natural gas pipelines, etc.) will be present at the investigation areas near EGDY. Buried electrical and water lines are present near the East Gate air stripper tower and treatment plant, and lead from the treatment plant to the infiltration galleries. The location of these utilities will be marked prior to beginning field activities. A digging permit including a utility survey must be obtained through Fort Lewis Public Works prior to beginning drilling or excavation activities. Additional information is provided in SMS 34, Utility Clearances.

The potential for encountering buried ordnance/munitions in the EGDY is not considered to be significant enough to require additional protection during intrusive activities. This conclusion is based on the following:

- Other ordnance disposal areas were available on Fort Lewis during the time EGDY was active; therefore, ordnance generally would not have been disposed of at EGDY.
- The possibility of disposal of ordnance at EGDY was evaluated during the expanded site investigation and was considered to be unlikely.
- Intrusive work conducted to date has not uncovered any live ordnance/munitions.

In the event that munitions are uncovered during intrusive activities, the procedures described in Section 2.7.3 will be followed.

2.4.6 Decontamination Activities

Large sampling equipment will be decontaminated with a high-pressure, hot-water washer. These units use a gasoline-powered pump and diesel-powered boiler to produce water that is discharged from a spray nozzle at pressures exceeding 2,000 pounds per square inch and temperatures exceeding 160°F. The water discharged from a pressure washer nozzle can cause severe lacerations and burns if allowed to contact even covered parts of the body. The pressure washer can also violently dislodge pieces of soil or rock from the equipment being cleaned, propelling them at very high velocity. The hot water also can volatize or aerosolize chemical contaminants and contaminated soils. Personnel using a pressure washer to decontaminate equipment must comply with the operator's instructions for the pressure washer and wear the PPE described in Section 5.

2.4.7 Heat Stress

At temperatures of 70°F and greater, workers may suffer heat stress, especially if wearing impermeable clothing such as Tyvek. Heat stress is not anticipated to be a significant health hazard during this project, due to the moderate prevailing temperatures at the site. Short-term temperature extremes, however, may create conditions favorable to developing heat stress. SMS 18, Heat Stress (Appendix A) provides descriptions of symptoms, methods for prevention and control, and monitoring protocols for heat stress. This standard will be followed, as necessary, to prevent workers from suffering heat stress. Institution of physiological monitoring and work/rest schedules will be the decision of the HSO, Project Manager, and the USACE Technical Manager. This decision will be based upon site worker's response to site conditions (temperature, humidity, sunlight, wind).

2.4.8 Noise

Regulations require that hearing protection be used when noise levels exceed 85 decibels (dBA) averaged over an 8-hour work day. The only sources of noise that may exceed 85 dBA are anticipated to be during operation of sonic drilling, SCAPS, and dozer activity.

Noise monitoring is not planned because the use of the noise producing equipment is periodic and of relatively short duration and personnel will be wearing hearing protection during excessively noisy conditions.

Hearing protection will be worn when any site activities are performed that produce noise loud enough to make conversation difficult without raising the voice at a distance of 3 feet. Hearing protection will be required at all times during operation of the drill rig. Foam insert ear plugs or protective ear muffs capable of a 25 dBA noise reduction rating are considered sufficient. Additional information is provided in SMS 26, Noise and Hearing Conservation.

2.4.9 Solar Radiation

Working outdoors without proper skin and eye protection against solar radiation (sunlight) can result in sunburn of the skin and the retina and other eye tissues. Solar radiation can cause severe burns under certain conditions. Persons who are not conditioned (tanned) are more susceptible to sunburn. Eye injury due to solar radiation is more common when working near highly reflective surfaces such as water, snow, or light-colored surfaces. Severe sunburn can occur even during overcast or cloudy days. Long-term exposure to sunlight can increase the risk of skin cancer.

Symptoms of sunburn include reddening of the skin and minor to severe pain when the sunburned skin is touched. Severe sunburn may result in blistering and ultimate shedding of the burned skin. The potential for sunburn can be reduced by wearing clothing that covers portions of the body that are susceptible to sunburn such as the back of the neck, the top of the head and ears, and the arms. Long-sleeved shirts and long pants or other fully-covering protective clothing will be worn at all times. Head protection during drilling and excavation operations will be provided by wearing hard hats. Head protection from sunburn during other activities where overhead hazards do not exist can be provided by wearing hats or caps. Sunscreen lotion or gel will be worn over those portions of the body that are not conditioned, or which cannot be protected by clothing (face, neck and ears). A sunscreen lotion or gel with a sun protection factor (SPF) of 25 or greater is considered acceptable. If desired, a light-colored cloth may also be worn over the back of the neck to further reduce exposure to sunlight.

Symptoms of retinal sunburn include a painful, dry, scratched feeling on the eye surface, extreme sensitivity to sunlight, headache, and in extreme cases, temporary blindness. Protective eyewear meeting ANSI Z-87.1-1989 will be worn. Site personnel may want to wear protective eyewear equipped with shaded lenses.

2.4.10 Radiological Hazards

The potential for a significant radiological hazard is considered to be low. Monitoring for radiological hazards will not be required.

2.4.11 Biological Hazards

Being bitten or stung by noxious organisms such as insects, spiders, and small mammals may be a significant hazard, especially to those with known or unknown allergic sensitivity to insect stings. There are no known noxious reptiles at the EGDY site. All persons with known allergies should be identified prior to beginning work. At the recommendation of their personal physician, persons with severe allergies may wish to carry a self-administered treatment for allergic reaction.

Infectious agents such as bacteria and viruses can be present in any environment, but may be more prevalent within landfill materials. Infections can result if minor cuts, punctures, and abrasions are not thoroughly washed, disinfected, and treated. Infections can also occur if proper personal hygiene practices are not followed.

2.5 ACTIVITY HAZARD ANALYSIS

Table 2-1 presents an Activity Hazard Analysis for the various work tasks to be performed during the investigation.

2.6 CHEMICAL HAZARDS

Potential routes of exposure for the compounds listed in the previous sections include inhalation, ingestion, and dermal contact. Trenching and drilling activities within buried waste materials are the tasks that are most likely to result in release of volatile chemicals to worker breathing zones. However, due to the length of time since wastes were last disposed of (more than 25 years), and the coarse nature of the soils, most accumulations of volatile chemicals have probably volatized or migrated downward into the groundwater system. It is not anticipated that concentrations of VOCs into the air near the sampling or drilling sites will exceed the permissible exposure level (PEL) for TCE (100 parts per million [ppm]), the most prevalent compound expected to be present on site. However, real-time air monitoring with a photoionization detector (PID) will be performed during those activities that are most likely to result in a release of VOCs into the atmosphere. Respiratory and PPE upgrades will be instituted if the results for air monitoring exceed the action levels provided in Section 2.7.

With the exception of any residual VOCs present, most of the substances detected in soil at EGDY are not appreciably volatile. Contaminant-laden dusts may be generated during the planned work. Drilling and trenching operations may produce excessive dusts if the work is performed during dry summer or fall months. Generation of dusts at other times of the year is less likely because of soil moisture conditions. Ingestion of contaminated soils is unlikely to occur because workers will be wearing protective gloves while handling samples, and workers are required to wash their hands prior to eating, drinking, or smoking. Furthermore, these activities will not be allowed in the exclusion zone. The potential for exposure due to dermal contact is not considered significant because workers will be wearing protective clothing and gloves.

Exploratory trenching performed by URS during a previous project at the site failed to encounter hydrogen sulfide. Hydrogen sulfide can be present in landfills due to anaerobic decay of organic material. Hydrogen sulfide is unlikely to be present at significant concentrations at EGDY because it is unlikely that putrescible wastes were buried within the landfill. Buried materials encountered previously consisted of non-putrescible solid wastes, many of which showed evidence of burning prior to burial. Monitoring for hydrogen sulfide will not be required during the drilling or trenching tasks at EGDY. However, in the event that the odor of hydrogen sulfide is commonly detected by field personnel, the SSO must be contacted so that suitable modifications to this SSHP can be developed, if appropriate.

Methane was not encountered during the previous exploratory excavation conducted by URS. Methane is also a common byproduct of decay of organic landfill materials. Methane is an odorless, colorless, flammable gas. It is not toxic; however, it can be an asphyxiant in situations where it replaces the ambient air. The upper and lower explosive level for methane are 15 percent (150,000 ppm) and 5 percent (50,000 ppm), respectively. As indicated earlier, the majority of wastes encountered at EGDY are non-putrescible solid wastes. Monitoring for methane with a combustible gas indicator will be performed during drilling and excavation activities, because methane is an odorless gas and its presence cannot be determined without the use of monitoring instruments. Action levels for combustible gas are provided in Section 2.7.

Tables 2-2 through 2-5 present physical properties, regulatory thresholds, symptoms of overexposure, and target organs for TCE, DCE, vinyl chloride, hydrogen sulfide, methane, and other selected site contaminants.

2.7 ACTION LEVELS AND HAZARD MITIGATION

Action levels are conditions that must exist to require a certain action that is intended to reduce the hazards created by the condition. Action levels are presented in the following sections for the various safety, chemical, and physical hazards noted above.

2.7.1 Action Levels for Safety Hazards

Site workers shall be vigilant for and immediately correct any situation where a safety hazard exists. The recognition and mitigation of safety hazards is necessary to reduce the risk of injury due to these hazards. The use of common sense and communication of safety hazards to other site workers are proven methods of reducing the frequency of accidents. If any task appears to present a safety hazard, site workers shall bring the matter to the attention of the SSO so that proper mitigation of the hazard can be implemented.

2.7.2 Action Levels for Chemical Hazards

The probability of chemical exposure is anticipated to be low to moderate for this project. Ingestion and skin contact with potential contaminants is not expected to occur due to PPE and work practice requirements. Although unlikely, exposure by inhalation to VOCs may occur if site materials are discovered to be severely contaminated with VOCs or if contaminant-laden dusts are generated. Action levels for chemical hazards are based on the presence of total organic vapors as measured with a PID (Photovac Model 2020 equipped with a an 11.7 eV lamp). Action levels for vinyl chloride are based on concentrations measured with colorimetric tubes. Action levels for methane are based on measurements with a multi-gas detector. Action levels for airborne particulates are based the presence of visible and persistent airborne dusts.

2.7.2.1 Action Level for Total Organic Vapors and Vinyl Chloride

The action levels listed below are based upon the OSHA PELs for TCE (100 ppm) and vinyl chloride (1 ppm). These compounds were selected because they are the compounds with the lowest PELs that are most likely to be present on site. Monitoring for total organic vapors will be performed continuously with the PID during drilling operations. The other field tasks are not likely to produce significant concentrations of organic vapors; therefore, monitoring will not be required for other field tasks unless odors of organic vapors are apparent. The action level for upgrading to Level C respiratory protection is detecting persistent (3 minutes or more) total organic vapors in the breathing zone at 5 ppm or greater when measured with a PID. The action level for evacuating the work area is 50 ppm when measured with a PID. These action levels are based on the assumption that the majority of organic vapors detected are TCE and the response factor for the PID is 0.5 when the PID is calibrated with isobutylene.

Monitoring for vinyl chloride will be instituted if the PID measurements of total organic vapors exceed 5 ppm in the breathing zone continuously for at least 3 minutes. Because vinyl chloride is readily polymerized in air and sunlight, the proportion of airborne vinyl chloride is expected to compose a very small fraction of any total organic vapors detected. The action level to perform monitoring for vinyl chloride is thus very conservative. Airborne concentrations of vinyl chloride will be measured with colorimetric gas detector tubes. Tubes manufactured by Draeger Company shall be used, as they are the only readily available tubes with a measuring range sensitive enough to measure these compounds at concentrations below their PELs. The vinyl chloride tube shall be capable of measuring concentrations of 0.25 to 6 ppm. Measurements will be taken in the breathing zone of the worker most at risk once every 15 minutes that PID readings exceed 5 ppm. The SSO may decrease the sampling frequency based on site conditions, but the frequency must be no less than once every two hours.

Table 2-6 presents health and safety action levels for total organic vapors (assumed to be composed primarily of TCE) and vinyl chloride.

When measurements with a PID and colorimetric tubes indicate the presence of total organic vapors or vinyl chloride equal to or exceeding the action level to evacuate the work area, the following actions must be taken:

1. Personnel shall be moved at least 100 feet upwind of work area.
2. The HSO shall be contacted.
3. At the instruction of the HSO and after waiting 10 minutes for organic vapors to dissipate, the SSO may don an air-purifying respirator equipped with organic vapor/high-efficiency particulate air (HEPA) cartridges, and cautiously approach the work site from an upwind direction to determine the extent and concentration of organic vapor or vinyl chloride emissions. The SSO shall not enter any area where any of these readings exceed the action level to evacuate.
4. Personnel may reenter the work area only by clearance of the SSO after the cause of the emission has been determined and the source abated.
5. An incident report shall be prepared and submitted to the HSO. If the release of these substances cannot be controlled, or does not diminish below the action levels, the work may have to continue with supplied-air respiratory protection, in which case this SSHP would need to be modified and approved.

2.7.2.2 Action Level for Combustible Gases

Monitoring for combustible gases will be performed continuously during drilling operations using a direct-reading, multi-gas meter equipped with a sample draw pump. The meter must be capable of measuring combustible gases as a percent of the lower explosive limit for methane, and percent oxygen. Measurements of percent oxygen must be made to ensure that oxygen is present at concentrations between 19.5 and 22 percent. A breathing hazard exists and combustible gas readings are not reliable if oxygen is below 19.5 percent. Excessively flammable atmospheres may be present if oxygen concentrations exceed 22 percent.

The action levels for combustible gases presented in Table 2-7 are based on the presence of oxygen within the range of 19.5 to 22 percent.

When measurements indicate the presence of combustible gas levels equal to or exceeding the action level in the work area, the following evacuation action must be taken:

1. Personnel shall be moved at least 100 feet upwind of the work area.

2. The HSO shall be contacted.

3. At the instruction of the HSO and after waiting 15 minutes for combustible gases to dissipate, the SSO may use the detector to cautiously approach the work site from an upwind direction to determine the extent and concentration of combustible gas emissions. The SSO shall not enter any area where readings exceed the action level, nor shall the SSO make any approach if there is possibility of fire or explosion.

4. Personnel may reenter the work area only by clearance of the HSO after the cause of the emission has been determined and the source abated.

5. An incident report shall be prepared for submittal to the HSO. If the release of combustible gases cannot be controlled, or does not diminish below the action levels, the work may have to continue under additional engineering or administrative controls, in which case this SSHP would need to be modified and approved.

2.7.2.3 Action Level for Airborne Particulates

Semivolatile organic compounds, chlorinated pesticides, PCBs, and metals have been detected in soil samples at EGDY. These substances are not appreciably volatile and often adsorb strongly to soil particles. While these compounds are not likely to become airborne as vapors, they may be present in the breathing zone adsorbed to airborne dusts.

The action level for upgrading to Level C PPE is based on the presence of visible and persistent dusts in the breathing zone. It is emphasized that encountering or generating hazardous levels of dust is unlikely given that subsurface soils are moist or nearly saturated. Dust control measurements such as periodically wetting the soil with water will be instituted if persistent visible dusts are present. Real-time dust monitoring is not required for this project; however, if dusty conditions cannot be controlled, real-time monitoring for dusts may be necessary, which would require modification of this SSHP. The action levels for dusts are presented in Table 2-8.

2.7.3 Engineering Controls and Work Practices

It is not anticipated that engineering controls such as the use of fans or other equipment will be required at this site. Should discharge of significant levels of airborne contaminants be difficult to control, the HSO shall be notified so that appropriate engineering controls can be developed and incorporated into this SSHP.

The potential for injury or exposure can be greatly reduced by instituting the following work practices:

- If any ordnance (explosive shells, bombs, hand grenades, and other explosives) is discovered, the immediate area will be evacuated and Fort Lewis Explosives and Ordnance Disposal (EOD) will be notified. If munitions (small arms ammunition) are uncovered during excavation, the backhoe will place the munitions outside the immediate work area and Fort Lewis EOD will be called to make further identification and remove the munitions, if necessary. If munitions that are obviously spent are encountered, no further action is required, and work may proceed with caution. The decision to obtain the services of a military ordnance or hazardous materials disposal squad will be made by the Project Manager with consultation with Fort Lewis Public Works and the USACE Project Manager. The phone number for Fort Lewis EOD is (253) 967-5507.
- Personnel are forbidden from handling anything other than soil cuttings, pumped groundwater, and soil, sediment, seep, or groundwater samples collected for laboratory analysis.

- Dusts will be controlled by wetting the dust source areas with potable water obtained from a nearby hydrant.
- Ground fault circuit interruption safety cords, plugs and adapters will be used with any electrical tool or appliance to reduce the risk of electrical shock.

Work practices and PPE will be used to reduce the risk of injury due to certain site hazards. Personal protective equipment is discussed in Section 5 and work practices are described in Section 10.

2.7.4 Prevention of Public Exposure to Site Hazards

The EGDY site is sometimes used by military personnel and families for personal exercise (jogging, etc.). In the event that unauthorized person(s) approach a work area, the person(s) will be asked to remain approximately 100 yards outside the work area. Prior to the Phase I expanded site investigation, Fort Lewis Range Control indicated that the EGDY area is not used for military training/maneuvering. Therefore, it is not necessary to coordinate with Fort Lewis Range Control prior to starting work for the Phase II RI.

Table 2-1
ACTIVITY HAZARD ANALYSIS

ACTIVITY	POTENTIAL HAZARDS	RECOMMENDED CONTROLS
Site preparation with heavy equipment	1. Heat stress	A. Follow SMS 18 in Appendix A
	2. Physical hazards (e.g., being struck or run over) from large equipment	A. Notify equipment operators of your presence in work area B. Work well away from the hazard radius presented by heavy equipment C. Work within the operator's field of view
	3. Slip, trip and fall hazards	A. Correct situations where such hazards exist B. Wear proper footwear C. Maintain a clutter-free work area
	4. Noise (>85 dBA)	A. Wear hearing protection
	5. Sunburn	A. Wear sunscreen on exposed portions of body
	6. Poisonous/hazardous animals and plants	A. Inspect area to identify hazards plants/animals/insects prior to beginning work B. Remove or eradicate pests C. Persons with known allergies to bee/wasp stings may carry antihistamines under advice of personal physician
EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
Level D and other PPE as described in Section 5	1. Inspect all heavy equipment each day prior to use	A. Training as required in Section 4
	2. Inspect area to be cleared for the presence of bee and wasp nests	

Table 2-1 (Continued)

ACTIVITY HAZARD ANALYSIS

ACTIVITY	POTENTIAL HAZARDS	RECOMMENDED CONTROLS
Groundwater investigation (drilling, well construction, well development, collecting soil samples from well borings) and working near drilling rig	1. Heat stress	A. Follow SMS 18 in Appendix A
	2. Physical hazards (e.g., being struck or run over or smashed fingers or toes) from large equipment	A. Follow requirements of SMS 19 in Appendix A B. Use machine guards as appropriate
	3. Lifting hazards	A. Use proper lifting techniques B. Use proper tools or request assistance if object is too heavy
	4. Slip, trip and fall hazards	A. Correct situations where such hazards exist B. Wear proper footwear C. Maintain a clutter-free work area
	5. Noise (>85 dBA)	A. Wear hearing protection
	6. Electrocution or explosions due to contact with underground utilities	A. Do not drill until utility survey is complete
	7. Airborne chemical hazards (methane, H_2S, organic vapor, dusts)	A. Monitor for chemicals using instruments/methods described in Section 8 B. Ventilate area to remove vapors or wet soils to prevent dusts C. Wear respiratory protection (Section 5) or evacuate area based on action levels specified in Section 2.7
	8. Encountering small arms munitions, ordnance	A. Identify and avoid metallic debris B. Minimize number of personnel in work area during drilling C. Do not touch or disturb ordnance, contact Fort Lewis EOD (253) 967-5507
	9. Fire hazards	A. Smoke only in designated areas B. Ensure spark arrester is in working order C. Refuel vehicles only at a commercial fuel dispenser D. Keep fire extinguisher readily available
EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
Drilling rig and associated equipment, PPE and air monitoring equipment as described in SSHP	1. Have buried utility survey performed prior to work	1. Training as described in Section 4
	2. Inspect rig and equipment each day prior to work	2. Rig crew shall be trained in proper and safe operation of the rig

Table 2-1 (Continued)

ACTIVITY HAZARD ANALYSIS

ACTIVITY	POTENTIAL HAZARDS	RECOMMENDED CONTROLS
Decontamination activities (large or small equipment)	1. Heat stress	A. Follow requirements of SMS 18 in Appendix A
	2. Lifting hazards	A. Use proper lifting techniques B. Use proper tools or request assistance if object is too heavy
	3. Slip, trip, or fall hazards	A. Correct situations where severe hazards exist B. Wear proper footwear
	4. Sunburn	A. Wear sunscreen on exposed portions of body
	5. Airborne chemical exposure	A. Monitor for airborne contaminants and wear respiratory protection, if necessary
	6. Contact with contaminated soil/water/sediment	A. Wear PPE as described in Section 5
	7. Contact with hot water pressure washer stream	A. Always point washer wand away from body. B. Wear PPE as described in Section 5
	8. Contact with acid or methanol rinse agents	A. Wear PPE B. Reneutralize acids with sodium bicarbonate after use, dilute methanol with water after use
EQUIPMENT	**INSPECTION REQUIREMENTS**	**TRAINING REQUIREMENTS**
Brushes, pressure washer, acid rinse, methanol rinse, Liquinox solution, potable and distilled water, PPE	1. Inspect pressure washer prior to use	A. Training as described in Section 4

Table 2-1(Continued)

ACTIVITY HAZARD ANALYSIS

ACTIVITY	POTENTIAL HAZARDS	RECOMMENDED CONTROLS
NAPL sampling	1. Heat or cold stress	A. Follow SMS 18 in Appendix A
	2. Chemical exposure	A. Wear PPE described in Section 5 B. Limit amount of NAPL removed from well to the minimum necessary for analysis C. Work from cross-wind direction of potential airborne chemical source
	3. Lifting hazards	A. Use proper lifting techniques B. Use proper tools or request assistance if object is too heavy
	4. Slip, trip and fall hazards	A. Correct situations where such hazards exist B. Wear proper footwear C. Maintain a clutter-free work area
	5. Sunburn	A. Wear sunscreen on exposed portions of body
	6. Poisonous/hazardous animals and plants	A. Inspect area to identify hazards plants/animals/insects prior to beginning work B. Remove or eradicate pests C. Persons with known allergies to bee/wasp stings may carry antihistamines under advice of personal physician

EQUIPMENT	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Syringes, VOC containers, tubing, caps; PPE as described in Section 5	1. Determine presence of NAPL with drop line and water-finding paste	A. Training as required in Section 4
	2. Inspect well to be opened for the presence of bee and wasp nests	

Notes:

NAPL: nonaqueous-phase liquid
PPE: personal protective equipment
SSHP: Site Safety and Health Plan
VOC: volatile organic compound

Table 2-2
PROPERTIES OF POTENTIAL CHEMICALS OF CONCERN

CHEMICAL	LOWER EXPLOSIVE LIMIT (percent in air)	UPPER EXPLOSIVE LIMIT (percent in air)	APPEARANCE AND ODOR
Trichloroethene	8	10.5	Colorless, combustible liquid with chloroform-like odor.
1,2-Dichloroethene	5.6	12.8	Colorless, flammable liquid with chloroform-like odor.
1,1,1-Trichloroethane	6	15	Colorless, flammable liquid with chloroform-like odor.
Tetrachloroethene	Noncombustible	Noncombustible	Colorless liquid with mild chloroform-like odor.
Vinyl chloride	3.6	33	Flammable gas with pleasant odor at high concentrations.
Hydrogen sulfide	4	44	Flammable gas with odor of rotten eggs.
Methane	5	15	Flammable odorless gas.

Notes:
ppm: parts per million

Source: Genium Publishing Corporation Material Safety Data Sheets (MSDS) collection.

Table 2-3

REGULATORY THRESHOLDS FOR POTENTIAL CHEMICALS OF CONCERN

CHEMICAL	OSHA PEL	STEL	IDLH
Trichloroethene	100 ppm	200 ppm (ceiling)	1,000 ppm
1,2-Dichloroethene	200 ppm	--	1,000 ppm
1,1,1-Trichloroethane	350 ppm	--	700 ppm
Tetrachloroethene	100 ppm	200 ppm (ceiling)	150 ppm
Vinyl chloride	1 ppm	5 ppm (ceiling)	NA
Hydrogen sulfide	--	20 ppm (ceiling)	100 ppm
Methane	--	--	10 % LEL (5,000 ppm)

Source: Online NIOSH Pocket Guide to Chemical Hazards, http://www.cdc.gov/niosh/npg/pgdstart.html, June 27, 2001

Notes:

IDLH - immediately dangerous to life or health
LEL - lower explosive limit
NA - not applicable
OSHA - Occupational Safety and Health Administration
PEL - permissible exposure limit
STEL - short-term exposure limit

Table 2-4

SYMPTOMS OF OVEREXPOSURE AND EFFECTS OF POTENTIAL CHEMICALS OF CONCERN

	SIGNS OF OVEREXPOSURE							
CHEMICAL	**HEADACHE**	**IRRITATION**[a]	**DERMATITIS**	**GI DISTURBANCE**[b]	**NAUSEA**	**NERVOUS SYSTEM** [c]	**OTHER**	**PRIMARY ENTRY ROUTE**
Trichloroethene		X	X		X		Fatigue, giddiness, cardiac arrythmia	Inhalation, absorption, skin contact
1,2-Dichloroethene		X				X		Inhalation, absorption, skin contact
1,1,1-Trichloroethane		X	X			X		Inhalation, absorption, skin contact
Tetrachloroethene	X	X	X		X	X	Flushed face and neck, somnolence	Inhalation, absorption, skin contact
Vinyl chloride				X			Weakness, abdominal pain	Inhalation
Hydrogen sulfide	X	X		X	X	X	Apnea, convulsions, lacrimation, photosensitivity	Inhalation
Methane							Non toxic, but simple asphyxiant when it displaces oxygen	Inhalation

Notes:

[a] Irritation means irritation of eyes, skin, respiratory system, mucous membranes

[b] Gastrointestinal (GI) disturbance includes abdominal pain, constipation, weight loss, etc.

[c] Nervous system effects include nervousness, narcosis, spasms, depression, euphoria, giddiness, light headedness, numbness, vertigo, dizziness, etc.

Table 2-5

TARGET ORGANS OF POTENTIAL CHEMICALS OF CONCERN

CHEMICAL	TARGET ORGAN							
	NERVOUS SYSTEM	SKIN	KIDNEYS	LIVER	RESPIRATORY SYSTEM	EYES	CANCER	OTHER
Trichloroethene	X	X		X	X	X	X	Heart
1,2-Dichloroethene	X				X	X		
1,1,1-Trichloroethane	X	X			X	X	X	
Tetrachloroethene	X	X	X	X	X	X	X	
Vinyl chloride	X	X		X		X	X	
Hydrogen sulfide	X				X	X		Causes olfactory fatigue
Methane								Simple asphyxiant, not toxic. Hazard due to flammable properties

Table 2-6
HEALTH AND SAFETY ACTION LEVELS FOR TOTAL ORGANIC VAPORS

MONITORING EQUIPMENT	RESULT	ACTION
PID	< 5 ppm	• Monitor continuously with PID
PID	> 5 ppm and <50 ppm	• Upgrade to Level C, continue monitoring with PID, measure for vinyl chloride every 30 minutes with colorimetric tubes. The SSO may decrease sampling frequency based on site conditions, but frequency may be no less than every 2 hours.
PID	> 50 ppm	• Evacuate work area, contact HSO
Vinyl chloride detector tubes	> 0.5 ppm in breathing zone	• Evacuate work area, contact HSO
Observation	Work conducted in visibly contaminated materials or splash hazard with potentially contaminated materials	• Upgrade to modified Level D

Note:
The PID should be calibrated with isobutylene. The concentration identified on the cylinder for calibration of a PID with an 11.7 eV lamp should be a benzene equivalent.

Table 2-7
ACTION LEVELS FOR COMBUSTIBLE GASES

COMBUSTIBLE GAS MEASUREMENT	ACTION
Combustible gas < 10 percent LEL	Continue working and monitoring
Combustible gas ≥ 10 percent LEL	Extinguish all possible ignition sources in the work area and shut down all powered equipment. Evacuate work area.

Table 2-8
ACTION LEVELS FOR DUSTS

BREATHING ZONE OBSERVATION	REQUIRED PPE LEVEL
Visible and persistent dusts **NOT** present in the breathing zone	Level D PPE
Visible and persistent dusts present in the breathing zone	Institute dust control measurements. If dusts cannot be controlled, wear Level C PPE (organic vapor/HEPA cartridge)

URS' health and safety program has been established to provide sound, uniform health and safety practices and procedures company-wide. The Corporate Heath and Safety Administrator (CHSA) is responsible for the comprehensive company-wide administration of the program. Regional administration and supervision is performed by the Regional Health and Safety Manager (RHSM). Administration of the Health and Safety Program within individual offices is the responsibility of the office of the Health and Safety Officer (HSO). Implementation of the program for specific projects is the direct responsibility of the Project Manager.

The CHSA and RHSM are typically Certified Industrial Hygienists who have extensive experience in hazardous waste operations. The HSOs are typically scientists or engineers with experience working at many different types of sites encompassing many different types of site hazards.

The personnel composing the project health and safety organization and their respective safety-related and project responsibilities are described in this section of the SSHP.

Corporate Health and Safety Administrator (CHSA) – Phil Jones, CIH

Responsibilities

- Track health and safety regulations and implement improvements to the contractor health and safety program
- Maintain records pertaining to medical surveillance, training, fit testing, chemical exposure, and incidents
- Update health and safety manual
- Manage medical surveillance program
- Develop and implement the health and safety training program
- Provide industrial hygiene/chemical safety guidance to RHSM and HSO
- Audit key aspects of health and safety program and report effectiveness to the Executive Vice President for the Practice

Authority

- Approve the health and safety qualifications of employees to work at hazardous waste sites
- Approve or disapprove Site Safety and Health Plans
- Establish employee training and medical surveillance procedures
- Suspend work on any project that jeopardizes the health and safety of personnel

Regional Health and Safety Manager (RHSM) – Tim Reinhardt, CIH

Responsibilities

- Direct the implementation of the health and safety program of the operating group and provide recommendations for improvement of the program

- Coordinate health and safety activities of the business unit offices in the operating group
- Determine need for project Site Safety and Health Plans
- Review and approve Site Safety and Health Plans
- Monitor implementation of Site Safety and Health Plans
- Investigate reports of incidents or accidents and report accidents or incidents to the CHSA
- Assist CHSA with employee health and safety training in the operating group
- Determine whether an accidental exposure or injury merits a change in the affected individual's work assignments and whether changes in work practices are required
- Coordinate business units with regard to health and safety equipment needs

Authority

- Approve or disapprove Site Safety and Health Plans
- Direct business unit HSO to prepare project Site Safety and Health Plans
- Access project files
- Direct changes in personnel work practices to improve health and safety of employees involved in hazardous waste management projects
- Remove individuals from projects if their conduct jeopardizes their health and safety or that of co-workers
- Suspend work on any project which jeopardizes the health and safety of personnel involved

Health and Safety Officer (HSO) – Heather Boge

Responsibilities

- Interface with project managers in matters of health and safety
- Report to RHSM on health and safety matters
- Develop or review and approve project Site Safety and Health Plans prior to submittal to the RHSM for review
- Conduct staff training and orientation on health and safety related activities
- Appoint or approve site safety officers
- Monitor compliance with Site Safety and Health Plans and conduct site audits
- Assist project managers to obtain required health and safety equipment
- Approve personnel to work on hazardous waste management projects with regard to medical examinations and health and safety training

Authority

- Suspend work or otherwise limit exposure to personnel if a Site Safety and Health Plan appears to be unsuitable or inadequate
- Direct personnel to change work practices if existing practices are deemed to be hazardous to health and safety of personnel
- Remove personnel from projects if their actions or condition endangers their health and safety or the health and safety of co-workers

Project Manager – Janette Rau

Responsibilities

- Ensure that the project is performed in a manner consistent with the contractor health and safety program
- Ensure that the project Site Safety and Health Plan is prepared, approved, and properly implemented
- Provide the HSO with the information needed to develop Site Safety and Health Plans
- Implement Site Safety and Health Plans
- Ensure that adequate funds are allocated to fully implement project Site Safety and Health Plans
- Ensure compliance with Site Safety and Health Plans of contractor personnel
- Coordinate with the HSO on health and safety matters

Authority (Safety Related)

- Assign HSO-approved SSO to project and, if necessary, assign a suitably qualified replacement
- Suspend field activities if health and safety of personnel are endangered, pending an evaluation by the HSO and/or RHSM
- Suspend an individual from field activities for infractions of the Site Safety and Health Plan, pending an evaluation by the HSO, RHSM, and/or CHSA

Site Safety Officer (SSO) – John Rapp

Responsibilities

- Direct health and safety activities on site
- Report immediately all safety-related incidents or accidents to the RHSM, HSO, and Project Manager
- Assist project managers in all aspects of implementing Site Safety and Health Plans
- Maintain health and safety equipment on site
- Implement emergency procedures as required

Authority

- Temporarily suspend field activities if health and safety of personnel are endangered, pending further consideration by the HSO and/or RHSM
- Temporarily suspend an individual from field activities for infractions of the Site Safety and Health Plan, pending further consideration by the HSO and/or RHSM

Site Workers

Responsibilities

- Perform all site activities described in this SSHP according to the guidelines and procedures established in this SSHP
- Report immediately all safety-related incidents or accidents to the SSO
- Assist the SSO in all aspects of implementing the SSHP
- Properly use, maintain, and store safety equipment according to the provisions of this SSHP and the contractor health and safety program
- Notify the SSO of any actual or potential emergency situations and correct those that require immediate attention

Authority

- Temporarily suspend field activities if health and safety of personnel are endangered, pending further consideration by the SSO, HSO and/or RHSM

Subcontractors

Responsibilities

- Perform all site activities described in this SSHP according to the guidelines and procedures established in this SSHP
- Report immediately all safety-related incidents or accidents to the SSO
- Properly use, maintain, and store safety equipment according to the provisions of this SSHP and the contractor health and safety program
- Notify the SSO of any actual or potential emergency situations and correct those that require immediate attention

Authority

- Temporarily suspend field activities if health and safety of personnel are endangered, pending further consideration by the SSO, HSO and/or RHSM

All URS and subcontractor employees will obtain health and safety clearance from the HSO before beginning work at the sites. Employees assigned to field operations must have had the training described in the following sections prior to working at the site.

4.1 HAZARDOUS WASTE SITE OPERATIONS

Personnel assigned to work at the site must have received Hazardous Waste Site Operations training as required by 29 CFR 1910.120. At a minimum, the requirements listed below apply to all site workers who handle samples or sampling equipment.

- All personnel must be currently participating in a medical surveillance program as required by 29 CFR 1910.120, be physically fit, and able to perform assigned field work as certified by an approved occupational health physician.
- Employees of URS and its subcontractors assigned to work at the site must have completed 40-hour basic Hazardous Waste Site Operations training as stipulated in 29 CFR 1910.120.
- Field Managers and SSOs who are directly responsible for, or who supervise employees engaged in hazardous waste site operations shall receive 40 hours of basic training and at least 8 hours of specialized supervisor training, as required by 29 CFR 1910.120. The specialized training must include topics such as the employer's Health and Safety Program, PPE, spill containment techniques, health hazard monitoring, and accident liability and reporting procedures. Persons who are on site to perform limited, specific tasks that do not have the potential to expose the worker to hazardous substances may substitute the 40-hour training with a 24-hour course as stipulated by 29 CFR 1910.120. The survey crew and site clearing crew may operate under the 24-hour training provision.
- As required by 29 CFR 1910.120, all employees will have received 8 hours of refresher training on an annual basis after the first year of 40-hour training (or 24-hour) has passed. The refresher training should include a review of information presented in the basic course, critique of safety incidents that may have occurred during the past year, and other relevant topics.
- The SSO and at least one other person on site shall have completed basic first aid and adult cardiopulmonary resuscitation (CPR) training, at a minimum. When any field activities are performed in isolated areas, a minimum of two persons trained in first aid/adult CPR must be present.
- All personnel must have passed a respirator fit test with isoamyl acetate and/or irritant smoke as an indicator of fit within the past year.
- Each employee assigned to work at the site shall also have a minimum of 3 days of field experience under the direct supervision of trained, experienced personnel. The field experience shall include hands-on training in the proper use and calibration of field instruments being used on site.

4.2 SITE-SPECIFIC TRAINING

Before beginning field work, employees and subcontractors must be briefed by the SSO on safety procedures as they pertain to individual anticipated work assignments at the site. At the end of the meeting, attendees will be requested to sign the Safety Compliance Agreement Form attached to the front of this SSHP stating that they have been briefed on the plan, understand it, and agree to comply with the provisions of this plan as they apply to their particular work assignments. Individuals refusing to sign the agreement will be prohibited from working at the site. The completed form is to be maintained in the URS project file. Additional daily safety meetings shall be held as necessary to ensure that health and safety procedures are being followed.

Visitors, including USACE and regulatory personnel, who wish to be present during sampling activities must also receive an initial health and safety briefing, and sign the Compliance Agreement Form. Visitors must also present documentation of training and medical surveillance. This is to ensure visitors are familiar with the activities to be performed, the hazards associated with these activities, and the controls for those hazards. This SSHP is to be followed by all visitors to protect the health and safety of both visitors and site personnel.

4.3 TRAINING DOCUMENTATION

Certificates and other documents providing proof that individual workers have received the necessary training described above must be readily available. URS reserves the right to request training certificates from any persons prior to allowing them to begin work at the site.

5.1 URS PERSONAL PROTECTIVE EQUIPMENT PROGRAM

As required by OSHA, URS maintains a written PPE program. The PPE program includes selection and use of PPE, including respiratory protection equipment, respirator fit testing, and care maintenance and storage of PPE. Additional information is provided in SMS 29, Personal Protective Equipment.

5.2 LEVELS OF PROTECTION

During site preparation and heavy equipment operation, Level D or modified Level D will be worn. Modified Level D will be worn when handling contaminated soil or groundwater. Level C will only be worn if action levels described in Section 2.7.2.1 are exceeded. Levels of protection for PPE requirements for this project are as follows:

Level D

- Long-sleeve, long-pant outfit.
- Additional wind-proof, water-proof, and insulating clothing to protect against prevailing weather conditions.
- Hard hat meeting ANSI Z-89.1-1986. (Hard hat required during site clearing, drilling, excavation, and direct-push sampling operations, or any other operation where a significant overhead hazard exists.)
- Steel-toe and shank boots meeting ANSI Z-41-1991. Chemical-resistant rubber boots must be worn while working in chemically impacted areas. Steel-toe leather boots may be worn if significantly contaminated soils will not be contacted.
- Safety glasses with side shields meeting ANSI Z-87.1-1989. Glasses may be tinted or clear depending upon lighting conditions. A face shield must be worn when operating chain saws, line-trimmers, or chipper/shredders during site clearing operations.
- Leather work gloves can be worn by the site clearing crew and any other personnel performing activities that require hand protection where potentially contaminated materials are not handled.
- Hearing protection, as required. Foam insert earplugs or earmuffs meeting ANSI S3.19-1974 are acceptable.
- Safety vest.

Modified Level D

- Standard Tyvek or KleenGuard-type coveralls.
- Additional wind-proof, water-proof, and insulating clothing to protect against prevailing weather conditions.

- Hard hat meeting ANSI Z-89.1-1986. (Hard hat required during site clearing, drilling, excavation, and direct-push sampling operations, or any other operation where a significant overhead hazard exists.)
- Steel-toe and shank boots meeting ANSI Z-41-1991. Chemical-resistant rubber boots must be worn while working in chemically impacted areas.
- Safety glasses with side shields meeting ANSI Z-87.1-1989. Glasses may be tinted or clear depending upon lighting conditions.
- Splash shield meeting must be worn when sampling chemically impacted water.
- Nitrile outer gloves with a minimum length of 13 inches when handling potentially contaminated materials.
- Latex or nitrile inner gloves when handling potentially contaminated materials.
- Hearing protection, as required. Foam insert earplugs or earmuffs meeting ANSI S3.19-1974 are acceptable.
- Safety vest.

Level C

- Full face respirator (approved by the Mine Safety and Health Administration and National Institute for Occupational Safety and Health and meeting ANSI Z-88.2-1968) with combination organic vapor/HEPA filter cartridges.
- Tyvek or coated Tyvek coveralls.
- Additional wind-proof, water-proof, and insulating clothing to protect against prevailing weather conditions.
- Hard hat meeting ANSI Z-89.1-1986. (Hard hat required during site clearing, drilling, excavation, and direct-push sampling operations, or any other operation where a significant over head hazard exists.)
- Chemical-resistant, rubber, steel-toe and shank boots meeting ANSI Z-41-1991.
- Nitrile outer gloves with a minimum length of 13 inches when handling potentially contaminated materials.
- Latex or nitrile inner gloves when handling potentially contaminated materials.
- Hearing protection, as required. Foam insert earplugs or earmuffs meeting ANSI S3.19-1974 are acceptable.
- Safety vest.

Level B

Level B PPE is beyond the scope of services for this project. This SSHP will need to be amended if site conditions require Level B personal protection. Level B PPE is described here purely for reference.

- Self-contained or supplied-air breathing apparatus with a positive-pressure, full-face air mask (approved by the Mine Safety and Health Administration and National Institute for Occupational Safety and Health and meeting ANSI Z-88.2-1968) utilizing Grade D breathing air. A 5-minute escape bottle must be used if a supplied-air respirator is used.
- Coated Tyvek or Saranax coveralls with hood, ankles, and arm cuffs taped closed with duct tape.
- Chemical-resistant rubber boots, with coverall cuff taped to outside of boot.
- Butyl outer gloves with a minimum length of 13 inches taped to the coated Tyvek suit on the outside of the arm.
- Latex or nitrile inner gloves.

5.3 PERSONAL PROTECTIVE EQUIPMENT EFFECTIVENESS AND RESPIRATOR FIT CHECK

Procedures to determine the effectiveness of the PPE program would include wipe testing of PPE, quantitative measurements of airborne chemical concentrations inside and outside of respiratory protective equipment, and measurement of biological exposure indices for specific contaminants in blood, urine, or other body fluids and tissues. This type of testing is more applicable to larger, longer-term projects where concentrations of contaminants are commonly above the PEL. This type of testing is not anticipated be required during this project because of the very low probability of encountering significantly hazardous levels of chemicals. However, this type of testing may be instituted if conditions encountered in the field indicate that the chemical hazards are significantly greater than anticipated. This type of testing would be described in a modification to this SSHP.

The SSO will ensure that site workers are wearing PPE as required by this SSHP.

URS and subcontractors shall perform qualitative respirator fit testing at a minimum frequency of once per year. Respirator fit testing certificates will be in possession by all field personnel. A respirator fit check shall be performed each time a respirator is donned. Respirators are to be properly cleaned, maintained, inspected, and stored according to the manufacturer’s specifications after each use.

URS and subcontractor employees who are assigned to work at the site are required to participate in an on-going medical surveillance program satisfying the requirements of 29 CFR 1910.120.

An occupational health physician must have examined the employee within the past 12 months and must certify that the employee is physically fit to wear a respirator and perform work at hazardous waste sites. Documentation of medical clearance and the physician's opinion shall be in the form of a letter or document signed by the reviewing physician. Individuals whose medical clearance is not current will not be permitted to work on site. All medical records must be maintained by the physician in accordance with 29 CFR 1910.20.

6.1 EXAMINATION FREQUENCY AND PROTOCOL

The medical examination frequency and protocol must meet the requirements of 29 CFR 1910.120. URS and subcontractor personnel performing less than 30 days of field work per year at hazardous waste sites with low to moderate hazards may receive biennial physicals based on the reviewing physician's recommendations. Those persons who typically work more than 30 days per year at hazardous waste sites are required to have annual physical exams. Due to the relatively low probability of encountering significant chemical hazards at this site, special medical monitoring will not be required.

6.2 OCCUPATIONAL HEALTH PHYSICIAN

URS and subcontractor medical surveillance programs are required to be administered by a physician certified in occupational medicine by the American Board of Preventative Medicine.

6.3 MEDICAL MONITORING PROGRAM CERTIFICATION/PHYSICIAN'S OPINION

URS and subcontractor medical surveillance physicians may be required to provide health status medical reports for personnel participating in the program. The reports certify the employee's participation in a medical surveillance program and include the written opinion and signature of the occupational health physician.

6.4 MEDICAL MONITORING RECORDS

Medical monitoring records are retained by the occupational health physician in accordance with and for the period specified by 29 CFR 1910.20.

The probability of radiation sources being present at the site is very low. Radiation dosimetry will not be required unless evidence is encountered that suggests a significant probability that radioactive substances may be present in EGDY. Evaluation of radiation sources would require that this SSHP be amended to include a radiation safety plan.

The following SMSs, which are applicable to the work to be performed during this investigation, are provided in Appendix A. These SMSs are referred to throughout this SSHP. The procedures are intended to provide a base of broadly applicable procedures and requirements.

SMS 18	Heat Stress
SMS 19	Heavy Equipment Operations
SMS 21	Housekeeping
SMS 26	Noise and Hearing Conservation
SMS 29	PPE
SMS 34	Utility Clearances and Isolation
SMS 42	Respiratory Protection
SMS 45	Back Injury Prevention
SMS 49	Injury/Illness/Incident Reporting

8.1 SITE RULES

The following rules apply to the activities to be conducted at EGDY.

- Whenever possible, field personnel will work from a position upwind of possible contamination.
- Personnel will not work alone at any time
- Smoking, eating, drinking, chewing gum or tobacco, storing food or food containers shall not be permitted in the work area. Food and water may be stored in the temporary site office. Good personal hygiene must be practiced by field personnel to avoid ingestion of contaminants or spread of contaminated materials.
- Hands shall be thoroughly cleaned with soap and water prior to eating, drinking, smoking, or other activities.
- No one will approach or enter areas or spaces where toxic concentrations of vapors or dust may exist without proper equipment available to enable safe entry.
- Entry into trenches is forbidden.

The sampling personnel shall work in pairs. Crew members must observe each other for signs of toxic exposure. Indication of adverse effects include, but are not limited to:

- Changes in complexion and skin discoloration
- Changes in coordination
- Changes in demeanor
- Excessive salivation and pupil response
- Changes in speech pattern

Also, employees shall inform each other and the SSO of non-visible effects of toxic exposure such as:

- Headaches
- Dizziness
- Nausea
- Blurred vision
- Cramps
- Irritation of eyes, skin, or respiratory tract

8.2 WORK PERMIT AND INSPECTION REQUIREMENTS

Fort Lewis Public Works must be notified 2 weeks prior to beginning work so that a Digging Permit can be issued. The Digging Permit requires that an underground utility survey be performed prior to the permit being issued.

8.3 MATERIAL HANDLING PROCEDURES

All samples shall be handled as described in the Sampling and Analysis Plan. All necessary protective equipment listed in Section 5 will be worn when handling sample material. IDW such as drill cuttings and excess sample material, used PPE, used decontamination solutions, and other solid wastes will be handled as described in the FSP.

8.4 CONTAINER HANDLING PROCEDURES

If it becomes necessary to store drill cuttings or other potentially contaminated materials, Washington State Department of Transportation (DOT)-approved type 1A2 drums (open-topped steel drums) will be used. Drums and other containers shall be handled using a drum dolly or other mechanical handling means, as applicable and necessary. Drum lids shall be fastened and sealed prior to handling or moving drums.

Drums shall be appropriately labeled and stored within an area indicated by the USACE. Following receipt of laboratory results, proper disposal of the drum contents can be arranged.

8.5 FALL PROTECTION

If it is necessary for a member of the drill rig crew to climb the drill rig derrick to make a repair of the derrick, every effort will be made to lower the derrick to allow the work to be performed from a lower position. If it cannot be lowered, the crew member must wear a full body harness system secured to a fall protective anchor with a 6-foot lanyard. The harness and lanyard must meet the requirements of 29 CFR 1926.104 and ANSI A10.14. The drilling subcontractor must have a written Fall Protection Work Plan meeting the requirements of 29 CFR 1926.104.

8.6 HAZARD COMMUNICATION

This SSHP serves to communicate to site workers all anticipated safety, chemical, physical, and biological hazards as well as methods for identifying and minimizing such hazards. Tables 2-1 through 2-4 describe health effects and physical properties of selected compounds that may be present on site. Material safety data sheets for contaminants potentially present in site media are not required, as these substances may be present as very low concentration residues rather than commercial products. All containers of chemicals or chemical wastes are required to be properly labeled. All personnel will have received Hazard Communication Standard (HAZCOM) training consistent with their tasks. This plan requires the use of engineering controls, safe work practices, and/or protective clothing for all tasks where hazardous substances or situations may be present.

8.7 ILLUMINATION

All tasks will be performed during daylight hours. Although it is not anticipated to be necessary to leave excavations open overnight, any excavations that may be left open will be marked with caution tape and fluorescent cones to protect military personnel who may be conducting night exercises in the area.

The temporary field office will be equipped with overhead fluorescent lighting capable of producing ample light for the intended use of the office.

8.8 SANITATION

A portable toilet will be brought on site, and potable water will be available in the field office for face and hand washing. The locations of sanitation areas will be discussed during the site safety briefing.

8.9 SIGNS AND LABELS

A warning sign indicating that the site is a “restricted area” will be posted at the main entrance. The drill rig must be equipped with all necessary signs and markings that indicate various hazards (steps, moving machinery, locations of fire extinguisher and first aid kit, etc.). Red or yellow barricade tape with the words “Caution Do No Enter” will be placed around each work area to indicate dangerous conditions and restrict entry of unauthorized persons.

8.10 COMMUNICATIONS EQUIPMENT

The sampling crew and drill rig crew will have cellular telephones. The numbers of the cellular telephones assigned to the field will be recorded by all necessary parties at the time of the initial site safety briefing. Fixed telephones also will be available in the field office.

9.1 SITE ACCESS AND SECURITY

The work will be performed in a remote area generally not available to public access. All work areas will be restricted to members of the sampling or drill rig crew. Unauthorized personnel entering EGDY will be requested to remain at least 100 yards from the work areas.

9.2 WORK ZONES

The area surrounding each immediate work area will be delineated by traffic cones and plastic barricade tape. Small sampling equipment (spoons, split-spoons, etc.) will be decontaminated within the exclusion zone at each separate drilling or sampling area. Large equipment will be decontaminated at each drilling or excavation location. The support zone is designated to be the field office. Actual work zones will be determined and delineated based on field conditions.

9.3 ON-SITE AND OFF-SITE COMMUNICATIONS

On-site communications will be by voice. Three two-second blasts of a vehicle horn or portable air horn will be used to signal site evacuations. If respirators are donned, the following hand signals/gestures will be used:

- Hand on throat - can’t breathe
- Hand on wrist - leave exclusion zone
- Thumbs up - okay
- Thumbs down - not okay

Off-site communications will be by cellular telephone and fixed telephone. Cellular telephone numbers will be exchanged during the initial safety briefing.

10.1 SANITARY FACILITIES

A portable toilet will be brought on site, and potable water will available in the field office for face and hand washing. The locations of sanitation areas will be discussed during the site safety briefing.

10.2 PERSONNEL DECONTAMINATION PROCEDURES

Because concentrations of contaminants are expected to be very low, construction of a multi-station personnel decontamination facility will not be required. Sampling personnel will decontaminate by removing gloves and any outer protective clothing and thoroughly washing their hands with soap and water. Soils adhering to boots may be washed off at each drilling area with a stream of water augmented by brushing with a nylon brush and Liquinox detergent solution, if necessary. All personnel shall thoroughly wash their hands prior to eating, drinking, or smoking and prior to leaving the site each day.

Emergency personnel decontamination will be performed if anyone is exposed to or comes in contact with severely contaminated materials.

Small sampling equipment such as spoons, split-spoons, shovels, drive-point sampling probes, etc., will be washed with a solution of Liquinox laboratory-grade detergent and potable water, and final rinsed with distilled water. The washed sampling equipment will be placed in an area or container to keep them clean until they are used for collecting another sample. The Liquinox solution and rinsewater can be discharged directly onto the ground next to the sampling locations. Small equipment will be decontaminated as follows:

- Rinse and brush with potable water
- Wash with Liquinox detergent and potable water solution
- Rinse with potable water
- Final rinse with distilled water
- Air dry
- Wrap in plastic, or place in a clean area such as an ice chest where dusts cannot be deposited onto the surface

Larger equipment such as excavation and drilling equipment will be decontaminated at each drilling or excavation site with a hot water, high-pressure washer or laboratory-grade detergent and potable water. A nylon brush may be used to loosen soils that cannot be removed by the pressure washer. Decontamination solutions will be discharged to the ground surface in the area just sampled/excavated.

12.1 FIRST AID EQUIPMENT AND SUPPLIES

One large industrial-sized (minimum 16-unit size) first aid kit will be available on site at all times. The kits shall be maintained fully stocked; all perishable materials within the kits must be replaced as soon as possible after the expiration date. The location of the kit will be discussed during the initial site briefing so that all site workers are aware of its location.

12.2 EMERGENCY EYEWASH AND SHOWER FACILITIES

An emergency eyewash meeting ANSI Z358.2-1990 (as a personal eyewash) will be available on site in the field office. Small hand-held eyewash bottles will be available in field vehicles or the drill rigs.

Emergency showers will not be required because of the low probability of encountering hazardous levels of contamination.

12.3 EMERGENCY-USE RESPIRATORS

Site contamination is not expected to be significant enough to keep emergency use supplied air respirators on site.

12.4 SPILL CONTROL MATERIALS AND EQUIPMENT

Fueling of vehicles and drill rigs will be performed at a commercial fueling facility. These facilities maintain equipment for controlling and cleaning up minor spills. Fueling of small equipment such as chain saws or brush trimmers will be performed over a tray or tub so that any spilled fuel can be recovered. Small spills of fuels onto soil will be immediately absorbed with clay. The clay will not be placed into a container or drum which then may accumulate explosive concentrations of fuel vapors. The clay may be placed onto plastic sheeting to allow the fuels to evaporate. The clay may be placed into a container after the fuels have evaporated sufficiently such that they are no longer able to produce flammable vapors. The clay will then be properly disposed of according to state and federal regulations.

12.5 FIRE EXTINGUISHERS

One 20-pound Class ABC fire extinguisher will be kept readily available during field operations. Site personnel shall be made familiar with the locations of extinguishers prior to beginning work, and training in the use of extinguishers will be presented during the initial site safety briefing.

13.1 LOCAL FIRE/POLICE/RESCUE AUTHORITIES

The local fire, police, and rescue authorities can be contacted by dialing 911.

13.2 MEDICAL FACILITIES

The nearest medical facility offering 24-hour emergency care is Madigan Army Medical Center. Figure 13-1 depicts the route to the hospital from EGDY.

Route to Madigan Army Hospital

From the site entrance, cross East Lincoln Drive and follow Rainier Drive approximately 1 mile to South "F" Street. Turn left (west) onto South "F" Street and proceed approximately ½ mile to Jackson Avenue. South "F" Street will veer right, then left, and then right before intersecting Jackson Avenue at a traffic signal-controlled intersection. Madigan Hospital will be prominently visible from this intersection. Turn left (south) onto Jackson Avenue and proceed approximately ¼ mile to the emergency entrance on the right (west) side of Jackson Avenue. Large red signs indicating the emergency entrance will be visible.

13.3 EMERGENCY RESPONSE PLAN

In the event of an emergency (injury, fire, fuel spill, etc.) the proper procedures must be followed so that rapid attention by emergency care providers and emergency response agencies can be arranged. Proper emergency response requires planning and coordination prior to an actual emergency. This section describes the procedures that must be followed in order to ensure rapid and appropriate emergency response.

13.3.1 Pre-emergency Planning

This SSHP provides detailed information on the hazards and risks associated with the site. The SSHP requires that a site safety briefing be performed prior to beginning work, and daily safety meetings during the period the work is performed. The contents of the entire SSHP will be discussed during the initial safety meeting. During that meeting, the procedures of this section must be stressed so that all site workers are familiar with the emergency response procedures. The contents of this section must be reviewed and discussed during the daily safety meetings to ensure that site workers remain familiar with the emergency procedures.

13.3.2 Personnel Roles, Lines of Authority, Communications

In the event of an emergency, the following response operations will be enacted:

13.3.2.1 Notification

1. All site personnel will be alerted to the emergency. This may be done by speaking directly to all persons in the area or by three 2-second blasts of a vehicle horn.

2. The SSO will assume responsibility and authority for coordinating all emergency response activities. The SSO or designee will call for emergency assistance if necessary. The SSO or designee will maintain responsibility until proper authorities arrive and assume control.
3. All work will stop, as necessary. All personnel will move to an agreed upon gathering area for a head count and further instruction.
4. The SSO will be briefed with essential information about the emergency. Information will include what happened; the location of the emergency; who was involved/injured; when and how the emergency occurred; the extent of damage/injury; what aid may be needed.

13.3.2.2 Evaluation

The information will be evaluated by the SSO and emergency response procedures will be considered. The following information should be considered prior to initiating emergency response:

- What happened: Type and cause of incident; extent of chemical release; extent of damage to structures and equipment.
- Casualties: Number, location, and condition of victims; treatment required; missing personnel.
- Possible secondary emergencies: potential for fire, explosion, and release of hazardous chemicals; potential for injuries to other on-site/off-site personnel.
- What actions can be taken: Equipment and personnel needed for victim rescue and hazard mitigation; number and skills of uninjured personnel available for response; resources available on site; resources available from outside groups and agencies; time required for outside resources to reach site; hazards involved for rescue and response.

13.3.2.3 Rescue/Response Action

Based on the information obtained about the incident, the type of action necessary should be decided, and the necessary steps implemented. Some actions may be done concurrently. No action should be taken that would result in injury to the rescuer(s). Rescue and response actions should always be performed using the buddy system. Rescue and response actions may include:

1. Survey casualties: Locate all victims and assess their condition; determine resources needed for stabilization and transport.
2. Request aid: Contact the appropriate responders (fire department, ambulance, hospital).
3. Institute control: Bring the emergency under control; begin procedures to stop or limit the spread of the emergency; if safe to do so, remove victims from danger areas.
4. Perform emergency medical care: Administer first aid to victims with any life-threatening injuries.
5. Evacuate: Move site personnel and victims to a safe location upwind of the incident; monitor the incident for significant changes that may affect rescuers or responders; do **not** institute large-scale public evacuation, this is the responsibility of public authorities.

13.3.2.4 Follow-up

Before site activities resume, personnel must take the following actions to be fully prepared to handle another emergency:

1. Notify appropriate governmental agencies.
2. Restock equipment and supplies, repair or replace damaged equipment, clean and refuel equipment for later use.
3. Review and revise as necessary the emergency response and contingency procedures incorporating information gained from the incident so that emergency response during future incidents will be more efficient and effective.

13.3.2.5 Documentation

The incident should be thoroughly documented by the persons who are best qualified to describe the incident. An Incident Report Form (SMS 49, contained in Appendix A), will be completed. Detailed information should be recorded, especially if injuries to site workers or the public occurred. Documentation may be used to avert future incidents, as evidence in litigation, for assessment of liability by insurance companies, and review by governmental agencies. The documents produced must be:

- Accurate and objective.
- Authentic: All documentation should be dated and signed by the preparer; no record should be erased or defaced. Entries should be deleted with a single strike mark. All entries should be in blue or black ink.
- Complete: At a minimum, the documentation should include chronological history of the incident, facts about the incident, names of personnel on site, list of decisions made and actions taken during the incident, and results of sampling and air monitoring.

13.3.3 Emergency Contacts

ALL EMERGENCIES	
Fort Lewis Fire, Military Police and Ambulance	**911**
Fort Lewis Explosives and Ordnance Disposal (EOD)	**253-967-5507**
Fort Lewis Hazardous Materials Response	**253-967-4786**
Fort Lewis Range Control	**253-967-7974**
U.S. Army Corps of Engineers Project Manager:	
Bill Goss (Seattle, Washington)	(206) 764-3267
URS Project Manager:	
Janette Rau	(206) 438-2283
URS Health and Safety Officer:	
Heather Boge	(206) 438-2034

URS Regional Health and Safety Manager:

Tim Reinhardt	(206) 438-2286

URS Medical Surveillance Physician:

Peter Greany, M.D.	(714) 535-8221

13.3.4 Emergency Recognition and Prevention

In general, any incident that results in the injury of personnel (including non-project personnel) and/or damage to property, structures, and equipment may be considered an emergency. Any circumstance that is observed to have the potential for creating a fire, explosion, chemical release, or injury is also considered an emergency. The key to preventing emergencies is the recognition of a potentially hazardous situation and subsequent actions that are taken to mitigate the hazard before an emergency develops. Site workers are required to communicate to each other hazardous circumstances (no matter how inconsequential the hazards may seem) that may cause an emergency.

13.3.5 Site Layout, Prevailing Weather Conditions

Sampling will be performed within and near EGDY. A temporary field office will be set up and will serve as the site support zone. Site features are shown in the Work Plan.

Prevailing weather conditions will be monitored by the sampling team. Observations such as wind speed and direction, temperature, and precipitation will be noted in the field logbook, as necessary. The prevailing weather conditions, and the effect that they may have on emergency response actions, will be given appropriate consideration should any emergency occur.

13.3.6 Site Evacuation

Evacuation of the site would occur during a life-threatening emergency such as encountering ordnance or if a fire is ignited that cannot be quickly extinguished and controlled. Evacuation of the site would be signaled verbally to nearby persons or by three 2-second blasts of a vehicle horn or portable air horn. All personnel shall be accounted for prior to leaving the work area and every effort should be attempted to leave the area as a group. The work area should be evacuated in the upwind direction in the case of a chemical release. Evacuation of the area in case of fire should be done in the direction away from the migrating path of the fire. All personnel should assemble at the field office, where all persons should be accounted for and emergency help should be summoned, if necessary.

In the event that ordnance (hand grenades, rockets, bombs, artillery shells, etc.) is discovered, the work area will be evacuated and the USACE Project Manager will be notified. The USACE Project Manager will be responsible for notifying military specialists trained to handle and dispose of chemical warfare agents. Work will not be resumed until a UXO clearance has been performed.

13.3.7 Procedures for Decontamination and Emergency Medical Treatment of Personnel

13.3.7.1 Emergency Personnel Decontamination

Site personnel are not expected to become contaminated to such a degree that they would endanger emergency responders or medical personnel. Removal of gloves or other protective outer clothing is considered sufficient.

13.3.7.2 Emergency Medical Treatment

If an employee working in a contaminated area is physically injured, Red Cross first aid procedures will be followed. Depending on the severity of the injury, emergency medical response may be sought. If the employee can be moved, he/she will be taken to the edge of the work area where contaminated clothing will be removed (if necessary) and emergency first aid administered.

Emergency Medical Procedures

For severe injuries, illnesses, or overexposure:

1. Remove the injured or exposed person(s) from immediate danger.
2. If necessary, at least partial decontamination should be completed. Wash, rinse, and/or cut off protective clothing and equipment and redress the victim in clean coveralls. *Decontamination will be performed only if the victim will not be further endangered or injured by undergoing decontamination.*
3. Render emergency first aid and call an ambulance for transport to local hospital immediately. Notify emergency personnel of contaminants on site. This information, which is included in Section 2, should be sent with the victim to the hospital.
4. Evacuate other personnel on site to a safe place until the SSO determines that it is safe to resume work.
5. Report the accident to the Project Manager, and HSO, RHSM, and USACE Technical Manager immediately and complete an incident report (SMS 49 in Appendix A).

For minor injuries or illnesses:

1. Remove contaminated PPE, if necessary.
2. Administer first aid. Minor injuries may be treated on site, but all injuries will be examined by trained medical personnel. Victims of serious bites or stings will be taken to a medical center.
3. Notify the Project Manager and HSO immediately.

First Aid - Chemical Injury

If the injury to the worker is chemical in nature (e.g., overexposure), the following first aid procedures are to be instituted as soon as possible:

Eye Exposure	If contaminated solid or liquid gets into the eyes, wash eyes immediately using emergency eyewash solution. Lift the lower and upper lids occasionally. Cover the eye with a dry pad and obtain medical attention immediately.
Skin Exposure	If contaminated solid or liquid gets on the skin, promptly wash contaminated skin for 15 minutes using soap or mild detergent and water. If solids or liquid penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Obtain medical attention immediately if symptoms warrant.
Swallowing	If contaminated solid or liquid has been swallowed do not induce vomiting since the material may contain petroleum hydrocarbons. Obtain medical attention immediately.
Inhalation	Remove the victim from the hazardous atmosphere into fresh air. Provide emergency first aid, as necessary. Obtain medical attention immediately.

First Aid - Physical Injury

Animal Bites	Thoroughly wash the wound with soap and water. Flush the area with running water and apply a sterile dressing. Immobilize affected part until the victim has been attended by a physician. If possible, see that the animal is kept alive and in quarantine.
Burns (Minor)	Do not apply Vaseline or grease of any kind. Apply cold water applications until pain subsides. Cover with a wet sterile gauze dressing. Do not break blisters or remove tissue. Seek medical attention.
Burns (Severe)	Do not remove adhered particles of clothing. Do not apply ice or immerse in cold water. Do not apply ointment, grease or Vaseline. Cover burns with thick, dry sterile dressings. Keep burned feet or legs elevated. Seek medical attention immediately.
Cuts	Apply pressure with sterile gauze dressing, and elevate the area until bleeding stops. Apply a bandage and seek medical attention.
Eyes	Keep the victim from rubbing the eye. Flush the eye with water. If flushing fails to remove the object, apply a dry, protective dressing and consult a physician.

Fracture	Deformity of an injured part usually means a fracture. If fracture is suspected, do not attempt to move the injured part. Seek emergency help and medical attention immediately.
Heat Stress	See SMS 18 in Appendix A.
Insect Stings or Bites	Remove "stinger" if present. Keep affected part below the level of the heart. Apply ice bag. For minor bites and stings apply soothing lotions, such as calamine. Seek medical attention immediately if the person has a known allergy to insect bites or stings. Observe for signs of adverse reaction (swelling, difficulty breathing, hives). Seek medical attention immediately if a reaction develops. Persons with known severe allergies should carry treatment kits with their personal physician's approval.
Puncture Wounds	If puncture wound is deeper than skin surface, seek medical attention. Serious infection can arise unless proper treatment is received.
Sprains	Elevate injured part and apply ice bag or cold packs. Do not soak in hot water. Seek medical attention.
Unconsciousness	Never attempt to give anything by mouth. Keep victim flat, maintain an open airway. If victim is not breathing, provide artificial respiration and call for an ambulance immediately.

13.3.8 Fire/Explosion

In the event of a fire or explosion, Fort Lewis Fire Department should be notified immediately. Upon arrival of the fire personnel, the SSO will advise the fire commander of the location, nature, and identification of the hazardous materials on site.

Under the direction of the SSO, site personnel may:

- Use fire fighting equipment available on site to control or extinguish the fire
- Remove or isolate flammable or other hazardous materials that may contribute to the fire

Otherwise, evacuate the area immediately and summon emergency help.

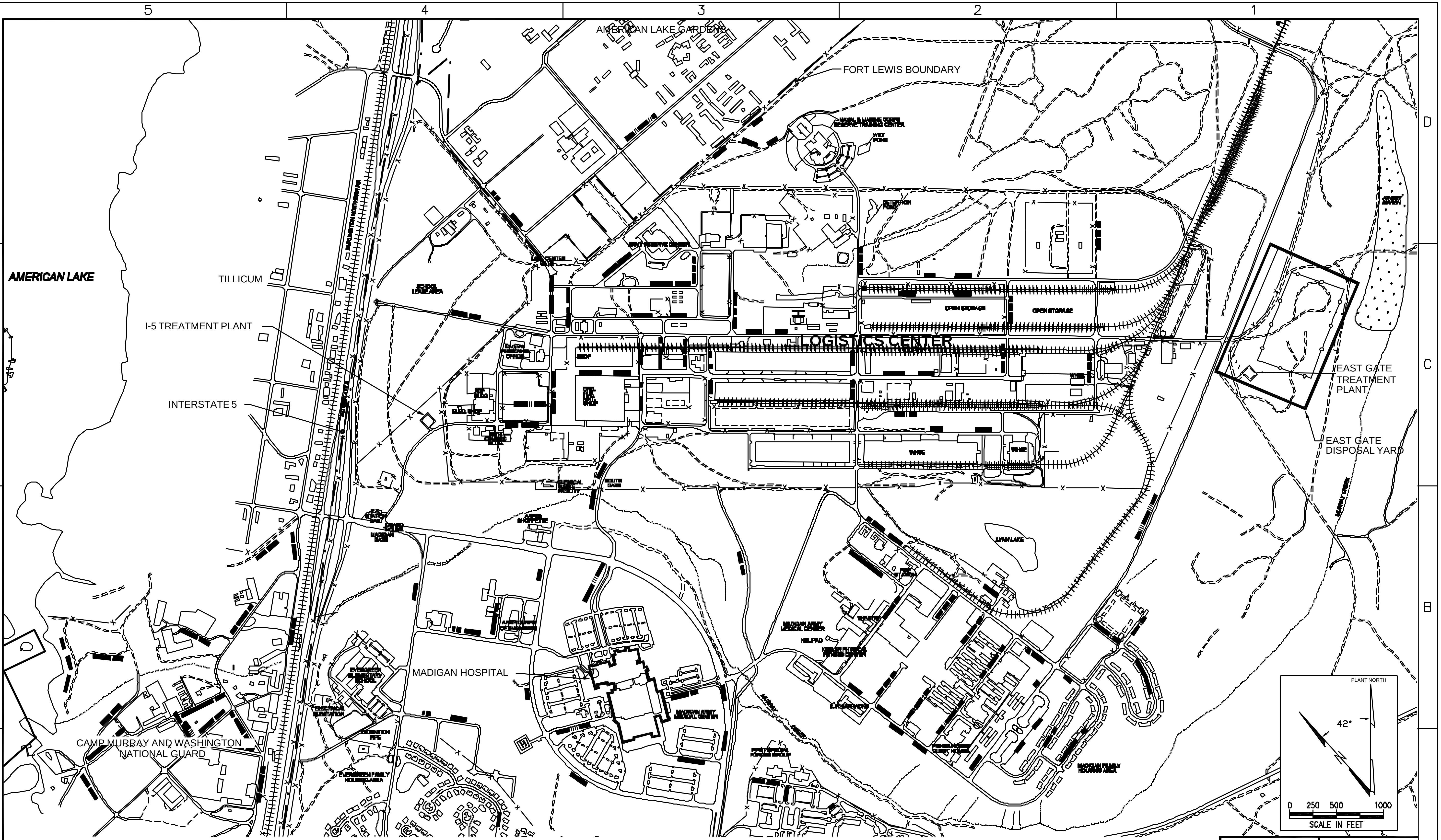
13.3.9 Community Alert Program

The site hazards are extremely unlikely to affect off-site personnel. A community alert program is not necessary.

13.3.10 Critique of Emergency Response and Follow-up

Following any emergency, an incident report form (SMS 49 in Appendix A) will be completed and submitted to the Project Manager, HSO, RHSM, CHSA, and the USACE Contracting Officer within 24 hours of the occurrence. Within 2 working days of any reportable accident, the Contractor will complete and submit an accident report on ENG Form 3394 in accordance with USACE requirements.

The emergency will be critically reviewed by all parties noted above. As necessary, this SSHP will be revised according to new site conditions and knowledge gained from the incident. Consideration of ways to improve the SSHP and prevent future incidents will be developed and incorporated into this and other SSHP, as necessary. A memorandum noting the results of the critique and any modifications to health and safety procedures will be developed and retained in the project file.



LEGEND

—·—·— CREEK
+++++++ RAILROAD TRACKS
—x— FENCE
—o— HISTORICAL FENCE
– – – – TRAIL
—·— FORT LEWIS BOUNDARY

URS

U.S. ARMY
ENGINEER DISTRICT, SEATTLE
CORPS OF ENGINEERS
SEATTLE,WASHINGTON

EAST GATE DISPOSAL YARD AND
LOGISTICS CENTER
PHASE II RI

MADIGAN HOSPITAL LOCATION

FT. LEWIS PN 53F0074209 WASHINGTON

FIGURE 13-1 SSHP

FILENAME: T:\COE\egate\Sub-Tasks\PHASEII-RI\FSP Fig 13-1.dwg
EDIT DATE: 05/25/01 AT: 16:13

14.1 SAFETY BRIEFINGS AND INSPECTIONS

Accident prevention depends on the recognition and mitigation of hazardous situations. This SSHP will be provided to URS and subcontractor personnel prior to mobilizing to the site so that all workers have time to thoroughly read and understand the SSHP. An initial safety briefing will take place on site prior to beginning work. All subjects covered in this SSHP will be discussed. The hazards that are most likely to cause injury will be discussed in detail. Recognition and prevention of hazardous situations and emergency response will be stressed.

Following the initial site safety briefing, all field personnel who are directly employed by or subcontracted to URS are required to sign the Health and Safety Compliance Agreement Form attached to the front of this SSHP. Those persons refusing to comply with the SSHP will not be permitted to work on site.

At the beginning of each day, an informal safety meeting will be held. Topics to be discussed include the work to be performed during the day and any problems or unsafe acts that have been observed. Daily safety inspections will be performed to identify and correct unsafe conditions before an accident or incident occurs. The daily safety inspection will be documented in the field logbook.

Any visitors who wish to enter the work area during sampling activities must be provided with a copy of this SSHP, briefed on the contents of the SSHP, and requested to sign a Health and Safety Compliance Agreement Form. Visitors entering the exclusion zones must meet all training, medical surveillance, and respirator fit testing requirements of this SSHP. Visitors must also provide their own respirator approved by the SSO.

14.2 REPORTING OF ACCIDENTS

All accidents and incidents will be reported to the SSO, who will notify the Project Manager, HSO, RHSM, and CHSA, as appropriate. The SSO will then prepare an incident report for submittal to URS and USACE safety personnel. An incident report form is in SMS 49, Injury/Illness/Incident Reporting.

The following logs, reports, and records shall be developed as necessary, and retained in URS and USACE project files.

15.1 TRAINING LOGS

Site specific training, other than the initial site safety briefing, is not required. The health and safety compliance agreement forms documenting the initial site safety briefing will be retained by URS and made available to the USACE on request.

Copies of certificates of health and safety training, medical surveillance status forms, first aid/CPR training, and respirator fit test forms will be made available upon request.

15.2 DAILY SAFETY INSPECTION LOGS

Daily safety inspections and briefings will be recorded into the field logbook. All persons present and a record of topics discussed and items inspected will be entered. The results of site safety audits and any health and safety deficiencies will also be noted in the field logbook.

15.3 EQUIPMENT MAINTENANCE LOGS

Records of maintenance and calibration of monitoring instrument will be entered into the field logbook.

15.4 EMPLOYEE/VISITOR REGISTER

A record of URS and subcontractor employees will be retained in the field logbook. Visitors will be requested to sign and print their name, date, and company affiliation on a visitor log. Visitors who wish to observe sampling and have received a site safety briefing will be required to sign a health and safety compliance agreement form.

15.5 ENVIRONMENTAL/PERSONAL EXPOSURE MONITORING RESULTS

Results for organic vapor monitoring, dust observations, and weather conditions and observations will be recorded in the field logbook.

U.S. Army Corps of Engineers (USACE). 2000. *Safety and Occupational Health Document Requirements for Hazardous, Toxic, and Radioactive Waste (HTRW) Activities*. ER-385-1-92. CESO. September 1, 2000.

_________. 1996. *Safety and Health Requirements Manual, ENG Form 5044-R.* EM-385-1-1. CESO. September 3, 1996.

Appendix A

URS Safety Management Standards

CONTENTS

SMS 018
Issue Date 5/04/01
Revision 1

URS **SAFETY MANAGEMENT STANDARD**

Heat Stress

1. Applicability

This procedure applies to URS field projects where ambient (not adjusted) temperatures exceed 70^{o}F (21^{o}C) for personnel wearing chemical protective clothing, including Tyvek coveralls, and 90^{o}F (32^{o}C) for personnel wearing normal work clothes.

2. Purpose and Scope

The purpose of this procedure is to protect project personnel from the effects of heat related illnesses.

3. Implementation

Field Activities - Implementation of this procedure is the responsibility of the Project Manager.

4. Requirements

A. Monitor ambient temperatures and conduct Heat Stress Monitoring when threshold temperatures (see Section 1) are reached.

B. Conduct initial monitoring to determine first rest break.

  1. Measure the air temperature with a standard thermometer with the bulb shielded from radiant heat; this yields T (actual).

  2. Estimate the fraction of sunshine by judging what percent time the sun is not shielded by clouds that are thick enough to produce a shadow. 100 percent sunshine - no cloud cover = 1.0; 50 percent sunshine - 50 percent cloud cover = 0.5; 0 percent sunshine - full cloud cover = 0.0.

  3. Plug these variables into the following equation to determine the adjusted temperature:

     T (adjusted) = T (actual) + (13 x fraction sunshine)

C. Body Temperature Monitoring

  1. Monitor oral body temperature to determine if employees are adequately dissipating heat buildup. Ear probe thermometers which are adjusted to oral temperature are convenient and the

preferred method of measurement. Determine work/rest regimen as follows:

a. Measure (oral adjusted) temperature at the end of the work period.

b. If temperature exceeds 99.6 ^{o}F (37.5^{o}C)., shorten the following work period by 1/3 without changing the rest period.

c. If temperature still exceeds 99.6 ^{o}F (37.5^{o}C), shorten the following work period by 1/3.

d. Do not allow a worker to wear impermeable PPE when his/her oral temperature exceeds 100.6 ^{o}F (38.1^{o}C).

2. Oral temperatures are to be obtained prior to the employee drinking water or other fluids.

D. Record monitoring results on Heat Stress Monitoring Form (Attachment 18-2).

E. Investigate the use of auxiliary cooling devices in extreme heat conditions.

F. Conduct briefings for employees regarding health hazards and control measures associated with heat stress whenever conditions require the implementation of heat stress monitoring. Review the information provided in Attachment 18-3.

G. Provide water and electrolyte replacement drinks fluids as described in Attachment 18-3.

H. Allow employees who are not accustomed to working in hot environments appropriate time for acclimatization (see Attachment 18-3).

I. Provide break areas as described in Attachment 18-3.

5. Documentation Summary

File these records in the Project Safety File.

A. Heat Stress Monitoring Forms.

B. Employee Safety Briefing Verification Forms.

6. Resources

A. NIOSH - "Working in Hot Environments"

B. AFL-CIO Building Trades Division - "Heat Stress in Construction"

The following documents are PDF Files that must be read with Adobe Reader.

C. Attachment 18-1 - Initial Work Monitoring Cycles

D. Attachment 18-2 - Heat Stress Monitoring Record

E. Attachment 18-3 -Informational Supplement

URS SAFETY MANAGEMENT STANDARD

Heavy Equipment Operations

1. Applicability

This procedure applies to URS field projects where heavy equipment is in operation.

2. Purpose and Scope

The purpose of this procedure is to require that heavy equipment is operated in a safe manner, that the equipment is properly maintained and that ground personnel are protected.

3. Implementation

Field Activities - Implementation of this procedure is the responsibility of the Project Manager.

4. Requirements

A. Authorized Operators

1. Evaluate operators through documentable experience (resume) and a practical evaluation of skills.
2. Allow only qualified operators to operate equipment.
3. Prohibit equipment from being operated by any personnel who have not been specifically authorized to operate it.
4. Maintain a list of operators for the project and the specific equipment that they are authorized to operate.
5. Require operators to use seat belts at all times in all equipment and trucks.
6. Brief operators on the following rules of operation:
    a. Operators are in control of their work area.
    b. Equipment will be operated in a safe manner and within the constraints of the manufacturer's Operation Manual.
    c. Operators will stop work whenever unauthorized ground personnel or equipment enter their work area and only resume work when the area has been cleared.

B. Ground Personnel

1. Require that ground personnel on the site have received training and comply with the following rules of engagement:
    a. All ground personnel must wear orange protective vests when in work areas with any operating equipment.
    b. Ground personnel will stay outside of the swing zone or work area of any operating equipment.
    c. Ground personnel may only enter the swing or work area of any operating equipment when:
        1. They have attracted the operator's attention and made eye contact.
        2. The operator has idled the equipment down and grounded all extensions.
        3. The operator gives the ground personnel permission to approach.
    d. Ground personnel shall never walk or position themselves between any fixed object and running equipment or between two running pieces of equipment.

C. Equipment

1. Maintain operations manuals at the site for each piece of equipment that is present on the site and in use.
2. Require that operators are familiar with the manual for the equipment and operate the equipment within the parameters of the manual.
3. Require that all equipment is provided with roll-over protection systems (ROPS). Tracked excavators are exempt from ROPS requirements but must have a cab which provides protection from overhead hazards
4. Verify that seatbelts are present and functional in all equipment.

5. Prohibit the use of equipment which has cab glass which is cracked, broken or missing.

6. Require that backup alarms are functional on all trucks and equipment. Tracked excavators must have bidirectional alarms or the operator must be provided with a spotter whenever tracking in either direction.

7. Require all extensions such as buckets, blades, forks, etc. to be grounded when not in use.

8. Require brakes to be set and wheels chocked (when applicable) when not in use.

D. Inspection and Maintenance

1. Require daily inspections of equipment by operators using Attachment 19-1.

2. Prohibit use of equipment deemed to be unsafe as a result of daily inspection until required repairs or maintenance occur.

3. Conduct maintenance as prescribed by the manufacturer in the Operations Manuals for each piece of equipment.

4. During maintenance/repair, require that:

   a. Motors are turned off.

   b. All extensions are grounded or securely blocked.

   c. Controls are in a neutral position.

   d. Brakes are set.

5. Documentation Summary

File the following documents in the Project Health and Safety File.

A. List of authorized operators.

B. Operator qualifications.

C. Daily Equipment Inspection Logs.

D. Site Briefing documentation for operator rules and ground personnel "rules of engagement".

6. Resources

A. U.S. OSHA Standard - Motorized Vehicles and Mechanized Equipment - 29 CFR 1926, Subpart O

B. National Association of Demolition Contractors – Safety Manual (http://www.demolitionassociation.com/)

C. Queensland Workplace Health and Safety - Competency Standard for Users & Operators of Industrial Equipment

D. Attachment 19-1 - Equipment Inspection Form

URS

Health and Safety Program

DAILY HEAVY EQUIPMENT SAFETY INSPECTION CHECKLIST

Attachment 19-1

Equipment Id No. ______________________ Inspector's Name ______________________

Equipment Name ______________________ Employee No. ______________________

Beg. Hours ______________ End Hours ______________ Date ______________

INSTRUCTIONS: Each shift shall inspect all applicable items indicated. If an unsatisfactory condition is observed, suspend operation of the equipment and report the unsatisfactory condition to the site supervisor immediately.

ITEM INSPECTED	CHECK IF SATISFACTORY	COMMENTS
Falling Object Protective Structure (FOP)		
Roll-Over Protection Structure (ROP)		
Seat Belts		
Operator Seat Bar(s)		
Side Shields, Screens or Cab		
Lift Arm Device		
Grab Handles		
Back-up Alarm – Working		
Lights		
Guards		
Horn		
Anti-Skid Tread Clear of Mud		
Safety Signs (i.e., counterbalance swing area)		
Fire Extinguisher		
General Condition		
Fuel Connection		
Oil (fuel and no leaks)		
Clear of Extra Materials		
Controls Function Properly		
Damaged Parts		
Hydraulic System (full and no leaks)		
Parking Brake		
Lift Arm and Bucket		
Tires/Tracks		
Steering		
Breathing Air System		
Blast Shields		
Gallons of Fuel Added		
Quarts of Oil Added		

Operator Signature ______________________________________

URS SAFETY MANAGEMENT STANDARD

Housekeeping

1. Applicability

This procedure applies to URS facilities and field operations.

2. Purpose and Scope

Proper housekeeping in office locations, on construction sites, and fixed work facilities is essential to prevent fires as well as injuries resulting from slips, trips and falls.

3. Implementation

Office Locations -	Implementation of this program is the responsibility of the Office Manager.
Field Activities -	Implementation of this program is the responsibility of the Project Manager.

4. Requirements

A. Maintain the cleanliness of the site.

1. Require tools and equipment to be stowed at the end of the day.
2. Store supplies in locations away from walkways and in a manner that will not trip workers.
3. Keep weeds and vegetation away from stockpiled materials and walkways.
4. Maintain flooring and walkways in a clean, dry, smooth condition.
5. Dispose of construction debris in a timely manner.

B. Regularly inspect the work area for slip and trip hazards.

1. Office locations - inspect work areas at least semi-annually. Utilize the check-sheet provided as Attachment 21-1.
2. Field sites - inspect sites at least monthly. Utilize the check- sheet provided as Attachment 21-1.

C. Thoroughly investigate all injuries resulting from slips, trips and falls on site. Correct conditions contributing to injuries.

5. Documentation Summary

A. Office/Laboratory

File Completed Housekeeping Inspection Sheets (Attachment 21-1), in the Office Safety Filing System.

B. Field

File Completed Housekeeping Inspection Sheets (Attachment 21-1), in the Project Safety File.

6. Resources

A. U.S. OSHA Standard - Sanitation - 29 CFR 1910.141

B. U.S. OSHA Standard - Aisles and Passageways - 29 CFR 1910.22.

C. U.K. - 'The Workplace' (Health & Safety and Welfare) Regulations

D. U.K. - 'The Construction' (Health and Welfare) Regulations

E. Attachment 21-1 - Housekeeping Inspection Sheet

URS

Health and Safety Program

HOUSEKEEPING INSPECTION SHEET

Attachment 21-1

Building or Location: ______________________________

Inspection Conducted by: ______________________ **Date:** ______________

		Yes	**No** must be completed	**N/A**
	General Site Housekeeping			
1.	No blocking of exits or emergency equipment.			
2.	Equipment or materials are not left lying on the ground.			
3.	Storage areas are free from the accumulation of materials that constitute trip hazards.			
4.	Scrap materials and other debris is kept free from work area.			
5.	Combustible scrap and debris is removed by safe means at regular intervals.			
6.	Oily rags are stored in metal cans with tight fitting lids. Oily rags are removed at the end of the day.			
	Visibility			
7.	Halls, stairways and walkways are well lit.			
8.	Well designed light switches are present in areas where walkways are not always lighted.			
9.	Dust, smoke or steam does not create poor visibility.			
10.	Glare from floodlights or windows does not create poor visibility in work areas.			
	Stairs			
11.	Handrails are tight and at the proper level.			
12.	Handrails extend past the top and bottom step.			
13.	White or yellow strips are painted on the first and last step for better visibility. (Not an OSHA requirement – recommendation only).			
14.	Steps are not rough or defective.			
15.	Stair treads are wide enough and risers consistently spaced.			
16.	Stairs are free of obstructions.			
	Floor Conditions			
17.	Floors of every workroom are clean, and so far as possible, in a dry condition.			
18.	Floors are not oily or overly waxed or polished.			
19.	Where wet floors or processes are present, proper drainage is provided and false floors, mats, or other dry standing places are provided.			
20.	Floor surfaces are finished with non-slip coatings where spills are likely.			
21.	Floors and passageways are free from protruding nails, splinters, holes, or loose boards.			

		Yes	No must be completed	N/A
22.	Floors are free of holes and depressions.			
23.	Aisles or pathways are wide enough for easy passage and for carrying objects (48 inches is recommended).			
24.	Ramps are covered with non-slip surfaces or matting.			
25.	Carpets or rugs do not have loose or frayed edges that may catch boots or shoes.			
26.	Walkways are free from extension cords, air hoses and cables.			
27.	Boxes, containers, machine parts or other tripping hazards do not lie in pathways.			
Ground Conditions				
28.	Trip hazards are not present.			
29.	Fall hazards are not present.			
30.	Holes or changes in ground elevation are either filled or guarded.			
31.	Muddy walkways are filled with gravel to reduce slipping.			
32.	All employees who work in wet or greasy conditions wear slip resistant footwear.			
Equipment				
33.	Vehicle steps are of adequate size, surface placement for safe dismounting.			
34.	Hand grips or ladders are adequate for getting in and out of equipment.			
35.	Ladders have been checked for damage and removed from service if found unsafe.			

I certify that the above inspection was performed to the best of my knowledge and ability, based on the conditions present on ______________________________

____

Signature

Noise and Hearing Conservation

1. Applicability

This procedure applies to URS Corporation facilities and field operations where URS Corporation personnel may encounter noise exposures that may exceed 85 dBA as an 8 hour Time Weighted Average.

2. Purpose and Scope

The purpose of this procedure is to protect employees from hazardous noise exposures and to prevent hearing loss.

3. Implementation

Office/Lab locations:	High noise is unlikely to be encountered at URS offices, however, if applicable, the implementation of this program is the responsibility of the Office Manager.
Field Activities:	Implementation of this program is the responsibility of the Project Manager.

4. Requirements

A. General

The use of hearing protectors in any location where powered or motorized equipment or any other noise source could reasonably be expected to exceed 85 dBA. Use of hearing protectors may only be discontinued when noise levels are verified to be less than 85 dBA through a properly conducted noise survey. Whenever information indicates that any employee’s exposure may equal or exceed an 8-hour time-weighted average of 85 decibels, the project manager or location manager will be responsible to enforce the proper use of hearing protectors.

B. Hearing Protectors

1. Require that at least two (2) types of hearing protectors are available to employees free of charge, preferably a plug and a muff type.

2. Minimum Noise Reduction Ratings (NRR)

   Hearing protectors issued must have the following minimum NRR:

Ear Plug	Muffs
29 dBA	27 dBA

3. Require that hearing protectors are used and thus effectively protect hearing.

C. Noise Surveys

1. Noise surveys must be conducted in a manner that reasonably reflects the exposure of the affected employees. Surveys must be conducted under the supervision of a URS Safety Program Representative.

2. Sound level meters and audio dosimeters used to determine employee exposure to noise sources must be Type II (accurate to within +/- 2 dBA), operated in “slow” response, on the “A” scale, and be calibrated to factory guidelines (including periodic factory recalibration).

D. Noise Controls

Eliminate noise sources to the extent possible. Examples of controls that must be considered follow:

1. Addition or replacement of mufflers on motorized equipment.

2. Addition of mufflers to air exhausts on pneumatic equipment.

3. Following equipment maintenance procedures to lubricate dry bearings.

4. Isolation of loud equipment with newer and quieter models.

E. Audiometric Exams

1. Tests

Details on the medical surveillance program (including audiometric testing) are included in SMS 24.

Audiometric tests shall be performed by a person meeting OSHA’s 1910.95 (g)(3)’s definition. Within 6 months of an employee’s first exposure at or above the action level, a valid baseline audiogram shall be established against which subsequent audiograms can be compared. Testing to establish a baseline audiogram shall be preceded by 14 hours without exposure to noise. Hearing protectors may be used as a substitute for the requirement that baseline audiogram shall be preceded by 14 hours without exposure to workplace noise. The medical surveillance provider shall notify employees of the need to avoid high levels of non-occupational noise exposure during the 14-hour period immediately preceding the audiometric examination. For multi-year projects, an annual audiogram shall be obtained for each employee exposed at or above an 8-hour time-weighted average of 85 decibels.

Each employee's annual audiogram shall be compared to that employee's baseline audiogram to determine if the audiogram is valid and if there is a standard threshold shift (STS). If the annual audiogram shows that an employee has suffered a standard threshold shift, the employer will obtain a retest within 30 days and consider the results in assessing an STS as the annual audiogram. The audiologist, otolaryngologist, or physician shall review problem audiograms and shall determine whether there is a need for further evaluation. If an STS has occurred, the medical surveillance provider will notify the employee within 21 days of the determination.

2. Standard Threshold Shifts

   If an employee's test results show a confirmed STS, their hearing protection will be evaluated and refitted, and a medical evaluation may be required.

F. Training

Verify that each employee who must work in a noisy environment is current on the required Hearing Conservation Training. Training must include the following topics:

1. The effects of noise on hearing.
2. The purpose of hearing protectors.
3. The advantages and disadvantages of various types of hearing protectors.
4. The attenuation of various types of hearing protection.
5. The selection, fitting, care, and use of hearing protectors.
6. The purpose of audiometric testing.

7. An explanation of the audiometric testing procedure.

5. Documentation Summary

A. File these records in the Office Safety Filing System:

1. Noise surveys, when applicable.
2. Training Records.

B. File noise surveys, when applicable, in the Project Safety File:

6. Resources

A. U.S. OSHA Standard – Occupational noise exposure – 29 CFR 1910.95

B. U.S. OSHA Construction Standard – Occupational noise exposure – 29 CFR 1926.52

C. U.S. OSHA Technical Links - Noise and Hearing Conservation

D. American Industrial Hygiene Association: The Occupational Environment – Its Evaluation and Control, Chapter 20. Fairfax, VA: 1997

E. National Hearing Conservation Association web site

F. URS SMS 24 Medical Screening and Surveillance

SMS 029
Issue Date 7/10/00
Revision 1

URS **Safety Management Standard**

Personal Protective Equipment

1. Applicability

This program applies to URS Corporation laboratory and field operations where the use of Personal Protective equipment (PPE) is warranted. Refer to SMS 42, “Respiratory Protection”, for respiratory hazards. Hearing Protection issues are additionally addressed in SMS 26, “Noise and Hearing Conservation.”

2. Purpose and Scope

This procedure provides information on recognizing those conditions that require personal protective equipment as will as selecting personal protective equipment for hazardous activities.

3. Implementation

Shop/Lab Locations -	Implementation of this program is the responsibility of the Office Manager.
Field Activities -	Implementation of this program is the responsibility of the Project Manager.

4. Requirements

A. Perform hazard assessments for those work activities that are likely to require the use of PPE.

   1. Use Attachment 29-1 to perform the assessment.

   2. Reevaluate completed hazard assessments when the job changes.

B. Eliminate the hazards identified in Attachment 29-1, if possible, through engineering or administrative controls.

C. Select PPE that will protect employees if hazards cannot be eliminated.

   1. See Attachment 29-1 for recommended PPE.

   2. Review Material Safety Data Sheets for chemicals used for PPE recommendations.

   3. If needed, consult with the URS Health and Safety Representative for assistance in selecting PPE.

D. Provide required PPE to employees free of charge (excluding in some instances components of standard work attire such as steel-toed boots), assuring that it fits properly giving them a choice if more than one type is available.

E. Whenever a hazard is recognized, and PPE is required, the employees will be provided with the appropriate PPE. However, when a PPE is not required, and the employee selects to wear his or her own PPE, the project manager shall ensure that the employee is properly trained in the fitting, donning, doffing, cleaning, and maintenance of his or her employee owned equipment.

F. Conduct and document employee training.

1. Train all employees who are required to wear PPE.

2. Require that training includes:

   a. When PPE is necessary to be worn.

   b. What PPE is necessary.

   c. How to properly don, doff, adjust and wear PPE.

   d. Limitations of PPE

   e. Proper care, maintenance, useful life and disposal of PPE.

3. Training must be conducted before PPE is assigned.

4. Refresher training is needed when:

   a. New types of PPE are assigned to the worker.

   b. Worker cannot demonstrate competency in PPE use.

5. Keep written records of the employees trained and type of training provided, including the date of training.

G. Maintain Protective Equipment

1. Check personal protective equipment for damage, cracks, and wear prior to each use. Replace or repair equipment not found in good condition.

2. Wash off contaminated protective equipment with water and mild soap, if necessary, to prevent degradation of the equipment.

H. Periodically inspect worksites where employees are using personal protective equipment, using Attachment 29-2.

   1. Field activities – inspect work sites at least monthly.

   2. Office locations – inspect work sites semi-annually.

5.0 Documentation Summary

A. Records required in the Project Safety File:

   1. Completed Hazard Assessment Certification Forms (Attachment 29-1)

   2. Completed Personal Protective Equipment Inspection Sheet (Attachment 29-2)

   3. Documentation of employee training.

B. Records required in the Laboratory Safety Filing System:

   1. Completed Hazard Assessment Certification Forms (Attachment 29-1)

   2. Completed Personal Protective Equipment Inspection Sheet (Attachment 29-2)

   3. Documentation of employee training.

6.0 Resources

A. U.S. OSHA Standards - Personal Protective Equipment -29CFR 1910 Subpart I (http://www.osha-slc.gov/SLTC/lead/index.html)

B. U.S. OSHA Construction Standard - Personal Protective Equipment –29 CFR 1926 Subpart E (http://www.osha-slc.gov/OshStd_toc/OSHA_Std_toc_1926_SUBPART_E.html)

C. U.S. OSHA Technical Links - Personal Protective Equipment (http://www.osha-slc.gov/SLTC/personalprotectiveequipment/index.html)

D. Australian Standards SAA HB9-1994 - Occupational Personal Protection

E. American National Standards Institute, ANSI Z89.1-1986, Protective Headwear
(http://www.ansi.org/cat_top.html)

F. American National Standards Institute, ANSI Z87.1 - 1989, Eye and Face Protection
(http://www.ansi.org/cat_top.html)

G. American National Standards Institute, ANSI Z41.1 - 1991, Foot Protection
(http://www.ansi.org/cat_top.html)

H. SMS 40 - Fall Protection

I. Attachment 29-1 Hazard Assessment Form

J. Attachment 29-2 PPE Inspection Form

Attachment 29-1

URS Corporation

URS Corporation Health & Safety Program
HAZARD ASSESSMENT CERTIFICATION FORM

Location:______________________________ **Job No:**________________

Date : ________________ **Assessment Conducted by:** ____________________

Specific tasks performed at this location: ________________________________

____

Are any of the following present during the task?		No	Yes (Hazard Present)	Eliminate Hazard or Use Following PPE
Overhead Hazards				
1.	Suspended loads that could fall			Hard hat, ANSI Class A, B
2.	Overhead beams or load that could strike head			Hard hat, ANSI Class A, B
3.	Energized wires or equipment that could strike head			Hard hat, ANSI Class B
4.	Employees working above at an elevated site who could drop objects on others below			Hard hat, ANSI Class A, B
5.	Sharp objects or corners at head level			Hard hat, ANSI Class A, B or C
Eye Hazards				
6.	Chemical splashes or irritating mists			Chemical protective goggles See Attachment 29-3
7.	Excessive dust			Safety glasses or impact goggles
8.	Smoke & fumes			Chemical protective goggles
9.	Welding operations			See Attachment 29-3 and 29 T-1
10.	Lasers/optical radiation			See Attachment 29-3 and Reference F
11.	Projectiles			See Attachment 29-3
12.	Sawing, cutting, chipping, grinding			See Attachment 29-3
Face Hazards				
13.	Chemical splashes or irritating mists			Face shield if chemical is irritating to the skin or is corrosive. See Attachment 29-3
14.	Welding operations			See Attachment 29-3 and 29-T1
15.	Projectiles			See Attachment 29-3 and face shield
Hand Hazards				
16.	Chemical exposure			Use resistant gloves as recommended by manufacturer - See Best Chemrest Guide
17.	Sharp edges, splinters, etc.			Leather gloves

Location :______________________________________**Job No:**_________________________

	Are any of the following present during the task?	**No**	**Yes** (Hazard Present)	**Eliminate Hazard or Use Following PPE**
18.	Temperature extremes - heat			Leather gloves; hot mill gloves; Kevlar gloves, welders' gloves
19.	Temperature extremes - cold			Leather gloves; insulated gloves
20.	Blood, fungus			Nitrile gloves
21.	Exposure to live electrical current			Electrical gloves - See Reference H
22.	Sharp tools, machine parts, etc.			Leather gloves, kevlar gloves
23.	Material handling			Leather gloves
	Foot Hazards			
24.	Heavy materials (greater than 50 pounds) handled by employees			Safety shoes or boots
25.	Potential to crush whole foot			Safety shoes or boots with metatarsal guard
26.	Sharp edges or points - puncture risk			Safety shoes or boots
27.	Exposure to electrical wires			Safety shoes or boots with electrical protection
28.	Unusually slippery conditions			Rubber soled boots or grips
29.	Chemical contamination			Rubber, nitrile boots or boot covers
30.	Wet conditions			Rubber boots or boot covers
31.	Construction/demolition			Safety shoes or boots with metatarsal guard if who foot crushing hazard exists.
	Fall Hazards			
32.	Elevations above 6 feet without guardrails			Full body harness, ANSI A-10.14 - 1991 - See Reference G
33.	Suspended scaffolds, boatswain's chairs, float scaffolds, suspended staging.			ANSI Type II - full body harness - See Reference G
34.	Working in trees			ANSI Type I full body harness - See Reference G
35.	Working in vehicle mounted, elevating work platforms (bucket trucks, pin-on platforms, etc.)			ANSI Type II full body harness - see Reference G
	Water Hazards			
36.	Working on or above water where drowning hazards exist			U.S. Coast Guard approved personal flotation device, Type I, II, or III PFD
	Excessive Heat or Flame			
37.	Full body chemical protective clothing in temperatures greater than 80 degrees			Cooling vest
38.	Work around molten metal or flame			Nomex or kevlar clothing

Location :______________________________________**Job No:**_________________________

	Are any of the following present during the task?	**No**	**Yes** **(Hazard Present)**	**Eliminate Hazard or Use Following PPE**
39.	Welding activities			Welding leathers for those areas that are exposed to flame, spark or molten metal
	Respiratory Hazards			
40.	See SMS for RESPIRATORY PROTECTION for selection guidance			
	Excessive Noise			
41.	Exposure to noise			Ear plugs or muffs
	Body and Leg Protection			
42.	Chemical exposure			Have local DMG H&S representative assist you in proper selection
43.	Using chainsaw, cutting brush			Chainsaw chaps

I certify that the above inspection was performed to the best of my knowledge and ability, based on the hazards present on _____________________.

____
Signature

URS	Health and Safety Program PERSONAL PROTECTIVE EQUIPMENT INSPECTION SHEET	Attachment 29-2

Name of Inspector ______________________ **Date Inspected** ____________________

	True	**False** (= Hazard - Needs to be fixed)
Hard Hats		
1. The brim or shell does not show signs of exposure and excessive wear, loss of surface gloss, chalking or flaking.		
2. Suspension system in hard hat does not show signs of deterioration including cracking, tearing or fraying.		
3. The brim or shell is not cracked, perforated or deformed.		
4. Employees use hard hats in marked areas.		
5. Hard hat areas are marked.		
Safety Shoes		
6. Safety shoes used by employees do not show signs of excessive wear.		
7. Safety shoe required areas are marked.		
Work Gloves		
8. Gloves are worn when needed.		
9. Gloves do not show signs of excessive wear such as cracks, scrapes, or lacerations, thinning or discoloration or break through to the skin.		
Protective Clothing		
10. Protective clothing is worn by employees when required.		
Hearing Protection		
11. Noise hazardous areas are marked.		
12. Employees are using earplugs or muffs when using noise hazardous equipment or working in noise hazardous areas.		
Safety Glasses		
13. Eye hazardous areas are marked or posted.		
14. Employees use safety glasses when working in eye hazardous areas or working with eye hazardous equipment.		

REMARKS

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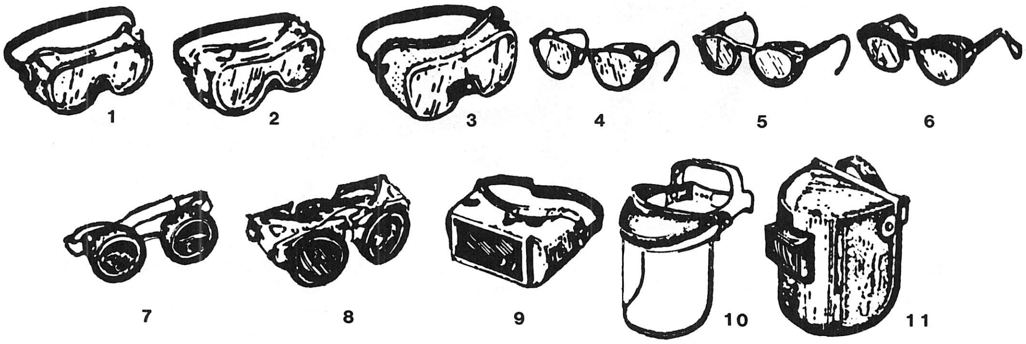
URS Corporation Health & Safety Program

EYE AND FACE PROTECTOR SELECTION GUIDE



1. **GOGGLES,** Flexible Fitting, Regular Ventilation
2. **GOGGLES,** Flexible Fitting, Hooded Ventilation
3. **GOGGLES,** Cushioned Fitting, Rigid Body

*4. **SPECTACLES,** Metal Frame, with Sideshields

*5. **SPECTACLES,** Plastic Frame, with Sideshields

*6. **SPECTACLES ,** Metal-Plastic Frame, with Sideshields

*7. **WELDING GOGGLES,** Eyecup Type, Tinted Lenses (Illustrated)

7A. **CHIPPING GOGGLES,** Eyecup Type, Clear Safety Lenses (Not Illustrated)

*8. **WELDING GOGGLES,** Coverspec Type, Tinted Lenses (Illustrated)

8A. **CHIPPING GOGGLES,** Coverspec Type, Clear Safety Lenses (Not Illustrated)

*9. **WELDING GOGGLES,** Coverspec Type, Tinted plate Plate Lens

10. **FACE SHIELD,** (Available with Plastic or Mesh Window)
11. **WELDING HELMETS**

APPLICATIONS		
OPERATION	HAZARDS	RECOMMENDED PROTECTORS Bold Type Numbers Slightly Preferred Protection
ACETYLENE-BURNING ACETYLENE-CUTTING ACETYLENE-WELDING	SPARKS, HARMFUL RAYS MOLTEN METAL, FLYING PARTICLES	**7,8,9**
CHEMICAL HANDLING	SPLASH, ACID BURNS, FUMES	**2,10** (For severe exposure add 10 over 2)
CHIPPING	FLYING PARTICLES	**1,3,4,5,6,7A,8A**
ELECTRIC (ARC) WELDING	SPARKS, INTENSE RAYS, MOLTEN METAL	**9,11** (11 in combination with 4,5,6 in tinted lenses, advisable)
FURNACE OPERATIONS	GLARE, HEAT, MOLTEN METAL	**7,8,9** (For severe exposure add 10)
GRINDING-LIGHT	FLYING PARTICLES	**1,3,4,5,6,10**
GRINDING -HEAVY	FLYING PAPTICLES	**1,3,7A,8A** (For severe exposure add 10)
LABORATORY	CHEMICAL SPLASH, GLASS BREAKAGE	**2** (10 when in combination with 4,5,6)
MACHINING	FLYING PARTICLES	**1,3,4,5,6,10**
MOLTEN METALS	HEAT, GLARE, SPARKS, SPLASH	**7,8** (10 in combination with 4,5,6 in tinted lenses)
SPOT WELDING	FLYING PARTICLES, SPARKS	**1,3,4,5,6,10**

*Non-side shield spectacles are available for limited hazard use requiring only frontal protection.

Utility Clearances And Isolation

1. Applicability

This procedure applies to URS projects where personnel may encounter subsurface or overhead utilities.

2. Purpose and Scope

Many field activities are conducted near aboveground and underground utilities. The primary purpose of this Standard is to establish operating requirements that will permit employees to work safely in the vicinity of electrical, natural gas, fuel, water, and other utility systems and installations. The secondary purpose is to prevent economic damage to utility systems from operations associated with project-related activities.

The term "utility clearance" includes

A. The positive locating of utility systems in or near the work area.

B. A signed statement by an appropriate representative attesting to the location of underground utilities and/or the positive de-energizing (including lockout) and testing of electrical utilities.

Note that in some cases, utility representatives may deem it appropriate or necessary to use insulating blankets to isolate a power line; this is an acceptable alternative to positive de-energizing (only utility representatives can make the determination).

"Contact" with overhead power lines is considered to occur when equipment is closer to power lines than permitted by the criteria in the table in Section 4.0.C.2.b below. (See note for U.K. operations).

3. Implementation

Field Operations - Implementation of this procedure is the responsibility of the Project Manager.

4. Requirements

A. Time for Completion

Complete utility clearances prior to the start of any work in the area of the utility that could feasibly result in contact with or damage to that utility.

B. Local Regulations

Research local codes and regulations regarding utility locating and isolation requirements. Utility companies and locating services are among the appropriate resources.

C. Overhead Power Lines

1. Proximity to Power Lines

   No work is to be conducted within 50 feet (15 meters) of overhead power lines without first contacting the utility company to determine the voltage of the system. No aspect of any piece of equipment is to be operated within 50 feet (15 meters) of overhead power lines without first making this determination.

2. Operations adjacent to overhead power lines are **PROHIBITED** unless one of the following conditions is satisfied:

   a. Power has been shut off, positive means (such as lockout) have been taken to prevent the lines from being energized, lines have been tested to confirm the outage, and the utility company has provided a signed certification of the outage.

   b. The minimum clearance from energized overhead lines is as shown in the table below, or the equipment will be repositioned and blocked so that no part, including cables, can come within the minimum clearances shown in the table.

MINIMUM DISTANCES FROM POWERLINES	
Powerlines Nominal System kV	Minimum Required Distance
0-50	10 feet (3 meters)
51-100	12 feet (3.6 meters)
101-200	15 feet (4.6 meters)
201-300	20 feet (6.1 meters)
301-500	25 feet (7.6 meters)
501-750	35 feet (10.7 meters)
751-1000	45 feet (13.7 meters)

Note: for U.K. operations, the specific safe distance is determined by the utility company.

   c. The power line(s) has been isolated through the use of insulating blankets which have been properly placed by the utility. If insulating blankets are used, the utility will determine the minimum safe operating distance; get this determination in writing with the utility representative's signature.

3. All inquiries regarding electric utilities must be made in writing and a written confirmation of the outage/isolation must be received by the Project Manager prior to the start of work.

D. Underground Utilities

1. Do not begin subsurface work (e.g., trenching, excavation, drilling, etc.) until a check for underground utilities and similar obstructions has been conducted. The use of as-built drawings must be confirmed with additional geophysical or other survey.

2. Contact utility companies or the state/regional utility protection service at least two (2) working days prior to excavation activities to advise of the proposed work, and ask them to establish the location of the utility underground installations prior to the start of actual excavation.

3. Obtain utility clearances for subsurface work on both public and private property. Clearances are to be in writing, signed by the party conducting the clearance.

4. Protect and preserve the markings of approximate locations of facilities until the markings are no longer required for safe and proper excavations. If the markings of utility locations are destroyed or removed before excavation commences or is completed, the Project Manager must notify the utility company or utility protection service to inform them that the markings have been destroyed.

5. Do not conduct mechanical-assisted subsurface work (e.g., powered drill rig, mechanical excavator, etc.) within five (5) feet (1.5 meters) of a confirmed or suspected utility or other subsurface structure. Confirm minimum distances for mechanical-assisted subsurface work with the utility owner, as distances beyond this five foot minimum may be required.

6. Subsurface work within five feet (1.5 meters) of a confirmed or suspected utility or other subsurface structure must be done by hand (e.g., hand auger, shovel) to the point where the obstruction is visually located and exposed. Once the obstruction location is confirmed in this manner, mechanical-assisted work may commence.

7. Reference SMS 13, "Excavation Safety" for additional information regarding subsurface operations.

E. Training

Conduct a site briefing for site employees regarding the hazards associated with working near the utilities and the means by which the operation will maintain a safe working environment. Detail the method used to isolate the utility and the hazards presented by breaching the isolation.

5. Documentation Summary

File these records in the Safety Filing System:

1. Documents requesting utility clearance.
2. Documents confirming utility clearance.
3. Training/briefing documentation of each isolation.

6. Resources

1. Utility Locating Services (typically under "Utility" in the Yellow Pages)
2. NIOSH Alert - Preventing Electrocutions from Contact Between Cranes and Power Lines (http://www.cdc.gov/niosh/crane.html)
3. One Call Utility Locating List (http://www.underspace.com/refs/ocdir.htm)
4. National Utility Locating Contractor's Association (http://www.underspace.com/nu/index.htm)
5. U.K. - Health and Safety Executive GS6

URS **SAFETY MANAGEMENT STANDARD**

Respiratory Protection

1. Applicability

This program defines responsibilities and procedures and is applicable to URS operations that may require the use of respiratory protection including Immediately Dangerous to Life and Health (IDLH) and emergency conditions. This program also addresses the voluntary use of respirators.

2. Purpose and Scope

The purpose of this procedure is to protect those employees performing operations for which exposures can not be controlled by use of conventional engineering or administrative controls and prior to establishing a negative air exposure assessment, and to require that respiratory protective equipment is selected, used, maintained, and stored in accordance with acceptable practices.

3. Implementation

Laboratory/Office/Shop Locations -	Implementation of this program is the responsibility of the Office Manager.
Field Activities -	Implementation of this program is the responsibility of the Project Manager.
Program Administration-	URS Health and Safety Director is responsible for the development and annual review of this program.

URS Health and Safety Program Representatives are responsible to:

- Assist responsible employees in the implementation of the program.
- Assessing local compliance with the program.

4. Requirements

A. Determine if respirators are needed or going to be used for hazardous jobs before assigning that job to an employee.

   1. If the determination is that a potential for respiratory hazards exists with any portion of that job activity then, complete Attachment 42-1.
   2. Contact a URS Health and Safety Program Representative if any of the questions in Attachment 42-1 are checked "yes."

3. Follow instructions in Attachment 42-2 for employees who wish to voluntarily use dust masks.

4. Follow all the requirements of this procedure for employees who wish to voluntarily use tight-fitting (e.g., air purifying) respirators.

5. Required respirators will be paid for by URS and will be provided without cost to the employee.

B. Select the proper respirator for the job.

1. For those jobs identified in Attachment 42-1, contact a URS Health and Safety Program Representative for assistance in respirator selection.

2. Contact a URS Health and Safety Program Representative for follow up if there are any problems implementing the recommendations made.

C. Require employees who will use respirators to be medically qualified before fit testing and assigning them a respirator.

1. For program details, refer to SMS 24, Medical Screening and Surveillance.

2. Require that employees have a current and accurate Medical Surveillance form (Attachment 24-2)

3. Obtain a copy of the employee's Health Status Medical Report from the Health and Safety Representative. The consulting occupational physician of the medical service provider following each work related examination issues the Health Status Medical Report. Employees cannot be assigned respirators unless they are medically cleared for respirator use.

D. Require respirator users to receive appropriate training.

1. All respirator users must be trained:

   a. Before they are assigned a respirator.

   b. Annually thereafter.

   c. Whenever a new hazard or job is introduced.

   d. Whenever employees fail to demonstrate proper use or knowledge.

2. Training must address, at a minimum, the following:
   a. Why the respirator is necessary, and what conditions can make the respirator ineffective.
   b. What the limitations and capabilities of the respirators are.
   c. How to use respirators effectively in emergency situations.
   d. How to inspect, put on and remove, and check the seals of the respirator.
   e. What the respirator maintenance and storage procedures are.
   f. How to recognize medical signs and symptoms that may limit or prevent effective use of the respirator.

E. Require respirator users to be fit tested.

1. Any employee who has been assigned a reusable respirator must be fit tested on an annual basis (no more than one year may elapse between fit tests), or when the employee is assigned a respirator of a different make, type or size from that previously tested.
2. Fit testing can be performed by contract or in house personnel.
3. Obtain a signed written copy of the fit test results. The fit test results should include:
   a. Employee's name and social security number.
   b. Respirator brand, model and size fitted for.
   c. Date fit tested.
   d. Method of fit testing used.
   e. Name and signature of fit tester.
   f. Statement that fit test protocol met the requirements of 29 CFR 1910.134.

        g. Manufacturer and serial number of fit testing apparatus.

    A fit test results form is available at Attachment 42-5.

F. Provide qualified employees with respirator(s) and adequate amounts of parts and cartridges.

    1. Assign employees whose duties require respirators their own respirator for which they have been fit tested.

    2. Provide special eyeglass inserts designed for the respirator if an employee must wear eyeglasses with a full facepiece respirator. Contact lenses may be worn when wearing a full facepiece respirator.

G. Require respirators to be used properly.

    1. Prohibit facial hair where the respirator-sealing surface meets the wearer's face.

    2. Require employees to perform a positive and negative fit check every time the respirator is put on.

    3. Employees will leave the area where respirators are being used:

        a. Before removing the facepiece for any reason.

        b. To change cartridges.

        c. If any of the following is detected:

            1. Vapor or gas breakthrough.

            2. Leakage around the facepiece.

            3. Changes in breathing resistance.

    4. Use cartridges with End of Service Life Indicators or determine the respirator cartridge changeout schedule. See Attachment 42-4 for Guidance.

H. Require respirators to be cleaned and stored properly.

    1. Clean and disinfect respirators after each use.

2. Store respirators in a plastic bag or case and in a clean location.

3. Inspect respirators before use and after each cleaning.

I. Address issues associated with special use respirators self-contained breathing apparatus; air supply respirators; emergency use respirators).

  1. Self Contained Breathing Apparatus

     Inspect self-contained breathing apparatus and other emergency use respirators monthly and after each use in accordance with manufacturer's instructions.

  2. Air Supplied Respirators

     a. Air used for atmosphere-supplying respirators must meet or exceed the requirements for Type 1 - Grade D breathing air. Never use oxygen.

        1. A certificate of analysis must accompany bottled air.

        2. Compressors used to supply breathing air must:

           i. Prevent entry of contaminated air into the air supply.
           ii. Minimize moisture content.
           iii. Have suitable in-line sorbent beds and filter to provide appropriate air quality.
           iv. Have a high carbon monoxide alarm that sounds at 10 ppm.

     b. Couplings on air hose lines must be incompatible with other gas systems.

J. Require follow up training and medical surveillance to be provided as directed.

  1. Provide follow-up physical examinations as directed by the SMS 24-3, Medical Screening and Surveillance Exam Protocol table.

  2. Provide follow-up physicals as directed by the Regional Medical Surveillance Administrator.

3. Provide annual refresher training.

4. Provide annual fit testing.

5. Documentation Summary

A. Laboratory

1. File these records in the Laboratory Safety Filing System

    a. Completed forms:

        1. "Identifying When A Respirator Is Needed" - Attachment 42-1; and,

        2. "Respirator Standard Operating Procedure" - Attachment 42-3.;

    b. Employee Health Status Medical Report includes clearance for respirator use.

    c. Employee Fit Test Records; and,

    d. Employee Respirator Training Records.

2. Send a copy of the following records to the Regional Health and Safety Manager:

    a. Completed "Voluntary Use of Respirators" form - Attachment 42-2.

    b. Employee Fit Test Records.

    c. Employee Respirator Training Records.

B. Field

1. File these records in the Project Health and Safety File:

    a. Completed forms:

        1. "Identifying When A Respirator Is Needed" - Attachment 42-1; and,

        2. "Respirator Standard Operating Procedure" - Attachment 42-3.
        3. Employee Health Status Medical Report includes clearance for respirator use.;
        4. Employee Fit Test Records; and,
        5. Employee Respirator Training Records.

    2. Send a copy of the following records to the Regional Health and Safety Manager:
        a. Completed "Voluntary Use of Respirators" form - Attachment 42-2;.
        b. Employee Fit Test Records; and,
        c. Employee Respirator Training Records.

6. Resources

A. U.S. OSHA Standard - Respiratory Protection - 29 CFR 1910.134

B. U.S OSHA Technical Links - Respiratory Protection

C. ANSI Z88.6, Respirator Use – Physical Qualifications for Personnel, Current Revision

D. ANSI Z88.2, Respiratory Protection, Current Revision

E. 3M Cartridge Service Life Interactive Program

F. Australian Standards AS/N25 1715 - 1994. Selection, Use, and Maintenance of Respiratory Protection Devices

G. Australian Standards HB9-1994. Occupational Personal Protection

H. AIHA, The Occupational Environment - Its Evaluation and Control

The following documents are PDF files which must be read with Adobe Reader:

I. NIOSH Respirator Decision Logic

J. NIOSH Guide to Industrial Respiratory Protection

K. Attachment 42-1 - Identifying When a Respirator is Needed

L. Attachment 42-2 - Voluntary Use of Respirators

M. Attachment 42-3 - Respirator Standard Operating Procedure

N. Attachment 42-4 - Respiratory Cartridge Change Schedule

O. Attachment 42-5 - Fit Test Results Form

P. Medical Screening and Surveillance Program - SMS 24

URS Corporation Health & Safety Program
IDENTIFYING WHEN A RESPIRATOR IS NEEDED

Site Location:___________________________________**Date:**_________________________

Name of Person Performing Evaluation:____

Project:____

Answer the questions below for the jobs you are to perform on site. If a "yes" response is checked, consult with a URS Corporation Health and Safety Professional to determine:

- ***if a respirator is truly needed for the job, as well as,***
- ***the type of respirator needed for the job.***

MATERIAL USED OR PROCESS TO BE PERFORMED	YES Respirator may be needed	NO	NOTES
Abrasive Blasting • Abrasive blasting (with any type of grit or material) will be performed. • Employee will fill abrasive blasting pots or perform clean-up activities. • Employee will be in a contained area where abrasive blasting is taking place.			
Acids • Liquid or powder acids will be used in a situation where acid vapors, mists or dust may be breathed.			
Adhesives • Aerosol-propelled adhesives are to be used in areas where there is no or insufficient local exhaust ventilation. • Two-part adhesives (mix part one with two, let set then use) are to be used in areas where there is limited ventilation.			
Alkalis/Bases/Caustics • Powdered alkalis will be used in a situation where an airborne dust may be breathed.			
Asbestos Abatement • Asbestos will be removed, repaired or sampled. • Employees will be inspecting or overseeing areas where asbestos will be removed or disturbed.			

MATERIAL USED OR PROCESS TO BE PERFORMED	YES Respirator may be needed	NO	NOTES
Cleaning Compounds • Degreasers or carbon removers will be used in areas where local exhaust ventilation is not provided. • Aerosol propelled cleaning compounds will be used in areas where there is no local exhaust ventilation. • Degreasers or carbon removers will be used in voids, tanks, or other confined spaces.			
Corrosion Preventive Compounds • Corrosion prevention compounds, including chemical conversion compounds and corrosion inhibitors, will be used in areas where there is no local exhaust ventilation.			
Detergents/Soaps • Ammonia based detergents will be used in large quantity (more than five gallons) in areas where local exhaust ventilation cannot be provided. • Large quantities (5 or 55 gallon containers) of high pH powder detergent/soap will be used in a situation where dust may be breathed.			
Fuels (including regular or unleaded gasoline, kerosene, diesel fuel, JP-5) • Employees will be inside unventilated fuel cells or other confined spaces containing fuels.			
Grinding, Cutting, Sanding • Cutting, grinding or sanding surfaces that have coatings containing lead, cadmium, chromium, zinc or beryllium. • Cutting, grinding or sanding surfaces that are concrete or glass without use of ventilation or water.			
Hazardous Waste Sites • Employees will be performing tasks on a hazardous waste site that requires the use of respirator (as indicated in the site safety & health plan). • Employees will be performing site assessments on potential hazardous waste sites.			
Hydraulic Fluids (including petroleum-based fluids, synthetic fire-resistant fluids, and water based fire resistant fluids) • Hydraulic fluids and the vapors generated will not be exhausted using local exhaust ventilation. • Synthetic fire-resistant fluids or water-based fire-resistant fluids will be used in an area where the air is contaminated with visible mist or spray from hydraulic fluids.			

MATERIAL USED OR PROCESS TO BE PERFORMED	YES Respirator may be needed	NO	NOTES
Inspection Penetrants (including Flouro-finder, water indicating pastes, and penetrant removers) • An aerosol-propelled inspection penetrant will be used in an area where local exhaust ventilation cannot be provided, or in a situation where the solvent vapors can be breathed.			
Lead Abatement Activities • Lead containing materials will be disturbed, removed or sampled. • Employees will be inspecting or overseeing areas were lead will be removed or disturbed.			
Lubricants/Oils • Aerosol lubricants/oils will be sprayed with no immediate exhaust ventilation.			
Oxidizers (materials that give off oxygen including chlorine laundry bleach, calcium hypochlorite, calcium oxide, oxygen candles, lithium hydroxide, hydrogen peroxide, and sodium dichromate) • Oxidizers containing organic chlorine will be used in a situation where the dusts/vapors may be breathed. • Powdered oxidizers will be used in a situation where airborne dust may be breathed.			
Paint Materials (including paints, primers, thinners, enamels, lacquers, strippers, coatings and varnishes) • Paint materials will be spray applied in areas where there is no local exhaust ventilation. • Two part (mix part a with part b, let set, then apply) polyurethane or epoxy polyamide paints will be brush or spray applied. • Paints containing lead, chromium, cadmium, beryllium, and zinc (refer to the MSDS). • Paint materials will be applied in confined spaces.			
Solvents (including hydrocarbon solvents such as acetone, methyl ethyl ketone, toluene, xylene, and alcohols, as well as mixed solutions like antifreeze, heat transfer fluid, turpene, dope and naphtha thinner) • Local exhaust ventilation will not be provided and work will involve breathing solvent vapors. • Solvents will be used within confined spaces. • Solvents will be applied using aerosols.			
Thermal Insulation (including asbestos & non-asbestos materials like pipe lagging, fiberglass insulation, boiler insulation, packing materials and floor/ceiling tiles) • Insulation will be disturbed, removed or sampled.			

MATERIAL USED OR PROCESS TO BE PERFORMED	YES Respirator may be needed	NO	NOTES
Water Treatment Chemicals (includes corrosive chemicals such as tri-sodium phosphate, hardness buffer, tritrating solution, morpholine, caustic soda, citric acid and nitric acid as well as toxic chemicals such as mercuric nitrate, hydrazine, EDTA and sodium nitrate) • Morpholine, EDTA, or harness buffer/titrating solution is to be used in poorly ventilated spaces. • Powdered water treatment chemicals will be used in a situation where chemical dusts may be breathed.			
Welding/Brazing • Welding will be performed in confined spaces. • Welding galvanized metal or stainless steel. • Brazing with cadmium or lead.			
For Any of The Above Listed Activities • A employee will be in the immediate area - within 10 feet of the job or operation, or • Employee will be inside confined space where activities are taking place, or • Employee will be inside a "controlled area" such as found in asbestos abatement, lead abatement, radiation control area, or a hazardous waste site.			
Material Safety Data Sheets • For any chemical product used, a respirator is recommended.			
Product Labels • For any chemical or process that indicates respirators should be used.			
Product Use Instructions For any product used, instructions indicate a respirator should be used.			
Standard Operating Procedures A Standard Operating Procedure indicates the use of a respirator.			

URS Corporation

URS Corporation Health & Safety Program
VOLUNTARY USE OF RESPIRATORS

Instructions: Have the employee that is opting to use a respirator for non-overexposure conditions read this page, then sign on the bottom of the page. Forward a copy of the signed form to the Regional Training Records Administrator, and maintain a copy in the employee's personnel file.

Respirators are an effective method of protection against designated hazards when properly selected and worn. Respirator use is encouraged, even when exposures are below the exposure limit, to provide an additional level of comfort and protection for employees. However, if a respirator is used improperly or not kept clean, the respirator itself can become a hazard to the employee. Sometimes employees may wear respirators to avoid exposures to hazards, even if the amount of the hazardous substance does not exceed the limits set by OSHA standards. If your employer provides respirators for your own voluntary use, or if you provide your own respirator, you need to take certain precautions to be sure that the respirator itself does not pose a hazard.

You should do the following:

1. Read and follow all instructions provided by the manufacture on use, maintenance, cleaning and care, and warnings regarding the respirators limitations.

2. Choose respirators certified for use to protect against the contaminant of concern. NIOSH, the National Institute for Occupational Safety & Health of the U.S. Department of Health and Human Services, certifies respirators. A label or statement of certification should appear o the respirator or respirator packaging. It will tell you what the respirator is designed for and how it will protect you.

3. Do not wear your respirator into atmospheres containing contaminants for which your respirator is not designed to protect you against. For example, a respirator designed to filter dust particles will not protect you against gases, vapors, fumes, smoke or very small solid particles.

4. Keep track of your respirator so that you do not mistakenly use someone else's respirator.

5. If you have any health conditions (asthma; high blood pressure; emphysema; heart disease) that could be aggravated by using a respirator, you should check with your doctor before using one.

I have read and understand this information on:___________________________ (date)

Employee's name:____

Employee's signature:____

URS Corporation

URS Corporation Health & Safety Program
RESPIRATOR STANDARD OPERATING PROCEDURE

Job Task Reviewed:____

Date Reviewed:____

Task Reviewed by:____

ADMINISTRATIVE PROCEDURES

1. All respirator users must be medically qualified to use respirators. Point of contact for scheduling is the Regional Medical Surveillance Administrator.
2. Respirator users must be trained annually in respirator use and fit tested annually.
3. Respirator will be used only by the person to whom it was issued.
4. Persons using glasses who are required to use a full-face respirator may use contact lenses or eyeglass inserts designed for the respirator.

GUIDANCE FOR SELECTION OF RESPIRATOR & CARTRIDGES/FILTERS

1. ____ respirators are currently being issued and used for the following job activity: ________________________ ____.
2. The respirator will be equipped with the following cartridges/filters:______________________ ____.
3. Filters are to be changed when the breathing resistance increases.
4. Cartridges are to be changed:____________________________________ or when the contaminant you are protecting yourself from can be smelled or tasted.

FIT TESTING & FIT CHECKING

1. Fit testing is required annually. To arrange for fit testing call your local safety representative.
2. Respirator users will "fit check" the respirator every time the respirator is put on:

- **Negative Check** - cover filters/cartridges with palms of hands and breath in, leakage should not be detected around the face seal of the respirator. Do not use if leakage is detected.
- **Positive Check** - cover the exhalation valve cover with palm of hand and blow out slightly, leakage should not be detected around the respirator seal.
- **For Air Supply Respirators** - kink or close off air supply hose and breath in, leakage should not be detected around the face seal of the respirator.

CLEANING & MAINTENANCE OF RESPIRATOR

1. Clean and disinfect respirator after every use.
2. Inspect respirator after every day in use to ensure parts are not missing. Replace missing parts from stock supply.
3. Store clean respirator in labeled plastic bag out of direct sunlight.
4. Do not alter respirator in any way.

URS Corporation

URS Corporation Health & Safety Program
RESPIRATOR CARTRIDGE CHANGE SCHEDULE

A cartridge change schedule must be developed for cartridges or canisters used with air purifying respirators that do not have an End of Service Life Indicator (ESLI). The purpose of this is to prevent contaminants from breaking through the respirator's sorbent cartridge(s), and thereby over-exposing employees. NIOSH has approved ESLIs for only four cartridges or canisters (mercury vapor, carbon monoxide, ethylene oxide, and hydrogen sulfide). Historically we have relied on the warning properties (odor, irritation) of a contaminant to dictate cartridge change. OSHA no longer allows this as the sole basis for changing respirator cartridges. In developing a change schedule the following factors should be considered:

- Contaminants.
- Concentration.
- Frequency of use (continuously or intermittently throughout the shift).
- Temperature and humidity.
- Work rate.
- The presence of potentially interfering chemicals.

The worst case conditions should be assumed to avoid early breakthrough. This must be documented in the project health and safety plan or, in the cases of office or labs, in the site specific Respiratory Protection Program.

Sources of Help

Manufacturers

3M has an interactive “Cartridge Service Life” program that can be downloaded for free (http://www.mmm.com/market/safety/ohes2/index.html)

This program will estimate cartridge service life for 3M products against many contaminants. The program does not evaluate the service life against mixtures (multiple contaminants). Because of the complexity in evaluating mixtures, OSHA offers the following guidance:

- When the individual compounds in the mixture have similar breakthrough times (i.e., within one order of magnitude), service life of the cartridge should be established assuming the mixture stream behaves as a pure system of the most rapidly migrating component with the shortest breakthrough time (i.e., sum up the concentration of the components).
- Where the individual compounds in the mixture vary by 2 odors of magnitude or greater, the service life may be based on the contaminant with the shortest breakthrough time.

Rule of Thumb (*“The Occupational Environment - Its Evaluation and Control)*

- If the chemical’s boiling point is >70°C and the concentration is less than 200 ppm you can expect a service life of 8 hours at a normal work rate.
- Service life is inversely proportional to work rate.
- Reducing concentration by a factor of 10 will increase service life by a factor of 5.
- Humidity above 85% will reduce service life by 50 %.

OSHA Interpretation

The OSHA inspection procedures for the respiratory protection standard specifies that where contaminant migration is possible, respirator cartridges/canisters should be changed after each work shift where exposure occurs unless there is objective data to the contrary (desorption studies) showing the performance in the conditions and schedule of use/non-use found in the workplace.

Respiratory Fit Test Record

Attachment 42-5

Name: ___________________________________

Social Security No: ________________________

Company/Office:___________________________

Last Medical Exam: ________________________

Fit Test Date: ______________________________

Corrective Lenses Needed: Yes ☐ No ☐

Briefed on fundamental principles of respiratory protection, use, selection, inspection cleaning, maintenance and storage of equipment. Yes ☐ No ☐

Isoamyl acetate odor recognition Yes ☐ No ☐

	RESPIRATOR 1	RESPIRATOR 2	RESPIRATOR 3
Equipment Type			
Manufacturer's Name			
Model			
Size			
Facepiece Composition (Rubber/Silicone)			

TEST PERFORMED	RESPIRATOR 1	RESPIRATOR 2	RESPIRATOR 3
Negative Pressure Test:	P ☐ F ☐	P ☐ F ☐	P ☐ F ☐
Positive Pressure Test:	P ☐ F ☐	P ☐ F ☐	P ☐ F ☐
Isoamyl Acetate Vapor Test:	P ☐ F ☐	P ☐ F ☐	P ☐ F ☐
Irritant Smoke Test:	P ☐ F ☐	P ☐ F ☐	P ☐ F ☐

This qualitative fit test protocol has been adapted from OSHA Respiratory Protection Standard 29 CFR 1910.134, Appendix A.

______________________________ **Examiner's Name (Please Print)**

______________________________ **Examiner's Signature**

____________________ **Date**

______________________________ **Employee's Signature**

______________________________ **Date**

URS

URS **SAFETY MANAGEMENT STANDARD**

Back Injury Prevention

1. Applicability

This procedure applies to URS operations where personnel perform manual lifting.

2. Purpose and Scope

The purpose of this procedure is to prevent back injuries to URS personnel.

3. Implementation

Office Locations -	Implementation of this procedure is the responsibility of the Office Manager.
Field Activities -	Implementation of this procedure is the responsibility of the Project Manager.

4. Requirements

A. Safe Lifting Practices in the Office

1. Require that personnel receive the training described in (C) below.
2. Evaluate all assignments that involve lifting, such as moving boxes of files and paper, computer equipment, and the like to see that the task can be completed without risk of back injury to assigned personnel.
3. Provide material handling devices, such as carts and dollies, to assist in the safe moving of materials.
4. Obtain outside assistance, such as contract movers, if the job cannot be safely accomplished by URS personnel.
5. Require that heavier items are stored on lower shelving units.

B. Safe Lifting Practices in the Field

1. Recognize that field assignments tend to be lifting-intensive, and that URS has a duty to provide the means by which personnel can perform lifting duties without risk of injury.
2. Require that personnel receive the training described in (C) below.

3. Evaluate all field assignments that involve lifting to see that the tasks can be completed without risk of back injury to assigned personnel.

4. Provide material handling devices, such as carts, dollies, trucks with lift gates, to assist in the safe moving of materials. If required, assign additional personnel to the task.

5. Direct field personnel not to assist in lifting tasks that are normally undertaken by subcontractor personnel.

6. Contact a URS Health and Safety Program Representative when assistance is necessary to evaluate a lifting task that may pose a back injury risk to assigned personnel.

C. Training

1. Require that personnel who may have lifting as part of their duties receive training that includes the following topics:

    a. Showing personnel how to avoid unnecessary physical stress and strain.

    b. Teaching personnel to become aware of what they can comfortably handle without undue strain.

    c. Instructing personnel on the proper use of equipment.

    d. Teaching personnel to recognize potential hazards and how to prevent or correct them.

2. This training must be completed prior to an employee being assigned to a task that involves lifting.

D. Office Moves and Relocations

1. Utilize professional movers (who are appropriately insured) to move office furniture such as desks, file cabinets, and bookcases, even if such a move is only between offices or cubicles at a particular location (on-site move).

2. Utilize professional movers for intensive moving of file boxes and other heavy materials.

E. Material Packaging

1. Use only smaller size (<18") file ("Banker") boxes for file storage, as the larger (>18") boxes are awkward and readily overloaded.
2. Use only smaller coolers for field samples, as the larger coolers are awkward and readily overloaded.

5. Documentation Summary

File the following documents in the Office Health and Safety File

- Training rosters

File the following documents in the Project Health and Safety File

- Training rosters

6. Resources

A. Work Practices Guide for Manual Lifting, NIOSH

URS **SAFETY MANAGEMENT STANDARD**

Injury / Illness / Incident Reporting

1. Applicability

This procedure applies to URS Corporation offices and field operations.

2. Purpose and Scope

The purpose of this procedure is to provide guidance for the timely reporting of work related injuries, illness, and incidents.

3. Implementation

Office Locations -	Implementation of this program is the responsibility of the employee's Supervisor.
Field Activities -	Implementation of this program is the responsibility of the Project Manager.

4. Requirements

A. Reporting: All employees shall immediately notify their appropriate level of management (line, project, and/or office) of a reportable incident. A reportable incident includes the following:

1. An injury to any URS employee, subcontractor, client representative, or private citizen, even if the injury does not require medical attention;
2. An injury to a member of the public occurring on a URS work site or possibly resulting from a URS or subcontractor activity or involving URS or subcontractor property, equipment, or resource;
3. Illness resulting from suspected chemical exposure;
4. Chronic or re-occurring conditions such as back pain or cumulative trauma disorders (example: carpal tunnel syndrome);
5. Fire, explosion, or flash;
6. Any vehicle accidents occurring on site, while traveling to or from client locations, or with any company-owned or leased vehicle;
7. Property damage resulting from any URS or subcontractor activity;
8. Structural collapse or potential structural hazards;

9. Unexpected release or imminent release of a hazardous material;
10. Unexpected chemical exposures to workers or the public;
11. A safety related complaint from the public regarding URS activities.
12. Any other significant occurrence that could impact safety.

B. Actions: The following actions will be taken following a reportable incident:

1. Employees:
    a. If necessary, suspend operations and secure and/or evacuate the area;
    b. Immediately notify your supervisor and/or project manager
    c. Record information pertaining to the incident (e.g., time, date, location, name and company of person(s) involved, description of event, and actions taken);
    d. Assist with incident investigation as directed by management;
    e. Implement corrective actions as directed by management;
    f. *Do not* discuss the incident with members of the news media or legal representatives (except URS legal counsel or your personal legal advisor) unless directed to do so by URS management;
    g. *Do not* make statements pertaining to guilt, fault, or liability.
2. Line/Project Management:
    a. Review circumstances of the incident with applicable employee(s);
    b. Notify local Health and Safety representative. If incident involves and an injury/illness of a URS employee, also notify the local Human Resources Representative;
    c. Complete and distribute injury/incident report within 24 hours. (Note: If the employee is unable to complete the

report, another company employee, line manager, project manager, or local health and safety representative may complete the report.);

  d. Review and verify that necessary corrective actions are identified and implemented;

  e. Discuss with department or project staff the circumstances surrounding the incident and corrective actions taken.

3. Local Health And Safety Representative

   a. Assist with incident evaluation;

   b. With management, identify cause(s) of incident and identify corrective actions needed to avoid recurrence;

   c. Review injury/incident report for completeness and accuracy;

4. Local Human Resources Representative

   a. Report work-related injuries and illness to worker compensation carrier

      AIG Claim Services @ 1-877-366-8423

5. Corporate Health and Safety Management

   The Occupational Health Specialist (OHS), Corporate Health and Safety Director, and Construction Services Division Safety and Health Director will review all reported incidents (U.S.-based employees only) to determine OSHA reporting and recording requirements. All decisions will be based strictly on current Federal OSHA guidelines.

   a. Official records (including required reports, logs, for all reported incidents will be maintained at one central location by the OHS.

   b. The OHS will send each establishment any required government report for their establishment following receipt of an incident report.

c. Each January the OHS will prepare and distribute, to each URS establishment, the appropriate government injury/illness reports. These reports will summarize all required government information for incidents that occurred during the preceding calendar year. Each establishment will post these reports in a prominent location for the time specified by current regulations.

5. Documentation Summary

A. File these records in the Office Safety File:

1. Attachment 49-1 - Incident Report Form
2. Maintain OSHA 200 Log.

B. File these records in the Project Health and Safety File

1. Attachment 49-1 - Incident Report Form
2. Maintain OSHA 200 Log if applicable for Project.

6. Resources

A. U. S. OSHA

http://www.osha.gov/

URS	**Health and Safety Program** **INCIDENT REPORT FORM**	Attachment 49-1 Revised: 5/08/01

ADMINISTRATIVE INFORMATION:

URS Division/Company: ______________________

Project Office: ______________________

Project Number: ______________________

Date/Time of Incident: ______________ ______________

Location/Client: ______________ ______________

FOR INJURIES / ILLNESSES:

Name of Injured Employee ______________________

Job Title ______________________

Phone Number ______________ Age ________

Sex ○ Male ○ Female

See a Doctor? ○ Yes ○ No
If yes, attach a doctor's report.

Describe Injury:

TYPE OF INCIDENT **(Check all applicable items)**			
☐ Illness	☐ Injury	☐ Fire, Explosion, Flash	☐ Unexpected Exposure
☐ Property Damage	☐ Vehicular Accident	☐ Other (describe):	

DESCRIPTION OF INCIDENT: (Describe the facts contributing to the incident. Identify individuals involved, witnesses, and their affiliations. Attach additional sheets, drawings, or photographs as needed.)

URS	**Health and Safety Program** **INCIDENT REPORT FORM**	Attachment 49-1 Revised: 5/08/01

PREPARED BY:

Name: ______________________________

Date: ______________________________

Signature: ______________________________

Reporter must deliver this report to the operating unit health and safety representative within 24 hours of the reported incident for medical treatment cases and within 5 days for other incidents.

REVIEWED BY:

____

Supervisor Date

____

Health and Safety Representative Date

DISTRIBUTION:

- Division Health and Safety Manager
- Project File
- Occupational Health Specialist (Fax 512-419-6413)
- Local Human Resources (Injury / Illness cases only)

CORRECTIVE ACTONS (*For Internal Use Only*):

Appendix B

USACE Tulsa District Health and Safety Plan

TULSA DISTRICT
SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM (SCAPS)

SITE SAFETY AND HEALTH PLAN

APRIL 2000

US ARMY CORPS OF ENGINEERS
TULSA DISTRICT

TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

TABLES AND FORMS

1.0 OVERVIEW AND PLAN APPROVAL

This Site Safety and Health Plan (SSHP) establishes procedures and work practices to protect Tulsa District Corps of Engineers (COE) employees and authorized on-site visitors from potential safety and health hazards during investigative activities. This SSHP will be supplemented as necessary with a site specific SSHP addressing procedures, requirements and safety and health hazards unique to each particular SCAPS project and location.

This SSHP along with the site specific SSHP have been prepared in accordance with Occupational Safety and Health Administration regulations outlined in 29 CFR 1910.120 along with US Army Corps of Engineers Safety and Health Requirements Manual EM 385-1-1.

All site personnel, subcontractors and visitors are required to be familiar with the requirements contained within the SSHP and comply with SSHP requirements prior to site entry. Supervisors and site safety and health personnel are to ensure that project personnel understand and follow the requirements set forth within this plan.

The SSHP and all site activities will be in compliance with the following regulations and guidelines:

United States Department of Labor, OSHA Standards
- 29 CFR 1910 (General Industry)
- 29 CFR 1910.120 (Hazardous Waste Operations and Emergency Response)
- 29 CFR 1910.1200 (Hazard Communication)
- 29 CFR 1910.146 (Confined Space)
- 29 CFR 1926 (Construction Standards)

USACE Safety and Health Requirements Manual, EM 385-1-1, latest revision
NIOSH/OSHA/USCG/EPA, Occupational Safety and Health Guidance Manual For Hazardous Waste Site Activities, October 1985.
American Conference of Governmental Industrial Hygienists, Threshold Limit Values and Biological Exposure Indices, latest revision
NIOSH, Pocket Guide to Chemical Hazards, June 1994

This SSHP for Tulsa District SCAPS operations, has been prepared and approved by the following:

GREG SNIDER DATE:____________
PROJECT INDUSTRIAL HYGIENIST

SITE SAFETY AND HEALTH ACKNOWLEDGMENT FORM

I have read, understand and agree to follow the guidelines described in this Site Safety and Health Plan

SIGNATURE	ORGANIZATION	DATE

2.0 SITE LOCATION AND HISTORY

2.1 Site History

Site specific locations and site histories for individual SCAPS project will be included in individual project workplans and will be included in the site specific safety and health plan.

3.0 PROJECT SCOPE OF WORK

Detailed descriptions of project work tasks are described in the project work plan. Anticipated work can be broken down into tasks listed below and were the basis for the development of generic SSHP requirements.

- Mobilization and Site Setup
- SCAPS Operations

- Groundwater monitoring well installation
- LIF Operations
- Soil Sampling
- Groundwater Sampling
- Grouting Operations
- Decontamination
- IDM Management
- Site Restoration and Demobilization

4.0 SAFETY AND HEALTH PERSONNEL RESPONSIBILITIES

The following personnel are responsible for site safety and health during project activities and ensuring compliance with the requirements and procedures contained within this SSHP.

Tulsa District Safety Officer	Bob Vandegriff	office	(918) 669-7360
Project Industrial Hygienist	Greg Snider	office	(918) 832-4122
		mobile	(918) 605-9341
Site Safety and Health Officer/ SCAPS Field Manager	Steve Brewer	office	(918) 832-4122
		mobile	(918) 605-9342
Sampling Team Leader	TBD	office	(918)
		mobile	(918)
SCAPS Rig Operator	TBD	office	(918) 832-4122
		mobile	(918) 688-5243

4.1 Safety Officer

- Overall responsibility for safety and health on COE projects.
- Oversight and approval of safety and health plan requirements.
- Direction of air monitoring and PPE requirements.
- Implementation of medical surveillance and training program.
- Ensure project is performed in accordance with SSHP, OSHA and EM 385-1-1 requirements.

4.2 Project Industrial Hygienist

- Development and preparation of SSHP.
- Direct field implementation of SSHP.
- Approve PPE upgrade and downgrades as outlined in SSHP.

- Perform and direct air monitoring as outlined in SSHP.
- Oversee implementation of site specific training as outlined in SSHP.
- Coordinate with SSHO on implementation of SSHP.
- Ensure project is performed in accordance with SSHP, OSHA and EM 385-1-1 requirements.

4.3 Site Safety and Health Officer (SSHO) / SCAPS Field Manager

- Direct safety and health activities on-site.
- Direct on-site implementation of SSHP.
- Coordinate with project industrial hygienist on implementation of SSHP.
- Perform on-site air monitoring and maintain documentation of air monitoring results.
- Establish and enforce site zonation requirements.
- Suspend field activities if action levels are exceeded or site conditions change.
- Implement SSHP on-site training requirements.
- Ensure project is performed in accordance with SSHP, OSHA, activity hazard analysis and EM 385-1-1 requirements.

4.4 SCAPS Rig Operator

- Inspect all SCAPS and associated equipment daily and ensure equipment is in a safe operating condition.
- Perform necessary maintenance and make repairs to ensure equipment operates as designed in a safe manner.
- Ensure equipment is operated in accordance with SSHP, OSHA, activity hazard analysis and EM 385-1-1 requirements.
- Suspend unsafe SCAPS operations and report unsafe conditions to SSHO.

4.5 Sampling Team Leader

- Inspect all sampling and associated equipment daily and ensure equipment is in a safe operating condition.
- Perform necessary maintenance and make repairs to ensure equipment operates as designed and in a safe manner.
- Ensure equipment is operated in accordance with SSHP, OSHA, activity hazard analysis and EM 385-1-1 requirements.
- Suspend unsafe sampling activities and report unsafe conditions to the SSHO.

5.0 PROJECT HAZARD ANALYSIS

Site specific chemical contaminants of concern will be included in the site specific SSHP.

5.1 Chemical Hazard Evaluation

A variety of chemical hazards potentially exist at SCAPS investigation sites with primary routes of exposure through inhalation, ingestion, contact and absorption. Exposure potentials will be reduced by employee experience and safe work practices along with adherence to the procedures and requirements set forth in this SSHP. Contaminants of concern consist of volatile organics, semi volatile organics, pesticides, herbicides, petroleum hydrocarbons and heavy metals. The potential for overexposure will be minimal due to the non-confined nature of the work site. The potential for exposure will be reduced through good work practices, engineering controls, decontamination, and proper use of personal protective equipment. Exposure potentials will be evaluated daily in relation to air monitoring data, work activities being performed and field analytical data. Exposure values for potential site contaminants are summarized below.

CONTAMINANT EXPOSURE LEVELS / EXPOSURE ROUTES

CONTAMINANTS	ACGIH TLV	OSHA PEL	EXPOSURE
DDT	1 mg/m3 (A3)	1 mg/m3, skin	Ih, Ig, Cn, Ab
Chlordane	0.5 mg/m3, skin (A3)	0.5 mg/m3, skin	Ih, Ig, Cn, Ab
Heptachlor	0.05 mg/m3, skin (A3)	0.5 mg/m3, skin	Ih, Ig, Cn, Ab
Dieldrin	0.25 mg/m3, skin	0.25 mg/m3, skin	Ih, Ig, Cn, Ab
Diazinon	0.1 mg/m3, skin	n/a	Ih, Ig, Cn, Ab
Malathion	10 mg/m3, skin	15 mg/m3, skin	Ih, Ig, Cn, Ab
Diethyl phthalate	5 mg/m3	n/a	Ih, Ig, Cn
Di(2-ethylhexyl)phthalate	5 mg/m3 (A3)	n/a	Ih, Ig, Cn
Phenol	5 ppm	5 ppm, skin	Ih, Ih, Cn, Ab
Parathion	0.1 mg/m3, skin	0.1 mg/m3, skin	Ih, Ig, Cn, Ab
Styrene	20 ppm	100 ppm	Ih, Ig, Cn
2,4-D	10 mg/m3	10 mg/m3	Ih, Ig, Cn
Dioxin	n/a	n/a	Ih, Ig, Cn, Ab
PCBs	n/a	n/a	Ih, Ig, Cn, Ab
Arsenic	0.01 mg/m3	0.01 mg/m3	Ih, Ig, Cn
Barium	0.5 mg/m3	0.5 mg/m3	Ih, Ig, Cn
Cadmium	0.01 mg/m3 (A2)	0.2 mg/m3	Ih, Ig, Cn
Chromium	0.5 mg/m3	1.0 mg/m3	Ih, Ig, Cn
Lead	0.05 mg/m3	0.05 mg/m3	Ih, Ig, Cn
Mercury	0.01 mg/m3, skin	0.01 mg/m3	Ih, Ig, Cn
Selenium	0.2 mg/m3	0.3 mg/m3	Ih, Ig, Cn
Silver	0.1 mg/m3	0.01 mg/m3	Ih, Ig, Cn
Dichloroethane	100 ppm	100 ppm	Ih, Ig, Cn
Trichloroethene	50 ppm	50 ppm	Ih, Ig, Cn
Methyl ethyl ketone	200 ppm	200 ppm	Ih, Ig, Cn
Benzene	0.5 ppm, skin (A1)	1.0 ppm	Ih, Ig, Cn
Toluene	50 ppm, skin	100 ppm	Ih, Ig, Cn
Xylene	100 ppm	100 ppm	Ih, Ig, Cn
Ethyl benzene	100 ppm	100 ppm	Ih, Ig, Cn
Gasoline	300 ppm	n/a	Ih, Ig, Cn

CONTAMINANTS	ACGIH TLV	OSHA PEL	EXPOSURE
Diesel	n/a	n/a	Ih, Ig, Cn
Napthalene	10 ppm	10 ppm	Ih, Ig, Cn, Ab
Acetone	500 ppm	500 ppm	Ih, Ig, Cn
Aldrin	0.25 mg/m3	0.25 mg/m3	Ih, Ig, Cn, Ab
Asbestos	0.1 f/cc (A1)	0.1 f/cc (A1)	Ih, Ig, Cn
Carbon Black	3.5 mg/m3	3.5 mg/m3	Ih, Ig, Cn
Carbon tetrachloride	5 ppm, skin (A2)	5 ppm, skin (A2)	Ih, Ig, Cn, Ab
Vinyl chloride	1 ppm (A1)	1 ppm (A1)	Ih, Ig, Cn, Ab
Perchloroethylene	25 ppm	25 ppm	Ih, Ig, Cn
TNT	0.1 mg/m3, skin	0.1 mg/m3, skin	Ih, Ig, Cn, Ab
Pentachlorophenol	0.5 mg/m3, skin	0.5 mg/me, skin	Ih, Ig, Cn, Ab

A1- Confirmed Human Carcinogen	Ih-Inhalation	Ig- Ingestion
A2- Suspected Human Carcinogen	Cn- Skin and/or eye contact	Ab- Absorption

5.2 Physical Hazard Evaluation

Physical hazards associated with the project consist of hazards associated with the operation of SCAPS equipment, soil sampling equipment, groundwater sampling equipment and site support equipment. Employee experience in the operation of equipment will reduce exposure potential.
All equipment operations will be in accordance with EM 385-1-1, standard equipment operating procedures and activity hazard analysis.

5.3 Noise Hazard Evaluation

The Tulsa District Hearing Conservation Program requires all personnel working in potential noise hazardous environments to receive an annual audiometric evaluation. Hearing protection procedures will be implemented when noise levels exceed 85 dB(A). Noise level surveys will be performed as necessary throughout the project. Noise level protection requirements are based on previous noise level surveys conducted during similar operations and are summarized below:

HEARING CONSERVATION REQUIREMENTS

ACTIVITY	HEARING PROTECTION
SCAPS Operations	**Outside SCAPS Truck** (Ear muffs or foam inserts required as necessary) **Inside SCAPS Truck** (Ear muffs or foam inserts as necessary)
Soil and Groundwater Sampling Operations	Ear muffs or foam inserts (as necessary)
Decontamination Operations	Ear muffs or foam inserts (as necessary)

5.4 Biological Hazards

Biological hazards associated with this project consist of contact with snakes, vermin, and poisonous plants and insects. Avoidance of poisonous plants and animals will limit exposure. Good work practices, protective clothing and insect repellents will also reduce exposure. **Care must be taken to prevent contamination of environmental samples with insect repellents.**

Snake Bite Procedures

- Seek immediate medical attention.
- Keep victim calm and immobile.
- Hold affected extremity lower than body while waiting for medical assistance.
- **Do not** cut the bite area as it will accelerate the affect of the venom.
- **Do not** apply suction to the wound.
- **Do not** apply a tourniquet since the venom is most dangerous when concentrated in a small area.
- **Do not** allow the victim to run for help or move rapidly as this will accelerate circulation.

Animal Bite Procedures

- Get description of animal if possible.
- Keep victim calm and immobile.
- Seek immediate medical attention.

5.5 Severe Weather

Meteorological conditions will be closely watched when field operations are being performed. The SCAPS operator, field sampling team leader and SSHO will be responsible for determining if weather conditions are creating an unsafe work environment for equipment and personnel. In the event that unsafe conditions are present, work operations will be terminated until it is safe to proceed with field activities. Extreme caution must be taken when severe weather conditions are present during drilling operations and field sampling activities. The SCAPS rig operator, sampling team leader and SSHO will be responsible for terminating field operations when severe weather and lightening conditions are present.

Severe Thunderstorm or Tornado Watch

A severe thunderstorm or tornado watch indicates that conditions in the area are favorable for severe thunderstorms or tornadoes. Site conditions will be closely watched and work activities will be evaluated during thunderstorm and tornado watches. In the event that conditions become unfavorable for fieldwork creating an unsafe environment, fieldwork activities will be terminated.

Severe Thunderstorm or Tornado Warning

A severe thunderstorm or tornado warning indicates that a thunderstorm or tornado has been sighted or is present in the area of the warning. Field activities will be terminated during a severe thunderstorm or tornado warning.

Tornado Procedures

In the event that personnel are in the field during a tornado event the following steps should be taken:

- Evacuate office trailers and vehicles.
- If outdoors, lie flat in a nearby surface depression or ditch.
- Stay away from power poles, electrical equipment and metal objects.
- Seek some form of structural shelter if possible.
- **Do not** try to outrun a tornado.

5.6 Heat Stress

Heat produced by the body and the environmental heat together determine the total heat load in which field personnel are exposed. When work activities are being performed in high temperature environments the potential exists for the following:

- Heat rash
- Heat cramps
- Heat exhaustion
- Heat stroke

Impermeable Work Ensembles (PPE)

An action level of 75° F ambient temperature will be established when site personnel are working in chemical protective clothing. The following work/rest schedule is recommended, with personnel drinking fluids at rest periods. If possible site personnel should remove chemical protective clothing during rest periods and take breaks in shaded areas.

Ambient Temperature (degrees F)	Work Period (minutes)	Rest Period (minutes)
75 - 80	120	15
80 - 85	90	15
85 - 90	60	15
90 - 95	30	15
95 - 100	15	15

The actual work/rest schedule may be adjusted by conducting pulse monitoring before and after the work period. The action level for adjusting the work/rest schedule will be 110 beats per minute (bpm), obtained immediately after the work period in a seated position.

When a persons pulse exceeds 110 bpm, that person is considered to be undergoing heat stress which will require the work period to be reduced in 15-minute intervals while maintaining the same rest period until post work period pulse monitoring is maintained below 110 bpm.

Field activities in which site personnel are required to wear chemical protective clothing at ambient temperatures higher than 95^o F will be avoided whenever feasible by scheduling these activities during the work day to avoid peak ambient temperatures (10 a.m. - 2 p.m.).

Heat rash may result from continuous exposure to heat or humid air.

Heat cramps are caused by heavy sweating with inadequate electrolyte replacement. To reduce occurrence of heat cramps increase amount of fluid consumption. Signs and symptoms include:

- muscle spasms
- pain in the hands, feet and abdomen

Heat exhaustion occurs from increased stress on various body organs including inadequate blood circulation due to cardiovascular insufficiency or dehydration. In the event of heat exhaustion, measures need to be taken to cool the body and replace body electrolytes. Signs and symptoms include:

- pale, cool, moist skin
- heavy sweating
- dizziness
- nausea
- fainting

Heat stroke is the most serious form of heat stress. Temperature regulation fails and the body temperature rises to critical levels. Immediate action must by taken to cool the body before serious injury and death occurs. Competent medical attention must be obtained. Sign and symptoms include:

- red, hot, usually dry skin
- lack of /or reduced perspiration
- nausea
- dizziness and confusion
- strong, rapid pulse
- unconsciousness / coma

5.7 Cold Stress

Fatal exposure to cold among workers have almost always resulted from accidental exposure involving failure to escape from low air temperatures or from immersion in low temperature water. The single most import aspect of life-threatening hypothermia is the fall in deep core temperature of the body. Employees should be protected from exposure to cold so that the deep core temperature does not fall below 36 ^{o} C (96.8 ^{o} F).

Evaluation and Control

For exposed skin, continuous exposure should not be permitted when the air speed and temperature results in an equivalent chill index of -32 ^{o} C. At temperatures of 2 ^{o} C or less wet clothing should be immediately replaced. Special precautions for the protection of hands, face, ears and feet should be taken.

For work activities at or below 4 ^{o} C the following provisions shall be implemented:

- Employees shall wear cold protective clothing appropriate for the level of cold and physical activity.
- If air velocity at the site is increased by wind or artificial ventilation, the cooling effect of the wind shall be reduced by shielding the work area, or by wearing outer wind breaking garments.
- If protective clothing is not available or does not give adequate protection to prevent hypothermia or frostbite, work shall be modified or suspended.
- Employees handling and working around liquids shall take special precaution to avoid soaking of clothing or gloves.

For work activities at or below -12 ^{o} C the following provisions shall be implemented.

- Employees shall be under constant protective observation (buddy system).
- Rest periods must be taken in heated shelters and opportunity for changing into dry clothing must be provided.

- New employees shall not be required to work full-time in cold environments for a few days until they become acclimated to cold weather conditions.
- Work conditions should be structured in a way that minimizes sitting or standing still for long periods of time.
- Workers must be properly trained in safe work practices, first aid treatment, rewarming techniques, clothing requirements, eating and drinking habits and recognition of hypothermia and frostbite conditions.

5.8 Buried/Overhead Utilities

Prior to initiating intrusive field operations, drilling and digging clearance permits will be obtained from appropriate agencies which could potentially have underground utility lines in the vicinity of the work site. Safe clearance distances from overhead electrical utilities will be maintained in accordance with Section 11 (Table 11-3) of EM 385-1-1.

5.9 Confined Space Entry

Confined space entry hazards are not anticipated for the field work tasks associated with this project. In the event that confined space entry is required, the Project Industrial Hygienist will be notified and confined space entry requirements outlined in 29 CFR 1910.146 and the Tulsa District Confined Space Entry Program will be implemented

5.10 Laser Hazards

Hazards associated with the operation of SCAPS laser equipment will minimized by employee experience and training with the SCAPS laser system. Employees engaged in SCAPS laser operations will adhere to the standard operating procedures outlined in the SCAPS operations manual. Laser eye protection will used when the laser system is in operation. Employees engaged in SCAPS laser operations will participate in the Tulsa District Laser Safety Program, which includes annual eye examinations.

5.11 Barge Operation Hazards

Hazards associated with SCAPS barge operations will be minimized by employee experience. All SCAPS barge operations will be conducted in accordance with EM 385-1-1 Section 05.1 (Personal Flotation Devices), Section 16 (Machinery and Mechanized Equipment) and Section 19 (Floating Plant and Marine Activities). An Activity Hazard Analysis for SCAPS barge operations is included in Attachment A.

6.0 SITE CONTROL AND WORK ZONES

Due to the varied nature of work activities and operations associated with this project and remote nature of the work site, specific zonation requirements will be determined based upon site activities and the nature of surrounding activities. The goal of site zonation is to prevent potential exposure to chemical, physical and equipment hazards at the site by non-authorized personnel. Site zonation will also help make site personnel aware of the hazards which are present at the site. The SSHO will be responsible for determining the degree and extent of site specific requirements for each specific work task based upon work activities being performed and site specific conditions. Only authorized personnel will be allowed to access the site during field investigations. The SSHO will be responsible for controlling access to the site by non-authorized personnel.

In the event that access to the site by non-authorized personnel cannot be controlled and the hazards present at the site require formal site zonation, printed hazard tape will be used to establish an exclusion zone around the specific work location. Entry into the exclusion zone will be controlled by a contamination reduction corridor entry point.

For most SCAPS operations the push room and area directly under the push room will be considered to be the exclusion zone. The control room will be considered the contamination reduction zone. Unauthorized personnel are not permitted in either the control room or push room during intrusive activities. Personnel not meeting requirements outlined in 29 CFR 1910.120 are not permitted in the control room or push room during SCAPS operations.

7.0 PERSONAL PROTECTIVE EQUIPMENT

In order to minimize bodily contact and exposure to hazardous substances potentially present at the site, and reduce exposure to physical and equipment hazards, the following personal protective equipment requirements shall apply for site investigative activities.

Due to the wide degree of activities performed in support of this project, personal protective equipment (PPE) levels will be evaluated daily based on site specific conditions and hazards associated with the specific activity being performed to determine the most effective level of protection. If necessary, changes in levels of protection (upgrades or downgrades) will be made after consultation with the SSHO, project industrial hygienist and safety officer.

Level D

- standard work uniform
- boots, steel toe/shank
- safety glasses
- hard hat (as necessary where overhead hazards are present)
- cotton work gloves (drilling personnel)
- chemical resistant gloves (sampling personnel/decontamination)
- hearing protection (as necessary)

Level D Modified

- tyvek coveralls
- boots, steel toe/shank
- chemical resistant boots or boot covers
- safety glasses
- hard hat (as necessary where overhead hazards are present)
- cotton work gloves (drilling personnel)
- chemical resistant gloves (sampling personnel / decontamination)
- coated tyvek coveralls (as necessary)
- face shield (as necessary)
- hearing protection (as necessary)

Level C

- full face air purifying respirator (OV/HEPA cartridge)
- tyvek coveralls
- boots, steel toe/shank
- chemical resistant boots or boot covers
- hard hat (as necessary)
- chemical resistant gloves
- coated tyvek coveralls (as necessary)
- face shield (as necessary)
- hearing protection (as necessary)

PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

SITE ACTIVITY	INITIAL PPE LEVEL	UPGRADE PPE LEVEL
Mobilization and Site Setup	D	D
SCAPS Operations		
CPT Push	D	D Mod / C
Laser Operations	D	D Mod / C
Grouting Operations	C (Dust Mask)	C (APR)
Barge Operations	D w/ PFD	D Mod / C w/ PFD
Soil and Groundwater Sampling Operations	D Mod **	D Mod / C
Decontamination Operations	D	D Mod / C
Site Restoration/Demobilization	D	D

** Tyvek suit as required by site-specific conditions. Tyvek suit when sampling under the SCAPS truck. Tyvek suit as necessary when sampling within the SCAPS truck

PFD Coast Guard Approved Type I Personal Flotation Device

7.1 Respiratory Protection

All personnel involved in HTRW investigative activities will have a physician's interpretation as to the employee's ability to wear a respirator. Appropriate respirators and cartridges will be made available to field personnel as necessary determined by site conditions. Respirator use will be in accordance with the requirements outlined in the Tulsa District Respiratory Protection Program. Respirator use is not authorized without notification of the project industrial hygienist and Tulsa District Occupational Safety and Health Office.

8.0 AIR MONITORING

Air monitoring will be conducted in order to determine airborne contamination levels at site work areas. Air monitoring procedures will be used to determine if personal protective equipment levels are appropriate to prevent exposure of site personnel and evaluate chemical hazards present at the site. The following air monitoring procedures will be implemented during intrusive site investigations Air monitoring protocols may be modified based upon site specific conditions as determined by the SSHO and project industrial hygienist.

8.1 Air Monitoring Instrumentation

Air monitoring instrumentation will be calibrated daily and air monitoring data will be documented. Air monitoring data will include instrument used, calibration data, instrument reading, site location, type of reading (breathing zone or work area), and site specific operations being performed. The SSHO and project industrial hygienist will periodically review air monitoring data. Calibration, operation and maintenance of air monitoring instrumentation will adhere to manufacturer guidelines.

8.2 Photoionization Detector (PID) Monitoring

As necessary, a Photoionization detector (PID) will be used as necessary to monitor airborne concentrations of ionizable compounds potentially present at the site. PID monitoring frequency will be determined by the SSHO and project industrial hygienist as determined by site specific conditions and work activity being performed.

PID MONITORING ACTION LEVELS

METER RESPONSE	RESPONSE ACTION
< 10 PID units above background (sustained, breathing zone)	- Continue activities in level D/D Mod PPE
10 PID units above background (sustained, breathing zone)	- Monitor for site specific air contaminants with detector tubes, direct reading instrumentation or integrated air sampling - Notify project industrial hygienist - PPE upgrade as determined by site specific air monitoring results and site specific chemical PELs and TLVs
> 10 PID units above background (sustained, breathing zone)	- Terminate work operations, contact project industrial hygienist for recommended procedures

8.3 Lower Explosive Limit (LEL)/Oxygen (O2) Monitoring

As necessary, a combustible gas indicator (CGI) and oxygen meter will be used as necessary to monitor explosive gas and oxygen concentration present at the site. LEL/O2 monitoring frequency will be determined by the SSHO and project industrial hygienist as determined by site conditions and work activity being performed.

LEL/O2 MONITORING ACTION LEVELS

METER RESPONSE	RESPONSE ACTION
< 19.5 % O2, **oxygen deficient atmosphere** > 23.5 % O2, **oxygen enriched atmosphere** > 10% LEL, **explosive atmosphere**	- Terminate work operations. - Exit exclusion zone. - Contact project industrial hygienist for recommended procedures.

8.4 Compound Specific Air Monitoring

Based on photoionization detector monitoring and site condition, compound specific air monitoirng procedures may be implemented. Compound specific monitoirng will consist of integrated air sampling in the workers breathing zones. Compound specific air monitoring paramaters will be selected based on potential site contaminants of concern. Workers will notified of air sampling results and calculated time-weighted averages (TWA).

As necessary based on site specific conditions and nature of contaminants present, airborne dust levels will be monitored with an aerosol (dust) monitor. Engineering controls will be utilized to minimize airborne dust generation. In the event that airborne dust levels cannot be controlled with engineering controls personal protective equipment levels will be modified to control employee exposure to potential respiratory hazards from contaminated dust.

9.0 DECONTAMINATION PROCEDURES

The purpose of decontamination procedures is to ensure that personnel and equipment are free from contamination when they leave the work site and prevent cross contamination between sites. Decontamination procedures listed in this SSHP are primarily for the purpose of protecting site personnel from contamination. Detailed environmental sampling decontamination procedures are included in the project workplan.

9.1 Personnel Decontamination

Decontamination procedures for site personnel will consist of disposal of PPE (gloves, coveralls, boot covers) into designated waste containers upon exit of the exclusion zone or between investigation sites based upon site conditions and location of individual investigation areas. Sampling gloves will be changed between each sample. All site personnel will wash hands and exposed skin prior to breaks, lunch and at the end of the work day. Disposal of PPE will be in accordance with waste management plan requirements.

9.2 Equipment Decontamination

Sampling and SCAPS equipment and associated site support equipment will be water washed or steam cleaned between sampling locations or between investigation sites as determined by site conditions and project requirements. Decontamination fluids will be managed in accordance with waste management plan requirements.

SCAPS rods will be decontaminated by steam cleaning as push rods are extracted. Care will be taken to minimize bringing potentially contaminated soil into the push room as rods are being extracted.

10.0 EMERGENCY RESPONSE

Careful consideration must be given to the relative possibility to fire, explosion, environmental incident, spill, or release of vapors, dusts or gasses which may impose on nearby facilities. The most likely off-site impact from this investigation involves the potential for increased airborne contaminants as a result of intrusive activities. Control measures will be employed as necessary to preclude any possibility of off-site migration of contaminants. As a result of the hazards on site and the conditions under which investigations will be conducted, the possibility of an emergency situation exists. An emergency plan is required by 29 CFR 1910.120 to be available for use and is included below.

10.1 Site Safety and Health Officer

The Site Safety and Health Officer (SSHO) shall implement this emergency plan whenever conditions at the site warrant such action. The SSHO will be responsible for assuring the evacuation, emergency treatment, emergency transport of site personnel as necessary, and notification of emergency response units and appropriate management functions.

10.2 Evacuation

In the event of an emergency situation, such as fire, explosion, significant release of contaminants, etc., the SSHO will notify all site personnel indicating the initiation of evacuation procedures. All personnel in both the restricted and nonrestricted areas of the site will evacuate and assemble in the support zone or other safe area as identified by the SSHO. The SSHO will have authority to initiate proper action if outside services are required. Under no circumstances will incoming personnel or visitors be allowed to proceed into the area once the emergency has been identified. The SSHO shall see that access for emergency response personnel is provided and that all equipment has been shut down if possible once the emergency situation has been identified. Once the safety of all site personnel and the environment is established, personnel listed below will be notified of the situation by the SSHO.

Bob Vandegriff	Tulsa District Safety Officer	(918) 669-7360
Greg Snider	Project Industrial Hygienist	(918) 832-4122

10.3 Personnel Exposure

In the event of personnel exposure, skin contact, inhalation or ingestion the following procedures shall be implemented:

Skin/Eye Contact - Wash/rinse affected area thoroughly with copious amounts of soap and water, then provide appropriate medical attention if required. Eyes should be rinsed for at least 15 minutes following chemical exposure.

Inhalation - Move to fresh air and if necessary decontaminate and transport to nearest hospital for professional medical attention..

Ingestion - Decontaminate and transport to nearest hospital for professional medical attention.

Puncture Wound or Laceration - Decontaminate and transport to nearest hospital for professional medical attention.
Fire or Explosion - Immediately evacuate the site and notify the local fire and/or police departments, and appropriate emergency response groups.

Environmental Incident - Secure spread of contamination if possible. Notify appropriate response group if assistance is required. If a significant release has occurred, the National Response Center or similar agency should be contacted.

10.4 Accident/Incident Reporting

All serious incidents/accidents resulting in equipment damage, emergency response, lost work time, medical treatment or fatality will be reported through the supervisory chain to the Tulsa District Safety and Occupational Health Office. A written report (ENG FORM 3394) will be forwarded to the Safety and Occupational Health Office, at the address listed below, within 48 hours of the accident/incident.

US Army Corps of Engineers
Safety and Occupational Health Office
P.O. Box 61
Tulsa, Oklahoma 74121

Emergency and non-emergency phone numbers are listed below. A hospital location map is included in Figure 10-1.

EMERGENCY / NON EMERGENCY PHONE NUMBERS

Ambulance	911 /
Police	911 /
Fire Department	911 /
Hospital	911 /
COE Tulsa, SCAPS Coordinator, Field Manager Steve Brewer	918-832-4122 mobile (918) 605-9342
COE Tulsa, Project Industrial Hygienist Greg Snider	918-832-4122 mobile (918) 629-1927
COE Tulsa, Safety Officer Bob Vandegriff	918-669-7360
COE Tulsa, ER Support Section Rex Ostrander	918-669-4916
COE Tulsa, SCAPS Chemist	
Eddie Mattioda	(918) 669-7445
Chris Kennedy	(918) 669-7072

FIGURE 10-1
HOSPITAL LOCATION MAP

(To Be Added)

11.0 TRAINING REQUIREMENTS

All personnel entering the site during field investigative activities must meet training requirements outlined in 29 CFR 1910.120. Personnel performing intrusive activities or personnel entering the project site will be required to receive 40 hour hazardous waste operations training and an annual 8 hour refresher. Training documentation for Tulsa District COE personnel are managed by the Tulsa District Occupational Safety and Health Office. Supervisors are responsible for ensuring personnel sent to the project site are in compliance with OSHA training requirements.

11.1 Site-Specific Training

Prior to initiating field activities project personnel will receive additional site specific training addressing the unique hazards which are potentially present at the site. Site specific training will be conducted by the SSHO and/or the field manager under the direction of the project industrial hygienist. Site specific training will address the following areas:

- History of the site.
- Field activities planned.
- Safety and health hazards present at the site.
- Personal protective equipment requirements.
- Safe work practices.
- Air monitoring activities.
- Industrial hygiene sampling activities.
- Signs and symptoms of potential chemical exposure.
- Decontamination procedures.
- Emergency response and evacuation procedures.

11.2 First Aid and CPR Training

All Tulsa District COE field personnel receive first aid and CPR training every 3 years. A minimum of one person trained in first aid and CPR will be on the project site at all times during field activities.

11.3 Hazard Communication Program

The Tulsa District COE has developed a Hazard Communication Program in accordance with 29 CFR 1910.1200. MSDS for chemicals brought onto or used at the site will be made available to project personnel. All COE personnel receive Hazard Communication Training in the following areas:

- Chemicals and their hazards in the work area.
- How to prevent exposure to these hazardous chemicals.
- Procedures to follow if chemical exposures occur.
- How to read and interpret labels and MSDS .

12.0 MEDICAL SURVEILLANCE

All COE employees (and COE contractors) working at hazardous waste sites are required to participate in the Tulsa District (or contractor) Medical Surveillance Program as required by 29 CFR 1910.120. Each employee is also required to receive a physician's interpretation as to the employee's ability to wear a respirator. Employee medical surveillance records are managed by the Tulsa District Safety and Occupational Health Office.

Category	Frequency
Occupational Physical Examination	Annual
Medical History	Annual
Work History	Annual
Audiogram (OSHA 1910.95 criteria)	Annual
Blood Chemistry Profile	Annual
Complete Blood Count	Annual
Urinalysis	Annual
Pulmonary Function Testing	Annual
Vision Screening	Annual
Chest x-ray	Every 4 Years
EKG	Baseline
Laser Eye Exam	Job Specific
Blood, Urine (Mercury Screening)	Job Specific
Blood Lead	Job Specific
Cholinesterase	Job Specific

13.0 SAFETY AND HEALTH STANDARD OPERATING PROCEDURES

The following is a table of contents of the US Army Corps of Engineers Safety and Health Requirements Manual (EM 385-1-1) that serves as minimum safety and health procedures that must be implemented as part of this SSHP. EM 385-1-1 will be available on-site during all field work activities. Tulsa District Confined Space Entry Program is included as attachment one to this section. Activity Hazard Analysis for site operations is included in attachment two.

US ARMY CORPS OF ENGINEERS
SAFETY AND HEALTH REQUIREMENTS MANUAL

1.0 Program Management
2.0 Sanitation
3.0 Medical and First Aid Requirements
4.0 Temporary Facilities
5.0 Personal Protective and Safety Equipment
6.0 Hazardous Substances, Agents, and Environments
7.0 Lighting
8.0 Accident Prevention Signs, Tags, Labels and Signals and Piping System Identification
9.0 Fire Prevention and Protection
10.0 Welding and Cutting
11.0 Electrical
12.0 Control of Hazardous Energy (Lockout/Tagout)
13.0 Hand and Power Tools
14.0 Material Handling, Storage and Disposal
15.0 Rigging
16.0 Machinery and Mechanized Equipment
17.0 Conveyors
18.0 Motor Vehicle and Aircraft
19.0 Floating Plant and Marine Activities
20.0 Pressurized Equipment and Systems
21.0 Safe Access and Fall Protection
22.0 Work Platforms
23.0 Demolition
24.0 Floor and Wall Holes and Openings
25.0 Excavations
26.0 Underground Construction (Tunnels), Shafts and Caissons
27.0 Concrete and Masonry Construction and Steel Erection
28.0 Hazardous, Toxic, and Radioactive Waste (HTRW) and UST Activities
29.0 Blasting
30.0 Contract Diving Operations
31.0 Tree Maintenance and Removal
32.0 Airfield Operations

ATTACHMENT A
ACTIVITY HAZARD ANALYSIS

ACTIVITY HAZARD ANALYSIS

TASK: SCAPS Operations

Personal Protective Equipment**: Minimum**: Hardhat (as necessary), steel toe boots, safety glasses, hearing protection **HTRW**: site specific requirements outlined in SSHP.

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
Mobilization / Site Set Up	1. Struck By	1. All equipment, rods and tools will be properly secured during transport. All vehicles and equipment will comply with DOT requirements.
	2. Tip Over	2. Set hydraulic leveling jacks before initiating SCAPS push operations. Ensure the site foundation is stable and as level as possible.
	3. Backing	3. Use a ground guide along with a functioning back-up alarm during equipment backing.
	4. Electrocution / Explosion	4. Inspect for buried and overhead utilities in the vicinity of the push location. A drilling clearance permit shall be obtained from base personnel or utility companies prior to initiating intrusive operations.
	5. Slips, Trips, Falls	5. Clear trees, roots, weeds, limbs and other ground hazards from the push location. Practice good housekeeping to keep the ground around the site clear of obstructions, equipment and other tripping hazards. Wear appropriate foot protection to prevent slips and trips. Use caution when working on uneven and wet ground surfaces. Practice good houskeeping inside the push room and keep the floor free from obstructions.
	6. Fall	6. Install railing structure around SCAPS deck platform and stairs.
Tool Handling	1. Struck By	1. Push pipe shall be transported in racks and secured to prevent shifting. Unload push pipe layer by layer. Ensure that nitrogen bottles are secured on the decon trailer rack. Ensure that valve caps are in place when transporting the trailer and loading and unloading nitrogen bottles. Inspect gas bottle valve and regulator prior to each use.
	2. Back Strain	2. Use proper lifting techniques when manually handling rods and tools. Use mechanical equipment during lifting whenever possible. Use the buddy system when lifting tools and supplies. Use mechanical lifting equipment when unloading drums.
Laser Operations	1. Eye hazards	1. Use laser safety goggles during laser operations. Inspect laser-warning light daily. Unauthorized personnel not allowed inside the control room or push room during laser operations. Personnel involved with laser activities will participate in Tulsa District Laser Safety Program.
Push Operations	1. Back Strain	1. Use caution when handling, lifting and threading push pipe sections.
	2. Pinch Points	2. SCAPS push room operator must use caution during push operations to ensure push room helper is clear

ACTIVITY / PHASE	POTENTIAL HAZARDS	RECOMMENDED ACTIONS / CONTROLS
	3. Slips, Trips, Falls	of hydraulics prior to engaging RAM. Push room helper must keep hands and feet clear of RAM and push pipe during push operations. 3. Use good housekeeping and keep push room floor clear of tools, umbilical, and push pipe. Minimize number of employees within the push room during push operations.
Barge Operations	1. Drowning 2. Tip Over	1. Follow EM 385-1-1 requirements for floating plant and marine activities. All personnel on the barge and in the SCAPS truck must wear a PFD when working on or adjacent to water. A throwable life ring must be available. Barge operations must comply with USCG requirements. 2. Secure SCAPS rig to the barge to prevent rolling or tipping off of the barge.
Weather	1. Electrocution	1. Observe weather forecasts and warnings. Suspend SCAPS operations during inclement weather or lighting.
Maintenance	1. Equipment Hazards 2. Fire	1. The SCAPS rig and associated equipment must be maintained in a proper functioning condition. All motors must be shut off and electrical, mechanical and hydraulic components locked out of service when making repairs. All equipment must be inspected daily prior to use. Equipment must be operated and maintained in accordance with EM 385-1-1 and manufacturers guidelines. Bleed off pressure on hydraulic lines before undoing fittings. 2. All motors must be shut off during refueling. Smoking in the vicinity of the SCALPS rig is not permitted. An A-B-C fire extinguisher must be maintained on the SCAPS rig and associated motorized equipment. Fuel containers will not be stored within 10’ of the SCAPS rig motor. Fuel will be stored in UL approved safety containers with contents clearly labeled.
Grouting	1. Inhalation Hazards	1. Dust mask respirators must be worn when using silica flour grout additives. Use engineering controls to reduce airborne particulate generations and dust exposure.
HTRW Operations	1. Chemical Exposure	1. All SCAPS personnel will wear personnel protective equipment specified in the SSHP. Personnel and equipment decontamination procedures will be followed. HTRW SCAPS personnel will meet training and medical surveillance requirements outlined in 29 CFR 1910.120. Site specific air monitoring procedures will be implemented as specified in the SSHP for HTRW locations.
Decon	1. Equipment Hazards	1. Inspect the steam cleaner pop off valve daily