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U.S. Army
Environmental
Center

FORT DEVENS
SITE INVESTIGATION
GROUPS 3, 5, AND 6

REVISED
FINAL SITE INVESTIGATION REPORT
DATA ITEM A009

VOLUME I of II
REPORT TEXT

CONTRACT DAAA15-91-D-0008

U.S. ARMY ENVIRONMENTAL CENTER
ABERDEEN PROVING GROUND, MARYLAND

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PREFACE

In 1991, the U.S. Department of the Army and the U.S. Environmental Protection Agency signed a Federal Facility Agreement under Section 120 of the Comprehensive Environmental Response, Compensation, and Liability Act, for environmental investigations and remedial actions at Fort Devens. The agreement requires that Site Investigations be undertaken at each Study Area (SA) to verify whether a release or potential exists, to determine the nature of the associated risks to human health and the environment, and to determine whether further investigations or response action may be required.

In 1991, Fort Devens was identified for closure, by July 1997, under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990. This has resulted in accelerated schedules for the environmental investigations at Fort Devens.

In 1991, under Contract DAAA15-91-D-0008, the U.S. Army Environmental Center tasked ABB Environmental Services, Inc. (ABB-ES) to conduct site investigations at eleven SAs in SA Groups 3, 5, and 6 as described in the Fort Devens Master Environmental Plan. This Revised Final Site Investigation Report summarizes ABB-ES' findings, conclusions, and recommendations for the site investigations conducted at SA Groups 3, 5, and 6.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

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EXECUTIVE SUMMARY

The U.S. Army Environmental Center (AEC) tasked ABB Environmental Services, Inc. (ABB-ES), under Contract No. DAAA15-91-D-0008, to conduct site investigation (SI) activities at the following eleven Study Areas (SAs) located at Fort Devens, Massachusetts:

GROUP 3 (Barnum Road area of the Main Post)

- SA 38 - Battery repair area (Building 3713)
- SA 44 - Cannibalization yard
- SA 52 - TDA maintenance yard

GROUP 5 (Treatment plant area of North Post)

- SA 09 - North Post Landfill (Landfill No. 5)
- SA 19 - Wastewater treatment plant (Imhoff tanks)
- SA 20 - Rapid infiltration sand beds
- SA 21 - Sludge drying beds

GROUP 6 (Moore Army Airfield)

- SA 30 - Drum storage area
- SA 31 - Fire-fighting training area
- SA 47 - Underground storage tank (at flight-control tower)
- SA 50 - World War II fuel point

These SAs are identified in the Fort Devens Master Environmental Plan and are included as part of the Federal Facility Agreement between U.S. Environmental Protection Agency (USEPA) and the U.S. Department of the Army.

The purpose of the SI at each SA was to evaluate existing information and to identify and obtain additional information necessary to verify the absence or presence of environmental contamination, in order to determine whether further investigation or response action is warranted.

ABB-ES prepared a Task Order Work Plan establishing the specific scope of the SIs for each SA. ABB-ES also prepared a Project Operations Plan, which sets forth the health and safety, sampling and analysis, and quality assurance requirements and procedures. These documents were reviewed by Fort Devens, AEC, USEPA, the Massachusetts Department of Environmental Protection (MADEP), and other, nonregulatory members of the Technical Review Committee. Upon completion of the review process, ABB-ES finalized the plans.

The initial field investigations were conducted from May to October 1992, and the associated laboratory analyses were completed in November 1992. A third round of groundwater sampling and analysis was conducted in January and February 1993.

ABB-ES evaluated the chemical and physical data for each SA. For SAs at which contamination was found, ABB-ES evaluated the sources, potential extent and migration pathways, and potential receptors. ABB-ES then performed preliminary human health and ecological risk evaluations. In December 1992 ABB-ES issued SI Data Packages for the eleven SAs, summarizing the data, findings, and recommendations. In order to meet critical deadlines, the SI Data Packages provided preliminary evaluations for the decision-makers of the absence or presence of contamination, potential migration pathways, and potential risks to human and ecological receptors. These preliminary evaluations permitted the expediting of necessary next-phase planning and contracting while the SI Report was being prepared.

The SI Data Packages were reviewed by Fort Devens, AEC, USEPA, and MADEP. The views and concerns of these agencies were discussed with ABB-ES at meetings and teleconferences held in January 1993. The Final Site Investigation Report was prepared in April 1993 based on the information, evaluations, and recommendations presented in the SI Data Packages, and it incorporated the modifications identified at the review meetings.

On the basis of the data and evaluations, ABB-ES recommended no further action at six SAs (09, 19, 20, 30, 31, and 47) and supplemental site investigations (SSIs) at three SAs (38, 21, and 50). ABB-ES recommended that SAs 44 and 52 be recategorized as Areas of Contamination (AOCs) and that focused Feasibility Studies be conducted. However, because of identified data gaps at AOCs 44 and 52, these sites were included in the SSI program. None of the SAs required immediate remedial actions.

ABB-ES prepared a draft work plan for the SSIs, which was reviewed by Fort Devens, AEC, USEPA, and MADEP. Based on review comments, the Final SSI Work Plan was prepared in April 1993. The investigations were conducted from May to October 1993.

ABB-ES evaluated the SSI data and prepared SSI Data Packages in September 1993. The SSI Data Packages were reviewed by Fort Devens, AEC, USEPA, and MADEP. ABB-ES recommended no further action at SA 38 and SA 21. ABB-ES also recommended that a removal action be undertaken for source control at SA 50 and that further (Phase III) SIs be conducted at SA 50.

A work plan was prepared by IT Corporation in November 1993 for the removal action, and a soil-vapor extraction system was installed in January 1994. A work plan was prepared by ABB-ES for the Phase III SIs at SA 50. It was reviewed by Fort Devens, AEC, USEPA, and MADEP and was modified accordingly in May and December 1994.

In January and February 1994, contaminated soil was removed from SA 38 during previously scheduled replacement of the concrete floor and underground piping in the current battery room.

The Phase III SI was conducted at SA 50 in August 1994 and January 1995. Based on evaluation of the collective results of investigations, ABB-ES prepared a Phase III SI Data Package and recommended that SA 50 be recategorized as AOC 50 and that a Remedial Investigation be conducted.

Additional (Phase III SI) sampling was conducted at SA 21 in May 1995 in response to review comments on the SSI Data Package. On the basis of evaluation of those results and earlier sampling results, ABB-ES recommends no further action at SA 21.

This Revised Final SI Report incorporates the information, evaluations, findings, and recommendations for all phases of the SIs conducted at the SAs of Groups 3, 5, & 6, as modified based on the review comments received. The findings and recommendations are summarized in Table E-1.

TABLE E-1
SUMMARY OF FINDINGS AND RECOMMENDATIONS
SITE INVESTIGATION REPORT
FORT DEVENS

SITE	MEDIUM	CONTAMINANTS[1]	PRELIMINARY RISK EVALUATION		RECOMMENDATION
			HUMAN HEALTH	ECOLOGICAL	
SA 38 – Battery repair area	Soil	Inorganics	Acceptable	Acceptable	No further action.
SAs 44/52 – Cannibalization and Maintenance yards	Soil	Petroleum hydrocarbons (PAHs[2]) and inorganics	Exceeds acceptable risk values due to PAHs	Acceptable	Focused Feasibility Study for unsaturated zone soils.
SA 09 – North Post landfill	Soil	Petroleum hydrocarbons (PAHs) and inorganics	Acceptable	Acceptable	No further action.
	Sediment	Inorganics			
	Surface water	Inorganics			
SA 19 – Wastewater treatment plant	Groundwater	VOCs[2] and BIS[2]	Acceptable	Acceptable	No further action.
SA 20 – Rapid infiltration beds	Groundwater	VOCs and BIS	Acceptable	Acceptable	No further action.
SA 21 – Sludge drying beds	Soil	Petroleum hydrocarbons (PAHs) and inorganics	Acceptable	Acceptable	No further action.
	Groundwater	VOCs and BIS			
SA 30 – Drum storage area	Soil	PAHs and inorganics	Acceptable	Acceptable	No further action.
SA 31 – Fire fighting training area	Soil	Petroleum hydrocarbons (PAHs) and inorganics	Acceptable	Acceptable	No further action.
	Groundwater	BIS and inorganics			
SA 47 – Underground storage tank	Soil	Petroleum hydrocarbons (PAHs) and inorganics	Acceptable	Acceptable	No further action.
	Groundwater	BIS and inorganics			
SA 50 – World War II fuel point	Soil	Petroleum hydrocarbons and VOCs	Exceeds acceptable risk values due to PCE[2] in soil and groundwater.	Acceptable	Remedial Investigation.
	Groundwater	VOCs, BIS, and inorganics			

NOTE: [1] Contaminants detected above background.

[2] PAHs = polycyclic aromatic hydrocarbons; VOCs = volatile organic compounds; BIS = bis(2-ethylhexyl)phthalate; PCE = tetrachloroethylene

1.0 INTRODUCTION

1.1 BACKGROUND

In accordance with U.S. Army Environmental Center (AEC; formerly U.S. Toxic and Hazardous Materials Agency [USATHAMA]) Contract DAAA15-91-D-0008, Task Order No. 2, ABB Environmental Services, Inc. (ABB-ES) conducted Site Investigations (SIs) at 11 Study Areas (SAs) within SA groups designated 3, 5, and 6 at Fort Devens, Massachusetts (Table 1-1). The locations of these SAs are shown in Figure 1-1.

In 1985, Fort Devens applied for a Resource Conservation and Recovery Act Part B Permit for its hazardous waste storage facility. The submission included a list of Solid Waste Management Units (SWMUs) that showed potential for the release of hazardous materials to the environment. Under the Federal Facility Agreement between the U.S. Army (Army) and the U.S. Environmental Protection Agency (USEPA) (USEPA and Army, 1991), these potential areas of contamination are referred to as Study Areas. In cooperation with the Massachusetts Department of Environmental Protection (MADEP), USEPA Region I issued a draft permit and selected ten SAs for corrective action. In 1986, a final permit was issued along with a list of 40 SAs. At the request of Fort Devens, six additional SAs were added to the list, for a total of 46 SAs.

Argonne National Laboratory's (ANL) Environmental Assessment and Information Sciences Division conducted an environmental assessment of the 46 SAs in November 1988, as part of the environmental restoration of Fort Devens. The objective of the ANL assessment was to characterize on-site contamination and provide recommendations for potential response actions. In 1989, Fort Devens was placed on the National Priority List. During a subsequent site visit by ANL in 1990, eight more SAs were added, bringing the total to 54. Since that time, five more areas of potential contamination have been identified, for a current total of 59 SAs, as well as eleven Areas Requiring Environmental Investigation (AREE). Table 1-2 lists the 59 SAs by priority group, and the eleven AREE.

1.2 PREVIOUS STUDIES

The results of ANL's assessment are reported in a document entitled the Master Environmental Plan (MEP) for Fort Devens, Massachusetts (Biang et al., 1992). The MEP summarizes preliminary assessment activities conducted by ANL and provides an historical summary of the installation, discusses the geologic and hydrologic setting, discusses the nature and extent of contamination, and proposes response actions for each of the 58 SAs. The MEP provided the basis for much of the planning effort for investigation of each of the Groups 3, 5, and 6 SAs.

1.3 PROJECT OBJECTIVES

The objective of the Task Order No. 2 project at Fort Devens was to perform Site Investigations in accordance with all relevant State and USEPA guidance and in compliance with AEC-approved field methods and procedures. The purpose of the SIs conducted at SAs in Groups 3, 5, and 6 was to verify the presence or absence of environmental contamination and to determine whether further investigation or remediation is warranted.

1.4 PROJECT APPROACH

In order to meet the project objectives, a significant amount of effort was focused on the production of SI planning documents. The planning documents were developed in compliance with the appropriate regulatory guidance for site investigations through the review of pertinent data, interviews with site personnel, and information gathered during site visits.

After completion of the site investigations, ABB-ES prepared SI Data Packages for the Groups 3, 5, and 6 SAs (ABB-ES, Dec. 1992). These SI Data Packages presented the results of the site investigations and provided preliminary evaluations of the absence or presence of contamination, potential pathways of contaminant migration, and potential risks to human and ecological receptors.

1.4.1 Project Operations Plan

The principal planning document was the ABB-ES Project Operations Plan (POP) (ABB-ES, July 1992 and July 1993), which presents detailed descriptions and discussions of the elements essential to conducting field investigation activities. The purpose of this plan was to define responsibilities and authorities for data quality, and to prescribe requirements for assuring that the site investigation activities undertaken by ABB-ES at Fort Devens were planned and executed in a manner consistent with AEC quality assurance (QA) program objectives. The POP includes the specified elements of a Sampling and Analysis Plan (SAP) and Health and Safety Plan (HASP). The SAP includes the essential elements of the Quality Assurance Project Plan (QAPP) and the Field Sampling Plan (FSP). USEPA has prepared guidance on the preparation of a POP in "Guidance for Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring" (OWRS QA-1: May, 1984). The guidance was designed to eliminate the necessity for preparation of multiple, redundant documents.

The requirements of the POP were applied to all ABB-ES and subcontractor activities related to the collection of environmental data at Fort Devens. The POP adheres to the requirements and guidelines contained in the "AEC QA Program, January 1990" for collection and analysis of samples and the AEC "Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports, March 1987" for the installation of borings and monitoring wells, and for land survey location. In addition, the POP meets guidelines of AEC chain-of-custody procedures.

The ABB-ES Fort Devens POP provides guidance and specifications to ensure that samples are obtained under controlled conditions using appropriate, documented procedures; and samples are identified uniquely, and controlled through sample tracking systems and chain-of-custody (COC) protocols. The POP also includes specifications to ensure that field determinations and laboratory analytical results are of known quality and are valid, consistent, and compatible with the AEC chemical data base through the use of certified methods, preventive maintenance, calibration and analytical protocols, quality control (QC) measurements, review, correction of out-of-control situations, and audits. The Plan also specifies the methods and procedures to be used to ensure that calculations and evaluations are accurate, appropriate, and consistent throughout the projects; generated data are validated and their use in calculations is documented; and records are retained as documentary evidence of the quality of samples, applied processes, equipment, and results.

The HASP has been prepared as an integral element of the POP in accordance with the same schedule and review requirements (ABB-ES, July 1993, Appendix A). The HASP complies with EM 385-1-1, AMC-R-385-100, and Fort Devens safety requirements, as well as Occupational Safety and Health Administration (OSHA) Regulations 29 CFR (Code of Federal Regulations) 1910.120. The HASP development was based on appropriate information contained in previous investigation documents from Fort Devens. The HASP portion of the POP ensures that health and safety procedures are maintained by requiring inclusion of the health and safety staff function in the project organization.

1.4.2 Task Order Work Plans

The background, rationale, and specific scope for the Groups 3, 5, and 6 investigations are set forth in companion planning documents -- the Task Order Work Plans (ABB-ES, June and Sept. 1992, April 1993b; Rice, May and Dec. 1994). These Task Order Work Plans were developed to comply with the Massachusetts Contingency Plan (310 CMR [Code of Massachusetts Regulations] 40.000); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986; the corrective action provisions of the Hazardous and Solid Waste Amendments; and the Toxic Substances Control Act. Work conducted under the Task Order Work Plans was performed in accordance with the provisions of the Federal Facility Agreement (USEPA and Army, 1991).

The background information provided in the initial Task Order Work Plan (ABB-ES, Sept. 1992) for the eleven SAs was based largely on information in the MEP, review of installation documents, observations made during site visits, and interviews with installation personnel. Summaries of information documented in the MEP for the selected SAs and discussions of specific field activities to be conducted under Task Order No. 2 were included in the Task Order Work Plan. The discussions focused specifically on the objectives and scope of proposed SI activities. To facilitate a comprehensive discussion of each assigned area of the facility, the Task Order Work Plan was organized by SA Group because many SI tasks were common to the SAs within each group. For supplemental site investigations at specific SAs, the background and scope presented in the associated Task Order Work Plans incorporated the results of preceding SI phases (ABB-ES, April 1993b; Rice, May and Dec. 1994).

1.4.3 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative or quantitative statements developed by the data user to specify the quality of data needed from a particular data activity to support specific decisions. The DQOs are the starting point in the design of the investigation. The DQO development process matches sampling and analytical capabilities to the data targeted for specific uses and ensures that the quality of the data does not underestimate project requirements. The USEPA has identified five general levels of analytical data quality as being potentially applicable to field investigations conducted at potential hazardous waste sites under CERCLA. These levels are summarized as follows:

- Level I - Field Screening. This level is characterized by the use of portable instruments which can provide real time data to assist in the optimization of sampling point locations and for health and safety support. Data can be generated regarding the presence or absence of certain contaminants (especially volatiles) at sampling locations.

- Level II - Field Analysis. This level is characterized by the on-site use of portable analytical instruments and mobile laboratories which can render qualitative and quantitative data.

- Level III - Laboratory analysis using methods other than the Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is used primarily in support of engineering studies using standard USEPA-approved procedures. Some procedures may be equivalent to the USEPA RAS, without the CLP requirements for documentation.

- Level IV - CLP RAS. This level is characterized by rigorous QA/QC protocols and documentation, which provide qualitative and quantitative analytical data.

- Level V - Non-standard methods. This level includes analyses which may require modification and/or development. CLP Special Analytical Services (SAS) are considered Level V.

For Fort Devens SI and Remedial Investigation (RI) efforts, field measurements such as pH, temperature, conductivity, and readings from an organic vapor analyzer (OVA) or photoionization detector (PID) and O_2/Explosimeter constituted Level I field analytical data. Analyses of soil, groundwater, and surface water/sediments for organics, metals, total organic carbon (TOC), total petroleum hydrocarbons (TPHC), water quality parameters, and explosives were considered approximately equivalent to USEPA analytical support Level III. The sampling approaches and analytical procedures described in the POP have been selected to meet the Level III data quality.

DQOs were established to support the level of detail required for SI activities. Data generated during the field and laboratory tasks were used to characterize SA conditions and to perform preliminary risk evaluations. These data were also used to scope further investigations or to support decisions of no further action.

DQOs and quality control for field measurements and laboratory analyses conform to AEC and USEPA requirements (as specified in the AEC Quality Assurance Manual, 1990 and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, 1988).

AEC requirements and analytical processes are discussed in Section 3.0 of this report. They focus on the use of laboratory control spikes in associated data lots to measure the performance of the laboratory in the use of AEC methods. Many of the AEC methods are identical to standard USEPA methods. The certification process, required by laboratories performing AEC work, is discussed in Section 3.2.2.1. The data review and evaluation process are described in Section 3.2.2.6.

Laboratory data was evaluated for precision, accuracy, representativeness, completeness and comparability (PARCC) in order to meet USEPA Level III requirements. This was accomplished through the collection of field quality control blanks such as field blanks, trip blanks and equipment rinsates and through the evaluation of laboratory blanks such as method blanks. The specific purpose of collecting each of these is discussed in Section 3.2 of this report.

Laboratory control spikes are run in the certification process to generate control charts that help to establish control limits that are used to ensure accuracy of the results. This process is described in the text of the report in Section 3.2. Matrix spike/matrix spike duplicate samples and duplicate samples were also analyzed to meet PARCC data quality objectives. These are broken down by group and are presented in Appendix F. MS/MSD discussions are found in Sections 4.3.2, 5.3.2 and 6.5.2. Duplicate data are discussed in Sections 4.3.3, 5.3.3 and 6.5.3.

The precision of the data is a measurement of the ability to reproduce a value under certain conditions. It is a quantitative measurement based on the differences of two values. Precision was evaluated using the relative percent difference (RPD) of matrix spike/matrix spike duplicate sample pairs and field duplicate sample pairs. Evaluations of the precision of the data are found for each of the groups in Section 2.0 of Appendix F.

Accuracy measurements identify the performance of a measurement system based on tests with known values. The laboratory, sampling, and media effects on accuracy were assessed by reviewing the percent recoveries of spiked analytes for MS/MSDs, laboratory control samples, and surrogate compounds.

Representativeness refers to the extent to which a measurement accurately and precisely represents a given population within the accepted variation of laboratory and sampling measurements. Collection techniques that obtained samples characteristic of the matrix and location being evaluated were chosen. Historic information was used to identify sample locations. Representativeness was also evaluated using method blanks and field quality control sample data. By evaluating method blank and field quality control samples false positive results should be identified. Representativeness was also measured by evaluating field duplicate pair precision.

Completeness refers to the percentage of usable, valid values obtained through data evaluation. Completeness was determined by the success rate in meeting holding time criteria and acceptance of sample lots by AEC.

Comparability is a qualitative assessment describing the confidence with which one data set may be compared with another. Comparability was assured using standard operating procedures for sampling, and by reporting analytical results in standard units.

1.4.4 Site Investigation Data Packages

Due to the need to meet critical deadlines, the decision makers in charge of hazardous waste projects at Fort Devens developed the SI Data Packages concept. The purpose of the SI Data Packages is to evaluate on a preliminary basis the absence or presence of contamination and, if present, the potential pathways of contaminant migration and potential risks to human and ecological receptors at each subject study area. This preliminary evaluation allows expedited next-phase planning and contracting while the SI Report is being prepared. The SI Data Packages approach relies primarily on tables and figures with minimum supporting text.

The preliminary contamination assessments in the SI Data Packages for Groups 3, 5, and 6 (ABB-ES, Dec. 1992 and Sept. 1993) provided the interpretive link between the tabulated chemical data, field observations, and the hydrogeological and physical environment. The major outputs of the contamination assessments were the spatial distribution of chemical contaminants in each environmental medium and identification and characterization of contaminant sources (qualitative and, to the extent possible, quantitative). These data were used in assessments of contaminant migration potential.

The information from the contaminant assessment was then used to preliminarily assess human health risks and environmental impacts. The preliminary human health and environmental risk evaluation was the basis for conclusions and recommendations concerning the study area. Based on the results of the preliminary evaluation, one of the following recommendations was made:

- Take no further action;
- Initiate an immediate removal or interim action; or
- Include in a supplemental SI or Remedial Investigation/Feasibility Study (RI/FS).

In order to support the decision makers, the SI Data Packages also included lists of issues which should be considered when implementing the recommended actions.

The SI Data Packages for Groups 3, 5, and 6 (ABB-ES, Dec. 1992) were reviewed by the Army, USEPA, MADEP, and the public Technical Review Committee

(TRC). A meeting was held on January 20, 1993 (with a follow-up teleconference on January 22) among the Army (Fort Devens, AEC, and the Corps of Engineers New England Division), USEPA, MADEP, and ABB-ES, at which the conclusions and recommendations of the Data Packages were discussed (ABB-ES, Feb. 1993). Several issues were identified, and they are addressed and incorporated as appropriate in the presentations for each of the Groups 3, 5, and 6 SAs, in Sections 4.0, 5.0, and 6.0 of this report. Below is a list of general issues raised and brief summaries of followup activities:

Nashua River/Cold Spring Brook investigations: Surface water and sediment contamination identified in Cold Spring Brook and the Nashua River, as part of the Groups 3, 5, and 6 SIs, has been investigated further by the Army under Area Requiring Environmental Evaluation (AREE) 70 (Arthur D. Little [ADL], 1994).

Background concentrations of inorganic analytes: Background concentrations for groundwater have been recalculated with the addition of four wells from the Groups 2 and 7 database.

Groundwater cross contamination: The Army presented a full and specific discussion of volatile organic compound (VOC) cross contamination of Round 2 groundwater samples in the SI Report.

Groundwater depression at Group 3: The water table depression at well MNG-3 (at the National Guard facility) reported in the Group 3 SI Data Packages was found to be the result of an error in the reference elevation. The corrected water table map shows a gentle gradient into Grove Pond.

Detection limits: The Army has included detection limits in the analytical data tables of the SI Report.

Phthalates: The Army has evaluated the sources of phthalates detected in groundwater samples at Moore Army Airfield.

These issues were fully addressed in the Final Site Investigation Report (ABB-ES, April 1993a).

After completing supplemental site investigations at SAs 38, 44 and 52, 31, and 50, ABB-ES prepared Supplemental SI Data Packages (Sept. 1993). These were reviewed by the Army (AEC and Fort Devens Environmental Management Office [EMO]), USEPA, and MADEP, and a review meeting was held by ABB-ES and representatives of those agencies on September 27, 1993 (ABB-ES, Oct. 1993). Below is a list of issues raised and brief summaries of followup activities:

Quantity of disposed electrolyte and concentration of dissolved lead at SA 38: The Army has investigated the quantities of waste electrolyte disposed in the battery maintenance operation, investigated typical concentrations of lead in lead-acid battery electrolyte, and determined that those findings are consistent with the background levels of lead detected in surface soils in the East Disposal Area.

Battery-room floor repairs at SA 38: The Army removed lead- and TPHC-contaminated soil from beneath the floor of the current battery-room in January 1994, as part of routine (non-CERCLA) floor maintenance.

Extent of contamination at SA 21: It was agreed by all parties that the lateral extent of contamination had been adequately determined. However, at a later meeting (April 9, 1995) the USEPA stated the opinion of the U.S. Fish and Wildlife Service (USFWS) that the lateral extent had not been sufficiently defined in the direction of the Nashua River. As part of that later meeting, representatives of ABB-ES, the Army, USEPA, and MADEP visited SA 21 and jointly staked locations for three additional surface-soil samples and two sediment samples. In accordance with the discussions at that meeting, the samples were collected and analyzed for metals.

Interim measure source-control of free-phase tetrachloroethylene (PCE) in vadose-zone soil at SA 50: In December 1993 - January 1994, the Army installed a soil-vapor extraction system, and it has been operating almost continuously since that time.

Additional site investigation activities at SA 50: Based on the findings of the supplemental site investigation, the Army has conducted additional (Phase III) site investigation activities to address PCE contamination of groundwater and PCE contamination of soil at depth.

1.5 PROJECT ORGANIZATION AND RESPONSIBILITIES

Because of its importance to the success of project tasks, the following discussion focuses primarily on the QA/QC organization and responsibilities for the Fort Devens project. Emphasis is directed toward the chemical analysis program where accuracy and reliability were critical. Figure 1-2 illustrates the functional relationships (i.e., lines of authority/responsibility and communication) for QC and QA for the Fort Devens effort; a description of key project roles follows.

1.5.1 AEC Commander

Ultimate responsibility for all activities conducted in support of AEC projects rests with the Commander of AEC and is delegated to an AEC Contracting Officer's Representative (COR) and the Chemistry Branch.

1.5.2 AEC Contracting Officer's Representative

During the Groups 3, 5, and 6 SI effort, the duties of the AEC COR have included acting as the principal contact between AEC, ABB-ES, and Fort Devens; requiring effective implementation of the AEC QA Program; providing ABB-ES' Project Operations Plan to the Chemistry Branch for review and approval; forwarding Chemistry Branch review comments to ABB-ES; and providing formal notification to the Contracting Officer of unapproved deviations from the QA Program. Other responsibilities have included informing the Chemistry Branch of difficulties and problems encountered by ABB-ES in implementing the QA Program; discussing proposed changes in approved sampling and analysis procedures with the Chemistry Branch; providing any ABB-ES/Subcontractor Laboratory certification documentation to the Chemistry Branch for review and approval; and notifying ABB-ES of certification status.

1.5.3 AEC Chemistry Branch

The duties of the AEC Chemistry Branch, Technical Support Division have included advising the Commander on QA/QC practices; recommending to the Commander QA practices to be used to support AEC projects; reviewing and approving project plans; providing standardized analytical methods, as necessary; and providing analytical reference materials to the laboratory. Additional responsibilities have included supplying Target Reporting Limits to the AEC COR based on the formal list of applicable analytes; reviewing and recommending approval of any proposed modifications to analytical methodology; recommending certification of laboratory analytical methods as necessary prior to collecting field samples; providing guidance to the AEC COR on implementation of QA/QC by the laboratory; providing guidance to the AEC COR on chemistry matters; and evaluating the quality of data generated by the laboratory. Other QA/QC Chemistry Branch responsibilities have included monitoring the effective implementation of QA/QC and reporting questionable practices to the Commander of AEC; conducting on-site audits of laboratory and field sampling activities, if necessary; and coordinating data reporting requirements with the AEC Data Management Group.

1.5.4 ABB-ES Program Manager

The ABB-ES Program Manager is responsible for the overall AEC program at ABB-ES. During the Groups 3, 5, and 6 SI effort, specific responsibilities have included overall technical responsibility for the program; establishing and overseeing all subcontracts for support services; initiating program activities; and participating in the work plan preparation and staff assignments. Additional duties have included identifying and fulfilling equipment and other resource requirements; monitoring task activities to ensure compliance with established budgets, schedules, and the scope of work; regularly interacting with the client regarding the status of the project; coordinating and reviewing monthly performance and cost reports (PCRs); and ensuring that appropriate financial record and reporting requirements were met.

Within the overall technical responsibility for the program, the Program Manager has supported the ABB-ES QA Supervisor in the development of the POP and the enforcement of its requirements in the implementation of the project. The Program Manager has reviewed and resolved conflicts relative to corrective action.

1.5.5 ABB-ES QA Supervisor

Specific QA and QC tasks for the implementation of the Fort Devens POP have been assigned to quality assurance and management personnel in ABB-ES and the laboratory. Each member of the ABB-ES technical project team has been responsible for performing work in accordance with the approved POP and for providing required documentation. Management personnel have provided the overall QC documentation, control, and assessment/corrective action. QA and QC personnel have provided oversight and review of data quality.

For the Groups 3, 5, and 6 SI effort, project-specific responsibility for QA/QC within ABB-ES has occurred under the supervision of the ABB-ES Project QA Supervisor. The ABB-ES QA Supervisor has authority independent of the Fort Devens Project Manager and Program Manager to issue corrective actions up to and including cessation of work performed out of compliance with the approved POP. In one instance, the ABB-ES QA Supervisor required work (sampling and analysis) to be repeated with the concurrence of the U.S. Army Armament, Munitions, and Chemical Command (AMCCOM) Contracting Officer, AEC COR, and the Chemistry Branch.

The ABB-ES QA Supervisor has responsibility for establishing, overseeing, and auditing specific procedures for documenting and controlling analytical and field data quality. Many of the procedures were implemented by other individuals, but the QA Supervisor ensured that procedures were being implemented properly and the results interpreted correctly. The QA Supervisor's oversight function has included making unannounced inspection trips to the site to ensure that sampling and laboratory analysis were conducted in a manner consistent with the POP, the AEC QA Program, and other AEC guidelines.

1.5.6 ABB-ES Project Manager

The ABB-ES Project Manager is responsible for effective day-to-day management of all operations. The Project Manager has responsibilities which specifically include preparing work plans, including approval of monitoring locations, chemical analysis parameters, schedules, and labor allocations; managing all funds for labor and materials procurement; monitoring and controlling the schedule; managing the site team toward unified, productive project accomplishment; preparing PCRs; communicating directly with the AEC COR; and reviewing all task deliverables and providing technical leadership. Within this framework, the Project Manager has supported the ABB-ES QA Supervisor in the development and implementation of the QA Program, and provided resources for review, audit, and corrective action.

1.5.7 Laboratory Program Manager

The laboratory analytical program was conducted by Environmental Science and Engineering, Inc. (ESE) of Gainesville, Florida; an AEC-approved laboratory.

The Laboratory Program Manager has provided direction to the analysts at ESE and has been responsible for implementing the AEC QA Program. Major Laboratory Program Manager responsibilities have included supporting the efforts of the ESE Laboratory Quality Assurance Coordinator (QAC) to ensure that the AEC QA Program was being properly implemented; providing sufficient work space, instrumentation, resources, and personnel to conduct all analyses according to the AEC QA Program requirements; ensuring that all purchased chemicals (i.e., standards, solvent, and reagents) were checked for proper identity and adequate purity; and ensuring the implementation of any corrective actions which were deemed necessary to mitigate QA/QC deficiencies.

1.5.8 Laboratory QA Coordinator

In the fulfillment of QC requirements, the Laboratory QAC has provided the ABB-ES QA Supervisor with all QC data for review and intermittent status reports.

The ABB-ES QA Supervisor and Project Manager have delegated implementation of analytical QC functions as appropriate to the ESE Laboratory QAC. Major activities in the continued implementation of the AEC QA Program at ESE have include monitoring the QA/QC activities of the laboratory to ensure conformance with the established protocols and good laboratory practices, as appropriate; informing the Laboratory Program Manager, individual analysts, and ESE corporate management, as appropriate, of nonconformance to the QA Program and recommending corrective actions to reestablish conformance with the requirements of the QA Program; and requesting the appropriate Standard Analytical Reference Materials from AEC upon receipt of delivery orders.

The QAC has also been responsible for ensuring that all documents pertaining to the Fort Devens effort (i.e., records, logs, standard procedures, project plans and analytical results) are maintained in a retrievable fashion and distributed to the appropriate personnel; establishing, with the analysts, the proper analytical lot size for daily analysis and correct daily QC samples to be included in each lot according to the established procedures for evaluating acceptable, in-control analytical performance (i.e., initial and daily calibration and appropriate control charts); and establishing, with the designated sample custodian, that samples received in the laboratory are logged in properly, and are the appropriate analytical lot size. In addition, it has been the QAC's responsibility to verify that sample numbers for the QC samples were allocated in the correct manner.

Other duties have included ensuring that analysts were preparing the proper QC samples, maintaining control charts, and implementing any recommended corrective actions; ensuring that instrument logs and QC documents were being maintained with all the required information documented; collecting control charts from the analysts, discussing the results with the analysts and Laboratory Program Manager, and submitting these control charts to ABB-ES on a regular basis; reviewing all laboratory data prior to the reporting of data to other project participants; and maintaining an awareness of the entire laboratory operation for adherence to the procedures specified in the AEC QA Program.

1.5.9 Project Review Committee

A key component of ABB-ES' corporate QC policy is the designation of a Project Review Committee (PRC) for each project or task. The members of the PRC were assigned according to the technical functions to be conducted. During the Groups 3, 5, and 6 SI effort, the function of this group of senior technical and/or management personnel has been to provide guidance on the technical aspects of the project. This has been accomplished through periodic reviews of the services provided to ensure they (1) reflected the accumulated experience of the firm, (2) were being produced in accordance with corporate policy, and, most importantly, (3) met the objectives of the program as established by ABB-ES and AEC.

1.6 SITE INVESTIGATION REPORT ORGANIZATION

After identifying chemical-specific applicable or relevant and appropriate requirements (ARARs) and acquiring and evaluating the supplemental field and laboratory data, ABB-ES has prepared this Revised Final SI Report for the Groups 3, 5, and 6 SAs in accordance with USEPA and AEC guidance. The report describes the field methods employed and presents, summarizes, and evaluates the relevant background information and the field and laboratory data.

Section 2.0 of this report describes the history and physical setting of Fort Devens. Section 3.0 summarizes the site investigation program, including the field procedures, analytical program, quality assurance and quality control, data management, background concentrations of inorganic analytes, and preliminary risk evaluation methods. Sections 4.0, 5.0, and 6.0 present the site investigation data, evaluations, conclusions, and recommendations for Groups 3, 5, and 6, respectively.

Because of the success of the SI Data Packages concept and in the interest of accelerating the process, the decision-makers have elected to waive the standard draft report submittal and review process. This report is submitted as the Revised Final version of the SI Report.

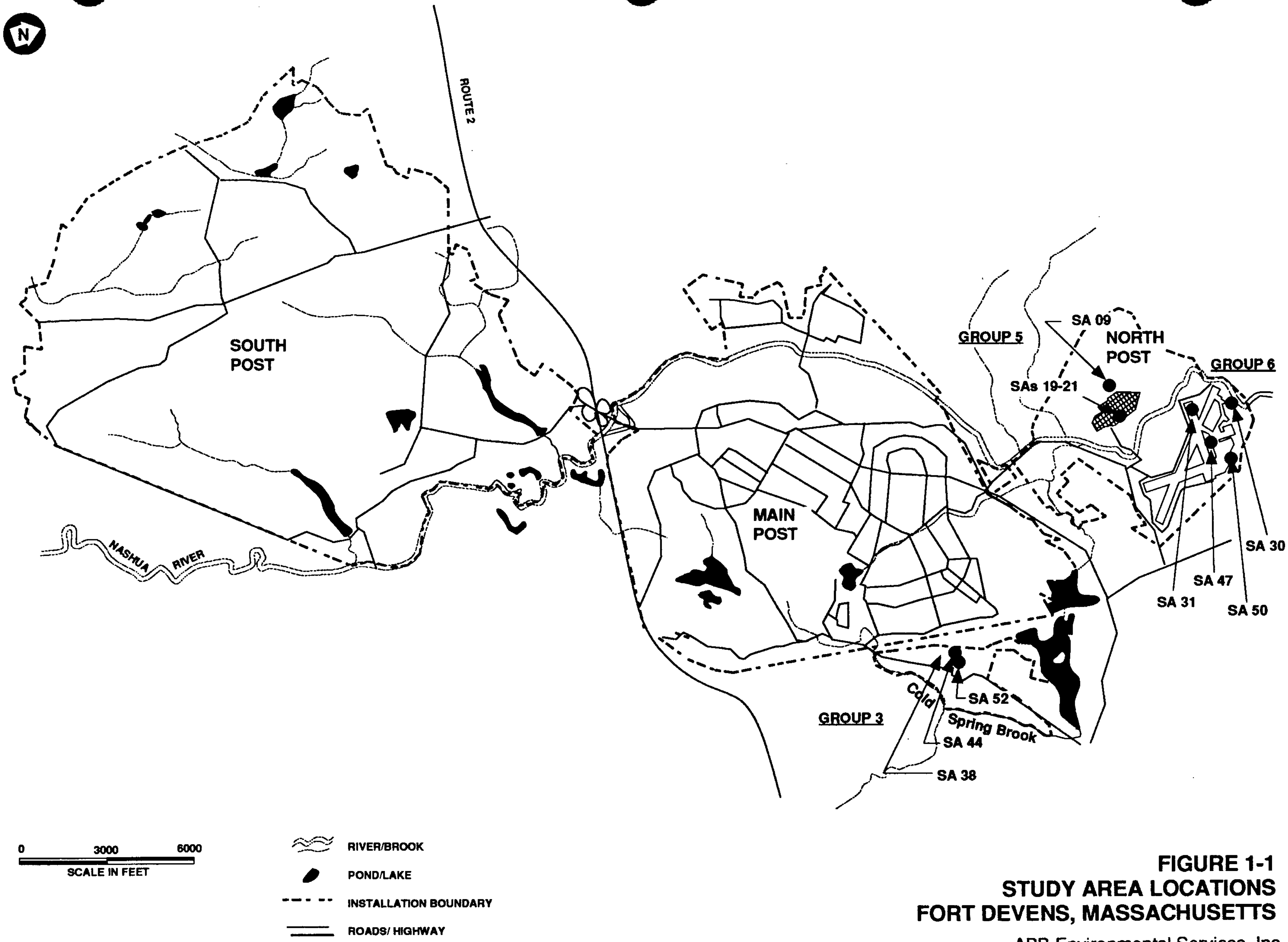


FIGURE 1-1
STUDY AREA LOCATIONS
FORT DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.

7053-07 A

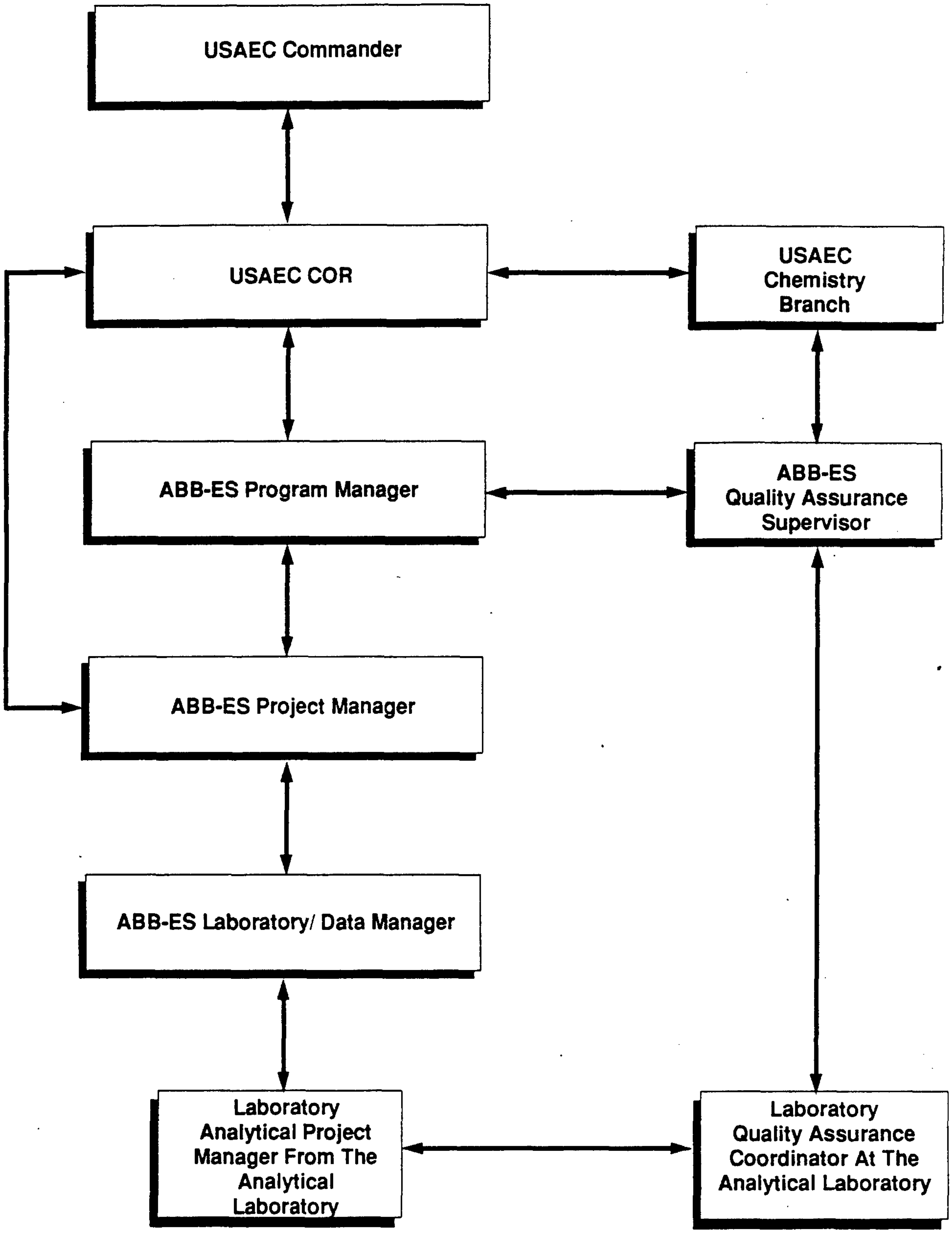


FIGURE 1-2
QA/QC FUNCTIONAL ORGANIZATIONAL CHART
FORT DEVENS, MASSACHUSETTS

TABLE 1-1
LIST OF STUDY AREAS

SITE INVESTIGATION REPORT
FORT DEVENS

GROUP	STUDY AREA NUMBER	STUDY AREA NAME
3	38	Building 3713/Battery Repair Area
	44	Cannibalization Yard
	52	TDA Maintenance Yard (Class III Leak Storage Yard)
5	9	North Post Landfill (No. 5)
	19	Wastewater Treatment Plant
	20	Rapid Infiltration Sand Beds
	21	Sludge Drying Beds
6	30	Moore Army Airfield Drum Storage Area
	31	Moore Army Airfield Fire-Fighting Training Center
	47	Moore Army Airfield Underground Storage Tank Site
	50	Moore Army Airfield World War II Fuel Point

TABLE 1-2
LIST OF INSTALLATION-WIDE STUDY AREAS

SITE INVESTIGATION REPORT
FORT DEVENS

GROUP NO.	STUDY AREA	GROUP NO.	STUDY AREA
1A	4 Sanitary landfill incinerator 5 Sanitary landfill 18 Sanitary landfill asbestos cell 40 Cold Spring Brook landfill	7	12 Landfill No. 8 14 Landfill No. 10 27 Waste explosives detonation range (Hotel) 28 Waste explosives detonation range (Training Area 14) 41 Unauthorized dump area (Site A) 42 Popping furnace
1B	15 Landfill No. 11 24 Waste explosives storage bunker 187 25 Waste explosives detonation range(EOD range) 26 Waste explosives detonation range (Zulu I and II) 32 DRMO yard 48 Bldg. 202 LUST site	8	16 Landfill No. 12 17 Little Mirror Lake (Landfill No. 13) 29 Transformer storage area 39 Transformer near Bldg. 4250
		9	10 Landfill No. 6 11 Landfill No. 7 51 O'Neil building spill site 55 Shirley Housing Area trailer park fuel tanks
2	13 Landfill No. 9 43 Historic gas station sites 45 Lake George Street vehicle wash area 49 Bldg. 3602 LUST site 54 Bldg. 2680 LUST site (same as 43-0) 56 Bldg. 2417 leaking underground storage tank site 57 Bldg. 3713 fuel oil spill 58 Bldgs. 2648 and 2650 fuel oil spills	10	6 Landfill No. 2 7 Landfill No. 3 8 Landfill No. 4 46 Training Area 6c 53 South Post POL spill area
3	38 Battery repair area 44 Cannibalization yard 52 TDA maintenance yard	11	1 Cutler Army Hospital incinerator 2 Veterinary clinic incinerator 3 Intelligence School incinerator
4	33 DEH entomology shop (Bldg. 262) 34 Former DEH entomology shop at Bldg. 245 35 Former DEH entomology shop at Bldg. 254 36 Former DEH entomology shop at Bldg. 2728 37 Golf course entomology shop (Bldg. 3622)	12	22 Hazardous waste storage facility at Bldg. 1650 23 Paper recycling center 59 Bridge 526
5	9 Landfill No. 5 19 Wastewater treatment plant 20 Rapid infiltration beds 21 Sludge drying beds	AREE	60 Training areas and ranges 61 Maintenance and Waste Accumulation Areas 62 Existing underground storage tanks 63 Previously removed underground storage tanks 64 Above ground storage tanks 65 Asbestos 66 Transformers 67 Radon 68 Lead paint 69 Past spill sites 70 Storm sewer systems
6	30 Moore Army Airfield drum storage area 31 Moore Army Airfield fire-fighting training area 47 Moore Army Airfield LUST site (Bldg. 3816) 50 Moore Army Airfield WWII fuel point		

Note: AREE = Area requiring environmental investigation.

2.0 INSTALLATION DESCRIPTION

Fort Devens is located in the towns of Ayer and Shirley (Middlesex County) and Harvard and Lancaster (Worcester County), approximately 35 miles northwest of Boston, Massachusetts. It lies within the Ayer, Shirley, and Clinton map quadrangles (7½-minute series). The installation occupies approximately 9,260 acres and is divided into the North Post, the Main Post, and the South Post (Figure 2-1).

Over 6,000 acres at Fort Devens are used for training and military maneuvers, and over 3,000 acres are developed for housing, buildings, and other facilities; the installation has been reported as the largest undeveloped land holding under a single owner in north-central Massachusetts (USFWS, 1992).

The South Post is located south of Massachusetts Route 2 and is largely undeveloped. The Main Post and North Post primarily contain developed lands, including recreational areas (e.g., a golf course and Mirror Lake), training areas, and an airfield. All Groups 3, 5, and 6 SAs are located on either the Main or North Posts.

The following sections describe the history and physical setting of Fort Devens.

2.1 HISTORY

Camp Devens was created as a temporary cantonment in 1917 for training soldiers from the New England area. It was named after Charles Devens -- a Massachusetts Brevet Major General in the Union Army during the Civil War who later became Attorney General under President Rutherford Hayes. Camp Devens served as a reception center for selectees, as a training facility, and, at the end of World War I, as a demobilization center (Marcoa Publishing Inc., 1990). At Camp Devens the 1918 outbreak of Spanish influenza infected 14,000 people, killed 800, and caused the installation to be quarantined (McMaster et al., 1982). Peak military strength during World War I was 38,000. After the war, Camp Devens became an installation of the U.S. Army Forces Command (FORSCOM) (Biang et al., 1992).

In 1921, Camp Devens was placed in caretaker status. During summers from 1922 to 1931, it was used as a training camp for National Guard troops, Reserve units, Reserve Officer Training Corps (ROTC) cadets, and the Civilian Military Training Corps (CMTC). In 1929, Dr. Robert Goddard used Fort Devens to test his early liquid-fuel rockets, and there is a monument to him on Sheridan Road near Jackson Gate (Fort Devens Dispatch, 1992).

In 1931, troops were again garrisoned at Camp Devens. It was declared a permanent installation, and in 1932 it was formally dedicated as Fort Devens. During the 1930s, there was a limited building program, and beautification projects were conducted by the Works Progress Administration (WPA) and Civilian Conservation Corps (CCC).

In 1940, Fort Devens became a reception center for New England draftees. It expanded to more than 10,000 acres. Approximately 1,200 wooden buildings were constructed, and two 1,200-bed hospitals were built. In 1941, the Army Airfield was constructed by the WPA in a period of 113 days (Fort Devens Dispatch, 1992). In 1942, the Whittemore Service Command Base Shop for motor vehicle repair (Building 3713) was built, and at the time it was known as the largest garage in the world (U.S. Department of the Army, 1979). The installation's current wastewater treatment plant was also constructed in 1942 (Biang et al., 1992).

During World War II, more than 614,000 inductees were processed. Fort Devens' population reached a peak of 65,000. Three Army divisions and the Fourth Women's Army Corps trained at Fort Devens, and it was the location of the Army's Chaplain School, the Cook & Baker School, and a basic training center for Army nurses. A prisoner of war camp for 5,000 German and Italian soldiers was operated from 1944 to 1946. At the end of the war, Fort Devens again became a demobilization center, and in 1946 it reverted to caretaker status.

Fort Devens was reactivated in July 1948 and again became a reception center during the Korean Conflict. It has been an active Army facility since that time.

Currently the mission at Fort Devens is to command and train its assigned duty units, operate the South Boston Support Activity in Boston, Massachusetts, Sudbury Training Annex and Hingham USAR Annex and to support the 10th Special Forces Group (A), the U.S. Army Intelligence School, Fort Devens, the

U.S. Army Reserves, Massachusetts Army National Guard, and Reserve Officer Training Programs. No major industrial operations occur at Fort Devens, although several small-scale industrial operations are performed under (1) the Directorate of Plans, Training, and Security; (2) the Directorate of Logistics; and (3) the Directorate of Engineering and Housing. The major waste-producing operations performed by these groups are photographic processing and maintenance of vehicles, aircraft, and small engines. Past artillery fire, mortar fire, and waste explosive disposal at Fort Devens are potential sources for environmental explosives contamination (AEC, 1993).

Under Public Law 101-510, the Defense Base Closure and Realignment Act of 1990 (BRAC), Fort Devens has been identified for closure by July 1997, and retention of 4,600 acres to establish a Reserve Component enclave and regional training center.

2.2 PHYSICAL SETTING

The climate, vegetation, ecology, physiography, soils, surficial and bedrock geology, and regional hydrogeology of Fort Devens are described in the sections that follow.

2.2.1 Climate

The climate of Fort Devens is typical of the northeastern United States, with long cold winters and short hot summers. Climatological data were reported for Fort Devens by U.S. Department of the Army (1979), based in part on a 16-year record from Moore Army Airfield (MAAF).

The mean daily minimum temperature in the coldest months (January and February) is 17 degrees Fahrenheit (° F), and the mean daily maximum temperature in the hottest month (July) is 83° F. The average annual temperature is 58° F. There are normally 12 days per year when the temperature reaches or exceeds 90° F and 134 days when it falls to or below freezing.

The average annual rainfall is 39 inches. Mean monthly precipitation varies from a low of 2.3 inches (in June) to a high of 5.5 inches (in September). The average annual snowfall is 65 inches, and snowfall has been recorded in the months of September through May (falling most heavily from December through March).

Wind speed averages 5 miles per hour (mph), ranging from the highest monthly average of 7 mph (March-April) to the lowest monthly average of 4 mph (September).

Average daytime relative humidities range from 71 percent (January) to 91 percent (August), and average nighttime relative humidities range from 46 percent (April) to 60 percent (January).

2.2.2 Vegetation

The Main and North Posts at Fort Devens are primarily characterized by urban and developed cover types. Approximately 56 percent of that area is covered by developed lands, the golf course, the airfield, and the wastewater infiltration beds. Early successional forest cover types (primarily black cherry-aspen hardwoods) encompass approximately 2 percent of the area, mixed oak-red maple hardwoods approximately 20 percent, and white pine-hardwood mixes approximately 11 percent. The rest of the North and Main Posts are characterized by various coniferous species, shrub habitat, and herbaceous cover types.

Much of the South Post is undeveloped forested land. The area includes approximately 8 percent early successional forest (black cherry, red birch, grey birch, quaking aspen, red maple); 26 percent mixed oak hardwoods; and 9 percent coniferous forest (white pine, pitch pine, red pine). Four percent of the area comprises a mixed shrub community. The 200-acre Turner Drop Zone is maintained as a grassland that represents a "prairie" habitat. Vegetative cover in the large "impact area" of the central South Post has not been mapped in detail. It is dominated by fire-tolerant species such as pitch pine and scrub oak.

Extensive sandy glaciofluvial soils are found in the Nashua River Valley, particularly in the South and North Post areas of Fort Devens. Extensive accumulations of these soils are unusual in Massachusetts outside of Cape Cod and adjacent areas of southeastern Massachusetts, and they account for some of the floral and faunal diversity at the installation.

2.2.3 Ecology

Fort Devens encompasses numerous terrestrial, wetland, and aquatic habitats in various successional stages. Floral and faunal diversity is strengthened by the installation's close proximity to the Nashua River; the amount, distribution, and nature of wetlands; and the undeveloped state and size of the South Post (USFWS, 1992). Much of Fort Devens was formerly agricultural land and included pastures, woodlots, orchards, and cropped fields. Existing habitat types reflect this agrarian history, ranging from abandoned agricultural land to secondary growth forested regions. Fort Devens is generally reverting back to a forested state.

There are 1,313 acres of wetlands at Fort Devens. The wetlands are primarily palustrine, although riverine and lacustrine types are also found. Forested palustrine floodplain wetlands associated with the Nashua River and its tributary Nonacoicus Brook are located on Fort Devens' Main and North Posts. These include 191 acres of flooded areas, emergent marsh, and shrub wetlands. Also present are 245 acres of isolated regions of palustrine wetlands and lacustrine systems. On the South Post, there are 877 acres of wetlands, consisting of deciduous forested wetlands, deciduous shrub swamps, emergent marsh, open lacustrine waters in ponds, and open riverine waters.

Approximately half of Fort Devens' land area abuts the northern boundary of the Oxbow National Wildlife Refuge (NWR), a federal resource administered as part of the Great Meadows NWR (USFWS, 1992).

Fort Devens supports an abundance and diversity of wildlife (ABB-ES, August 1993). Identified taxa include 771 vascular plant species, 538 species of butterflies and moths, eight tiger beetle species, 30 vernal pool invertebrates, 15 amphibian species (six salamanders, two toads, seven frogs), 19 reptile species (seven turtles, 12 snakes), 152 bird species, and 42 mammal species. The status of fish populations in Fort Devens aquatic systems has not been fully defined.

Rare and endangered species at Fort Devens include the federally listed (endangered) bald eagle and peregrine falcon (both occasional transients); the state-listed (endangered) upland sandpiper, ovoid spike rush, and Houghton's flatsedge; the state-listed (threatened) Blanding's turtle, cattail sedge, pied-billed grebe, and northern harrier; and the state-listed (special concern) blue-spotted salamander, grasshopper sparrow, spotted turtle, wood turtle, water shrew, blackpoll warbler, American bittern, Cooper's hawk, sharp-shinned hawk, and Mystic Valley amphipod. Also state listed as rare or endangered are three Lepidoptera (butterfly and moth) species identified at Fort Devens.

The Massachusetts Natural Heritage Program has developed Watch Lists of unprotected species that are uncommon or rare in Massachusetts. From the Watch Lists 14 plant species, two amphibian species, and 15 bird species have been observed at Fort Devens.

Additional detail concerning the ecology of Fort Devens was reported by ABB-ES (Aug. 1993) and can be found in Section 3.8.2 and in the ecological risk evaluations of individual study areas presented in Sections 4.0, 5.0, and 6.0 of this report.

2.2.4 Physiography

Fort Devens is in a transitional area between the coastal lowland and central upland regions of Massachusetts. All of the landforms are products of glacial erosion and deposition on a crystalline bedrock terrain. Glacial erosion was superimposed on ancient bedrock landforms that were developed by the erosional action of preglacial streams. Generally, what were bedrock hills and ridges before the onset of Pleistocene glaciation were only moderately modified by glacial action, and they remain bedrock hills and ridges today. Similarly, preglacial bedrock valleys are still bedrock valleys. In post-glacial time, streams have locally modified the surficial glacial landforms but generally have not affected bedrock.

The predominant physiographic (and hydrologic) feature in the Fort Devens area is the Nashua River (see Figure 2-1). It forms the eastern installation boundary on the South Post, where its valley varies from a relatively narrow channel (at Still River Gate), to an extensive floodplain with a meandering river course and numerous cutoff meanders (at Oxbow NWR). The Nashua River forms the western boundary of much of the Main Post, and there its valley is deep and comparatively steep-sided with extensive bedrock outcroppings on the eastern bank. The river flows through the North Post in a well defined channel within a broad forested floodplain.

Terrain at Fort Devens falls generally into three types. The least common is bedrock terrain, where rocks that have been resistant to both glacial and fluvial erosion remain as topographic highs, sometimes thinly veneered by glacial deposits. Shepley's Hill on the Main Post is the most prominent example.

A similar but more common terrain at Fort Devens consists of materials (tills) deposited directly by glaciers as they advanced through the area or as the ice masses wasted (melted). These landforms often conform to the shape of the underlying bedrock surface. They range from areas of comparatively low topographic relief (such as near Lake George Street on the Main Post) to elongated hills (drumlins) whose orientations reflect the direction of glacier movement (such as Whittemore Hill on the South Post).

The third type of terrain was formed by sediment accumulations in glacial-meltwater streams and lakes (glaciofluvial and glaciolacustrine deposits). This is the most common terrain at Fort Devens, comprising most of the North and South Posts and much of the Main Post. Its form bears little or no relationship to the shape of the underlying bedrock surface. Landforms include extensive flat uplands such as the hills on which Moore Army Airfield and the wastewater infiltration beds are located on the North Post. Those are large remnants of what was once a continuous surface that was later incised and divided by downcutting of the Nashua River. Another prominent glacial meltwater feature is the area around Cranberry Pond and H-Range on the South Post. This is classic kame-and-kettle topography formed by sand and gravel deposition against and over large isolated ice blocks, followed by melting of the ice and collapse of the sediments. The consistent elevations of the tops of these ice-contact deposits are an indication of the glacial-lake stage with which they are associated. Mirror Lake and Little Mirror Lake on the Main Post occupy another conspicuous kettle.

2.2.5 Soils

Fort Devens lies within Worcester County and Middlesex County in Massachusetts (Figure 2-1). The soils of Worcester County have been mapped by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture (USDA) (SCS, 1985). Mapping of the soils of Middlesex County has not been completed. However, an interim report (SCS, 1991), field sheet #19 (SCS, 1989), and an unpublished general soil map (SCS, undated) are available.

Soil mapping units ("soil series") that occur together in intricate characteristic patterns in given geographic areas are grouped into soil "associations." Soils in the Worcester County portions of Fort Devens consist generally of three associations. Three associations also have been mapped in the Middlesex County portions of Fort Devens. Although the mapped associations are not entirely the same on both sides of the county line, the differences reflect differences in definition and the interim status of Middlesex County mapping. The general distributions of the soil associations are shown in Figure 2-2, and descriptions of the soil series in those associations are provided below.

WORCESTER COUNTY (SCS, 1985)

Winooski-Limerick-Saco Association:

Winooski Series. Very deep; moderately well drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Limerick Series. Very deep; poorly drained; slopes 0 to 3 percent; occurs on floodplains; forms in silty alluvium.

Saco Series. Very deep; very poorly drained; slopes 0 to 3 percent; occurs on floodplains; derived mainly from schist and gneiss.

Hinckley-Merrimac-Windsor Association:

Hinckley Series. Very deep; excessively drained; slopes 0 to 35 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Merrimac Series. Very deep; excessively drained; slopes 0 to 25 percent; occurs on stream terraces, eskers, kames, and outwash plains.

Windsor Series. Very deep; moderately well drained; slopes 0 to 3 percent; occurs on floodplains.

Paxton-Woodbridge-Canton Association:

Paxton Series. Very deep; well drained; slopes 3 to 35 percent; occurs on glacial till uplands; formed in friable till overlying firm till.

Woodbridge Series. Very deep; moderately well drained; slopes 0 to 15 percent; occurs on glacial till uplands; formed in firm till.

Canton Series. Very deep; well drained; slopes 3 to 35 percent; occurs on glaciated uplands; formed in friable till derived mainly from gneiss and schist.

MIDDLESEX COUNTY (SCS, 1991)

Hinckley-Freetown-Windsor Association (This is a continuation of the Hinckley-Merrimac-Windsor Association mapped in Worcester County):

Hinckley Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash terraces, kames, and eskers; formed in gravelly and cobbley coarse textured glacial outwash.

Freetown Series. Deep; very poorly drained; nearly level, organic; occurs in depressions and on flat areas of uplands and glacial outwash plains.

Windsor Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, deltas, and escarpments; formed in sandy glacial outwash.

Quonset-Carver Association:

Quonset Series. Deep; excessively drained; nearly level to very steep; occurs on glacial outwash plains, terraces, eskers, and kames; formed in water-sorted sands derived principally from dark phyllite, shale, or slate.

Carver Series. Deep; excessively drained; nearly level to steep; occurs on glacial outwash plains, terraces, and deltas; formed in coarse, sandy, water-sorted material.

Winooski-Limerick-Saco Association (This is a continuation of the same association mapped along the Nashua River floodplain in Worcester County).

2.2.6 Surficial Geology

Fort Devens lies in three topographic quadrangles: Ayer, Clinton, and Shirley. The surficial geology of Fort Devens has been mapped only in the Ayer quadrangle (Jahns, 1953) and Clinton quadrangle (Koteff, 1966); the Shirley quadrangle is unmapped.

Unconsolidated surficial deposits of glacial and postglacial origin comprise nearly all of the exposed geologic materials at Fort Devens. The glacial units consist of till, deltaic deposits of glacial Lake Nashua, and deposits of glacial meltwater streams.

The till ranges from unstratified gravel to silt, and it is characteristically bouldery. Jahns (1953) and Koteff (1966) recognize a deeper unit of dense, subglacial till, and an upper, looser material that is probably a slightly younger till of englacial or superglacial origin. Till is exposed in ground-moraine areas of the Main Post (such as in the area of Lake George Street) and on the South Post at and south of Whittemore Hill. It also underlies some of the water-laid deposits (Jahns, 1953). Till averages approximately 10 feet in thickness but reaches 60 feet in drumlin areas (Koteff, 1966).

Most of the surficial glacial units in the Nashua Valley are associated with deposition in glacial Lake Nashua, which formed against the terminus of the Wisconsinan ice sheet as it retreated northward along the valley. Successively lower outlets were uncovered by the retreating glacier, and the lake level was correspondingly lowered. Koteff (1966) and Jahns (1953) recognize six lake levels (stages) in the Fort Devens area, distinguished generally by the elevations and distribution of their associated deposits. The stages are, in order of development: Clinton Stage; Pin Hill Stage; Old Mill Stage; Harvard Stage; Ayer Stage; and Groton Stage.

The glacial lake deposits consist chiefly of sand and gravelly sand. Coarser materials are found in topset beds of deltas built out into the lakes and in glacial stream beds graded to the lakes. Delta foreset beds are typically composed of medium to fine sand, silt, and clay. Lake-bottom deposits, which consist of fine sand, silt, and clay, are mostly covered by delta deposits and are seldom observed in glacial Lake Nashua deposits. One of the few known exposures of glacial lake-bottom sediments in the region is on the South Post near A- and C-Ranges. There a section of more than 14 feet of laminated clay was mined for brick-making in the early part of this century (Alden, 1925, pp. 70-71). The general physical characteristics of glacial lake deposits are the same regardless of the particular lake stage in which the deposits accumulated (Koteff, 1966; Jahns, 1953). Although glaciofluvial and glaciolacustrine sediments are typically well stratified, correlations between borings are difficult because of laterally abrupt changes characteristic of these generally high-energy depositional environments.

Postglacial deposits consist mostly of river-terrace sands and gravels; fine alluvial sands and silts beneath modern floodplains; and muck, peat, silt, and sand in swampy areas.

Jahns (1953) also observed a widespread veneer of windblown sand and ventifacts above the glacial materials (and probably derived from them in the brief interval between lake drainage and the establishment of vegetative cover).

2.2.7 Bedrock Geology

Fort Devens is underlain by low-grade metasedimentary rocks, gneisses, and granites. The rocks range in age from Late Ordovician to Early Devonian (approximately 450 million to 370 million years old). The installation is situated approximately 2 miles west of the Clinton-Newbury-Bloody Bluff fault zone, which developed when the ancestral European continental plate collided with and underthrust the ancestral North American plate. The continents reseparated in the Mesozoic to form the modern Atlantic Ocean. Fort Devens is located on the very eastern edge of the ancestral North American continental plate. A piece of the ancestral European continent (areas now east of the Bloody Bluff fault) broke off and remained attached to North America.

Preliminary bedrock maps (at scale 2,000 feet/inch) are available for the Clinton quadrangle (Peck, 1975 and 1976) and Shirley quadrangle (Russell and Allmendinger, 1975; Robinson, 1978). Bedrock information for the Ayer quadrangle is from the Massachusetts state bedrock map (at a regional scale of 4 miles/inch) (Zen, 1983) and in associated references (Robinson and Goldsmith, 1991; Wones and Goldsmith, 1991). Among these sources, there is some disagreement about unit names and stratigraphic sequence; however, there is general agreement about the distribution of rock types.

In contrast to the high metamorphic grade and highly sheared rocks of the Clinton-Newbury zone, the rocks in the Fort Devens area are low grade metamorphics (generally below the biotite isograd) and typically exhibit less brittle deformation. Major faults have been mapped, however, including the

Wekepeke fault exposed west of Fort Devens (in an outcrop 0.25 mile west of the old Howard Johnson rest stop on Route 2).

Figure 2-3 is a generalized summary of the bedrock geology of Fort Devens. It is compiled from Peck (1975), Robinson (1978), Russell and Allmendinger (1975), and Zen (1983), and it adopts the nomenclature of Zen (1983). Because of limited bedrock exposures, the locations of mapped contacts are considered approximate, and the mapped faults are inferred. Rock units strike generally northward to northeastward but vary locally. The bedrock units underlying Fort Devens are as follows:

DSw **WORCESTER FORMATION** (Lower Devonian and Silurian) Carbonaceous slate and phyllite, with minor metagraywacke to the west (Zen, 1983; Peck, 1975). Bedding is typically obscure due to a lack of compositional differences. It is relatively resistant to erosion and forms locally prominent outcrops. The abandoned Shaker slate quarry on the South Post is in rocks of the Worcester Formation. The unit corresponds to the "DSgs" and "DSs" units of Peck (1975) and the "e3" unit of Russell and Allmendinger (1975).

So **OAKDALE FORMATION** (Silurian) Metasiltstone and phyllite. It is fine-grained and consists of quartz and minor feldspar and ankerite, and it is commonly deformed by kink banding (Zen, 1983; Peck, 1975; Russell and Allmendinger, 1975). In outcrop it has alternating layers of brown siltstone and greenish phyllite. The Oakdale Formation crops out most visibly on Route 2 just east of the Jackson Gate exit and on the east side of Jackson road approximately 500 feet north of the gate. It corresponds to the "DSsp" unit of Peck (1975), the "e2" unit of Russell and Allmendinger (1975), and the "ms" unit of Robinson (1978).

Sb **BERWICK FORMATION** (Silurian) Thin- to thick-bedded metamorphosed calcareous metasiltstone, biotitic metasiltstone, and fine-grained metasandstone, interbedded with quartz-muscovite-garnet schist and feldspathic quartzite (Zen, 1983; Robinson and Goldsmith, 1991). In areas northwest of Fort Devens, cataclastic zones have been observed (Robinson, 1978).

Dcgr **CHELMSFORD GRANITE** (Lower Devonian) Light-colored and gneissic, even and medium grained, quartz-microcline-plagioclase-muscovite-biotite, pervasive ductile deformation visible in elongate quartz grains aligned parallel to mica. It intrudes the Berwick Formation and Ayer granite (Wones and Goldsmith, 1991).

AYER GRANITE

Sacgr **Clinton facies** (Lower Silurian) Coarse-grained, porphyritic, foliated biotite granite with a nonporphyritic border phase; it intrudes the Oakdale and Berwick Formations and possibly the Devens-Long Pond Facies (Zen, 1983; Wones and Goldsmith, 1991).

SOad **Devens-Long Pond facies** (Upper Ordovician and Lower Silurian) Gneissic, equigranular to porphyoblastic biotite granite and granodiorite. Its contact relationship with the Clinton facies is unknown (Wones and Goldsmith, 1991). Observations of mapped exposures of this unit on Fort Devens indicate that it may not be intrusive.

Bedrock is typically unweathered to only slightly weathered in the region. Glaciers stripped away virtually all of the preglacially weathered materials, and there has been insufficient time for chemical weathering of rocks in the comparatively brief geologic interval since glacial retreat. However, in the Fort Devens area weathered zones have developed on argillaceous units (e.g., the Worcester and Oakdale Formations) beneath glacial sediments. These weathered zones vary locally from a few inches in thickness, to several feet (apparently representing compositional differences in the parent rock). Where weathered argillites underlie clayey till, it is sometimes difficult to distinguish them in boring samples.

2.2.8 Regional Hydrogeology

Fort Devens is in the Nashua River drainage basin, and the Nashua River is the eventual discharge locus for all surface water and groundwater flow at the installation.

The water of the Nashua River has been assigned to Class B under Commonwealth of Massachusetts regulations. Class B surface water is "designated for the uses of protection and propagation of fish, other aquatic life and wildlife, and for primary and secondary contact recreation" (314 CMR 4.03).

The principal tributaries of the north-flowing Nashua River at Fort Devens are Nonacoicus Brook and Walker Brook on the North Post; Cold Spring Brook (which is a tributary of Nonacoicus Brook) on the Main Post; and Spectacle Brook and Ponakin Brook (tributaries of the North Nashua River), Slate Rock Brook, and New Cranberry Pond Brook on the South Post (Figure 2-4).

There are two ponds on Fort Devens' South Post that are called Cranberry Pond. For the purpose of the SIs, the isolated kettle pond located east of H-Range is referred to as Cranberry Pond, and the pond impounded in the 1970s 0.5-mile west of the Still River gate is referred to as New Cranberry Pond.

Glacial meltwater deposits constitute the primary aquifer at Fort Devens. In aquifer tests performed as part of the SIs (refer to Appendix A), measured hydraulic conductivities in meltwater deposits were comparatively high-- typically 10^{-3} to 10^{-2} centimeters per second (cm/sec). In till and in clayey lake-bottom sediments, measured hydraulic conductivities were lower and ranged generally from 10^{-6} to 10^{-4} cm/sec. Groundwater also occurs in the underlying bedrock; however, flow is limited because the rocks have no primary porosity and water moves only in fractures and dissolution voids.

Groundwater in the surficial aquifer at Fort Devens has been assigned to Class I under Commonwealth of Massachusetts regulations. Class I consists of "groundwaters that are found in the saturated zone of unconsolidated deposits or consolidated rock and bedrock and are designated as a source of potable water supply" (314 CMR 6.03).

The transmissivity of an aquifer is the product of its hydraulic conductivity and saturated thickness, and as such it is a good measure of groundwater availability. Figure 2-4 shows aquifer transmissivities at Fort Devens, based on the regional work of Brackley and Hansen (1977). Transmissivities in the meltwater deposits range from 10 square feet per day (ft^2/day) to more than 4,000 ft^2/day. Aquifer transmissivities between 10 and 1,350 ft^2/day correspond to potential well yields generally between 10 and 100 gallons per minute (gpm); transmissivities from 1,350 to 4,000 ft^2/day typically yield from 100 to 300 gpm; and where transmissivities exceed 4,000 ft^2/day, well yields greater than 300 gpm can be expected. (Most domestic wells in the area are drilled 100 to 200 ft into bedrock and yield less than 10 gpm. Higher yields are associated with deeper bedrock wells.)

In Figure 2-4, the zones of highest transmissivity are found in areas of thick glacial meltwater deposits on the North and Main Posts, and these encompass the Sheboken, Patton, and McPherson production wells and the largely inactive Grove Pond well-field. The zones of lowest transmissivity are associated with exposed till and bedrock and are located on the Main Post surrounding Shepley's Hill and between Jackson Gate and the parade ground, and on the South Post at Whittemore Hill and isolated areas to the north and west.

A regional study of water resources in the Nashua River basin was reported by Brackley and Hansen (1977). A digital model of groundwater flow at Fort Devens is available in a draft final report by Engineering Technologies Associates, Inc. (1992).

According to Engineering Technologies Associates, Inc. (1992), in the absence of pumping or other disturbances, groundwater recharge occurs in upland areas (e.g., the high ground on the Main Post between Queenstown, Givry, and Lake George Streets, and on the South Post the area around Whittemore Hill). The groundwater flows generally from the topographic highs to topographic lows. It discharges in wetlands, ponds, streams, and directly into the Nashua River. Groundwater discharge maintains the dry-weather flow of the rivers and streams.

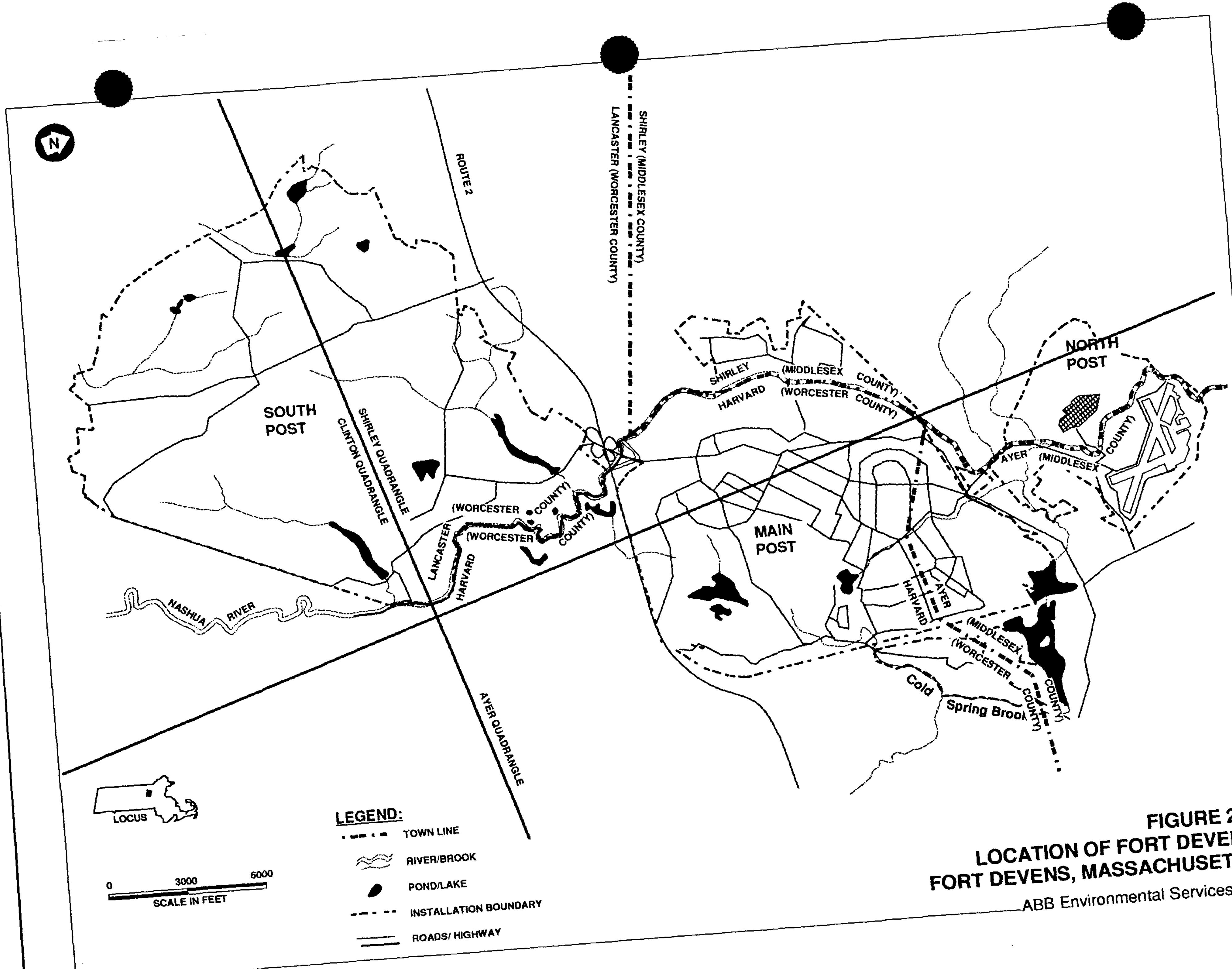
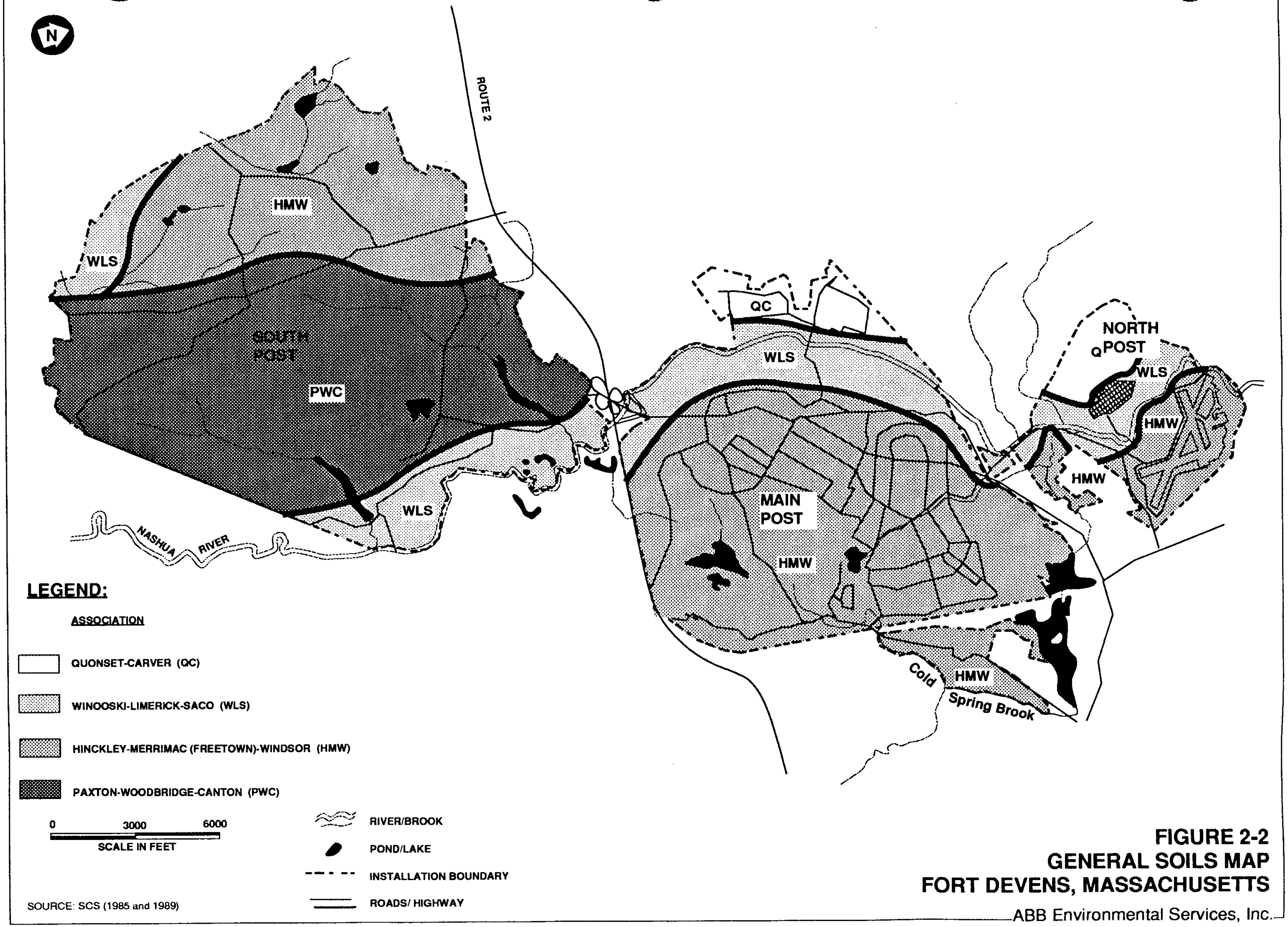


FIGURE 2-1
LOCATION OF FORT DEVENS
FORT DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.

7053-07 A

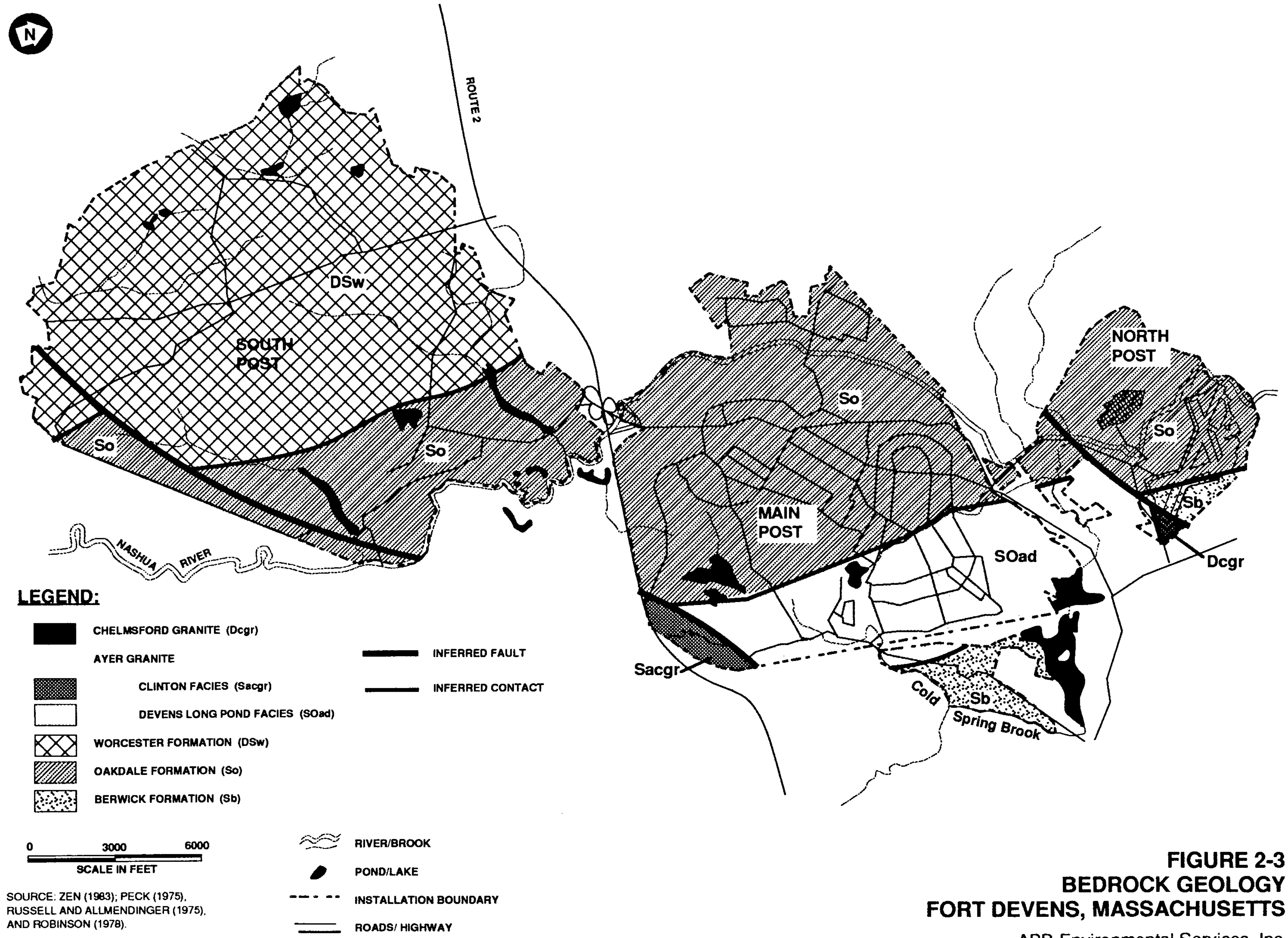


SOURCE: SCS (1985 and 1989)

FIGURE 2-2
GENERAL SOILS MAP
FORT DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.

7053-07 A



SOURCE: ZEN (1983); PECK (1975), RUSSELL AND ALLMENDINGER (1975), AND ROBINSON (1978).

FIGURE 2-3
BEDROCK GEOLOGY
FORT DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.

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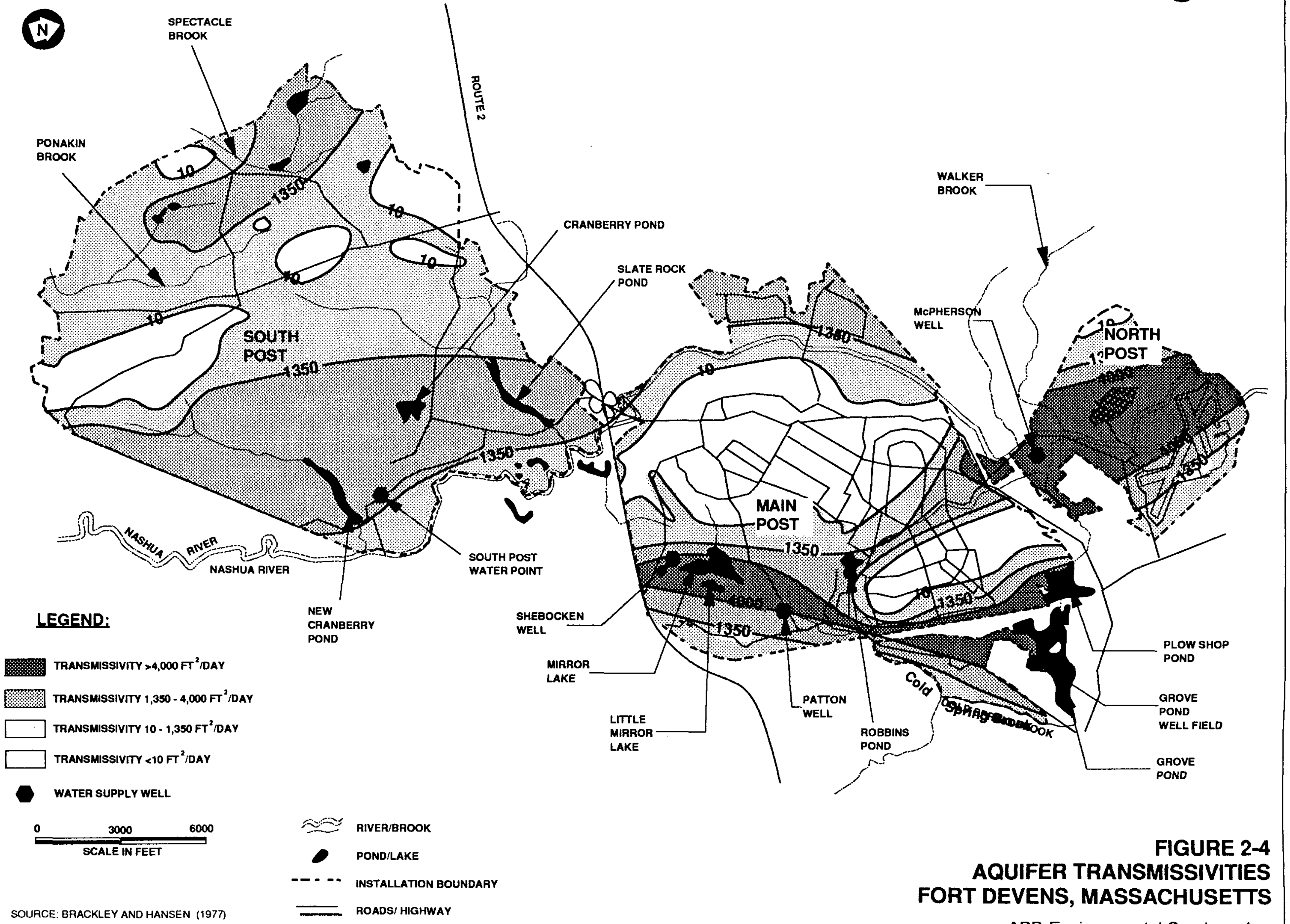

SOURCE: BRACKLEY AND HANSEN (1977)

FIGURE 2-4
AQUIFER TRANSMISSIVITIES
FORT DEVENS, MASSACHUSETTS

ABB Environmental Services, Inc.

7053-07 A

3.0 SITE INVESTIGATION PROGRAM SUMMARY

The SI investigations were conducted in conformance with the Task Order Work Plans (ABB-ES, June and Sept. 1992, April 1993b; Rice, May and Dec. 1994) and the Project Operations Plan (ABB-ES, July 1992 and July 1993).

The SI program for the Groups 3, 5, and 6 SAs consisted of:

- geophysical surveys for utility clearance and subsurface characterization;
- drilling of soil borings;
- excavation of test pits;
- surface soil sampling;
- soil-vapor survey;
- installation of monitoring wells;
- well development;
- survey of explorations;
- groundwater sampling;
- aquifer characterization;
- surface water and sediment sampling;
- laboratory chemical analysis;
- synoptic (installation-wide) water-level measurements; and
- stream-flow measurements in Cold Spring Brook and the Nashua River.

ABB-ES established a project field office in Building 201 on Fort Devens' Main Post. The field office was used for equipment storage and maintenance, sample management, shipping and receiving, staff meetings, and communications. A radio base-station and telephone were maintained in the field office; each field crew was issued a hand-held radio or portable telephone.

ABB-ES and its field subcontractors initiated the Groups 3, 5, and 6 field program in June 1992, and it was conducted during the following periods:

Initial SIs (all SAs in Groups 3, 5, & 6):
June 1992 - January 1993

Supplemental SIs (SAs 38, 44/52, 21 and 50):
May 1993 - September 1993

Phase III SIs:

SA 50 -	August 1994 - January 1995
SA 21 -	May 1995

A decontamination pad was constructed adjacent to the field office by the first drilling subcontractor (D.L. Maher,Inc.), and it remained in use through the end of the SI program. For each field effort, ABB-ES mobilized its field office equipment and supplies, its health and safety equipment, and its sampling and monitoring equipment. ABB-ES and subcontractor staff were briefed about the nature of the SAs, health and safety information, Fort Devens traffic regulations, and key technical requirements.

DIGSAFE was notified more than three days before each phase of drilling and excavation were undertaken. Where installation records indicated the presence of buried utilities, or where buried utilities were otherwise considered possible, a ground-penetrating radar (GPR) survey was conducted by ABB-ES to clear the proposed explorations.

The subcontractors used by ABB-ES in conducting the SI program were as follows:

Drilling, monitoring-well installation, test-pit excavation:

- D. L. Maher, Inc., North Reading, MA
- Soil Exploration, Inc., Leominster, MA
- New Hampshire Boring, Inc., Derry NH

Surveying of site explorations:

- Golden Land Survey, Plymouth, MA
- Howe Surveying Assoc., Inc., North Chelmsford, MA
- Martinage Engineering Assoc., Inc., Reading, MA

Chemical analysis of environmental samples:

- Environmental Science & Engineering, Inc. (ESE), Gainesville, FL

Coliform analysis of groundwater and surface-water samples:

- Revet Laboratories, Worcester, MA

Geotechnical testing (seive analysis) of soil and sediment samples:

- Civil Test, Needham, MA

3.1 FIELD INVESTIGATION PROCEDURES

The following sections provide summaries of the procedures used by ABB-ES and its subcontractors in performing the investigations and related activities. The results of these investigations are summarized in Sections 4.0, 5.0, and 6.0.

3.1.1 Geophysical Surveying

Geophysical methods were employed on the ground surface to locate buried utilities, tanks, and associated piping, and to determine the extent of landfilled materials. The principal methods used were magnetometry, ground-penetrating radar, and terrain conductivity. In some applications a combination of these techniques was used to correlate geophysical anomalies and provide a more comprehensive interpretation. For magnetic and terrain-conductivity surveys, grids were laid out and marked by stakes and wire flags or by spray-painting (on pavement). Geophysical measurements were made and recorded at the grid nodes.

3.1.1.1 Magnetometry. Magnetometers measure variations in the Earth's magnetic field and are used to identify anomalies caused by buried ferrous-metal objects. Fences, power lines, and ferrous metal objects at or above the ground surface can cause interference, and such conditions were avoided.

At Fort Devens, ABB-ES used a magnetic gradiometer consisting of two total-field magnetic sensors mounted on a pole that was held vertically. Simultaneous total-field measurements were made at each station, and from those the magnetic gradient was calculated. Data were recorded on a portable data-logging device and were later down-loaded to a personal computer.

The data were processed by establishing uniform-grid data sets and contouring the total field and gradients. Anomalies were identified and were compared to the results of other geophysical techniques for interpretation.

Since magnetic field is subject to diurnal variations, measurements of total field were made periodically during the survey at a base station to monitor variations and provide a basis for correcting total field data from the survey.

3.1.1.2 Ground-Penetrating Radar. The GPR technique transmits electromagnetic waves in the frequency range of 80 to 1,000 megahertz (radio waves) directly into the ground. The waves are reflected back to a receiver from interfaces between materials of differing electromagnetic properties (including buried objects and changes in geologic materials).

At Fort Devens, GPR was used to check for buried utilities at proposed drilling and excavating locations and to provide better resolution of magnetic and terrain-conductivity anomalies identified in surveys. A radar transceiver was pulled slowly by hand along parallel traverse lines. Reflected radar signals were recorded on a graphic strip-chart and were interpreted in the field. Additional GPR traverses were conducted as needed to clarify the interpretations.

3.1.1.3 Terrain Conductivity. Terrain conductivity measures variations in the electrical conductivity of soil, and one of its uses is for mapping landfill boundaries.

At Fort Devens, measurements were made on a pre-established grid using a transmitter/receiver carried above the ground. The transmitter was energized using an alternating electric current which produced a primary magnetic field. The primary electric field induced small electric currents to flow in the ground, which produced a secondary magnetic field. The receiver measured the secondary magnetic field and compared it to the primary magnetic field, and the ratios were converted to ground conductivity values (in millimhos per meter).

The data were recorded on a digital data-logger and were down-loaded to a personal computer for map contouring and identification of anomalies.

3.1.2 Soil Borings

Soil borings were drilled at Fort Devens to determine the nature of the subsurface geologic materials, to collect subsurface soil samples for chemical analysis, and in some cases, to install monitoring wells.

Borings were rotary drilled using 4- or 6-inch inside diameter (ID) hollow-stem augers (HSA). HSAs have auger flights on the outside to carry penetrated soil to the ground surface, and they have a removable plug held in the bottom of the auger to prevent entry of soil into the hollow stem. To collect soil samples at specific depths, the plug was withdrawn, a 24-inch split-spoon sampler was driven ahead of (below) the auger into undisturbed soil and then retrieved, and the plug was reinserted for continued drilling.

In some cases, when drilling below the water table, soil flowed up into the augers when the plug was withdrawn. In those cases it was necessary to add drilling fluid

(AEC-approved water from the South Post Water Point) to equalize the pressure before collecting a split-spoon sample. For borings in which wells were to be installed, a record was maintained of the volume of any drilling fluid not recovered during drilling as a basis for purging during well development (Section 3.1.6).

During drilling, ABB-ES logged descriptions of the soils and other relevant conditions, used a PID to measure total volatile organic compounds (VOCs) in the breathing zone and in the split-spoon sampler as it was opened, and collected reference samples and samples for chemical analysis. Analytical samples were placed in pre-labeled sample jars and were stored on ice in coolers to maintain temperatures below 4 degrees Celsius (° C). Approximately 10 percent of soil samples were sent to a laboratory to be tested for grain-size distribution. Sampling information was recorded on soil-sampling data sheets. Procedures for handling investigation-derived waste (IDW) consisting of drill cuttings are described in Section 3.1.13. Field boring logs for the Groups 3, 5, and 6 SI are presented in Appendix B.

3.1.3 Test Pit Excavations

Test pits were dug to provide a means of directly observing and recording subsurface conditions at identified geophysical anomalies in landfilled materials, and for collecting soil samples for chemical analysis.

First, trees and brush were cleared as necessary, then the test pits were excavated by a tire-mounted backhoe to depths less than 10 feet below ground surface (bgs). Equipment and personnel remained on the upwind side of the excavations. ABB-ES recorded test-pit descriptions on test-pit log forms, and monitored the wind direction.

Personnel did not enter the test pits. Soil samples were collected from the backhoe, placed in pre-labeled sample jars, and stored on ice in coolers. Sampling information was recorded on soil-sampling data sheets. Each test pit was backfilled with the excavated soil upon completion of sampling. Field test pit logs for the Groups 3, 5, and 6 SI are presented in Appendix B.

3.1.4 Surface Soil Sampling

Soil grab samples were collected at locations of visible or suspected contamination, using a stainless steel spoon. Care was taken not to collect vegetative material. Samples were placed in pre-labeled sample jars and were stored on ice in coolers. Sampling information was recorded on soil-sampling data sheets.

3.1.5 Groundwater Monitoring Wells

Twenty-two monitoring wells were installed as part of the Groups 3, 5, and 6 investigations to provide a means of sampling groundwater, measuring water-table depths, and determining aquifer conductivities.

Monitoring wells were installed in soil borings commencing not more than 12 hours after boring completion and continuing uninterrupted until well construction was finished. All of the wells of the Groups 3, 5, and 6 SI effort were screened across the water table in unconsolidated glacial sediments.

The water, filter sand, and bentonite used for well installation were approved by the AEC prior to the beginning of the drilling program. A 10-foot-long, 4-inch ID, schedule 40 polyvinyl chloride (PVC), 0.010-inch machine-slotted well screen with threaded bottom plug was placed between 0 and 3 feet above the bottom of each boring. A solid 4-inch ID schedule 40 PVC riser was installed from the screen to approximately 2 feet above the ground surface. All PVC joints were flush-threaded, and no solvents or adhesives were used. Typically, well screens were placed in the interval from 8 feet below to 2 feet above the water table as observed at the time of installation.

Filter sand was emplaced around the well screen to a level between 5 and 6 feet above the top of the screen. Care was taken to prevent voids in the well screen annulus and to prevent contact between the formation and the well screen. Above the sandpack in the annulus around the riser, a 5-foot-thick bentonite-pellet seal was installed; and in the annulus from the top of the bentonite seal to the ground surface a cement-bentonite grout mixture was tremie-emplaced.

A slotted or loose-fitting cap was placed on top of the riser to protect the well from entry of water while allowing equalization of the well water with atmospheric pressure. A 6-inch ID protective steel casing was installed approximately 2.5 feet into the grout with approximately 2.5 feet stick-up (above the ground), and the steel casing was provided with a locking cap. Four protective steel posts were installed around each well, and a 6-inch-thick pad of coarse gravel or crushed stone was added for drainage.

Monitoring well completion diagrams for the Groups 3, 5, and 6 SI are presented in Appendix C.

3.1.6 Well Development

All newly installed wells were developed beginning between 48 hours and seven days after well completion. Development was conducted to remove any foreign substances potentially introduced during drilling, to increase efficiency of the wells, and to reduce the turbidity of the groundwater. In the initial SI phase, the wells were developed with a submersible stainless-steel pump. The pump and hose were decontaminated before use in each well. For wells that were slow to recharge, development was accomplished using dedicated Teflon™ bailers. For the supplemental and Phase III SI programs, all wells were develeped using dedicated submersible Whale™ pumps and teflon tubing.

During development, each well-volume of water removed was monitored for specific conductance, temperature, pH, and turbidity. A well volume was calculated as the volume of standing water in the well screen plus the volume of standing water in the sandpack (assuming 30 percent porosity).

Wells were considered fully developed when the following criteria were met:

- Well water was clear to the unaided eye;
- Sediment thickness in the well was less than 1 percent of the screen length;
- Total water removed from the well equaled 5 well volumes plus 5 times the volume of any drilling water lost; and, where possible,
- Turbidity measurements varied by less than approximately 10 percent.

In wells that were very slow to recharge, fewer volumes were withdrawn. Well development was documented on Well Development Record sheets. Groundwater purged from each well during development was collected in drums for disposal characterization. Procedures for handling this IDW are detailed in Section 3.1.13.

3.1.7 Groundwater Sampling

Groundwater samples were collected from all of the newly installed monitoring wells, no sooner than two weeks after well development. (Groundwater samples were also collected from designated pre-existing on-site wells.)

All wells were purged before sampling, using a submersible pump (decontaminated before each use, unless dedicated) or dedicated Teflon™ bailers. Purging was considered complete when water equal to 5 well-volumes had been removed and when the monitored parameters (specific conductance, temperature, pH, and turbidity) varied by less than approximately 10 percent. Redox potential was measured at the completion of purging. For the pre-existing wells, purge-volumes were calculated based on well dimensions and measured water depths.

Each well was sampled with a dedicated Teflon™ bailer. Prior to sample collection, all sample jars (except VOC vials) were triple-rinsed with sample water. Water was then poured directly from the bailer into the appropriate pre-labeled sample jars. Samples to be analyzed for dissolved inorganic compounds were filtered using disposable 0.45-micron high-capacity in-line filters to remove suspended solids. Groundwater samples were preserved in the field in accordance with the requirements of the POP (ABB-ES, July 1992 and 1993, Section 4.2) and stored on ice in coolers. Sampling information was recorded on Groundwater Sample Field Data Record sheets.

3.1.8 Aquifer Characterization

In-situ measurements were made to evaluate groundwater flow patterns and aquifer conductivities.

Groundwater flow patterns were determined from water-level measurements made installation-wide in monitoring wells and surface-water bodies. Measurements in wells were made from surveyors' marks (typically at the top of the PVC risers), using electronic water-level meters. Surface-water measurements were made by measuring from survey marks on stakes installed in the water or by measuring with the aid of an optical level from nearby on-shore survey pins. Water levels were measured to the nearest 0.01 foot and were referenced to the National Geodetic Vertical Datum (NGVD).

Slug tests were performed to determine aquifer conductivities. The tested wells included all of the newly installed wells and designated preexisting on-site wells. At least two tests were performed in each well. The water table was displaced (usually in a rising-head mode) using a solid PVC cylinder approximately 3 feet long. An In-Situ™ Hermit 1000B Datalogger and 10 pound-per-square-inch (psi) down-hole pressure transducer were used to record head recovery.

The data were downloaded to a personal computer, and aquifer conductivities were calculated based on the method of Hvorslev (1951) and the method of Bouwer and Rice (1976). Aquifer test data collected as part of the Groups 3, 5, and 6 SI are presented in Appendix A.

3.1.9 Surface-Water and Sediment Sampling

Surface-water and sediment samples were collected from each of several predesignated locations in streams, wet areas, and ponds at Fort Devens. In all cases, the water sample was collected before the sediment sample.

Total VOCs were measured by PID above the surface water, and temperature, pH, and specific conductance were monitored in-situ. Prior to sample collection, all water-sample jars (except VOC vials) were triple-rinsed with sample water. The appropriate pre-labeled sample jars were then filled with water by direct immersion immediately below the surface of the water. Water samples were preserved in the field in accordance with the requirements of the POP (ABB-ES, July 1992, Section 4.2).

Sediment was collected at the water/sediment interface in pre-labeled sample jars with a stainless steel spoon. Every sediment sample was sent to the laboratory to be tested for grain-size distribution and moisture content.

All surface-water and sediment samples were stored on ice in coolers. Sampling information was recorded on Surface Water and Sediment Sampling Data sheets.

3.1.10 Stream-Flow Estimates

Stream-flow estimates were made in the Nashua River and in Cold Spring Brook by measuring the channel cross-sectional areas and the linear velocities of the water.

Cross sections were measured by establishing segments of equal width across the stream and measuring the water depth at the midpoint of each segment. Flow velocities were measured with a mechanical current meter at the midpoint of each segment, at depths 0.6 times total depth. Each measurement was made for a period of 60 seconds, and the measured velocity was assumed to be the average velocity for the segment. Discharge in cubic feet per second (cfs) was calculated by multiplying the linear velocities by the segment cross-sectional areas and summing the segment discharges. A discussion of the results of investigations performed as part of this task and data sheets with field readings and calculations for stream-flow measurements are presented in Appendix D.

3.1.11 Elevation and Location Survey

All new explorations were surveyed by a Massachusetts Registered Land Surveyor.

Elevations were referenced to the NGVD of 1929. They were measured to the nearest 0.01 foot for monitoring well casings and risers and for surface-water reference points. Ground surface was measured to the nearest 0.1 foot.

Horizontal locations were surveyed with reference to the Massachusetts Coordinate System grid to an accuracy of ± 1 foot.

3.1.12 Decontamination

Field equipment was decontaminated with AEC-approved water from the South Post Water Point.

All drilling and excavating equipment was decontaminated before arriving and prior to leaving the installation, and before each new exploration location. For on-site decontamination, high-pressure hot water was used.

Miscellaneous tools, samplers, and certain monitoring probes were brushed off and rinsed with AEC-approved water and then were thoroughly scrubbed, triple-rinsed with AEC-approved water, and air-dried.

Sample containers, after being filled, were wiped and cleaned as necessary in the field to prevent contamination of the sample handling/shipping area.

3.1.13 Investigation-Derived Waste

Wastes were generated in association with personal protection, drilling, well construction and development, sampling, and decontamination.

Soil brought to the ground surface by drilling was isolated into separate piles for each 5-foot depth. Soils excavated from test pits were temporarily piled at the excavation locations. A soil headspace PID measurement was taken from each pile; and piles with associated headspace measurements at background were discarded at the drilling or excavation locations. Piles with headspace measurements above background (or with overt evidence of contamination) were placed in drums which were labeled, covered, and transported to a temporary storage area near the field office, where they were tested for hazardous-waste characteristics.

Drilling water circulated back to the ground surface, well-development purge water, and decontamination fluids were collected in drums. A headspace measurement was made by PID on water from each drum. Drums with headspace values at background were discharged at the point of collection. Drums with headspace values above background (or with overt evidence of contamination) were covered, labeled, and transported to the temporary storage area to be tested for hazardous-waste characteristics.

Pre-sampling purge water was collected in drums only if the well-development purge water had failed the PID screening.

Drums at the temporary storage area were tested for the full suite of Toxic Compound Leachate Procedure (TCLP) compounds and hazardous waste characteristics. None failed the tests. The drums were then hauled away from the installation under manifest as nonhazardous materials by a licensed hazardous waste transporter.

3.2 ANALYTICAL PROGRAM

An analytical program was conducted to identify contaminants that were expected, based on available information about conditions and operations, to be encountered at the SAs. The program included an extensive range of organic and inorganic analytes. The specific analyses performed on samples from the individual SAs are discussed in the respective subsections of Sections 4.0, 5.0, and 6.0 of this report.

3.2.1 Analytical Parameters

Soil, sediment, and groundwater samples collected at the SAs were analyzed for Fort Devens Project Analyte List (PAL) analytes. Laboratory analyses for the PAL organics, inorganics, and explosives is considered approximately equivalent to USEPA analytical support Level III quality data (Contract Laboratory Program Routine Analytical Services). The Fort Devens PAL is presented in Appendix E.

ESE, an AEC-certified laboratory, was the primary laboratory used for the Groups 3, 5, and 6 PAL analytical program. Revet Laboratories performed coliform analysis of groundwater and surface water samples; coliform analysis does not require AEC certification.

A list of AEC-certified methods used for analysis of PAL compounds in samples collected during the Groups 3, 5, and 6 SI is provided in Table 3-1. The table includes a description of the methods used as well as equivalent USEPA methods where they exist. The method numbers (e.g., method JS16) are specific to the project and to the particular laboratory performing the analyses.

3.2.2 Quality Assurance/Quality Control

Laboratories performing the analytical work for Task Order No. 2 have been required to implement the AEC QA Program. The following section describes the procedures implemented to achieve the objectives of the AEC QA Program.

3.2.2.1 Laboratory Certification. In accordance with the AEC QA Program, laboratories require formal certification for PAL analytical methods conducted in association with site investigations. AEC requires that a laboratory must demonstrate proficiency in performing AEC methods for specific analytes.

Laboratories become certified by submitting data from runs of pre-certification calibration standards. Performance samples are then sent for analysis to the laboratory from AEC. The concentrations of the analytes in these samples are unknown by the laboratory. The data are then sent to AEC where the precision and accuracy of the analyses are determined. Certification is either awarded to or denied the laboratory based on this performance. A certification method code is assigned to each method and reported with results.

Some methods such as alkalinity, total organic carbon, total suspended solids do not require certification. AEC recognizes standard USEPA protocols or internal laboratory methods for these parameters. Laboratories are required to submit information on procedures for analyzing samples using these methods to the AEC Chemistry Branch before they are implemented.

3.2.2.2 Laboratory Methods Quality Control. All Fort Devens samples submitted to the laboratory were organized into lots which were assigned a three digit code using letters of the alphabet. Each lot consisted of the maximum number of samples, including QC samples that can be processed through the rate limiting step of the method during a single time period (not exceeding 24 hours).

Associated with each lot were laboratory control samples. Control samples are spikes of both high and low concentration of specific analytes that help monitor laboratory precision and accuracy. The recoveries of these spikes were plotted on control charts generated by the laboratory and submitted to AEC. Data generated from the certification process was used to calculate a mean of the recoveries. Control and warning limits were statistically generated by the AEC Chemistry Branch to help measure laboratory data quality. Certified Reporting Limits (CRLs) were also determined from this process. CRLs for each particular analyte are listed on the PAL in Appendix E.

Method blanks were also run at the laboratory to evaluate the potential for target analytes to be introduced during the processing and analysis of samples. One method blank was included in each analytical lot. The method blank sampling results are summarized in Tables F-1 and FS-1 and are discussed in Section 1.2 and 1.3 of Appendix F. A summary of the impact to data quality for the Groups 3, 5, and 6 SI is presented as part of Sections 4.1.4, 4.2.4, 5.1.4, 5.2.4, 6.1.4, 6.2.4, 6.3.4, and 6.4.4.

3.2.2.3 Data Reduction and Validation. Initial responsibility for accuracy and completeness of Fort Devens analytical data packages rested with the laboratory itself. All data submissions to AEC first underwent the review process. This review included checks on the data quality which evaluated completeness of laboratory data, accuracy of reporting limits, compliance with quality control limits and holding times, and correlation of laboratory data to associated laboratory tests.

The following items were also validated by the laboratories before being submitted to AEC:

- Chain of custody records.
- Instrument printouts for agreement with handwritten results.
- Calibration records to ensure a particular lot is associated with only one calibration.
- Chromatograms and explanations for operator corrective actions (such as manual integrations).
- Standard preparation and documentation of source.
- Calculations on selected samples.
- Notebooks and sheets of paper to ensure all pages were dated and initialed, and explanations of procedure changes.
- Gas chromatograph/mass spectrometer (GC/MS) library search of unknown compounds.
- Transfer files and records to ensure agreement with analysis results.

To document the data review and validation process, a data-review checklist was submitted as part of each data package.

3.2.2.4 Data Reporting. After review and validation by the laboratory, the dates were encoded for transmission into AEC's Installation Restoration Data

Management Information System (IRDMIS) as Level 1 data. IRDMIS, a computerized data management system used by AEC, is described in detail in Section 3.3.2. Once into the system, the data were subjected to a group and records check.

Data were then transferred to an Army data management contractor. During this phase, the data were considered to be Level 2. Another group and records check was performed and data were reviewed by the AEC Chemistry Branch. When errors were identified, the data were returned to the laboratory for correction. Once data were reviewed by the AEC Chemistry Branch, the determination was made on a lot-by-lot basis whether the data were acceptable. The data that were accepted were then elevated to Level 3 and made available to AEC personnel and contractors by modem to a main frame computer.

3.2.2.5 Field Quality Control Samples. During the Groups 3, 5, and 6 field phases, quality control samples collected in the field included matrix spikes, matrix spike duplicates, rinsate blanks, trip blanks, field blank (source water), and duplicate samples.

Matrix spikes and matrix spike duplicates (MS/MSDs) were collected at a rate of one set per 20 samples; and as specified in the POP, MS/MSDs were analyzed for PAL inorganics, explosives, VOCs, SVOCs, and pesticides/polychlorinated biphenyls (PCBs). Site investigators made the determination of which samples were to be designated as MS/MSDs. This was noted on the chain of custody forms submitted to the laboratory. The samples designated as MS/MSDs were spiked at the laboratory with analytes that were requested for the regular field samples in order to determine matrix effects. MS/MSD sampling results are presented in Tables F-8, F-10, F-12 FS-9, and FS-10 and are discussed in Section 2.0 of Appendix F. Interpretations of the MS/MSD results for each SA Group are summarized in Sections 4.3.2, 5.3.2, and 6.5.2 of this report.

As required by the POP, duplicate samples were collected at the same rate as MS/MSDs. The samples were submitted to the laboratory to be analyzed for the same compounds as the corresponding regular field samples. The purpose of submitting these samples was to assess laboratory precision for a particular method. Duplicate sampling results are summarized in Tables F-9, F-11, F-13, FS-7, and FS-8 and are discussed in Section 2.0 of Appendix F. Interpretations of duplicate results for each SA Group are summarized in Sections 4.3.3, 5.3.3, and 6.5.3 of this report.

At the beginning of the Groups 3, 5, and 6 SI effort, a sample of AEC-approved water was collected. For the purpose of laboratory QC, this was identified as the field blank. The information gained from the analysis of this blank provided data on the quality of the AEC-approved water used in the decontamination of the sampling equipment. Field blank information was also used to explain the presence of certain analytes or compounds in rinsate blanks.

Rinsate blanks were collected and analyzed for VOCs, semivoloatile organic compounds (SVOCs), PCBs/pesticides, and inorganics. They were collected by running laboratory "chemically pure" deionized water through the sampling apparatus that was used to collect the samples. Analysis of this water provided information used to evaluate the potential for sample contamination during sample collection. The results were also used to assess whether an adequate job was done during the decontamination of the equipment. As required by the POP, rinsate blanks were also collected at a rate of one per 20 samples per decontamination event.

For every shipment of VOC samples to the laboratory there was an accompanying pair of trip blanks that traveled with the samples. The trip blank was a VOC sample container previously filled at the laboratory. Once the trip blanks were received at ESE, they were analyzed for VOCs to assess cross contamination during shipment.

Quality control blank results are summarized in Tables F-1 through F-7 and FS-1 through FS-6 in Appendix F. Interpretations of field blank results (including field blanks, rinsate blanks, and trip blanks) for each SA Group are summarized in Sections 4.3.1, 5.3.1, and 6.5.1 in this report and are discussed in more detail in Section 1.0 of Appendix F.

3.2.2.6 Analytical Data Quality Evaluation. Groups 3, 5, and 6 laboratory data collected during the 1992 sampling effort at Ft. Devens were evaluated for possible laboratory or sampling-related contamination. This evaluation did not include validation by USEPA guidelines. (This was completed separately from the SI report on only 10 percent of the samples collected.) Sample results reported and discussed in this SI report were not adjusted for reported analytes that were also detected at similar concentrations in blanks associated with that sample; action levels were not established, and the 10X rule was not applied to compounds considered common laboratory contaminants by the USEPA. These contaminants include the VOCs acetone, methylene chloride, toluene and SVOC phthalate esters (e.g., bis(2-ethylhexyl)phthalate [BIS]). Likewise, action levels for other analytes using the 5X rule application were not established. Analytes which would have been below these action levels were not removed from the data as they would be in the USEPA validation process.

General trends relating to blank and sample contamination were examined. Comparison of blank data with results from the entire data set are discussed as a data assessment. Assessments are made based on analyte detection in blanks, the frequency of this detection and the concentrations of these analytes. These assessments are made in Sections 4.0, 5.0, and 6.0 of this report.

3.2.3 Cross-Contamination Issue

During the comparison of Round 1 and Round 2 groundwater analytical results, significant differences in the VOC compounds and concentrations were observed. Specifically, a suite of chlorinated solvents that included tetrachloroethylene, 1,1,1-trichloroethane, 1,1-dichloroethene, and methylene chloride; and purgeable aromatic compounds including ethylbenzene, toluene, and xylenes were detected at significant concentrations in nearly all the groundwater wells sampled in Round 2 (Table 3-2). Lower concentrations of some of these compounds were found in three of the same 37 wells sampled in Round 1. Comparison among the Round 2 sampling results showed that the concentration ratios between certain compounds were constant. Figures 3-1, 3-2, and 3-3 show examples of the concentration ratios. These constant ratios suggested to ABB-ES that the contaminants were derived from the same source.

Because of the elevated concentration levels, broad geographic distribution (found in all three groups of monitoring wells), and consistency in the types of compounds detected, it was suspected the compounds were the result of contamination from an external source and not representative of true groundwater conditions. An assessment of potential sample contaminant sources associated with laboratory analysis, sampling procedures, and sabotage was conducted.

The consistency in the suite of contaminants found in nearly all the samples and the consistency in ratios of concentrations from sample to sample initially pointed toward some form of laboratory analytical error as the possible source of the contamination. The lack of contamination in rinsate and trip blanks was not consistent with this theory, however. Similar compounds and concentrations in USEPA replicate samples provided by CDM Federal Programs finally discounted the laboratory error theory.

After discounting the laboratory error source, the search focused on the evaluation of field sampling procedures as a possible source of contamination. The potential for sample bottle and preservation acid contamination was evaluated since these were used for each sample collected in Round 2. Because the USEPA replicate samples (discussed above) were collected in CDM-supplied bottles and preserved with their own acid, the theory of contaminated bottles and acid was eliminated from consideration.

An evaluation of sampling procedures that were common to both the Army's samples and USEPA's replicate samples was then conducted. Dedicated Teflon™ bailers were used to collect Round 2 samples. The bailers, also used to collect Round 1 samples, were stored in labeled map tube containers at ABB-ES' Fort Devens field office along with the sample bottles during the time period between both sampling rounds. To determine whether the bailers were the source of the contaminants, the dedicated bailer used in monitoring well WWTMW-07 (where the Round 2 contaminant concentrations were highest) was selected for the collection of a rinsate blank. The blank was collected on December 29, 1992 by pouring deionized water over the outside and through the inside of the bailer. The sample was GC-screened in ABB-ES' Wakefield, Massachusetts laboratory and found to be free of the contaminants detected in the Round 2 sample. The bailers were ruled out as a possible source.

The only remaining potential sources of contamination from the sampling procedure common to both the Army's and USEPA's samples was the presample purging pump and the decontamination water used. The decontamination water was first evaluated as a possible source of contamination. At each well location, water from the South Post water supply well (potable) had been used to decontaminate the pump after presample purging at each well location. A sample from this water supply well was collected on December 29, 1992 and GC-screened in ABB-ES' Wakefield laboratory. No detectable concentrations of the subject contaminants were observed in the sample. Thus, the decontamination water was eliminated from further consideration as a possible source of contamination.

The evaluation finally considered contamination from the purging pump itself. Contaminant residue in the pump and pump hose from a source on- or off-site was considered. Analysis of the Round 2 concentration from a chronological perspective did not support the contaminated pump theory. Assuming the pump had been contaminated prior to the initiation of Round 2 sampling, concentrations of the contaminants were expected to decrease with each consecutive well given the copious volume of purge water and decontamination water pumped through the pump and hose at each well. The Round 2 concentrations show no trend with time. Likewise, water samples collected from the submersible pump on December 29, 1992 and GC screened showed no detectable concentrations of the contaminants.

Review of the groundwater sampling data sheets (completed in the field during sampling) revealed that at one groundwater monitoring well, WWTMW-01A, the submersible pump in question had not been used because of an obstruction inside the PVC casing. A different, peristaltic pump was used in place of the submersible pump to purge the well prior to sampling. The groundwater sample collected from this well was the only sample of all 37 samples not contaminated with at least one of the compounds observed in the suite of VOCs detected in Round 2 samples.

Sabotage was considered a remote possibility, and for the sake of completeness, it was evaluated. No evidence of sabotage was found. In the absence of other logical sources of contamination, the available evidence suggests that contaminants were introduced to the wells during sampling and the submersible pump was the most likely source.

Pursuant to the ABB-ES Fort Devens POP (Section 13.1 - Immediate Corrective Action), corrective measures were applied to the potential cross contamination condition in the Round 2 groundwater samples. ABB-ES elected to resample the 37 Groups 3, 5, and 6 monitoring wells for VOCs only. To reduce the potential for further cross contamination, dedicated submersible pumps and tubing were used to purge each well. Sampling procedures followed the standard methods used in Round 1 and Round 2 sampling as prescribed in the ABB-ES POP. The results of this third round of sampling showed that the suite of contaminants found in Round 2 samples was absent and the contaminants detected were consistent with the results of Round 1. The results further support the contaminated pump theory. As a result, for the purpose of this site investigation, the VOC results from Round 2 were rejected as invalid data and have been replaced with the results of Round 3 sampling.

With regard to impacts to the wells due to the contaminants introduced into the samples from a single submersible pump, the results of Round 3 sampling showed only minor concentrations of VOCs remained in wells that exhibited these compounds in Round 1. No significant impacts to the monitoring wells or the groundwater aquifer were found.

3.3 CHEMICAL DATA MANAGEMENT

Chemical data from the SAs were managed by ABB-ES' Sample Tracking System and the AEC's IRDMIS. These systems are described in the following sections.

3.3.1 Sample Tracking System

ABB-ES employed its computerized Sample Management System to track environmental samples from field collection to shipment to the laboratory. ABB-ES also tracked the status of analyses and reporting by the laboratory.

Each day the field sampling teams carried computer-generated sample labels into the field that stated the sample control number, sample identification, size and type of container, sample preservation summary, analysis method code, and sample medium. The labels also provided space for sampling date and time and the collector's initials to be added at the time of collection.

Samples were temporarily stored in the ABB-ES field office refrigerator. They were checked-in on the computer, and the collector's initials and the sampling date and time were entered. The system would then indicate the sample status as "COLLECTION IN PROGRESS."

When the samples were prepared for shipment, they were "RELEASED" by the sample management system. Upon request, the system printed an Analysis Request Form (ARF) and a Chain of Custody (COC), which were signed and included with the samples in the shipment. The system would then indicate the sample status as "SENT TO LAB."

This system substantially reduced the time required for preparation of sample tracking documentation, and it provided an automated record of sample status.

After shipment of samples to the laboratory, ABB-ES continued to track and record the status of the samples, including the date analyzed (to determine actual holding times), the date a transfer file was established by ESE, and the date the data were sent to IRDMIS (Section 3.3.2)

3.3.2 Installation Restoration Data Management Information System (IRDMIS)

IRDMIS is an integrated system for collection, validation, storage, retrieval, and presentation of data of the AEC's Installation Restoration and Base Closure Program. It uses personal computers (PCs), a UNIX-based minicomputer, printers, plotters, and communications networks to link these devices.

For each sample lot, ABB-ES developed a "provisional" map file for the sample locations, which was entered into IRDMIS by Potomac Research, Inc. (PRI), AEC's data management contractor.

Following analysis of the sample lot, ESE created chemical files using data codes provided by ABB-ES, and entered the analytical results (Level 1) on a PC in accordance with the User's Manual (PRI, 1993). For each sample lot, a hard copy was printed and was reviewed and checked by ESE's Laboratory Program Manager. ESE created a transfer file from accepted records which was sent to ABB-ES (Level 2). ABB-ES performed a group and record check and sent approved records in a chemical transfer file to PRI. PRI checked the data and, if accepted, entered it into the IRDMIS minicomputer (Level 3). Level 3 chemical data are the data used for evaluating site conditions and are the data used in SA reports and decision-making.

3.4 BACKGROUND CONCENTRATIONS

As a means to evaluate concentrations of inorganic analytes detected in samples collected as part of the SI, background concentrations of these analytes were calculated for the Fort Devens installation. Background concentration calculations were based on analytical data results gathered from soil and groundwater samples collected throughout the Fort Devens installation, selected as representative of background (non-contaminated) conditions. Though most of the calculations include assumptions on both the distribution of chemical concentrations and on the selection of representative samples that are not statistically rigorous, the results are considered conservatively representative of actual background concentrations at Fort Devens.

For soil, chemical data gathered from 20 soil samples collected by Ecology & Environment, Inc. (E&E) as part of their Group 1A and 1B investigation activities were used. The samples were collected from the major soil associations throughout Fort Devens specifically to establish background concentrations of inorganic analytes in soil. After these data were reviewed, apparent statistical outliers were eliminated from the data sets, and the 95th percentile concentrations (the mean value plus two standard deviations) were calculated. Though environmental data are rarely truly "normally distributed", it was assumed that the resulting 95th percentile concentrations were conservative representatives of installation-wide background concentrations. Outlier values were identified in the data sets using both graphical observation and relative changes to recalculate 95th percentile values (i.e outliers were removed from the data sets only if a significant decrease in the recalculated 95th percentiles was observed).

The calculations were performed on 19 of the 23 PAL inorganic analytes (no data were available for antimony, cobalt, selenium, and thallium). In special cases, where an analyte was not detected in a given sample, ABB-ES used a conservative value of one half the detection limit of the analyte in the statistical analysis. For analytes that were not detected in the majority of soil samples, the detection limit for that analyte was selected as the background concentration. Data ranges, mean values, and calculated background concentrations are summarized in Appendix G. Details of the calculations are also provided in Appendix G.

For groundwater, ABB-ES selected ten representative groundwater samples collected from the Round 1 groundwater sampling events for SA Groups 2, 3, 5, 6, and 7 for the purpose of calculating background inorganic analyte concentrations in groundwater. Representative groundwater samples were selected from up gradient monitoring well exhibiting low TSS and/or low aluminum concentrations. Knowing that elevated TSS concentrations artificially elevate inorganic analyte concentrations, ABB-ES selected samples that exhibited TSS concentrations on the same order of magnitude as the South Post Water Supply Well (i.e., representative of typical TSS concentrations in potable groundwater). Because a close correlation between TSS concentrations and aluminum concentrations was observed in all the groundwater samples analyzed, the aluminum concentration was used as an alternate selection criterion in the absence of TSS data. The concentration values detected in the ten samples were calculated using the same assumptions on outliers and detection limits applied to the soils background concentration calculations. The statistical analysis calculations for groundwater inorganics, and the resulting background concentrations are provided in the summary table in Appendix G. Data ranges, mean values, calculated background concentrations, and details of the calculations are also provided in Appendix G.

3.5 PRELIMINARY RISK EVALUATION METHODOLOGY

This section presents the approach employed for the SI Public Health and Ecological Preliminary Risk Evaluations (PREs); SA-specific PREs are presented in the respective SA discussions of Sections 4.0, 5.0, and 6.0. PREs have been completed to help to establish whether environmental contamination at an SA will require one of the following actions:

- Nomination for No Further Action (NFA)
- SI Removal Action (with/without subsequent NFA nomination)
- Supplemental SI or RI/FS

Environmental sampling conducted during the Groups 3, 5, and 6 SI field program at Fort Devens revealed the presence of organic and inorganic contaminants in the following environmental media:

- Surface Soil (defined as soil to a depth of 3 feet)
- Subsurface Soil (defined as soil between 3 and 15 feet deep)
- Wetland Sediments
- Wetland Surface Water
- Nashua River and Cold Spring Brook Sediments
- Nashua River and Cold Spring Brook Surface Water
- Groundwater

Human health and ecological PREs were conducted for contaminants detected in wetland sediments and wetland surface water. Because analytes detected in Cold Spring Brook and the Nashua River are not specifically derived from the Groups 3, 5, and 6 SAs, the Army and regulatory authorities have agreed that surface water and sediment from these water bodies will be evaluated in a separate study (AREE 70). Therefore, Cold Spring Brook and Nashua River contamination has not been considered in these SI PREs.

No background database has been established for surface water and sediment at Fort Devens. Therefore, all VOCs, SVOCs, and pesticides/PCBs detected in wetland sediment were evaluated as Chemicals of Potential Concern (CPCs) in the SA Groups 3, 5, and 6 PREs. A number of essential inorganic nutrients (e.g., calcium, iron, magnesium, sodium, and potassium) in environmental media were not evaluated in these PREs because they have low relative toxicity at high concentrations.

Human health and ecological PREs were conducted to evaluate contamination in surface soil; only the human health PRE was conducted to evaluate contamination in subsurface soils. For the purposes of selecting soil inorganic CPCs at the Groups 3, 5, and 6 SAs, the SA-specific maximum soil inorganic analyte concentrations were screened against the Fort Devens background database. Inorganic analytes in soil were retained for evaluation in the PREs if their maximum concentrations exceeded the Fort Devens background values.

ABB-ES also calculated arithmetic averages of soil inorganic analytes. Because repeated exposure to maximum concentrations is unlikely, averages are also used in the PREs to represent likely exposure point concentrations. The SA Groups 3, 5, and 6 PREs are screening evaluations. Therefore, the averages include only detects (i.e., samples whose concentrations are above detection limits). These arithmetic means of detects represent overestimates of SA averages. For quantitative risk assessments, following both USEPA and MADEP guidance, averages should include non-detect samples with their concentrations set at one-half the sample quantitation limit.

All VOCs, SVOCs, and pesticides/PCBs detected in soil were evaluated as CPCs in the Groups 3, 5, and 6 PREs.

Only the human health PRE was conducted to evaluate contamination in groundwater. All VOCs, SVOCs, and pesticides/PCBs detected in groundwater were evaluated as CPCs in the Groups 3, 5, and 6 PREs.

3.5.1 Human Health Risk Evaluations

The Human Health PREs at the Groups 3, 5, and 6 SAs include the following elements:

- **Current and Future Land Use**: Current and foreseeable future land uses at the individual SAs are considered in the PREs and are particularly relevant with respect to the applicability of soil screening values used in the PREs. Two sets of soil screening values are used in the evaluation. One set, USEPA Region III risk-based concentrations for residential soil, is appropriate when the current and/or foreseeable future use of the SA is residential. The other set, USEPA Region III risk-based concentrations for commercial/industrial soil, is appropriate when the current and/or foreseeable future use of the SA is commercial or industrial.

- **Comparison to Public Health Standards and Guidelines**: For soil and groundwater, human health standards and/or guidelines exist which can be used as screening criteria for the evaluation of the significance of sampling data at the individual SAs. To evaluate the concentrations of compounds detected in the groundwater, federal and Massachusetts drinking water standards and guidelines are used. Although MADEP is currently developing soil cleanup standards as part of its Waste Site Cleanup Program Redesign, these standards are in draft form (in MADEP's proposed regulations) and are not to be cited or quoted. Therefore, USEPA's Region III risk-based concentrations are used to evaluate the results of the soil sampling programs. The human health standards and guidelines used in the PREs are presented in Section 3.4 (ARARs) and summarized in Table 3-3. The basis and applicability of these standards and guidelines are discussed below.

  USEPA Drinking Water Regulations. Federal drinking water standards (both final and proposed) are used to evaluate the significance of the groundwater sampling data for Groups 3, 5, and 6. These standards have been extracted from the USEPA Office of Water's "Drinking Water Regulations and Health Advisories", November 1992. This publication is updated periodically by USEPA to reflect any changes in federal drinking water standards and guidelines.

Massachusetts Drinking Water Standards and Guidelines. For some compounds, MADEP has promulgated drinking water standards that are more stringent than the federal drinking water standards. MADEP has also developed drinking water guidelines for compounds for which no federal standards exist.

OSWER Lead Guidance (OSWER Directive: 9355.4-02). USEPA has set forth an interim soil cleanup level for total lead which is protective for direct contact exposure at residential settings. The interim guidance was published in September 1988. Further guidance will be developed after the USEPA has developed a verified Cancer Potency Factor and/or a Reference Dose for lead.

USEPA Region III Risk-Based Concentration Table (First Quarter, 1993). This table is used by USEPA Region III toxicologists as a risk-based screening tool for Superfund sites, as a benchmark for evaluating preliminary site investigation data and preliminary remediation goals. Although it has no official status either as regulation or guidance, it is useful as a screening tool. The table is updated quarterly and therefore regularly incorporates new USEPA toxicity constants as they are developed.

The table contains references, doses, and carcinogenic potency slopes for nearly 600 chemicals. These toxicity constants have been combined with "standard" exposure scenarios to calculate chemical concentrations corresponding to fixed levels of risk (i.e., a hazard quotient of 1, or lifetime cancer risk of 10^{-6}, whichever occurs at a lower concentration) in water, air, fish tissue, and soil. The use of 10^{-6} as a target cancer risk level is consistent with both USEPA and MADEP risk management guidelines. USEPA has established a cumulative site target cancer risk range of 10^{-4} to 10^{-6} for Superfund sites while MADEP has established a total site cancer risk limit of 10^{-5}. For noncarcinogenic health effects, USEPA has set a hazard index limit of one; MADEP has set a total site noncarcinogenic site risk limit of 0.2. While Region III's hazard index of one exceeds MADEP's limit of 0.2, MADEP has proposed in its draft waste site cleanup regulations to change its total noncancer risk limit to one.

> For the SA Groups 3, 5, and 6 Human Health PREs, Region III risk-based concentrations for tap water, commercial/industrial soil, and residential soil are used. Risk-based concentrations for tap water assume daily consumption of two liters of water for a residential lifetime of 30 years; these also assume exposure from the inhalation of volatiles from household water uses (including showering, laundering, and dish washing). The derivation of the volatilization factor used to address inhalation risks is provided in USEPA's "Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals)", December 1991.
>
> For soil, Region III risk-based concentrations have been developed for commercial/industrial soil exposure as well as for residential exposure. Risk-based concentrations for commercial/industrial soil assume that a worker ingests soil 250 days per year for 25 years, at an ingestion rate of 100 mg/day. Risk-based concentrations for residential soil assume that an individual ingests soil 350 days per year for a residential lifetime of 30 years, at an age-adjusted ingestion rate of 100 mg/day.

However, for SAs 44 (Cannibalization Yard) and 52 (TDA Maintenance Yard), quantitative risks were estimated to gain a more detailed understanding of the potential health risks. For most of the Human Health PREs conducted by ABB-ES for SA Groups 3, 5, and 6, quantitative risk estimates were not generated. The qualitative evaluations conducted at all the other SAs consisted of a comparison of SA sampling data to human health standards and guidelines.

3.5.2 Ecological Risk Evaluations

The ecological PREs at the Groups 3, 5, and 6 SAs include the following elements:

- **Ecological Characterization**: The purpose of the ecological characterization is to identify ecological receptors potentially exposed to contamination at the Groups 3, 5, and 6 SAs at Fort Devens. Section 2.0 of this report presents general descriptions of vegetative cover-types at Fort Devens, based upon a review of scientific literature and other published accounts, site-specific reports and records, contact with regional authorities, and observations made during site inspections. The presence or absence of any rare and endangered flora and fauna at the site, as well as information regarding any other critical ecological receptors (e.g., wetlands, surface water bodies, Areas of Critical Environmental Concern [ACECs], wildlife refuges, etc.) is also reviewed in Section 2.0. For part of research being conducted for the U.S. Army Corps of Engineers, ABB-ES has developed a database of all flora and fauna known to seasonally or permanently occur at, or migrate through, Fort Devens (ABB-ES, November 1992). Particular emphasis has been paid to rare and endangered biota; the term "rare and endangered" is used to refer to those species with protected status under the Federal Endangered Species Act (FESA) of 1973, as amended in 1988, and the Massachusetts Endangered Species Act (MESA) of 1990. The most current versions of both state and federal rare and endangered species lists have been included in this Fort Devens Biological Database.

Information regarding all rare and endangered species known to occur at Fort Devens has been obtained from the Massachusetts Natural Heritage Program (MNHP) and the USFWS. As a program within the Massachusetts Division of Fisheries and Wildlife (MADFW), the MNHP is responsible for the conservation and protection of rare and endangered species within the Commonwealth. In addition, the ABB-ES database contains records that have not yet been incorporated into the MNHP database.

In order to ascertain whether or not Groups 3, 5, and 6 SAs are providing rare and endangered species habitat, the ABB-ES master biological database has been checked for each SA. Information regarding rare and endangered species at individual SAs can be found in the respective SA discussions. Additional detail regarding the ecological characterization of the individual Groups 3, 5, and 6 SAs can also be found in the respective SA discussions.

- **Comparison to Ecological Standards and Criteria**: This element of the ecological PRE identifies possible ecological exposure pathways, and serves to characterize the risk to terrestrial and aquatic receptors potentially exposed to environmental contamination at the Groups 3, 5, and 6 SAs at Fort Devens.

  Exposure pathways describe the mechanism(s) by which ecological receptors are exposed to contaminated media, and consist of a: (1) contaminant source; (2) environmental transport medium; (3) point of receptor contact; and (4) the exposure route (e.g., ingestion of prey items that have bioaccumulated contaminants in their tissues, drinking of contaminated surface water, incidental sediment ingestion, dermal absorption, inhalation, etc.). Potential receptors at Fort Devens include:

- Terrestrial biota in uplands
- Aquatic biota in the North Post Landfill palustrine wetland (SA 09)
- Semi-terrestrial biota in the North Post Landfill palustrine wetland (i.e., wetlands wildlife)

The screening-level evaluation of exposure to aquatic and semi-terrestrial receptors in these PREs has been conducted through direct comparison of state and federal standards and guidance values to maximum concentrations of detected CPCs in Fort Devens sediments and surface water. Limited data are available to evaluate the potential for toxic effects of Fort Devens wetland sediment contaminants on aquatic and semi-terrestrial life. Available information includes state and federal sediment quality criteria and guidance, laboratory-derived toxicity data, and toxicity threshold values developed using toxicological extrapolation techniques. Sediment standards and guidelines used for the Groups 3, 5, and 6 PREs are presented in Section 3.4, summarized in Table 3-4, and discussed below.

USEPA Sediment Quality Criteria (SQC). SQC for several hydrophobic organic compounds have been developed and published by the USEPA (1988a). No USEPA SQC are available to evaluate the effects of inorganic constituents on aquatic life. The USEPA SQC are intended to protect benthic organisms which are primarily impacted by contaminants in the interstitial water between sediment particles. USEPA developed SQC using an equilibrium partitioning approach to identify sediment concentrations which could be associated with interstitial water concentrations equal to chronic federal Ambient Water Quality Criteria (AWQC).

For non-polar, hydrophobic organic compounds, such as PCBs, the degree to which compounds are released from sediment particles into the interstitial water is strongly influenced by their low solubility and strong binding affinity to TOC within the sediment particle. The higher the TOC content of the sediments, the lower the potential for contaminant release to the interstitial water. Therefore, the toxicity of sediments containing hydrophobic compounds (and subsequently the associated sediment toxicity criteria) varies on a site-specific basis in an inverse relationship with the fraction of sediment that is organic carbon. For this reason, when appropriate, Fort Devens sediment toxicity threshold criteria were normalized to reflect TOC: carbon-normalized data are expressed as microgram contaminant per gram of organic carbon (μg/gC) in sediment. When appropriate, an SA-specific criterion was calculated by multiplying the organic carbon-normalized criterion by the fraction of TOC present in the SA's sediments.

N.Y. State Department of Environmental Conservation SQC. The NYSDEC Bureau of Environmental Protection, Division of Fish and Wildlife, has published a document entitled "Sediment Criteria - December 1989" (NYSDEC, 1989). This report is a guidance document, not a NYSDEC standard or policy. The NYSDEC SQC document contains a methodology for developing sediment criteria, a description of the use of these criteria in risk management decision-making processes, and a table of sediment criteria derived for various human and ecological receptors. Organic contaminant sediment criteria developed in NYSDEC (1989) are based on the TOC equilibrium partitioning approach. The NYSDEC (1989) guidance document contains recommended criteria for several organic and inorganic constituents found in Fort Devens sediments.

National Oceanographic and Atmospheric Administration (NOAA) Sediment Threshold Values. Long and Morgan (1990) have developed biological effects-based criteria for evaluating sediment contaminant data. Although this NOAA study is designed primarily for evaluating the toxicity of marine and estuarine sediments, USEPA has suggested that Long and Morgan (1990) criteria may also be used as a source of information for the evaluation of freshwater sediments at hazardous waste sites. The Effects Range-Medium (ER-M) of Long and Morgan (1990) represents the 50th percentile concentration of contamination in estuarine sediments with observed (or predicted) effects. The Effects Range-Low (ER-L) of Long and Morgan (1990) represents the 10th percentile concentration of contamination in estuarine sediments with observed (or predicted) effects. The NOAA ER-L was used as a sediment screening tool for the Fort Devens PREs.

Information available to evaluate the toxicity of Fort Devens surface water contaminants include state and federal water quality criteria, laboratory-derived toxicity data, and toxicity threshold values developed using toxicological extrapolation techniques. Surface water standards and guidance values used for the SA Groups 3, 5, and 6 ecological PREs are presented in Section 3.4, summarized in Table 3-4, and discussed below.

USEPA Ambient Water Quality Criteria. AWQC have been developed and published by the USEPA for the protection of aquatic life and human health. The aquatic life AWQC are intended to be protective of all life stages of aquatic animals and plants. These criteria specify the contaminant concentration in ambient surface water that, if not exceeded, should protect most species of aquatic life and their uses. The chronic criterion represents the contaminant concentration that should not be exceeded by the four-day average chemical concentration more than once every three years (USEPA, 1983). In developing a chronic AWQC, USEPA estimates protective contaminant levels based on chronic toxicological data for animals, plants, and on residue levels in aquatic organisms. The acute criterion represents the level that should not be exceeded by the one-hour average concentration more than once every three years. For the purpose of the Fort Devens PREs, the chronic AWQC was used as a screening tool for evaluation of risk in surface waters. USEPA has not yet developed national AWQC for all contaminants detected at Fort Devens. When USEPA Water Quality documents did not contain chronic AWQC, the Lowest Observed Effects Level (LOEL) was identified from USEPA Water Quality Criteria documents and used as the screening tool for Fort Devens surface water.

No state or federal standards or guidelines exist for surface soil exposure, so it has been evaluated through comparison of maximum analyte concentrations in surface soils to protective contaminant levels (PCLs) obtained through a computer-generated chronic exposure food web model. In order to establish conservative PCLs for the screening level PREs, an acceptable level of risk (Hazard Index [HI] equals 1) associated with chronic exposure to each surface soil contaminant isolated at Fort Devens was established. Surface soil ecological PCLs are summarized in Table 3-5. The food model is further described in Appendix H.

Collectively, the state and federal standards and guidance values for surface water and sediment, as well as the surface soil PCLs, have been referred to as benchmark values. When more than one benchmark value is available per analyte per medium, professional judgment has been used to select the appropriate value for use in the PRE. A summary of ecological benchmark values is presented in Table 3-6.

Screening of ecological risk at the Groups 3, 5, and 6 SAs is based on establishing a contaminant-specific ratio between the average exposure concentrations and the benchmark values. This comparison of the exposure concentration with the appropriate benchmark results in an index of potential impact associated with exposure to environmental contaminants. When the average exposure concentration is less than the benchmark value (i.e., the ratio of the exposure concentration to the benchmark value < 1), ecological risk has been assumed to be insignificant. When the value exceeds the exposure concentration (i.e., the ratio of the exposure concentration to the benchmark value > 1), a discussion of the ecological significance of this exceedance has been included in the individual PREs. This conservative approach provides a screening-level evaluation of potential effects of individual CPCs on ecological receptors.

Several of the Groups 3, 5, and 6 SAs have little to no ecological habitat; for instance, several SAs are in light industrial use and contain no open space. Other SAs may provide limited ecological habitat, but no ecological exposure pathways exist (e.g., subsurface contamination in the vicinity of former underground storage tanks [USTs]). PREs at these SAs reflect the lack of habitat or ecological exposure pathways and do not include all sections outlined above.

3.5.3 General PRE Uncertainties

The evaluation of human health and ecological risks at the Groups 3, 5, and 6 SAs involves numerous uncertainties and assumptions. Although many of the assumptions and uncertainties at Fort Devens are inherent in the human health and ecological assessment process (i.e., are inherent in development and formulation of the conceptual model), others are related to data limitations and natural environmental stochasticity (USEPA, 1992a).

A list of general assumptions and uncertainties for the Fort Devens PREs has been included in Appendix H.

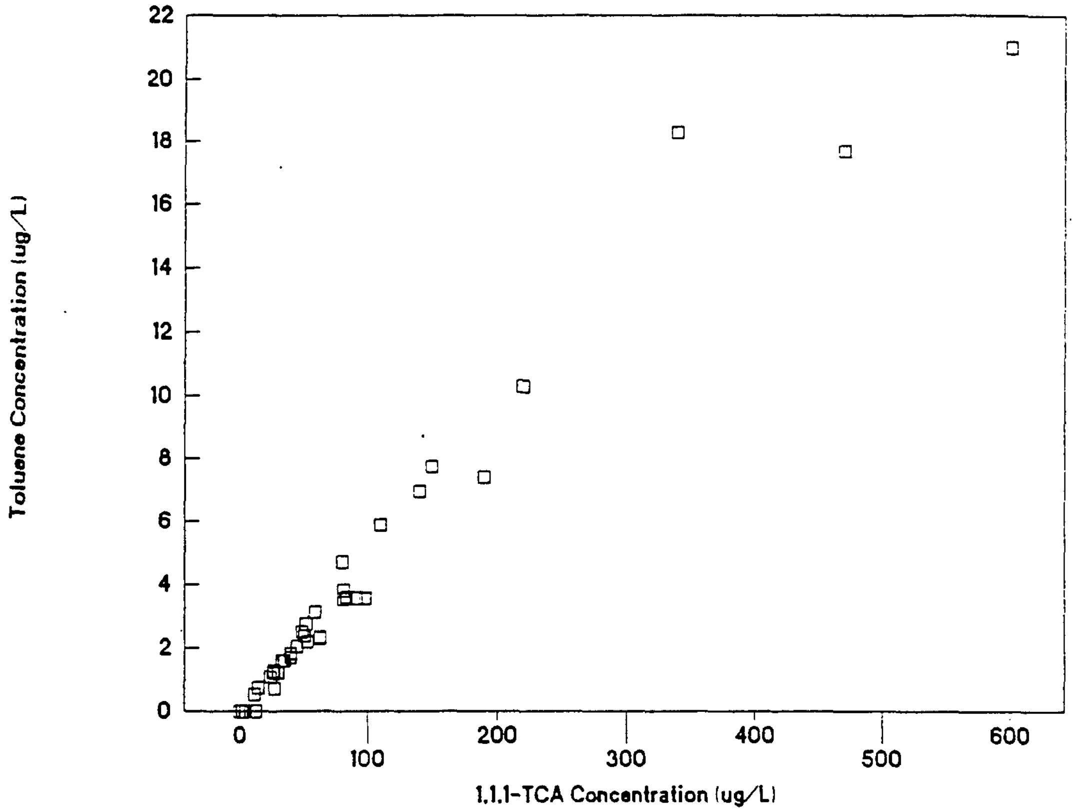

FIGURE 3-1
ROUND 2 VOCS IN GROUNDWATER
1,1,1-TRICHLOROETHANE vs TOLUENE
SA GROUP 3, 5, AND 6
FORT DEVENS, MASSACHUSETTS

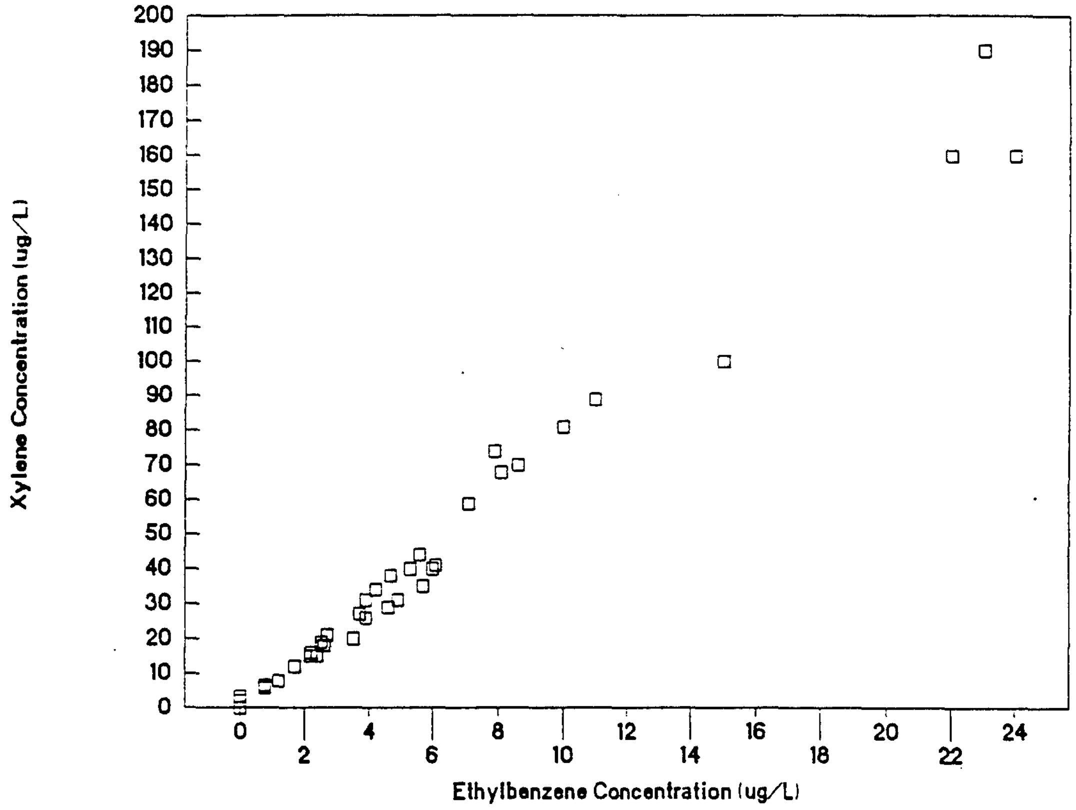

FIGURE 3-2
ROUND 2 VOCS IN GROUNDWATER
ETHYLBENZENE vs XYLENE
SA GROUP 3, 5, AND 6
FORT DEVENS, MASSACHUSETTS

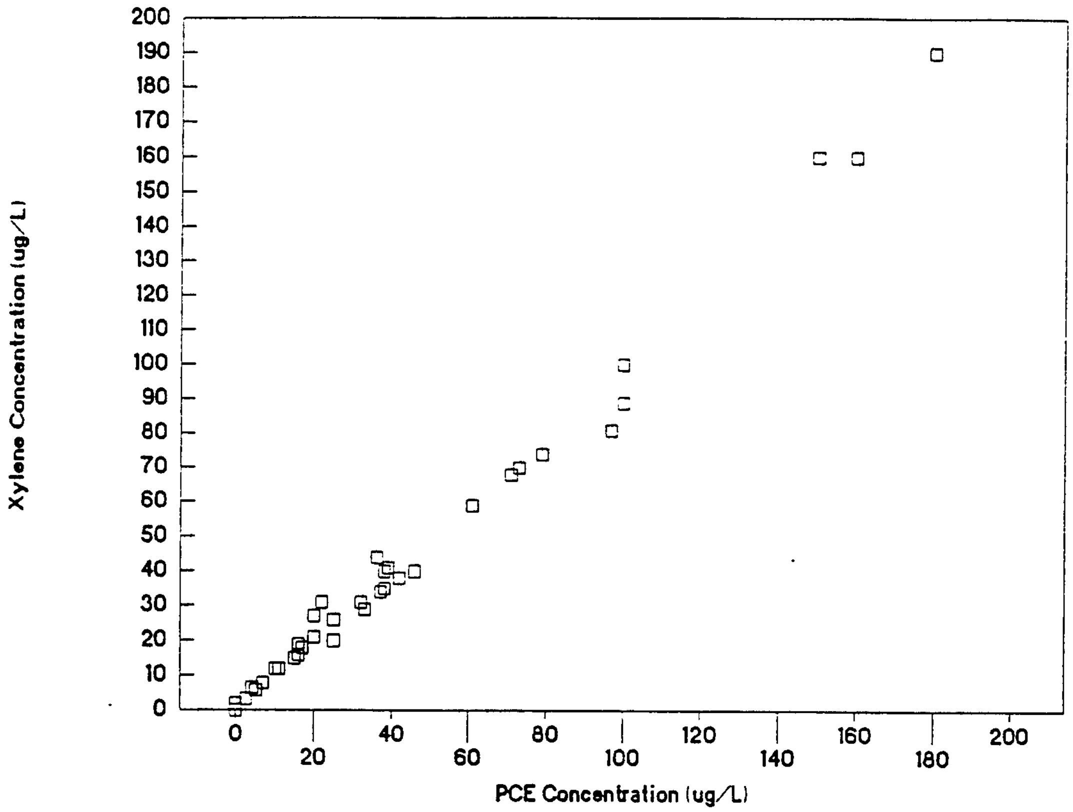

FIGURE 3-3
ROUND 2 VOCS IN GROUNDWATER
TETRACHLOROETHYLENE vs XYLENE
SA GROUP 3, 5, AND 6
FORT DEVENS, MASSACHUSETTS

Table 3-1
List of AEC Methods

Groups 3, 5, and 6 Site Investigation Report
Ft. Devens, Massachusetts

AEC Method Number	Comparable USEPA Method Number	Method Description
JB01	7471	Mercury in Soil by CVAA.
JD15	7740	Selenium in Soil by GFAA.
JD16	7911	Vanadium in Soil by GFAA.
JD17	7421	Lead in Soil by GFAA.
JD18	7761	Silver in Soil by GFAA.
JD19	7060	Arsenic in Soil by GFAA.
JD24	279.2	Thallium in Soil.
JD25	204.2	Antimony in Soil.
JS16	6010	Metals in Soil by ICP.
LH10	8080	Organochlorine Pesticides in Soil by GC-EC.
LH11	8150	Herbicides in Soil by GC-EC.
LH16	8080	PCBs in Soil by GC-EC.
LM18	8270	Extractable Organics in Soil by GC/MS.
LM19	8240	Volatile Organics in Soil by GC/MS.
-	9060	Total Organic Carbon in Soil.
-	9071	Total Petroleum Hydrocarbons in Soil.
LW12	8090	Nitroaromatics in Soil by HPLC.
SB01	245.1	Mercury in Water by CVAA.
SD09	279.2	Thallium in Water.
SD20	239.2	Lead in Water by GFAA.
SD21	270.2	Selenium in Water by GFAA.
SD22	206.2	Arsenic in Water by GFAA.
SD23	272.2	Silver in Water by GFAA.
SD28	204.2	Antimony in Water.
SS10	200.7	Metals in Water by ICAP.
TF22	300.0	Nitrate/Nitrite in Water by Auto Analyzer.

Table 3-1
List of AEC Methods

Groups 3, 5, and 6 Site Investigation Report
Ft. Devens, Massachusetts

AEC Method Number	Comparable USEPA Method Number	Method Description
TF26	351.2	TKN in Water by Autoanalyzer.
TF27	365.1	Total Phosphate in Water by Autoanalyzer.
TT10	300.0	Anions in Water by IC.
UH02	608	PCBs in Water by GC.
UH13	608	Organochlorine Pesticides in Water by GC.
UH14	615	Herbicides in Water by HPLC.
UM18	625	Extractable Organics in Water by GC/MS.
UM20	624	Volatiles in Water by GC/MS.
UW19	-	PETN/Nitroglycerin in Water.
UW32	609	Nitroaromatics in Water by HPLC.
-	160.2	Total Suspended Solids.

TABLE 3-2
ROUND 2 GROUNDWATER RESULTS (VOCs in ug/l) - GROUPS 3, 5 & 6

SITE INVESTIGATION REPORT, GROUPS 3, 5, & 6
FORT DEVENS

WELL	11DCE	ETHYL-BENZENE	METHYLENE-CHLORIDE	PCE	TOLUENE	111TCA	XYLENE
G5M-92-02X	<0.50	<0.50	<2.3	<1.6	<0.50	2	<0.84
G5M-92-03B	<0.50	<0.50	<2.3	<1.6	<0.50	2.4	<0.84
G5M-92-01X	<0.50	0.77	3.3	5.2	0.71	28	5.7
WWTMW-01	<0.50	<0.50	<2.3	2.6	<0.50	13	3.3
WWTMW-08	<0.50	<0.50	<2.3	<1.6	<0.50	4.9	2
WWTMW-09	<0.50	1.7	<.23	10	1.06	24	12
WWTMW-02A	1.33	6.1	4.3	39	3.8	81	41
WWTMW-03	1.02	6	3.2	38	3.52	81	40
WWTMW-04	<0.50	2.6	<2.3	17	1.57	33	18
WWTMW-10	<0.50	1.7	<2.3	11	1.21	30	12
WWTMW-05	<0.50	1.2	<2.3	6.9	0.73	15	7.8
WWTMW-06	<0.50	2.2	2.3	16	1.81	40	16
WWTMW-13	6.63	22	25	150	17.7	470	160
WWTMW-14	<0.50	3.7	2.2	20	2.17	53	27
G6M-92-01X	12.1	24	18	160	18.3	340	160
WWTMW-01A	<0.50	<0.50	<2.3	<1.6	<0.50	<0.50	<0.84
WWTMW-11	<0.50	3.9	2.8	22	2.33	63	31
WWTMW-12	<0.50	0.77	<2.3	4.2	0.53	12	6.4
WWTMW-02	2.4	5.6	2.8	36	3.55	91	44
WWTMW-07	11.1	23	18	180	21	600	190
G6M-92-06X	5.36	10	6	97	7.72	150	81
G6M-92-09X	3.41	8.6	5.6	73	5.87	110	70
WWTMW-02 dup	<0.50	2.5	<2.3	16	1.68	40	19
G6M-92-02X	1.06	7.1	5.3	61	4.7	80	59
G6M-92-03X	1.69	11	5.5	100	6.94	140	89
G6M-92-04X	2.95	7.9	15	79	7.4	190	74
G6M-92-05X	3.28	8.1	5.9	71	5.88	110	68
G6M-92-07X	<0.50	4.2	2.4	37	2.73	52	34
G6M-92-07X dup	<0.50	4.7	3	42	3.11	59	38
G6M-92-08X	0.59	5.3	3.9	46	3.59	83	40
G6M-92-11X	<0.50	2.7	<2.3	20	1.59	35	21
G3M-92-02X	<0.50	2.4	<2.3	15	1.26	27	15
G3M-92-03X	<0.50	2.2	2.5	15	1.18	26	15
G3M-92-04X	2.1	4.6	2.3	33	2.49	49	29
G3M-92-05X	4.25	5.7	7.8	38	3.54	98	35
G3M-92-06X	1.81	4.9	2.4	32	2.36	51	31
G6M-92-10X	2.24	3.5	2.9	25	2.29	63	20
G3M-92-07X	0.57	3.9	3.1	25	2.04	45	26
G3M-92-01X	7.68	15	10	100	10.3	220	100

TABLE 3-3
HEALTH RISK-BASED GUIDELINES FOR ORGANIC COMPOUNDS

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL(mg/kg)	REGION III COMM/IND. SOIL(mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
VOLATILES					
ACETONE	7,800	100,000	3,700	--	3,000(1)
CARBON TETRACHLORIDE	13	22	0.22	5	5
CHLOROFORM	280	470	0.21	100(2)	5(1)
ETHYLBENZENE	7,800	100,000	1,300	700	700
TETRACHLOROETHYLENE	33	55	1.4	5	5
TOLUENE	16,000	200,000	750	1,000	1,000
1,1,1-TRICHLOROETHANE	7,000	92,000	1,300	200	200
TRICHLOROETHYLENE	150	260	2.1	5	5
XYLENES	160,000	2,000,000	12,000	10,000	10,000
SEMIVOLATILES					
2-METHYLNAPHTHALENE	--	--	--	--	--
ACENAPHTHENE	4,700	61,000	2,200	--	--
ACENAPHTHYLENE	--	--	--	--	--
ANTHRACENE	23,000	310,000	11,000	--	--
BIS(2-ETHYLHEXYL)PHTHALATE	120	200	6.1	--	--
BENZO[A]ANTHRACENE	1.6	2.7	0.08	0.1(3)	--
BENZO[A]PYRENE	0.23	0.39	0.012	0.2(3)	0.2(1)
BENZO[B]FLUORANTHENE	1.9	3.2	0.095	0.2(3)	--
BENZO[G,H,I]PERYLENE	11	18	0.55	--	--
BENZO[K]FLUORANTHENE	4.4	7.4	0.22	0.2(3)	--
CARBAZOLE	85	140	4.3	--	--

TABLE 3–3 (continued)
HEALTH RISK–BASED GUIDELINES FOR ORGANIC COMPOUNDS

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL(mg/kg)	REGION III COMM/IND. SOIL(mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
CHRYSENE	--	--	--	0.2(3)	--
DIBENZO[A,H]ANTHRACENE	0.21	0.35	0.011	0.3(3)	--
DIBENZOFURAN	--	--	--	--	--
FLUORANTHENE	3,100	41,000	1,500	--	--
FLUORENE	3,100	41,000	1,500	--	--
INDENO[1,2,3–C,D]PYRENE	0.84	1.4	0.042	0.4(3)	--
NAPHTHALENE	3,100	41,000	1,500	--	--
PHENANTHRENE	2,300	30,000	1,100	--	--
PYRENE	2,300	31,000	1,100	--	--
OTHER					
TRICHLOROFLUOROMETHANE	23,000	310,000	1,300	--	--

NOTE: (1) MASSACHUSETTS GUIDELINES
(2) LISTED FOR REGULATION
(3) PROPOSED

TABLE 3–4
HEALTH RISK–BASED GUIDELINES FOR INORGANIC ANALYTES

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL(mg/kg)	REGION III COMM/IND. SOIL(mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
ALUMINUM	230,000	3,000,000	110,000	50 – 200(3)	– –
ANTIMONY	31	410	15	10(5)	6(4)
ARSENIC	0.97	1.6	0.049	50(UR)	50
BARIUM	5,500	72,000	2,600	2,000	2,000
BERYLLIUM	0.4	0.67	0.02	1(5)	4(4)
CADMIUM	39	510	18	5	5
CALCIUM	– –	– –	– –	– –	– –
CHROMIUM	390(1)	5,100(1)	180(1)	100(2)	100(2)
COBALT	– –	– –	10	– –	– –
COPPER	2,900	38,000	1,400	1,000(3)	1,300(4)
IRON	– –	– –	– –	300(3)	– –
LEAD	500(6)	– –	– –	15	50
MAGNESIUM	– –	– –	– –	– –	– –
MANGANESE	7,800	100,000	3,700	50(3)	– –
MERCURY	23	310	11	2	2
NICKEL	1,600	20,000	730	100(5)	100(4)
NITRATE	130,000	1,600,000	58,000	10,000 (As N)	10,000 (As N)
NITRITE	7,800	100,000	3,700	1,000 (As N)	1,000 (As N)
NITRATE/NITRITE	– –	– –	– –	10,000 (As N)	10,000 (As N)

TABLE 3–4 (continued)
HEALTH RISK–BASED GUIDELINES FOR INORGANIC ANALYTES

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL(mg/kg)	REGION III COMM/IND. SOIL(mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
POTASSIUM	--	--	--	--	--
SILVER	390	5,100	180	100(3)	50
SODIUM	--	--	--	--	28,000(4)
VANADIUM	550	7,200	260	--	--
ZINC	23,000	310,000	11,000	5,000(3)	--

NOTES: (1) CHROMIUM (VI) VALUES
(2) TOTAL CHROMIUM VALUES
(3) *SECONDARY MCLs – ALL FINAL*
(4) MASSACHUSETTS GUIDELINES
(5) PROPOSED STANDARDS
(6) LEAD VALUE FROM INTERIM GUIDANCE ON ESTABLISHING SOIL LEAD CLEANUP LEVELS AT SUPERFUND STIES (OSWER DIRECTIVE 9355.4–02)

TABLE 3–3
HEALTH RISK–BASED GUIDELINES FOR INORGANIC ANALYTES

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL (mg/kg)	REGION III COMM/IND. SOIL (mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
ALUMINUM	230,000	3,000,000	110,000	50 – 200(3)	--
ANTIMONY	31	410	15	10(5)	6(4)
ARSENIC	0.97	1.6	0.049	50(UR)	50
BARIUM	5,500	72,000	2,600	2,000	2,000
BERYLLIUM	0.4	0.67	0.02	1(5)	4(4)
CADMIUM	39	510	18	5	5
CALCIUM	--	--	--	--	--
CHROMIUM	390(1)	5,100(1)	180(1)	100(2)	100(2)
COBALT	--	--	10	--	--
COPPER	2,900	38,000	1,400	1,000(3)	1,300(4)
IRON	--	--	--	300(3)	--
LEAD	500(6)	--	--	15	50
MAGNESIUM	--	--	--	--	--
MANGANESE	7,800	100,000	3,700	50(3)	--
MERCURY	23	310	11	2	2
NICKEL	1,600	20,000	730	100(5)	100(4)
NITRATE	130,000	1,600,000	58,000	10,000 (As N)	10,000 (As N)
NITRITE	7,800	100,000	3,700	1,000 (As N)	1,000 (As N)
NITRATE/NITRITE	--	--	--	10,000 (As N)	10,000 (As N)

TABLE 3-3 (continued)
HEALTH RISK-BASED GUIDELINES FOR INORGANIC ANALYTES

SITE INVESTIGATION REPORT
GROUPS 3, 5, & 6
FORT DEVENS

ANALYTE	REGION III RESIDENTIAL SOIL(mg/kg)	REGION III COMM/IND. SOIL(mg/kg)	REGION III TAP WATER (ug/l)	EPA DRINKING WATER REGS. (ug/l)	MASS. DRINKING WATER STAND. (ug/l)
POTASSIUM	--	--	--	--	--
SILVER	390	5,100	180	100(3)	50
SODIUM	--	--	--	--	28,000(4)
VANADIUM	550	7,200	260	--	--
ZINC	23,000	310,000	11,000	5,000(3)	--

NOTES: (1) CHROMIUM (VI) VALUES
(2) TOTAL CHROMIUM VALUES
(3) SECONDARY MCLs – ALL FINAL
(4) MASSACHUSETTS GUIDELINES
(5) PROPOSED STANDARDS
(6) LEAD VALUE FROM INTERIM GUIDANCE ON ESTABLISHING SOIL LEAD CLEANUP LEVELS AT SUPERFUND STIES (OSWER DIRECTIVE 9355.4-02)

Table 3–5
Surface Soil Ecological Protective Contaminant Levels [a]

Site Investigation Report
Fort Devens

Analyte	Background Concentration [e]	Ecological Receptors [b,c,d]					
		Short–tailed shrew	White–footed mouse	American robin	Garter snake	Red fox	Red–tailed hawk
		Protective Contaminant Level (mg/kg)					
Organics							
acenaphthene		5000	30000	220000	140000	NEL	NEL
acenaphthylene		2600	13500	98000	75000	NEL	NEL
anthracene		14000	92000	580000	410000	NEL	NEL
benzo(a)anthracene		8.9	79	380	250	53000	610000
benzo(a)pyrene		5.5	52	240	160	33000	380000
benzo(b)fluoranthene		180	1700	7800	5000	NEL	NEL
benzo(g,h,i)perylene		440	4300	19000	12000	NEL	NEL
benzo(k)fluoranthene		320	3000	14000	9100	NEL	NEL
bis(2–ethylhexyl)phthalate		84	710	3600	2400	500000	570000
carbazole		43	175	1500	1200	240000	270000
chrysene		440	3900	19000	12000	NEL	NEL
dibenz(a,h)anthracene		5.5	54	210	160	32000	36000
dibenzofuran		10	24	270	290	510000	56000
fluoranthene		1100	9400	47000	31000	NEL	NEL
fluorene		1100	6000	42000	31000	NEL	NEL
indeno(1,2,3–cd)pyrene		320	3100	14000	9100	NEL	NEL
naphthalene		170	1600	7400	4800	NEL	NEL
phenanthrene		510	1600	16000	15000	NEL	NEL
pyrene		550	4200	23000	16000	NEL	NEL
tetrachloroethylene		280	470	6300	8300	NEL	NEL
toluene		1800	3000	40000	52000	NEL	NEL
trichlorofluoromethane		2000	3300	43000	57000	NEL	NEL
xylenes		2100	4600	54000	60000	NEL	NEL

Table 3–5 (continued)
Surface Soil Ecological Protective Contaminant Levels [a]

Site Investigation Report
Fort Devens

Analyte	Background Concentration [e]	Ecological Receptors [b,c,d]					
		Short–tailed shrew	White–footed mouse	American robin	Garter snake	Red fox	Red–tailed hawk
		Protective Contaminant Level (mg/kg)					
Inorganics [e]							
aluminum	**15000**	1700	2800	38000	52000	NEL	NEL
antimony		**7**	11.7	155	210	33000	35000
arsenic	21	**33**	160	810	650	NEL	220000
barium	**42.5**	41	68	900	1200	190000	200000
berylium	0.347	**0.88**	1.5	20	27	4200	4400
cadmium	**2.00**	0.44	0.8	45	40	1400	1900
chromium	31	**830**	18000	1800	2100	NEL	280000
cobalt		**50**	83	1100	1500	94000	250000
copper	8.39	**34**	54	280	400	170000	69000
lead	**48.4**	4	31	340	240	44000	110000
manganese	300	**1500**	2500	33000	45000	470000	NEL
mercury	0.22	5	**3.6**	220	480	1600	23000
nickel	14	**100**	110	350	680	640000	120000
selenium		**0.48**	0.8	155	210	2300	35000
silver	0.086	**72**	120	1600	2200	34000	360000
vanadium	**28.7**	10	17	180	240	47000	40000
zinc	35.5	**640**	1100	14000	20000	NEL	NEL

Notes:

[a] All Protective Contaminant Levels (PCLs) in surface soil were calcualted through the use of a computer–generated chronic exposure food web model. Assumptions incorporated in the model can be found in Section 3.5.2 and in Appendix O.

[b] Ecological receptors were chosen to represent diverse trophic levels, feeding strategies, and taxa.

[c] Shaded values indicate the lowest PCL calculated through the terrestrial food web model, or the background level (whichever is higher).

[d] Based on the exposure assumptions incorporated in the food web model, several analytes are not likely to have an adverse effect on higher trophic level ecological receptors. These analytes have been denoted NEL (No Effect Likely).

[e] Because the back–calculated food web models employ a number of conservative assumptions, the background levels of four inorganics (Al, Ba, Vn, and Pb) exceed the small mammal PCL. Therefore, for these compounds, background concentrations were selected as the PCLs for the Groups 3,5, and 6 PREs.

Table 3-6
Ecological Benchmark Values for PREs

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Analyte	Surface Soil Benchmark [b] (ug/g)	Surface Water Benchmark [b] (ug/l)	Sediment Benchmark [b] (ug/g)
Inorganics			
aluminum	15,000	87	NA
antimony	7	---	---
arsenic	33	190	5
barium	42.5	NA	NA
beryllium	0.88	---	---
cadmium	2	---	---
chromium	830	---	26
cobalt	50	---	---
copper	34	---	19
iron	---	1,000	24,000
lead	48.4	1.4	27
manganese	1,500	NA	428
mercury	3.6	---	0.11
nickel	100	---	22
selenium	0.48	---	---
silver	72	---	---
vanadium	28.7	---	NA
zinc	640	---	85
Organics			
acenaphthene	5,000	---	---
acenaphthylene	2,600	---	---
acetone	---	---	NA
anthracene	14,000	---	---
benzo[a]anthracene	8.9	---	---
benzo[a]pyrene	5.5	---	---
benzo[b]fluoranthene	180	---	---
benzo[g,h,i]perylene	440	---	---
benzo[k]fluoranthene	320	---	---
bis(2-ethylhexyl)phthalate	84	360	---
carbazole	43	---	---
chrysene	440	---	---
dibenzofuran	10	---	---
dibenzo[a,h]anthracene	5.5	---	---
fluoranthene	1,100	---	---
fluorene	1,100	---	---
indeno[1,2,3-cd]pyrene	320	---	---
naphthalene	170	---	---
phenanthrene	510	---	---
pyrene	550	---	---
tetrachloroethylene	280	---	---
toluene	1,800	1,750	---
trichlorofluoromethane	2,000	---	---
xylenes	2,100	---	---

Notes:

[a] Protective Contaminant Levels (PCLs) for surface soil analytes are presented in Table 3-5

[b] Surface water and sediment benchmark values are presented in Tables 3-4

NA = Not available.

--- = Analyte not a CPC for this medium.

4.0 GROUP 3 STUDY AREA INVESTIGATIONS

The Group 3 Study Areas include SA 38 (Building 3713/Battery Repair Area), SA 44 (Cannibalization Yard), and SA 52 (TDA Maintenance Yard), which are located in the northeastern part of the Main Post along Barnum Road (Figure 1-1). These SAs are associated generally with vehicle maintenance and vehicle storage operations of the Directorate of Logistics (DOL), formerly the Directorate of Industrial Operations Maintenance Division, in Building 3713 (Figure 4-1).

4.1 SA 38 - BATTERY REPAIR AREA (BUILDING 3713)

Building 3713 was built in 1942 as the Whittemore Service Command Base Shop for motor vehicle repair. The building occupies an area of approximately 250,000 square feet (6 acres), and at the time of its construction it was known as the largest garage in the world (U.S. Department of the Army, 1979). It is currently operated by the DOL for vehicle maintenance.

Battery repair is one of the activities conducted in Building 3713. Battery repair is currently conducted in a small room on the southwest side of the building (Figure 4-2).

4.1.1 Study Area Background and Conditions

Secondary sources (U.S. Army Environmental Hygiene Agency [AEHA], 1977; Biang et al., 1992; Brown, 1981; and McMaster et al., 1982) reported that, before 1978, waste battery acid electrolyte was disposed of and neutralized with sodium bicarbonate in a single dug pit located either northwest of Building 3713 (Biang et al., 1992) or east of Building 3713 (Brown, 1981). The initial SI field investigation was planned and executed based on these secondary sources and was directed at what was thought, on the basis of possible stained soil identified in aerial photographs (Detrick, 1991, Figures 17 and 18), to be a possible disposal pit located northwest of the building (Figure 4-2).

However, after completion of initial SI activities, two additional sources of information were identified. The first was an original construction plan for Building 3713 (prior to 1943) that locates the battery maintenance room in what is currently the Canvas Repair Area of Building 3713. However, no as-built plan was found confirming that the battery maintenance operation was ever actually located there, and there is no visual evidence that this room was ever used for battery maintenance.

The second source of information was Mr. Ernest Moyen, a retired facility employee who managed the battery-maintenance operation between 1963 and the late 1970s. In May 1993 he conducted an Army representative on a tour of the facility and associated waste-disposal locations, and he provided a history of the battery maintenance operation and associated waste disposal practices (Moyen, 1993).

According to Mr. Moyen, battery maintenance was originally conducted in what is now the Equipment Concentration Site (ECS) Maintenance Area (Figure 4-2). Before 1961, waste electrolyte generated in this room was disposed of by pouring it, unneutralized, directly into a floor drain inside the building (in the ECS maintenance area). Between 1961 and 1973, after the battery maintenance operation was moved to its current location, waste battery-electrolyte was disposed of at a location east of Barnum Road in an outdoor area known as the Equipment Concentration Area (East Disposal Area), and at two outdoor locations in the unpaved area to the rear (northwest) of Building 3713, across the access road (West Disposal Area). In both the East and West Disposal Areas, unneutralized electrolyte was poured directly onto the ground. Between 1973 and 1978, waste battery electrolyte was neutralized in 250-gallon fiberglass tanks and then poured down the floor drain located inside the current battery room. The drain is connected to the storm drain that discharges to Cold Spring Brook south of Building 3713 (Figure 4-1).

On the basis of this new information, a supplemental SI was planned and conducted.

Prior to the initial SI field investigation, no contaminant investigations had been conducted in the Building 3713 area. Conceptually, there was a potential for the release of contaminants due to leakage through the battery room floor and in outdoor disposal area(s). The types and quantities of waste were not known, although lead, zinc, cadmium, and sodium bicarbonate were suspected of being the primary residual contaminants in soil and groundwater. Potential routes of migration include groundwater flow from beneath the outdoor disposal area(s), from beneath the battery maintenance room floor, and through the stormwater discharge.

4.1.2 SA 38 Investigation Program Summary

The SI program at SA 38 consisted of the initial investigation conducted in 1992, and the supplemental investigation, conducted in 1993. Between these field efforts, the Army removed lead- and TPHC-contaminated soil from beneath the floor of the current battery room, as part of routine floor maintenance/reconstruction.

4.1.2.1 Initial Site Investigation. The objective of sampling at Study Area 38 was to investigate the potential presence of environmental contamination generated by the historical use of a possible waste-battery-electrolyte disposal pit located outside of Building 3713 and, if found, assess the vertical and horizontal extent of contaminant migration and recommend further actions. Possible contaminants include lead, zinc, cadmium, and sodium; and anions/cations including sulfate and bicarbonate. Because the actual location of the disposal pit was not known, the investigation focused on sampling soil in the presumed location of the pit for residual contamination and sampling groundwater to assess potential contaminant migration from the pit.

Because of its proximity to SAs 44 and 52, the investigation of groundwater, surface water, and sediment were combined into a single Group 3 investigation of groundwater quality and contaminant impacts to Cold Spring Brook. Specifically, groundwater monitoring wells were located around SAs 38, 44, and 52 to assess local groundwater flow directions and contaminant impacts to groundwater due to releases at any of the SAs. Similarly, surface water and sediment sampling locations were selected to gather information on contamination upstream of and within areas where contaminants may have entered Cold Spring Brook. Soil sampling and analysis plans were developed on an SA-specific basis for the three SAs in Group 3.

Soil samples were collected at 5-foot intervals in each of the Group 3 monitoring well borings, except G3M-92-04X and G3M-92-06X, where samples were collected continuously for field screening by a PID and for field classification. The soil samples were collected with a 2-inch (OD) split-spoon sampler (or a 3-inch-OD sampler where additional volume was needed for analytical samples). Seven soil samples were selected and tested for grain-size distribution to verify field classifications. At a minimum, a soil sample was collected from the saturated zone of each monitoring well boring and analyzed for TOC. Additional analytes included PAL organics (VOCs and SVOCs), PAL inorganics, and TPHC.

Specific to SA 38, the single soil boring G3M-92-06X was drilled in the location of the stained soil identified northwest of Building 3713 (Figure 4-3). Three of the split-spoon samples from this boring were sent to the laboratory for analysis for PAL organics, PAL inorganics, and TPHC. One of the analytical samples was collected from a depth of 0 to 2 feet bgs; one was collected from an intermediate depth; and one sample was collected in saturated soil at the approximate depth of the water table.

Seven monitoring wells (G3M-92-01X through G3M-92-07X) were installed and screened at the water table in borings drilled to approximately 10 feet below the water table, at locations generally surrounding the Group 3 SAs (Figure 4-3). The borings were drilled with 6¼-inch-diameter hollow-stem augers (HSAs), to accommodate installation of 4-inch-OD PVC well screens and risers. All monitoring wells were developed between two and seven days after completion.

The distribution of monitoring wells was planned to provide sampling points for groundwater in several directions from potential contaminant sources. Although groundwater flow directions in the Group 3 area were not specifically known, it was inferred that G3M-92-01X was the most upgradient of the Group 3 wells, and it therefore was expected to indicate non-Group 3 groundwater conditions. Monitoring well G3M-92-06X was installed at the time in a soil boring drilled in the presumed location of the waste-acid disposal pit. Monitoring wells G3M-92-02X, G3M-92-03X, and G3M-92-07X were located approximately between Group 3 and Cold Spring Brook to monitor potential contaminant migration in that direction. Monitoring wells G3M-92-05X and G3M-92-04X were located in other possible downgradient locations.

Three rounds of groundwater samples were collected from Group 3 monitoring wells. The first was conducted in July 1992, the second in October, and the third in December. The samples collected in Round 1 and Round 2 were analyzed for PAL organics, inorganics, anions/cations, TSS, and TPHC. The third-round groundwater samples were analyzed for PAL VOCs only (to replace rejected Round 2 VOC data rejected because of cross-contamination; see Section 3.2.3).

Aquifer hydraulic conductivities in the Group 3 area were determined by performing two slug tests per well in every newly installed monitoring well. The aquifer tests were conducted soon after the Round 1 groundwater sampling.

Five sets of surface water and sediment samples were collected from Cold Spring Brook in the locations shown in Figure 4-4. Location G3D-92-01X was situated south of the Group 3 SAs to determine upstream conditions. Sampling locations G3D-92-02X and G3D-92-03X were located downgradient of the Group 3 SAs. Sampling locations 57D-92-01X and 57D-92-02X were part of the SA Groups 2 and 7 SI, but are included in data discussions for SA Group 3 because of their proximity to this Group. All sediment samples were collected from areas of deposition when sampling in flowing water. Surface water and sediment samples were submitted to ESE for analysis of PAL organics, inorganics, and TPHC. In addition, surface water samples were analyzed for PAL water quality parameters and TSS. Sediment samples were also analyzed for TOC and were tested for grain-size distribution.

4.1.2.2 Current Battery-Room Floor Reconstruction and Removal Action. Soon after the completion of the initial Site Investigation, lead and TPHC contaminated soil were discovered in screening samples collected from beneath the current battery room floor during a concrete floor reconstruction project. On October 7, 1992, Fort Devens personnel collected five shallow soil samples as part of preconstruction assessment of disposal options for excavated soil and demolition debris (concrete). Each of these five samples was a composite of from one to two of the five borings, collected from similar depth intervals within the borings. These samples were analyzed for the eight Resource Conservation and Recovery Act (RCRA) metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver), and TCLP for lead. A combined composite sample was also collected and analyzed for TPHC.

The highest concentrations of contaminants in the samples were detected adjacent to the floor drain located inside the room. In consideration of these findings, the repair effort was temporarily suspended until contaminant distributions could be fully characterized. With discovery of significant soil contamination beneath the current battery room floor, further research into historic battery maintenance practices was conducted.

Floor reconstruction and soil removal was conducted in January - February 1994 by GAS Environmental, Inc. of Stoneham MA, and associated waste (contaminated soil, concrete, and pipes) was transported by J. T. Russo, Inc. to the BFI Northern Disposal, Inc. landfill in East Bridgewater MA, in April - May 1994. Details of the reconstruction, removal action, and waste disposal were reported by ABB-ES (December 1994).

4.1.2.3 Supplemental Site Investigation. With the newly acquired information on historic disposal activities and locations (see Figure 4-2), a supplemental investigation sampling plan was established to assess Study Area 38-derived contamination in each of the newly-identified areas. The supplemental investigation focused on detecting lead (as a residual contaminant of waste battery electrolyte) in shallow soils and groundwater.

Lead was selected as the most representative residual contaminant that would be associated with the release of battery electrolyte by virtue of its relative insolubility and abundance in lead-acid battery construction. Surface water and sediment quality data collected during the initial investigation were sufficient to assess conditions in Cold Spring Brook. The investigation of these media was not expanded in the Supplemental SI. Similarly, except for the installation and sampling of two additional groundwater monitoring wells in the East Disposal Area, the investigation of local (Group 3) groundwater quality was not expanded for the purpose of evaluating impacts due to SA 38 (ABB-ES, April 1993b).

The following paragraphs provide detailed descriptions of supplemental site investigation (SSI) field activities at each of the areas of concern.

East Disposal Area

The East Disposal Area is located within the limits of the ECS currently under the management of the U.S. Army Reserves. The ECS is predominantly unpaved (except for several drip pads where loaded fuel tanker vehicles are parked) and is used as a motor pool for Reserve motor vehicles and other equipment items. The ECS is currently bordered by chain-link fencing around its perimeter. The East Disposal Area is located on the southeast side of the ECS behind the K Building (Building T-3759). During a site visit, Mr. Moyen used the K Building (Building T-3759) as a reference point to locate the spot where he routinely disposed of battery electrolyte. Mr. Moyen was certain of this location.

A total of 12 soil borings were advanced in a 2,400-square-foot area (20-foot centers) in and around the East Disposal Area (38B-93-01X through 38B-93-11X, and G3M-93-08X). A thirteenth boring (G3M-93-09X) was advanced downgradient, outside the perimeter fence. Borings G3M-93-08X and -09X were converted to groundwater monitoring wells (Figure 4-5). Borings 38B-93-01X through -11X were advanced to a depth of 5 feet. Because it was evident that the surface material (primarily sand) has been disturbed and reworked as a result of constant motor vehicle traffic, analytical samples were collected from the interval between 3 and 5 feet below the surface to obtain undisturbed samples representative of historic disposal activities. Soils consisted primarily of poorly graded sands, gravelly sands, with little or no fines (Table 3-1). These soil samples were tested for pH in the field and submitted to the laboratory for lead analysis.

Monitoring well G3M-93-08X was installed within the reported limits of the historical disposal area. Soil samples were collected continuously from the surface to a depth of 28 feet (10 feet below the water table). Three soil samples (6 to 8 feet bgs, 8 to 10 feet bgs, and 18 to 20 feet bgs) were selected for laboratory analysis of lead and field monitoring of pH. The sample collected from the interval 18 to 20 feet bgs (the monitoring well screen zone) was also analyzed for TOC. G3M-93-09X was installed roughly 200 feet downgradient of the disposal area. Samples were collected at 5-foot intervals to a depth of 27 feet bgs. Only the sample from the well screen zone (20 to 22 feet bgs) was selected from laboratory analysis (TOC only) and pH monitoring. Three samples were selected for grain size analysis from the group of samples collected from the East Disposal Area.

The two newly installed monitoring wells were developed, sampled, and tested for aquifer characteristics. Groundwater samples were collected on June 23, 1993 (Round 1) and September 21, 1993 (Round 2) and submitted to the laboratory for analysis of PAL inorganic analytes (filtered and nonfiltered), anion/cations, TSS, and hardness. Groundwater elevations measured in these two wells (Appendix I, Table I-1) were consistent with earlier assumptions that show groundwater flow roughly east beneath the East Disposal Area (Figure 4-6).

West Disposal Area

The West Disposal Area consists of two disposal sites, identified by Mr. Moyen, on the western side of the access road behind Building 3713. The sites are soil covered (not paved) and are currently used for vehicle and equipment storage and employee parking. The sites are abutted on the southeast side by the access road and on the northwest side by a wooded area roughly coincident with the installation boundary. The southernmost disposal site in the West Disposal Area is located directly across the access road from Door No. 14 of Building 3713 (entrance to the ECS maintenance area). The northernmost of the two disposal sites was located just beyond a former storage building (currently a concrete slab) where snow plowing in the winter allowed access. Based, in part, on specific landmarks including utility poles located nearby, Mr. Moyen was certain of his ability to locate these former disposal sites.

A total of 12 soil samples were collected from four soil borings (38B-93-12X through -15X) advanced in the two known disposal locations within the West Disposal Area (Figure 4-7). Each of the borings were advanced to a depth of 15 feet bgs and samples were collected at 5-foot intervals. Samples were submitted for laboratory analysis of lead and beryllium. Soil pH was monitored in the field. Two soil samples collected were selected for grain size analysis.

Well G3M-92-06X is located north of these disposal areas, and groundwater collected from this well is assumed to represent downgradient groundwater conditions. No additional groundwater monitoring wells were considered necessary.

Canvas Repair Area

The Canvas Repair Area, located on the northwest side of Building 3713 (Figure 4-2), is a room that was identified on a proposed construction plan for the maintenance building as the battery maintenance room. Two soil borings (38B-93-16X and 38B-93-17X) were advanced through the concrete in the Canvas Repair Area (Figure 4-18) adjacent to an existing floor drain and at a location adjacent to the discharge pipe from that drain. The two borings were advanced to a depth of 12 feet bgs and samples were collected at 5-foot intervals for laboratory analysis. The six samples were submitted for analysis of lead and were field monitored for pH.

ECS Maintenance Area

The ECS maintenance area is currently used by the Reserves to service motor vehicles and equipment and was identified by Mr. Moyen as a former battery repair room.

Three soil borings (38B-93-18X, -19X, and -20X) were advanced beneath the concrete floor, two adjacent to a floor drain in the presumed battery maintenance area and a third near a floor sump located in the northern portion of the room (see Figure 4-8). Two borings (38B-93-18X and -20X) were advanced to a depth of 12 feet with soil samples collected at 5-foot intervals. The third soil boring (38B-93-19X) encountered an obstruction (possibly concrete) at a depth of 3 feet. Only the top soil sample (from the interval from 1 to 3 feet bgs) was collected for laboratory analysis. All samples were submitted for laboratory analysis of lead and field monitored for pH. Two soil samples collected from the ECS maintenance area were selected for grain size analysis.

Current Battery Room

Based on the distribution of contaminants detected in the current battery room during the preconstruction sampling effort, five soil boring locations (38B-93-21X through -26X) were selected to further characterize the distribution of lead contamination beneath the concrete (see Figure 4-8). Borings were advanced at each location and a total of 11 soil samples were collected ranging in depth from 3 to 10 feet bgs depending on sample recovery and obstructions. Samples collected were submitted for laboratory analysis of lead and TPHC and were field monitored for pH. Six of these soil samples were submitted for grain size analysis.

4.1.3 Field Investigation Results and Observations

The Group 3 SAs are located on a kame terrace associated with the last of 12 successive fluvial-outwash sequences in the region (Jahns, 1951). The deposits consist of stratified sands and gravelly sands possibly overlying till.

Soil data from borings and monitoring wells at Group 3 are summarized in soil boring logs and well completion diagrams provided in Appendices B and C, respectively. The soils observed in Group 3 monitoring well borings were generally sand with variable gravel and silt content. None of the borings penetrated to bedrock.

Quarterly installation-wide water-level surveys of monitoring wells and surface-water stations were conducted from September 1992 to January 1995. Included in these surveys were the eleven Group 3 monitoring wells, the seven Massachusetts National Guard (MNG) monitoring wells (installed by AEHA in December 1991), a well triplet installed at the National Guard facility by MADEP in 1993, and a nearby surface-water measurement at Grove Pond. Water-table elevations are listed in Table I-1 (Appendix I). Water levels and inferred groundwater flow directions are shown in Figure 4-6. Groundwater flow is inferred to be northeastward toward the MNG property and eastward toward Cold Spring Brook.

Average horizontal hydraulic gradients in the Group 3 and MNG area range from approximately 0.002 ft/ft to approximately 0.01 ft/ft. Near G3M-92-06X the gradient was approximately 0.0024 ft/ft.

Aquifer hydraulic conductivities at the water-table, as determined in the eleven Group 3 monitoring wells, are summarized in Appendix A. The lowest conductivity is 8.1×10^{-5} cm/sec, measured in the most upgradient well (G3M-92-01X). At monitoring well G3M-92-07X the conductivity is 9.95×10^{-3} cm/sec, and at the other nine wells conductivities were all on the order of 10^{-2} cm/sec. The average measured hydraulic conductivity at monitoring well G3M-92-06X is 0.024 cm/sec, and the average measured hydraulic conductivities at monitoring wells G3M-93-08X and G3M-93-09X are cm/sec and cm/sec, respectively. The MNG wells were not tested.

At monitoring well G3M-92-06X, assuming an average effective porosity of 0.30, the average groundwater velocity at the water table would be approximately 195 ft/yr.

Sediments from Cold Spring Brook were tested for grain size. The samples were silts and/or clays with very high organic (vegetative) contents and with water contents ranging from 550 to 1,275 percent. The classification of sediment samples from Cold Spring Brook is given in Table 4-2. The results of sediment sample grain size analyses are provided in Appendix J.

No ground staining was observed at the location of monitoring well G6M-92-06X. However, the area is a low spot where clay has accumulated in rainwater puddles. The clay is darker than the surrounding sandy soils, and it is the clay that likely was misidentified in aerial photographs as potential staining (Detrick, 1991, Figures 17 and 18). No ground staining was observed in the East or West Disposal Areas.

Visual evidence of waste battery-electrolyte releases was observed in the ECS maintenance area and the current battery room. The concrete floor in the ECS maintenance area was pitted in the southern part of the room near the outside wall, and adjacent to a floor drain. Inside the current battery room, the concrete floor was stained and pitted in the northeast portion of the room near the interior wall, and the manhole and catch basin grate located in the center of the room. No visible signs were observed of battery maintenance in the Canvas Repair Area.

4.1.4 Nature and Extent of Contamination (Laboratory Results)

The analytical results for samples collected in SA 38/Group 3 were evaluated and are summarized in the following subsections. The raw laboratory analytical results are included in Appendix K.

4.1.4.1 Soils. Three soil samples were collected from G3M-92-06X, installed in the presumed former location of the disposal pit. The laboratory results for detected analytes in the three soil samples are provided in Table 4-3.

Two organic compounds were reported in the soil analysis: BIS and trichlorofluoromethane (TCFM). The source of the low BIS concentrations in soil is not known, but the compound is suspected to be a laboratory contaminant (Appendix F, Section 1.2). BIS was found only in the surface soil sample at a concentration of 4 micrograms per gram ($\mu g/g$) and was not present at depth. Low concentrations of TCFM (0.0057 to 0.007 $\mu g/g$) were detected in all soils collected and concentrations apparently increase with depth. TCFM was also detected in two of 24 method blanks at a comparable concentration to what was detected in all three soil samples from G3M-92-06X. It is, therefore, likely that the presence of TCFM in soil is the result of laboratory contamination (see Appendix F, Section 1.2). TPHC was not detected in this boring. Several inorganic analytes were detected in soil samples above the calculated background concentrations. Beryllium, copper, and sodium were all detected in the surface sample. Only sodium was detected in the deeper soil samples. The concentrations of sodium are relatively constant. Figure 4-9 shows the relative distribution of organic and inorganic analytes detected in each of the soil samples.

In the West Disposal Area, only one of the 16 soil samples (including those collected from the G3M-92-06X well boring and a duplicate sample in 38B-93-12X) exhibited a lead concentration above the background concentration (see Table 4-4). This elevated lead concentration (240 μg/g) was detected in the surface sample collected from 38B-93-15X (Figure 4-9). Beryllium was detected above the 0.347 μg/g background concentration in nearly all samples collected from the West Disposal Area ranging from the detection limit of less than 0.500 μg/g to a maximum value of 1.33 μg/g. No obvious lateral or vertical distribution pattern in the beryllium concentrations is evident.

In the East Disposal Area, the maximum concentration of lead detected in the 14 samples collected was well below the established background concentration for Fort Devens (Figure 4-10 and Table 4-4).

Of the 25 soil samples collected from beneath the concrete floor inside Building 3713 in the Canvas Repair Area, ECS maintenance area, and current battery room, only three exhibited concentrations of lead greater than the established background concentration for Fort Devens (see Table 4-4). None of the six soil samples collected from the Canvas Repair Area borings had lead concentrations above background (Figure 4-11). One sample collected from 38B-93-19X in the ECS maintenance area had a concentration of 350 μg/g (Figure 4-12). The results of soil analysis in the current battery room were consistent with the earlier results of soil screening conducted during the floor reconstruction effort in the current battery room. Two samples were collected from 38B-93-25X in the current battery room exhibited concentrations of 510 μg/g (0 feet) and 140 μg/g (4 feet) (Figure 4-13). TPHC concentrations detected beneath the current battery room ranged from less than the detection limit of 28.3 μg/g to a maximum of 764 μg/g (at 38B-93-22X).

4.1.4.2 Groundwater. Eleven groundwater monitoring wells were installed and sampled as part of the Group 3 groundwater quality assessment. Analytical results are provided in Tables 4-5, 4-6, and 4-7. Organic compounds detected in Group 3 groundwater samples included BIS, chloroform, trichloroethylene (TCE), and TPHC. Based on the evaluation of laboratory QC samples, chloroform concentrations detected in groundwater are likely attributable to laboratory contamination. BIS may also be a laboratory contaminant, but it was detected at a low frequency in water method blank samples. (See Section 1.2 of Appendix F for discussion and summary of QA/QC data.) TPHC concentrations were relatively low (316 to 520 μg/l) and were not consistently found in the same wells from round to round. TCE was detected just above the detection limit (0.55 μg/l) in G3M-92-07X during Round 2. The groundwater from the well located in SA 38 (G3M-92-06X) contained no organic compounds.

Inorganic analytes including sodium, manganese, zinc, and barium were widely detected above background in Group 3 groundwater samples. Arsenic, copper, potassium, iron, lead, and vanadium were also detected above background at a limited number of locations (primarily at G3M-92-05X). Elevated concentrations of these compounds correlate well with elevated TSS; a filtered sample collected from G3M-92-05X only contained copper and sodium above background concentrations, supporting the contention that these inorganic analytes are not dissolved in the groundwater. No inorganic analytes were detected above calculated Fort Devens background concentrations for groundwater from the well located in SA 38 (G3M-92-06X), except for zinc in the Round 2 sample only. Concentrations of zinc were higher in the other Group 3 monitoring wells sampled during Round 2 sampling. Sulfate concentrations in G3M-92-06X where consistent with the other six groundwater samples collected in the Group 3 monitoring wells. Bicarbonate, however, was somewhat elevated compared to most of the other groundwater samples collected in Round 1, but not Round 2. The sodium concentration in G3M-92-06X was the lowest of all Group 3 groundwater samples.

One unfiltered groundwater sample collected from the monitoring well G3M-93-09X in the East Disposal Area had a lead concentration slightly above the established background concentration for Fort Devens in Round 1; however, lead was not detected above the background concentration in Round 2 samples (Figure 4-14 and Table 4-7). Copper was detected above the established background concentration in unfiltered groundwater samples from monitoring wells G3M-93-08X and G3M-93-09X in Round 2 only. No notably elevated concentrations of anions/cations were observed in either of the East Disposal Area wells in Rounds 1 and 2.

4.1.4.3 Surface Water and Sediment. Five surface water and sediment sample pairs were collected from Cold Spring Brook to assess potential contaminant migration from the Group 3 study areas. Analytical results for surface water and sediment samples are provided in Tables 4-8 and 4-9, respectively. No organic compounds were detected in surface water. Inorganic analytes detected in surface water include aluminum, arsenic, barium, calcium, iron, lead, magnesium, manganese, potassium, and sodium.

Organic compounds (primarily SVOCs and TPHC) were detected in all sediment samples collected from Cold Spring Brook. The highest concentrations of these compounds were found in the downstream sample at G3D-92-03X. Nearly all of the PAL inorganic analytes were detected in the three sediment samples collected for Group 3 (inorganic analytes were not included in analyses conducted for samples collected as part of the Groups 2 and 7 SI). Figures 4-15 and 4-16 show the distribution of analytes detected in surface water and sediment samples, respectively.

4.1.5 Source Evaluation and Migration Potential

In the initial SI Round 1 groundwater samples, significant concentrations of inorganic contaminants were found only in a duplicate groundwater sample from monitoring well G3M-02-05X, but not in the original sample from that well. In Round 2, this well was free of significant concentrations. Based on that difference, and on the high TSS concentrations in both the original and duplicate samples, it is likely that the concentrations in the Round 1 duplicate sample are associated with suspended particulates. Contaminants detected in other Group 3 monitoring wells, particularly calcium, sodium, and chloride, are likely attributable to road salting.

The low concentration of TPHC detected in G3M-92-02X and G3M-92-07X and the low concentration of TCE detected in G3M-92-07X, based on groundwater flow directions, are not likely associated with the Group 3 SAs.

Except for elevated sodium concentrations in soil, no contaminants associated with battery acid disposal were detected in the originally suspected location of the disposal pit (G3M-92-06X). Because sodium concentrations are elevated in other soil samples collected in the other Group 3 study areas, the concentrations found in G3M-92-06X are not likely due to the disposal of neutralized electrolyte.

In the East Disposal Area, no significant lead concentrations or decreased pH values were detected in soil that could would suggest the disposal of waste battery electrolyte.

In the West Disposal Area, lead and beryllium were detected above background in surface soil. However, there is no clear lateral or vertical pattern of distribution, and similar concentrations were detected in Group 3 soils at locations not associated with waste battery electrolyte disposal. These concentrations appear to represent localized natural background conditions.

In an effort to address concerns about the absence of significant concentrations of lead in soils collected at former disposal areas outside the building at SA 38, the Army evaluated the concentration of lead in a representative sample of waste battery electrolyte. The sample was collected on July 1, 1994 from the maintenance building waste electrolyte storage container and was submitted for laboratory analysis. The analysis results reported a lead concentration of 510 μg/L.

Calculations using conservative assumptions on disposal practices and historical maintenance activities were made to evaluate the impacts of electrolyte disposal on soil lead concentrations (Table 4-14). The results reveal two significant findings:

- If the electrolyte was disposed of over a broad area or in multiple areas (as is likely the case), the increase in soil lead concentrations above background would not be significant enough to detect.
- Assuming all the electrolyte was disposed of in a small, localized area (which is not likely), and that area was sampled, then a noticeable increase in soil lead concentrations above natural background concentrations could be detected. For example, using the assumptions in Table 4-14, all of the waste battery electrolyte would have had to have been disposed of in a 2.7-foot square area at sample location 38B-93-15X to produce a lead concentration of 240 μg/g in soil. The exposure potential of an area this small would be minimal.

In the wells downgradient of the East Disposal Area, no battery-acid-related contaminants were detected consistently, in both supplemental SI sampling rounds, above the established groundwater background concentrations for Fort Devens.

Because groundwater was determined to be free of battery acid contaminants, migration of contaminants from SA 38 via groundwater flow to surface water and sediment is not likely.

Surface runoff from the Group 3 SAs is discharged to Cold Spring Brook and migration of contaminants is possible through this mechanism. The results of sediment sampling support the conclusion that contaminant migration via storm and surface water runoff is the likely source of sediment contamination in Cold Spring Brook. The Army intends to address sediment issues under AREE 70 - Storm Water Discharge System.

4.1.6 Preliminary Human Health Risk Evaluation

The current use of this area for military vehicle maintenance and related use is not expected to change for the foreseeable future. Tables 4-10 through 4-12 present the statistics and human health standards and guidelines used in the human health PRE for SA 38 summarized below.

Based on the additional information gathered on historical battery maintenance practices, and in considering the absence of supporting evidence (no related contaminants detected there), the originally suspected disposal pit northwest of Building 3713 (at the location where monitoring well G6M-92-06X was installed) was determined not to represent a historical disposal area for waste electrolyte. Therefore, the originally suspected disposal pit was not considered in the PREs. With the exception of the originally suspected disposal pit, individual risk evaluations were conducted on each of the identified battery maintenance and electrolyte disposal areas.

4.1.6.1 Soil. The PRE considered all soils to a depth of 3 feet as surface soil. Detected contaminant concentrations were compared to Region III risk-based concentrations for commercial/industrial exposure. The Revised Massachusetts Contingency Plan [MCP] Method 1 standards were not used in the PRE because they were not in effect at the time the PRE was conducted. The use of Region

III commercial/industrial soil is appropriate because, as agreed upon with EPA, the expected future use of the area is to remain industrial. It is not likely that the future use of SA 38 will be residential. Contaminants detected in soil at a depth of between 3 and 15 feet also were compared to Region III risk-based concentrations for commercial/industrial exposure.

Surface Soil

Table 4-10 presents summary statistics on surface soil at SA 38 and human health guidelines for comparison. All but three of the 25 detections of lead (out of 26 samples analyzed) in the five areas evaluated during the Supplemental SI (i.e., the East Disposal Area, the West Disposal Area, the Canvas Repair Area, the ECS maintenance area, and the current battery room) were less than the Fort Devens background concentration. One sample from the West Disposal Area (245 μg/g), one sample from the current battery room (513 μg/g), and one sample from the ECS Maintenance Room (346 μg/g) exceeded the background concentration. The USEPA Interim Guidance for Superfund soil lead cleanup level of 500 μg/g, based on a residential exposure scenario, was exceeded only in the current battery room. However, the battery-room samples were collected from beneath a concrete floor.

Beryllium was detected in each of the five surface soil samples in the West Disposal Area above background (0.347 μg/g) and above the Region III commercial/industrial risk-based concentration (0.28 μg/g). The concentrations of beryllium detected in surface soil, however, are considered to be the results of a localized background phenomenon.

To evaluate the health risk associated with TPHC in soil during the SI, ABB-ES developed risk-based concentrations for petroleum products. These concentrations were calculated using the same exposure assumptions as those used by USEPA toxicologists in the USEPA Region III Risk-Based Concentration Table, First Quarter, 1993 for residential soils and commercial/industrial soils. Dose response values for gasoline and marine diesel used in the calculations are provisional values developed by USEPA, Environmental Criteria and Assessment Office (USEPA, 1992). USEPA suggests using the reference dose value for diesel oil as a surrogate for No. 2 fuel.

The table below presents the risk-based concentrations developed for petroleum products:

Analyte	Commercial/Industrial Soil ($\mu g/g$)
Gasoline	1,800
No. 2 Fuel Oil	8,180

Because the origin of the TPHC in the current battery room soil was unknown, the maximum TPHC concentration was compared to the lowest risk-based value for commercial/industrial soil (1,800 $\mu g/g$ for No. 2 Fuel oil) in the Supplemental SI. TPHC concentrations detected were relatively low. The maximum concentration (764 $\mu g/g$ in the current battery room) was below the calculated commercial/industrial risk-based concentration.

Subsurface Soil

Table 4-11 presents summary statistics on subsurface soil at SA 38 and human health standards and guidelines for comparison. All the detections of lead (in the 25 samples analyzed) were less than the background concentration (34.4 $\mu g/g$) except for one detection from the same location in the current battery room as the surface soil concentration exceeding background (146 $\mu g/g$ at 4 feet). This is below the USEPA interim guidance for Superfund soil lead cleanup of 500 $\mu g/g$ and was taken from beneath the concrete floor; therefore, it was not considered to pose a risk.

In all subsurface soil samples in the West Disposal Area in which beryllium was detected (6 out of 9 samples), the concentration was above the Fort Devens background concentration (not likely representative of the local background concentration), and all but one detection was also above the Region III risk-based concentration for commercial/industrial exposure (0.67 $\mu g/g$). The maximum TPHC concentration in subsurface soil (32 $\mu g/g$ in the Battery Room) was well below the lowest risk-based value for commercial/industrial soil (1,800 $\mu g/g$ for gasoline).

4.1.6.2 Groundwater. Table 4-12 presents summary statistics on groundwater around SA 38 and human health standards and guidelines for comparison. Only unfiltered samples were used in the PRE. Two monitoring well locations were used to evaluate groundwater quality at this SA (G3M-93-08X and G3M-93-09X). The maximum detected concentrations of all analytes, except lead, were below statistical background concentrations in Round 1. Statistical background concentrations were not exceeded for any analyte except copper in Round 2. No background value exists for nitrate/nitrite. The maximum concentrations of lead (4.45 micrograms per liter [μg/L]), copper (13.6 μg/L), and nitrate/nitrite (1,500 μg/L) are below their drinking water standards of 15 μg/L, 1,300 μg/L, and 10,000 μg/L, respectively. The maximum concentrations of aluminum (3,740 μg/L), iron (4,420 μg/L), and manganese (192 μg/L), which do not exceed background, exceed their secondary maximum contaminant levels (SMCLs) of 50 to 200 μg/L, 300 μg/L, and 50 μg/L, respectively. SMCLs are federal standards promulgated for aesthetic reasons, not health reasons. The Region III risk-based tap water concentration for manganese of 180 μg/L was also slightly exceeded.

4.1.6.3 Qualitative Evaluation of Residual Risk. Cleanup standards for the soil removal action beneath the current battery room were established using the then current MCP Method 1 S-1/GW-1 soil standards. Soil with lead and TPHC concentrations exceeding 300 μg/g and 500 μg/g, respectively, was removed during the soil removal action in January 1994. The maximum detected lead concentration in confirmation soil samples (43 μg/g) is well below the 300 μg/g standard, and only slightly above the Fort Devens background concentration. The maximum detected TPHC concentration in confirmation samples (170 μg/g) is below the MCP S-1/GW-1 soil standard of 500 μg/g. The low residual concentrations of lead and TPHC suggest that no significant residual risks to human health exist at the current battery room.

4.1.7 Preliminary Ecological Risk Evaluation

The purpose of the PRE at SA 38 is to provide a screening-level evaluation of actual and potential risks that environmental contaminants may pose to the resident and migratory ecological receptors at the site.

SA 38 consist of five distinct regions located in and adjacent to Building 3713. The Canvas Repair Area, ECS maintenance area, and current battery room are located within Building 3713. The West and East Disposal Areas are exterior regions located adjacent to Building 3713. Only the East and West Disposal Areas were evaluated in this SA 38 PRE. These two regions are currently dirt parking lots with little to no vegetative cover.

No rare and endangered species are known to occur in the vicinity of SA 38. The un-vegetated study area provides minimal habitat and it is unlikely that any significant ecological exposure pathways are completed at the site. However, the potential risk from exposure to surface soil has been evaluated in this PRE in order to conservatively evaluate ecological risk at SA 38.

Lead and beryllium were detected in the five surface soil samples taken from soil borings at the West Disposal Area (38B-93-12X, 38B-93-13X, 38B-93-14X, 38B-93-15X, G3M-92-06X). No surface soil samples were taken at the East Disposal Area. Concentrations of beryllium in all five samples were above soil background (0.347 μg/g), ranging from 0.784 to 1.33 μg/g. Lead concentrations were below background (34.4 μg/g) in four of the five samples evaluated. The fifth surface soil sample, 38B-93-15X, contained 240 μg/g lead, approximately five times the background concentration.

Potential contaminant exposure pathways exist at SA 38 for terrestrial ecological receptors by incidental ingestion of surface soils and food web exposure. A screening-level evaluation of potential effects from beryllium and lead through surface soil exposures was conducted by comparison of the maximum concentrations of these analytes with their respective ecological benchmark values (PCLs) (Table 4-13).

The maximum concentration of beryllium in surface soils at SA 38 was 1.33 μg/g, only slightly in excess of the beryllium ecological PCL (0.88 μg/g). The concentration of lead in one surface soil sample from the West Disposal Area exceeded the PCL for lead by a factor of 5. However, the average lead concentration in the site's surface soils was 60 μg/g, only slightly higher than the background soil concentration for Fort Devens.

Ecological receptors at SA 38 may be marginally at risk from lead contamination in surface soils in the West Disposal Area. The concentration of lead from one sampling location exceeded the lead PCL of 34.4 μg/g (the background concentration of lead at Fort Devens). However, because of the limited surface area of contaminated soils and the relative lack of ecological habitat at SA 38, lead and beryllium are not considered to be posing significant ecological risks at SA 38.

4.1.8 Conclusions and Recommendations

No further action is recommended for SA 38. This recommendation is based on historical site use as confirmed by physical observations, sampling, and chemical analysis. It is also based on the results of human health and ecological PREs.

Historical information on the maintenance of batteries and disposal of waste electrolyte did not support early assumptions regarding disposal of electrolyte in a pit. Aerial photographic interpretation of stained soil used to locate the Alleged Disposal Pit identified darkened soil associated with the periodic ponding of parking lot runoff. The inferred disposal pit investigated during the initial SI was determined not to represent a former waste battery electrolyte disposal area and was not considered further under this SA.

The data collected from the East Disposal Area showed no indication of significant lead concentrations or decreased pH values in soil that could be associated with the disposal of waste battery electrolyte. The lead concentration detected in monitoring well G3M-93-09X in Round 1 is considered to be a background concentration and not likely indicative of contamination associated with the disposal of waste battery electrolyte there. Round 2 groundwater sampling results detected lead below the statistical background concentration in monitoring wells G3M-93-08X and G3M-93-09X. Copper was detected in Round 2 unfiltered groundwater samples above the background concentration, but below the USEPA action level for copper in drinking water.

Data collected in the West Disposal Area exhibited evidence of possible lead contamination associated with waste battery electrolyte disposal in the surface soil collected from 38B-93-15X. Data in surrounding soil borings suggest a correlation with the highest concentrations of lead in surface soils; however, a lateral distribution pattern is not evident. Beryllium concentrations in most soils collected from the West Disposal Area were in excess of background as were most of the samples collected and analyzed for beryllium in Group 3 soil borings (i.e., at the nearby maintenance yards). The lack of any clear distribution pattern at the surface or with depth, along with the consistency in the range of concentrations observed, suggests that these concentrations are caused by a localized natural background concentration and are not the result of a contaminating source. Data collected from two rounds of groundwater sampling from G3M-92-06X suggest that groundwater has not been adversely impacted by either the lead or beryllium detected in West Disposal Area soils, or any other contaminants.

Visual observation and the results of soil samples beneath the Canvas Repair Area suggest that this area was never used as a battery maintenance area.

Visual observation and laboratory data suggest that the ECS maintenance area did at one time function as a battery maintenance room. The elevated concentration of lead was observed nearest the floor drain where pitted and cracked concrete is easily observed. Historical repair work is also visually evident around the floor drain. Based on these data, it is likely that batteries were stored and repaired along the outside wall of the ECS maintenance area in the southern portion of the room. Battery electrolyte may have been spilled on the floor and may have migrated toward the floor drain along depression and cracks where considerable pitting took place in the concrete. The soil contamination beneath the floor appears to be localized to the floor drain area. The highest concentration of lead detected in soils collected from beneath the floor were determined not to pose a significant risk to human health.

A similar pattern of visual and analytical evidence suggests that releases of battery electrolyte occurred in the current battery room resulting in migration of lead to soil beneath the concrete floor. The highest concentrations of lead contamination were near the floor drain where battery electrolyte likely seeped through cracks in the concrete flooring. The TPHC found in subfloor soil samples are probably associated with the floor staining observed in the current battery room and have migrated to the underlying soils by the same mechanism around the floor drain. Soil contamination at the current battery room, detected during the Supplemental SI, has been mitigated by a soil removal action conducted in January 1994. Concentrations of lead and TPHC in soil remaining beneath the floor are below the MCP S-1/GW-1 Method 1 standards and thus pose no significant risk to human health.

Ecological receptors at SA 38 were determined to be marginally at risk from lead contamination in surface soils only in the West Disposal Area. However, because of the limited surface area of contaminated soils and the relative lack of ecological habitat at SA 38, contaminants associated with the disposal of waste battery electrolyte are not considered to be posing significant ecological risks at SA 38.

Surface water and sediment samples were collected from Cold Spring Brook upstream and downstream of the SA 38 stormwater discharge point. Numerous organic and inorganic analytes were detected in both surface water and sediment samples collected from the brook, but none could be shown to be directly related to historic battery electrolyte disposal activities. Cold Spring Brook contamination are being investigated in a separate study.

4.2 SAs 44/52 - CANNIBALIZATION YARD AND TDA MAINTENANCE YARD

SAs 44 and 52 are located northeast of Building 3713, on Barnum Road, and on the Main Post (Figure 4-1). SA 44 is known as the Cannibalization Yard. It is a 75-by-100-foot unpaved lot where vehicles are stored before being dismantled for usable parts. SA 52 was previously known as the TDA (Table of Distribution and Allowances) Maintenance Yard. It is a 5.5-acre unpaved maintenance yard (Class III, Leak Storage) located southeast of and adjacent to the Cannibalization Yard and used for high-volume temporary storage of vehicles with oil leaks that are awaiting repairs.

Northwest of the Cannibalization Yard is a separately fenced 60-by-230-foot unpaved vehicle storage yard known as the Regional Training Service (RTS) Yard. A separately fenced, unpaved 2.5-acre area southeast of the Maintenance Yard is known as the K-Yard. The Cannibalization Yard, Maintenance Yard, and K-Yard are controlled and operated by the DOL. All four of these yards have a long and continuing history of vehicle storage and repair; hence, they have all been included in the SA 44 and 52 SIs.

4.2.1 SAs 44/52 Background and Conditions

Gasoline, solvent, motor oil, and other automotive fluids (e.g., battery electrolyte, brake fluid, hydraulic fluid, antifreeze, etc.) were likely released during vehicle dismantling operations. Removal of contaminated surface soil for off-site disposal was a common practice in the yard, and this probably accounts for the lack of observed surface soil staining. Individual releases are not likely to have been of any significant volume, but numerous releases during the period in which the yard has been used accounts for the soil contamination problem. Historically, 55-gallon drums of waste oil were also stored in the yard.

Approximately 20 gallons of "mogas" (motor vehicle gas) and hydraulic fluid were reportedly released in the center of the Cannibalization Yard (SA 44) on April 25 through 26, 1985, during the vehicle cannibalization process. Visibly contaminated soil was immediately excavated by installation personnel and drummed for off-site disposal (Army, 1985).

A 1,000-gallon UST used to store waste oil was located in the Cannibalization Yard until its removal in May 1992 (Figure 4-1). Visibly contaminated soil was stockpiled, and laboratory analysis of soil samples from the bottom and one side of the tank excavation showed TPHC concentrations of 17,600 ppm and 9,780 ppm, respectively (Baldi, 1992).

Visible surface-soil staining has been observed at SA 52, suggesting the potential for soil contamination. Exploratory test pits, excavated in the storage yard for construction of a spill containment basin in the southeast corner of the Maintenance Yard (Figure 4-1), revealed zones of contaminated soil below the surface (Mullen, 1991; ABB-ES, December 1992; Lincoln Environmental, 1992). TCLP analyses detected 3 to 7 μg/l of benzene in leachate from the soil samples. Petroleum hydrocarbons were found at moderate to high concentrations in surface soil samples and at a low concentration in one sample from a 4-foot depth. Petroleum hydrocarbons were not detected in the 8-foot-deep soil samples. The results of laboratory analysis of samples collected from the test pits are provided in Table 4-15.

Topography in SAs 44 and 52 is generally flat; precipitation or other surface liquids likely infiltrate into the soil so minimal surface runoff is expected. The stormwater drainage system in the SA Group 3 area is shown in Figures 4-1 and 4-4.

4.2.2 Summary of Initial Site Investigation Program at SAs 44/52

The objective of sampling at SAs 44 and 52 was to investigate the potential presence of environmental contamination generated by the current and historical vehicle maintenance operations in the yards and, if found, assess the vertical and horizontal extent of contaminant migration and recommend further actions. Possible contaminant types include petroleum hydrocarbons associated with gasoline, diesel fuel, motor oil, hydraulic fluid, and other vehicle fluids. Incidental releases of chlorinated degreasing solvents were also considered. Because of the potential variety of contaminants, the investigation focused on sampling soil and groundwater for analysis of organic and inorganic analytes and for TPHC. In considering potential migration of contaminants, surface water and sediment samples were collected from Cold Spring Brook and analyzed for the same analytes.

The entire SA 44 was identified as a potential contaminant source area. Six soil borings were drilled in the Cannibalization Yard and RTS yard at locations more or less randomly located in areas where vehicles are typically parked (Figure 4-17). The borings (44B-92-01X through 44B-92-06X) were drilled with hollow stemmed augers to a depth of 10 feet. Three soil samples were collected from each soil boring; one sample from 0 to 2 feet bgs, another from 5 to 7 feet bgs, and a final sample from 10 to 12 feet bgs. The samples were analyzed for PAL organics, PAL inorganics, and TPHC.

In SA 52, nine soil borings (52B-92-01X through 52B-92-09X; seven in the Maintenance Yard and two in the K-yard) were drilled to a depth of 10 feet. Borings were located on a more-or-less evenly spaced grid (Figure 4-17), avoiding areas where test pits were previously excavated and avoiding the spill-pad excavation and associated soil stockpiles. Three soil samples were collected from each boring and analyzed for PAL organics, PAL inorganics, and TPHC. Samples were collected from 0 to 2 feet bgs, 5 to 7 feet bgs, and 10 to 12 feet bgs.

An additional soil boring, G3M-92-04X, was drilled in the TDA Maintenance Yard to determine the profile of soil contamination between the ground surface and the water table and to install a monitoring well in a downgradient location from the SAs. Three of the split-spoon samples were analyzed for PAL organics, PAL inorganics, and TPHC. Samples were collected from the surface (0 to 2 feet bgs), at an intermediate depth interval (12 to 14 feet bgs) and from the saturated zone at the approximate depth of the water table (26 to 28 feet bgs). The water-table soil sample was analyzed for TOC in addition to the analytes listed above.

A water table well was installed in G3M-92-04X. This well was included in the Group 3 groundwater sampling rounds (see Section 4.1.2.1).

4.2.3 Results and Observations of Initial Field Investigation

The surficial geologic deposits, Cold Spring Brook sediment characteristics, and Group 3 groundwater characteristics are discussed in Section 4.1.3

Soil data from borings installed in the SA 44 and SA 52 yards are summarized on the boring logs located in Appendix B. The soils consisted generally of sand with variable gravel and silt content. None of the borings penetrated to bedrock.

One inferred groundwater flow path from SA 52 would be from well G3M-92-04X to Grove Pond. The average hydraulic gradient along that flow path was approximately 0.0047 ft/ft on September 15, 1992, and the arithmetic average of the measured hydraulic conductivities at G3M-92-04X is 0.0405 cm/sec. Assuming that conductivity is representative of average conditions along the flow path, and assuming an average effective porosity of 0.30, the average groundwater velocity at the water table would be approximately 650 ft/yr.

4.2.4 Nature and Extent of Contamination (Laboratory Results)

The raw laboratory analytical results for samples collected as part of the SAs 44 and 52 initial site investigation are included in Appendix K and are discussed by medium in the following subsections.

4.2.4.1 Soils. At SAs 44 and 52, ABB-ES collected three soil samples from each of 16 soil borings. One of these soil borings, G3M-92-04X, was converted to a monitoring well. The laboratory results for organic compounds in the 48 soil samples are provided in Tables 4-8 and 4-9. The results for inorganic analytes are provided in Tables 4-18 and 4-19.

The aromatic VOCs -- ethylbenzene, toluene, and xylene (typical petroleum product compounds) -- were detected in three samples, at the surface in borings 52B-92-08X and G3M-92-04X, and at 5 feet in 44B-92-06X. No VOCs were detected in the remaining 45 soil samples. There is no obvious lateral or vertical distribution of VOCs in soil. A suite of SVOCs, predominantly polycyclic aromatic hydrocarbons (PAHs), were detected in many of the soil samples collected. SVOC concentrations in the study area are typically higher in surficial samples and are generally absent or of lower concentration at depth. TPHC appears to mimic the distribution of SVOCs. Higher concentrations of TPHC were observed in surface samples and correlate well with the relative distribution of SVOC concentrations. No lateral distribution is evident.

Figures 4-18, 4-19, and 4-20 show the distribution of total VOCs, SVOCs, and TPHC in soils collected at the three depth intervals within the study areas. All the organic contaminants detected are typical of petroleum product contamination except for TCFM, which was reported in boring 44B-92-03X at a depth of 5 feet below the surface. The low concentration and single occurrence of the compound suggests it is likely a laboratory contaminant; this is substantiated by the fact that TCFM was detected in two of 24 method blank samples at a similar concentration (see Section 1.3 of Appendix F).

Numerous inorganic analytes were detected in soil samples above the calculated Fort Devens background concentrations. Figures 4-21, 4-22, and 4-23 show the distribution of those inorganic analytes at each depth interval exceeding calculated background concentrations for typical Fort Devens soils. Generally, the same vertical trend in concentrations found for the organic compounds appears to exist with the inorganic analytes. Higher concentrations of inorganics are found near the ground surface.

4.2.4.2 Groundwater. Seven groundwater monitoring wells were installed and sampled in three rounds as part of the Group 3 groundwater quality assessment. The results of the group-wide groundwater data evaluation are summarized in Subsection 4.1.4.2. Analytical results are provided in Tables 4-5 and 4-6.

Of the organic compounds tested for in the samples collected from monitoring well G3M-92-04X (the only well located in SAs 44 and 52), only chloroform was detected. This is likely a laboratory contaminant, as chloroform was also detected in half of the method blanks at a similar concentration (see Section 1.2 of Appendix F). Manganese and sodium, were detected above the calculated background concentration at this well location in both rounds of groundwater samples analyzed for inorganic analytes.

4.2.4.3 Surface Water and Sediment. Five surface water and sediment sample pairs were collected from Cold Spring Brook to assess potential contaminant migration from the Group 3 study areas. Analytical results for surface water and sediment samples are provided in Tables 4-8 and 4-9 and Figures 4-15 and 4-16, respectively. Analytical results for Group 3 surface water and sediment samples are discussed in Subsection 4.1.4.3.

4.2.5 Source Evaluation and Migration Potential

Petroleum-related organic compounds are prevalent in soils throughout the two study areas, concentrating in surface samples. This is entirely consistent with the presumed release mechanisms discussed earlier. Concentrations of these analytes decrease with depth suggesting that some downward migration has occurred. However, significant concentrations are not observed at depth. The absence of chlorinated solvents in all of the soils suggests that releases of these compounds have not occurred in the study areas. Inorganic analyte concentrations were observed in a distribution similar to organic compounds, suggesting coincidental releases and perhaps sources. Crank case oil is a potential source of these organic and inorganic analytes. Cutting and welding activities may be an additional source of the inorganic analytes associated with metal alloys.

Inorganic analytes, particularly sodium, present above background in G3M-92-04X are likely attributable to road salting. Because groundwater is typically clean, migration of contaminants from SAs 44 and 52 via groundwater flow to surface water and sediment is not likely. There is no evidence suggesting that contaminants found in study area soils are impacting groundwater quality. Thus migration of study area contaminants via groundwater is not likely.

4.2.6 Preliminary Human Health Risk Evaluation

SAs 44 and 52, the Maintenance Yards, have a long history of vehicle storage and repair. The most probable future use of these SAs is to remain industrial/ commercial in use.

Tables 4-20 through 4-22 present summary statistics and human health standards and guidelines used in the PRE for SAs 44 and 52, based on the results of the initial site investigation.

4.2.6.1 Soils. This PRE considered all soils to a depth of 3 feet as accessible under a residential future use exposure scenario. This approach is conservative (i.e., health-protective) because the most likely future use of SAs 44 and 52 is industrial/commercial. All subsurface soil (defined as 3 to 10 feet in depth) will be considered as accessible under a commercial/industrial future use exposure scenario.

Tables 4-20 and 4-21 present summary statistics on surface and subsurface soil at SAs 44 and 52 and USEPA Region III residential and commercial/industrial soil concentrations for comparison. Soil samples at SAs 44 and 52 are represented by samples 44B-92-01X through 44B-92-05X, 52B-92-01X through 52B-92-09X, and G3M-92-04X.

An assessment of the inorganic data for SAs 44 and 52 soils shows that there is no apparent gross contamination present. However, there is a clear pattern of decreasing concentration with depth. Surficial soils exhibit inorganic analyte concentrations generally two to three times higher than soils at both the 5-foot and 10-foot depths. When comparing soil concentrations to the statistical Fort Devens background, there are only a few compounds which show a pattern of consistent exceedances: copper, nickel, and zinc in almost all surficial soil samples; and beryllium on a more random basis. The copper, nickel, and zinc could be the result of vehicle maintenance activity; the beryllium does not appear to be related to Army activity and is probably naturally occurring. On a lateral basis, there are a few locations where the surficial soils appear to contain the most inorganics: in SA 44 at locations 44B-92-01X and 44B-92-06X; and in SA 52 at locations 52B-92-01X and 52B-92-06X.

When considering the SA activity-derived inorganic analytes copper, nickel, and zinc, the USEPA Region III Risk-Based Concentration Tables values are two to three orders of magnitude above the concentrations found in the SAs during the SI activity. Therefore, it is clear that inorganic analytes in SAs 44 and 52 do not pose a significant risk to human health.

The fact that aromatic VOCs, PAHs, and TPHC are the primary organic compounds in the SA soils adds additional evidence that vehicle maintenance activity is the only source of contaminant release. The pattern of decreasing concentration with depth also holds true for organic compounds, suggesting surficial spills of petroleum-based materials. In general, organic compounds detections were limited to the surficial soil sample in each boring. However, PAHs were consistently detected at the 5-foot sampling depth in SA 44 at location 44B-92-01X and in SA 52 at location 52B-92-05X.

When considering the SA activity-derived aromatic compounds, the USEPA Region III Risk-Based Concentration Table values are many orders of magnitude above the concentrations found in the SA soils during the SI activity.

In general and where available, the USEPA Region III residential soil concentrations values for PAHs in soil are two to three or more orders of magnitude above the concentrations found in SA soils. However, each of four PAHs: benzo(a)anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene has a Region III residential soil value of 1.6 ppm or less. In approximately half of the surficial soil samples from SAs 44 and 52, concentrations exceed Region III residential values. At the 5-foot depth, soil sample PAH concentrations rarely exceed Region III commercial/industrial values. Therefore, the surficial soils present a potential risk to human health.

4.2.6.2 Groundwater. Table 4-22 presents summary statistics on groundwater at SAs 44 and 52 and drinking water standards for comparison. Monitoring well G3M-92-04X has been used to define the groundwater quality for SAs 44 and 52.

Organic contaminants in soils at the SAs have not been consistently detected in groundwater during the SI. Only one organic analyte, chloroform, was detected at G3M-92-04X. The detected concentration of 0.79 μg/L is, however, below the Massachusetts drinking water guideline of 5 μg/L.

Of the inorganic analytes detected, only manganese was detected at a concentration above its drinking water standard. However, only a secondary MCL (set for economic or aesthetic reasons) exists for manganese. No health-based drinking water standard exists for manganese.

4.2.6.3 PRE Summary. The results of this preliminary human health risk evaluation indicate that soils in SAs 44 and 52, particularly surficial soils, present a potential risk to human health. Therefore, to gain a more detailed understanding of the potential human health risks, a supplemental risk evaluation for soil at SAs 44 and 52 was performed. This supplemental evaluation follows in Section 4.2.7.

4.2.7 Supplemental Risk Evaluation for Soil

At SAs 44 and 52, the results of the PRE show that the contaminant levels and distribution require a thorough evaluation of risk. Therefore, quantitative risks are estimated on the basis of the results of the initial site investigation, to gain a more detailed understanding of the potential human health risks.

In Subsection 4.2.7.1, risk estimates are made for soil contamination associated with crankcase releases at SAs 44 and 52. These releases have occurred across the SAs for many years. In Subsection 4.2.7.2, risk estimates are made for the motor vehicle gas (mogas) spill localized in SA 44. Both sections contain the four components of a quantitative risk assessment: hazard identification, exposure assessment, toxicity assessment, and risk characterization.

4.2.7.1 Crankcase Releases. This section presents risk estimates calculated by ABB-ES for soil contamination associated with crankcase releases at SAs 44 and 52. Health risk estimates are developed for two exposure scenarios: one involving a construction worker and the other involving a long-term worker employed at SAs 44/52 for a working lifetime. A summary of the risk assessment for these releases follows.

Findings

Risk estimates made under a construction worker exposure scenario for crankcase releases at SAs 44 and 52 fall within the USEPA Superfund target risk range of 1E-4 to 1E-6 excess cancer risk for carcinogens and a target index of 1. The cancer risk estimates, assuming exposure to SA average and maximum concentrations (in soil to a depth of 10 feet), range from 2E-6 to 1E-5. The hazard indices are below or approximately 1.

Risk estimates made under a long-term worker exposure scenario exceed the USEPA Superfund target risk range of 1E-4 to 1E-6 excess cancer risk for carcinogens. The cancer risk estimates, assuming exposure to SA average and maximum concentrations (in soil to a depth of 2 feet), range from 9E-4 to 2E-4. The HIs are below one (average concentrations: HI=0.16; maximum concentrations: HI = 0.42).

Hazard Identification

Potentially hazardous chemicals associated with these releases were identified using sampling data presented in Tables 4-16 through 4-19 and Figures 4-21, 4-22 and 4-23 and were used to identify chemicals of potential concern.

With the exception of a few inorganic substances, all of the chemicals reported in these tables were included as chemicals of potential concern. Inorganic substances were excluded if they were detected at concentrations below installation-wide statistical background. The elimination of compounds from the risk estimation process for this reason is consistent with the most recent MADEP guidance (MADEP, 1992).

Four inorganic compounds were excluded from this risk evaluation: aluminum, antimony, calcium, and cobalt. Aluminum, antimony, and cobalt were detected at concentrations below background (see Figures 4-21 through 4-23). Calcium was detected at a concentration above background only once; because of its low frequency of detection and low toxicity, it was also excluded.

Although TPHC was detected in soil at SAs 44/52, it was not included as such in the quantitative risk estimation. This is because the common constituents of automotive used oil (including crankcase releases) were detected and measured in the soil at SAs 44/52. A better representation of the toxicity of crankcase releases is made using the analytical data on the 38 individual compounds detected. Table 4-23, taken from the report titled "Used Oil in New England", lists the potentially hazardous constituents in automotive/vehicular used oil.

Exposure Assessment

SAs 44 and 52 historically and currently are used as vehicle maintenance areas. The future use of these areas is expected to remain commercial/industrial in nature. Under current and future use, it is possible that a worker could be exposed to chemicals detected in soil if excavation were to occur. This might occur for utility repair or new building construction. It is also possible that an employee of Building 3713 could contact contaminants in surface soil during an activity such as grounds maintenance.

For the construction worker exposure scenario, it was assumed that a construction worker is exposed to chemicals in the surface and subsurface soil (to a depth of 10 feet) in SAs 44 and 52 for a period of three months (5 workdays for 12 weeks). It was further assumed that the worker would be exposed through direct contact with the chemicals and through the incidental ingestion of soil particles. Although some exposure to soil particles could occur though the inhalation of airborne particles, this exposure route is not expected to contribute significantly to the overall risk. It is assumed that any inhalation health risks can be minimized through the use of dust control measures during construction activities.

For the long-term worker exposure scenario, it was assumed that an employee of Building 3713 could be exposed to chemicals in the surface soil (to a depth of 2 feet) in SAs 44 and 52 for a working lifetime of 25 years (250 days/year). These exposure assumptions (i.e., exposure duration and frequency) are standard USEPA default exposure parameter values. ABB-ES believes that these exposure assumptions most likely over-estimate worker risks at SAs 44 and 52. Because most vehicle maintenance activities occur within Building 3713 and the ground is frozen or covered for at least three months of the year, the frequency of soil contact is expected to be much lower. As for the construction worker scenario, it was assumed that the worker would be exposed through direct contact and incidental ingestion.

To estimate the exposure point concentrations to which a construction worker might be exposed, ABB-ES used both SA-wide average concentrations as well as SA maximums. For the construction worker scenario, SA arithmetic averages were calculated using all soil sampling locations at three depths. For the long-term worker scenario, averages were calculated using soil samples at depths of 0 to 2 feet. For samples reported as non-detects, it was assumed that a compound was present at one-half the sample detection limit. For both exposure scenarios, the maximum concentration was that which was found anywhere (within the respective limits on soils depth) on SAs 44 and 52.

Toxicity Assessment

Dose-response values were obtained from three sources: USEPA Integrated Risk Information System (IRIS), USEPA Health Effects Assessment Summary Tables (HEAST, 1992), and MADEP's Documentation for the Risk Assessment Shortform - Residential Scenario (MADEP, 1992).

For the construction worker scenario, subchronic oral reference doses (RfD), when available, were used to estimate risk. If a subchronic RfD was not available, a chronic RfD was used. The use of subchronic RfDs is appropriate given that the duration of exposure is less than seven years; this is consistent with USEPA and MADEP risk assessment guidance. For the long-term worker scenario, chronic oral reference doses were used.

To evaluate the carcinogenic potential of PAHs, an approach taken by USEPA Region IV was taken. It involves the application of toxic equivalency factors to carcinogenic PAHs based on each compound's relative potency to that of benzo(a)pyrene. The toxic equivalency factor (TEF) approach is expected to become an agency-wide approach in the near future.

Following USEPA Interim Region IV guidance (dated February 10, 1992), the following TEFs were used to convert each carcinogenic PAH's concentration to an equivalent concentration of benzo(a)pyrene:

Compound	**TEF**
Benzo(a)pyrene	1.0
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenzo(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene	0.1

Relative absorption factors (RAFs) were obtained from the MADEP's Documentation For the Risk Assessment Shortform. Several inorganic compounds did not have RAFs; it was assumed for these compounds that an RAF equal to that of nickel, which has the highest RAF of the inorganic compounds. This represents a conservative or health-protective approach. The inorganic compounds without RAFs include beryllium, barium, iron, magnesium, manganese, potassium, sodium, and vanadium.

Risk Estimation

The spreadsheets used to generate preliminary risk estimates for SAs 44 and 52 are included as Tables 4-24 through 4-27. Below is a summary of the risk estimates under the two exposure scenarios:

Exposure Scenario	Cancer Risk	Hazard Index
Construction Worker:		
SA-Wide Average Concentrations	2E-6	0.47
SA-Wide Maximum Concentrations	1E-5	1.4
Long-Term Worker:		
SA-Wide Average Concentrations	2E-4	0.2
SA-Wide Maximum Concentrations	9E-4	0.4

4.2.7.2 Mogas Spill. This section presents risk estimates calculated by ABB-ES for the motor vehicle gas (mogas) spill at SA 44. Health risk estimates are developed for a construction worker exposure scenario for the mogas spill reported to have taken place in the area of sampling location 44B-92-06X. A summary of the risk assessment for this release follows.

Findings

Risk estimates made under a construction worker exposure scenario for the mogas spill in SA 44 essentially fall within the USEPA Superfund target risk range of 1E-4 to 1E-6 excess cancer risk for carcinogens and a target hazard index of 1. The cancer risk estimate, assuming exposure to the maximum concentration found at sampling location 44B-92-06X, is 2E-6. The hazard index approximates one (1.9). The risk estimates comply with MADEP's total site cancer risk limit of 1E-5 but exceed its current target hazard index of 0.2. MADEP has proposed to raise its target hazard index to one in its draft regulations for revising Chapter 21E.

Hazard Identification

Potentially hazardous chemicals associated with this release were identified using sampling data presented in Tables 4-16 and 4-18 and Figure 4-21, and were used to identify chemicals of potential concern.

With the exception of a few inorganic compounds, all of the chemicals reported in these tables were included as chemicals for potential concern. Inorganic compounds were excluded if they were detected at concentrations below base-wide statistical background. The elimination of compounds from the risk estimation process for this reason is consistent with the most recent MADEP guidance (MADEP, 1992). Four compounds were excluded based on their detection at levels below background. These compounds include antimony, cadmium, cobalt and lead.

Exposure Assessment

SA 44 historically and currently is used as a vehicle maintenance area. The future use of this area is expected to remain commercial/industrial in nature. Under current and future use, it is possible that a worker could be exposed to chemicals detected in soil if excavation were to occur. This might occur for utility repair or new building construction. Because of the limited areal extent of this spill (represented by sampling location 44B-92-06X), long- term, repeated exposure is considered to be unlikely. Therefore, worker exposure that would be chronic in duration was not evaluated.

For this risk assessment, it was assumed that a construction worker is exposed to chemicals in the surface and subsurface soil in the area of the mogas spill for a period of three months (5 workdays for 12 weeks). This represents a very conservative assumption because repeated exposure to soil in this particular area is unlikely. It was further assumed that the worker would be exposed through direct contact with the chemicals and through the incidental ingestion of soil particles. Although some exposure to soil particles could occur through the inhalation of airborne particles, this exposure route is not expected to contribute significantly to the overall risk. It is assumed that any inhalation health risks can be minimized through the use of dust control measures during construction activities.

The maximum concentration detected at any depth at sampling location 44B-92-06X was selected to represent the exposure point concentration.

Toxicity Assessment

Dose response values were obtained from three sources: USEPA Integrated Risk Information System (IRIS), USEPA Health Effects Assessment Summary Tables (HEAST, 1992), and MADEP's Documentation For the Risk Assessment Shortform - Residential Scenario (MADEP, 1992).

When available, subchronic oral reference doses were used to estimate risk. If a subchronic RfD was not available, a chronic RfD was used. The use of subchronic RfDs is appropriate given that the duration of exposure is less than seven years; this is consistent with USEPA and MADEP risk assessment guidance.

Most of the residual contamination associated with the mogas release was detected and reported as TPHC. This is consistent with the composition of mogas, a high-octane leaded gasoline. Because no dose-response value exists with which to evaluate the toxicity of TPHC, ABB-ES used as a surrogate dose-response value that of gasoline. The USEPA's Superfund Health Risk Technical Support Center has issued and oral reference dose and cancer potency factor for gasoline (USEPA, 1992).

Relative absorption factors (RAFs) were obtained from the MADEP's Documentation for the Risk Assessment Shortform. Several inorganic compounds did not have RAFs; it was assumed for these compounds that an RAF equal to that of nickel, which has the highest RAF of the inorganic compounds. This represents a conservative or health-protective approach. The inorganic compounds without RAFs include beryllium, barium, iron, magnesium, manganese, potassium, sodium, and vanadium.

Risk Estimation

The spreadsheet used to generate risk estimates for the mogas spill at SA 44 is attached as Table 4-28. Below is a summary of the risks posed to a construction worker working in the area of the mogas spill:

Exposure Scenario	Cancer Risk	Hazard Index
Sampling Location 44B-92-06X, Maximum Concentrations	2E-6	1.9

4.2.8 Preliminary Ecological Risk Evaluation

SAs 44 and 52 consist of four unpaved, fenced-in yards, covering approximately six acres. These two SAs are located northeast of Building 3713, on Barnum Road. The yards are typically filled with parked heavy equipment vehicles, and are surrounded by barbed-wire fence. The sites are devoid of any woody or herbaceous vegetation.

No significant habitat for resident or migratory ecological receptors occur at these SAs, and no rare or endangered species are known to occur in the vicinity of SAs 44 and 52. Therefore, based on the lack of ecological habitat at SAs 44 and 52, and the resulting lack of ecological exposure pathways, no comparison of surface soil analytes to PCL reference values was conducted.

4.2.9 Supplemental Site Investigations and Data Gathering

It was recommended, based on the Human Health PRE and the supplemental quantitative risk evaluation, that SAs 44/52 are Areas of Contamination (AOCs) requiring a Feasibility Study (ABB-ES, April 1993a). No additional SI activities were considered necessary to support that conclusion. However, development of the Feasibility Study for AOCs 44 and 52 identified data gaps which required additional investigation. The data gaps included the need to:

- investigate the groundwater directly downgradient of the hot spot areas defined as the removed underground waste oil storage tank and mogas spill in the Cannibalization Yard;
- better define the vertical and horizontal extent of contamination around the mogas spill area and the contamination that remains around the excavated waste oil storage tank area;
- quantify the effectiveness of the biological treatment process options of bioventing, landfarming and composting in reducing the

concentration of carcinogenic polycyclic aromatic hydrocarbon (cPAH) contaminants in AOCs 44 and 52 soils; and

- investigate the influence of bituminous pavement on soil analysis for cPAH contaminants.

Due to the concurrent timing of the ongoing supplemental SI program for Group 3, 5, and 6 SAs, the additional investigations were included in the Supplemental SI field effort. The scope of the supplemental SI program is summarized in the following subsections. The results are presented by ABB-ES (January 1994, Section 1.4).

4.2.9.1 Groundwater. To assess groundwater conditions near the removed waste-oil tank and mogas spill, in May 1993 two additional groundwater monitoring wells (G3M-93-10X and G3M-93-11X) were installed downgradient of these two potential contamination sources, respectively (Figure 4-24). Groundwater was sampled in June and September 1993, and the samples were analyzed for PAL organics, PAL inorganics, PAL anions/cations, and TSS.

4.2.9.2 Soils (Mogas Spill and Waste Oil Storage Tank Area). Defining the vertical and horizontal extent of contamination around the former tank and spill areas was required to better assess the remedial alternatives to be evaluated in the FS. Although soil removal actions have taken place around the excavated tank, the extent (specifically depth) of contamination remaining was not readily defined due to the lack of conclusive analytical data at the time of the soil over-excavation. The horizontal and vertical extent of contamination from the mogas spill was unknown except perhaps in the vicinity of existing boring 44B-92-06X. This boring may have been located only at the periphery of the spill or not in the spill area at all. An Army Pollution Incident Report was discovered which located the mogas spill closer to the center of the Cannibalization Yard.

The supplemental field investigation entailed drilling a total of four borings, 44B-93-07X, -08X, -09X and -10X, in the Cannibalization Yard in the vicinity of the excavated underground tank area and mogas spill area (Figure 4-24) and then sampling soil from these borings to better define the extent of contamination. Soil analyses were conducted for inorganics (only lead in 44B-93-09X and -10X) SVOCs, TPHC, and PCBs.

4.2.9.3 Bioremediation Feasibility Testing. Feasibility testing was conducted to assist in evaluating the effectiveness of the bioremediation technology for reducing the concentration of cPAHs and TPHC in AOCs 44 and 52 soils. Data obtained from the testing was used to evaluate the remedial action alternatives in the FS which involve bioventing, landfarming and composting (described in more detail in later sections).

The supplemental field investigation entailed obtaining a total of four shelby tube soil samples from two of the four borings (44B-93-07X and 44B-93-09X) in an effort to obtain undisturbed soil samples for air permeability testing. Additionally, a surficial soil sample (0 to 2 feet) was to be taken from an area in the Maintenance Yards where the soil was either visibly stained with oil or from an area previously recorded as having high PAH concentrations (44B-92-01X, 44B-92-05X, or 52B-92-03X). The areas previously recorded as having high PAH concentrations were found to have broken pavement either at or below the ground surface; consequently, soil was obtained from a visibly oil-stained spot located in the north corner of the Cannibalization Yard, taking precautions to avoid collecting any pieces of bituminous paving in the sample. The surficial sample was used for a variety of tests including bacterial analysis, chemical analysis, and nutrient adsorption.

4.2.9.4 Bituminous Pavement Analysis. The apparent randomness in detecting PAH compounds in AOCs 44 and 52 soils during the SI raised questions about the potential source of these contaminants. Based on visual observations, broken-up bituminous paving is present in various areas of AOCs 44 and 52 surface soils. However, there appear to be no historical records indicating when and in what areas the pavement was applied. Aerial photographs taken over the past 50 years also do not show any evidence of paving. Bituminous paving contains PAH compounds and it is believed that the presence of paving in AOCs 44 and 52 soils may impact the soil analytical results.

To investigate the potential influence of bituminous pavement on soil analysis for cPAH contaminants, a sample of non-oil stained bituminous pavement was obtained from the north corner of the TDA Maintenance Yard and analyzed for chromatographable organic compounds, including target cPAHs contaminants of concern to establish a general fingerprint of contaminants potentially associated with paving. The same analysis was performed on the oil-stained surficial soil sample (0 to 2 feet) taken from the Cannibalization Yard. Chemical analyses was performed for aromatic and alkane compounds using a gas chromatograph/flame ionization detector (GC/FID) fingerprint (modified USEPA Method 8100). A split soil and pavement sample was submitted to another laboratory where chemical analysis was performed for Project Analyte List (PAL) SVOCs using mass spectrometry as was used for the SI analytical work. Contaminant concentrations present in the paving were compared with those present in the soil sample and with the contaminants detected in the surficial soils during the SI.

4.2.10 Conclusions and Recommendations

Supplemental risk estimates calculated by ABB-ES for residual surficial soil contamination (primarily PAHs) associated with crankcase releases exceed the USEPA Superfund target excess cancer risk range. Residual soil contamination associated with both the crankcase oil releases and the mogas spill will require additional evaluation. A focused Feasibility Study is recommended to evaluate, compare, and recommend appropriate remedial actions for the SAs 44 and 52 unsaturated soils.

4.3 ANALYTICAL QUALITY CONTROL

Laboratory water method blanks contained the following PAL compounds: lead (1.8 μg/L), iron (143 μg/L), potassium (578 μg/L), BIS (6.6 μg/L, 5.1 μg/L, and 6.2 μg/L), toluene (0.15 μg/L), acetone (18 μg/L), chloroform (1.3 μg/L and 0.73 μg/L), and 1,1,1-TCA (2.5 μg/L). Laboratory soil method blanks contained the following PAL compounds (exclusive of inorganic compounds): toluene (0.2 μg/g and 0.00086 μg/g), BIS (1.1 μg/g), acetone (0.036 μg/g), TCFM (0.008 μg/g), chloroform (0.002 μg/g), and diethylphthalate (0.27 μg/g). Any compounds detected in a method blank sample are considered laboratory-introduced contamination.

4.3.1 Group 3 Field Quality Control Blank Sample Results

Field quality control samples collected from Group 3 include rinsate blanks and trip blanks. Rinsate blanks were analyzed for any inorganics, SVOCs, pesticides/PCBs, and VOCs that may have carried over into the sample from the decontamination process via the sampling equipment. Trip blanks were analyzed for VOCs that may have been introduced from storage or shipment of the samples.

Evaluation of the Group 3 rinsate blanks showed detections of lead, iron and potassium. The VOCs methylene chloride, 1,1,1-trichloroethane, and chloroform were also present in measurable quantities. A more detailed discussion of Group 3 rinsate blanks is presented in Sections 1.3.1 and 1.3.4 of Appendix F.

Rinsate blanks collected during the supplemental site investigations contained the metals cobalt, chromium, copper, iron, potassium, and manganese and the VOCs and SVOCs TCA, 1,2-dichloroethane, acetone, methylene chloride, chloroform, toluene, 2-ethyl-1-hexanol, BIS, and dodecanoic acid. Additional information on rinsate blanks collected during the supplemental site investigation is presented in Table FS-5 of Appendix F, and the frequency of detection and the minimum and maximum detected concentrations are shown in Table FS-6.

Trip blank analysis indicated no VOC contamination with the exception of methylene chloride. Trip blank results are reported in Table F3 of Appendix F.

The following target compounds were detected in trip blanks collected during the supplemental investigations at concentrations above the CRLs: trifluorochloromethane, methylene chloride, chloroform, and toluene. The results are presented in Table FS-3, and the frequency of detection and the minimum and maximum detections are reported in Table FS-4. A more detailed discussion of trip blank results from the Supplemental Site Investigation is presented in Section 2.3.1 of Appendix FS.

Data from these blank results provided strong support for meeting data quality objectives. Specifically, the results showed that the sample data are complete and representative of true concentrations of the various analytes. The evidence for this assertion is the fact that holding times were met and there was little gross contamination of the blanks. In addition none of the sample lots were rejected due to "out of control" situations as described in Section 3.2 of the text. The blank data indicate that sample integrity was affected very little by decontamination procedures or by shipment and storage.

4.3.2 Matrix Spike/Matrix Spike Duplicate Results

MS/MSD samples from Group 3 were analyzed to observe matrix effects on the recovery of concentrations of inorganic elements. Results from these analyses also help to determine the accuracy of the method. Group 3 matrix spike results are presented in Tables F8 and FS-7 of Appendix F. A discussion of those results can be found in Section 2.2 of Appendix F and Section 3.2 of Appendix FS.

MS/MSD results indicate that data quality objectives of precision representativeness, and accuracy were met. With the exception of lead and arsenic results for a couple of samples, all recoveries met the criteria specified in Section 2.1 of Appendix F. For MS/MSD data collected during the SSI, all recoveries were within the control criteria with the exception of aluminum, antimony, arsenic, iron, lead, manganese, mercury, selenium, silver, and zinc for soil samples.

4.3.3 Duplicate Sample Results

Group 3 duplicate samples were analyzed to measure how well the reported concentrations agree. The RPD of these results was calculated to provide this measurement. Duplicate results are presented in Table F9 of Appendix F, and duplicate results from the SSI are presented in Tables FS-9 and FS-10 of Appendix FS. RPDs were calculated and are also presented in this table. A detailed discussion of the Group 3 duplicate results is presented in Section 2.3 of Appendix F and Section 3.3 of Appendix FS.

Duplicate results were used to evaluate whether data quality objectives such as precision and accuracy were met. The results of several inorganic elements showed some variability. Overall there was good agreement of the sample results to duplicate results and data quality objectives for precision and accuracy were met.

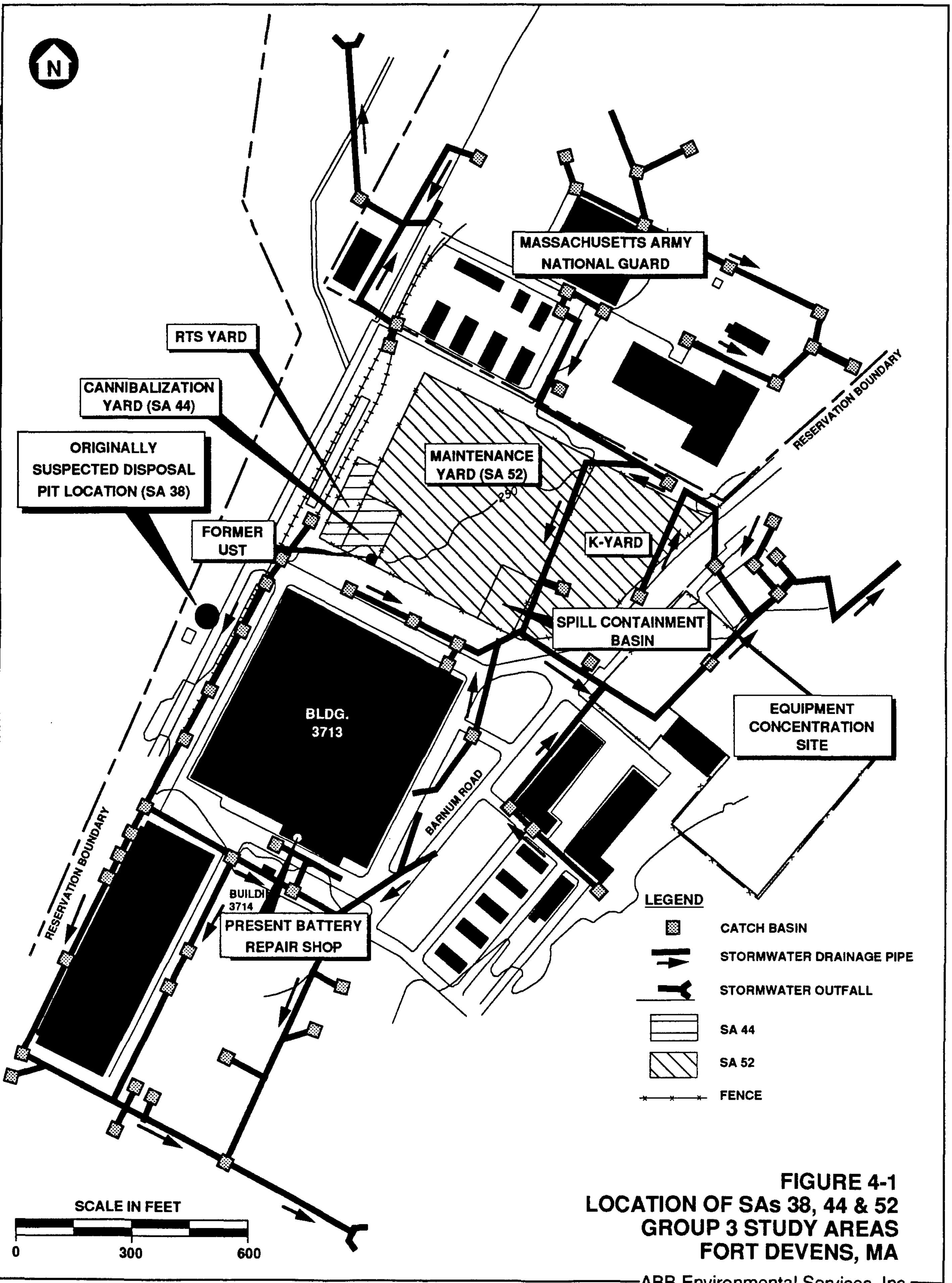


FIGURE 4-1
LOCATION OF SAs 38, 44 & 52
GROUP 3 STUDY AREAS
FORT DEVENS, MA

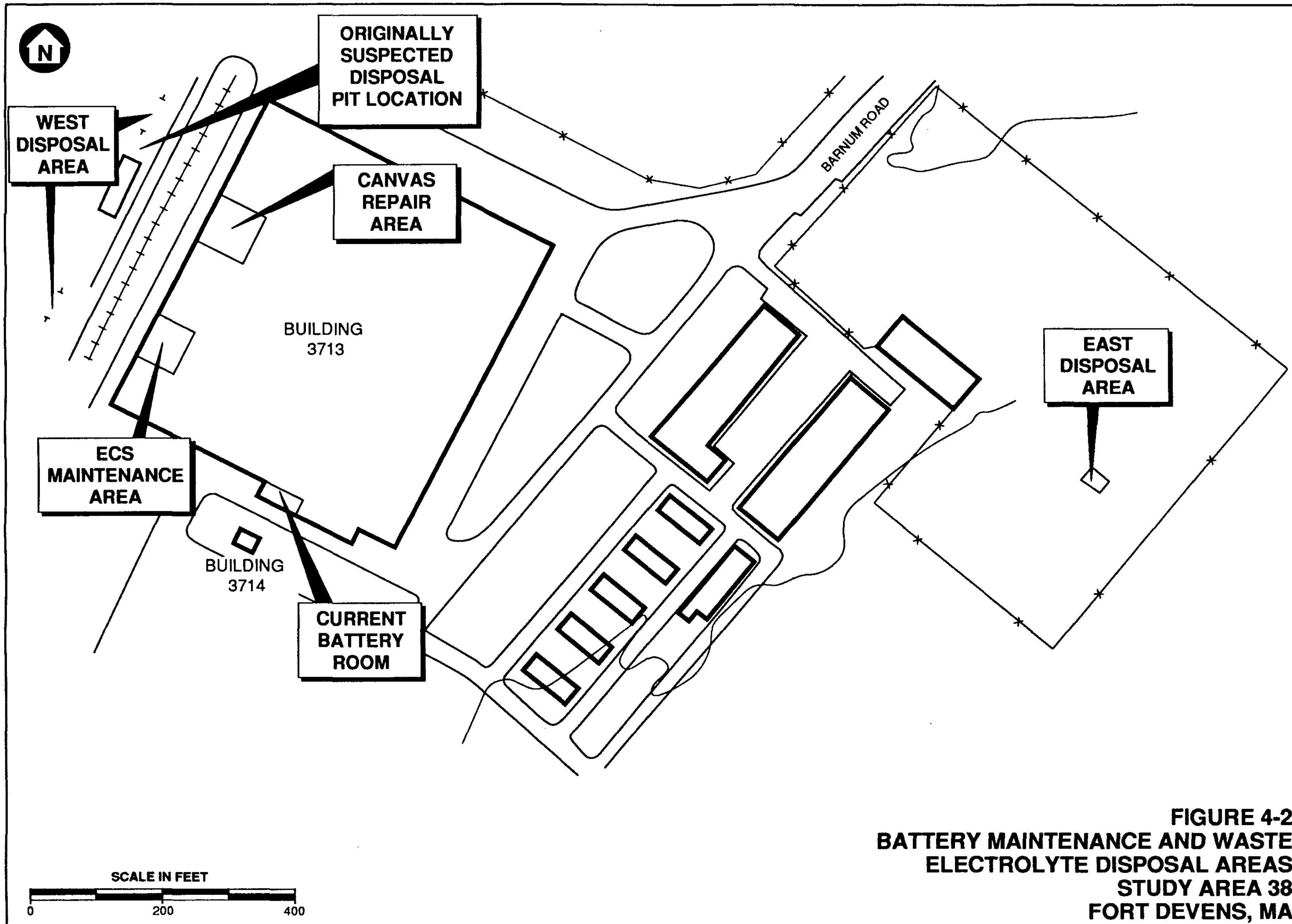


FIGURE 4-2
BATTERY MAINTENANCE AND WASTE
ELECTROLYTE DISPOSAL AREAS
STUDY AREA 38
FORT DEVENS, MA

9308013W12

ABB Environmental Services, Inc.

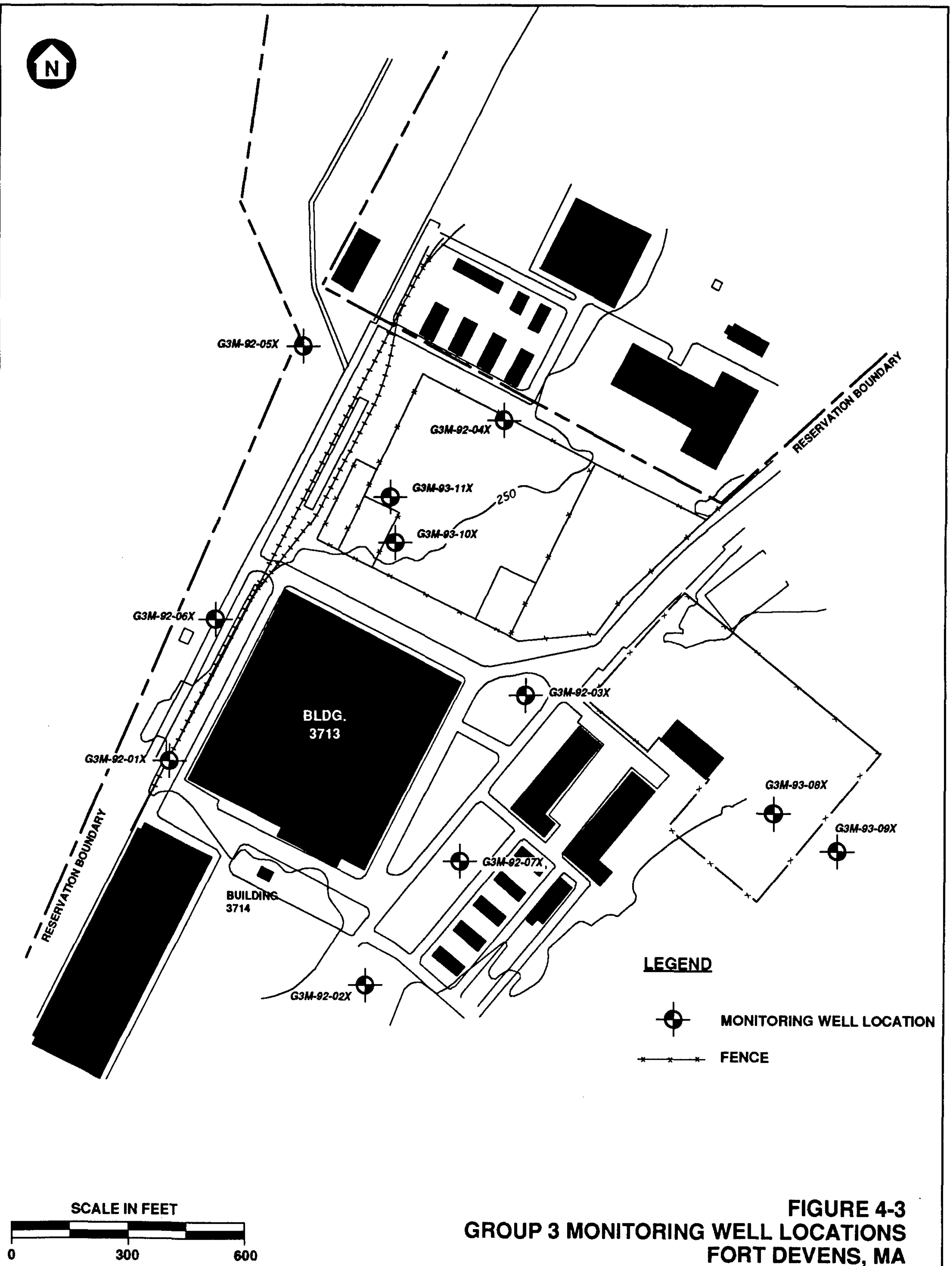


FIGURE 4-3
GROUP 3 MONITORING WELL LOCATIONS
FORT DEVENS, MA

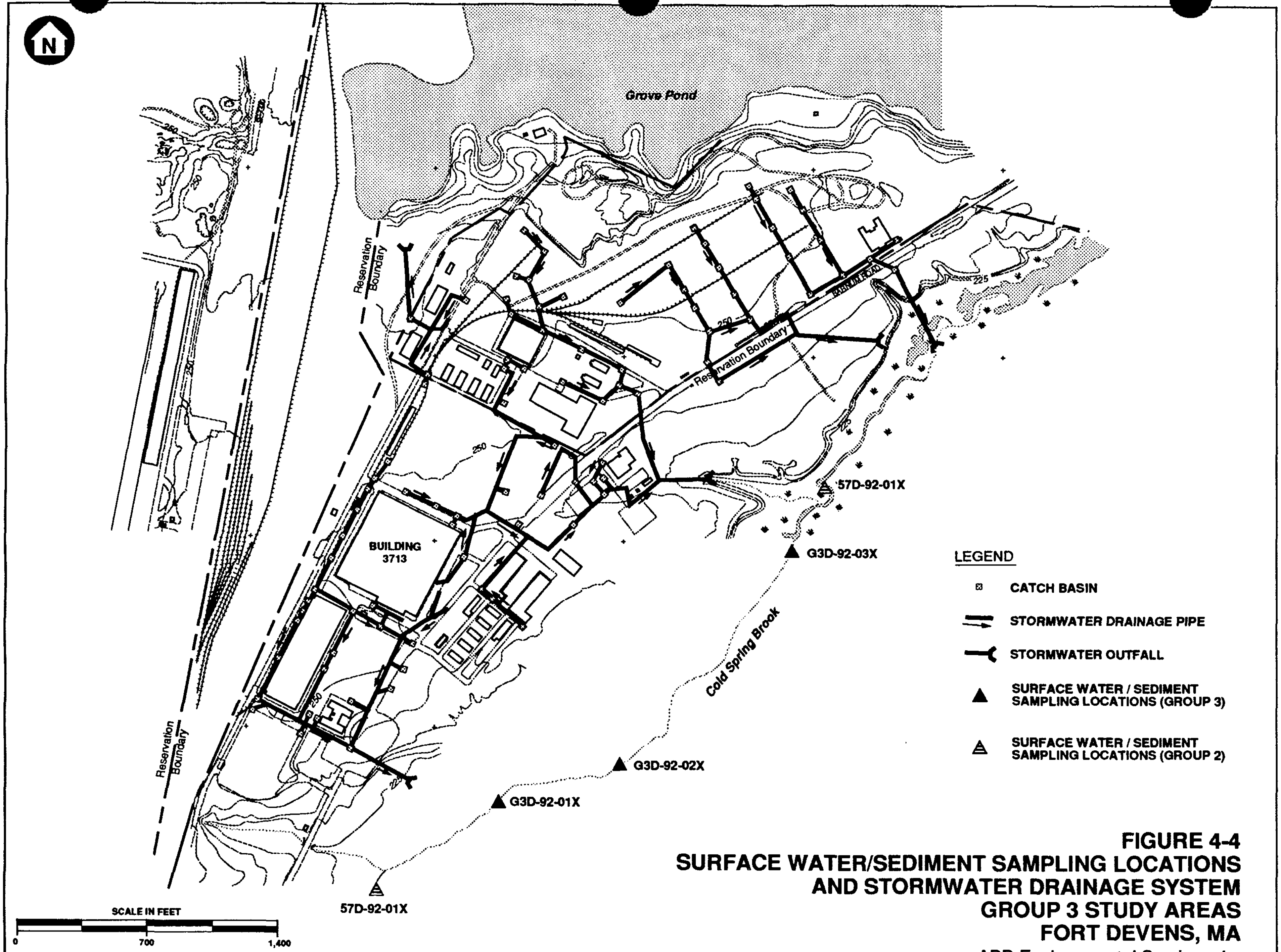


FIGURE 4-4
SURFACE WATER/SEDIMENT SAMPLING LOCATIONS
AND STORMWATER DRAINAGE SYSTEM
GROUP 3 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(J) 1

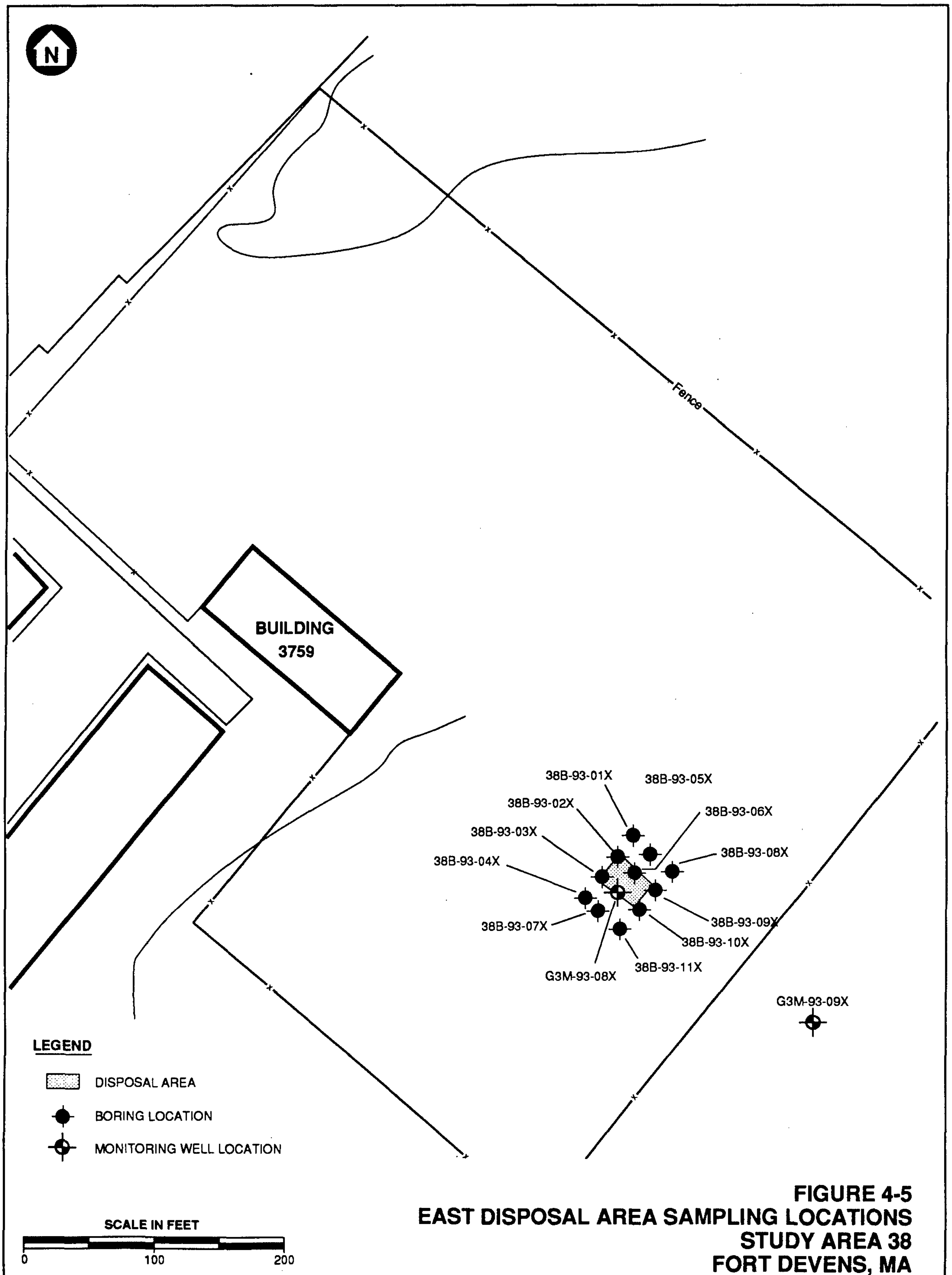


FIGURE 4-5
EAST DISPOSAL AREA SAMPLING LOCATIONS
STUDY AREA 38
FORT DEVENS, MA

ABB Environmental Services, Inc.

9308003W123

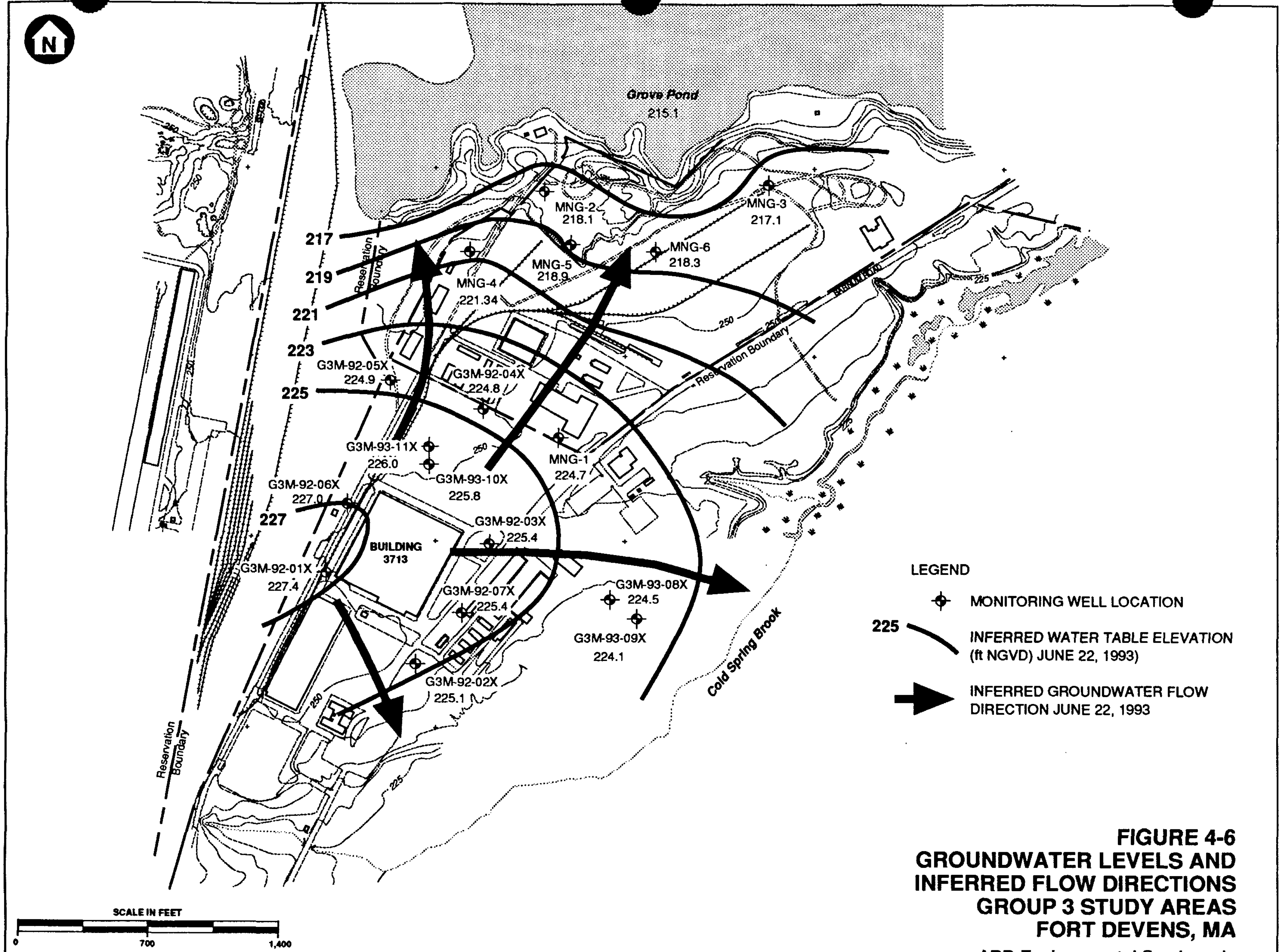


FIGURE 4-6
GROUNDWATER LEVELS AND INFERRED FLOW DIRECTIONS GROUP 3 STUDY AREAS FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(J)

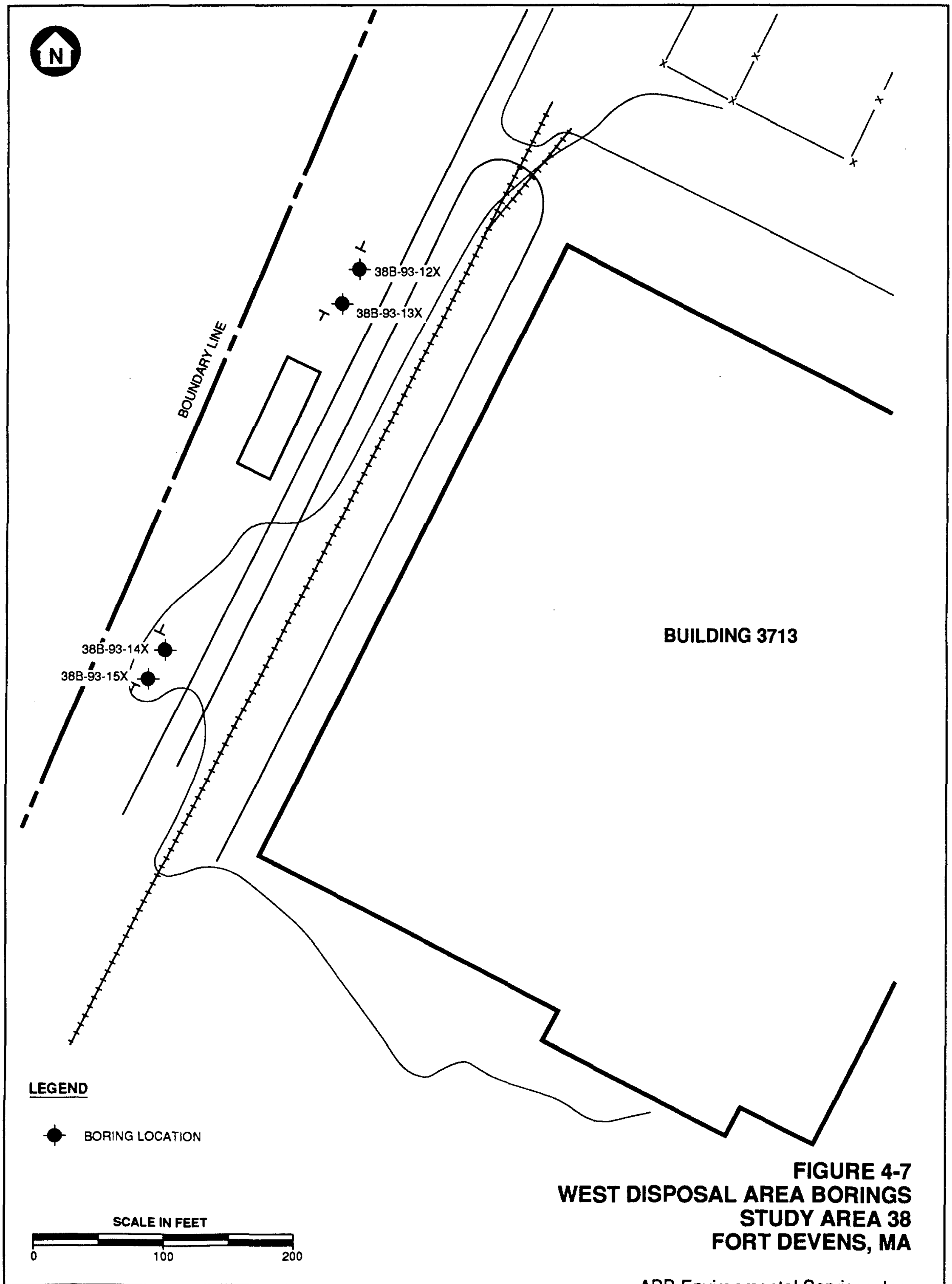


FIGURE 4-7
WEST DISPOSAL AREA BORINGS
STUDY AREA 38
FORT DEVENS, MA

ABB Environmental Services, Inc.

9308005W12

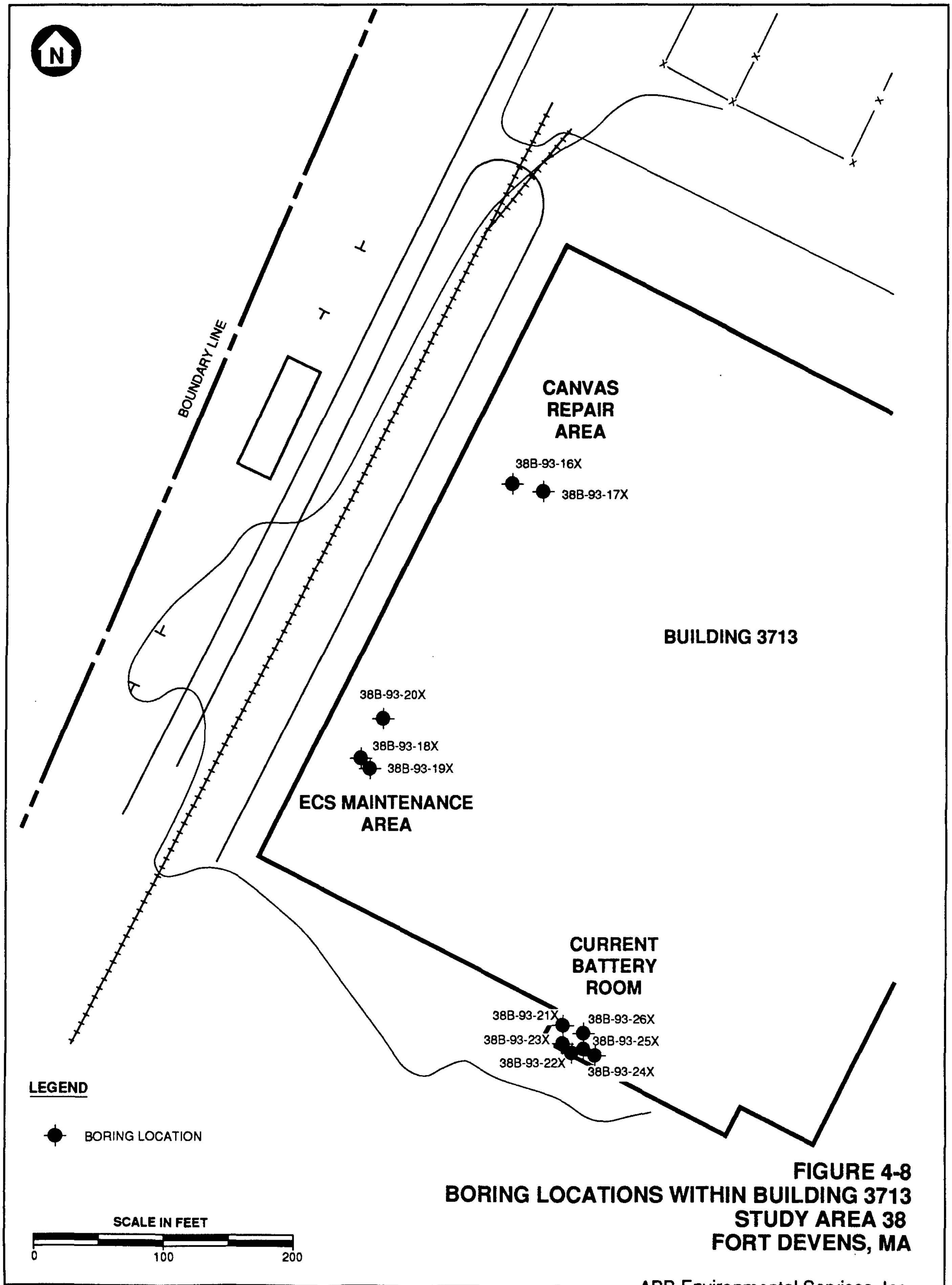


FIGURE 4-8
BORING LOCATIONS WITHIN BUILDING 3713
STUDY AREA 38
FORT DEVENS, MA

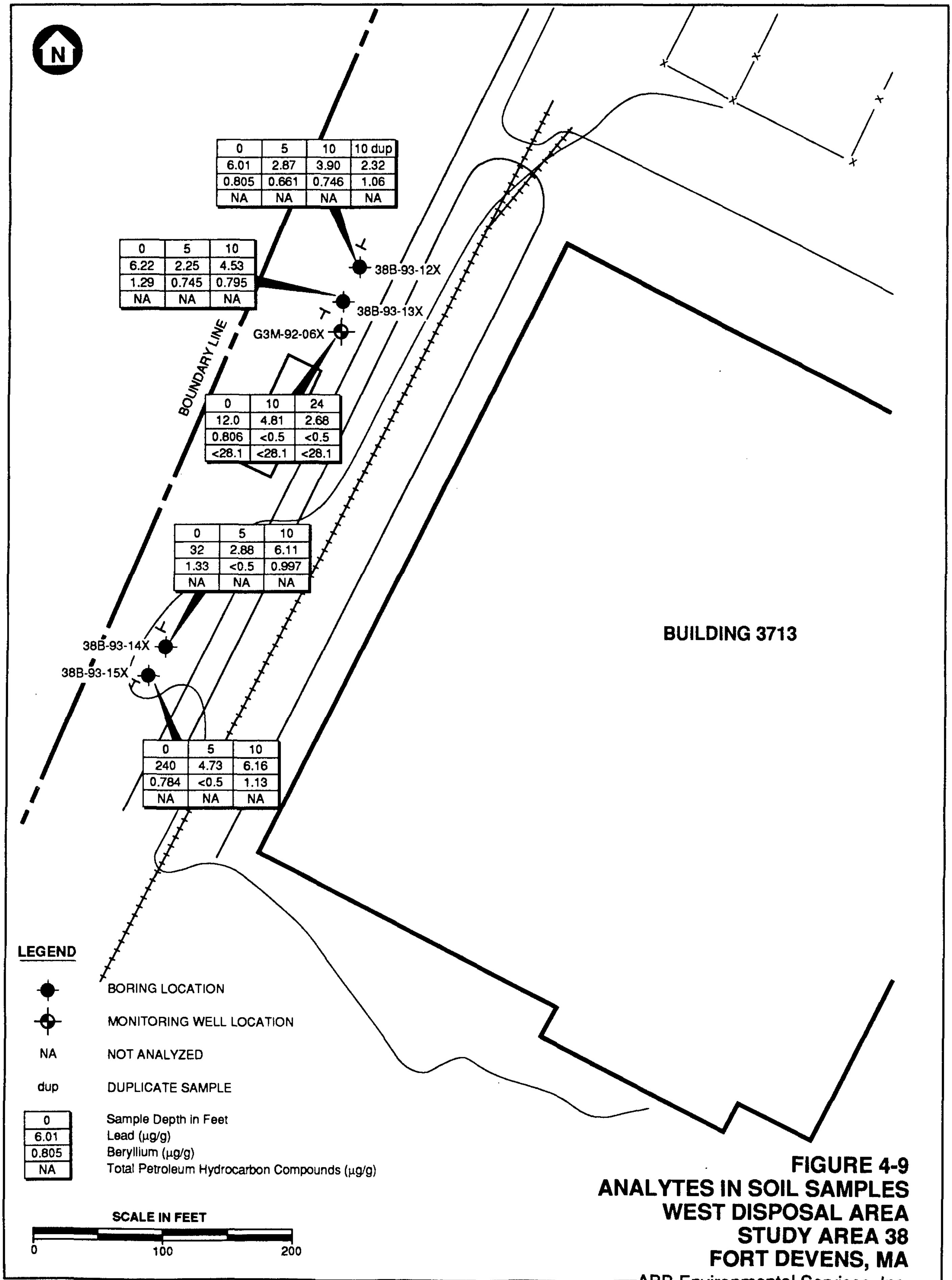


FIGURE 4-9
ANALYTES IN SOIL SAMPLES WEST DISPOSAL AREA STUDY AREA 38 FORT DEVENS, MA

ABB Environmental Services, Inc.

9308005W123

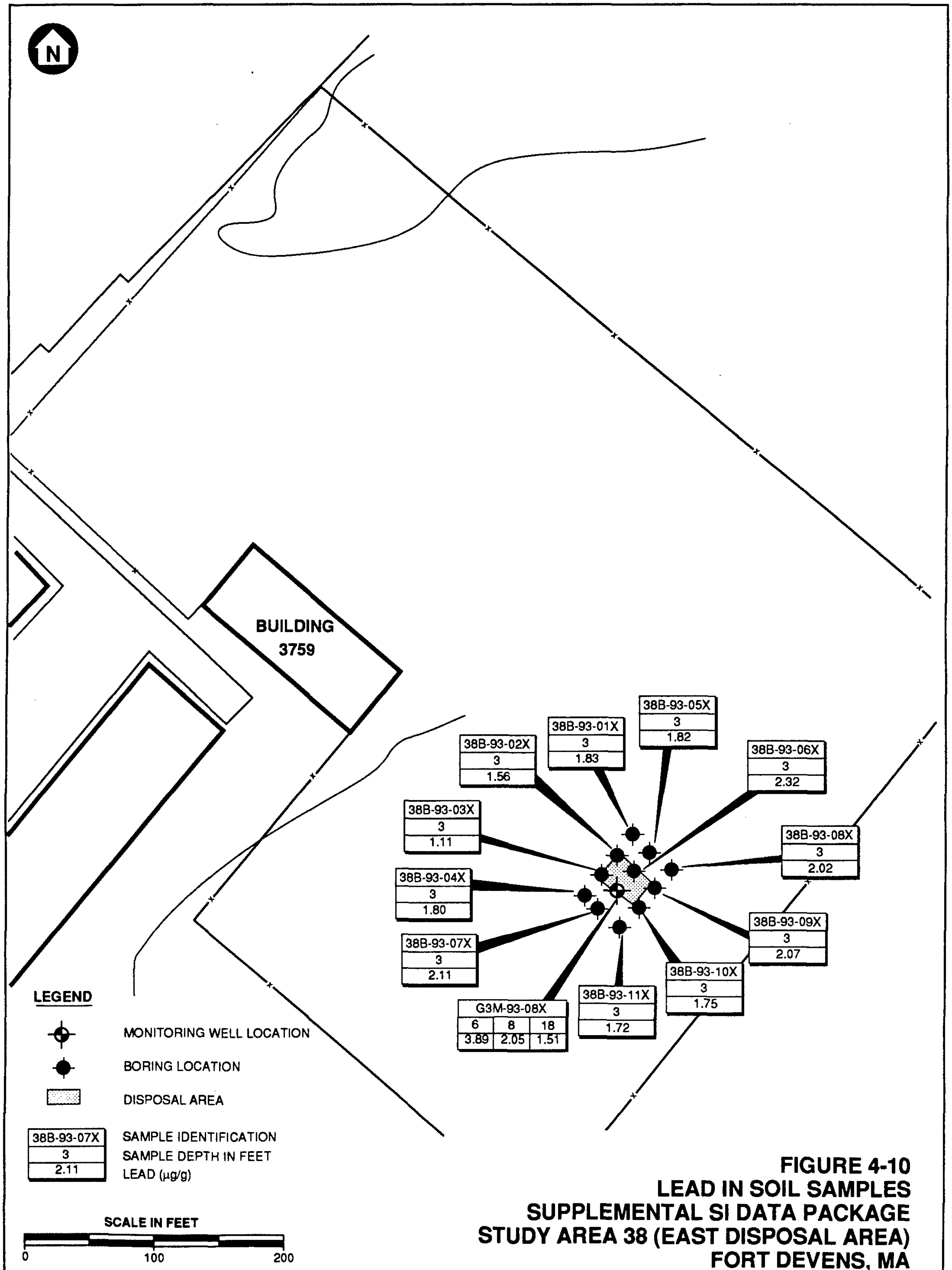
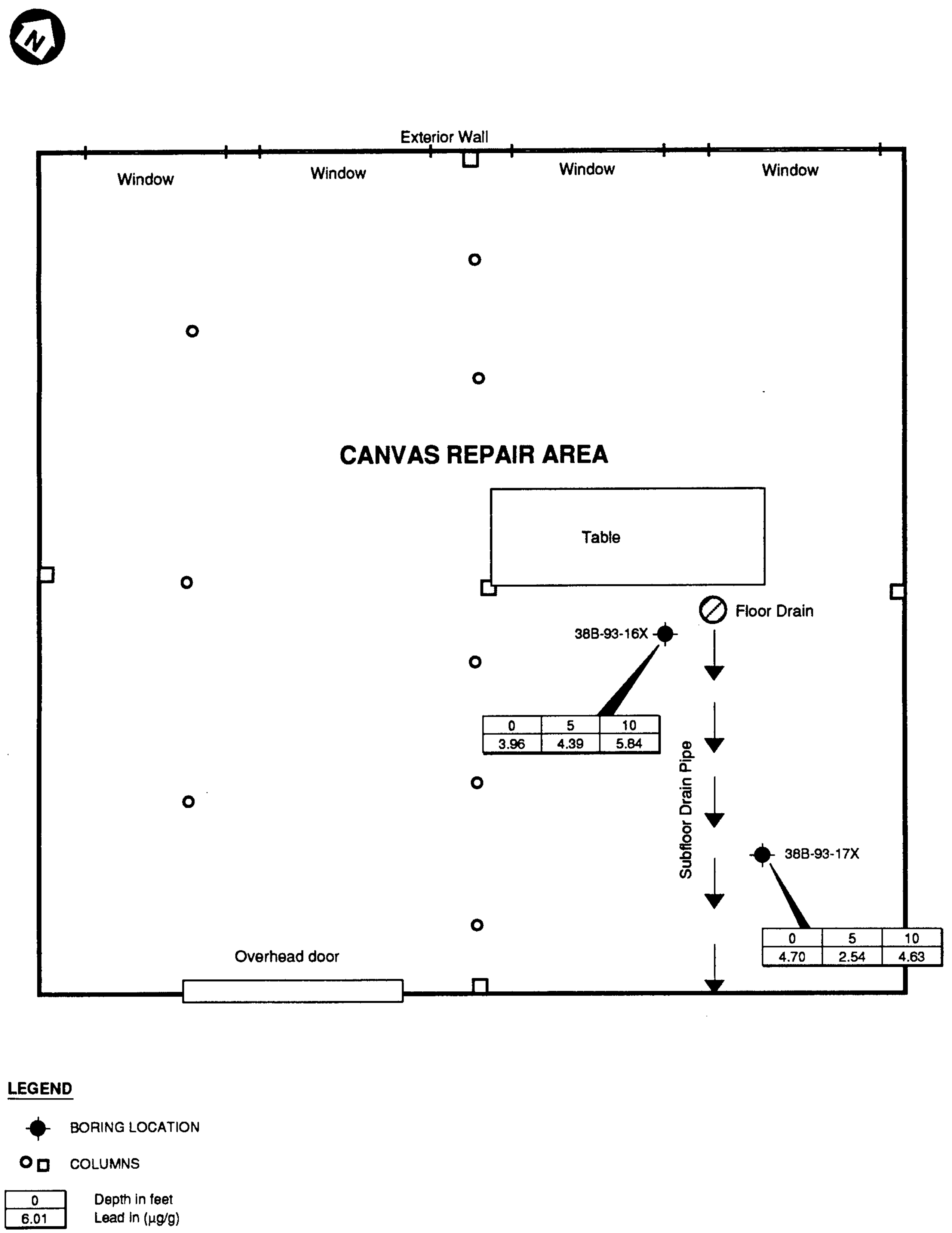


FIGURE 4-10
LEAD IN SOIL SAMPLES
SUPPLEMENTAL SI DATA PACKAGE
STUDY AREA 38 (EAST DISPOSAL AREA)
FORT DEVENS, MA



NOT TO SCALE

FIGURE 4-11
LEAD IN SOIL SAMPLES
CANVAS REPAIR AREA
STUDY AREA 38
FORT DEVENS, MA

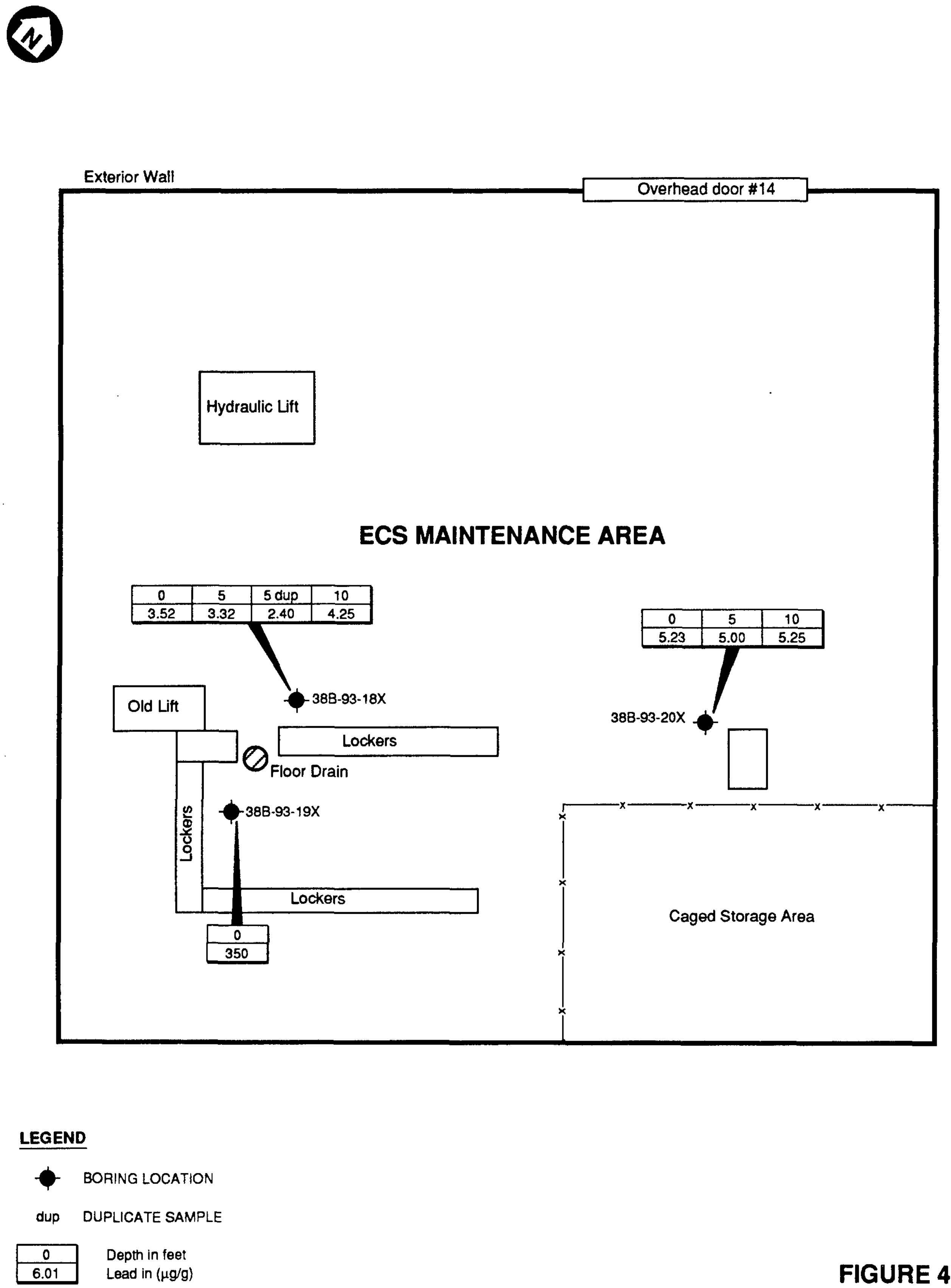


FIGURE 4-12
LEAD IN SOIL SAMPLES
ECS MAINTENANCE AREA
STUDY AREA 38
FORT DEVENS, MA

NOT TO SCALE

9308006W12

ABB Environmental Services, Inc.

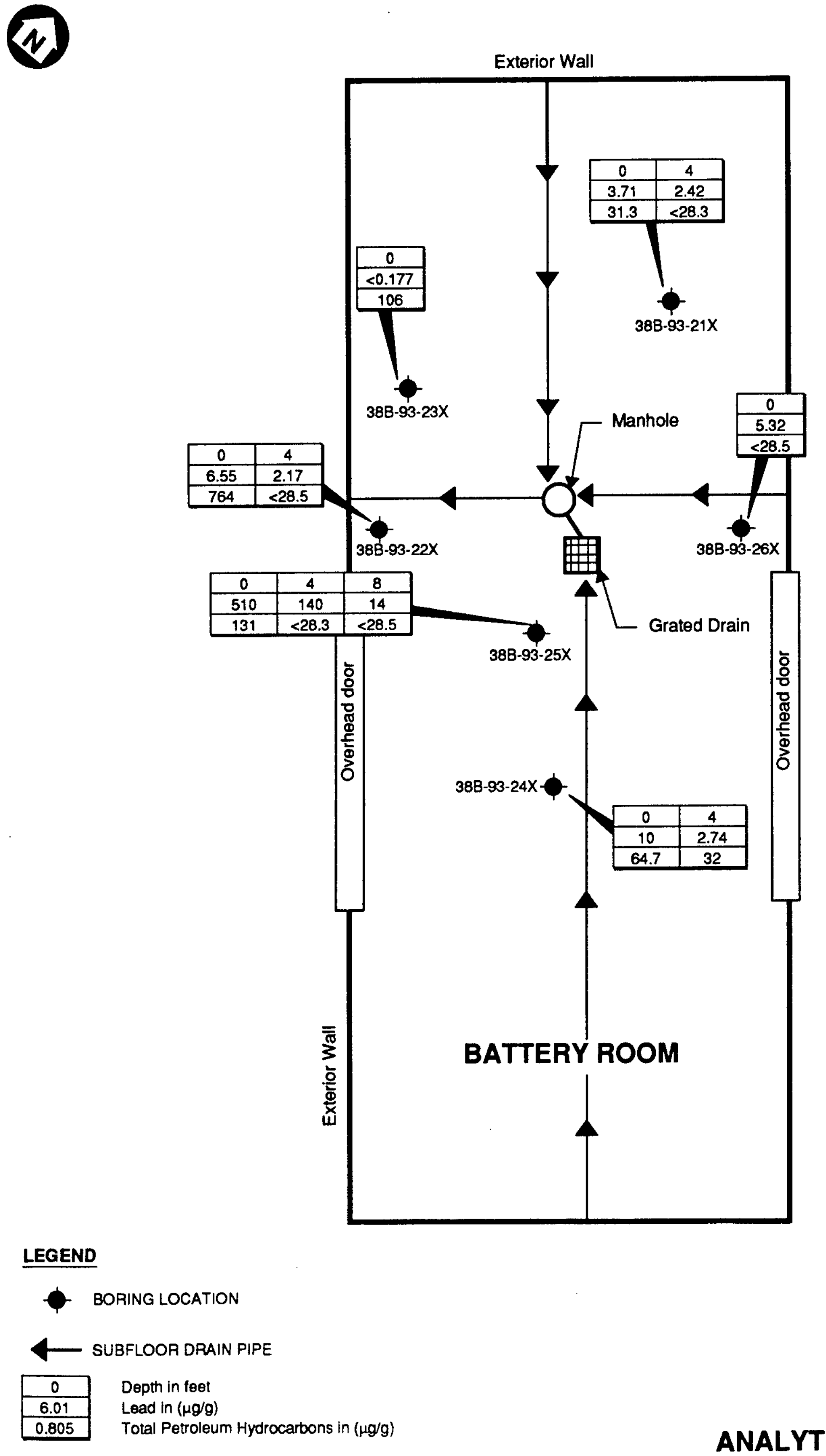


FIGURE 4-13
ANALYTES IN SOIL SAMPLES
CURRENT BATTERY ROOM
STUDY AREA 38
FORT DEVENS, MA

NOT TO SCALE

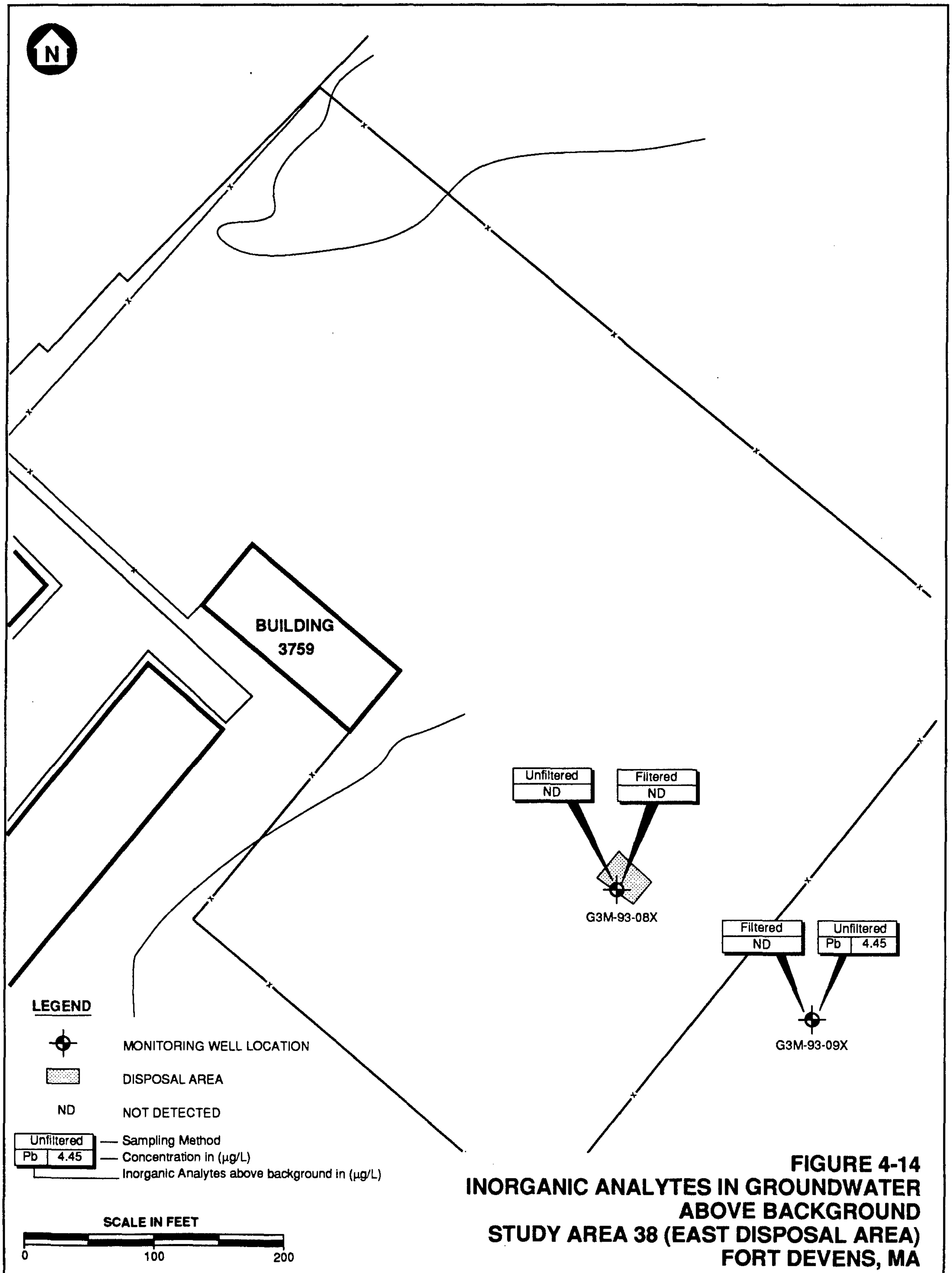
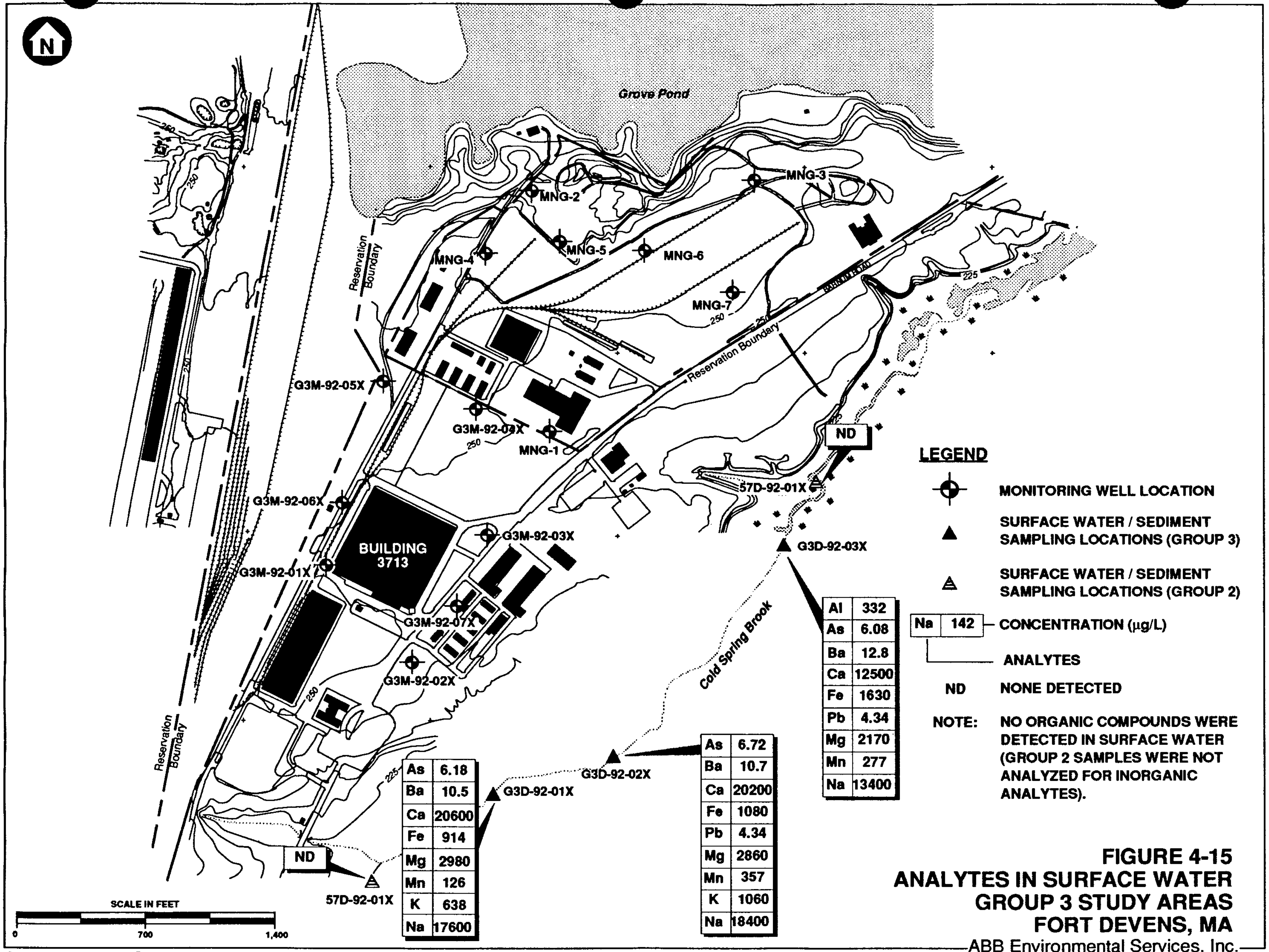


FIGURE 4-14
INORGANIC ANALYTES IN GROUNDWATER ABOVE BACKGROUND
STUDY AREA 38 (EAST DISPOSAL AREA)
FORT DEVENS, MA



G3D-92-01X

As	6.18
Ba	10.5
Ca	20600
Fe	914
Mg	2980
Mn	126
K	638
Na	17600

G3D-92-02X

As	6.72
Ba	10.7
Ca	20200
Fe	1080
Pb	4.34
Mg	2860
Mn	357
K	1060
Na	18400

G3D-92-03X

Al	332
As	6.08
Ba	12.8
Ca	12500
Fe	1630
Pb	4.34
Mg	2170
Mn	277
Na	13400

LEGEND

⊕ MONITORING WELL LOCATION

▲ SURFACE WATER / SEDIMENT SAMPLING LOCATIONS (GROUP 3)

△ SURFACE WATER / SEDIMENT SAMPLING LOCATIONS (GROUP 2)

Na | 142 — CONCENTRATION (µg/L)

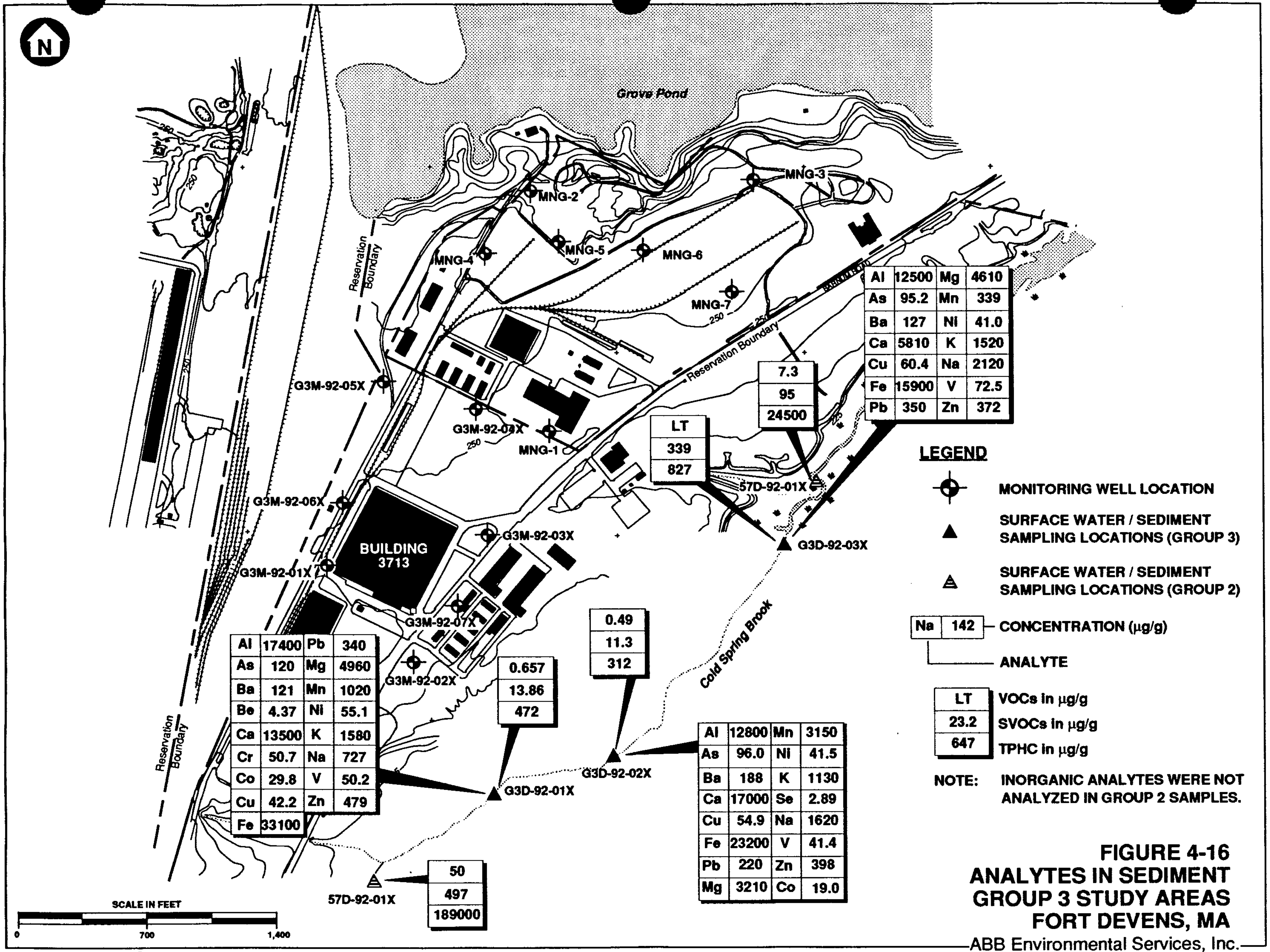
— ANALYTES

ND NONE DETECTED

NOTE: NO ORGANIC COMPOUNDS WERE DETECTED IN SURFACE WATER (GROUP 2 SAMPLES WERE NOT ANALYZED FOR INORGANIC ANALYTES).

FIGURE 4-15
ANALYTES IN SURFACE WATER
GROUP 3 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.



NOTE: INORGANIC ANALYTES WERE NOT ANALYZED IN GROUP 2 SAMPLES.

FIGURE 4-16
ANALYTES IN SEDIMENT GROUP 3 STUDY AREAS FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(d) 12 6 8

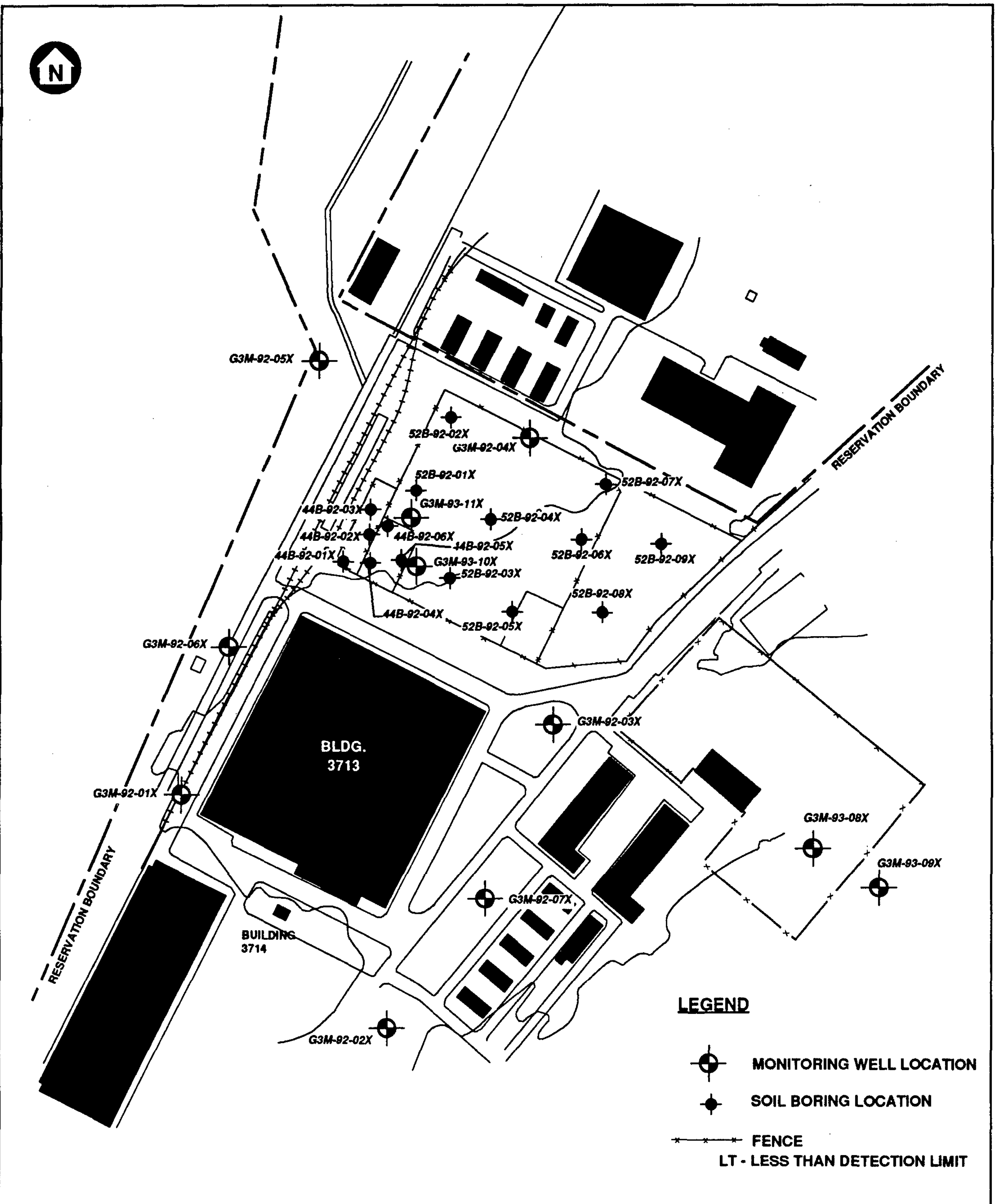


FIGURE 4-17
SOIL BORINGS AND
MONITORING WELL LOCATIONS
GROUP 3 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

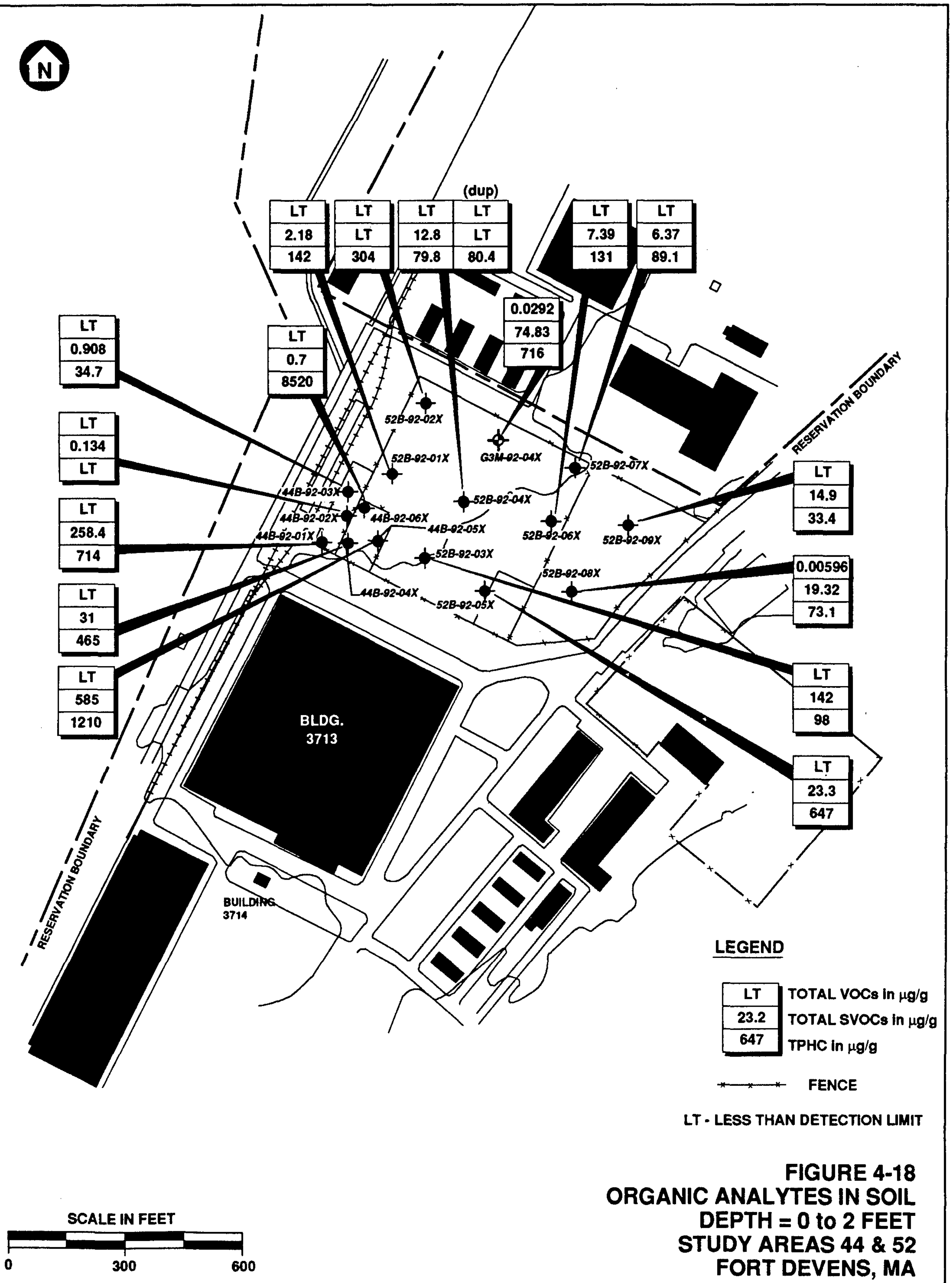


FIGURE 4-18
ORGANIC ANALYTES IN SOIL
DEPTH = 0 to 2 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

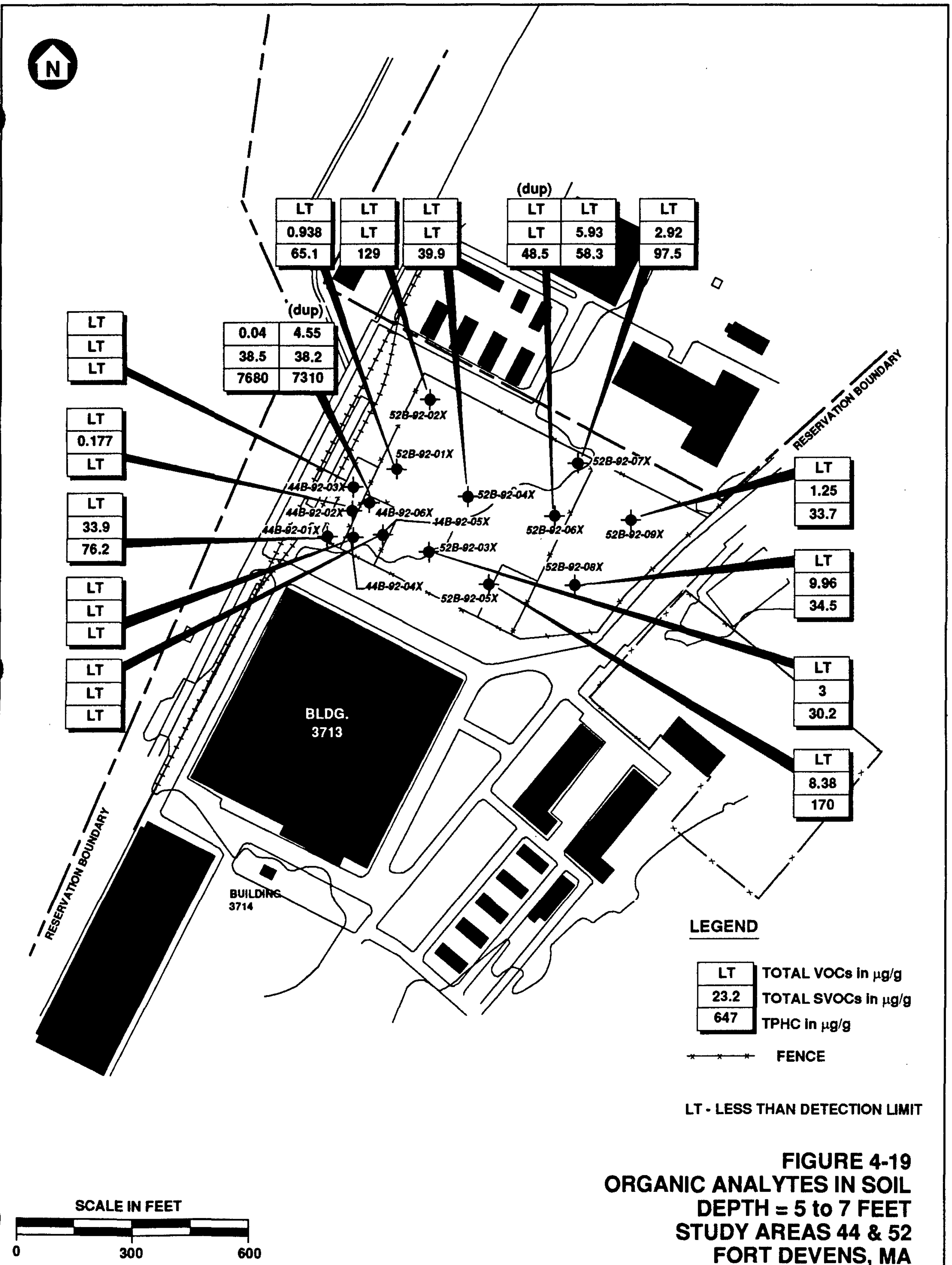


FIGURE 4-19
ORGANIC ANALYTES IN SOIL
DEPTH = 5 to 7 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

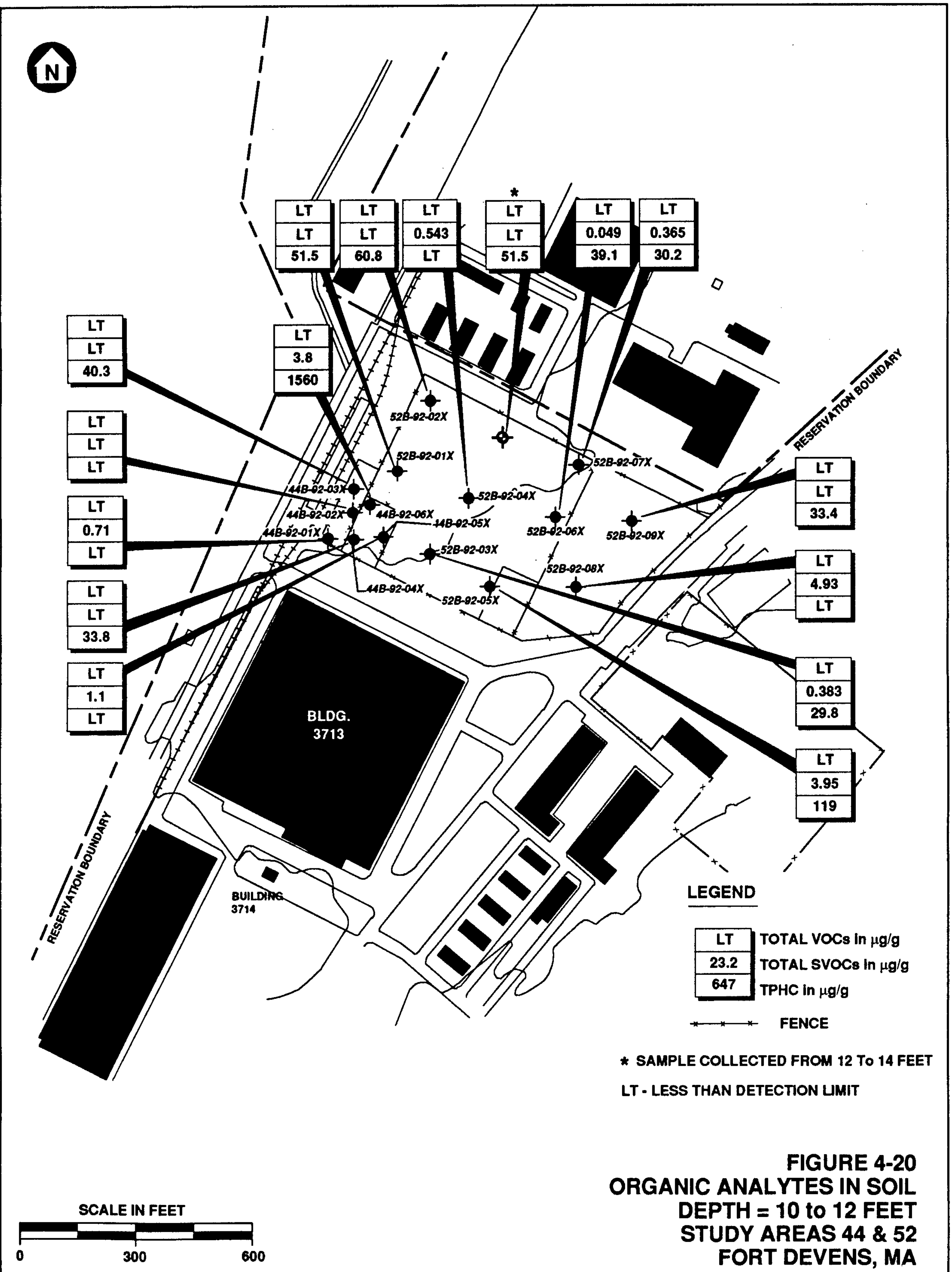


FIGURE 4-20
ORGANIC ANALYTES IN SOIL
DEPTH = 10 to 12 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

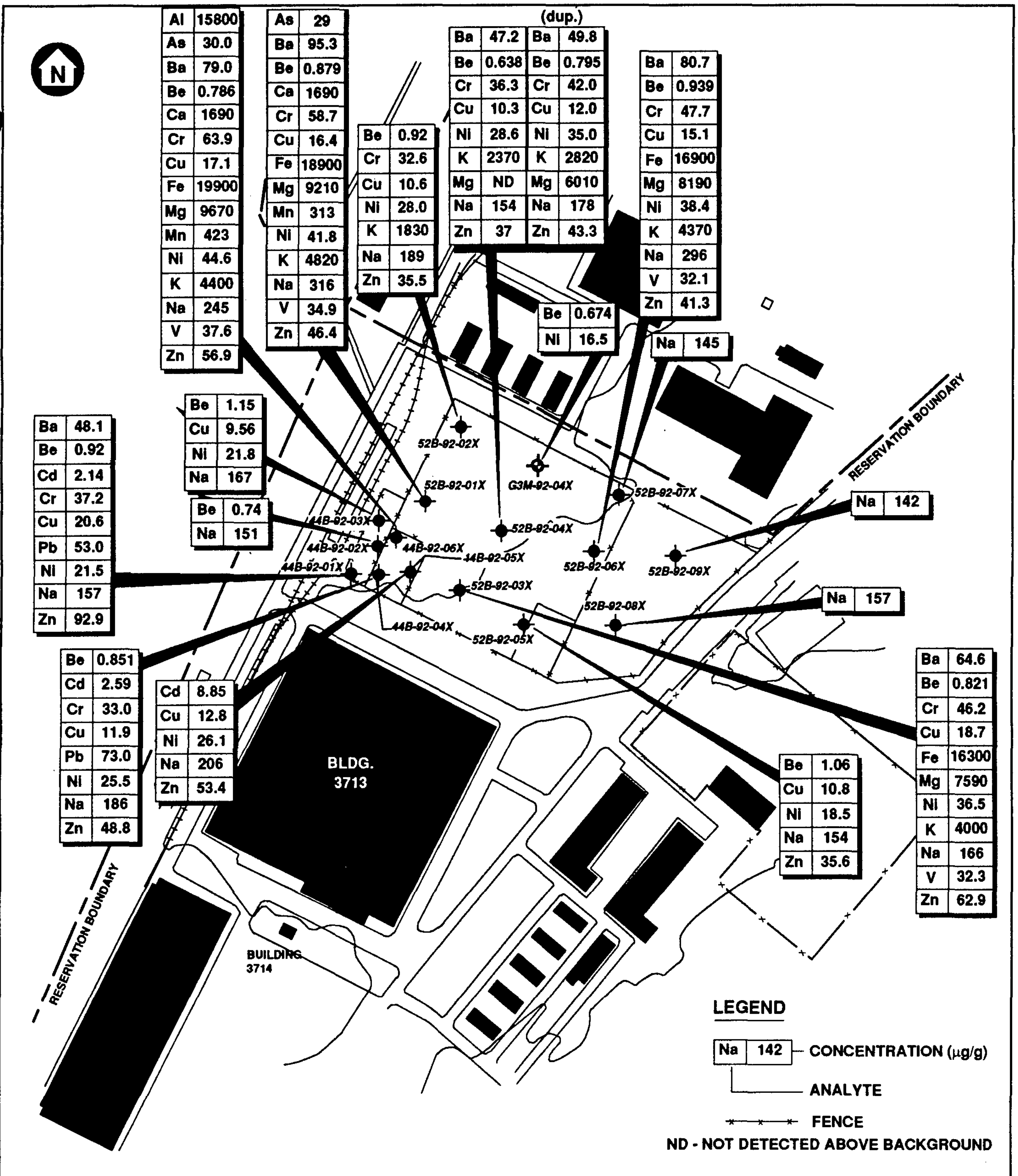


FIGURE 4-21
INORGANIC ANALYTES IN SOIL ABOVE BACKGROUND CONCENTRATIONS
DEPTH = 0 to 2 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

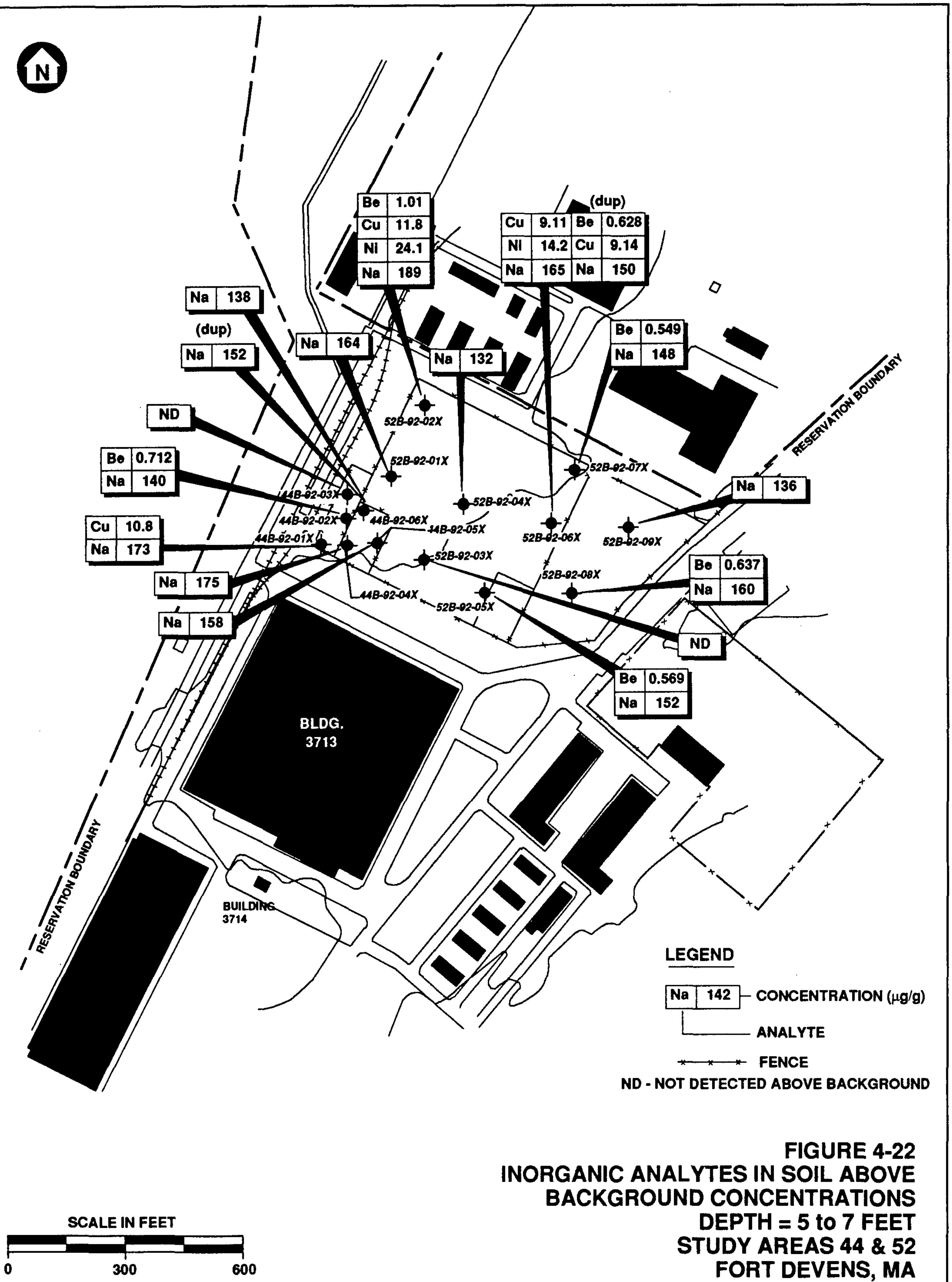


FIGURE 4-22
INORGANIC ANALYTES IN SOIL ABOVE BACKGROUND CONCENTRATIONS
DEPTH = 5 to 7 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

ABB Environmental Services, Inc.

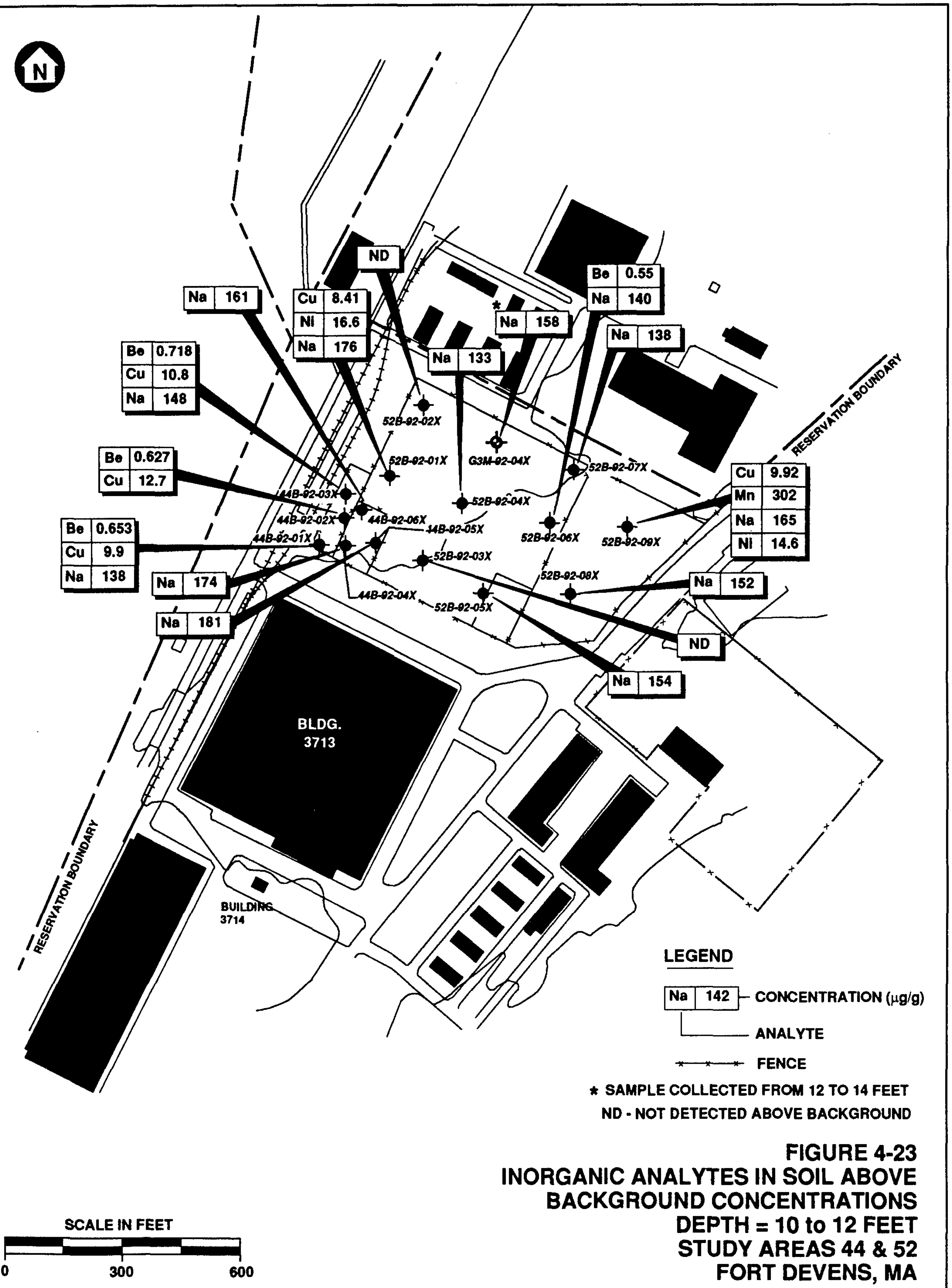


FIGURE 4-23
INORGANIC ANALYTES IN SOIL ABOVE
BACKGROUND CONCENTRATIONS
DEPTH = 10 to 12 FEET
STUDY AREAS 44 & 52
FORT DEVENS, MA

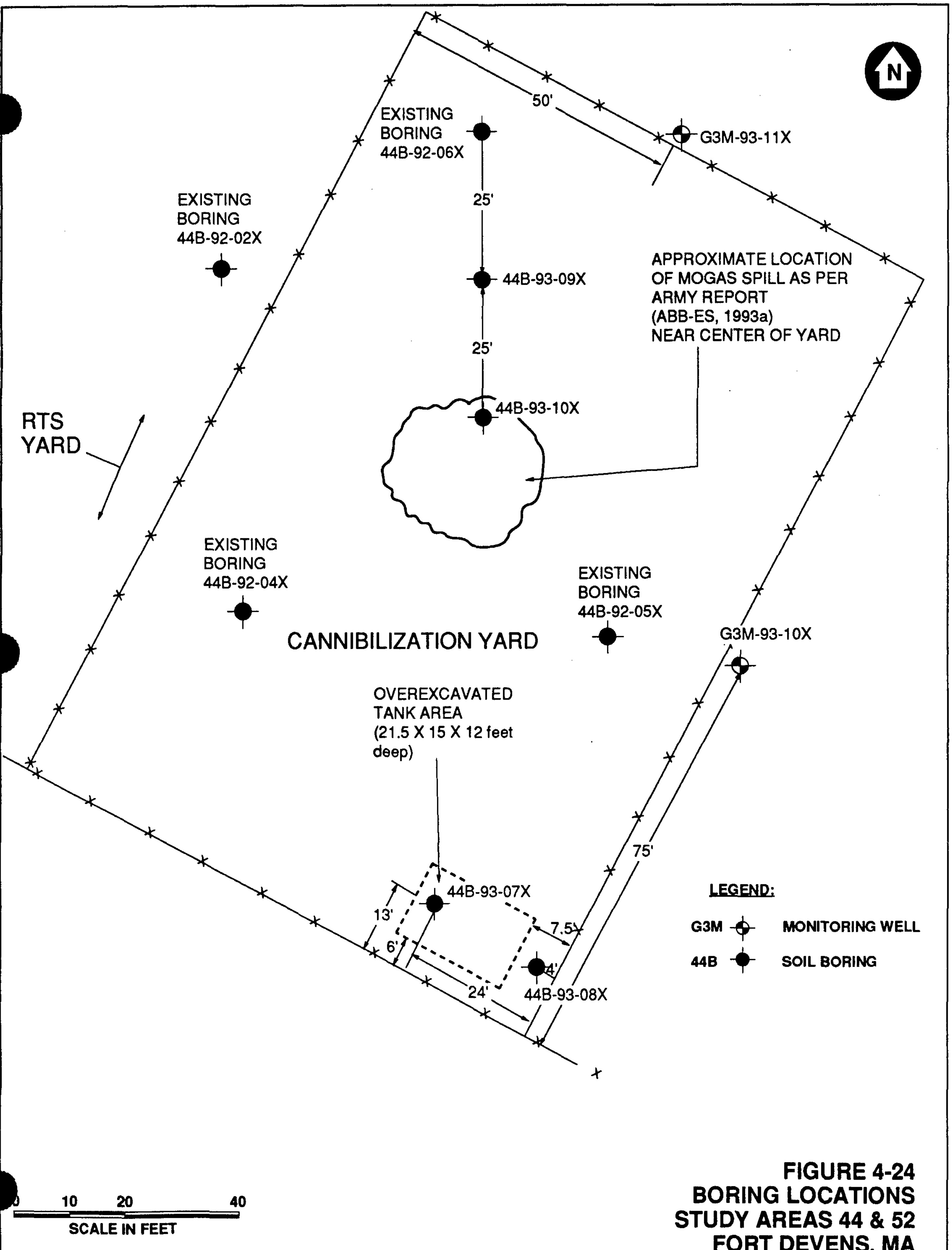


FIGURE 4-24
BORING LOCATIONS
STUDY AREAS 44 & 52
FORT DEVENS, MA

ABB Environmental Services, Inc.

TABLE 4-1
SUMMARY OF SOIL BORINGS
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	COMMENTS
EAST DISPOSAL AREA						
38B-93-01X	5	3 – 5	YES	SP	BKG	pH = 8.6
38B-93-02X	5	3 – 5	YES	SP	2	pH = 6.3
38B-93-03X	5	3 – 5	YES	SP	BKG	pH = 6.3
38B-93-04X	5	3 – 5	YES	SP	2	pH = 6.1
38B-93-05X	5	3 – 5	YES	SP	BKG	pH = 7.5
38B-93-06X	5	3 – 5	YES	SP	BKG	pH = 7.0
38B-93-07X	5	3 – 5	YES	SP	BKG	pH = 6.9
38B-93-08X	5	3 – 5	YES	SP	BKG	pH = 6.7
38B-93-09X	5	3 – 5	YES	SP	BKG	pH = 6.9
38B-93-10X	5	3 – 5	YES	SP-SM	BKG	pH = 6.8
38B-93-11X	5	3 – 5	YES	SP	BKG	pH = 6.5
G6M-93-08X	28	0 – 2		SP	2	
		2 – 4		SP – SM	BKG	
		4 – 6		SP – SM	2	
		6 – 8	YES	SW	4	pH = 5.9
		8 – 10	YES	SP	3	pH = 6.1
		10 – 12		SP	2	
		12 – 14		SW	1	
		14 – 16		SP	2	
		16 – 18		SP	3	
		18 – 20	YES	SP	2	pH = 7.2

TABLE 4-1
SUMMARY OF SOIL BORINGS
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	COMMENTS
		20 – 22		SP	BKG	
		22 – 24		SP	2	
G6M–93–08X		24 – 26		SP	2	
		26 – 28		SP	2	
G6M–93–09X	27	0 – 2		SP – SM	BKG	
(downgradient)		5 – 7		SP	BKG	
		10 – 12		SP – SM	BKG	
		15 – 17		SP – SM	BKG	
		20 – 22	YES	SM	BKG	pH = 6.6
		25 – 27		SM	BKG	
WEST DISPOSAL AREA						
38B–93–12X	12	0 – 2	YES	SP – SM	BKG	pH = 6.6
		5 – 7	YES	SW	BKG	pH = 6.9
		10 – 12	YES	SW	BKG	pH = 6.9
38B–93–13X	12	0 – 2	YES	SP	BKG	pH = 5
		5 – 7	YES	SP	BKG	pH = 5
		10 – 12	YES	SW	BKG	pH = 5
38B–93–14X	12	0 – 2	YES	SP + SW	BKG	pH = 5
		5 – 7	YES	SP	BKG	pH = 5
		10 – 12	YES	SW	BKG	pH = 5

TABLE 4-1
SUMMARY OF SOIL BORINGS
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	COMMENTS
38B-93-15X	12	0 – 2	YES	SP	BKG	pH = 5
		5 – 7	YES	SW + SP	BKG	pH = 5
		10 – 12	YES	GP-GM	BKG	pH = 5
CANVAS REPAIR AREA – BUILDING 3713						
38B-93-16X	12	1 – 3	YES	SP	BKG	pH = 5
		5 – 7	YES	SP	BKG	pH = 6
		10 – 12	YES	SP – SM	BKG	pH = 6
38B-93-17X	12	1 – 3	YES	SP	BKG	pH = 5
		5 – 7	YES	SP	BKG	pH = 5
		10 – 12	YES	SW	BKG	pH = 6
FORMER BATTERY ROOM – BUILDING 3713						
38B-93-18X	12	1 – 3	YES	SP	BKG	pH = 5
		5 – 7	YES	SP	BKG	pH = 5
		10 – 12	YES	SP	BKG	pH = 5
38B-93-19X	12	1 – 3	YES	SP	BKG	pH = 5
38B-93-20X	12	1 – 3	YES	SW	BKG	pH = 8
		5 – 7	YES	SW	BKG	pH = 5
		10 – 12	YES	SW	BKG	pH = 5

TABLE 4-1
SUMMARY OF SOIL BORINGS
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION ID	COMPLETION DEPTH (Feet bgs)	REFERENCE SAMPLE INTERVALS (Feet bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	COMMENTS
CURRENT BATTERY ROOM – BUILDING 3713						
38B-93-21X	6	1 – 3	YES	SW	BKG	pH = 5
		4 – 6	YES	SP	BKG	pH = 5
38B-93-22X	6	1 – 3	YES	SP	BKG	pH = 6
		4 – 6	YES	SW	BKG	pH = 5
38B-93-23X	6	1 – 3	YES	SP	BKG	pH = 7
38B-93-24X	6	1 – 3	YES	SP	BKG	pH = 6
		4 – 6	YES	SP	BKG	pH = 5
38B-93-25X	6	1 – 3	YES	SW	BKG	pH = 6
		4 – 6	YES	SP	BKG	pH = 5
		8 – 10	YES	SP	BKG	pH = 6
38B-93-26X	6	4 – 6	YES	SP	BKG	pH = 5

TABLE 4–2
SOIL CLASSIFICATION OF SEDIMENT SAMPLES
GROUP 3 STUDY AREAS

SITE INVESTIGATION REPORT
FORT DEVENS

SITE ID	SAMPLE ID	USCS SYMBOL	PERCENT SOLIDS	GRAVEL (1) DRY WT %	FINES (1) DRY WT %	COMMENTS
G3D–92–01X	DXG300100	ML	15.38	0.0	91.8	Very organic
G3D–92–02X	DXG300200	ML	12.21	0.0	92.3	Very high organic content
G3D–92–03X	DXG300300	ML	7.27	0.0	95.6	Very high organic content

NOTE: (1) WT % OF SOIL FRACTION = 100 x DRY WEIGHT OF SOIL FRACTION / TOTAL DRY WEIGHT OF SOIL

TABLE 4-3
ANALTYES IN SOIL AND GROUNDWATER (G3M-92-06X)
STUDY AREA 38 - BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL				GROUNDWATER		
	BACKGROUND	0 ft	10 ft	24 ft	BACKGROUND	ROUND 1	ROUND 2
INORGANICS		ug/g				ug/L	
ALUMINUM	15000	3520	6630	2540	6870	611	317
ARSENIC	21	11.5	15	8.24	10.5	4.69	2.98
BARIUM	42.5	16.7	22.8	13.4	39.6	11.5	37.7
BERYLLIUM	0.347	0.806	< 0.500	< 0.500	5.00	< 5.00	< 5.00
CALCIUM	1400	362	584	535	14700	5690	6920
CHROMIUM	31	10.3	10.9	6.63	14.7	< 6.02	< 6.02
COBALT	NA	4.09	3.19	2.70	25.0	< 25.0	< 25.0
COPPER	8.39	10.0	7.20	5.76	8.09	< 8.09	< 8.09
IRON	15000	7170	7520	4800	9100	1250	601
LEAD	34.4	12.0	4.81	2.68	4.25	1.84	1.52
MAGNESIUM	5600	1710	1500	1310	3480	692	723
MANGANESE	300	175	143	105	291	122	71.4
NICKEL	14.0	12.8	10.7	10.5	34.3	< 34.3	< 34.3
POTASSIUM	1700	575	477	305	2370	561	1700
SODIUM	131	132	150	143	10800	4010	5810
VANADIUM	28.7	6.10	8.69	4.96	11.0	< 11.0	< 11.0
ZINC	35.5	22.0	20.5	16.8	21.1	< 21.1	36.7
ORGANICS		ug/g				ug/L	
BIS(2-ETHYLHEXYL)PHTHALATE		4.00	< 0.620	< 0.620		< 4.80	< 4.80
TRICHLOROFLUOROMETHANE		0.0057	0.0063	0.007		< 1.40	< 1.40
TOTAL ORGANIC CARBON		NA	NA	3190		NA	NA
ANIONS/CATIONS (ug/L)							
BICARBONATE						122000	< 6000
CHLORIDE						6330	7050
SULFATE						12500	13300
NITRATE/NITRITE						770	1100
ALKALINITY						100000	< 5000
OTHER (ug/L)							
TOTAL SUSPENDED SOLIDS						14000	18000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED
☐ = GREATER THAN BACKGROUND CONCENTRATION
LEAD BACKGROUND CONCENTRATION REVISED FROM 48.4 ug/g (ABB-ES, 1994b).

TABLE 4–4
ANALYTES IN SOIL
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

SITE ID	SAMPLE DEPTH	ANALYTE CONCENTRATION (ug/g)		
		LEAD	BERYLLIUM	TPHC
EAST DISPOSAL AREA				
38B–93–01X	3	1.83	NA	NA
38B–93–02X	3	1.56	NA	NA
38B–93–03X	3	1.11	NA	NA
38B–93–04X	3	1.80	NA	NA
38B–93–05X	3	1.82	NA	NA
38B–93–06X	3	2.32	NA	NA
38B–93–07X	3	2.11	NA	NA
38B–93–08X	3	2.02	NA	NA
38B–93–09X	3	2.07	NA	NA
38B–93–10X	3	1.75	NA	NA
38B–93–11X	3	1.72	NA	NA
G3M–93–08X	6	3.89	NA	NA
	8	2.05	NA	NA
	18	1.51	NA	NA
WEST DISPOSAL AREA				
38B–93–12X	0	6.01	0.805	NA
	5	2.87	0.661	NA
	10	3.9	0.746	NA
	10 DUP	2.32	1.06	NA
38B–93–13X	0	6.22	1.29	NA
	5	2.25	0.745	NA
	10	4.53	0.795	NA
38B–93–14X	0	32	1.33	NA
	5	2.88	<0.500	NA
	10	6.11	0.997	NA
38B–93–15X	0	240	0.784	NA
	5	4.73	<0.500	NA
	10	6.16	1.13	NA
G3M–92–06X	0	12.0	0.806	<28.1
	10	4.81	<0.500	<28.1
	24	2.68	<0.500	<28.1

NOTES: NA = NOT ANALYZED
TPHC = TOTAL PETROLEUM HYDROCARBON COMPOUNDS

TABLE 4–4 (continued)
ANALYTES IN SOIL
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

SITE ID	SAMPLE DEPTH	ANALYTE CONCENTRATION (ug/g)		
		LEAD	BERYLLIUM	TPHC
CANVAS REPAIR AREA				
38B–93–16X	0	3.96	NA	NA
	5	4.39	NA	NA
	10	5.84	NA	NA
38B–93–17X	0	4.70	NA	NA
	5	2.54	NA	NA
	10	4.63	NA	NA
ECS MAINTENANCE AREA				
38B–93–18X	0	3.52	NA	NA
	5	3.32	NA	NA
	5 DUP	2.40	NA	NA
	10	4.25	NA	NA
38B–93–19X	0	350	NA	NA
38B–93–20X	0	5.23	NA	NA
	5	5.00	NA	NA
	10	5.25	NA	NA
BATTERY ROOM				
38B–93–21X	0	3.71	NA	31.3
	4	2.42	NA	<28.3
38B–93–22X	0	6.55	NA	764
	4	2.17	NA	<28.5
38B–93–23X	0	<0.177	NA	106
38B–93–24X	0	10	NA	64.7
	4	2.74	NA	32.0
38B–93–25X	0	510	NA	131
	4	140	NA	<28.3
	8	14	NA	<28.5
38B–93–26X	4	5.32	NA	<28.5

NOTES: NA = NOT ANALYZED

TPHC = TOTAL PETROLEUM HYDROCARBON COMPOUNDS

TABLE 4–5
ANALYTES IN GROUNDWATER – ROUND 1 (July 1992)
GROUP 3 GROUNDWATER MONITORING WELLS

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BACK–GROUND	G3M–92–01X	G3M–92–02X	G3M–92–03X	G3M–92–04X	G3M–92–05X	G3M–92–05X DUP	G3M–92–06X	G3M–92–07X
ORGANICS (ug/L)									
BIS(2–ETHYLHEXYL)PHTHALATE		< 4.80	< 4.80	< 4.80	< 4.80	< 4.80	6.27	< 4.80	< 4.80
TPHC		< 200	< 200	< 200	< 200	< 200	427	< 200	< 200
INORGANICS (ug/L)									
ALUMINUM	6870	< 141	< 141	304	< 141	3680	6480	611	< 141
ARSENIC	10.5	< 2.54	< 2.54	< 2.54	< 2.54	31.3	41.9	4.69	< 2.54
BARIUM	39.6	10.6	11.3	14.6	7.17	21.4	28.2	11.5	24.2
CALCIUM	14700	7930	4940	8090	4800	7870	8000	5690	13900
CHROMIUM	14.7	< 6.02	< 6.02	< 6.02	< 6.02	6.23	12.3	< 6.02	< 6.02
COPPER	8.09	< 8.09	< 8.09	< 8.09	< 8.09	9.15	17.0	< 8.09	< 8.09
IRON	9100	170	60.2	421	248	6380	11100	1250	122
LEAD	4.25	2.28	< 1.26	2.39	1.84	11.3	11.0	1.84	3.90
MAGNESIUM	3480	1000	< 500	< 500	515	1790	2800	692	825
MANGANESE	291	471	12.7	80.3	791	379	504	122	13.4
POTASSIUM	2370	1440	1190	1210	< 375	892	2720	561	1520
SODIUM	10800	8570	25400	18600	15500	8380	8160	4010	58900
VANADIUM	11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	12.5	< 11.0	< 11.0
ZINC	21.1	< 21.1	< 21.1	< 21.1	< 21.1	< 21.1	25.7	< 21.1	< 21.1
ANIONS/CATIONS (ug/L)									
BICARBONATE		13400	22000	29300	281000	20700	14600	122000	40300
CHLORIDE		13400	37000	16600	21200	16800	19000	6330	110000
SULFATE		13300	10800	< 10000	< 10000	10800	11800	12500	13300
NITRATE/NITRITE		200	1200	1400	1800	1300	110000	770	1300
ALKALINITY		11000	18000	24000	230000	17000	12000	100000	33000
OTHER (ug/L)									
TSS		< 4000	< 4000	< 4000	4000	545000	445000	14000	7000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY

G3WELLS1.WK1
06/12/95

TABLE 4-6
ANALYTES IN GROUNDWATER – ROUNDS 2 & 3 (Oct 1992/Jan 1993)
GROUP 3 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BACK-GROUND	G3M-92-01X	G3M-92-02X	G3M-92-03X	G3M-92-04X	G3M-92-05X	G3M-92-05X filtered	G3M-92-06X	G3M-92-07X
ORGANICS (ug/L)									
TRICHLOROETHYLENE		< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	NA	< 0.500	0.550
CHLOROFORM		< 0.500	0.710	< 0.500	0.790	1.10	NA	< 0.500	0.620
TPHC		< 186	520	< 178	< 180	< 171	NA	< 186	316
INORGANICS (ug/L)									
ALUMINUM	6870	779	251	464	< 141	1630	< 141	317	< 141
ARSENIC	10.5	< 2.54	< 2.54	< 2.54	< 2.54	10.7	< 2.54	2.98	< 2.54
BARIUM	39.6	14.7	62.8	12.3	18.7	29.6	13.9	37.7	36.3
CALCIUM	14700	11400	7380	8840	7010	10400	10100	6920	12200
COPPER	8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	9.83	< 8.09	< 8.09
IRON	9100	1030	404	741	143	2890	< 38.8	601	162
LEAD	4.25	< 1.26	2.93	3.04	< 1.26	3.69	< 1.26	1.52	< 1.26
MAGNESIUM	3480	1280	572	< 500	721	1750	1230	723	752
MANGANESE	291	381	32.8	125	518	151	19.7	71.4	11.3
POTASSIUM	2370	1540	1860	1850	1500	2370	1750	1700	2600
SODIUM	10800	8050	35500	16200	16800	13800	13600	5810	57000
ZINC	21.1	32.7	55.2	< 21.1	< 21.1	34.7	< 21.1	36.7	47.5
ANIONS/CATIONS (ug/L)									
BICARBONATE		37000	16000	27000	10000	7000	NA	< 6000	16000
SULFATE		12700	10100	< 10000	< 10000	14500	NA	13300	14000
CHLORIDE		11600	43000	21600	33000	23800	NA	7050	100000
NITRATE/NITRITE		143	1200	1200	2000	1900	NA	1100	1900
ALKALINITY		30000	13000	22000	8000	6000	NA	< 5000	13000
OTHER (ug/L)									
TSS		37000	109000	10000	19000	108000	NA	18000	12000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

G3WELLS2.WK1
06/12/95

TABLE 4–7
ANALYTES IN GROUNDWATER
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE (ug/L)		G3M–93–08X		G3M–93–09X	
	BACKGROUND	UNIFILTERED ROUND 1	FILTERED ROUND 1	UNIFILTERED ROUND 1	FILTERED ROUND 1
ALUMINUM	6870	2670	< 141	3740	<141
ARSENIC	10.5	8.21	< 2.54	8.85	< 2.54
ANTIMONY	3.03	< 3.03	< 3.03	2.86	< 3.03
BARIUM	39.6	20.4	< 5.0	28.5	11.9
CALCIUM	14700	3050	2710	5360	4850
COPPER	8.09	< 8.09	< 8.09	< 8.09	< 8.09
IRON	9100	3840	< 38.8	3980	97.1
LEAD	4.25	3.15	1.63	4.45	< 1.26
MAGNESIUM	3480	993	< 500	1220	577
MANGANESE	291	192	124	102	47.9
POTASSIUM	2370	1580	1210	1780	1280
SODIUM	10800	3140	3300	1730	1560
OTHER (ug/L)					
NITRATE/NITRITE		970	NA	1500	NA

NOTES:
Table lists detected analytes only.
NA = Not Analyzed
☐ = Greater than background concentration

TABLE 4-7
ANALYTES IN GROUNDWATER
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE (ug/L)		G3M-93-08X				G3M-93-09X	
	BACKGROUND	UNIFILTERED ROUND 2	UNIFILTERED ROUND 2 (DUP)	FILTERED ROUND 2	FILTERED ROUND 2 (DUP)	UNIFILTERED ROUND 2	FILTERED ROUND 2
ALUMINUM	6870	253	< 141	< 141	< 141	3500	<141
ARSENIC	10.5	< 2.54	< 2.54	< 2.54	< 2.54	9.06	< 2.54
ANTIMONY	3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03
BARIUM	39.6	8.3	6.97	6.37	6.81	27.9	12.5
CALCIUM	14700	2430	2440	2650	2510	5490	5240
COPPER	8.09	$\boxed{13.6}$	< 8.09	< 8.09	< 8.09	$\boxed{9.15}$	< 8.09
IRON	9100	334	132	< 38.8	< 38.8	4420	< 38.8
LEAD	4.25	4.01	2.28	< 1.26	< 1.26	3.36	< 1.26
MAGNESIUM	3480	< 500	< 500	< 500	< 500	1310	< 500
MANGANESE	291	46.8	53.4	74.1	67.9	63.6	8.71
POTASSIUM	2370	919	1240	706	1050	1620	824
SODIUM	10800	2510	3000	4790	4430	1420	1380
OTHER (ug/L)							
NITRATE/NITRITE		1100	1300	NA	NA	1500	NA

NOTES:
Table lists detected analytes only.
NA = Not Analyzed
☐ = Greater than background concentration

TABLE 4-8
ANALYTES IN SURFACE WATER
COLD SPRING BROOK

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	G3D-92-01X	G3D-92-02X	G3D-92-03X
INORGANICS (ug/L)			
ALUMINUM	< 141	< 141	332
ARSENIC	6.18	6.72	6.08
BARIUM	10.5	10.7	12.8
CALCIUM	20600	20200	12500
IRON	914	1080	1630
LEAD	< 1.26	4.34	4.34
MAGNESIUM	2980	2860	2170
MANGANESE	126	357	277
POTASSIUM	638	1060	< 375
SODIUM	17600	18400	13400
ANIONS/CATIONS (ug/L)			
CHLORIDE	43000	43000	23700
SULFATE	10200	10100	< 10000
NITRATE/NITRITE	181	138	< 10.0
KJELDAHL NITROGEN	333	524	1330
TOTAL PHOSPHOROUS	18.8	36.6	84.2
ALKALINITY	47000	45000	35000
OTHER (ug/L)			
HARDNESS	64200	66000	39400
TSS	< 4000	4000	46000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

G3SURFH2.WK1
06/12/95

TABLE 4-9
ANALYTES IN SEDIMENTS
COLD SPRING BROOK

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	G3D-92-01X	G3D-92-02X	G3D-92-03X
INORGANICS (ug/g)			
ALUMINUM	17400	12800	12500
ARSENIC	120	96.0	95.2
BARIUM	121	188	127
BERYLLIUM	4.37	< 0.500	< 0.500
CALCIUM	13500	17000	5810
CHROMIUM	50.7	< 4.05	< 4.05
COBALT	29.8	19.0	< 1.42
COPPER	42.2	54.9	60.4
IRON	33100	23200	15900
LEAD	340	220	350
MAGNESIUM	4960	3210	4610
MANGANESE	1020	3150	339
NICKEL	55.1	41.5	41.0
POTASSIUM	1580	1130	1520
SELENIUM	< 0.250	2.89	< 0.250
SODIUM	727	1620	2120
VANADIUM	50.2	41.4	72.5
ZINC	479	398	372
ORGANICS (ug/g)			
ACETONE	0.657	0.490	< 0.0170
ACENAPHTHYLENE	< 0.165	< 0.165	4.37
ANTHRACENE	< 0.165	< 0.165	4.42
BENZO(A)ANTHRACENE	< 0.800	< 0.800	18.1
BENZO(A)PYRENE	< 1.25	< 1.25	22.9
BENZO(B)FLOURANTHENE	< 1.05	< 1.05	32.7
BENZO(G,H,I)PERYLENE	< 1.25	< 1.25	18.9
BENZO(K)FLOURANTHENE	< 0.330	< 0.330	33.2
CARBAZOLE	ND 0.165	ND 0.165	4.68
CHRYSENE	< 0.600	< 0.600	47.1
FLOURANTHENE	3.69	4.50	59.4
INDENO(1,2,3-C,D)PYRENE	< 1.45	< 1.45	20.3
PHENATHRENE	2.63	2.22	19.8
PYRENE	7.54	4.59	53.1
OTHER (ug/g)			
TOTAL PETROLEUM HYDROCARBONS	472	312	827
TOTAL ORGANIC CARBON	4250	166000	219000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED

G3SEDS.WK1
06/12/95

TABLE 4-10
HUMAN HEALTH PRE EVALUATION OF SURFACE SOIL
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	MAXIMUM DETECTED CONCENTRATION	FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND?	REGION III COMMERCIAL/ INDUSTRIAL SOIL CONCENTRATION (ug/g)	MAXIMUM EXCEEDS REGION III CONCENTRATION?
EAST DISPOSAL AREA						
INORGANICS (ug/g)						
LEAD	34.4	2.32	11/11	NO	500 [c]	NO
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	NA				
WEST DISPOSAL AREA						
INORGANICS (ug/g)						
LEAD	34.4	240	5/5	YES	500 [c]	NO
BERYLLIUM	0.347	1.33	5/5	YES	0.67	YES
ORGANICS (ug/g)						
TPHC	NA	NA				
CANVAS REPAIR AREA						
INORGANICS (ug/g)						
LEAD	34.4	4.7	2/2	NO	500 [c]	NO
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	NA				

TABLE 4-10
HUMAN HEALTH PRE EVALUATION OF SURFACE SOIL
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	MAXIMUM DETECTED CONCENTRATION	FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND?	REGION III COMMERCIAL/ INDUSTRIAL SOIL CONCENTRATION (ug/g)	MAXIMUM EXCEEDS REGION III CONCENTRATION?
ECS MAINTENANCE AREA						
INORGANICS (ug/g)						
LEAD	34.4	350	3/3	YES	500 [c]	NO
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	NA				
BATTERY ROOM						
INORGANICS (ug/g)						
LEAD	34.4	510	4/5	YES	500 [c]	YES
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	764	5/5	NA	1800 [d]	NO

NOTES:

[a] Base-wide backgound soil inorganics database. Lead background concentration revised from 48.4 ug/g (ABB-ES, 1994b).

[b] Surface soil samples from sampling stations 38B-93-01X through 38B-93-11X, G3M-93-08X (East); 38B-93-12X through 38B-93-15X, G3M-92-06X (West); 38B-93-16X, 38B-93-17X (Canvas); 38B-93-18X through 38B-93-20X (ECS); 38B-93-21X through 38B-93-26X (Battery)

[c] USEPA interim guidance for Superfund soil lead cleanup

[d] Lowest calculated risk-based concentration for industrial/commercial soil (assumes TPHC originates from gasoline)

NA = Not analyzed

TABLE 4-11
HUMAN HEALTH PRE EVALUATION OF SUBSURFACE SOIL
SA 38 - BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	MAXIMUM DETECTED CONCENTRATION	FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND?	REGION III COMMERCIAL/ INDUSTRIAL SOIL CONCENTRATION (ug/g)	MAXIMUM EXCEEDS REGION III CONCENTRATION?
ECS MAINTENANCE AREA						
INORGANICS (ug/g)						
LEAD	34.4	5.25	4/4	NO	500[c]	NO
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	NA				
BATTERY ROOM						
INORGANICS (ug/g)						
LEAD	34.4	140	6/6	YES	500[c]	NO
BERYLLIUM	0.347	NA				
ORGANICS (ug/g)						
TPHC	NA	32	1/6	NA	1800 [d]	NO

NOTES:

[a] Base-wide backgound soil inorganics database. Lead background concentration revised from 48.4 ug/g (ABB-ES, 1994b).

[b] Subsurface soil samples from sampling stations G3M-93-08X (East); 38B-93-12X through 38B-93-15X, G3M-92-06X (West); 38B-93-16X, 38B-93-17X (Canvas); 38B-93-18X, 38B-93-20X (ECS); 38B-93-21X, 38B-93-22X, 38B-93-24X through 38B-93-26X (Battery)

[c] USEPA interim guidance for Superfund soil lead cleanup.

[d] Lowest calculated risk-based concentration for industrial/commercial soil (assumes TPHC originates from gasoline).

NA = Not analyzed

TABLE 4-12
HUMAN HEALTH PRE EVALUATION OF GROUNDWATER
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	GROUNDWATER BACKGROUND CONCENTRATION	MAXIMUM DETECTED CONCENTRATION [a]	MAXIMUM EXCEEDS BACKGROUND?	DRINKING WATER STANDARD GUIDELINE [b] (ug/L)	MAXIMUM EXCEEDS STANDARD/GUIDELINE?
INORGANICS (ug/L)					
ALUMINUM	6,870	3,740	NO	50–200	YES
ANTIMONY	3.03	2.86	NO	6	NO
ARSENIC	10.5	8.85	NO	50	NO
BARIUM	39.6	28.5	NO	2000	NO
CALCIUM	14,700	5,360	NO	NA	NA
COPPER	8.09	13.6	YES	1300	NO
IRON	9,100	3,985	NO	300	YES
LEAD	4.25	4.45	YES	15	NO
MAGNESIUM	3,480	1,220	NO	NA	NA
MANGANESE	291	192	NO	50	YES
POTASSIUM	2,370	1,780	NO	NA	NA
SODIUM	10,800	3,140	NO	28000	NO
ANIONS/CATIONS (ug/L)					
NITRATE/NITRITE		1,500		10,000	NO

NOTES:

[a] Only unfiltered samples are used for inorganics.

[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.

[c] SA 38 is represented by two rounds of samples from the following monitoring wells: G3M–93–08X and G3M–93–09X.

ND Not detected

NA Not available

TABLE 4-13
ECOLOGICAL PRE EVALUATION OF SURFACE SOIL
SA 38 – BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	DETECTED CONCENTRATION [b]		FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND?	ECOLOGICAL BENCHMARK (ug/g)	MAXIMUM EXCEEDS BENCHMARK?
		AVERAGE	MAXIMUM				
INORGANICS (ug/g)							
BERYLLIUM	0.347	1.00	1.33	5/5	YES	0.88	YES
LEAD	34.4	60.2	245	5/5	YES	34.4	YES

NOTES:
[a] Base-wide background soil inorganics database. Lead background concentration revised from 48.4 ug/g (ABB-ES, 1994b).
[b] Surface soil samples from from sampling stations 38B-93-12X, 38B-93-13X, 38B-93-14X, 38B-93-15X, 38B-92-06.
NA = not available.

TABLE 4-14
LEAD IN SOIL CALCULATIONS
SA 38 - BATTERY REPAIR AREA (BUILDING 3713)

SITE INVESTIGATION REPORT, GROUP 3, 5, AND 6 STUDY AREAS
FORT DEVENS

Assumed parameter values:

a. Concentration of lead in typical waste electrolyte - 510 μg/l
b. Waste electrolyte production rate - 106 gal/month (from Fort Devens MEP)
c. Period of surface disposal - 36 years (1942 to 1978)

Calculations:

Total Volume of Electrolyte Disposed

$$106 gal/month \cdot 12 months/year \cdot 36 years = 4.58\times10^{4} gal$$

Total Mass of Lead Disposed

$$45{,}800 gal \cdot 3{,}786 \ell/gal \cdot 510 \mu g/\ell = 88.4\times10^{6} \mu g$$
$$= 88.4\ grams$$

Density of Typical Soil in g/ft^3 (assuming dry, uncompacted density of 1.8g/cm^3)

$$1.8 g/cm^3 \cdot 28{,}300 cm^3/ft^3 = 5.10\times10^{4} g/ft^3$$

Assumed volume of effected soil in East Disposal Area - the area as indicated by Moyen (1993) to a depth of one foot

$$25 ft \cdot 35 ft \cdot 1 ft = 875 ft^3$$

Hypothetical increase in lead concentration in East Disposal Area soil

$$\frac{88.4 g\ [Pb]}{5.10\times10^{4} g\ [soil]/ft^3 \cdot 875 ft^3} = 2\times10^{-6} g/g$$
$$= 2 \mu g/g$$

TABLE 4–15
ANALYTES IN SOIL
SA 52 – TDA MAINTENANCE YARD TEST PITS

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	SAMPLE I.D. / DEPTH (feet)													
	1A2	2A4	2A4 (dup)	3A1	4B3	4B3 (dup)	5B3	6B4	6B4 (dup)	7B2	8C3	9C4	9C4 (dup)	10C1
	0	0	0	0	4	4	4	4	4	4	8	8	8	8
VOCS (TCLP organics in ug/L)														
BENZENE	ND	5	ND	ND	4	ND	ND	ND	7	ND	3	ND	ND	ND
INORGANICS (TCLP RCRA in ug/L)														
SILVER	ND	ND	ND	11	ND	ND	ND	ND	ND	126	ND	ND	ND	ND
BARIUM	61	233	215	297	64	69	156	85	86	65	83	69	75	97
CADMIUM	7	14	9	4	ND	ND	7	ND	ND	ND	ND	ND	7	ND
MERCURY	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4	122	ND
LEAD	ND	ND	ND	ND	ND	ND	109	ND	ND	ND	ND	ND	ND	ND
OTHERS (mg/kg)														
TPHC	ND	420	560	700	ND	ND	80	ND	ND	ND	ND	ND	ND	ND
PCBS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Source: Mullen, 1991.

Notes: ND = not detected above the detection limit

TABLE 4-16
ORGANIC COMPOUNDS IN SOIL
SA 44 - CANNIBALIZATION YARD

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BORING	44B-92-01X			44B-92-02X			44B-92-03X			44B-92-04X			44B-92-05X			44B-92-06X			
	DEPTH	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	5D	10
VOLATILES (ug/g)																				
ETHYLBENZENE		<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0017	<0.0080	0.500	<0.0017
TOLUENE		< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< .00078	< 0.0040	0.050	< .00078
XYLENES		< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	< 0.0015	0.040	4.00	< 0.0015
SEMIVOLATILES (ug/g)																				
2-METHYLNAPHTHALENE		< 0.200	<0.100	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 1.00	< 0.049	< 0.200	6.00	< 0.049	< 0.049	0.700	30.0	30.0	3.00
ACENAPHTHENE		0.400	<0.070	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.700	< 0.036	< 0.200	6.00	< 0.036	< 0.036	< 0.400	< 0.400	< 0.400	< 0.200
ACENAPHTHYLENE		4.00	0.300	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.700	< 0.033	< 0.200	3.00	< 0.033	< 0.033	< 0.300	< 0.300	< 0.300	< 0.200
ANTHRACENE		5.00	0.700	< 0.036	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	1.00	< 0.033	< 0.200	20.0	< 0.033	< 0.033	< 0.300	< 0.300	< 0.300	< 0.200
BIS(2-ETHYLHEXYL)PHTHALAT		< 3.00	<1.00	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 10.0	< 0.620	< 3.00	< 30.0	< 0.620	1.10	< 6.00	< 6.00	< 6.00	< 3.00
BENZO[A]ANTHRACENE		20.0	2.00	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 3.00	< 0.170	< 0.800	40.0	< 0.170	< 0.170	< 2.00	< 2.00	< 2.00	< 0.800
BENZO[A]PYRENE		30.0	2.00	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 5.00	< 0.250	< 1.00	30.0	< 0.250	< 0.250	< 2.00	< 2.00	< 2.00	< 1.00
BENZO[B]FLUORANTHENE		20.0	3.00	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 4.00	< 0.210	<1.00	30.0	< 0.210	< 0.210	< 2.00	< 2.00	< 2.00	< 1.00
BENZO[G,H,I]PERYLENE		20.0	3.00	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 5.00	< 0.250	< 1.00	20.0	< 0.250	< 0.250	< 2.00	< 2.00	< 2.00	< 1.00
BENZO[K]FLUORANTHENE		20.0	2.00	0.110	< 0.066	< 0.066	< 0.066	0.170	< 0.066	< 0.066	4.00	< 0.066	< 0.300	30.0	< 0.066	< 0.066	< 0.700	< 0.700	< 0.700	< 0.300
CARBAZOLE		2.00	0.500	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.700	ND 0.033	ND 0.200	20.0	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.300	ND 0.200
CHRYSENE		20.0	3.00	0.160	< 0.120	< 0.120	< 0.120	0.160	< 0.120	< 0.120	5.00	< 0.120	< 0.600	50.0	< 0.120	< 0.120	< 1.00	< 1.00	< 1.00	< 0.600
DIBENZO[A,H]ANTHRACENE		5.00	0.900	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 4.00	< 0.210	< 1.00	< 10.0	< 0.210	< 0.210	< 2.00	< 2.00	< 2.00	< 1.00
DIBENZOFURAN		0.400	0.200	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.700	< 0.035	<0.200	10.0	< 0.035	< 0.035	< 0.400	0.600	0.600	< 0.200
FLUORANTHENE		50.0	7.00	0.250	0.085	0.088	< 0.068	0.280	< 0.068	< 0.068	10.0	< 0.068	< 0.300	100	< 0.068	< 0.068	< 0.700	< 0.700	< 0.700	< 0.300
FLUORENE		1.00	0.300	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.700	< 0.033	< 0.200	20.0	< 0.033	< 0.033	< 0.300	1.00	1.00	0.300
INDENO[1,2,3-C,D]PYRENE		20.0	3.00	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 6.00	< 0.290	< 1.00	20.0	< 0.290	< 0.290	< 3.00	< 3.00	< 3.00	< 1.00
NAPHTHALENE		0.600	<0.070	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.700	< 0.037	< 0.200	20.0	< 0.037	< 0.037	< 0.400	6.00	6.00	0.300
PHENANTHRENE		20.0	3.00	< 0.033	< 0.033	< 0.033	< 0.033	0.078	< 0.033	< 0.033	4.00	< 0.033	< 0.200	100	< 0.033	< 0.033	< 0.300	0.900	0.600	0.200
PYRENE		20.0	3.00	0.190	0.049	0.089	< 0.033	0.220	< 0.033	< 0.033	7.00	< 0.033	< 0.200	60.0	< 0.033	< 0.033	< 0.300	< 0.300	< 0.300	< 0.200
OTHER (ug/g)																				
TRICHLOROFLUOROMETHANE		<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	<0.0059	< 0.0300	< 0.0059
TPHC		714	76.2	< 27.9	< 27.9	< 27.9	< 27.9	34.7	< 27.7	40.3	465	< 27.7	33.8	1210	<28.1	<27.7	8520	7680	7310	1560

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED

O44BORES.WK1
06/14/95

TABLE 4–17
ORGANIC COMPOUNDS IN SOIL
SA 52 – TDA MAINTENANCE YARD

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BORING	52B–92–01X			52B–92–02X			52B–92–03X			52B–92–04X				52B–92–05X		
	DEPTH	0	5	10	0	5	10	0	5	10	0	0D	5	10	0	5	10
VOLATILES (ug/g)																	
ETHYLBENZENE		< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170
TOLUENE		< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078
XYLENES		< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150
SEMIVOLATILES (ug/g)																	
ACENAPHTHENE		<0.900	< 0.036	< 0.036	< 0.900	< 0.900	< 0.180	0.315	< 0.200	< 0.036	< 0.072	< 0.900	< 0.036	< 0.036	< 0.070	< 0.072	< 0.072
ACENAPHTHYLENE		<0.825	< 0.033	< 0.033	< 0.825	< 0.825	< 0.165	1.18	< 0.200	< 0.033	0.193	< 0.825	< 0.033	< 0.033	0.500	0.142	0.090
ANTHRACENE		<0.825	< 0.033	< 0.033	< 0.825	< 0.825	< 0.165	2.99	< 0.200	< 0.033	0.171	< 0.825	< 0.033	< 0.033	0.500	0.143	0.100
BIS(2–ETHYLHEXYL)PHTHALATE		<15.5	< 0.620	< 0.620	< 15.5	< 15.5	< 3.10	< 3.10	< 3.00	< 0.620	< 1.24	< 15.5	< 0.620	< 0.620	< 1.00	< 1.24	< 1.24
BENZO[A]ANTHRACENE		<4.25	< 0.170	< 0.170	< 4.25	< 4.25	< 0.800	10.0	< 0.800	< 0.170	0.803	< 4.25	< 0.170	< 0.170	1.00	0.392	< 0.340
BENZO[A]PYRENE		< 6.25	< 0.250	< 0.250	< 6.25	< 6.25	< 1.25	12.4	< 1.00	< 0.250	1.01	< 6.25	< 0.250	< 0.250	2.00	0.743	< 0.500
BENZO[B]FLUORANTHENE		< 5.25	< 0.210	< 0.210	< 5.25	< 5.25	< 1.05	13.3	< 1.00	< 0.210	1.63	< 5.25	< 0.210	< 0.210	3.00	1.06	0.527
BENZO[G,H,I]PERYLENE		< 6.25	< 0.250	< 0.250	< 6.25	< 6.25	< 1.25	10.2	< 1.00	< 0.250	1.04	< 6.25	< 0.250	< 0.250	1.00	0.611	< 0.500
BENZO[K]FLUORANTHENE		< 1.65	0.085	< 0.066	< 1.65	< 1.65	< 0.330	6.48	0.500	< 0.066	0.883	< 1.65	< 0.066	0.087	1.00	0.647	0.430
CARBAZOLE		ND 0.825	ND 0.033	ND 0.033	ND 0.825	ND 0.825	ND 0.165	2.00	ND 0.200	ND 0.033	0.106	ND 0.825	ND 0.033	ND 0.033	0.500	0.104	ND 0.066
CHRYSENE		< 3.00	0.191	< 0.120	< 3.00	< 3.00	< 0.600	10.0	< 0.600	< 0.120	1.04	< 3.00	< 0.120	< 0.120	2.00	0.764	0.507
DIBENZO[A,H]ANTHRACENE		< 5.25	< 0.210	< 0.210	< 5.25	< 5.25	< 1.05	< 1.00	< 1.00	< 0.210	< 0.420	< 5.25	< 0.210	< 0.210	0.600	< 0.420	< 0.420
DIBENZOFURAN		< 0.875	< 0.035	< 0.035	< 0.875	< 0.875	< 0.175	0.600	< 0.200	< 0.035	< 0.070	< 0.875	< 0.035	< 0.035	< 0.070	< 0.070	< 0.070
FLUORANTHENE		< 1.70	0.288	< 0.068	< 1.70	< 1.70	< 0.340	20.0	1.00	0.200	2.22	< 1.70	< 0.068	0.230	4.85	1.69	1.20
FLUORENE		< 0.825	< 0.033	< 0.033	< 0.825	< 0.825	< 0.165	1.00	< 0.200	< 0.033	< 0.066	< 0.825	< 0.033	< 0.033	0.100	< 0.066	< 0.066
INDENO[1,2,3–C,D]PYRENE		< 7.25	< 0.290	< 0.290	< 7.25	< 7.25	< 1.45	11.0	< 1.00	< 0.290	1.57	< 7.25	< 0.290	< 0.290	2.21	0.658	< 0.580
NAPHTHALENE		< 0.900	< 0.037	< 0.037	< 0.900	< 0.900	< 0.185	0.243	< 0.200	< 0.037	< 0.074	< 0.900	< 0.037	< 0.037	< 0.074	< 0.074	< 0.074
PHENANTHRENE		< 0.825	0.092	< 0.033	< 0.825	< 0.825	< 0.165	20.0	0.500	0.074	0.659	< 0.825	< 0.033	0.076	1.51	0.429	0.400
PYRENE		2.18	0.282	< 0.033	< 0.825	< 0.825	< 0.165	20.0	1.00	0.109	1.51	< 0.825	< 0.033	0.150	2.48	1.00	0.700
OTHER (ug/g)																	
TOTAL ORGANIC CARBON		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPHC		142	65.1	51.5	304	129	60.8	98.0	30.2	29.8	79.8	80.4	39.9	<27.7	647	170	119

NOTES:
TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

O52BORE.WK1
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TABLE 4-17 (continued)
ORGANIC COMPOUNDS IN SOIL
SA 52 - TDA MAINTENANCE YARD

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE BORING	52B-92-06X				52B-92-07X			52B-92-08X			52B-92-09X			G3M-92-04X		
DEPTH	0	5	5D	10	0	5	10	0	5	10	0	5	10	0	12	26
VOLATILES (ug/g)																
ETHYLBENZENE	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	< 0.00170	0.0049	< 0.00170	< 0.00170
TOLUENE	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	0.00086	< 0.00078	< 0.00078	< 0.00078	< 0.00078	< 0.00078	0.0023	< 0.00078	< 0.00078
XYLENES	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	< 0.00150	0.00510	<0.00510	< 0.00150	< 0.00150	< 0.00150	< 0.00150	0.0220	< 0.00150	< 0.00150
SEMIVOLATILES (ug/g)																
ACENAPHTHENE	< 0.072	< 0.072	< 0.180	< 0.036	< 0.036	< 0.070	< 0.072	< 0.900	< 0.180	< 0.180	< 0.072	< 0.036	< 0.036	< 0.900	< 0.036	< 0.036
ACENAPHTHYLENE	0.168	< 0.066	< 0.165	< 0.033	0.144	< 0.070	< 0.066	< 0.825	< 0.165	< 0.165	0.469	< 0.033	< 0.033	< 0.825	< 0.033	< 0.033
ANTHRACENE	0.122	0.143	< 0.165	< 0.033	0.121	< 0.070	< 0.066	< 0.825	< 0.165	< 0.165	0.475	< 0.033	< 0.033	< 0.825	< 0.033	< 0.033
BIS(2-ETHYLHEXYL)PHTHALATE	< 1.24	< 1.24	< 3.10	< 0.620	< 0.620	< 1.00	< 1.24	< 15.5	< 3.10	< 3.10	< 1.24	0.974	< 0.620	< 15.5	< 0.620	< 0.620
BENZO[A]ANTHRACENE	0.399	0.391	< 0.800	< 0.170	0.239	< 0.300	< 0.340	< 4.25	< 0.800	< 0.800	0.780	< 0.170	< 0.170	4.95	< 0.170	< 0.170
BENZO[A]PYRENE	< 0.500	< 0.500	< 1.25	< 0.250	0.376	< 0.500	< 0.500	< 6.25	< 1.25	< 1.25	1.00	< 0.250	< 0.250	< 6.25	< 0.250	< 0.250
BENZO[B]FLUORANTHENE	1.08	< 0.420	< 1.05	< 0.210	0.980	0.800	< 0.420	< 5.25	2.04	< 1.05	1.32	< 0.210	< 0.210	10.0	< 0.210	< 0.210
BENZO[G,H,I]PERYLENE	0.622	< 0.500	< 1.25	< 0.250	0.682	< 0.500	< 0.500	< 6.25	< 1.25	< 1.25	1.01	< 0.250	< 0.250	< 6.25	< 0.250	< 0.250
BENZO[K]FLUORANTHENE	0.439	0.430	< 0.330	< 0.066	0.339	0.200	< 0.132	< 1.65	0.499	< 0.330	0.643	0.076	< 0.066	2.18	< 0.066	< 0.066
CARBAZOLE	ND 0.066	ND 0.066	ND 0.165	ND 0.033	0.063	ND 0.070	ND 0.066	ND 0.825	ND 0.165	ND 0.165	0.083	ND 0.033	ND 0.033	ND 0.825	ND 0.033	ND 0.033
CHRYSENE	0.777	0.761	< 0.600	< 0.120	0.581	0.500	< 0.240	3.41	1.31	1.29	1.52	< 0.120	< 0.120	10.0	< 0.120	< 0.120
DIBENZO[A,H]ANTHRACENE	< 0.420	< 0.420	< 1.05	< 0.210	< 0.210	< 0.420	< 0.420	< 5.25	< 1.05	< 1.05	< 0.420	< 0.210	< 0.210	< 5.25	< 0.210	< 0.210
DIBENZOFURAN	< 0.070	< 0.070	< 0.175	< 0.035	< 0.035	< 0.070	< 0.070	< 0.875	< 0.175	< 0.175	< 0.070	< 0.035	< 0.035	< 0.875	< 0.035	< 0.035
FLUORANTHENE	1.71	1.92	< 0.340	< 0.068	0.965	0.720	0.217	6.45	2.48	1.22	2.39	0.109	< 0.068	15.2	< 0.068	< 0.068
FLUORENE	< 0.066	< 0.066	< 0.165	< 0.033	< 0.033	< 0.066	< 0.066	< 0.825	< 0.165	< 0.165	0.169	< 0.033	< 0.033	< 0.825	< 0.033	< 0.033
INDENO[1,2,3-C,D]PYRENE	0.669	< 0.580	< 1.45	< 0.290	0.911	< 0.580	< 0.580	< 7.25	< 1.45	< 1.45	1.31	< 0.290	< 0.290	< 7.25	< 0.290	< 0.290
NAPHTHALENE	< 0.074	< 0.074	< 0.185	< 0.037	< 0.037	< 0.070	< 0.074	< 0.900	< 0.185	< 0.185	< 0.074	< 0.037	< 0.037	< 0.900	< 0.037	< 0.037
PHENANTHRENE	0.400	1.28	< 0.165	< 0.033	0.228	0.200	< 0.066	2.87	1.10	0.545	1.49	< 0.033	< 0.033	10.8	< 0.033	< 0.033
PYRENE	1.00	1.00	< 0.165	0.049	0.736	0.500	0.148	6.59	2.53	1.87	2.20	0.086	< 0.033	21.7	< 0.033	< 0.033
OTHER (ug/g)																
TOTAL ORGANIC CARBON	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	283
TPHC	131	58.3	48.5	39.1	89.1	97.5	30.2	73.1	34.5	< 28.1	33.4	33.7	33.4	716	51.5	61.1

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

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TABLE 4-18
INORGANIC ANALYTES IN SOIL
SA 44 – CANNIBALIZATION YARD

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	BORING	44B-92-01X			44B-92-02X			44B-92-03X			44B-92-04X			44B-92-05X			44B-92-06X			
(ug/g)		DEPTH	0	5	10	0	5	10	0	5	10	0	5	10	0	5	10	0	5	5D	10
ALUMINUM	15000		7030	5270	3940	7070	3940	3090	9550	4240	3840	7270	3920	3630	9470	4000	2890	15800	5040	4820	3720
ANTIMONY	NA		< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	< 1.09	1.96	< 1.09	< 1.09	< 1.09
ARSENIC	21		7.34	14.2	16.0	7.42	9.76	8.88	10.6	9.51	8.54	15.0	10.8	15.0	16.0	9.33	12.0	30.0	11.5	10.3	9.51
BARIUM	42.5		48.1	18.1	18.4	15.0	13.9	14.6	34.6	13.2	17.5	31.2	16.0	16.0	30.7	18.1	12.9	79.0	14.7	15.9	18.4
BERYLLIUM	0.347		0.92	< 0.500	0.653	0.740	0.712	0.627	1.15	< 0.500	0.718	0.851	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	0.786	< 0.500	< 0.500	< 0.500
CADMIUM	2.00		2.14	<0.700	<0.700	<0.700	<0.700	<0.700	<0.700	<0.700	<0.700	2.59	<0.700	<0.700	8.85	<0.700	<0.700	1.03	<0.700	<0.700	<0.700
CALCIUM	1400		922	307	334	140	141	304	404	130	378	724	546	342	1260	322	262	1690	214	249	362
CHROMIUM	31		37.2	13.3	12.2	8.20	9.15	8.90	22.2	7.47	12.3	33.0	7.72	8.73	28.6	10.3	5.92	63.9	10.1	10.6	9.06
COBALT	NA		5.26	4.68	3.97	2.15	3.12	3.27	5.44	2.09	3.46	5.17	3.36	2.79	6.58	3.69	2.50	9.82	2.70	3.33	3.20
COPPER	8.39		20.6	10.8	9.90	4.43	8.04	12.7	9.56	5.00	10.8	11.9	8.07	5.19	12.8	7.29	5.33	17.1	6.62	6.72	6.81
IRON	15000		11100	8830	7400	6400	6560	6290	11100	5240	6170	11800	7340	6410	14800	7340	6000	19900	8400	7560	6530
LEAD	48.4		53.0	15.2	4.96	4.44	7.45	3.23	6.87	3.70	3.81	73.0	3.73	6.41	21.0	4.21	3.09	22.0	5.12	4.40	3.83
MAGNESIUM	5600		3600	2010	1990	1030	1560	1460	3100	1100	1630	4240	1490	1510	5020	1860	1200	9670	1890	1840	1650
MANGANESE	300		181	173	162	57.3	106	147	187	68.3	159	211	140	114	247	142	129	423	148	118	138
NICKEL	14.0		21.5	13.4	11.4	7.91	9.40	10.5	21.8	7.02	11.7	25.5	10.9	9.16	26.1	10.5	7.59	44.6	9.52	9.93	10.8
POTASSIUM	1700		1480	551	1000	274	420	526	1260	346	779	1040	356	510	1130	424	319	4400	395	338	600
SODIUM	131		157	173	138	151	140	117	167	< 100	148	186	175	174	206	158	181	245	138	152	161
VANADIUM	28.7		19.3	8.39	8.56	7.42	6.54	5.40	15.5	5.83	6.88	15.1	5.24	5.84	18.0	6.34	4.07	37.6	6.75	7.64	6.66
ZINC	35.5		92.9	32.0	21.3	16.0	19.1	21.8	24.6	12.8	21.3	48.8	18.9	22.2	53.4	20.0	17.0	56.9	18.8	18.3	21.6

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA =NOT ANALYZED

TABLE 4-19
INORGANIC ANALYTES IN SOIL
SA 52 - TDA MAINTENANCE YARD

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-	BORING	52B-92-01X			52B-92-02X			52B-92-03X			52B-92-04X				52B-92-05X		
(ug/g)	GROUND	DEPTH	0	5	10	0	5	10	0	5	10	0	0D	5	10	0	5	10
ALUMINUM	15000		14700	5070	5120	10200	8150	4540	11500	3130	2930	10400	11500	2870	4080	8210	4360	4300
ARSENIC	21		29.0	9.54	10.6	17.0	18.0	10.6	20.0	8.82	10.9	19.0	20.0	12.0	9.88	14.0	10.5	10.5
BARIUM	42.5		95.3	16.5	37.4	38.4	36.4	20.2	64.4	15.2	17.4	47.2	49.8	9.35	14.0	24.3	16.5	18.7
BERYLLIUM	0.347		0.879	< 0.500	< 0.500	0.92	1.01	< 0.500	0.821	< 0.500	< 0.500	0.638	0.795	< 0.500	< 0.500	1.06	0.569	< 0.500
CADMIUM	2.00		< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	1.23	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700
CALCIUM	1400		1690	689	583	659	727	557	871	220	312	603	659	396	237	594	282	483
CHROMIUM	31		58.7	13.1	25.5	32.6	30.1	15.7	46.2	9.20	8.68	36.3	42.0	<4.05	9.51	18.9	12.1	14.8
COBALT	NA		9.18	3.01	4.24	6.73	6.05	4.19	10.7	3.24	3.54	7.19	8.03	1.78	3.18	4.56	3.95	3.78
COPPER	8.39		16.4	6.72	8.41	10.6	11.8	6.76	18.7	6.54	8.24	10.3	12.0	4.53	6.72	10.8	7.78	8.13
IRON	15000		18900	7700	8880	13000	12300	7810	16300	5470	5670	12300	14400	3990	6500	11000	7030	6840
LEAD	48.4		13.0	4.00	8.38	10.4	6.45	3.67	16.0	3.35	3.68	8.84	9.18	2.65	3.63	20.0	19.0	8.36
MAGNESIUM	5600		9210	2210	2890	5440	4480	2360	7590	1420	1450	5040	6010	696	1740	3140	1710	2040
MANGANESE	300		313	128	203	273	260	163	268	137	234	202	220	48.5	118	172	142	134
NICKEL	14.0		41.8	11.6	16.6	28.0	24.1	13.1	36.5	9.77	10.6	28.6	35.0	4.76	10.5	18.5	12.4	12.0
POTASSIUM	1700		4820	619	1670	1830	1530	964	4000	564	690	2370	2820	229	528	878	530	1030
SODIUM	131		316	164	176	189	189	<100	166	<100	115	154	178	132	133	154	152	154
VANADIUM	28.7		34.9	7.61	10.8	20.3	18.0	8.74	32.3	5.86	6.07	21.2	25.3	<3.39	6.40	14.0	7.31	9.34
ZINC	35.5		46.4	18.8	25.5	35.5	34.3	21.0	62.9	17.7	16.2	37.0	43.3	11.2	18.1	35.6	20.8	21.1

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

I52BORES.WK1
06/14/95

TABLE 4–19 (continued)
INORGANIC ANALYTES IN SOIL
SA 52 – TDA MAINTENANCE YARD

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK–	BORING	52B–92–06X				52B–92–07X			52B–92–08X			52B–92–09X			G3M–92–04X		
(ug/g)	GROUND	DEPTH	0	5	5D	10	0	5	10	0	5	10	0	5	10	0	12	26
ALUMINUM	15000		14200	5160	4390	3930	7010	5160	3550	6370	4210	2960	5410	3390	3900	7360	2690	4740
ARSENIC	21		21.0	16.0	19.0	15.0	9.04	10.7	14.0	5.81	6.80	6.78	7.03	8.21	15.0	11.2	7.11	7.54
BARIUM	42.5		80.7	21.0	19.5	15.2	19.0	16.1	15.2	20.6	16.6	12.6	11.3	12.0	17.8	19.6	14.2	19.9
BERYLLIUM	0.347		0.939	< 0.500	0.628	0.550	< 0.500	0.549	< 0.500	< 0.500	0.637	< 0.500	< 0.500	<0.500	< 0.500	0.674	< 0.500	1.13
CADMIUM	2.00		< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700	< 0.700
CALCIUM	1400		1280	439	386	358	196	326	426	292	361	365	< 100	178	450	304	322	446
CHROMIUM	31		47.7	15.2	13.3	11.5	12.5	12.9	11.6	9.52	7.07	5.17	7.49	7.01	10.7	18.3	5.15	12.3
COBALT	NA		8.66	4.35	3.9	3.65	3.68	4.00	3.59	2.74	2.25	2.26	2.50	2.30	3.80	4.54	2.60	4.22
COPPER	8.39		15.1	9.11	9.14	7.97	6.60	7.37	7.96	5.22	4.47	4.09	5.56	5.70	9.92	8.07	6.33	8.14
IRON	15000		16900	7910	6760	7580	8300	7790	6480	6410	5020	4280	6640	5220	8470	9280	5070	14600
LEAD	48.4		17.0	8.10	6.27	5.58	8.97	6.77	4.58	19.0	12.4	5.84	5.43	3.78	4.53	8.76	3.49	3.73
MAGNESIUM	5600		8190	2590	2130	1990	2240	2080	1790	1080	1010	789	1250	1150	1700	2900	1030	2570
MANGANESE	300		293	162	149	125	129	147	150	97.4	91.3	76.2	91.2	83.6	302	155	104	247
NICKEL	14.0		38.4	14.2	12.7	10.8	12.4	12.4	12.9	7.35	5.70	4.96	7.34	7.04	14.6	16.5	6.86	16.7
POTASSIUM	1700		4370	912	858	551	528	506	612	344	480	417	242	339	533	855	396	977
SODIUM	131		296	165	150	140	145	148	138	157	160	152	142	136	165	<100	158	192
VANADIUM	28.7		32.1	10.2	8.61	7.99	10.4	8.25	6.74	8.29	6.31	4.48	5.87	5.04	6.40	12.4	3.97	8.97
ZINC	35.5		41.3	21.4	19.2	19.8	22.0	21.0	21.2	24.1	17.7	14.5	18.0	14.1	21.0	20.9	14.9	28.4

NOTES:
TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

I52BORES.WK1
06/14/95

Table 4–20
Human Health PRE Evaluation of Surface Soil
Study Area 44 and 52 – Maintenance Areas

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency Of Detection	Maximum Exceeds Backgrouound?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15000	9,050	14,700	15/15	NO	230000	NO
arsenic	21	14.0	19.0	15/15	NO	0.97	YES
barium	42.5	38.7	95.3	15/15	YES	5500	NO
beryllium	0.347	0.872	1.15	11/15	YES	0.4	YES
cadmium	2.00	3.70	8.85	4/15	YES	39	NO
calcium	1400	710	1690	14/15	YES	NA	NA
chromium	31	27.8	58.7	15/15	YES	390	NO
cobalt	NA	5.67	10.7	15/15	NA	NA	NA
copper	8.39	11.1	20.6	15/15	YES	2900	NO
iron	15000	11615	18900	15/15	YES	NA	NA
lead	48.4	19.0	73.0	15/15	YES	500	NO
magnesium	5600	4204	9210	15/15	YES	NA	NA
manganese	300	192	313	15/15	YES	7800	NO
nickel	14.0	22.5	41.8	15/15	YES	1600	NO
potassium	1700	1695	4820	15/15	YES	NA	NA
sodium	131	185	316	14/15	YES	NA	NA
vanadium	28.7	17.8	34.9	15/15	YES	550	NO
zinc	35.5	38.6	92.9	15/15	YES	23000	NO

Table 4-20
Human Health PRE Evaluation of Surface Soil
Study Area 44 and 52 – Maintenance Areas

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency Of Detection	Maximum Exceeds Backgrouound?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Organics (ug/g)							
ethylbenzene		0.0049	0.0049	1/15	NA	7800	NO
toluene		0.0016	0.0023	2/15	NA	16000	NO
xylenes		0.01355	0.022	2/15	NA	160000	NO
2-methylnaphthalene		6.7	6.7	1/15	NA	NA	NA
acenaphthene		2.238	6.0	3/15	NA	4700	NO
acenapthylene		1.207	4.0	8/15	NA	NA	NA
anthracene		3.38	20.0	9/15	NA	23000	NO
benzo(a)anthracene		8.69	40.0	9/15	NA	1.6	YES
benzo(a)pyrene		10.97	30.0	7/15	NA	0.23	YES
benzo(b)fluoranthene		9.03	30.0	9/15	NA	1.9	YES
benzo(g,h,i)perylene		6.82	20.0	8/15	NA	11	YES
benzo(k)fluoranthene		6.01	30.0	11/15	NA	4.4	YES
carbazole		3.54	20.0	7/15	NA	85	NO
chrysene		8.71	50.0	12/15	NA	NA	NA
dibenzo(a,h)anthracene		2.8	5.0	2/15	NA	0.21	YES
dibenzofuran		3.67	10.0	3/15	NA	NA	NA
fluoranthene		16.5	100.0	13/15	NA	3100	NO
fluorene		4.45	20.0	5/15	NA	3100	NO
indeno(1,2,3-c,d)pyrene		7.21	20.0	8/15	NA	0.84	YES
naphthalene		6.95	20.0	3/15	NA	3100	NO
phenanthrene		13.5	100.0	12/15	NA	2300	NO
pyrene		10.4	60.0	14/15	NA	2300	NO
TPHC		946.9	8520.0	14/15	NA	NA	NA

Notes:
[a] Base-wide background soil inorganics database.
[b] Surface soil samples from sampling stations 44B-92-01X to 44B-92-05X, 52B-92-01X to 55B-92-09X, and G3M-92-04X.
NA = not available.

Table 4-21
Human Health PRE Evaluation of Subsurface Soil
Study Areas 44 and 52 - Maintenance Areas

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	4,109	8,150	31/31	NO	3000000	NO
arsenic	21	11.3	19	31/31	NO	1.6	YES
barium	42.5	17	378.4	31/31	YES	72000	NO
beryllium	0.347	0.708	1.13	11/31	YES	0.67	YES
calcium	1400	374.5	727	31/31	NO	NA	NA
chromium	31	11.5	30.1	30/31	NO	5100	YES
cobalt	NA	3.45	3.05	31/31	NA	NA	NA
copper	8.39	7.71	12.7	31/31	YES	38000	NO
iron	15000	7063	14600	31/31	NO	NA	NA
lead	48.4	5.94	19.0	31/31	NO	500	NO
magnesium	5600	1795	4480	31/31	NO	NA	NA
manganese	300	147	302	31/31	YES	100000	NO
nickel	14.0	11.2	24.1	31/31	YES	20000	NO
potassium	1700	650	1670	31/31	NO	NA	NA
sodium	131	154	192	28/31	YES	NA	NA
vanadium	28.7	7.34	18.0	30/31	NO	7200	NO
zinc	35.5	20.1	34.3	31/31	NO	310000	NO

Table 4–21
Human Health PRE Evaluation of Subsurface Soil
Study Areas 44 and 52 – Maintenance Areas

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Organics (ug/g)							
acenaphthylene		0.177	0.3	3/31	NA	NA	NA
anthracene		0.272	0.7	4/31	NA	310000	NO
bis(2–ethylhexyl)phthalate		1.04	1.1	2/31	NA	200	NO
benzo(a)anthracene		0.928	2.0	3/31	NA	2.7	NO
benzo(a)pyrene		1.37	2.0	2/31	NA	0.39	YES
benzo(b)fluoranthene		1.49	3.0	5/31	NA	3.2	NO
benzo(g,h,i)perylene		1.81	3.0	2//31	NA	18	NO
benzo(k)fluoranthene		0.460	2.0	11/31	NA	7.4	NO
carbazole		0.302	0.5	2/31	NA	140	NO
chrysene		0.943	3.0	9/31	NA	NA	NA
dibenzo(a,h)anthracene		0.90	0.90	1/31	NA	0.35	YES
dibenzofuran		0.20	0.20	1/31	NA	NA	NA
fluoranthene		1.24	7.0	15/31	NA	41000	NO
fluorene		0.30	0.30	1/31	NA	41000	NO
indeno(1,2,3–cd)pyrene		1.83	3.0	2/31	NA	1.4	YES
phenanthrene		0.70	3.0	11/31	NA	30000	NO
pyrene		0.907	3.0	14/31	NA	31000	NO
TPHC		60.6	170.0	22/31	NA	NA	NA

Notes:

[a] Base–wide background soil inorganics database.

[b] Subsurface soil samples from sampling locations 44B–92–01X to 44B–92–05X, 52B–92–01X to 55B–92–09X, and G3M–92–04X.

NA = not available.

Table 4-22
Human Health PRE Evaluation of Groundwater
SAs 44/52 – Maintenance Yard Monitoring Wells

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
chloroform		0.790	NA	5	NO
Inorganics (ug/l)					
barium	39.6	18.7	NO	2,000	NO
calcium	14,700	7,010	NO	NA	NA
iron	9,100	248	NO	300	NO
lead	4.25	1.84	NO	15	NO
magnesium	3,480	721	NO	NA	NA
manganese	291	791	YES	50	YES
potassium	2,370	1,500	NO	NA	NA
sodium	10,800	16,800	YES	28,400	NO
Anions/Cations (ug/l)					
nitrate/nitrite		2,000	NA	10,000	NO

NOTES:
[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.
[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.
[c] SAs 44 and 52 are represented by monitoring well G3M-92-04X.
NA Not available

TABLE 4-23
CONCENTRATION OF POTENTIALLY HAZARDOUS CONSTITUENTS IN AUTOMOTIVE/VEHICULAR USED OIL[1]

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

Constituent	Median Concentration (ppm)[2]
Metals	
arsenic	5
barium	48
cadmium	3
chromium	6.5
lead	240
zinc	480
total chlorine	1600
Chlorinated Solvents	
dichlorodifluoromethane	20
trichlorotrifluoroethane	160
1,1,1-trichloroethane	200
trichloroethylene	100
tetrachloroethylene	106
Other Organics	
benzene	20
toluene	380
xylene	550
benzo(a)anthracene	12
benzo(a)pyrene	10
naphthalene	330
PCBs[3]	5

Notes:
[1] Results of analysis of 1071 used oil samples.
[2] Half of the total samples analyzed had less than the concentrations at the median.
[3] For the purposes of determining median concentrations, undetected levels were assumed to be equal to the detection limit.

Source: Franklin Associates, Ltd., Composition and Management of Used Oil Generated in the United States, 1984.

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TABLE 4-24
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 – AVERAGE CONCENTRATIONS
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	Average	mg/kg	
INGESTION RATE	IR	480	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%		
SOIL ADHERENCE FACTOR	SAF	1	mg/cm²	USEPA, 1992
SURFACE AREA EXPOSED	SA	3,295	cm²/day	USEPA, 1989b (1)
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	70	kg	USEPA, 1989a
EXPOSURE FREQUENCY	EF	5	days/workweek	PRO.JUDGEMENT
EXPOSURE DURATION	ED	12	workweek(s)	PRO.JUDGEMENT
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989a
NONCANCER	AT	12	workweek(s)	USEPA, 1989a

USEPA, 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors".

USEPA, 1992. Dermal Exposure Assessment: Principles and Applications, Interim report, EPA/600/8-91/011B, January 1992.

USEPA, 1989a. RAGs, Part A. USEI

USEPA, 1989b. Exposure Factors Handbook.

(1) Arms and Hands

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

INTAKE-INGESTION (HQ) =
$$\frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 5 \text{ days/workweek}}$$

INTAKE-INGESTION (CANCER RISK) =
$$\frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

INTAKE-DERMAL (HQ) =
$$\frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 5 \text{ days/workweek}}$$

INTAKE-DERMAL (CANCER RISK) =
$$\frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

For noncarcinogenic effects: AT = ED

TABLE 4-24, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 - AVERAGE CONCENTRATIONS
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	1.941	1	3.1E-08	0.02	4.3E-09	0.014	4.4E-10	6.0E-11	5.0E-10
Benzo(a)anthracene	0.2078	1	3.3E-09	0.2	4.6E-09	7.3	2.4E-08	3.4E-08	5.8E-08
Benzo(a)pyrene	2.241	1	3.6E-08	0.2	5.0E-08	7.3	2.6E-07	3.6E-07	6.3E-07
Benzo(b)fluoranthene	0.2318	1	3.7E-09	0.2	5.1E-09	7.3	2.7E-08	3.7E-08	6.5E-08
Benzo(k)fluoranthene	0.1658	1	2.7E-09	0.2	3.7E-09	7.3	1.9E-08	2.7E-08	4.6E-08
Carbazole	0.621	1	1.0E-08	1	6.9E-08	0.02	2.0E-10	1.4E-09	1.6E-09
Chrysene	0.02581	1	4.2E-10	0.2	5.7E-10	7.3	3.0E-09	4.2E-09	7.2E-09
Dibenz(a,h)anthracene	0.782	1	1.3E-08	0.09	7.8E-09	7.3	9.2E-08	5.7E-08	1.5E-07
Indeno(1,2,3-cd)pyrene	0.2001	1	3.2E-09	0.2	4.4E-09	7.3	2.4E-08	3.2E-08	5.6E-08
Arsenic	12.36	1	2.0E-07	0.03	4.1E-08	1.8	3.6E-07	7.4E-08	4.3E-07
Beryllium	0.514	1	8.3E-09	0.35	2.0E-08	4.3	3.6E-08	8.6E-08	1.2E-07
Lead	10.188	0.5	8.2E-08	NA		NA			
						SUMMARY CANCER RISK	8E-07	7E-07	2E-06

TABLE 4-24, continued

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DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 - AVERAGE CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Ethylbenzene	0.000936	1	6.4E-09	0.2	8.8E-09	0.1	6.4E-08	8.8E-08	1.5E-07
Toluene	0.000441	1	3.0E-09	0.12	2.5E-09	2	1.5E-09	1.2E-09	2.8E-09
Xylenes	0.00129	1	8.8E-09	0.12	7.3E-09	4	2.2E-09	1.8E-09	4.0E-09
2-Methylnaphthalene	0.267	1	1.8E-06	0.1	1.3E-06	0.04	4.6E-05	3.1E-05	7.7E-05
Acenaphthene	0.235	1	1.6E-06	0.2	2.2E-06	0.6	2.7E-06	3.7E-06	6.4E-06
Acenaphthylene	0.297	0.91	1.9E-06	0.18	2.5E-06	0.04	4.6E-05	6.3E-05	1.1E-04
Anthracene	0.742	1	5.1E-06	0.29	1.0E-05	3	1.7E-06	3.4E-06	5.1E-06
Bis(2-ethylhexyl)phthalate	1.941	1	1.3E-05	0.02	1.8E-06	0.02	6.7E-04	9.1E-05	7.6E-04
Benzo(a)anthracene	2.078	0.91	1.3E-05	0.18	1.8E-05	0.04	3.2E-04	4.4E-04	7.6E-04
Bnezo(a)pyrene	2.241	0.91	1.4E-05	0.18	1.9E-05	0.04	3.5E-04	4.7E-04	8.2E-04
Benzo(b)fluoranthene	2.318	0.91	1.4E-05	0.18	2.0E-05	0.04	3.6E-04	4.9E-04	8.5E-04
Benzo(g,h,i)perylene	1.839	0.91	1.1E-05	0.18	1.6E-05	0.04	2.9E-04	3.9E-04	6.8E-04
Benzo(k)fluoranthene	1.658	0.91	1.0E-05	0.18	1.4E-05	0.04	2.6E-04	3.5E-04	6.1E-04
Carbazole	0.621	1	4.3E-06	1	2.9E-05	NA			
Chrysene	2.581	0.91	1.6E-05	0.18	2.2E-05	0.04	4.0E-04	5.5E-04	9.5E-04
Dibenz(a,h)anthracene	0.782	0.91	4.9E-06	0.08	2.9E-06	0.04	1.2E-04	7.4E-05	2.0E-04
Dibenzofuran	0.327	NA		NA		NA			
Fluoranthene	5.044	1	3.5E-05	0.2	4.7E-05	0.4	8.6E-05	1.2E-04	2.1E-04
Fluorene	0.564	1	3.9E-06	0.2	5.3E-06	0.4	9.7E-06	1.3E-05	2.3E-05
Indeno(1,2,3-cd)pyrene	2.001	0.91	1.2E-05	0.18	1.7E-05	0.04	3.1E-04	4.2E-04	7.4E-04
Naphthalene	0.554	1	3.8E-06	0.1	2.6E-06	0.04	9.5E-05	6.5E-05	1.6E-04
Phenanthrene	3.658	0.91	2.3E-05	0.18	3.1E-05	0.04	5.7E-04	7.7E-04	1.3E-03
Pyrene	3.405	1	2.3E-05	0.2	3.2E-05	0.3	7.8E-05	1.1E-04	1.8E-04
Arsenic	12.36	1	8.5E-05	0.03	1.7E-05	0.0003	2.8E-01	5.8E-02	3.4E-01
Barium	24.907	1	1.7E-04	0.35	4.1E-04	0.07	2.4E-03	5.9E-03	8.3E-03

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TABLE 4-24, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 - AVERAGE CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Beryllium	0.514	1	3.5E-06	0.35	8.5E-06	0.005	7.0E-04	1.7E-03	2.4E-03
Cadmium	0.635	1	4.4E-06	0.14	4.2E-06	0.001	4.4E-03	4.2E-03	8.5E-03
Chromium	17.192	1	1.2E-04	0.09	7.3E-05	0.02	5.9E-03	3.6E-03	9.5E-03
Copper	8.885	1	6.1E-05	0.35	1.5E-04	NA			
Iron	8547.391	1	5.9E-02	0.35	1.4E-01	NA			
Lead	10.189	0.5	3.5E-05	0.006	2.9E-06	NA			
Magnesium	2504.574	1	1.7E-02	0.35	4.1E-02	NA			
Manganese	154.293	1	1.1E-03	0.35	2.5E-03	0.1	1.1E-02	2.5E-02	3.6E-02
Nickel	15.299	1	1.0E-04	0.35	2.5E-04	0.02	5.2E-03	1.3E-02	1.8E-02
Potassium	1008.659	1	6.9E-03	0.35	1.7E-02	NA			
Sodium	155.042	1	1.1E-03	0.35	2.6E-03	NA			
Vanadium	10.942	1	7.5E-05	0.35	1.8E-04	0.007	1.1E-02	2.6E-02	3.6E-02
Zinc	26.532	1	1.8E-04	0.02	2.5E-05	0.3	6.1E-04	8.3E-05	6.9E-04
					SUMMARY HAZARD INDEX		0.33	0.14	0.47

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TABLE 4-25
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS

RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 – MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	Maximum	mg/kg	
INGESTION RATE	IR	480	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%		
SOIL ADHERENCE FACTOR	SAF	1	mg/cm²	USEPA, 1992
SURFACE AREA EXPOSED	SA	3,295	cm²/day	USEPA, 1989b (1)
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	70	kg	USEPA, 1989a
EXPOSURE FREQUENCY	EF	5	days/workweek	PRO.JUDGEMENT
EXPOSURE DURATION	ED	12	workweek(s)	PRO.JUDGEMENT
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989a
NONCANCER	AT	12	workweek(s)	USEPA, 1989a

USEPA, 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors".

USEPA, 1992. Dermal Exposure Assessment: Principles and Applications, Interim report, EPA/600/8-91/011B, January 1992.

USEPA, 1989a. RAGs, Part A. USEI

USEPA, 1989b. Exposure Factors Handbook.

(1) Arms and Hands

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day)^-1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

$$\text{INTAKE-INGESTION (HQ)} = \frac{\text{CS x IR x RAF x FI x CF x EF x ED}}{\text{BW x AT x 5 days/workweek}}$$

$$\text{INTAKE-INGESTION (CANCER RISK)} = \frac{\text{CS x IR x RAF x FI x CF x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

$$\text{INTAKE-DERMAL (HQ)} = \frac{\text{CS x SA x SAF x RAF x CF x EF x ED}}{\text{BW x AT x 5 days/workweek}}$$

$$\text{INTAKE-DERMAL (CANCER RISK)} = \frac{\text{CS x SA x SAF x RAF x CF x EF x ED}}{\text{BW x AT x 365 days/yr}}$$

For noncarcinogenic effects: AT = ED

TABLE 4-25, continued

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DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 - MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	7.75	1	1.2E-07	0.02	1.7E-08	0.014	1.7E-09	2.4E-10	2.0E-09
Benzo(a)anthracene	2	1	3.2E-08	0.2	4.4E-08	7.3	2.4E-07	3.2E-07	5.6E-07
Benzo(a)pyrene	30	1	4.8E-07	0.2	6.6E-07	7.3	3.5E-06	4.8E-06	8.4E-06
Benzo(b)fluoranthene	3	1	4.8E-08	0.2	6.6E-08	7.3	3.5E-07	4.8E-07	8.4E-07
Benzo(k)fluoranthene	3	1	4.8E-08	0.2	6.6E-08	7.3	3.5E-07	4.8E-07	8.4E-07
Carbazole	20	1	3.2E-07	1	2.2E-06	0.02	6.4E-09	4.4E-08	5.1E-08
Chrysene	0.5	1	8.1E-09	0.2	1.1E-08	7.3	5.9E-08	8.1E-08	1.4E-07
Dibenz(a,h)anthracene	5	1	8.1E-08	0.09	5.0E-08	7.3	5.9E-07	3.6E-07	9.5E-07
Indeno(1,2,3-cd)pyrene	2	1	3.2E-08	0.2	4.4E-08	7.3	2.4E-07	3.2E-07	5.6E-07
Arsenic	29	1	4.7E-07	0.03	9.6E-08	1.8	8.4E-07	1.7E-07	1.0E-06
Beryllium	1.15	1	1.9E-08	0.35	4.4E-08	4.3	8.0E-08	1.9E-07	2.7E-07
Lead	53	0.5	4.3E-07	NA		NA			
						SUMMARY CANCER RISK	6E-06	7E-06	1E-05

TABLE 4-25, continued

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS

RECEPTOR: CONSTRUCTION WORKER

SAs 44 AND 52 - MAXIMUM CONCENTRATIONS

FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Ethylbenzene	0.0049	1	3.4E-08	0.2	4.6E-08	0.1	3.4E-07	4.6E-07	8.0E-07
Toluene	0.0023	1	1.6E-08	0.12	1.3E-08	2	7.9E-09	6.5E-09	1.4E-08
Xylenes	0.022	1	1.5E-07	0.12	1.2E-07	4	3.8E-08	3.1E-08	6.9E-08
2-Methylnaphthalene	6	1	4.1E-05	0.1	2.8E-05	0.04	1.0E-03	7.1E-04	1.7E-03
Acenaphthene	6	1	4.1E-05	0.2	5.6E-05	0.6	6.9E-05	9.4E-05	1.6E-04
Acenaphthylene	4	0.91	2.5E-05	0.18	3.4E-05	0.04	6.2E-04	8.5E-04	1.5E-03
Anthracene	20	1	1.4E-04	0.29	2.7E-04	3	4.6E-05	9.1E-05	1.4E-04
Bis(2-ethylhexyl)phthalate	7.75	1	5.3E-05	0.02	7.3E-06	0.02	2.7E-03	3.6E-04	3.0E-03
Benzo(a)anthracene	20	0.91	1.2E-04	0.18	1.7E-04	0.04	3.1E-03	4.2E-03	7.4E-03
Bnezo(a)pyrene	30	0.91	1.9E-04	0.18	2.5E-04	0.04	4.7E-03	6.4E-03	1.1E-02
Benzo(b)fluoranthene	30	0.91	1.9E-04	0.18	2.5E-04	0.04	4.7E-03	6.4E-03	1.1E-02
Benzo(g,h,i)perylene	30	0.91	1.9E-04	0.18	2.5E-04	0.04	4.7E-03	6.4E-03	1.1E-02
Benzo(k)fluoranthene	30	0.91	1.9E-04	0.18	2.5E-04	0.04	4.7E-03	6.4E-03	1.1E-02
Carbazole	20	1	1.4E-04	1	9.4E-04	NA			
Chrysene	50	0.91	3.1E-04	0.18	4.2E-04	0.04	7.8E-03	1.1E-02	1.8E-02
Dibenz(a,h)anthracene	5	0.91	3.1E-05	0.08	1.9E-05	0.04	7.8E-04	4.7E-04	1.3E-03
Dibenzofuran	10	NA		NA		NA			
Fluoranthene	100	1	6.9E-04	0.2	9.4E-04	0.4	1.7E-03	2.4E-03	4.1E-03
Fluorene	20	1	1.4E-04	0.2	1.9E-04	0.4	3.4E-04	4.7E-04	8.1E-04
Indeno(1,2,3-cd)pyrene	20	0.91	1.2E-04	0.18	1.7E-04	0.04	3.1E-03	4.2E-03	7.4E-03
Naphthalene	20	1	1.4E-04	0.1	9.4E-05	0.04	3.4E-03	2.4E-03	5.8E-03
Phenanthrene	100	0.91	6.2E-04	0.18	8.5E-04	0.04	1.6E-02	2.1E-02	3.7E-02
Pyrene	60	1	4.1E-04	0.2	5.6E-04	0.3	1.4E-03	1.9E-03	3.3E-03
Arsenic	29	1	2.0E-04	0.03	4.1E-05	0.0003	6.6E-01	1.4E-01	8.0E-01
Barium	95.3	1	6.5E-04	0.35	1.6E-03	0.07	9.3E-03	2.2E-02	3.2E-02

TABLE 4-25, continued

DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: CONSTRUCTION WORKER
SAs 44 AND 52 – MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Beryllium	1.15	1	7.9E-06	0.35	1.9E-05	0.005	1.6E-03	3.8E-03	5.4E-03
Cadmium	8.85	1	6.1E-05	0.14	5.8E-05	0.001	6.1E-02	5.8E-02	1.2E-01
Chromium	58.7	1	4.0E-04	0.09	2.5E-04	0.02	2.0E-02	1.2E-02	3.3E-02
Copper	20.6	1	1.4E-04	0.35	3.4E-04	NA			
Iron	18900	1	1.3E-01	0.35	3.1E-01	NA			
Lead	53	0.5	1.8E-04	0.006	1.5E-05	NA			
Magnesium	9210	1	6.3E-02	0.35	1.5E-01	NA			
Manganese	313	1	2.1E-03	0.35	5.2E-03	0.1	2.1E-02	5.2E-02	7.3E-02
Nickel	41.8	1	2.9E-04	0.35	6.9E-04	0.02	1.4E-02	3.4E-02	4.9E-02
Potassium	4820	1	3.3E-02	0.35	7.9E-02	NA			
Sodium	316	1	2.2E-03	0.35	5.2E-03	NA			
Vanadium	34.9	1	2.4E-04	0.35	5.7E-04	0.007	3.4E-02	8.2E-02	1.2E-01
Zinc	92.9	1	6.4E-04	0.02	8.7E-05	0.3	2.1E-03	2.9E-04	2.4E-03
					SUMMARY HAZARD INDEX		0.89	0.47	1.36

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TABLE 4-26
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS

RECEPTOR: WORKER
SAs 44 AND 52 – AVERAGE CONCENTRATIONS
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	Average	mg/kg	
INGESTION RATE	IR	50	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%		
SOIL ADHERENCE FACTOR	SAF	1	mg/cm²	USEPA, 1992
SURFACE AREA EXPOSED	SA	3,295	cm²/day	USEPA, 1989b (1)
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	70	kg	USEPA, 1989a
EXPOSURE FREQUENCY	EF	250	days/year	USEPA, 1991
EXPOSURE DURATION	ED	25	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989a
NONCANCER	AT	25	years	USEPA, 1991

USEPA, 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors".
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications, Interim report, EPA/600/8-91/011B, January 1992.
USEPA, 1989a. RAGs, Part A. USEI
USEPA, 1989b. Exposure Factors Handbook.

(1) Arms and Hands

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

$$\text{INTAKE-DERMAL} = \frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

For noncarcinogenic effects: AT = ED

TABLE 4-26, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 – AVERAGE CONCENTRATIONS
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	NI	1		0.02		0.014			
Benzo(a)anthracene	0.574	1	1.0E-07	0.2	1.3E-06	7.3	7.3E-07	9.6E-06	1.0E-05
Benzo(a)pyrene	5.99	1	1.0E-06	0.2	1.4E-05	7.3	7.6E-06	1.0E-04	1.1E-04
Benzo(b)fluoranthene	0.609	1	1.1E-07	0.2	1.4E-06	7.3	7.8E-07	1.0E-05	1.1E-05
Benzo(k)fluoranthene	0.459	1	8.0E-08	0.2	1.1E-06	7.3	5.9E-07	7.7E-06	8.3E-06
Carbazole	1.79	1	3.1E-07	1	2.1E-05	0.02	6.3E-09	4.1E-07	4.2E-07
Chrysene	0.0717	1	1.3E-08	0.2	1.7E-07	7.3	9.1E-08	1.2E-06	1.3E-06
Dibenz(a,h)anthracene	1.64	1	2.9E-07	0.09	1.7E-06	7.3	2.1E-06	1.2E-05	1.4E-05
Indeno(1,2,3-cd)pyrene	0.503	1	8.8E-08	0.2	1.2E-06	7.3	6.4E-07	8.5E-06	9.1E-06
Arsenic	13.96	1	2.4E-06	0.03	4.8E-06	1.8	4.4E-06	8.7E-06	1.3E-05
Beryllium	0.71	1	1.2E-07	0.35	2.9E-06	4.3	5.3E-07	1.2E-05	1.3E-05
Lead	19.05	0.5	1.7E-06	NA		NA			
					SUMMARY CANCER RISK		2E-05	2E-04	2E-04

TABLE 4-26, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 - AVERAGE CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Ethylbenzene	0.0011	1	5.4E-10	0.2	7.1E-09	0.1	5.4E-09	7.1E-08	7.6E-08
Toluene	0.00055	1	2.7E-10	0.12	2.1E-09	0.2	1.3E-09	1.1E-08	1.2E-08
Xylenes	0.0025	1	1.2E-09	0.12	9.7E-09	2	6.1E-10	4.8E-09	5.4E-09
2-Methylnaphthalene	0.63	1	3.1E-07	0.1	2.0E-06	0.04	7.7E-06	5.1E-05	5.8E-05
Acenaphthene	0.6	1	2.9E-07	0.2	3.9E-06	0.06	4.9E-06	6.4E-05	6.9E-05
Acenaphthylene	0.78	0.91	3.5E-07	0.18	4.5E-06	0.04	8.7E-06	1.1E-04	1.2E-04
Anthracene	2.14	1	1.0E-06	0.29	2.0E-05	0.3	3.5E-06	6.7E-05	7.0E-05
Bis(2-ethylhexyl)phthalate	ND	1		0.02		0.02			
Benzo(a)anthracene	5.75	0.91	2.6E-06	0.18	3.3E-05	0.04	6.4E-05	8.3E-04	9.0E-04
Benzo(a)pyrene	5.99	0.91	2.7E-06	0.18	3.5E-05	0.04	6.7E-05	8.7E-04	9.4E-04
Benzo(b)fluoranthene	6.09	0.91	2.7E-06	0.18	3.5E-05	0.04	6.8E-05	8.8E-04	9.5E-04
Benzo(g,h,i)perylene	4.65	0.91	2.1E-06	0.18	2.7E-05	0.04	5.2E-05	6.7E-04	7.3E-04
Benzo(k)fluoranthene	4.59	0.91	2.0E-06	0.18	2.7E-05	0.04	5.1E-05	6.7E-04	7.2E-04
Carbazole	1.79	1	8.8E-07	1	5.8E-05	NA			
Chrysene	7.17	0.91	3.2E-06	0.18	4.2E-05	0.04	8.0E-05	1.0E-03	1.1E-03
Dibenz(a,h)anthracene	1.64	0.91	7.3E-07	0.08	4.2E-06	0.04	1.8E-05	1.1E-04	1.2E-04
Dibenzofuran	0.89	NA		NA		NA			
Fluoranthene	14.39	1	7.0E-06	0.2	9.3E-05	0.04	1.8E-04	2.3E-03	2.5E-03
Fluorene	1.63	1	8.0E-07	0.2	1.1E-05	0.04	2.0E-05	2.6E-04	2.8E-04
Indeno(1,2,3-cd)pyrene	5.03	0.91	2.2E-06	0.18	2.9E-05	0.04	5.6E-05	7.3E-04	7.9E-04
Naphthalene	1.57	1	7.7E-07	0.1	5.1E-06	0.04	1.9E-05	1.3E-04	1.5E-04
Phenanthrene	10.86	0.91	4.8E-06	0.18	6.3E-05	0.04	1.2E-04	1.6E-03	1.7E-03
Pyrene	9.74	1	4.8E-06	0.2	6.3E-05	0.03	1.6E-04	2.1E-03	2.3E-03
Arsenic	13.96	1	6.8E-06	0.03	1.4E-05	0.0003	2.3E-02	4.5E-02	6.8E-02
Barium	38.69	1	1.9E-05	0.35	4.4E-04	0.07	2.7E-04	6.2E-03	6.5E-03

TABLE 4-26, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 - AVERAGE CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Beryllium	0.71	1	3.5E-07	0.35	8.0E-06	0.005	6.9E-05	1.6E-03	1.7E-03
Cadmium	1.24	1	6.1E-07	0.14	5.6E-06	0.001	6.1E-04	5.6E-03	6.2E-03
Chromium	27.83	1	1.4E-05	0.09	8.1E-05	0.02	6.8E-04	4.0E-03	4.7E-03
Copper	11.11	1	5.4E-06	0.35	1.3E-04	NA			
Iron	11615	1	5.7E-03	0.35	1.3E-01	NA			
Lead	19.05	0.5	4.7E-06	0.006	3.7E-06	NA			
Magnesium	4205	1	2.1E-03	0.35	4.7E-02	NA			
Manganese	192	1	9.4E-05	0.35	2.2E-03	0.1	9.4E-04	2.2E-02	2.3E-02
Nickel	22.55	1	1.1E-05	0.35	2.5E-04	0.02	5.5E-04	1.3E-02	1.3E-02
Potassium	1695	1	8.3E-04	0.35	1.9E-02	NA			
Sodium	176	1	8.6E-05	0.35	2.0E-03	NA			
Vanadium	17.81	1	8.7E-06	0.35	2.0E-04	0.007	1.2E-03	2.9E-02	3.0E-02
Zinc	38.63	1	1.9E-05	0.02	2.5E-05	0.3	6.3E-05	8.3E-05	1.5E-04
						SUMMARY HAZARD INDEX	0.03	0.14	0.16

TABLE 4-27
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS

RECEPTOR: WORKER
SAs 44 AND 52 – MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	Maximum	mg/kg	
INGESTION RATE	IR	50	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%		
SOIL ADHERENCE FACTOR	SAF	1	mg/cm²	USEPA, 1992
SURFACE AREA EXPOSED	SA	3,295	cm²/day	USEPA, 1989b (1)
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	70	kg	USEPA, 1989a
EXPOSURE FREQUENCY	EF	250	days/year	USEPA, 1991
EXPOSURE DURATION	ED	25	years	USEPA, 1991
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989a
NONCANCER	AT	25	years	USEPA, 1991

USEPA, 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors".
USEPA, 1992. Dermal Exposure Assessment: Principles and Applications, Interim report, EPA/600/8-91/011B, January 1992.
USEPA, 1989a. RAGs, Part A. USEI
USEPA, 1989b. Exposure Factors Handbook.

(1) Arms and Hands

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

$$\text{INTAKE-INGESTION} = \frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

$$\text{INTAKE-DERMAL} = \frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/year}}$$

For noncarcinogenic effects: AT = ED

TABLE 4-27, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 – MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Bis(2-ethylhexyl)phthalate	ND	1		0.02		0.014			
Benzo(a)anthracene	4	1	7.0E-07	0.2	9.2E-06	7.3	5.1E-06	6.7E-05	7.2E-05
Benzo(a)pyrene	30	1	5.2E-06	0.2	6.9E-05	7.3	3.8E-05	5.0E-04	5.4E-04
Benzo(b)fluoranthene	3	1	5.2E-07	0.2	6.9E-06	7.3	3.8E-06	5.0E-05	5.4E-05
Benzo(k)fluoranthene	3	1	5.2E-07	0.2	6.9E-06	7.3	3.8E-06	5.0E-05	5.4E-05
Carbazole	20	1	3.5E-06	1	2.3E-04	0.02	7.0E-08	4.6E-06	4.7E-06
Chrysene	0.5	1	8.7E-08	0.2	1.2E-06	7.3	6.4E-07	8.4E-06	9.0E-06
Dibenz(a,h)anthracene	5	1	8.7E-07	0.09	5.2E-06	7.3	6.4E-06	3.8E-05	4.4E-05
Indeno(1,2,3-cd)pyrene	2	1	3.5E-07	0.2	4.6E-06	7.3	2.6E-06	3.4E-05	3.6E-05
Arsenic	29	1	5.1E-06	0.03	1.0E-05	1.8	9.1E-06	1.8E-05	2.7E-05
Beryllium	1.15	1	2.0E-07	0.35	4.6E-06	4.3	8.6E-07	2.0E-05	2.1E-05
Lead	73	0.5	6.4E-06	NA		NA			
					SUMMARY CANCER RISK		7E-05	8E-04	9E-04

TABLE 4-27, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL - USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 - MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Ethylbenzene	0.0049	1	2.4E-09	0.2	3.2E-08	0.1	2.4E-08	3.2E-07	3.4E-07
Toluene	0.0023	1	1.1E-09	0.12	8.9E-09	0.2	5.6E-09	4.4E-08	5.0E-08
Xylenes	0.022	1	1.1E-08	0.12	8.5E-08	2	5.4E-09	4.3E-08	4.8E-08
2-Methylnaphthalene	6	1	2.9E-06	0.1	1.9E-05	0.04	7.3E-05	4.8E-04	5.6E-04
Acenaphthene	6	1	2.9E-06	0.2	3.9E-05	0.06	4.9E-05	6.4E-04	6.9E-04
Acenaphthylene	4	0.91	1.8E-06	0.18	2.3E-05	0.04	4.5E-05	5.8E-04	6.2E-04
Anthracene	20	1	9.8E-06	0.29	1.9E-04	0.3	3.3E-05	6.2E-04	6.6E-04
Bis(2-ethylhexyl)phthalate	ND	1		0.02		0.02			
Benzo(a)anthracene	40	0.91	1.8E-05	0.18	2.3E-04	0.04	4.5E-04	5.8E-03	6.2E-03
Bnezo(a)pyrene	30	0.91	1.3E-05	0.18	1.7E-04	0.04	3.3E-04	4.4E-03	4.7E-03
Benzo(b)fluoranthene	30	0.91	1.3E-05	0.18	1.7E-04	0.04	3.3E-04	4.4E-03	4.7E-03
Benzo(g,h,i)perylene	20	0.91	8.9E-06	0.18	1.2E-04	0.04	2.2E-04	2.9E-03	3.1E-03
Benzo(k)fluoranthene	30	0.91	1.3E-05	0.18	1.7E-04	0.04	3.3E-04	4.4E-03	4.7E-03
Carbazole	20	1	9.8E-06	1	6.4E-04	NA			
Chrysene	50	0.91	2.2E-05	0.18	2.9E-04	0.04	5.6E-04	7.3E-03	7.8E-03
Dibenz(a,h)anthracene	5	0.91	2.2E-06	0.08	1.3E-05	0.04	5.6E-05	3.2E-04	3.8E-04
Dibenzofuran	10	NA		NA		NA			
Fluoranthene	100	1	4.9E-05	0.2	6.4E-04	0.04	1.2E-03	1.6E-02	1.7E-02
Fluorene	20	1	9.8E-06	0.2	1.3E-04	0.04	2.4E-04	3.2E-03	3.5E-03
Indeno(1,2,3-cd)pyrene	20	0.91	8.9E-06	0.18	1.2E-04	0.04	2.2E-04	2.9E-03	3.1E-03
Naphthalene	20	1	9.8E-06	0.1	6.4E-05	0.04	2.4E-04	1.6E-03	1.9E-03
Phenanthrene	100	0.91	4.5E-05	0.18	5.8E-04	0.04	1.1E-03	1.5E-02	1.6E-02
Pyrene	60	1	2.9E-05	0.2	3.9E-04	0.03	9.8E-04	1.3E-02	1.4E-02
Arsenic	29	1	1.4E-05	0.03	2.8E-05	0.0003	4.7E-02	9.3E-02	1.4E-01
Barium	95.3	1	4.7E-05	0.35	1.1E-03	0.07	6.7E-04	1.5E-02	1.6E-02

TABLE 4-27, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE SOIL – USEPA REGION IV TEF APPROACH FOR PAHS
RECEPTOR: WORKER
SAs 44 AND 52 – MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Beryllium	1.15	1	5.6E-07	0.35	1.3E-05	0.005	1.1E-04	2.6E-03	2.7E-03
Cadmium	8.85	1	4.3E-06	0.14	4.0E-05	0.001	4.3E-03	4.0E-02	4.4E-02
Chromium	58.7	1	2.9E-05	0.09	1.7E-04	0.02	1.4E-03	8.5E-03	1.0E-02
Copper	20.6	1	1.0E-05	0.35	2.3E-04	NA			
Iron	18900	1	9.2E-03	0.35	2.1E-01	NA			
Lead	73	0.5	1.8E-05	0.006	1.4E-05	NA			
Magnesium	9210	1	4.5E-03	0.35	1.0E-01	NA			
Manganese	313	1	1.5E-04	0.35	3.5E-03	0.1	1.5E-03	3.5E-02	3.7E-02
Nickel	41.8	1	2.0E-05	0.35	4.7E-04	0.02	1.0E-03	2.4E-02	2.5E-02
Potassium	4820	1	2.4E-03	0.35	5.4E-02	NA			
Sodium	316	1	1.5E-04	0.35	3.6E-03	NA			
Vanadium	34.9	1	1.7E-05	0.35	3.9E-04	0.007	2.4E-03	5.6E-02	5.9E-02
Zinc	92.9	1	4.5E-05	0.02	6.0E-05	0.3	1.5E-04	2.0E-04	3.5E-04
					SUMMARY HAZARD INDEX		0.07	0.36	0.42

CONST-5	22-Jun-95

TABLE 4-28
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL
RECEPTOR: CONSTRUCTION WORKER
SAs44 AND 52 – SAMPLING LOCATION 44B-92-06X, MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

EXPOSURE PARAMETERS

PARAMETER	SYMBOL	VALUE	UNITS	SOURCE
CONCENTRATION SOIL	CS	MAXIMUM	mg/kg	
INGESTION RATE	IR	480	mg/day	USEPA, 1991
FRACTION INGESTED	FI	100%		
SOIL ADHERENCE FACTOR	SAF	1	mg/cm²	USEPA, 1992
SURFACE AREA EXPOSED	SA	3,295	cm²/day	USEPA, 1989b (1)
CONVERSION FACTOR	CF	0.000001	kg/mg	
BODY WEIGHT	BW	70	kg	USEPA, 1989a
EXPOSURE FREQUENCY	EF	5	days/workweek	PRO.JUDGEMENT
EXPOSURE DURATION	ED	12	workweek(s)	PRO.JUDGEMENT
AVERAGING TIME				
CANCER	AT	70	years	USEPA, 1989a
NONCANCER	AT	12	workweek(s)	USEPA, 1989a

USEPA, 1991. "Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors".

USEPA, 1992. Dermal Exposure Assessment: Principles and Applications, Interim report, EPA/600/8-91/011B, January 1992.

USEPA, 1989a. RAGs, Part A. USEI

USEPA, 1989b. Exposure Factors Handbook.

(1) Arms and Hands

EQUATIONS

CANCER RISK = INTAKE (mg/kg-day) x CANCER SLOPE FACTOR (mg/kg-day) ^ -1

HAZARD QUOTIENT = INTAKE (mg/kg-day) / REFERENCE DOSE (mg/kg-day)

INTAKE = (INTAKE-INGESTION) + (INTAKE-DERMAL)

INTAKE-INGESTION (HQ) =
$$\frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 5 \text{ days/workweek}}$$

INTAKE-INGESTION (CANCER RISK) =
$$\frac{CS \times IR \times RAF \times FI \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

INTAKE-DERMAL (HQ) =
$$\frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 5 \text{ days/workweek}}$$

INTAKE-DERMAL (CANCER RISK) =
$$\frac{CS \times SA \times SAF \times RAF \times CF \times EF \times ED}{BW \times AT \times 365 \text{ days/yr}}$$

For noncarcinogenic effects: AT = ED

TABLE 4-28, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL
RECEPTOR: CONSTRUCTION WORKER
SAs44 AND 52 – SAMPLING LOCATION 44B-92-06X, MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

CARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	CANCER SLOPE FACTOR (mg/kg-day)^-1	CANCER RISK INGESTION	CANCER RISK DERMAL	TOTAL CANCER RISK
Arsenic	30	1	4.8E-07	0.03	9.9E-08	1.8	8.7E-07	1.8E-07	1.0E-06
Beryllium	0.786	1	1.3E-08	0.35	3.0E-08	4.3	5.4E-08	1.3E-07	1.9E-07
TPHC (As Gasoline)	8520	1	1.4E-04	0.2	1.9E-04	0.0017	2.3E-07	3.2E-07	5.5E-07
SUMMARY CANCER RISK							1E-06	6E-07	2E-06

TABLE 4-28, continued
DIRECT CONTACT WITH AND INCIDENTAL INGESTION OF SURFACE AND SUBSURFACE SOIL
RECEPTOR: CONSTRUCTION WORKER
SAs44 AND 52 - SAMPLING LOCATION 44B-92-06X, MAXIMUM CONCENTRATIONS
FORT DEVENS, MA

NONCARCINOGENIC EFFECTS

COMPOUND	SOIL CONCENTRATION (mg/kg)	INGESTION RAF	INTAKE INGESTION (mg/kg-day)	DERMAL RAF	INTAKE DERMAL (mg/kg-day)	REFERENCE DOSE (mg/kg-day)	HAZARD QUOTIENT INGESTION	HAZARD QUOTIENT DERMAL	TOTAL HAZARD QUOTIENT
Ethylbenzene	0.5	1	3.4E-06	0.2	4.7E-06	0.1	3.4E-05	4.7E-05	8.1E-05
Toluene	0.05	1	3.4E-07	0.12	2.8E-07	2	1.7E-07	1.4E-07	3.1E-07
Xylenes	4	1	2.7E-05	0.12	2.3E-05	4	6.9E-06	5.6E-06	1.3E-05
2-Methylnaphthalene	30	1	2.1E-04	0.1	1.4E-04	0.04	5.1E-03	3.5E-03	8.7E-03
Dibenzofuran	0.6	NA		NA		NA			
Fluorene	1	1	6.9E-06	0.2	9.4E-06	0.4	1.7E-05	2.4E-05	4.1E-05
Naphthalene	6	1	4.1E-05	0.1	2.8E-05	0.04	1.0E-03	7.1E-04	1.7E-03
Phenanthrene	0.9	0.91	5.6E-06	0.18	7.6E-06	0.04	1.4E-04	1.9E-04	3.3E-04
TPHC (As Gasoline)	8520	1	5.8E-02	0.2	8.0E-02	0.2	2.9E-01	4.0E-01	6.9E-01
Aluminum	15800	1	1.1E-01	0.35	2.6E-01	NA			
Arsenic	30	1	2.1E-04	0.03	4.2E-05	0.0003	6.9E-01	1.4E-01	8.3E-01
Barium	79	1	5.4E-04	0.35	1.3E-03	0.07	7.7E-03	1.9E-02	2.6E-02
Beryllium	0.786	1	5.4E-06	0.35	1.3E-05	0.005	1.1E-03	2.6E-03	3.7E-03
Calcium	1690	1	1.2E-02	0.35	2.8E-02	NA			
Chromium	63.9	1	4.4E-04	0.09	2.7E-04	0.02	2.2E-02	1.4E-02	3.5E-02
Copper	17.1	1	1.2E-04	0.35	2.8E-04	NA			
Iron	19900	1	1.4E-01	0.35	3.3E-01	NA			
Magnesium	9670	1	6.6E-02	0.35	1.6E-01	NA			
Manganese	423	1	2.9E-03	0.35	7.0E-03	0.1	2.9E-02	7.0E-02	9.9E-02
Nickel	44.6	1	3.1E-04	0.35	7.3E-04	0.02	1.5E-02	3.7E-02	5.2E-02
Potassium	4400	1	3.0E-02	0.35	7.2E-02	NA			
Sodium	245	1	1.7E-03	0.35	4.0E-03	NA			
Vanadium	37.6	1	2.6E-04	0.35	6.2E-04	0.007	3.7E-02	8.8E-02	1.3E-01
Zinc	56.9	1	3.9E-04	0.02	5.4E-05	0.3	1.3E-03	1.8E-04	1.5E-03
						SUMMARY HAZARD INDEX	1.10	0.78	1.87

5.0 GROUP 5 STUDY AREA INVESTIGATIONS

The Group 5 SAs include the North Post Landfill (SA 09; previously referred to as Landfill No. 5) and three components of the wastewater treatment system, all of which are located on the North Post. The wastewater treatment system SAs are the WWTP (SA 19), rapid infiltration beds (SA 20), and sludge drying beds (SA 21). Because of the geographical and operational association of the wastewater treatment system SAs, they were investigated together. The locations of the Group 5 SAs are illustrated on Figures 1-1 and 5-1.

Soils in the SA Group 5 area are stratified sands and gravels transported by glacial meltwater streams and deposited as deltas in a glacial lake. These soils are considered to be well drained, exhibiting hydraulic conductivities ranging from $3.0\text{x}10^{-4}$ to $2.4\text{x}10^{-2}$ cm/sec. A total of 16 groundwater monitoring wells, installed during previous investigations, are located in the Group 5 area.

The Nashua River flows northward around the SA Group 5 area (Figure 5-1), and groundwater in the area generally flows toward the river. Groundwater levels measured in existing monitoring wells indicate that there is no noticeable mounding of the water table beneath the infiltration beds.

5.1 SA 09 - NORTH POST LANDFILL

The North Post Landfill is located west of the wastewater treatment plant (WWTP), occupying approximately 7 acres of land (Figure 5-1). In a survey of landfills at Fort Devens, McMaster et al. (1982) identified the North Post Landfill as Landfill No. 5; it is also known informally as the old "stump dump" or "wood dump". The landfill is part of a larger area controlled by Fort Devens Range Control and is occasionally used for tactical training exercises.

5.1.1 Study Area Background and Conditions

The landfill occupies a low area that originally contained a small pond (Jahns, 1953), and the bluffs to the west have been used for gravel quarrying. The disposal of solid waste and placement of cover gravel have filled the depressions and raised the land surface approximately 35 to 40 feet (McMaster et al., 1982).

Because of the extent and effectiveness of the partially vegetated cover, the area is generally not recognizable as a former landfill. Figure 5-1 shows pre-landfill topography.

The landfill was operated from the late 1950s until 1978, and access was uncontrolled. It was used by the Army, National Guard, contractors, and off-post personnel (McMaster et al., 1982; Biang et al., 1992). Materials reportedly disposed of at this location include tree stumps, limbs, and the debris from about 100 demolished buildings. Automobiles, automobile parts, and other debris (including asphalt, bedsprings, and 5-gallon cans) were observed in a location above and adjacent to the north side of the landfill on the lower slope from the wastewater infiltration beds.

5.1.2 SA 09 Investigation Program Summary

The SA 09 site investigations consisted of both SA-specific investigations (geophysical surveys, monitoring wells, test pits, and surface water and sediment sampling near the landfill) and non-SA-specific investigations of the whole SA Group 5 area (existing monitoring wells and sampling of surface water and sediment in the Nashua River).

A geophysical survey was conducted at the landfill to supplement information derived from evaluation of aerial photographs and delineate the actual limits of the landfill. The results of the survey assisted in the placement of test pits and groundwater monitoring wells, and provided insight into the distribution of landfilled materials. Ground magnetics and terrain conductivity were selected for the survey. Ground magnetics, both total field and magnetic gradient, were used to detect buried ferrous metallic objects. Terrain conductivity (electromagnetic induction) was used to corroborate the ground magnetics results, and focused on mapping conductive soil, groundwater contaminant plumes, and the locations of buried objects. Details of the survey data collection efforts and the resulting interpretations are provided in Appendix L.

Ten sets of surface water and sediment samples were collected from the Nashua River. The sampling locations are shown in Figure 5-2. Sampling locations were adjusted in the field based on observation of sediment depositional areas and accessibility. At the time of sampling, the river banks were steep and slippery, and samplers were belayed by rope and harness to prevent accidents. Location

G5D-92-01X was specifically located in the Nashua River, upstream of the Group 5 SAs and upstream of the confluence of the river with Walker Brook. G5D-92-02X was located in Walker Brook, roughly south of existing well WWTMW-01. Location G5D-92-03X was located in the Nashua River between its confluence with Walker Brook and Nonacoicus Brook (which drains the area of the Ayer Publicly Owned Treatment Works [POTW]). Locations G5D-92-04X through G5D-92-09X were spaced along the Nashua River downgradient of the Group 5 SAs, as a means of assessing contaminated groundwater discharging to the river. G5D-92-10X was located in a small pond north of the infiltration beds.

Surface water and sediment samples were submitted for analysis of PAL organics, PAL inorganics, PAL explosives, and TPHC. In addition, surface water samples were analyzed for PAL water quality parameters, total and fecal coliform bacteria, and TSS. Sediment samples were also analyzed for TOC and tested for grain-size distribution.

The soil borings for monitoring wells G5M-92-01X through G5M-92-03B were drilled just outside the limits of the North Post Landfill (to avoid penetrating landfill materials), to approximately 10 feet below the water table. Soil borings were advanced with HSAs and samples were collected with split spoon samplers. Soil samples were collected at 5-foot intervals from boring G5M-92-01X and G5M-92-03X for field screening by PID and for field classification. Continuous soil samples were collected from boring G5M-92-02X. One sample from each boring was collected from saturated soil at the approximate depth of the water table in each boring and analyzed for TOC. Monitoring wells were installed in each boring so that the well screen intercepted the water table. The third installed well, G5M-92-03A, was dry and subsequently was replaced by G5M-92-03B drilled approximately 20 feet away. Well completion details are provided in Appendix C.

Each new monitoring well was developed between two and seven days after well installation. Two rounds of groundwater samples and water table measurements, collected three months apart, were collected from the three new monitoring wells and 16 existing monitoring wells. The 16 existing monitoring wells (the WWTMW-series) were installed to evaluate the effectiveness of the WWTP (SA 19). The most recent of those installations were by the AEHA in 1991 (Dzuray, 1992). The samples were analyzed for PAL organics, PAL inorganics, PAL anions/cations, TPHC, PAL explosives, TSS, PAL water quality parameters, and total- and fecal-coliform bacteria. Due to cross-contamination likely resulting from the pump used to purge the wells during the second sampling round (Section 3.2.3), a third round of groundwater samples was collected for PAL VOCs only. Aquifer hydraulic conductivities in the SA Group 5 area were evaluated by performing two tests per well in the three newly installed monitoring wells and in the 16 existing monitoring wells. The aquifer tests were completed after the first round of groundwater sampling.

To further characterize the nature of soils and landfilled materials, four test pits (09E-92-01X through 09E-92-04X) were excavated in areas where landfilled material was identified during the geophysical surveys. The test pits were designed to allow direct observation of a comparatively long profile of the landfilled materials, and thereby providing an advantage over soil borings. The test pits were excavated using a tire-mounted backhoe capable of excavating to depths of 10 feet. A total of eight soil samples were collected from the test pits for laboratory analysis. Soil samples were selected on the basis of staining, odor, and/or elevated levels of VOCs as determined from PID measurements. The samples were analyzed for PAL organics, PAL inorganics, and TPHC. Test pit logs are provided in Appendix B.

Plans were also made for collecting an estimated five surface-soil samples from the landfill in areas of visible soil staining. No soil staining, stressed vegetation, or other visible evidence of contamination was observed on the landfill or in the area of the junk cars and associated debris. Consequently, no surface soil samples were collected.

Three sets of surface water and sediment samples were collected from the swampy area to the southwest of the landfill. The surface water samples collected at 09D-92-01X, 09D-92-02X, and 09D-92-03X were analyzed for PAL organics, PAL inorganics, TPHC, TSS, PAL explosives, and PAL water quality parameters. Sediment samples from those locations were analyzed for PAL organics, PAL inorganics, TPHC, TOC, and PAL explosives.

5.1.3 Field Investigation Results and Observations

The landfill has been out of use since 1978, and is currently covered with a sparsely vegetated layer of gravel. The geophysical survey determined that the landfill occupies approximately 7 acres and consists of two areas: a larger northern pod containing the majority of landfilled materials, and a smaller southern pod adjacent to the wetlands containing mostly near-surface debris (Figure 5-3). Test pitting results showed the landfilled material to consist of mixed refuse including piping, brick, charred wood, roof slate, bottles, carpet, and plastic; and silt and sand.

Borings installed in the immediate vicinity of SA 09 were characterized by soils typical of kame, kame-plain, and ice-contact deposits consisting of sand and pebble to cobble gravel. These are also visible in the bluff to the west of the SA. Immediately south of the SA are post-glacial swamp and flood plain deposits (Jahns, 1953), consisting of sand with variable gravel and silt content. None of the borings penetrated to bedrock.

Installation-wide water-level surveys were conducted quarterly from May 1992 through January 1995. Included were the newly installed Group 5 (SA 09) monitoring wells, as well as the 16 existing WWTMW-series wells and a Nashua River measuring station at the Bailey bridge near the WWTP (Figure 5-2).

Water-table elevations are listed in Appendix I, and water levels and inferred groundwater flow directions for September 1992 are shown in Figure 5-4. The configuration of the groundwater table at Group 5 did not vary significantly between rounds or from conditions reported by AEHA (Dzuray, 1992). Groundwater flow is inferred to be generally eastward toward the Nashua River. The wastewater infiltration beds, and the large kame-plain remnant on which they are located, have little apparent influence on groundwater flow. Surface water in the swampy area south of the landfill appears to represent perched conditions and is not a zone of groundwater discharge from the water table aquifer.

Average horizontal hydraulic gradients in the SA Group 5 area in September 1992 ranged from approximately 0.002 ft/ft to approximately 0.017 ft/ft. The steeper gradients in the vicinity of monitoring well WWTMW-07 may be attributable in part to less transmissive soils in that area.

Aquifer hydraulic conductivities at the water table were determined in the three SA Group 5 (SA 09) water table wells and in the 16 AEHA wells, and they are summarized in Appendix A. Conductivities range from 3.05×10^{-6} cm/sec (in well WWTMW-07) to 5.1×10^{-2} cm/sec (in well G5M-92-02X), and they are highest adjacent to the North Post Landfill.

One inferred groundwater flow path from SA 09 would be approximately from well G5M-92-02X, past wells G5M-92-03B and WWTMW-01A and WWTMW-09, to the Nashua River. The average hydraulic gradient along that flow path was approximately 0.0028 ft/ft in September 1992 and the geometric average of the measured hydraulic conductivities at those wells is 0.015 cm/sec. Assuming that conductivity is representative of average conditions along the flow path, and assuming an aquifer effective porosity of 0.30, the average groundwater velocity at the water table would be approximately 140 ft/yr.

Sediments from the swampy area south of the landfill and from the Nashua River in the vicinity of Group 5 were tested for grain size. The samples were generally silty sands, with the fine fraction (silt and clay) ranging from 1.2 to 44.9 percent. The samples contained from 51 to 82 percent solids. The classification of sediment samples from SA Group 5 locations is summarized in Table 5-1. Results of sediment sample grain size analyses are presented in Appendix J.

5.1.4 Nature and Extent of Contamination (Laboratory Results)

Raw laboratory analytical results are included in Appendices L and N and are discussed below.

5.1.4.1 Soils. Soil samples were collected from apparent zones of contamination in the four test pits excavated within the suspected landfill limits. In most cases, the samples were collected from darkened or stained soil, presumably from burned materials. A total of eight soil samples were collected. The laboratory results for detected analytes are summarized in Table 5-2. Significant SVOC concentrations (mostly PAHs) were detected in soil samples from test pits 09E-92-01X and 09E-92-02X. SVOCs were, however, absent in soil collected from test pits 09E-92-03X and 09E-92-04X. TPHC levels were detected in all but test pit 09E-92-04X, which is located just outside the southern limit of mapped landfill materials. There is a rough correlation between SVOC and TPHC concentrations. Figure 5-5 illustrates the distribution of organic compounds detected in test pit soils. A rough correlation exists between SVOC and TPHC concentrations. The elevated concentrations of organic compounds detected in soil samples collected from the landfill test pits are likely derived from the ash and charred wood observed during sampling. The absence of volatile petroleum compounds in soil supports this contention.

Several inorganic analytes were detected above the calculated background concentrations for Fort Devens soils. The concentrations of barium in test pit 09E-92-01X and lead and zinc in 09E-92-02X are notable. Other inorganic analytes detected above background include beryllium, calcium, chromium, copper, nickel, potassium, silver, and sodium. A rough correlation is evident between elevated concentrations of organic and inorganic analytes in test pits soils. Figure 5-6 illustrates the distribution of inorganic analytes detected above background in test pit soils.

5.1.4.2 Groundwater. Nineteen groundwater monitoring wells were sampled as part of the SA Group 5 groundwater investigation (from 16 existing and three newly installed wells). To evaluate the potential impact to groundwater due to releases from the landfill, analytes detected in five selected wells located radially around the landfill were compared. The selected wells are WWTMW-07, WWTMW-08, G5M-92-01X, G5M-92-02X, and G5M-92-03B.

Groundwater around the landfill is generally free of organic analytes with a single detection of chloroform in the Round 1 sample collected from G5M-92-01X, and a single detection of TPHC in the Round 1 sample collected from G5M-92-02X. In both instances, the detected concentration was marginally above the detection limit. Chloroform was detected in G5M-92-01X at a concentration of 0.585 μg/L at the northernmost extent of the mapped landfill. Chloroform was also detected in half of the method blank samples at a similar concentration; therefore, it is likely that chloroform detected in groundwater samples from this location is attributable to laboratory contamination (see Section 1.2 of Appendix F).

TPHC was detected at a concentration of 209 μg/L located outside the limits of the landfill in an upgradient location. In Round 2, TPHC was detected in the samples collected from G5M-92-02X and G5M-92-03B at similar concentrations to the Round 1 sample. No other organic compounds were detected in the remaining Round 2 samples. Low counts of coliform bacteria were measured in landfill wells G5M-92-01X and G5M-92-02X in Round 1 and WWTMW-08 in Round 2. Tables 5-3 and 5-4 summarize organic compounds detected in SA Group 5 groundwater. Figures 5-7 and 5-8 show the distribution of organic compounds and coliform bacteria in SA Group 5 groundwater.

Inorganic analytes were detected above calculated background in virtually all groundwater samples collected from SA Group 5 monitoring wells during both rounds of sampling. Tables 5-5 and 5-6 list the inorganic analytes detected in SA Group 5 groundwater samples. In the five selected landfill wells, concentrations of several inorganic analytes were elevated in up-, down-, and cross-gradient wells. Elevated concentrations of these analytes correlated well with elevated TSS concentrations. Filtered samples collected during Round 2 exhibited significant reductions in the concentrations of relatively insoluble inorganic analytes such as arsenic, chromium, iron, lead, vanadium, and zinc. Other more soluble inorganic analytes also showed concentration reductions, but not to the same magnitude as the insoluble analytes. Figures 5-9 and 5-10 illustrate the distribution of inorganic analytes detected above background in SA Group 5 groundwater samples.

5.1.4.3 Surface Water and Sediment. Site-specific surface water and sediment samples were collected in the swampy area south of the landfill, and surface water and sediment samples were also collected along the Nashua River in relation to the Group 5 area generally.

Swamp Area

Three surface water and sediment sample pairs were collected from the swampy area located immediately south of the southern limit of the landfilled material. In surface water, toluene and BIS were detected in two samples at 1.37 μg/L and 6.8 μg/L, respectively. BIS and toluene were also detected in laboratory method blanks at similar concentrations, so it is likely that these compounds are attributable to laboratory contamination (see Section 5.3). No TPHC was detected in surface water samples. Very high counts of coliform bacteria, both total and fecal, were detected in all surface water samples. For inorganic analytes, only concentrations of iron and magnesium were notable. Arsenic, detected in 09D-02-01X surface water, was also elevated. The results of laboratory analysis are presented in Table 5-7. Surface water results are illustrated in Figure 5-11.

In sediment, acetone was detected in one of the three samples, at a concentration of 0.2 micrograms per gram (μg/g). Acetone is considered a common laboratory contaminant and was found in one soil method blank at a lower concentration than what was detected in sediment. It is, therefore, possible that acetone in sediment is attributable to laboratory contamination (Section 5.3). TPHC was detected in two sediment samples at concentrations of 75.1 μg/g and 53.6 μg/g. Various inorganic analyte concentrations were detected in all sediment samples.

The results of laboratory analysis are summarized in Table 5-7. The distribution of analytes in sediment is shown in Figure 5-12.

Nashua River

Surface water and sediment samples were also collected at nine locations along the Nashua River and one location in the small pond located to the north of the SAs in locations considered downgradient of the Group 5 SAs. The results of surface water and sediment analyses are provided in Tables 5-8 and 5-9, respectively.

Organic compounds were detected in two Nashua River surface water samples and the pond. The detected analytes include low concentrations of BIS, carbon disulfide, toluene, and 1,1,1-trichloroethane (TCA). No clear distribution of these analytes is apparent. BIS, toluene, and TCA were detected in laboratory method blanks at similar concentrations and are thus considered potential laboratory contaminants. (See Section 5.3 for discussion of laboratory method blanks.) Total and fecal coliform bacteria counts generally increased at downstream locations. The highest counts were observed at G5D-92-07X, G5D-92-08X, and G5D-92-09X. Figure 5-13 shows the distribution of organic compounds and coliform bacteria detected in Group 5 surface water samples.

Inorganic analyte concentrations were relatively consistent when comparing upstream and downstream Nashua River surface water samples. These concentrations are likely representative of typical Nashua River surface water. The distribution of selected inorganic analytes are provided in Figure 5-14.

Both VOCs and SVOCs were detected in sediment samples from the Nashua River and the pond nearby. Concentrations of these analytes (acetone, toluene, and several PAHs) were generally low and no consistent distribution along the river is apparent. Acetone and toluene were detected in soil method blanks at similar concentrations and are therefore considered to be potential laboratory contaminants (Section 5.3). TPHC was detected in sediment samples in a similar sporadic distribution, but no significant correlation between VOCs, SVOCs, and TPHC is evident. Figure 5-15 shows the distribution of organic compounds detected in the Nashua River and the nearby pond sediments.

Inorganic analyte concentrations were relatively consistent in upstream and downstream Nashua River sediment samples. These concentrations are likely representative of typical Nashua River sediments. The distributions of selected inorganic analytes are provided in Figure 5-16.

5.1.5 Source Evaluation and Migration Potential

The elevated concentrations of organic compounds detected in soil samples collected from the landfill test pits are likely derived from the ash and charred wood observed during sampling. The absence of volatile petroleum compounds in soil supports this contention. Furthermore, the absence of these organic compounds in groundwater adjacent to and downgradient from the mapped landfill suggests that the organic compounds in soil have not impacted groundwater quality.

Inorganic analytes detected in groundwater were elevated above calculated background, but there is no apparent distribution or source area attributable to the landfill.

Surface runoff and groundwater flow are two possible routes of contaminant migration from the landfill to nearby surface water bodies including the Nashua River to the east and Walker Brook to the south. In the southern swampy area, both organic and inorganic analytes were detected at similar concentrations all along this presumed surface water runoff zone. The surface water and sediment sampling results from the Nashua River also suggest that contaminant impacts from the North Post Landfill to the nearby water bodies are not significant.

5.1.6 Preliminary Human Health Risk Evaluation

SA 09 was used as a landfill from the late 1950s until 1978. Materials reported to have been disposed of in the landfill include tree stumps, limbs, and demolition debris from buildings. Automobile parts and other debris have also been observed at the landfill surface. Although SA 09 is not currently used as such, its expected future use is as a landfill.

Tables 5-10 through 5-14 present summary statistics and human health standards and guidelines used in the PRE for SA 09.

5.1.6.1 Soils. This preliminary risk evaluation will consider all soils to a depth of 3 feet as accessible under a residential future use exposure scenario. This assumption is conservative (i.e., health-protective) because, as discussed above, the expected future use of SA 09 is as a landfill. All subsurface soil (defined as 3-10 feet in depth) will be considered as accessible under a commercial/industrial future use exposure scenario.

Surface Soils. Table 5-10 presents summary statistics on surface soil at SA 09 and USEPA Region III residential soil concentrations for comparison. Surface soil at SA 09 is represented by samples 09E-92-03X and 09E-92-04X. Visual observations and an assessment of the organic compound data for SA 09 test pit soils show that there is no apparent surface and near-surface (< 3 feet) organic contamination.

For inorganics, only copper, lead, and nickel were detected at concentrations above base-wide background levels. The concentrations of all three compounds, however, are well below USEPA Region III residential soil concentrations. Although arsenic was detected at a concentration above the USEPA Region III residential soil concentration, it was detected at the base-wide statistical background concentration.

Subsurface Soils. Table 5-11 presents summary statistics on subsurface soil at SA 09 and USEPA Region III commercial/industrial soil concentrations for comparison. Subsurface soil at SA 09 is represented by samples 09E-92-01X through 09E-92-03X.

Organic compounds detected in SA 09 subsurface soil consist mostly of PAHs. Of the sixteen detected PAHs, the maximum detected concentrations of six PAHs exceed the USEPA Region III commercial/industrial soil concentrations. The highest concentrations of PAHs were detected in test pit sampling location 09E-92-02X.

Although several inorganic compounds were detected in SA 09 subsurface soil at concentrations above base-wide statistical background concentrations, only two compounds (arsenic and beryllium) were present at concentrations above the USEPA Region III commercial/industrial soil concentrations. In the case of arsenic, the maximum detected concentration was equal to the base-wide statistical background concentration. For beryllium, although the maximum detected concentration (1.0 μg/g) exceeds the USEPA Region III commercial/industrial concentration (0.67 μg/g), the exceedance is slight.

5.1.6.2 Groundwater. Table 5-12 presents summary statistics on groundwater around SA 09 and drinking water standards or guidelines for comparison. Groundwater in SA 09 is represented by five selected wells, located radially around the landfill: G5M-92-01X, G5M-92-02X, G5M-92-03B, WWTMW-07, and WWTMW-08.

Only two organic analytes were detected in the SA 09 monitoring wells. Chloroform was detected once (out of 10 samples) in Round 1 at a concentration below the Massachusetts drinking water guideline for chloroform. TPHC was detected in 3 out of 10 samples, once in Round 1 at G5M-92-02X and twice in Round 2 at G5M-92-02X and G5M-92-03B. No drinking water or guideline exists for TPHC.

Inorganic analytes were detected above background in virtually all groundwater samples collected from SA 09 monitoring wells. In the five selected landfill wells, concentrations of several inorganic analytes were elevated in up-, down-, and cross-gradient wells. The maximum detected concentrations of eight of the 18 inorganic analytes exceed their respective drinking water standard or guideline. The eight analytes include aluminum, arsenic, chromium, cobalt, iron, lead, manganese, and nickel.

Filtered samples collected during Round 2 showed significant reductions in the concentrations of these analytes. For chromium, lead, and nickel, the concentrations of four out of four filtered samples were below the respective drinking water standard or guideline. For aluminum, arsenic, and iron, the concentrations of three out of four filtered samples were below drinking water standards or guidelines. Cobalt was not detected at the detection limit in four out of four filtered samples (although the detection limit was above the USEPA Region III drinking water concentration). For manganese, the concentrations of two out of four filtered samples were below the USEPA secondary MCL for manganese.

5.1.6.3 Surface Water and Sediment. Tables 5-13 and 5-14 present summary statistics on surface water and sediment in the swampy area to the south of the southern limit of the landfill material. Surface water and sediment samples from locations 09D-92-01X through 09D-92-03X represent this area.

Of the eight analytes detected in the surface water in this area, only two (BIS and iron) were detected at concentrations above their respective drinking water standards and guidelines. BIS was detected in one of three samples at a concentration (6.8 μg/L) only slightly above the USEPA Region III tap water concentration (16.1 μg/L). Iron was detected in three of three samples at concentrations (average: 3,133 μg/L; maximum: 5,460 μg/L) above the USEPA secondary MCL for iron (300 μg/L).

The magnitude and frequency of exposure to surface water in this area would be expected to be much less than that upon which the drinking water guidelines are based. The use of drinking water guidelines for comparison to surface water concentrations is a conservative approach and is used due to a lack of available health-based guidelines for exposure to surface water and sediment. Neither the detected concentrations of BIS nor iron are expected to pose a significant health risk in the swampy area. Exposure to contaminants in the swampy area is expected to be limited to occasional wading.

Only the concentration of one of thirteen detected analytes in sediments in this area, arsenic, exceeds the USEPA Region III residential soil concentration for arsenic (0.97 μg/g). Arsenic was detected at a maximum concentration of 14 μg/g and an average concentration of 7.6 μg/g. Arsenic, however, is not expected to pose a significant health risk in the swampy area at detected concentrations. Exposure to sediment in this area would be much less than that expected in a residential setting. The USEPA Region III soil concentration is designed to be protective for exposures that could occur 350 days per year for a residential lifetime of 30 years.

5.1.7 Preliminary Ecological Risk Evaluation

The purpose of the PRE at SA 09 is to provide a screening-level evaluation of actual and potential risks that environmental contaminants may pose to the resident and migratory ecological receptors at the site.

SA 09 consists of a closed landfill with a surface area of approximately seven acres; the landfill is covered with a layer of gravelly fill. The landfill area is relatively devoid of woody vegetative cover, although sparse herbaceous vegetation covers approximately 20 to 30 percent of the landfill. Plant species observed on the landfill include staghorn sumac (*Rhus typhina*), bluestem grass (*Andropogon scoparius*), ragweed (*Ambrosia artimesiifolia*), aster (*Aster* sp.), viper's bugloss (*Echium vulgare*), sweet fern (*Comptonia peregrina*), and bush clover (*Lespedeza* sp.).

A shrubby palustrine wetland occurs to the southeast of the closed landfill. Dominant woody plant species observed in this wetland include red maple (*Acer rubrum*), red-osier dogwood (*Cornus stolonifera*), buckthorn (*Rhamnus cathartica*), and speckled alder (*Alnus rugosa*). Other species observed in the area include gray birch (*Betula populifolia*), quaking aspen (*Populus tremuloides*), white pine (*Pinus strobus*), white oak (*Quercus alba*), northern arrowwood (*Viburnum recognitum*), highbush blueberry (*Vaccinium corymbosum*), sweetfern (*Comptonia peregrina*), pussy willow (*Salix discolor*), broadleaf spirea (*Spiraea latifolia*), sensitive fern (*Onoclea sensibilis*), cinnamon fern (*Osmunda cinnamomea*), and tussock sedge (*Carex stricta*).

A pair of red-tailed hawks (*Buteo jamaicensis*), a red fox (*Vulpes vulpes*), and an unidentified small rodent were observed in the vicinity of the SA 09 landfill. The palustrine wetland adjacent to the landfill likely provides habitat for a variety of wetlands and semi-terrestrial wildlife, including passerine songbirds, mammals such as the raccoon (*Procyon lotor*) or muskrat (*Ondatra zibethicus*), amphibians (e.g., the green frog (*Rana clamitans*), reptiles such as the garter snake (*Thamnophis sirtalis*) and turtle species, and a variety of invertebrates.

No records exist documenting the current or historical presence of rare and endangered species in the region of SA 09. However, the Nashua River floodplain at Fort Devens is known to provide suitable habitat for the Blanding's turtle (*Emydoidea blandingii*), a state-threatened species in Massachusetts. The largest known population of Blanding's turtles in New England is located in the vicinity of Fort Devens (Butler, 1992). The status of this population has been well documented and none are known to occur at SA 09.

Inorganic analytes were detected in two surface soil samples taken from test pits on the SA 09 landfill. The maximum concentrations of copper, lead and nickel were higher than background and these analytes were therefore chosen as surface soil CPCs. Copper occurred at both test pit locations at a maximum concentration of 17 μg/g. Lead was detected in both samples at a maximum concentration of 81 μg/g. Nickel was detected at both locations at a maximum concentration of 16 μg/g (Table 5-15). No organic contaminants were detected in SA 09 test pit surface soils.

Three surface water samples were taken from wetlands located to the southeast of the SA 09 landfill. Two organic compounds and six inorganic compounds were detected and chosen as CPCs. Aluminum was detected once at 229 μg/L. Iron was detected in each location, at a maximum concentration of 5,460 μg/L. Lead was detected in each location, at a maximum concentration of 2.5 μg/L. BIS, toluene, arsenic, barium, and manganese were also detected and chosen as surface water CPCs (Table 5-16).

Three sediment samples were taken from wetlands to the southeast of the SA 09 landfill; surface water and sediment samples were collected at the identical sampling stations. One organic and twelve inorganic compounds were detected and chosen as CPCs. Arsenic was detected in each sample at a maximum concentration of 14 μg/g (see Figure 5-17).

Four potential contaminant exposure pathways exist for receptors at SA 09; incidental ingestion, food web exposure, dermal exposure and inhalation. As an SI screening tool, the ecological PRE for this study area evaluated incidental soil ingestion and terrestrial food web exposures, the two pathways which are expected to be the primary risk contributors at the site. In addition, wetlands and semi-terrestrial receptors in the site's palustrine wetlands may be exposed to environmental contaminants in surface water and sediment. The USEPA Dermal Exposure Assessment guidance (USEPA, 1992) indicates that the relative absorption pathway for inorganics via the dermal exposure pathway is "negligible". The potential inhalation of VOCs by burrowing receptors is not likely given that no VOCs were detected in SA 09 soils.

5.1.7.1 Surface Soils. A screening-level evaluation of potential effects from surface soil exposure was conducted by comparing the maximum concentrations of copper, lead, and nickel to their respective surface soil benchmark values (PCLs) (Table 5-15). The maximum concentrations of copper and nickel were less than their respective PCLs. Lead was detected at a maximum concentration of 81 μg/g, and at an average concentration of 44 μg/g. The maximum lead concentration was greater than the lead background concentration (48.4 μg/g), which was established as the PCL for lead in surface soils.

Because the maximum concentration of lead is less than twice the background value, and due to the presence of marginal, un-vegetated terrestrial habitat at the SA 09 landfill, lead is not considered to pose ecological risks to terrestrial receptors at the site. Furthermore, the PCL derived for the American robin, a receptor that may occasionally forage at the site, is 340 μg/g, an order of magnitude above the background concentration. PCLs for higher trophic level receptors (i.e., the red-tailed hawk and the red fox) are several orders of magnitude above the detected lead concentrations at SA 09.

5.1.7.2 Surface Water and Sediments. Risks to aquatic receptors in wetlands surface water were evaluated through direct comparison of maximum CPC concentrations to aquatic benchmark values (USEPA chronic AWQC). Risks to ecological receptors from wetlands sediments were evaluated through direct comparison of maximum CPC concentrations to sediment benchmark values. The maximum concentrations of aluminum, iron, and lead in SA 09 wetlands surface water, and the maximum concentrations of lead and arsenic in wetlands sediments were detected at levels greater than their benchmark values (Tables 5-16 and 5-17).

Aluminum was detected in one of the three surface water samples at a concentration of 229 μg/L; no aluminum was detected in the remaining two samples. The chronic AWQC for aluminum is 87 μg/L, and the acute AWQC is 750 μg/L. Aluminum is naturally present at high levels in background soils and groundwater at Fort Devens, and it is likely that the presence of aluminum in the SA 09 wetlands surface water is reflective of background conditions, and not of landfill impacts. Furthermore, a review of the aluminum AWQC document (USEPA, 1988) indicates that larval trout are among the most sensitive ecological receptors with regard to aluminum exposure. Because no salmonids (e.g., trout) are likely to occur in the site's palustrine wetland, it is unlikely that the levels of aluminum in surface water will have an adverse effect on the site's ecological receptors, which are likely to be more tolerant of aluminum than larval trout.

Lead concentrations in the three SA 09 surface water samples averaged 2.3 μg/L. This value is slightly higher than 1.4 μg/L, the hardness-dependent chronic AWQC for lead (site-specific hardness assumed as 53 mg/L $CaCO_3$). However, it is an order of magnitude below the acute AWQC, calculated as 36 μg/L at 53 mg/L hardness. A review of the lead AWQC document (USEPA, 1984) indicates that early life stages of trout are among the most sensitive ecological receptors with regard to lead exposure. Because no salmonids are likely to occur in the site's palustrine wetland, it is unlikely that the low levels of lead in surface water will have an adverse effect on the site's ecological receptors, which are likely to be more tolerant of lead than early life stages of trout. Lastly, lead is present at similar background concentrations in groundwater, and it is likely that the lead in the SA 09 surface water is reflective of background, rather than landfill-related conditions.

Iron was found in three surface water samples at an average of 3,133 μg/L. Although this value is in excess of the chronic AWQC (1,000 μg/L), iron is present at similar levels in background soils and groundwater at Fort Devens, and it is likely that the presence of iron in the SA 09 wetlands sediments is reflective of background conditions, and not of landfill impacts. Furthermore, many surface water samples collected in other studies at Fort Devens (i.e., Cold Spring Brook and the Nashua River) contained iron in excess of 1,000 μg/L; this finding supports the assumption that iron is present at background conditions in excess of the chronic AWQC.

Maximum lead and arsenic concentrations in wetlands sediments exceeded the screening level benchmark toxicity values. Lead was present at concentrations ranging from 9.07 to 46 μg/g, at an average concentration of 27 μg/g. This average lead concentration (27 μg/g) is identical to the NYSDEC sediment quality guideline (27 μg/g) and is less than 35 μg/g, the ER-L of NOAA (Long and Morgan, 1990). Therefore, lead is not considered to be causing significant ecological risk at SA 09. Arsenic was present at concentrations ranging from 2.78 to 13.6 μg/g, at an average concentration of 7.6 μg/g. This average arsenic concentration (7.6 μg/g) is only slightly greater than the NYSDEC sediment quality guideline (5 μg/g) and is considerably less than 33 μg/g, the ER-L of NOAA (Long and Morgan, 1990). Therefore, arsenic is not considered to be causing any significant ecological risk at SA 09.

5.1.8 Conclusions and Recommendations

Sampling and analyses conducted during the SA 09 investigation indicate that some organic (PAHs) and inorganic (beryllium) analytes are present in the SA subsurface soil at concentrations exceeding human health guidelines. These contaminants were likely derived from unspecified landfill material, but exposure to these contaminants is expected to be minimal under foreseeable site use scenarios. Furthermore, the landfilled material has been present on site for an extended period of time and has had no observable impact to groundwater quality. Groundwater samples from monitoring well locations in the subject area do not indicate that organic contamination from former landfilling operations has impacted groundwater. Although inorganic analytes are elevated in groundwater at all locations, their presence in samples can be readily explained by the high TSS levels (inorganic particulates). Arsenic is present in groundwater at a concentration exceeding drinking water standards but is detected in only the upgradient well location (WWTMW-07) and is therefore not considered to be attributable to SA 09.

Surface water and sediment locations 09D-92-01X, -02X, and -03X were selected to measure the effect of surface runoff and discharge of groundwater from the landfill area to the surface water of a swampy area to the south of the landfill. However, it appears from water-level measurements that water-table groundwater does not discharge to the ground surface in this area. In general, organic and inorganic compound concentrations are below human health and ecological risk guidelines in both media. BIS was detected in surface water samples at concentrations only slightly above guidelines, but is considered to be a likely laboratory contaminant (Section 5.3). Chemical compounds detected in sediment samples from the Nashua River and Walker Brook are not derived specifically from the subject SA, and at the request of the Army, will be addressed in a separate investigation (AREE 70).

Based on analytical results obtained and the results of the preliminary risk evaluation conducted, no further action has been recommended by the Army for the North Post Landfill.

5.2 SAS 19, 20, AND 21 - WASTEWATER TREATMENT PLANT AND ASSOCIATED FACILITIES

SAs 19, 20, and 21 are located west of the Nashua River on the North Post. These SAs correspond, respectively, to the WWTP (Imhoff tanks), the rapid infiltration sand beds, and the sludge drying beds (Figure 5-1). Collectively, these components comprise the Fort Devens WWTP, and consequently they are addressed together in this section (see also Biang et al., 1992, pp. 4-56).

5.2.1 SA Background and Conditions

The wastewater treatment facility was constructed in 1942 and is still in operation. It has a design capacity of 3 million gallons per day (MGD), but in 1989 the average annual effluent flow was 1.3 MGD.

Preliminary sewage treatment is conducted at the main pumping station (Figure 5-1), which has a bar screen, grit chamber, and comminutor. Following preliminary treatment, the effluent is pumped to three parallel Imhoff tanks located at the top of a kame terrace adjacent to the rapid infiltration sand beds. Settleable solids are anaerobically digested in the lower compartments of the tanks, and digestive gases are vented to the atmosphere. Clarified wastewater is discharged into a dosing tank, which intermittently applies this unchlorinated primary effluent to varying combinations of the 22 rapid infiltration basins (Biang et al., 1992; Dzuray, 1992; and McMaster et al., 1982).

Settled solids (typically 4 to 10 percent solids) from the Imhoff tanks are drained two or three times a year to sludge drying beds, and supernatant from the sludge is collected in a clay underdrain system. Before 1982, the supernatant was discharged at the surface to the adjacent Nashua River floodplain. The supernatant has since been collected in a sump and pumped back to the rapid infiltration beds.

5.2.2 SAs 19, 20, and 21 Investigation Program Summary

The initial site investigation, which was conducted from May 1992 to January 1993, was designed to determine whether the WWTP is discharging hazardous materials to the environment, and to identify the range of influence of sanitary sewage discharges in the area. A supplemental site investigation (conducted May-June 1993) and Phase III site investigation (conducted May 1995) addressed environmental contamination specifically associated with historic discharges from the sludge drying beds (SA 21).

5.2.2.1 Initial Site Investigation. Nineteen monitoring wells surrounding the WWTP were sampled as part of the Group 5 SI. Seven of those wells, located immediately downgradient of the WWTP, were selected specifically to evaluate impacts to groundwater due to releases from the infiltration beds and sludge-drying beds (WWTMW-01A, WWTMW-02, WWTMW-02A, WWTMW-03, WWTMW-04, WWTMW-09, and WWTMW-10; see Figure 5-2). Wells WWTMW-11, WWTMW-12, WWTMW-13, and WWTMW-14 are located on the east side of the Nashua River (across a hydrologic divide). Groundwater at those locations is not influenced by SAs 19, 20, and 21.

Surface water and sediment were sampled at 10 locations in the Nashua River, Walker Brook, and a pond north of the WWTP.

The groundwater, surface water, and sediment sampling program for the Group 5 SI is described in more detail in Section 5.1.2.

The field investigation activities specific to SAs 19, 20, and 21 included two surface soil samples (21S-92-01X and 21S-92-02X) collected near the former supernatant discharge pipe from the sludge-drying beds (Figure 5-17). These samples, collected to identify hazardous materials potentially associated with sanitary sewage discharges, were analyzed for PAL organics, PAL inorganics, TPHC, and TOC.

5.2.2.2 Supplemental Site Investigation. Based on the types and concentrations of contaminants detected in surface soils downslope of the sludge drying beds in the initial SI, it was determined that insufficient data had been collected to fully evaluate contaminant conditions. A supplemental SI was undertaken to further characterize the distribution of observed contaminants and provide for the evaluation of risk to human health and ecological receptors. To evaluate the downslope extent of contaminant migration, ten surface-soil samples (21S-92-03X through 21S-92-12X) were collected in low-lying areas within an approximate 80-foot radius downslope from the discharge pipe where surface-water discharge was presumed to have ponded historically (Figure 5-17). To assess potential downward migration, two shallow subsurface-soil samples (21B-92-01X and 21S-92-02X) were collected near and immediately downslope from the discharge pipe (Figure 5-17). Subsurface soil samples were collected by hand (using a shovel and post hole digger) from depths of approximately 2 to 4 feet bgs. Soil samples were analyzed for PAL inorganics and TPHC.

5.2.2.3 Phase III Site Investigation. To better define the extent of contamination at SA 21, three additional surface-soil samples (21S-92-13X through 21S-92-15X) were collected downslope from the SA 21 discharge pipe. Two sediment samples (21D-92-01X and 21D-92-02X) were collected at the west end of a closed linear depression. Sampling locations were selected jointly by representatives of the USEPA, the MADEP, and the Army. The soil and sediment samples were analyzed for PAL inorganics. Local topography was also surveyed to assess surface drainage flow paths. The topography and sampling locations and are shown on Figure 5-17.

5.2.3 Field Investigation Results and Observations

SA Group 5 surficial geologic deposits and groundwater and surface water/sediment characteristics were discussed in Section 5.1.3. Additional observations specific to SAs 19, 20, and 21 follow.

Water-level measurements and the resulting potentiometric surface map indicate that the wastewater infiltration beds, and the large kame-plain remnant on which they are located, have little apparent influence on groundwater flow. Groundwater flows generally eastward beneath the WWTP to the Nashua River. One inferred groundwater flow path from the WWTP would be approximately from beneath the infiltration beds (near monitoring well G5M-92-03B), past well WWTMW-02, to the Nashua River. The average hydraulic gradient along that flow path was approximately 0.0026 ft/ft in September 1992, and the geometric average of the measured hydraulic conductivities at wells G5M-92-03B and WWTMW-02 is 0.016 cm/sec. Assuming that conductivity is representative of average conditions along the flow path, and that the aquifer effective porosity is 0.30, the average groundwater velocity at the water table would be approximately 147 ft/yr.

Surface soil samples were collected from beneath a 2-inch thick mat of organic material (mostly pine needles) downslope of the discharge pipe. Samples collected consisted generally of fine to medium sands. No visual evidence of contamination was observed.

No obvious drainage erosional features were observed at the former supernatant discharge pipe. The discharge point is located on the slope between the sludge-drying beds and the Nashua River floodplain. The depression from which the sediment samples were collected is one of a series of trenches excavated for military training during World War I. Field observations and the mapped topography (Figure 5-17) indicate that flow from the discharge pipe probably does not enter the depression. The depression contains pooled surface water during periods of high groundwater.

5.2.4 Nature and Extent of Contamination (Laboratory Results)

Because of the wide variety of potential contaminants associated with the WWTP, samples collected in the SA 19, 20, and 21 investigations were analyzed for PAL VOCs, SVOCs, inorganic analytes, explosives, TPHC, and water quality parameters, as well as coliform bacteria and anions/cations (groundwater only). The raw laboratory analytical results of samples collected in SAs 19, 20, and 21 and in the SA Group 5 area are included in Appendices K and M and are discussed by sampling medium in the following subsections.

5.2.4.1 Soils. Two soil samples from depth 2 to 4 feet bgs (21B-93-01X and 21B-93-02X) and a total of fifteen surface soil samples (21S-92-01X and 21S-92-02X, 21S-93-03X through 21S-93-12X, and 21S-95-13X through 21S-95-15X) were collected at SA 21. Two sediment samples (21D-95-01X and 21D-95-02X) were collected at the ground surface at SA 21, and they are discussed in this subsection because of their close association with surface conditions at SA 21. (For a discussion of non-site-specific sediment sampling in the Group 5 area, refer to section 5.1.4.3).

No VOCs or SVOCs were detected in surface-soil samples collected at SA 21. All surface-soil (and sediment) samples collected at SA 21 had inorganic analyte concentrations in excess of calculated background concentrations (Table 5-18). Inorganic analyte distributions are illustrated in a series of concentration maps (Figures 5-18 through 5-24). The highest concentrations of barium, copper, mercury, and silver were detected in the samples collected nearest the discharge pipe and directly downslope from it (Figures 5-18, 5-21, 5-23, and 5-24). The highest concentrations of cadmium, chromium, and lead were detected at sampling locations farthest from the discharge pipe (nearest to the river), with progressively lower concentrations away from the river (Figures 5-19, 5-20, and 5-22). TPHC was detected in all surface soil samples collected, with concentrations ranging from 98 μg/g to 1,490 μg/g.

Soil samples collected from 2 to 4 feet bgs (21B-93-01X and 21B-93-02X) had markedly lower concentrations of inorganic analytes than the corresponding surface soil samples (Table 5-18). Only beryllium, copper, nickel, sodium, and zinc were detected above the calculated Fort Devens background concentrations for these analytes (marginally in most cases). TPHC was not detected in either subsurface sample. Concentrations of inorganic analytes detected above background in subsurface soil were slightly higher in the sample located closer to the discharge pipe (21S-93-01X).

5.2.4.2 Groundwater. Seven wells are located downgradient of the WWTP. Except for BIS (a suspected laboratory contaminant), organic compounds were detected only in WWTMW-02 and WWTMW-02A.

Organic compounds detected in groundwater from monitoring well WWTMW-02 included acetone, carbon tetrachloride, TCA, chloroform, and TCE. Only toluene was detected in WWTMW-02A, and it was detected only in Round 1. Its concentration was just above the detection limit, and it was also detected at similar concentrations in two method blanks. Therefore, toluene is considered to be a laboratory contaminant (see Section 1.2 of Appendix F). Total coliform bacteria counts were detected in all wells except WWTMW-04 during the two sampling rounds, but no fecal coliform bacteria were detected in any of the Group 5 wells. TPHC was not detected in any of the selected downgradient wells. Tables 5-3 and 5-4 list detected organic compounds in all Group 5 groundwater samples. Figures 5-7 and 5-8 show the distribution of organic compounds and coliform bacteria in groundwater.

5.2.4.3 Surface Water and Sediment. Surface water and sediment samples were collected at nine locations along the Nashua River and one location in the small pond located to the north of the WWTP. The analytical results are discussed in Section 5.1.4.3.

Two sediment samples were collected as part of the Phase III SI at SA 21, in the seasonally flooded linear depression between the discharge pipe and the Nashua River. The analytical results are discussed in subsection 5.2.4.1.

5.2.5 Source Evaluation and Migration Potential

The distribution of inorganic analytes in soils downslope from the sludge-drying beds suggests that supernatant from the former discharge pipe, and floodwaters from the Nashua River, were two likely sources of inorganic analytes detected in surface soils at SA 21.

Barium, copper, mercury, and silver are concentrated in an area generally east of the former discharge pipe, in a pattern consistent with a topographically controlled migration pathway (Figures 5-18, 5-21, 5-23, and 5-24). The data suggest that supernatant originating from the discharge pipe transported these analytes downslope and concentrated them in a low-lying area within which it likely ponded and infiltrated the ground. There is little evidence of contaminant migration from this area to the depression located farther east.

Other inorganic analytes such as cadmium, chromium, and lead show a distinctly different distribution (Figures 5-19, 5-20, and 5-22). The lowest concentrations of these analytes were detected along the western margin of the floodplain (including the area near the discharge pipe). Concentrations increase eastward, toward the Nashua River, in conformance with the topography. Moreover, concentrations of cadmium, chromium, and lead detected in Nashua River sediments collected east of SA 21 (Table 5-9) are similar to the highest concentrations observed at SA 21. This suggests that those inorganic analytes are associated with flood-stage deposition from the river.

The distribution of TPHC also appears to be unrelated to supernatant discharge. The absence of organic constituents (VOCs and SVOCs) in the samples suggests that the TPHC may be associated with vegetative matter observed on the ground surface.

A comparison of surface and subsurface soil contaminant concentrations suggests that significant downward migration of contaminants has not occurred.

During all sampling rounds, groundwater from WWTMW-02 contained the greatest number and highest concentrations of organic compounds. WWTMW-02 is closest to, and downgradient from, the sludge drying beds. Organic compounds detected in groundwater included acetone, carbon tetrachloride, TCA, chloroform, and TCE in WWTMW-02. Only toluene was detected in groundwater at

WWTMW-02A during Round 1 sampling; it was not detected at this location during Round 3 sampling. At the concentration detected in Round 1, toluene is likely attributable to laboratory contamination.

The source of the chlorinated solvents detected in monitoring well WWTMW-02 has been in question since the Round 1 groundwater sampling. The compounds of concern include TCE, TCA, and carbon tetrachloride. Information gathered from another groundwater study separately conducted by AEHA shows that the isolated appearance of TCE, the most prevalent chlorinated solvent compound, is consistent with the May 1991 installation of a replacement Hypalon liner for the sludge drying beds (Table 5-19). The solvent used to weld the liner material together consisted of 80 percent TCE. The appearance of TCE in the nearest downgradient well and the correlation between the composition of the solvent and the timing of the liner installation suggest that the contamination was released during liner installation. TCE concentrations declined with time with the highest concentration (61 μg/L) detected on July 9, 1991, to a concentration of 3.5 μg/L on August 19, 1993. The other compounds detected in Round 1 (TCA and carbon tetrachloride) were not detected in the AEHA samples, but they decreased in concentration in ABB-ES' samples from Round 1 to Round 3 to concentrations in Round 3 that were near the detection limits for each. TCA was detected in water method blank samples at similar concentrations and is, therefore, considered a potential laboratory contaminant.

The source of 2,4-dinitrotoluene detected in the Round 1 groundwater sample from WWTMW-02 is not clear, but may be the result of historical supernatant releases beneath the sludge drying beds.

One or more inorganic analytes were detected above calculated Fort Devens background levels in virtually all groundwater samples collected from SA Group 5 monitoring wells during both rounds of sampling. The highest concentrations of these inorganic analytes were observed in monitoring wells located nearest the WWTP (in WWTMW-02 and WWTMW-02A). However, filtered groundwater samples collected from Group 5 wells during Round 2 sampling indicate that much of the elevated concentrations are due to suspended solids.

Elevated concentrations of nitrate/nitrite, detected in monitoring wells located immediately downgradient of the WWTP in both rounds of sampling, are likely attributable to the continued operation of the sand infiltration beds.

The source of carbon disulfide in surface water at G5D-92-10X collected from the pond located north of the WWTP is not known, but it does not appear to be associated with the WWTP because the compound was not detected at any other location in any other media sampled as part of this SI.

5.2.6 Preliminary Human Health Risk Assessment

The WWTP has operated since 1942 and is expected to continue operation for the foreseeable future.

Tables 5-20 and 5-21 present summary statistics and human health standards and guidelines used in the PRE for SAs 19, 20 and 21. Average values presented in the following discussions reflect the average concentration of all samples collected. By convention, where a concentration is below the laboratory detection limit, one half the detection limit concentration is used in the calculation.

5.2.6.1 Surface Soil. This PRE considers all soils to a depth of 3 feet as accessible under a residential future use exposure scenario. This assumption is conservative (i.e., health-protective) because, as discussed above, the expected future use of the WWTP is the continued use of the associated facilities.

Table 5-20 presents summary statistics on surface soil at the WWTP, and USEPA Region III residential soil concentrations for comparison. Surface soil downslope of the sludge drying beds is represented by samples 21S-92-01X, 21S-92-02X, 21S-93-03X through -12X, 21S-95-13X through -15X, 21B-93-01X, and 21B-93-02X collected from the former supernatant discharge area. Also included in this surface soil evaluation are sediment samples 21D-95-01X and 21B-95-02X; they are closely associated with surface conditions at SA 21 and are accessible to direct human contact except during periods of high groundwater.

When comparing inorganic analyte concentrations in the 17 soil samples (and two sediment samples) at SA 21 to the USEPA Region III residential soil concentrations, two analytes exceeded these concentrations: arsenic detected in 19 of 19 samples (maximum concentration: 53 μg/g; Region III residential concentration: 0.97 μg/g), and beryllium detected in 12 of 15 samples (maximum concentration: 2.57 μg/g; Region III residential concentration: 0.4 μg/g). Arsenic was detected above the detection limit in 19 of 19 samples. The average arsenic concentration (24.9 μg/g) is slightly above the installation-wide calculated background concentration of 21.1 μg/g. The average beryllium concentration (1.77 μg/g) is above the installation-wide calculated background concentration of 0.347 μg/g.

Surface soil samples 21S-92-01X and 21S-92-02X were analyzed for VOCs and SVOCs. All results were below the detection limits. Although TPHC was detected in surface soil (maximum 1,490 μg/g; average 483 μg/g), the absence of organic constituents (from the PAL VOCs and SVOCs) in the samples suggest that it is not associated with the sludge drying beds.

5.2.6.2 Groundwater. Nineteen monitoring well locations have been used to define the groundwater quality in the vicinity of the WWTP. Monitoring well locations WWTMW-01A, -02, -02A, -03, -04, -09, and -10 are directly downgradient of the WWTP. Table 5-21 presents summary statistics for unfiltered samples collected from these wells and drinking water standards and guidelines for comparison.

The maximum detected concentration of most of the inorganic analytes exceed the statistical background concentrations.

There is a clear correlation between insoluble inorganic analytes (e.g., arsenic, copper, lead, nickel, zinc) levels and TSS. However, the number of analytes exceeding the statistical background concentrations cannot be explained fully by TSS levels. It must be concluded that the WWTP has affected groundwater quality immediately downgradient of the sand infiltration beds.

The maximum detected concentrations of six inorganic analytes in Table 5-21 exceed their respective drinking water standards or guidelines. The exceedances for three analytes -- aluminum, iron, and manganese -- involve secondary Maximum Contaminants Levels; these are federal standards promulgated for aesthetic or economic reasons, not health reasons. The maximum concentrations of aluminum and manganese are well below their respective USEPA Region III tap water concentrations. (No Region III tap water concentration exists for iron.) While the maximum detected concentration of arsenic exceeds the Massachusetts drinking water standard (50 μg/L), this occurs in only two of 14 downgradient samples (two sampling rounds from seven wells). The average concentration of arsenic in the downgradient wells is 20 μg/L. The maximum detected concentration of cadmium (14.9 μg/L) also exceeds the Massachusetts drinking water standards (5 µg/L). Cadmium was only detected in three of 14 groundwater samples collected (in two rounds). The average downgradient concentration of cadmium is 4 µg/L. Sodium was detected in excess of the Massachusetts drinking water guideline (28,400 µg/L) in roughly half of the samples collected from the downgradient wells. The average concentration of sodium in downgradient wells is 29,500 µg/L, slightly exceeding the guideline.

The only significantly detected organic compound in downgradient WWTP groundwater in Round 1 were the VOCs at monitoring well location WWTMW-02. However, the state and federal primary drinking water standards for all organic compounds, with the exception of TCE (5 µg/L standard, 14 µg/L maximum) at location WWTMW-02, were not exceeded in any groundwater sample from the WWTP wells.

In Round 2/3, two organic analytes were detected at concentrations above their respective drinking water standards or guidelines. BIS was detected at four downgradient locations in exceedance of the USEPA Region III tap water concentration. TCE was detected at one monitoring well at concentrations above the Massachusetts drinking water standard. The average concentrations of TCE and BIS across Rounds 1 and 2/3, in seven downgradient wells, are 2.5 and 6.6 µg/L, respectively; these averages approximate or are below the respective drinking water standards or guidelines.

The only anions/cations for which a health risk-based guideline exists is nitrate/nitrite. The Region III tap water value of 58,000 µg/L was not exceeded at any WWTP groundwater sampling location. However, the state and federal primary drinking water standard of 10,000 µg/L was exceeded at four of the seven immediately downgradient wells.

One explosive compound (2,4-dinitrotoluene) was detected in the downgradient monitoring wells. It was detected in WWTMW-02 at a concentration of 0.131 µg/L in Round 1. This concentration is below the USEPA Region III tap water concentration of 73 µg/L.

5.2.7 Preliminary Ecological Risk Evaluation

The purpose of this PRE at the WWTP is to provide a screening-level evaluation of actual and potential risks that environmental contaminants may pose to the resident and migratory ecological receptors at the site.

A mowed grassy area surrounds the sludge drying beds; this region slopes to the east toward the forested floodplain of the Nashua River. Dominant trees in the floodplain include red maple (*Acer rubrum*), American elm (*Ulmus americana*), and white pine (*Pinus strobus*). Other trees observed include pitch pine (*Pinus rigida*), black cherry (*Prunus serotina*), white oak (*Quercus alba*), European buckthorn (*Rhamnus frangula*), and white birch (*Betula papyrifera*). The open understory of the forested floodplain adjacent to the sludge drying beds includes cinnamon fern (*Osmunda cinnamomea*) and Japanese knotweed (*Polygonum cuspidatum*). The floodplain likely provides cover and foraging habitat for a variety of wetlands and semi-terrestrial wildlife, including passerine songbirds, mammals such as the raccoon (*Procyon lotor*) or mink (*Mustela vison*), amphibians (such as the green frog [*Rana clamitans]*), reptiles such as the garter snake (*Thamnophis sirtalis*) and turtle species, and a variety of invertebrates.

No records exist documenting the current or historical presence of rare and endangered species in the region of the WWTP. Although the largest known population of Blanding's turtles in New England is located in the vicinity of Fort Devens (Butler, 1992), the status of this population has been well documented and none are known to occur at the WWTP.

Petroleum hydrocarbons and 17 inorganic analytes were identified at the 17 surface and subsurface soil sample locations and the two sediment sample locations in the vicinity of the sludge drying beds. These samples were collected in the Nashua River floodplain adjacent to the sludge drying beds. Aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, vanadium, and zinc were detected at maximum levels exceeding background concentrations and were chosen as CPCs. In addition, cobalt and selenium were considered as CPCs in the absence of any soil background data.

A potential contaminant exposure pathway exists at the sludge drying beds for terrestrial (and wetlands) ecological receptors via incidental ingestion of floodplain surface soils and food web exposure. A screening-level evaluation of potential effects from soil exposure was conducted by comparison of the maximum concentrations of CPCs to their respective surface soil benchmark values (PCLs) (Table 5-22).

Surface soil benchmark values have been updated for SA 21, to address uncertainties identified in earlier phases of the SI (Appendix H). The maximum concentrations of aluminum and cadmium exceed their respective PCLs (Table 5-22). Aluminum was detected at a maximum concentration of 20,000 μg/g (associated PCL: 15,000 μg/g), and cadmium was detected at a maximum concentration of 22.7 μg/kg (associated PCL: 3.3 μg/g). Although silver did not exceed the PCL generated through the food web model, acute and chronic exposure to silver is known to result in a variety of effects, ranging from mortality to argyria (USEPA, 1980a).

5.2.8 Conclusions and Recommendations

No further action is recommended for SAs 19, 20 and 21. This recommendation is based on field observations, the evaluation of sampling and analysis results, and the results of the human health and ecological PRE.

Groundwater downgradient of the WWTP and surface soil downslope of the sludge drying beds were initially identified as areas of concern.

Insofar as no unacceptable threats to human health or the environmental due to hazardous waste contamination were identified in groundwater downgradient of the WWTP, no further action under CERCLA is appropriate for groundwater at SAs 19, 20 and 21. It is appropriate, however, that the nitrate/nitrite contamination observed in downgradient groundwater be addressed outside this Superfund hazardous waste site process as part of a compliance upgrading of the facility.

In surface soil at SA 21, concentrations of inorganic analytes derived from the former supernatant discharge pipe are below their respective screening values. At the 95th UCL, only cadmium exceeds its screening value. Cadmium is not associated with supernatant discharges. Its concentrations are consistent with levels detected in Nashua River samples collected nearby, and the areal distribution of cadmium at SA 21 indicates an association with river deposition along the floodplain.

The removal of cadmium-contaminated soil could potentially involve a large area of forested floodplain along the Nashua River and would be very disruptive of ecological habitat. Further, surface soil would be recontaminated by future periodic flooding of the Nashua River. The impermanence and detrimental effects of a removal action outweigh the existing risks to receptors. Therefore, no further action is recommended for SAs 19, 20, and 21.

5.3 ANALYTICAL DATA QUALITY CONTROL

Laboratory water method blanks contained the following PAL compounds: lead (1.8 μg/L), iron (143 μg/L), potassium (578 μg/L), BIS (6.6 μg/L, 5.1 μg/L, and 6.2 μg/L), toluene (0.15 μg/L), acetone (18 μg/L), chloroform (1.3 μg/L and 0.73 μg/L), and 1,1,1-TCA (2.5 μg/L). Laboratory soil method blanks contained the following PAL compounds (exclusive of inorganic compounds): toluene (0.2 μg/g and 0.00086 μg/g), BIS (1.1 μg/g), acetone (0.036 μg/g), TCFM (0.008 μg/g), chloroform (0.002 μg/g), and diethylphthalate (0.27 μg/g). Any compounds detected in a method blank sample are considered laboratory-introduced contamination.

5.3.1 Group 5 Field Quality Control Blank Sample Results

Field quality control samples that were associated with Group 5 samples include rinsate blanks and trip blanks. Rinsate blanks were analyzed for inorganics, SVOCs, VOCs, nitrate/nitrite as nitrogen, alkalinity, and carbonate ion. The purpose of collecting the rinsate was to determine if decontamination activities impacted the concentrations of the above analytes. Trip blanks were analyzed for the presence of VOCs. The purpose of trip blank collection was to measure potential cross contamination of samples from shipment and storage.

Rinsate results showed some carryover of inorganic elements into the blank. Alkalinity and nitrogen values indicated introduction of these parameters to the blanks, also. A more detailed discussion of Group 5 blank results is located in Sections 1.3.2 and 1.3.4 of Appendix F. A presentation of the results has been tabulated in Tables F-4 and F-5 of Appendix F.

Rinsate blanks collected during the supplemental site investigations contained the metals cobalt, chromium, copper, iron, potassium, and manganese and the VOCs and SVOCs TCA, 1,2-dichloroethane, acetone, methylene chloride, chloroform, toluene, 2-ethyl-1-hexanol, BIS, and dodecanoic acid. Additional information on rinsate blanks collected during the supplemental site investigation is presented in Table FS-5 of Appendix F, and the frequency of detection and the minimum and maximum detected concentrations are shown in Table FS-6.

There were no VOCs reported in the trip blanks indicating that no contamination occurred in the shipment or storage of the samples.

The following target compounds were detected in trip blanks collected during the supplemental investigations at concentrations above the CRLs: trifluorochloromethane, methylene chloride, chloroform, and toluene. The results are presented in Table FS-3, and the frequency of detection and the minimum and maximum detections are reported in Table FS-4. A more detailed discussion of trip blank results from the Supplemental Site Investigation is presented in Section 2.3.1 of Appendix FS.

Based on the data obtained from the field quality control blanks data quality objectives of completeness and representativeness were met. All holding times were met and the contamination found in the blanks was minimal.

5.3.2 Matrix Spike/ Matrix Spike Duplicates

MS/MSD samples were analyzed to determine matrix effects on the recovery of inorganics and explosives. The analysis results of these quality control samples were used to determine accuracy and precision of the methods. There were problems indicated in the recoveries of several elements using the inorganic methods. Specifically these elements are thallium, aluminum, chromium, lead, copper, iron, and zinc. There were low recoveries for one explosive compound, 1,3,5-trinitrobenzene. Details on these results are discussed in Section 2.2 of Appendix F. For MS/MSD data collected during the supplemental investigation, all recoveries were within the control criteria with the exception of aluminum, antimony, arsenic, iron, lead, manganese, mercury, selenium, silver, and zinc for soil samples. A discussion of these results is presented in Section 3.2 of Appendix FS. All Group 5 MS/MSD results are presented in Table F-10 in Appendix F and in Tables FS-7 and FS-8 of Appendix FS.

The recoveries reported for thallium, aluminum, chromium, lead, copper, iron, and zinc indicate that data quality objectives of accuracy and precision were not met for these elements as well as the inorganic compounds listed above for soil samples collected during the supplemental investigation. Overall the MS/MSD data do support the integrity of concentrations of other parameters.

5.3.3 Sample Duplicate Results

Group 5 duplicates were analyzed to determine precision and comparability of the results. The relative percent difference was calculated to make this determination. Duplicate results for Group 5 are presented in Table F-11 of Appendix F. In the same appendix, Section 2.5, there is a more specific discussion of these results. Duplicate results for samples collected during the supplemental investigation are presented in Tables FS-9 and FS-10 of Appendix FS, and a detailed discussion of these results is presented in Section 3.3 of Appendix FS.

There was variability shown in the concentrations of several inorganic elements. The RPDs of these elements was not within the limits specified in Section 3.2 used to evaluate the precision and comparability of these results. However, the precision and comparability of the data overall was sufficient to meet data quality objectives.

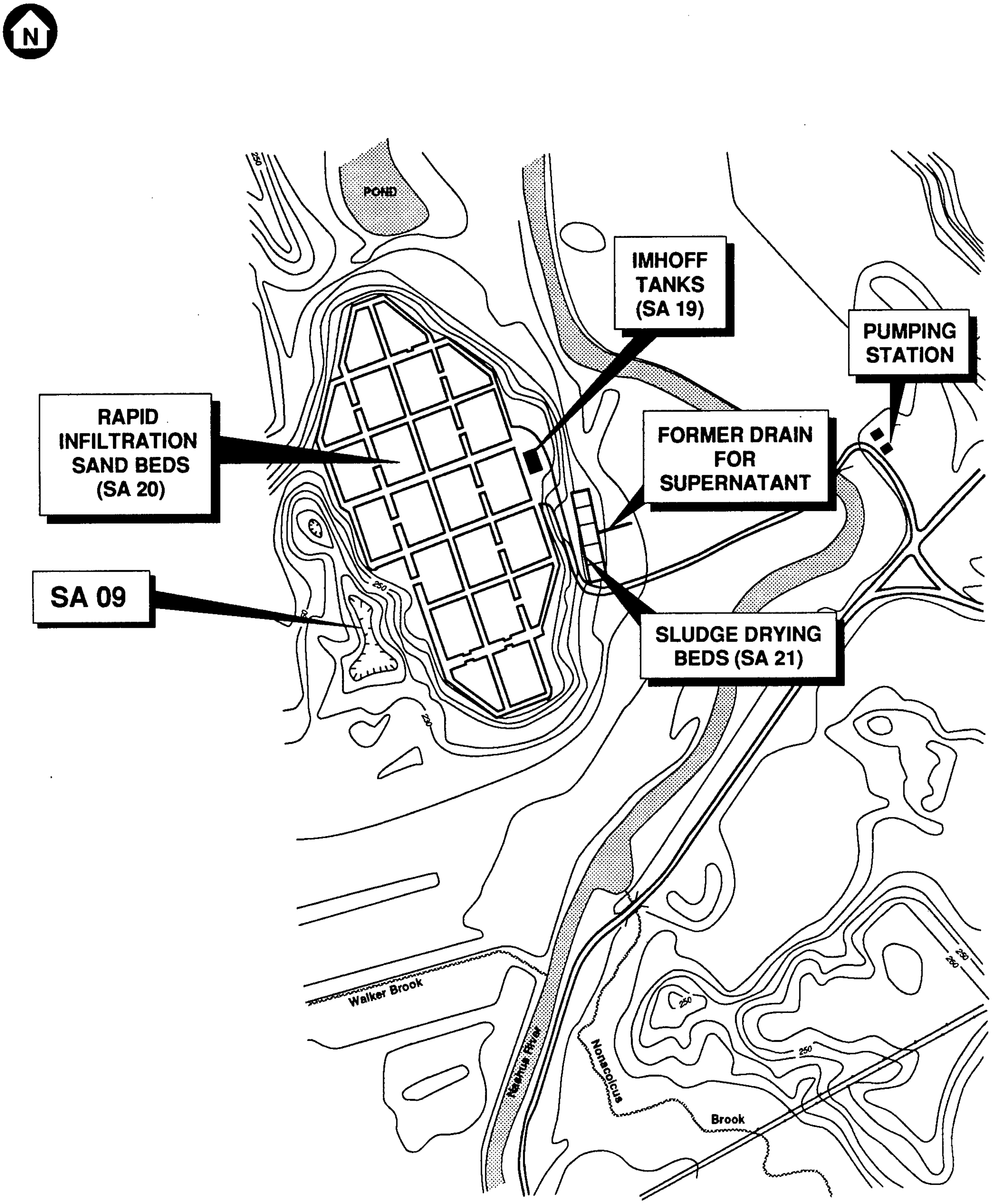


FIGURE 5-1
LOCATION OF SAs 09, 19, 20, & 21
GROUP 5 STUDY AREAS
FORT DEVENS, MA
ABB Environmental Services, Inc.

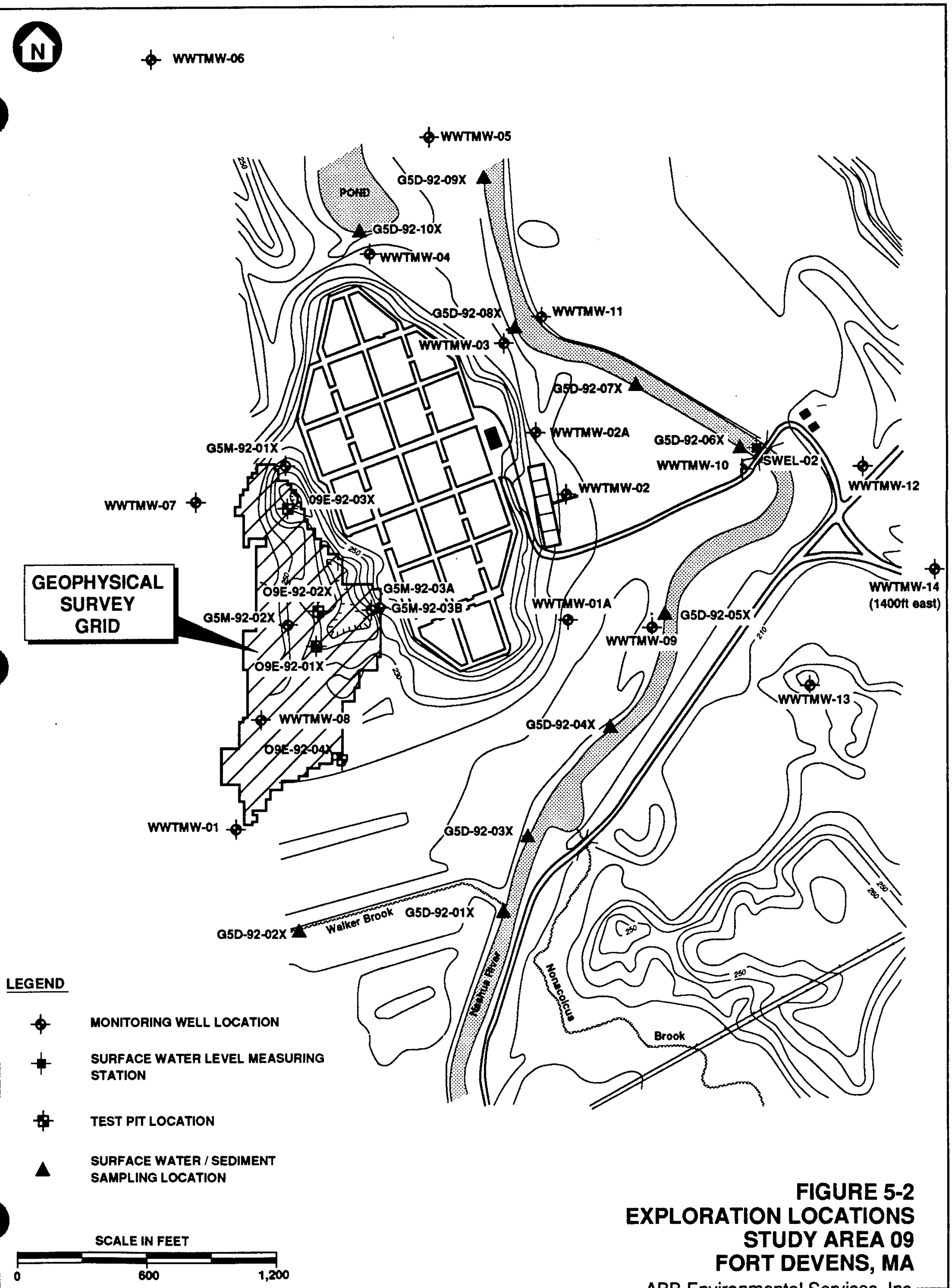


FIGURE 5-2
EXPLORATION LOCATIONS
STUDY AREA 09
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(c)123 5 9

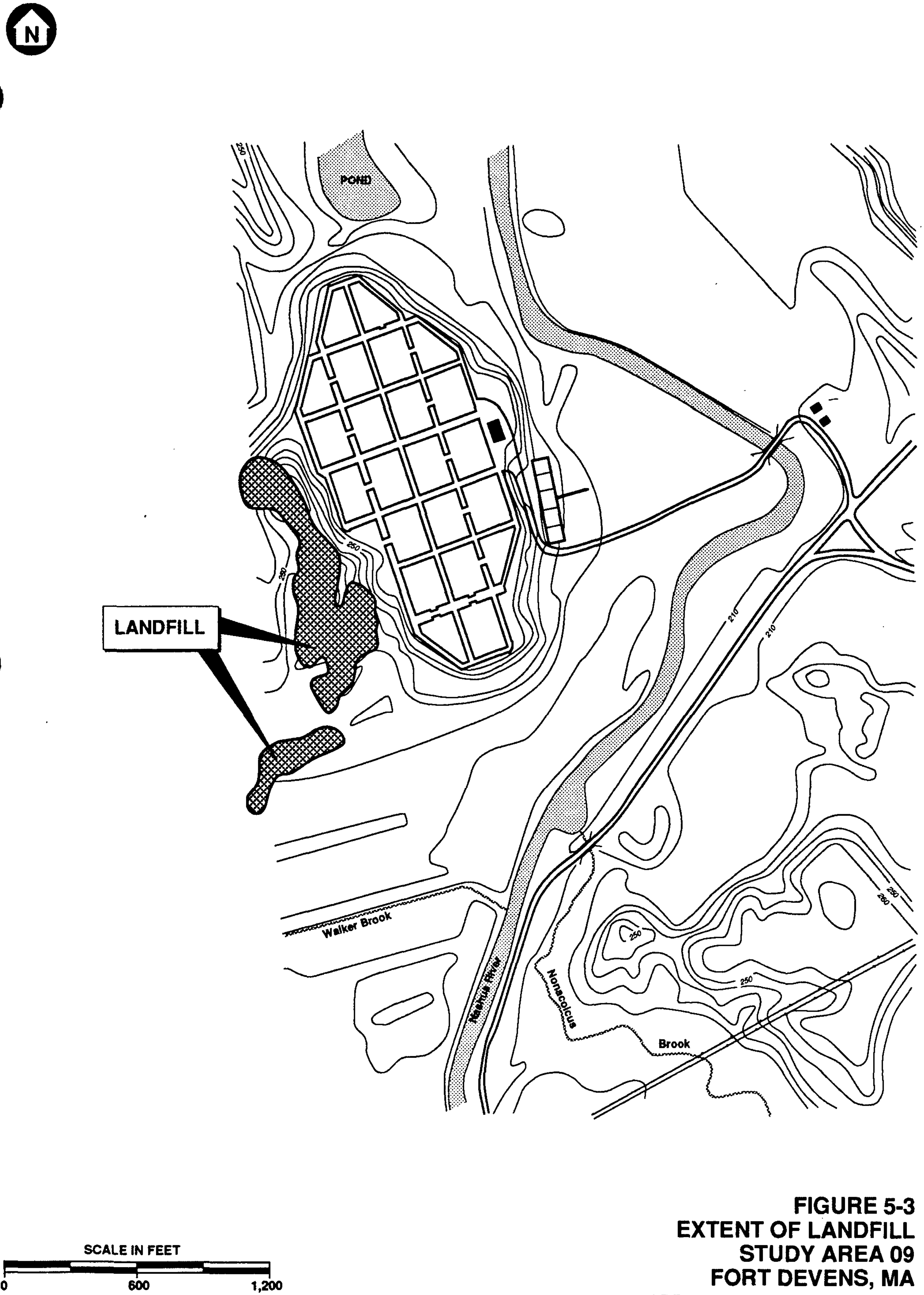


FIGURE 5-3
EXTENT OF LANDFILL
STUDY AREA 09
FORT DEVENS, MA

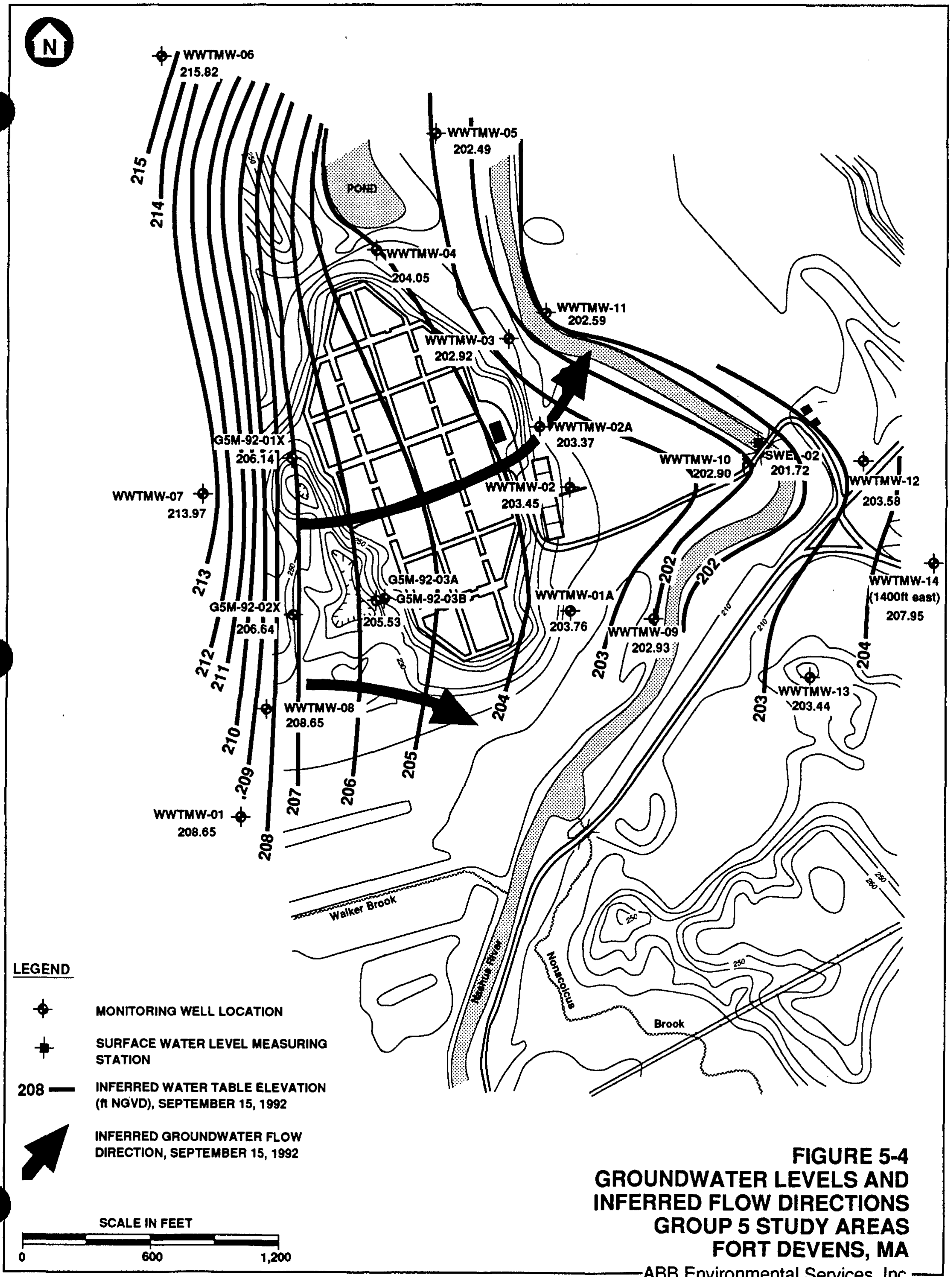


FIGURE 5-4
GROUNDWATER LEVELS AND
INFERRED FLOW DIRECTIONS
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

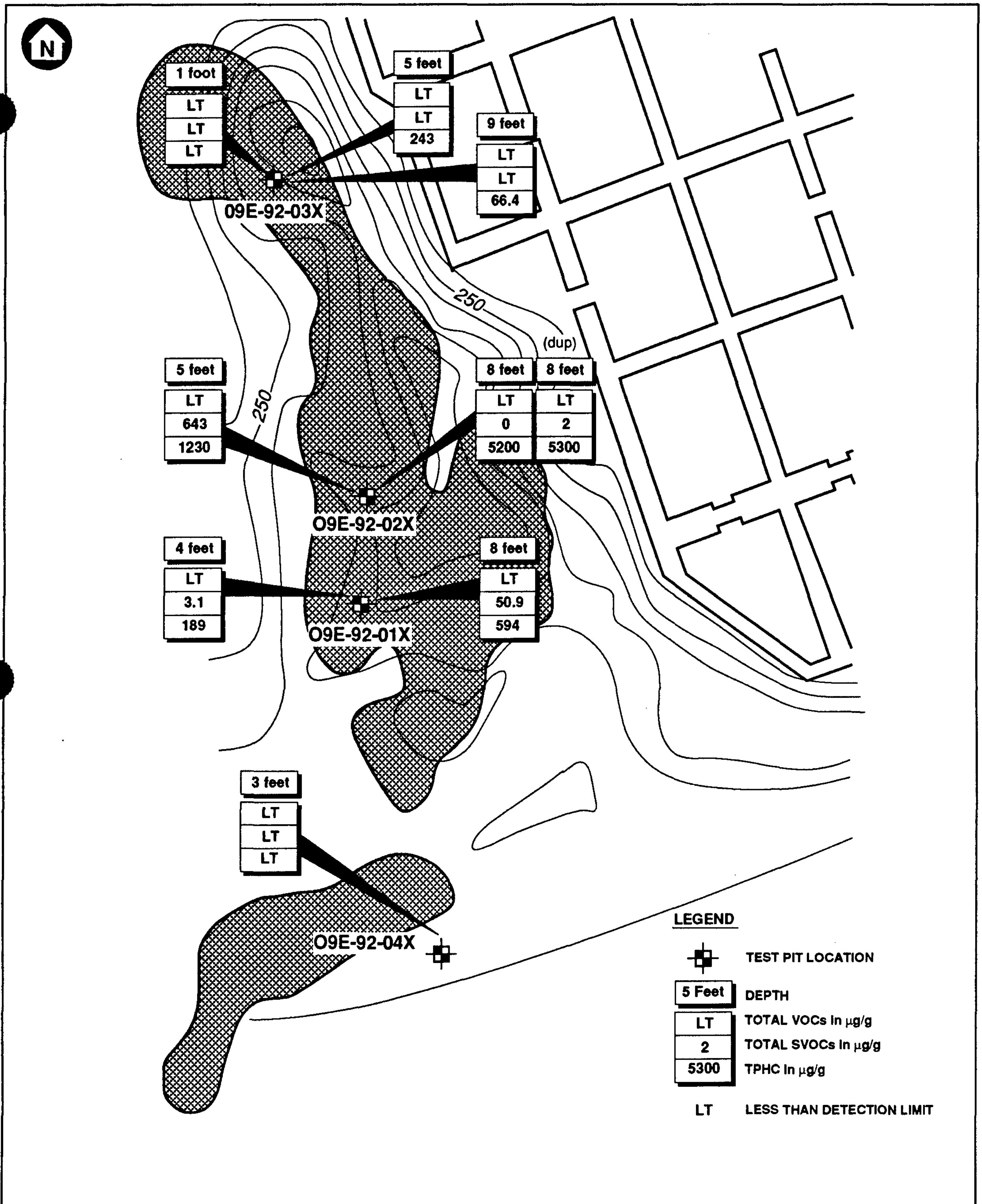
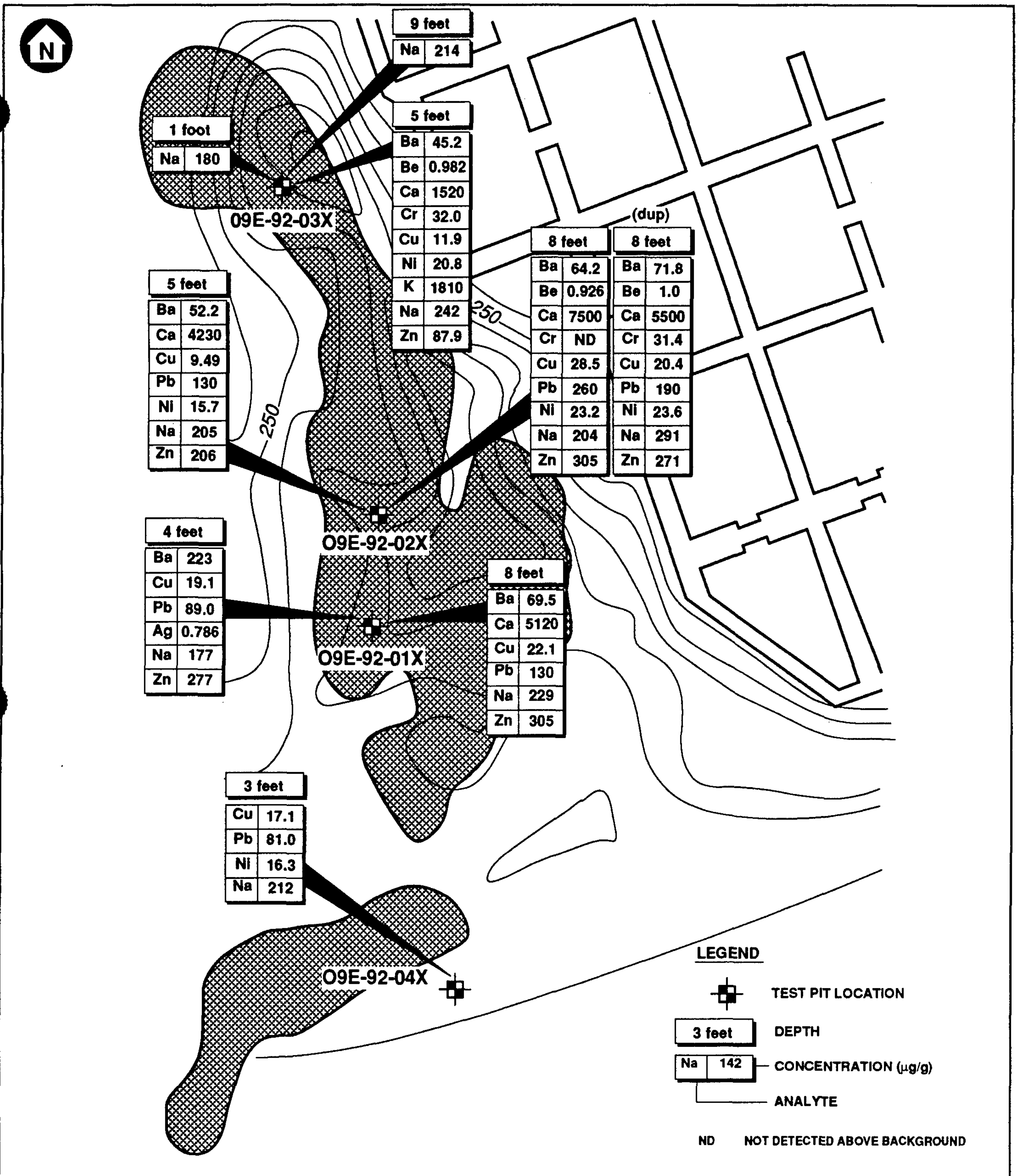


FIGURE 5-5
ORGANIC COMPOUNDS IN TEST PIT SOILS
STUDY AREA 09
FORT DEVENS, MA

ABB Environmental Services, Inc.



1 foot	
Na	180

9 feet	
Na	214

5 feet	
Ba	45.2
Be	0.982
Ca	1520
Cr	32.0
Cu	11.9
Ni	20.8
K	1810
Na	242
Zn	87.9

5 feet	
Ba	52.2
Ca	4230
Cu	9.49
Pb	130
Ni	15.7
Na	205
Zn	206

8 feet	
Ba	64.2
Be	0.926
Ca	7500
Cr	ND
Cu	28.5
Pb	260
Ni	23.2
Na	204
Zn	305

8 feet (dup)	
Ba	71.8
Be	1.0
Ca	5500
Cr	31.4
Cu	20.4
Pb	190
Ni	23.6
Na	291
Zn	271

4 feet	
Ba	223
Cu	19.1
Pb	89.0
Ag	0.786
Na	177
Zn	277

8 feet	
Ba	69.5
Ca	5120
Cu	22.1
Pb	130
Na	229
Zn	305

3 feet	
Cu	17.1
Pb	81.0
Ni	16.3
Na	212

FIGURE 5-6
INORGANIC ANALYTES IN TEST PIT SOILS
ABOVE BACKGROUND
STUDY AREA 09
FORT DEVENS, MA

ABB Environmental Services, Inc.

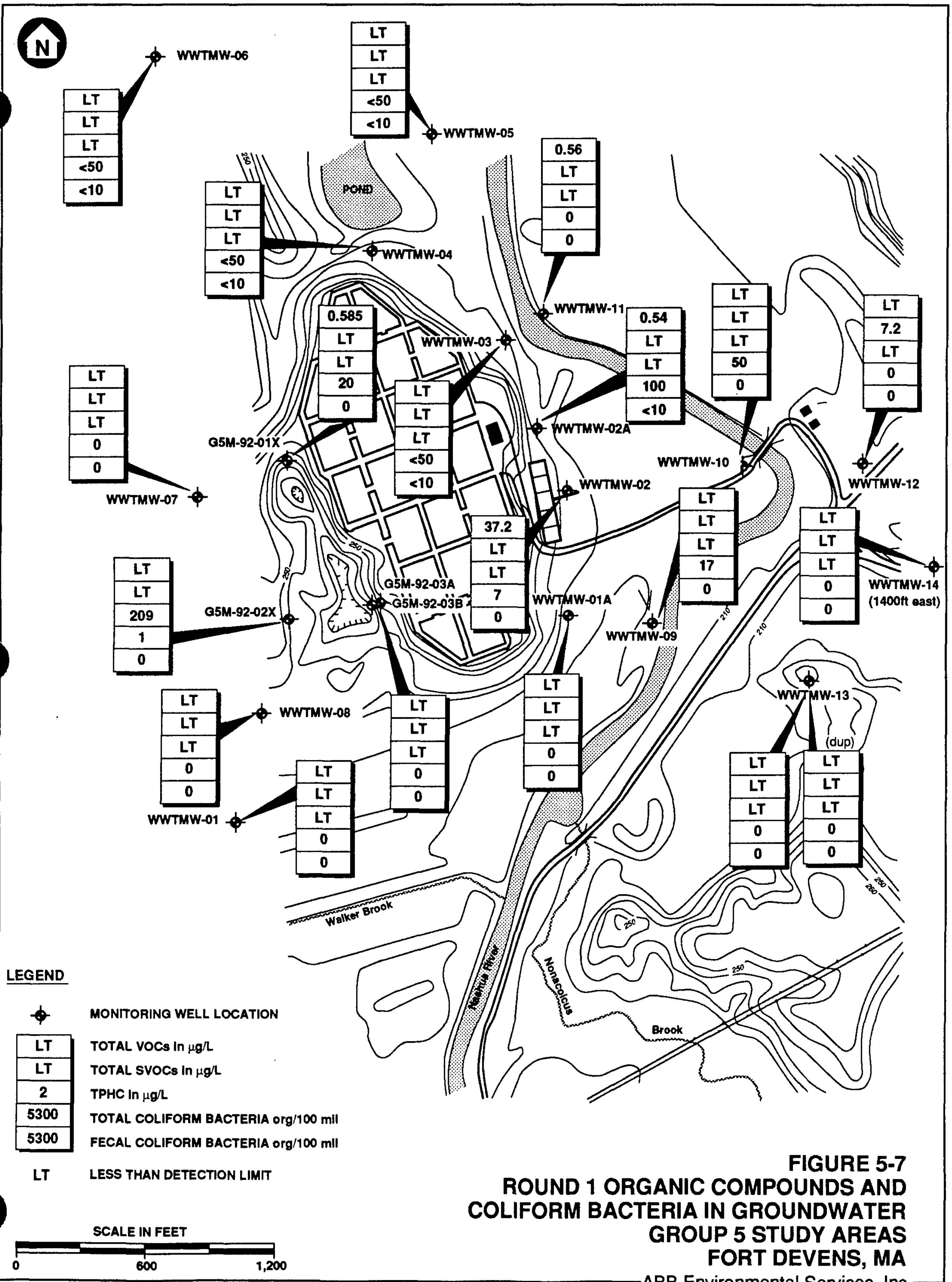


FIGURE 5-7
ROUND 1 ORGANIC COMPOUNDS AND COLIFORM BACTERIA IN GROUNDWATER GROUP 5 STUDY AREAS FORT DEVENS, MA

ABB Environmental Services, Inc.

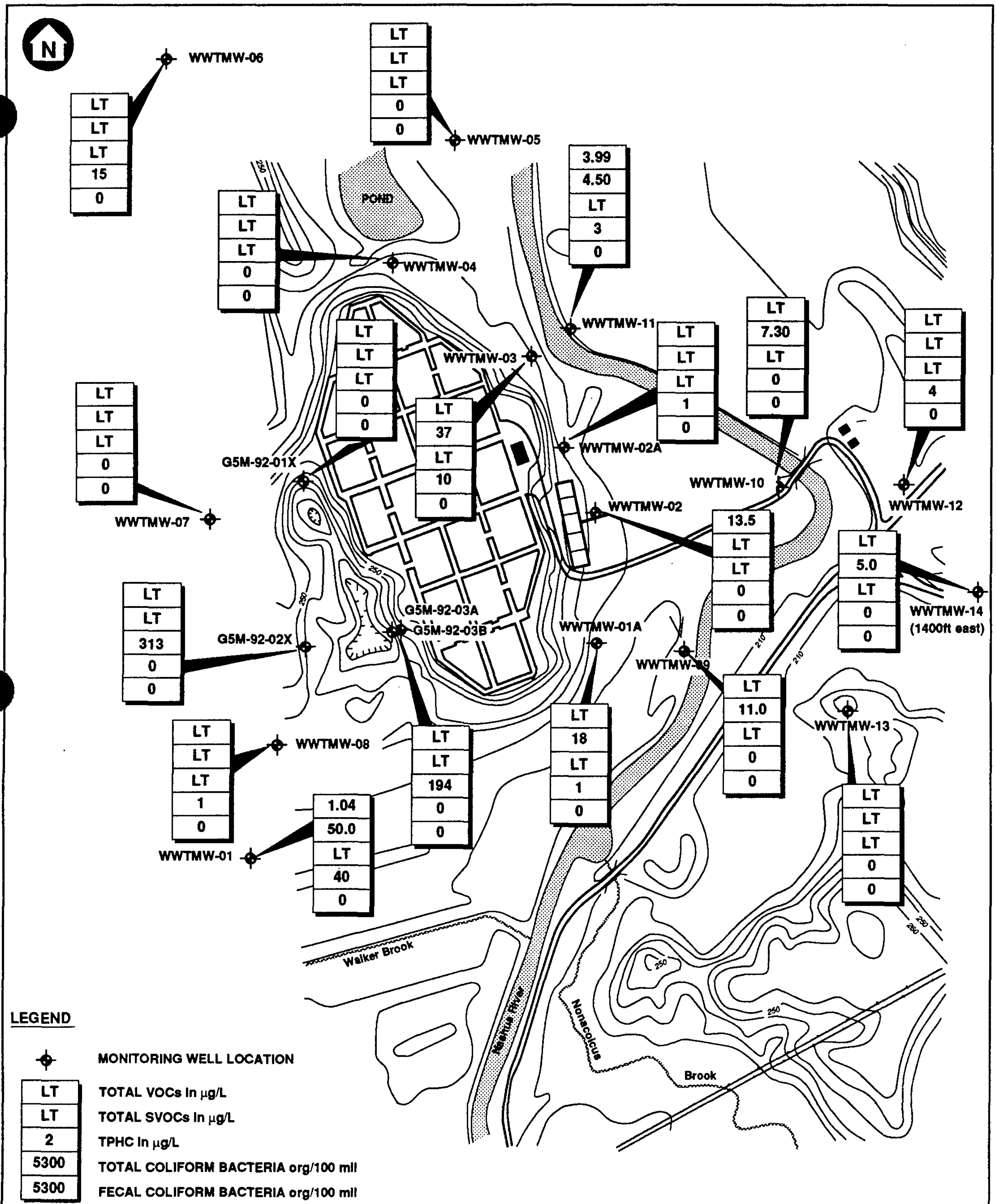
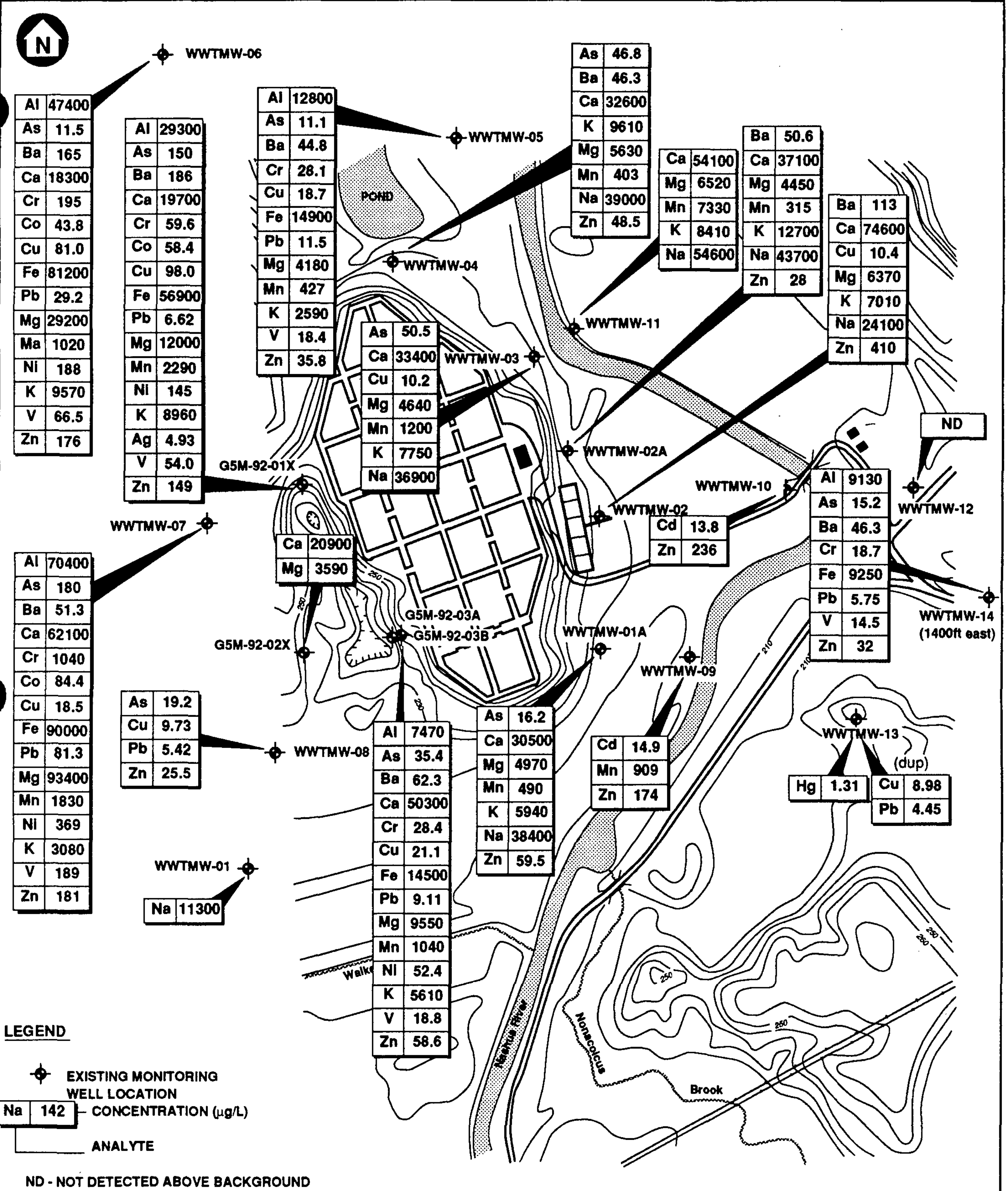


FIGURE 5-8
ROUND 2 ORGANIC COMPOUNDS AND
COLIFORM BACTERIA IN GROUNDWATER
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.



LEGEND

⌖ EXISTING MONITORING WELL LOCATION

Na 142 — CONCENTRATION (µg/L)

ANALYTE

ND - NOT DETECTED ABOVE BACKGROUND

NOTE: NITROGLYCERINE DETECTED AT 140 µg/LIN WWTMW-11 AND 2,4-DINITROTOLUENE DETECTED AT 0.131 ug/L IN WWTMW-02.

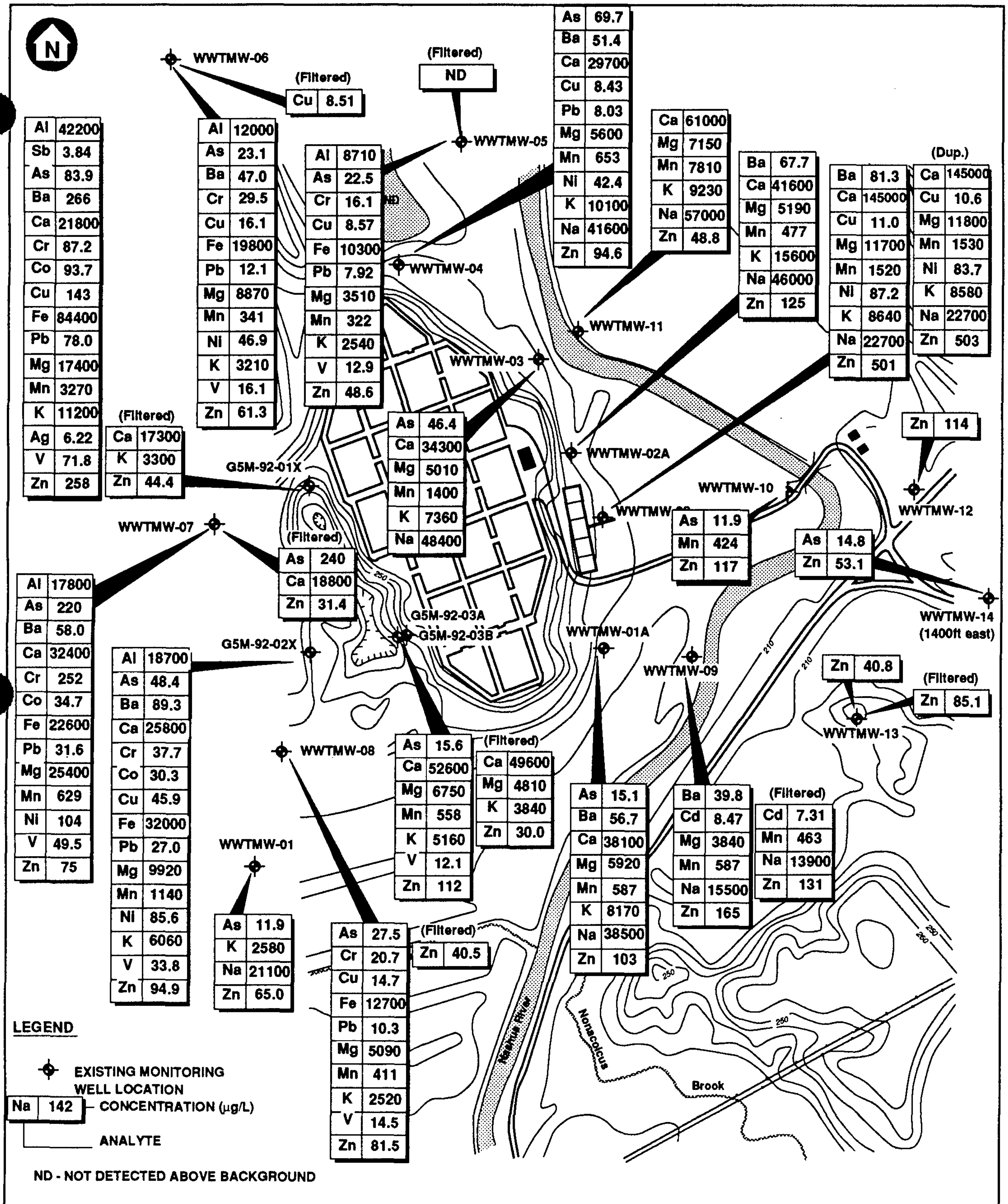
SCALE IN FEET

0 600 1,200

FIGURE 5-9
ROUND 1 INORGANIC ANALYTES IN GROUNDWATER ABOVE BACKGROUND
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(c)1 C



ND - NOT DETECTED ABOVE BACKGROUND

NOTE: NITROGLYCERINE DETECTED AT 63.5 µg/L in WWTMW-11.

SCALE IN FEET
0 600 1,200

FIGURE 5-10
ROUND 2 INORGANIC ANALYTES IN GROUNDWATER ABOVE BACKGROUND
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(c)1 J

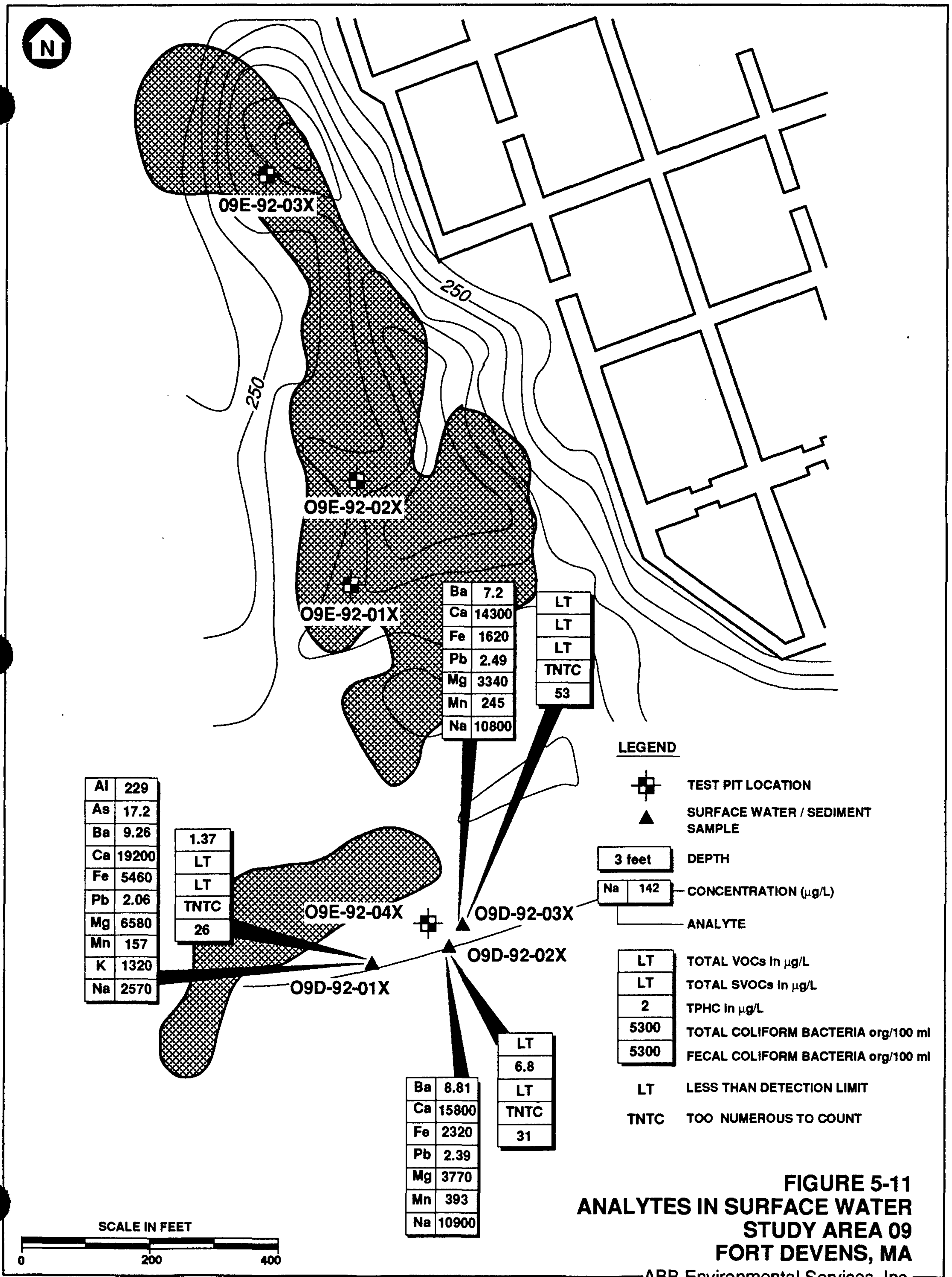


FIGURE 5-11
ANALYTES IN SURFACE WATER
STUDY AREA 09
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(k) 1 2 5

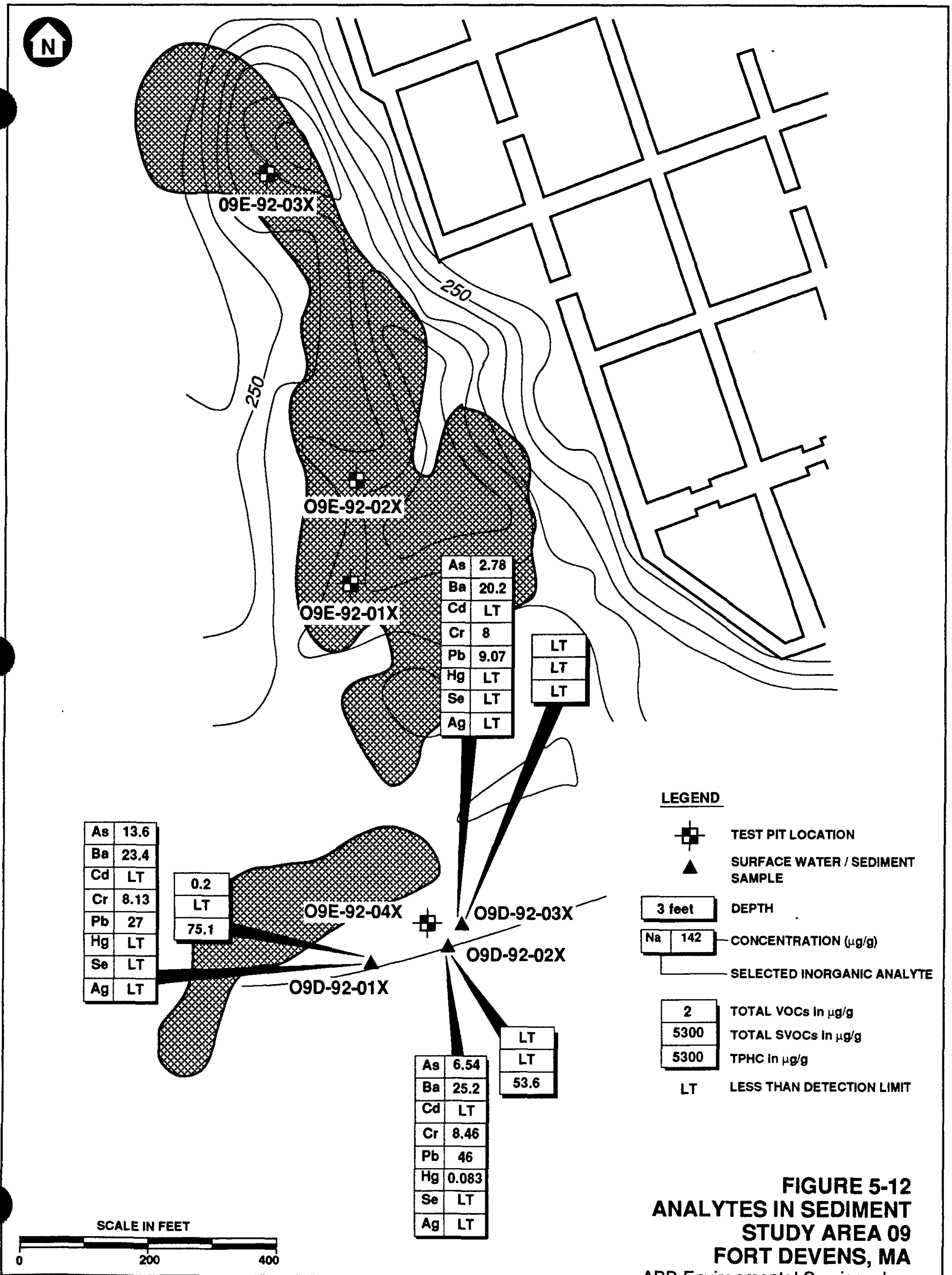


FIGURE 5-12
ANALYTES IN SEDIMENT
STUDY AREA 09
FORT DEVENS, MA

ABB Environmental Services, Inc.

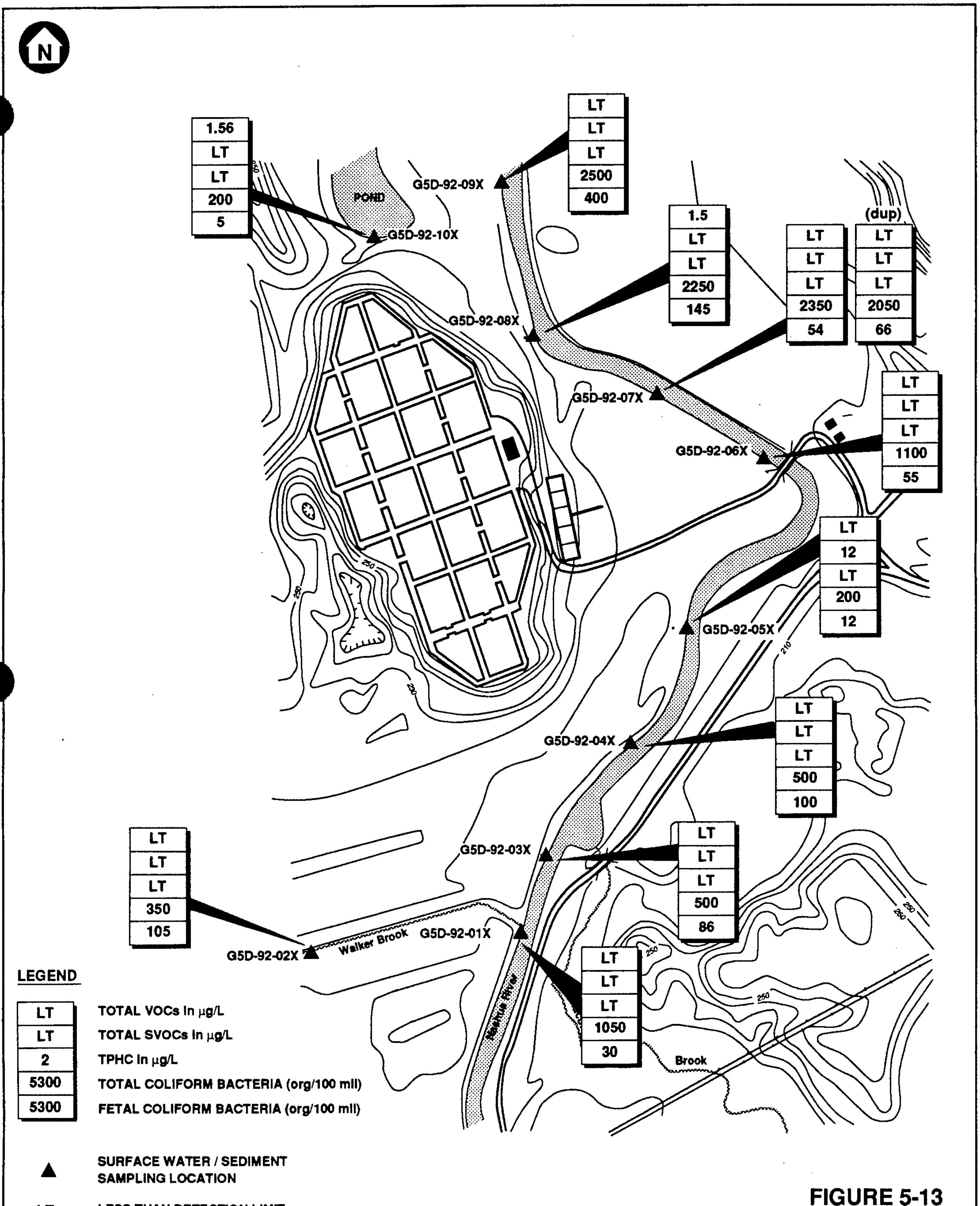
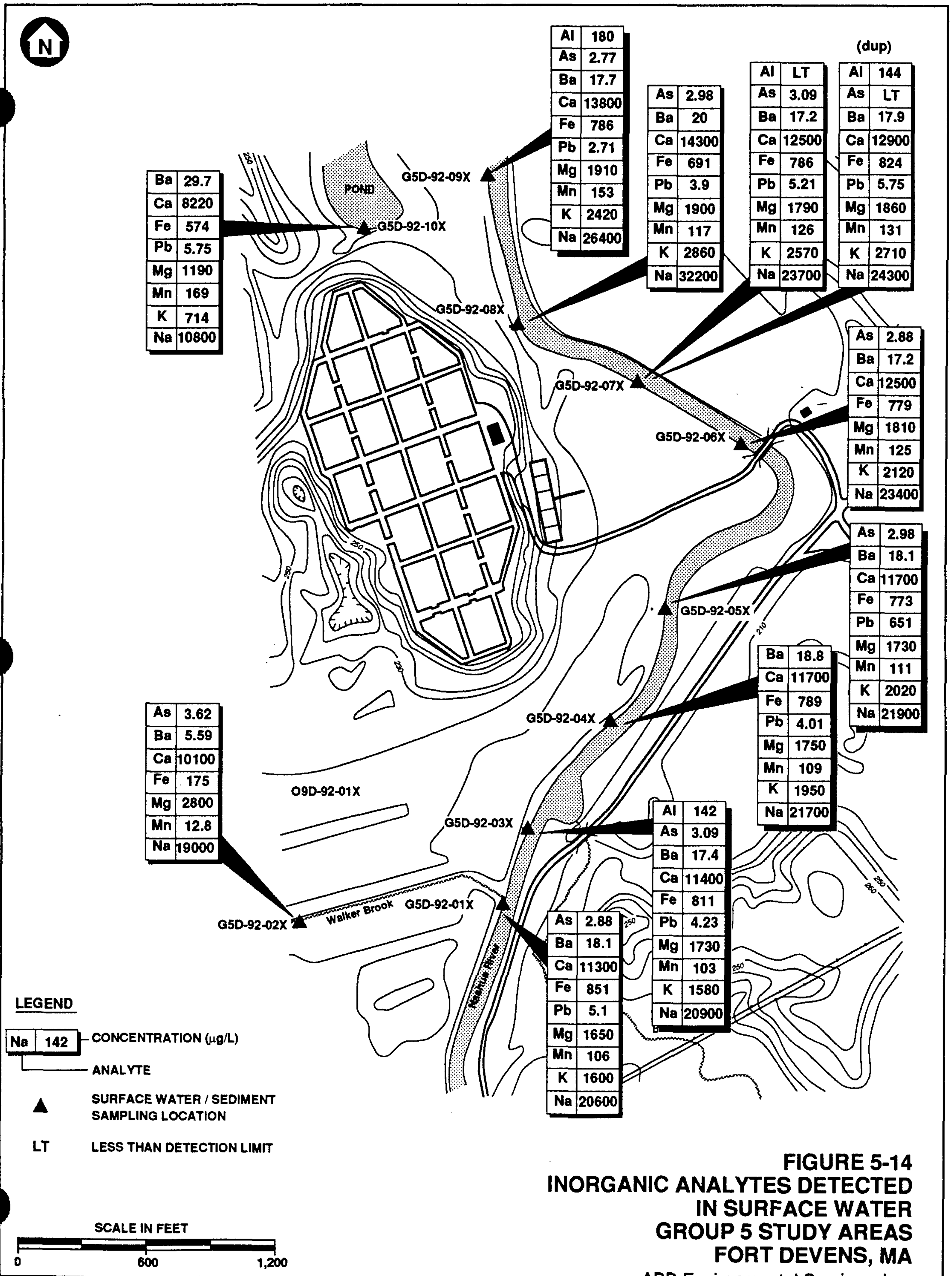


FIGURE 5-13
ORGANIC COMPOUNDS AND COLIFORM BACTERIA IN SURFACE WATER GROUP 5 STUDY AREAS FORT DEVENS, MA

ABB Environmental Services, Inc.



LEGEND

Na 142 — CONCENTRATION (µg/L)

ANALYTE

▲ SURFACE WATER / SEDIMENT SAMPLING LOCATION

LT LESS THAN DETECTION LIMIT

FIGURE 5-14
INORGANIC ANALYTES DETECTED
IN SURFACE WATER
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

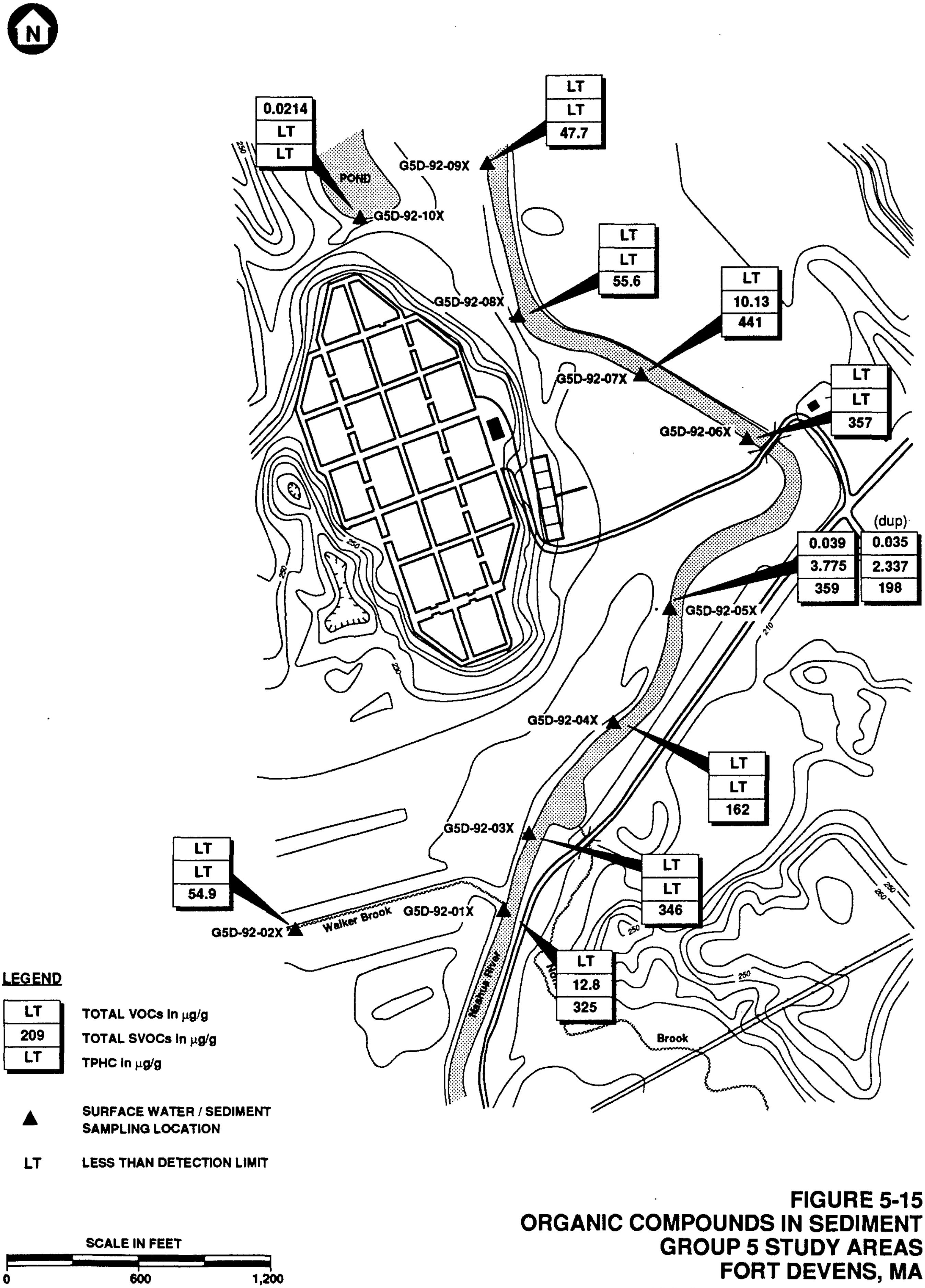


FIGURE 5-15
ORGANIC COMPOUNDS IN SEDIMENT
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

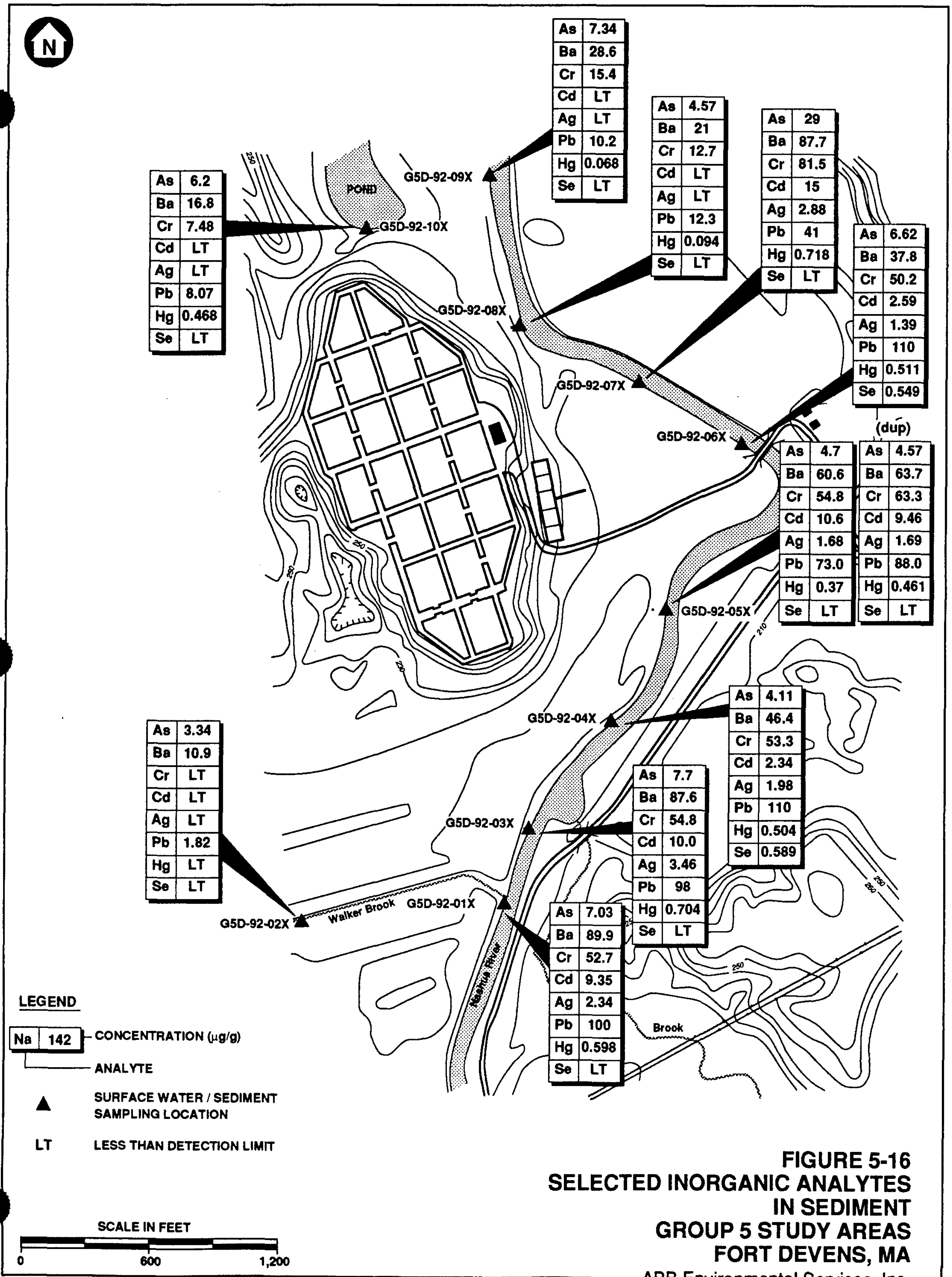


FIGURE 5-16
SELECTED INORGANIC ANALYTES
IN SEDIMENT
GROUP 5 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

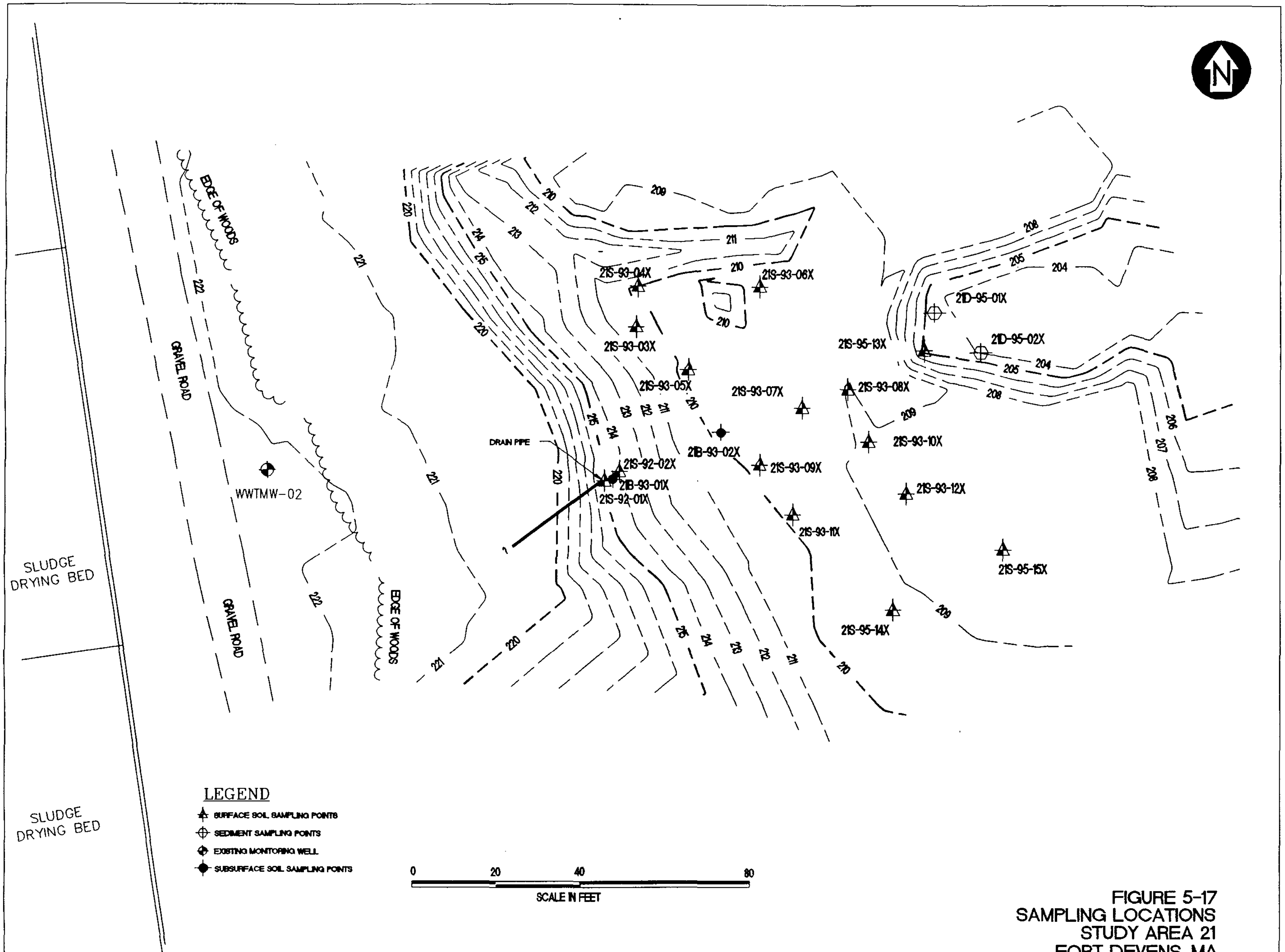
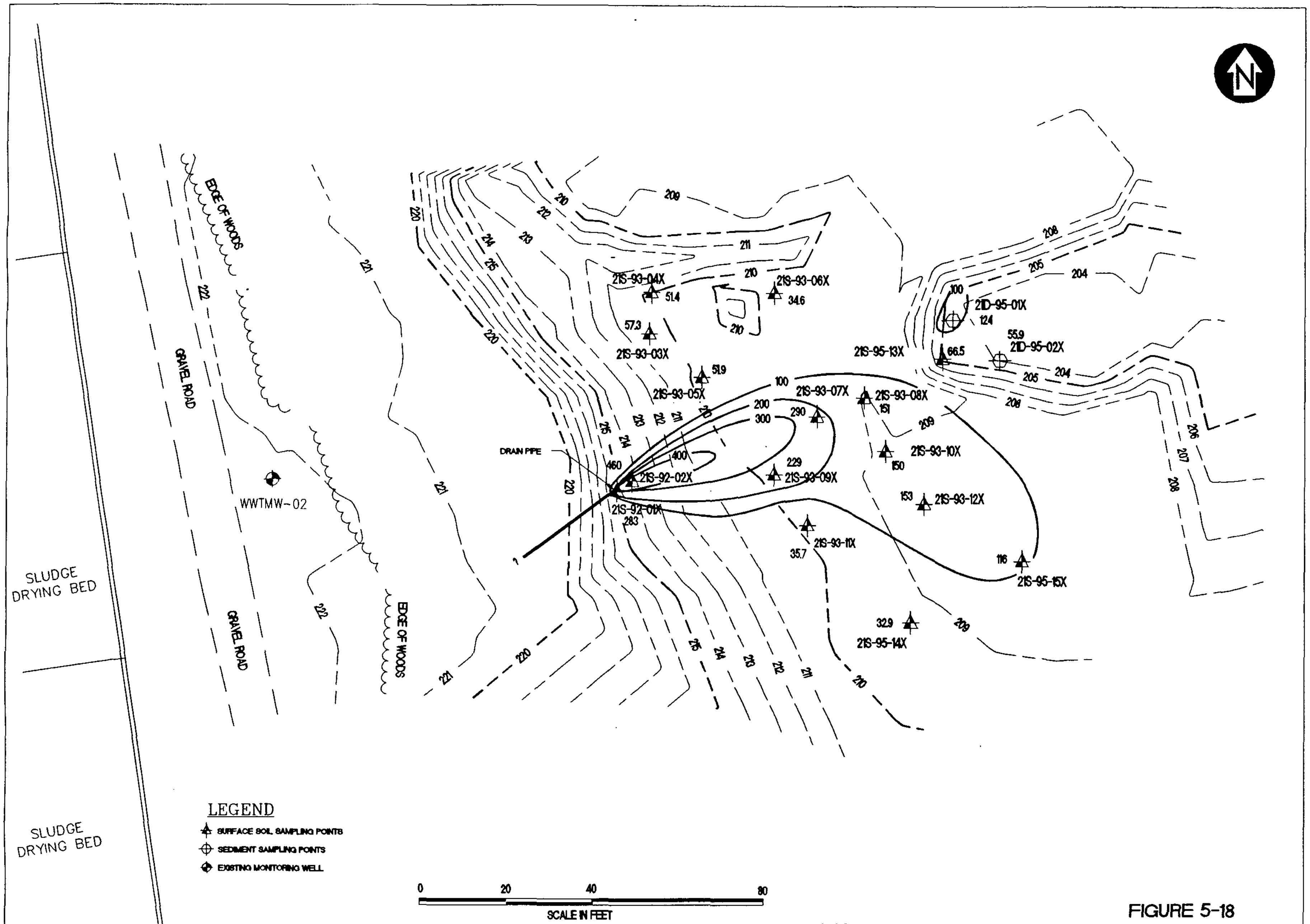


FIGURE 5-17
SAMPLING LOCATIONS
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

Source of topography: MEA.

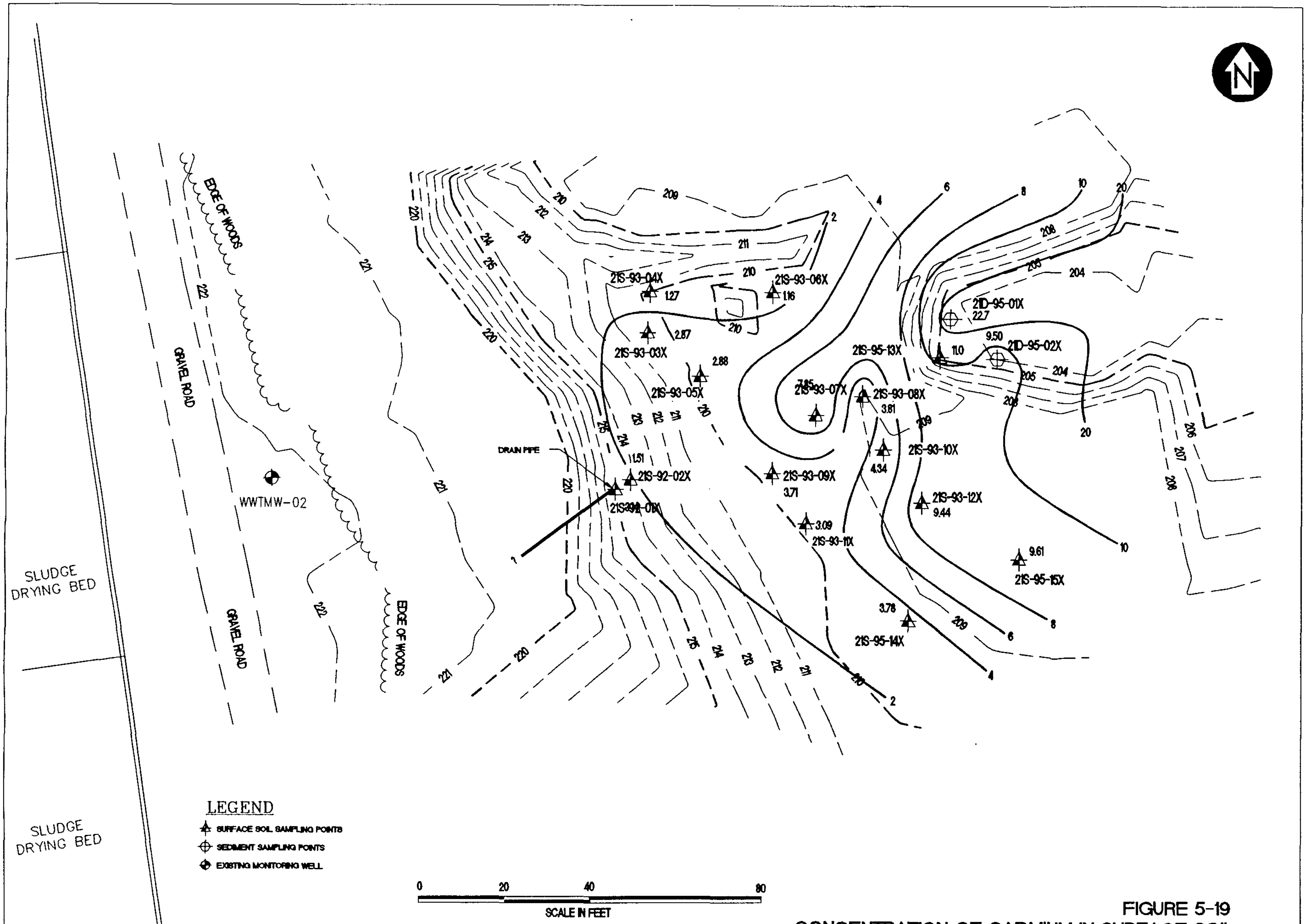


ANALYTE CONCENTRATIONS IN ug/L

Source of topography: MEA.

FIGURE 5-18
CONCENTRATION OF BARIUM IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.



ANALYTE CONCENTRATIONS IN ug/L

FIGURE 5-19
CONCENTRATION OF CADMIUM IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

Source of topography: MEA.

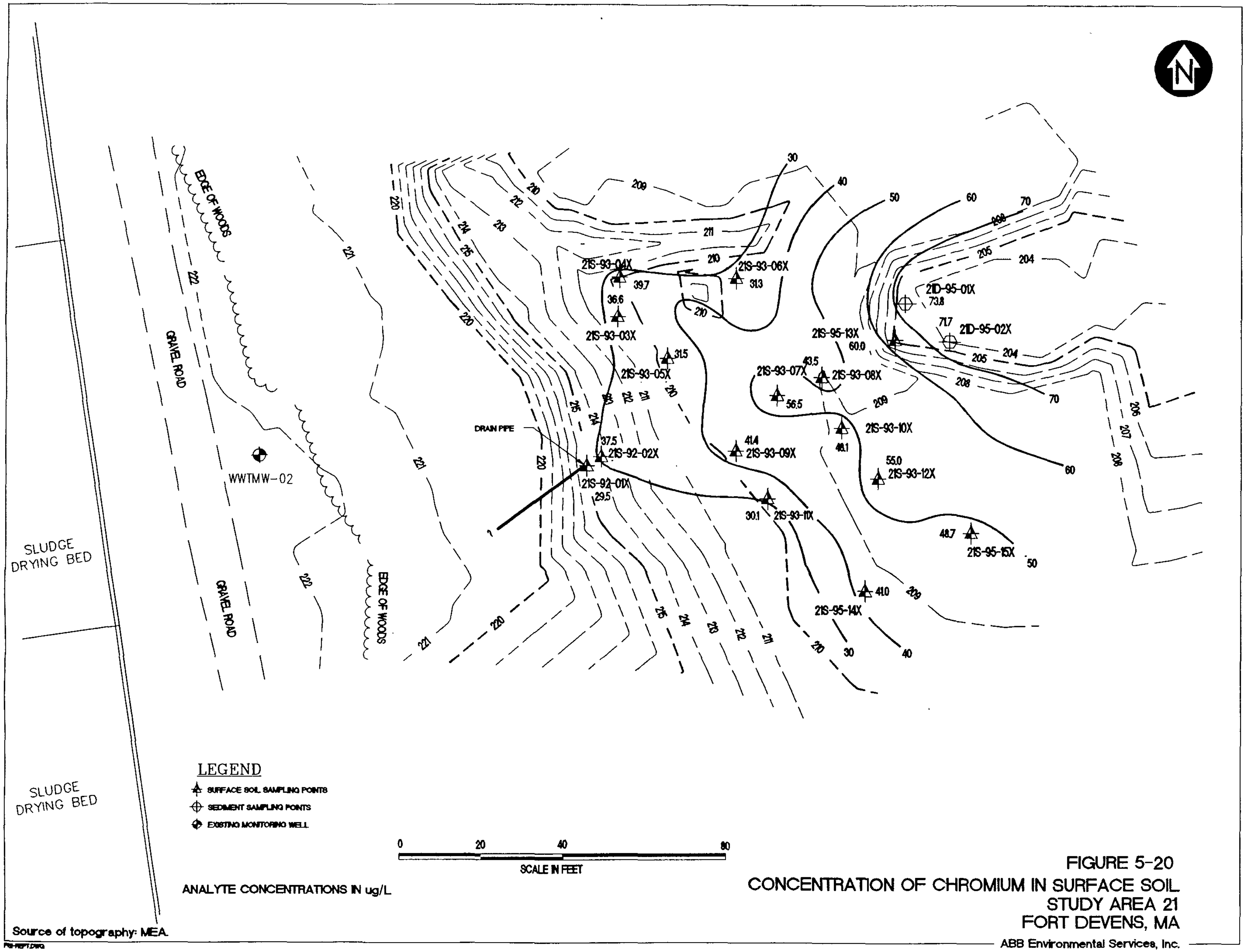
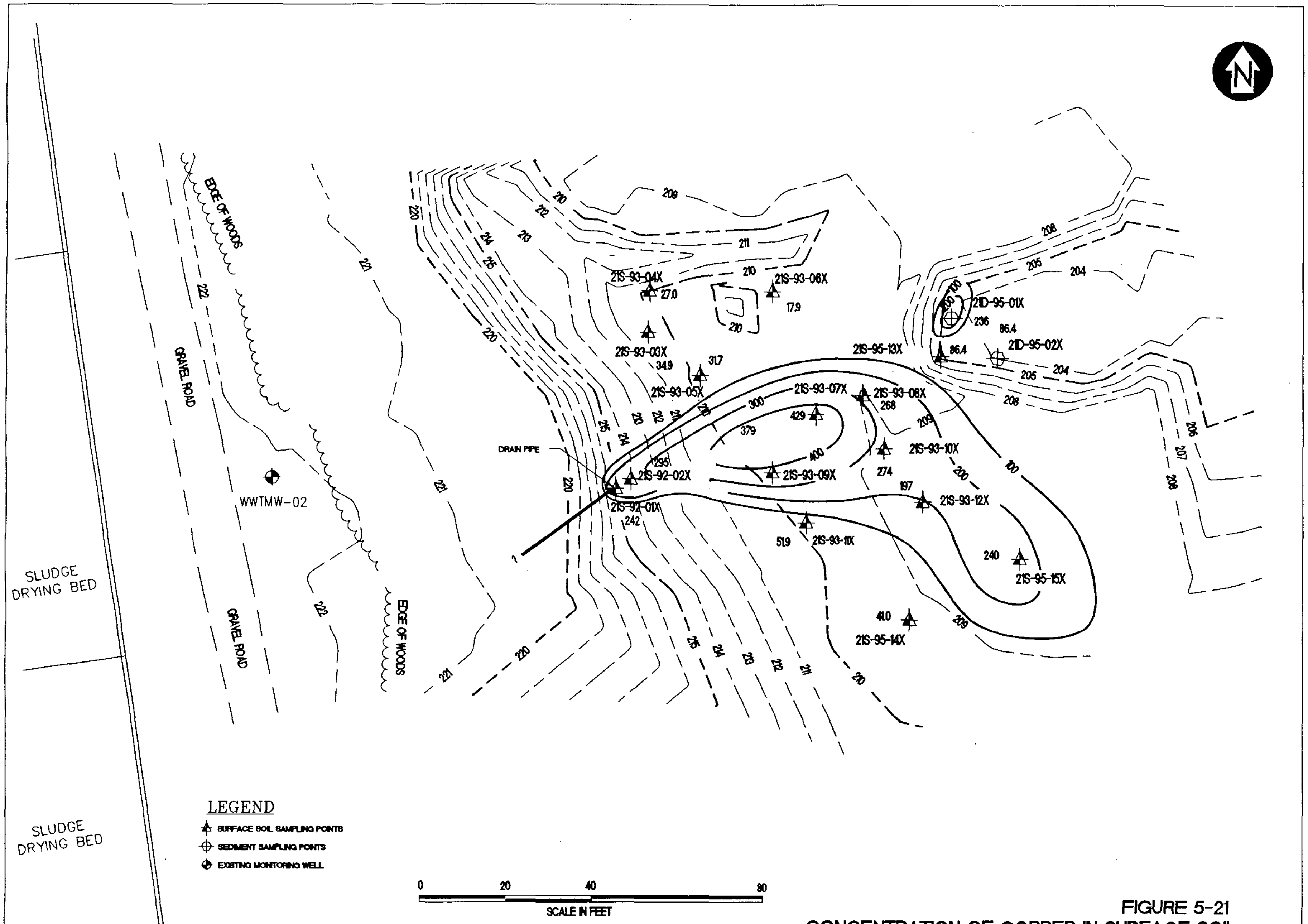


FIGURE 5-20
CONCENTRATION OF CHROMIUM IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

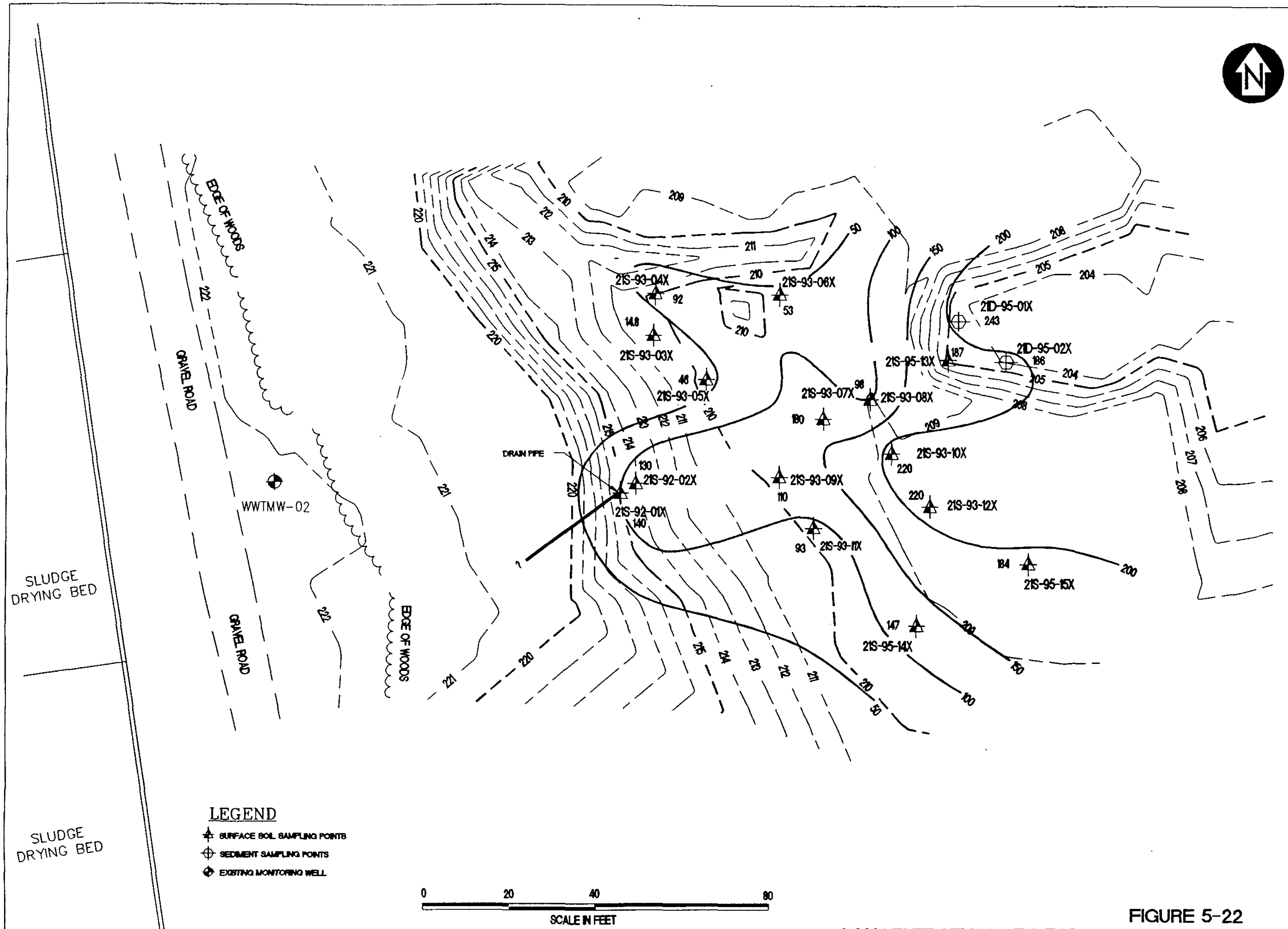


ANALYTE CONCENTRATIONS IN ug/L

Source of topography: MEA.

FIGURE 5-21
CONCENTRATION OF COPPER IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

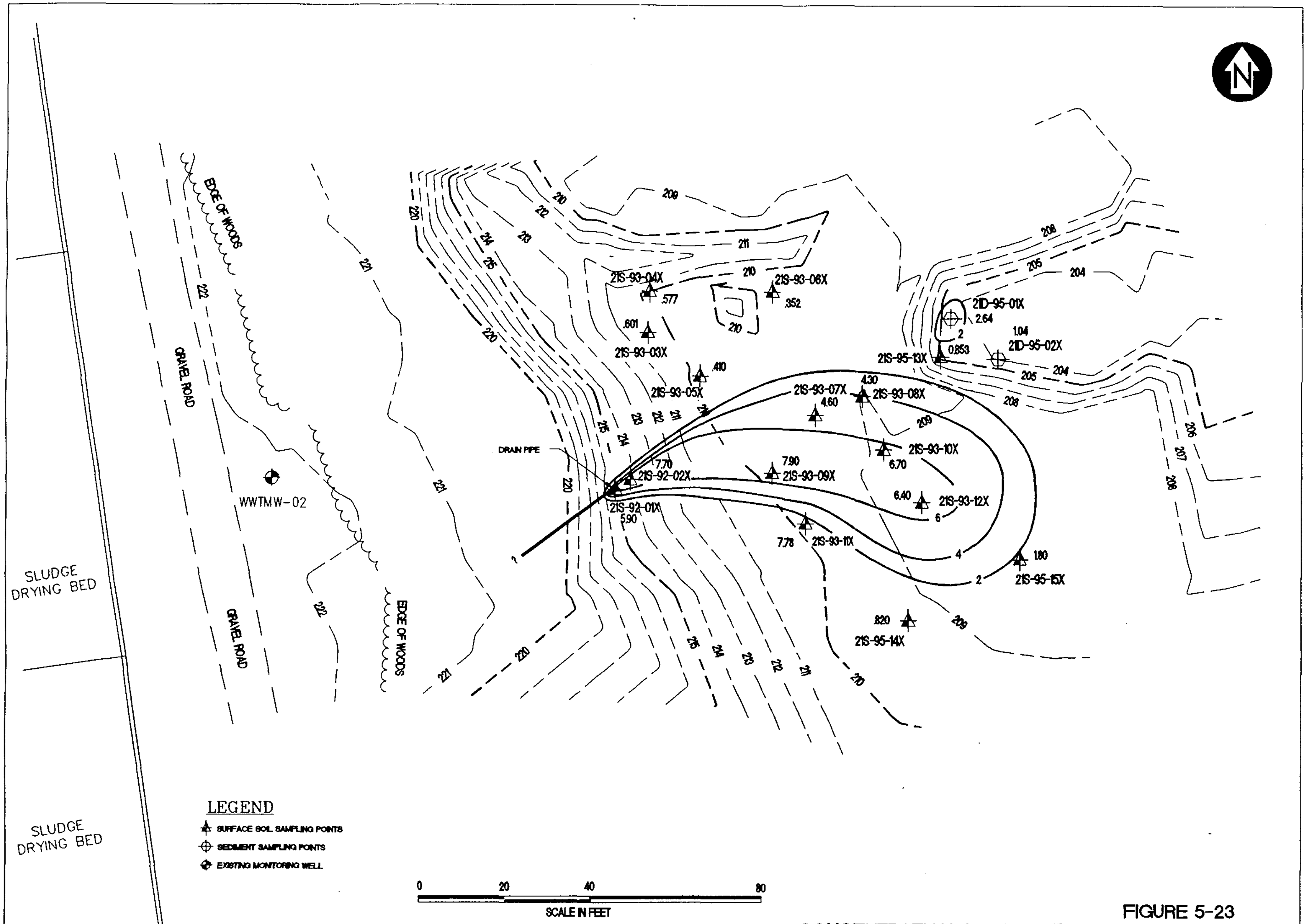


ANALYTE CONCENTRATIONS IN ug/L

Source of topography: MEA.

FIGURE 5-22
CONCENTRATION OF LEAD IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

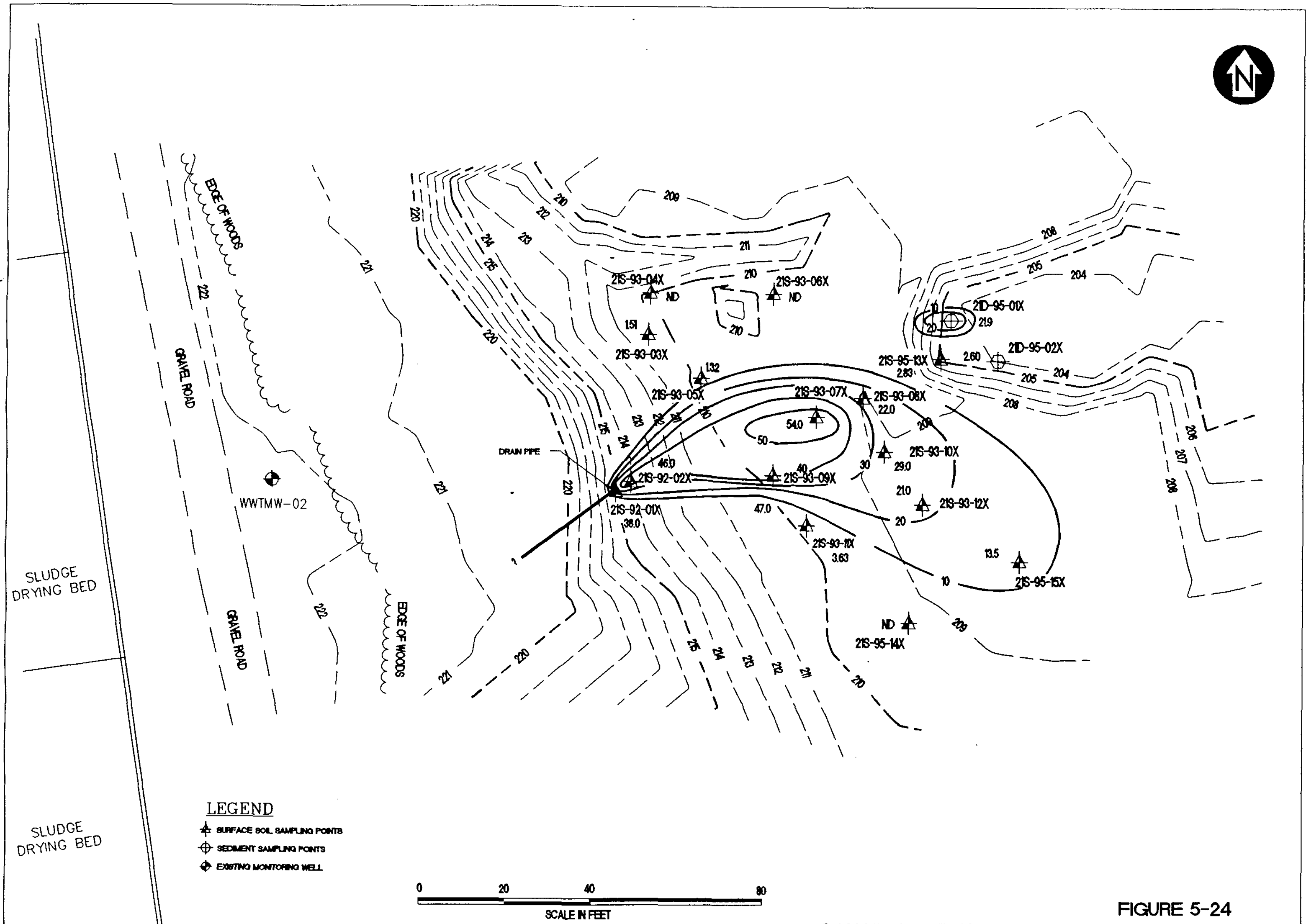


ANALYTE CONCENTRATIONS IN ug/L

FIGURE 5-23
CONCENTRATION OF MERCURY IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

Source of topography: MEA.



ANALYTE CONCENTRATIONS IN ug/L

Source of topography: MEA.

FIGURE 5-24
CONCENTRATION OF SILVER IN SURFACE SOIL
STUDY AREA 21
FORT DEVENS, MA

ABB Environmental Services, Inc.

TABLE 5-1
SOIL CLASSIFICATION OF SEDIMENT SAMPLES
GROUP 5 STUDY AREAS

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

SITE ID	SAMPLE ID	USCS SYMBOL	PERCENT SOLIDS	GRAVEL (1) DRY WT %	FINES (1) DRY WT %	COMMENTS
G5D-92-01X	DXG500100	SM	54.27	0.0	42.4	Trace organics
G5D-92-02X	DXG500200	SP	74.71	0.0	1.9	Standing water in jar
G5D-92-03X	DXG500300	SM	59.14	0.0	34.5	Sediment – organics
G5D-92-04X	DXG500400	SM	65.06	0.5	22.5	Little organics
G5D-92-05X	DXG500500	SM	63.51	0.0	16.8	Little organics
G5D-92-06X	DXG500600	SM	62.07	9.1	13.1	Little organics
G5D-92-07X	DXG500700	SM	51.68	0.0	32.3	Some organics
G5D-92-08X	DXG500800	SW-SM	78.33	12.3	5.1	
G5D-92-09X	DXG500900	SM	75.46	0.0	27.2	Little organics
G5D-92-10X	DXG501000	SW-SM	76.15	16.4	6.4	Trace organics
09D-92-01X	DX090100	SM	65.85	6.4	18.2	Little organics
09D-92-02X	DX090200	SM	66.26	0.0	44.9	Trace organics
09D-92-03X	DX090300	SP-SM	81.43	4.4	10.6	

NOTE (1) WT % OF SOIL FRACTION = 100 x DRY WEIGHT OF SOIL FRACTION / TOTAL DRY WEIGHT OF SOIL

TABLE 5-2
ANALYTES IN TEST PIT SOILS
SA 09 – NORTH POST LANDFILL

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	TEST PIT	09E-92-01X		09E-92-02X			09E-92-03X			09E-92-04X
		DEPTH	4	8	5	8	8D	1	5	9	3
ORGANICS (ug/g)											
2-METHYLNAPHTHALENE			<0.100	<0.200	3.00	<2.00	<2.00	<0.049	<1.00	<0.200	<0.049
ACENAPHTHENE			<0.070	2.00	20.0	<2.00	<2.00	<0.036	<0.700	<0.200	<0.036
ACENAPHTHYLENE			<0.070	0.300	<2.00	<2.00	<2.00	<0.033	<0.700	<0.200	<0.033
ANTHRACENE			<0.070	1.00	30.0	<2.00	<2.00	<0.033	<0.700	<0.200	<0.033
BENZO(A)ANTHRACENE			0.400	3.00	40.0	<8.00	<8.00	<0.017	<3.00	<0.800	<0.170
BENZO(A)PYRENE			<0.500	4.00	40.0	<10.0	<10.0	<0.250	<5.00	<1.00	<0.250
BENZO(B)FLUORANTHENE			<0.400	4.00	40.0	<10.0	<10.0	<0.210	<4.00	<1.00	<0.210
BENZO(G,H,I)PERYLENE			<0.500	2.00	20.0	<10.0	<10.0	<0.250	<5.00	<1.00	<0.250
BENZO(K)FLUORANTHENE			0.200	2.00	30.0	<3.00	<3.00	<0.066	<1.00	<0.300	<0.066
CARBAZOLE			ND 0.070	0.900	20.0	ND 2.00	ND 2.00	ND 0.033	ND 0.700	ND 0.200	ND 0.033
CHRYSENE			0.500	4.00	40.0	<6.00	<6.00	<0.120	<2.00	<0.600	<0.120
DIBENZOFURAN			<0.070	0.700	10.0	<2.00	<2.00	<0.035	<0.700	<0.200	<0.035
FLUORANTHENE			1.00	10.0	100	<3.00	<3.00	<0.068	<1.00	<0.300	<0.068
FLUORENE			<0.070	1.00	20.0	<2.00	<2.00	<0.033	<0.700	<0.200	<0.033
INDENO(1,2,3-C,D)PYRENE			<0.600	3.00	20.0	<10.0	<10.0	<0.029	<6.000	<1.00	<0.290
NAPHTHALENE			<0.070	1.00	20.0	<2.00	<2.00	<0.037	<0.700	<0.200	<0.037
PHENANTHRENE			0.200	6.00	100	<2.00	<2.00	<0.033	<0.700	<0.200	<0.033
PYRENE			0.800	6.00	70.0	<2.00	<2.00	<0.033	<0.700	<0.200	<0.033
TPHC			189	594	1230	5200	5300	<27.7	243	66.4	<27.7
INORGANICS (ug/g)											
ALUMINUM	15000		5690	6140	6860	7940	8660	4090	8910	4840	4660
ANTIMONY	NA		<1.09	<1.09	<1.09	<1.09	3.03	<1.09	<1.09	<1.09	<1.09
ARSENIC	21		12.0	18.0	12.7	17.0	12.8	20.0	15.0	21.0	18.0
BARIUM	42.5		223	69.5	52.2	64.2	71.8	22.3	45.2	19.9	20.5
BERYLLIUM	0.347		<0.500	<0.500	<0.500	0.926	1.00	<0.500	0.982	<0.500	<0.500
CADMIUM	2.00		1.41	1.55	<0.700	1.65	<0.700	<0.700	<0.700	<0.700	<0.700
CALCIUM	1400		924	5120	4230	7500	5500	327	1520	733	624
CHROMIUM	31		16.2	17.3	18.0	30.0	31.4	8.63	32.0	7.83	13.5
COBALT	NA		3.37	4.16	4.47	5.64	5.77	3.10	5.30	2.91	3.03
COPPER	8.39		19.1	22.1	9.49	28.5	20.4	7.73	11.9	7.56	17.1
IRON	15000		8530	11500	10600	13700	13400	6160	11800	7620	7220
LEAD	48.4		89.0	130	130	260	190	7.91	33.0	13.0	81.0
MAGNESIUM	5600		2370	2880	3010	3590	4360	1430	4330	1580	2180
MANGANESE	300		127	156	181	177	171	94.5	176	141	78.2
MERCURY	0.22		0.0614	0.154	0.11	0.176	0.124	<0.050	<0.050	<0.050	<0.050
NICKEL	14.0		12.6	14.0	15.7	23.2	23.6	9.81	20.8	9.50	16.3
POTASSIUM	1700		559	751	607	577	1070	426	1810	418	509
SILVER	0.086		0.786	<0.589	<0.589	<0.589	<0.589	<0.589	<0.589	<0.589	<0.589
SODIUM	131		177	229	205	204	291	180	242	214	212
VANADIUM	28.7		9.58	12.2	11.4	21.0	22.2	6.19	19.6	5.77	8.26
ZINC	35.5		277	305	206	305	271	19.7	87.9	22.5	23.2

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

SA09PITS.WK1
06/16/95

TABLE 5-3
ORGANIC COMPOUNDS IN GROUNDWATER - ROUND 1 (July 1992)
GROUP 5 GROUNDWATER MONITORING WELLS

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	G5M-92-01X	G5M-92-02X	G5M-92-03B	WWTMW-01	WWTMW-01A	WWTMW-02	WWTMW-02A	WWTMW-03	WWTMW-04	WWTMW-05
ORGANICS (ug/L)										
ACETONE	<13.0	<13.0	<13.0	<13.0	<13.0	18.0	<13.0	<13.0	<13.0	<13.0
BIS(2-ETHYLHEXYL)THPHALATE	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80
CARBON TETRACHLORIDE	<0.580	<0.580	<0.580	<0.580	<0.580	1.40	<0.580	<0.580	<0.580	<0.580
CHLOROFORM	0.585	<0.500	<0.500	<0.500	<0.500	1.60	<0.500	<0.500	<0.500	<0.500
TOLUENE	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.540	<0.500	<0.500	<0.500
1,1,1-TRICHLOROETHANE	<0.500	<0.500	<0.500	<0.500	<0.500	2.20	<0.500	<0.500	<0.500	<0.500
TRICHLOROETHENE	<0.500	<0.500	<0.500	<0.500	<0.500	14.0	<0.500	<0.500	<0.500	<0.500
TOTAL PETROLEUM HYDROCARBONS	<200	209	<200	<200	<200	<200	<200	<200	<200	<200
COLIFORM BACTERIA										
TOTAL (org/100ml)	20	1	0	0	0	7	100	<50	<50	<50
FECAL (org/100ml)	0	0	0	0	0	0	<10	<10	<10	<10

ANALYTE	WWTMW-06	WWTMW-07	WWTMW-08	WWTMW-09	WWTMW-10	WWTMW-11	WWTMW-12	WWTMW-13	WWTMW-13D	WWTMW-14
ORGANICS (ug/L)										
ACETONE	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0
BIS(2-ETHYLHEXYL)THPHALATE	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80	7.20	<4.80	<4.80	<4.80
CARBON TETRACHLORIDE	<0.580	<0.580	<0.580	<0.580	<0.580	<0.580	<0.580	<0.580	<0.580	<0.580
CHLOROFORM	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
TOLUENE	<0.500	<0.500	<0.500	<0.500	<0.500	0.560	<0.500	<0.500	<0.500	<0.500
1,1,1-TRICHLOROETHANE	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500
TRICHLOROETHENE	<0.500	<0.500	<0.500	<0.500	<0.500	<1.200	<1.200	<0.500	<0.500	<0.500
TOTAL PETROLEUM HYDROCARBONS	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
COLIFORM BACTERIA										
TOTAL (org/100ml)	<50	0	0	17	50	0	0	0	0	0
FECAL (org/100ml)	<10	0	0	0	0	0	0	0	0	0

NOTES: TABLE LIST DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

TABLE 5–4
ORGANIC COMPOUNDS IN GROUNDWATER – ROUNDS 2 & 3 (Oct 1992/Jan 1993)
GROUP 5 GROUNDWATER MONITORING WELLS

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTES	G5M–92–01X	G5M–92–01X filter'd	G5M–92–02X	G5M–92–03B	G5M–92–03B filter'd	WWTMW–01	WWTMW–01A	WWTMW–02	WWTMW–02 dup	WWTMW–02A	WWTMW–03	WWTMW–04	WWTMW–05	WWTMW–05 filter'd
ORGANICS (ug/L)														
BIS(2–EH)PHTHALATE	< 4.80	NA	< 4.80	< 4.80	NA	50.0	18.0	< 4.80	< 4.80	< 4.80	37.0	< 4.80	< 4.80	NA
CARBON TETRACHLORIDE	< 0.580	NA	< 0.580	< 0.580	NA	< 0.580	< 0.580	< 0.580	0.870	< 0.580	< 0.580	< 0.580	< 0.580	NA
CHLOROFORM	< 0.500	NA	< 0.500	< 0.500	NA	< 0.500	< 0.500	1.80	2.70	< 0.500	< 0.500	< 0.500	< 0.500	NA
TOLUENE	< 0.500	NA	< 0.500	< 0.500	NA	1.04	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	< 0.500	NA
1,1,1–TRICHLOROETHANE	< 0.500	NA	< 0.500	< 0.500	NA	< 0.500	< 0.500	1.40	1.00	< 0.500	< 0.500	< 0.500	< 0.500	NA
TRICHLOROETHYLENE	< 0.500	NA	< 0.500	< 0.500	NA	< 0.500	< 0.500	10.3	10.3	< 0.500	< 0.500	< 0.500	< 0.500	NA
TPHC	< 199	NA	313	194	NA	< 188	< 185	< 197	< 192	< 180	< 190	< 201	< 184	NA
COLIFORM BACTERIA (org/100ml)														
TOTAL	0	NA	0	0	NA	40	1	0	NA	1	10	0	0	NA
FECAL	0	NA	0	0	NA	0	0	0	NA	0	0	0	0	NA

ANALYTES	WWTMW–06	WWTMW–06 filter'd	WWTMW–07	WWTMW–07 filter'd	WWTMW–08	WWTMW–08 filter'd	WWTMW–09	WWTMW–09 filter'd	WWTMW–10	WWTMW–11	WWTMW–12	WWTMW–13	WWTMW–13 filter'd	WWTMW–14
ORGANICS (ug/L)														
BIS(2–EH)PHTHALATE	< 4.80	NA	< 4.80	NA	< 4.80	NA	11.0	NA	7.30	4.50	< 4.80	< 4.80	NA	5.00
CARBON TETRACHLORIDE	< 0.580	NA	< 0.580	NA	< 0.580	NA	< 0.580	NA	< 0.580	< 0.580	< 0.580	< 0.580	NA	< 0.580
CHLOROFORM	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	< 0.500	< 0.500	< 0.500	NA	0.660
TOLUENE	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	3.99	< 0.500	< 0.500	NA	< 0.500
1,1,1–TRICHLOROETHANE	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	< 0.500	< 0.500	< 0.500	NA	< 0.500
TRICHLOROETHYLENE	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	NA	< 0.500	< 0.500	< 0.500	< 0.500	NA	< 0.500
TPHC	< 206	NA	< 190	NA	< 182	NA	< 201	NA	< 192	< 182	< 190	< 183	NA	< 188
COLIFORM BACTERIA (org/100ml)														
TOTAL	15	NA	0	NA	1	NA	0	NA	0	3	4	0	NA	0
FECAL	0	NA	0	NA	0	NA	0	NA	0	0	0	0	NA	0

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

OG5WELS2.WK1
06/16/95

TABLE 5-5
INORGANIC ANALYTES IN GROUNDWATER - ROUND 1 (July 1992)
GROUP 5 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	G5M-92-01X	G5M-92-02X	G5M-92-03B	WWTMW-01	WWTMW-01A	WWTMW-02	WWTMW-02A	WWTMW-03	WWTMW-04	WWTMW-05
INORGANICS (ug/L)											
ALUMINUM	6870	29300	1430	7470	2330	228	1760	811	287	2970	12800
ARSENIC	10.5	150	7.57	35.4	9.81	16.2	6.08	<2.54	50.5	46.8	11.1
BARIUM	39.6	186	21.3	62.3	12.4	28.5	113	50.6	33.0	46.3	44.8
CADMIUM	4.01	<4.01	<4.01	<4.01	<4.01	<4.01	<4.01	<4.01	<4.01	<4.01	<4.01
CALCIUM	14700	19700	20900	50300	7140	30500	74600	37100	33400	32600	4440
CHROMIUM	14.7	59.6	<6.02	28.4	6.04	8.01	6.32	7.86	<6.02	6.46	28.1
COBALT	25.0	58.4	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
COPPER	8.09	98.0	<8.09	21.1	<8.09	<8.09	10.4	<8.09	10.2	<8.09	18.7
IRON	9100	56900	2330	14500	3250	356	1350	1560	266	3040	14900
LEAD	4.25	6.62	2.28	9.11	1.95	<1.26	1.41	2.93	1.84	3.58	11.5
MAGNESIUM	3480	12000	3590	9550	1890	4970	6370	4450	4640	5630	4180
MANGANESE	291	2290	81.8	1040	75.4	490	267	315	1200	403	427
MERCURY	0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243
NICKEL	34.3	145	<34.3	52.4	<34.3	<34.3	<34.3	<34.3	<34.3	<34.3	<34.3
POTASSIUM	2370	8960	2370	5610	1980	5940	7010	12700	7750	9610	2590
SILVER	4.60	4.93	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60
SODIUM	10800	3620	1830	3510	11300	38400	24100	43700	36900	39000	2370
VANADIUM	11.0	54.0	<11.0	18.8	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	18.4
ZINC	21.1	149	<21.1	58.6	<21.1	59.5	410	28	<21.1	48.5	35.8
EXPLOSIVES (ug/L)											
NITROGLYCERINE		<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
2,4 - DINITROTOLUENE		< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	0.131	< 0.064	< 0.064	< 0.064	< 0.064
ANIONS/CATIONS (ug/L)											
BICARBONATE		40.3	31700	28100	42700	40300	22000	84200	124000	40300	18300
CHLORIDE		<2120	<2120	<2120	3490	44000	31000	60000	60000	50000	<2120
SULFATE		<10000	<10000	23000	<10000	17900	138000	33800	24200	32700	<10000
NITRATE/NITRITE		200	1000	850	390	13000	19000	13000	4500	13000	15.7
KJELDAHL NITROGEN,TKN		210	<183	<183	<183	1140	3240	2480	9500	486	229
TOTAL PHOPHOROUS		990	79.2	178	82.2	356	54.4	60.4	1500	297	277
ALKALINITY		33000	26000	23000	35000	33000	18000	69000	102000	33000	15000
OTHER (ug/L)											
HARDNESS		54000	82000	70000	24000	56000	48000	120000	104000	106000	22000
TOTAL SUSPENDED SOLIDS		521000	57000	267000	20000	10000	6000	56000	12000	43000	373000

NOTES: TABLE LIST DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

TABLE 5–5
INORGANIC ANALYTES IN GROUNDWATER – ROUND 1 (July 1992)
GROUP 5 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK–GROUND	WWTMW–06	WWTMW–07	WWTMW–08	WWTMW–09	WWTMW–10	WWTMW–11	WWTMW–12	WWTMW–13	WWTMW–13D	WWTMW–14
INORGANICS (ug/L)											
ALUMINUM	6870	47400	70400	3320	1920	514	<141	<141	713	5570	9130
ARSENIC	10.5	11.5	180	19.2	5.76	10.4	<2.54	<2.54	3.20	7.57	15.2
BARIUM	39.6	165	51.3	25.1	39.6	27.8	5.62	<5.00	10.3	28.6	46.3
CADMIUM	4.01	<4.01	<4.01	<4.01	14.9	13.8	<4.01	<4.01	<4.01	<4.01	<4.01
CALCIUM	14700	18300	62100	11400	11700	7950	54100	9210	2920	3820	2560
CHROMIUM	14.7	195	1040	12.8	9.40	<6.02	<6.02	<6.02	6.46	13.8	18.7
COBALT	25.0	43.8	84.4	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0	<25.0
COPPER	8.09	81.0	18.5	9.73	<8.09	<8.09	<8.09	<8.09	<8.09	8.98	<8.09
IRON	9100	81200	90000	6320	3590	3720	<38.8	47.5	886	6770	9250
LEAD	4.25	29.2	81.3	5.42	2.60	1.52	<1.26	<1.26	1.84	4.45	5.75
MAGNESIUM	3480	29200	93400	3090	3440	1300	6520	1340	618	2160	1970
MANGANESE	291	1020	1830	195	909	236	7330	3.08	53.7	154	226
MERCURY	0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	<0.243	1.31	<0.243	<0.243
NICKEL	34.3	188	369	<34.3	<34.3	<34.3	<34.3	<34.3	<34.3	<34.3	<34.3
POTASSIUM	2370	9570	3080	2150	885	835	8410	932	726	1440	1980
SILVER	4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60
SODIUM	10800	4240	2050	2360	9870	7050	54600	4340	4320	4900	2100
VANADIUM	11.0	66.5	189	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	<11.0	14.5
ZINC	21.1	176	181	25.5	174	236	<21.1	<21.1	<21.1	<21.1	32.0
EXPLOSIVES (ug/L)											
NITROGLYCERINE		<10.0	<10.0	<10.0	<10.0	<10.0	140	<10.0	<10.0	<10.0	<10.0
2,4 – DINITROTOLUENE		< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	< 0.064	< 0.064
ANIONS/CATIONS (ug/L)											
BICARBONATE		28100	7320	36600	34200	17100	283000	37800	12200	17100	9760
CHLORIDE		<2120	<2120	<2120	14600	7180	71000	<2120	6140	6000	<2120
SULFATE		<10000	<10000	<10000	19700	<10000	24700	<10000	<10000	<10000	<10000
NITRATE/NITRITE		<10.0	12.3	52.4	68.8	920	<10.0	1700	66.8	40.4	<10.0
KJELDAHL NITROGEN,TKN		<183	<183	<183	295	171	876	<183	<183	<183	171
TOTAL PHOPHOROUS		485	3000	140	96.0	71.3	<13.3	<13.3	248	99.0	109
ALKALINITY		23000	6000	30000	28000	14000	232000	31000	10000	14000	8000
OTHER (ug/L)											
HARDNESS		36000	48000	72000	46000	32000	178000	36000	18000	22000	10000
TOTAL SUSPENDED SOLIDS		503000	733000	143000	125000	15000	<4000	10000	30000	199000	25000

NOTES: TABLE LIST DETECETED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY

TABLE 5-6
INORGANIC ANALYTES IN GROUNDWATER – ROUNDS 2 & 3 (Oct 1992/Jan 1993)
GROUP 5 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTES	BACK–GROUND	G5M–92–01X	G5M–92–01X filter'd	G5M–92–02X	G5M–92–03B	G5M–92–03B filter'd	WWTMW–01	WWTMW–01A	WWTMW–02	WWTMW–02 dup	WWTMW–02A	WWTMW–03	WWTMW–04	WWTMW–05	WWTMW–05 filter'd
INORGANICS (ug/L)															
ALUMINUM	6870	42200	724	18700	3230	< 141	3900	208	650	680	2060	1110	6150	8710	< 141
ANTIMONY	3.03	3.84	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03
ARSENIC	10.5	83.9	4.26	48.4	15.6	< 2.54	11.9	15.1	< 2.54	< 2.54	8.85	46.4	69.7	22.5	< 2.54
BARIUM	39.6	266	18.8	89.3	30.8	13.1	21.9	56.7	81.3	122	67.7	38.1	51.4	33.4	< 5.00
CADMIUM	4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01
CALCIUM	14700	21800	17300	25800	52600	49600	12800	38100	145000	145000	41600	34300	29700	4330	3480
CHROMIUM	14.7	87.2	< 6.02	37.7	9.79	< 6.02	9.25	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	8.83	16.1	< 6.02
COBALT	25.0	93.7	< 25.0	30.3	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0
COPPER	8.09	143	< 8.09	45.9	< 8.09	< 8.09	< 8.09	< 8.09	11.0	10.6	< 8.09	< 8.09	8.43	8.57	< 8.09
IRON	9100	84400	1480	32000	5920	104	5720	276	300	368	3090	1040	7430	10300	< 38.8
LEAD	4.25	78.0	2.28	27.0	3.80	< 1.26	3.36	< 1.26	2.06	2.17	1.84	< 1.26	8.03	7.92	< 1.26
MAGNESIUM	3480	17400	1820	9920	6750	4810	3400	5920	11700	11800	5190	5010	5600	3510	1600
MANGANESE	291	3270	235	1140	558	178	142	587	1520	1530	477	1400	653	322	6.75
NICKEL	34.3	213	< 34.3	85.6	< 34.3	< 34.3	< 34.3	< 34.3	87.2	83.7	< 34.3	< 34.3	42.4	< 34.3	< 34.3
POTASSIUM	2370	11200	3300	6060	5160	3840	2580	8170	8640	8580	15600	7360	10100	2540	789
SILVER	4.60	6.22	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60
SODIUM	10800	4450	2640	3230	3630	3260	21100	38500	22700	22700	46000	48400	41600	2330	1890
VANADIUM	11.0	71.8	< 11.0	33.8	12.1	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	12.9	< 11.0
ZINC	21.1	258	44.4	94.9	112	30.0	65.0	103	501	503	125	< 21.1	94.6	48.6	< 21.1
EXPLOSIVES (ug/L)															
NITROGLYCERINE		< 10.0	NA	< 10.0	< 10.0	NA	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	NA
ANIONS/CATIONS (ug/L)															
BICARBONATE		50000	NA	98000	160000	NA	46000	105000	38000	33000	81000	144000	18000	149000	NA
CHLORIDE		< 2120	NA	< 2120	< 2120	NA	35000	52000	25400	25700	48000	60000	48000	< 2120	NA
SULFATE		< 10000	NA	< 10000	15000	NA	< 10000	19700	253000	253000	33700	13500	25200	< 10000	NA
NITRATE/NITRITE		107	NA	590	830	NA	360	21000	47000	68000	21000	5200	30000	45.5	NA
KJELDAHL NITROGEN		267	NA	590	276	NA	< 183	1520	771	819	2480	8600	657	< 183	NA
TOTAL PHOSPHOROUS		2000	NA	990	208	NA	139	347	24.8	21.8	139	990	990	590	NA
ALKALINITY		41000	NA	80000	131000	NA	38000	86000	31000	27000	66000	118000	15000	122000	NA
OTHER (ug/L)															
HARDNESS		57500	NA	75500	171000	NA	46800	116000	364000	414000	102000	94000	78000	15200	NA
TSS		1330000	NA	876000	156000	NA	153000	4000	5000	12000	46000	10100000	10200000	224000	NA

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

TABLE 5-6
INORGANIC ANALYTES IN GROUNDWATER - ROUNDS 2 & 3 (Oct 1992/Jan 1993)
GROUP 5 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTES	BACK-GROUND	WWTMW-06	WWTMW-06 filter'd	WWTMW-07	WWTMW-07 filter'd	WWTMW-08	WWTMW-08 filter'd	WWTMW-09	WWTMW-09 filter'd	WWTMW-10	WWTMW-11	WWTMW-12	WWTMW-13	WWTMW-13 filter'd	WWTMW-14
INORGANICS (ug/L)															
ALUMINUM	6870	12000	< 141	17800	< 141	6240	< 141	1200	< 141	326	< 141	155	1040	< 141	2920
ANTIMONY	3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03	< 3.03
ARSENIC	10.5	23.1	< 2.54	220	240	27.5	< 2.54	5.44	< 2.54	11.9	< 2.54	< 2.54	4.69	< 2.54	14.8
BARIUM	39.6	47.0	15.6	58.0	< 5.00	26.7	< 5.00	39.8	30.4	23.9	7.30	< 5.00	14.7	10.0	22.9
CADMIUM	4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	8.47	7.31	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01	< 4.01
CALCIUM	14700	11600	9740	32400	18800	14000	13400	14700	13700	8750	61000	9320	3280	3200	1960
CHROMIUM	14.7	29.5	< 6.02	252	< 6.02	20.7	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02
COBALT	25.0	< 25.0	< 25.0	34.7	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0	< 25.0
COPPER	8.09	16.1	8.51	< 8.09	< 8.09	14.7	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09
IRON	9100	19800	< 38.8	22600	50.1	12700	< 38.8	2090	203	6700	75.6	194	1200	< 38.8	3190
LEAD	4.25	12.1	< 1.26	31.6	< 1.26	10.3	< 1.26	1.74	< 1.26	< 1.26	< 1.26	< 1.26	< 1.26	< 1.26	2.28
MAGNESIUM	3480	8870	1920	25400	3470	5090	1870	3840	3310	1410	7150	1380	741	< 500	857
MANGANESE	291	341	11.7	629	9.11	411	5.82	587	463	424	7810	20.1	79.1	49.3	108
NICKEL	34.3	46.9	< 34.3	104	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3	< 34.3
POTASSIUM	2370	3210	767	2210	1530	2520	1060	1660	1320	1510	9230	1520	1580	1150	1570
SILVER	4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60	< 4.60
SODIUM	10800	3240	2740	2040	2350	3230	3190	15500	13900	8730	57000	4650	5310	5390	1910
VANADIUM	11.0	16.1	< 11.0	49.5	< 11.0	14.5	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0	< 11.0
ZINC	21.1	61.3	< 21.1	75.0	31.4	81.5	40.5	165	131	117	48.8	114	40.8	85.1	53.1
EXPLOSIVES (ug/L)															
NITROGLYCERINE		< 10.0	NA	< 10.0	NA	< 10.0	NA	< 10.0	NA	< 10.0	63.5	< 10.0	< 10.0	NA	< 10.0
ANIONS/CATIONS (ug/															
BICARBONATE		171000	NA	93000	NA	54000	NA	45000	NA	87000	183000	24000	12000	NA	6000
CHLORIDE		< 2120	NA	< 2120	NA	2770	NA	23200	NA	10500	71000	< 2120	6880	NA	< 2120
SULFATE		< 10000	NA	< 10000	NA	< 10000	NA	15600	NA	11700	25200	< 10000	< 10000	NA	< 10000
NITRATE/NITRITE		< 10.0	NA	11.1	NA	52.7	NA	460	NA	2200	< 10.0	2000	36.0	NA	< 10.0
KJELDAHL NITROGEN		171	NA	< 183	NA	< 183	NA	190	NA	< 183	895	< 183	< 183	NA	171
TOTAL PHOSPHOROUS		406	NA	590	NA	228	NA	51.5	NA	39.6	< 13.3	< 13.3	68.3	NA	356
ALKALINITY		140000	NA	76000	NA	44000	NA	37000	NA	71000	150000	20000	10000	NA	5000
OTHER (ug/L)															
HARDNESS		32000	NA	69600	NA	43600	NA	51200	NA	26400	198000	27200	15200	NA	9600
TSS		295000	NA	543000	NA	261000	NA	34000	NA	16000	6000	4000	30000	NA	107000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

TABLE 5-7
ANALTYES IN SURFACE WATER AND SEDIMENT
STUDY AREA 09 – NORTH POST LANDFILL

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SEDIMENT (ug/g)			SURFACE WATER (ug/L)		
	09D-92-01X	09D-92-02X	09D-92-03X	09D-92-01X	09D-92-02X	09D-92-03X
ORGANICS						
ACETONE	0.200	<0.017	<0.017	<13.0	<13.0	<13.0
BIS(2-ETHYLHEXYL)PHTHALATE	<0.620	<0.620	<0.620	<4.80	6.80	<4.800
TOLUENE	<0.004	<0.00078	<0.00078	1.37	<0.500	<0.500
TPHC	75.1	53.6	<30.3	<1600	<1600	<1600
TOTAL ORGANIC CARBON	10200	8850	7670	NA	NA	NA
INORGANICS						
ALUMINUM	3610	4130	4360	229	<141	<141
ARSENIC	13.6	6.54	2.78	17.2	<2.54	<2.54
BARIUM	23.4	25.2	20.2	9.26	8.81	7.2
CALCIUM	1030	851	860	19200	15800	14300
CHROMIUM	8.13	8.46	8.00	<6.02	<6.02	<6.02
COPPER	7.54	12.4	3.89	<8.09	<8.09	<8.09
IRON	3680	3870	4630	5460	2320	1620
LEAD	27.0	46.0	9.07	2.06	2.39	2.49
MAGNESIUM	1060	942	1100	6580	3770	3340
MANGANESE	47.8	52.5	49.4	157	393	245
MERCURY	<0.050	0.083	<0.050	<0.243	<0.243	<0.243
NICKEL	5.12	5.86	6.46	<34.3	<34.3	<34.3
POTASSIUM	352	164	243	1320	<375	<375
SODIUM	256	200	181	2570	10900	10800
VANADIUM	7.22	5.62	5.96	<11.0	<11.0	<11.0
ZINC	19.8	29.5	21.9	<21.1	<21.1	<21.1
ANIONS/CATIONS						
CHLORIDE				2460	17700	17900
KJELDAHL NITROGEN				1140	581	638
TOTAL PHOSPHOROUS				55.4	30.7	30.7
ALKALINITY				56000	52000	54000
OTHER						
TOTAL SUSPENDED SOLIDS				16000	24000	7000
HARDNESS				56600	51800	50800
TOTAL COLIFORM (org/100ml)				TNTC	TNTC	TNTC
FECAL COLIFORM (org/100ml)				26	31	53

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED
TNTC = TOO NUMEROUS TO COUNT

SA9SWSED.WK1
06/16/95

TABLE 5-8
ANALYTES IN SURFACE WATER
GROUP 5 - NASHUA RIVER

SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	G5D-92-01X	G5D-92-02X	G5D-92-03X	G5D-92-04X	G5D-92-05X	G5D-92-06X	G5D-92-07X	G5D-92-07DUP	G5D-92-08X	G5D-92-09X	G5D-92-10X
ORGANICS (ug/L)											
BIS(2-ETHYLHEXYL)PHTHALATE	<4.80	<4.80	<4.80	<4.80	12.0	<4.80	<4.80	<4.80	<4.80	<4.80	<4.80
CARBON DISULFIDE	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.740
TOLUENE	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.820
1,1,1-TRICHLOROETHANE	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1.50	<0.500	<0.500
INORGANICS (ug/L)											
ALUMINUM	<141	<141	142	<141	<141	<141	<141	144	<141	180	<141
ARSENIC	2.88	3.62	3.09	<2.54	2.98	2.88	3.09	<2.54	2.98	2.77	<2.54
BARIUM	18.1	5.59	17.4	18.8	18.1	17.2	17.2	17.9	20.0	17.7	29.7
CALCIUM	11300	10100	11400	11700	11700	12500	12500	12900	14300	13800	8220
IRON	851	175	811	789	773	779	786	824	691	786	574
LEAD	5.10	<1.26	4.23	4.01	6.51	<1.26	5.21	5.75	3.90	2.71	5.75
MAGNESIUM	1650	2800	1730	1750	1730	1810	1790	1860	1900	1910	1190
MANGANESE	106	12.8	103	109	111	125	126	131	117	153	169
POTASSIUM	1600	<375	1580	1950	2020	2120	2570	2710	2860	2420	714
SODIUM	20600	19000	20900	21700	21900	23400	23700	24300	32200	26400	10800
ANIONS/CATIONS (ug/L)											
CHLORIDE	38000	35000	38000	40000	40000	42000	44000	44000	55000	46000	16900
SULFATE	12000	<10000	11600	12500	12500	12500	12600	12500	14100	11800	<10000
NITRATE/NITRITE	940	190	910	1000	920	880	910	860	1000	1100	<10.0
KJELDAHL NITROGEN	648	276	581	657	686	771	1140	952	810	781	2670
TOTAL PHOSPHOROUS	97.0	13.9	92.1	83.2	86.1	139	148	139	129	139	188
ALKALINITY	52000	35000	34000	27000	57000	36000	31000	35000	44000	46000	22000
OTHER (ug/L)											
HARDNESS	36800	38800	36800	38600	45000	38400	40600	40600	46000	43000	26200
TSS	9000	<4000	4000	11000	8000	<4000	17000	7000	<4000	9000	31000
TOTAL COLIFORM BACTERIA (org/100ml)	1050	350	500	500	200	1100	2350	2050	2250	2500	200
FECAL COLIFORM BACTERIA (org/100ml)	30	105	86	100	12	55	54	66	145	400	5

NOTES: TABLE LIST DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

G5SURF.WK1
01/19/96

TABLE 5-9
ANALYTES IN SEDIMENT
GROUP 5 - NASHUA RIVER
SITE INVESTIGATION REPORT, GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	G5D-92- 01X	G5D-92- 02X	G5D-92- 03X	G5D-92- 04X	G5D-92- 05X	G5D-92- 05D	G5D-92- 06X	G5D-92- 07X	G5D-92- 08X	G5D-92- 09X	G5D-92- 10X
INORGANICS (ug/g)											
ALUMINUM	6830	1480	7390	6090	4750	4480	3560	6540	4750	6300	4600
ANTIMONY	5.46	<1.09	6.58	9.92	7.19	8.51	4.86	3.73	5.87	<1.09	<1.09
ARSENIC	7.03	3.34	7.70	4.11	4.70	4.57	6.62	29.0	4.57	7.34	6.20
BARIUM	89.9	10.9	87.6	46.4	60.6	63.7	37.8	87.7	21.0	28.6	16.8
BERYLLIUM	1.24	<0.500	1.08	0.79	<0.500	<0.500	<0.500	0.978	<0.500	0.977	<0.500
CADMIUM	9.35	<0.700	10.0	2.34	10.6	9.46	2.59	15.0	<0.700	<0.700	<0.700
CALCIUM	1450	360	1800	916	840	891	1040	1720	612	761	336
CHROMIUM	52.7	<4.05	54.8	53.3	54.8	63.3	50.2	81.5	12.7	15.4	7.48
COBALT	5.16	<1.42	5.27	2.74	3.11	3.13	2.71	5.06	13.6	2.46	2.40
COPPER	67.1	<0.965	69.5	31.6	45.5	62.8	42.3	84.9	8.68	5.51	5.61
IRON	9700	2230	9350	7030	5710	5580	5290	7810	9690	7260	5860
LEAD	100	1.82	98.0	110	73.0	88.0	110	41.0	12.3	10.2	8.07
MAGNESIUM	2030	422	2000	1690	1380	1250	1040	1810	1790	1990	1080
MANGANESE	195	47.8	180	126	101	109	248	122	895	86.6	59.9
MERCURY	0.598	<0.050	0.704	0.504	0.37	0.461	0.511	0.718	0.094	0.068	0.468
NICKEL	13.0	2.58	12.7	9.33	9.99	10.5	9.36	15.1	15.4	7.88	8.00
POTASSIUM	700	<100	713	594	551	437	394	741	452	599	297
SELENIUM	<0.250	<0.250	<0.250	0.589	<0.250	<0.250	0.549	<0.250	<0.250	<0.250	<0.250
SILVER	2.34	<0.589	3.46	1.98	1.68	1.69	1.39	2.88	<0.589	<0.589	<0.589
SODIUM	342	222	360	277	247	<100	249	363	210	242	189
VANADIUM	13.6	<3.39	14.6	11.7	9.33	9.04	7.04	14.1	7.17	11.1	5.55
ZINC	169	13.0	176	55.6	100	97.0	61.2	179	26.5	40.3	20.7
ORGANICS (ug/g)											
ACETONE	<0.0170	<0.0170	<0.0170	<0.0170	0.039	0.035	<0.0170	<0.0170	<0.0170	<0.0170	<0.0170
TOLUENE	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	0.0214
ACENAPHTHYLENE	<0.300	<0.033	<0.700	<0.300	<0.165	<0.165	<0.165	0.408	<0.066	<0.033	<0.033
BENZO[A]PYRENE	<2.00	<0.250	<5.00	<2.00	<1.25	<1.25	<1.25	3.21	<0.500	<0.250	<0.250
BENZO[K]FLOURANTHENE	<0.700	<0.066	<1.00	<0.700	<0.330	<0.330	<0.330	0.900	<0.132	<0.066	<0.066
CHRYSENE	<1.00	<0.120	<2.00	<1.00	<0.600	<0.600	<0.600	2.20	<0.240	<0.120	<0.120
DICHLOROBENZENES	7.80	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100	ND 0.100
FLOURANTHENE	2.00	<0.068	<1.00	<0.700	1.68	0.855	<0.340	1.04	<0.136	<0.068	<0.068
PHENATHRENE	1.00	<0.033	<0.700	<0.300	0.375	0.609	<0.165	0.650	<0.070	<0.033	<0.033
PYRENE	2.00	<0.033	<0.700	<0.300	1.72	0.873	<0.165	2.13	<0.070	<0.033	<0.033
OTHER (ug/g)											
TPHC	325	54.9	346	162	359	198	357	441	55.6	47.7	<27.9
TOTAL ORGANIC CARBON	17900	1610	14200	9360	8370	13200	8640	11900	2550	4200	4340

NOTES: TABLE LIST DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED

Table 5–10
Human Health PRE Evaluation of Surface Soil
Study Area 09 – North Post Landfill

Site Investigation Report, Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background ?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration ?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	4,375	4,660	2/2	NO	230,000	NO
arsenic	21	19	20	2/2	NO	0.97	YES
barium	42.5	21	22	2/2	NO	5,500	NO
chromium	31	11	14	2/2	NO	390	NO
cobalt	NA	3.1	3.1	2/2	NA	NA	NA
copper	8.39	12	17	2/2	YES	2,900	NO
lead	34.4	44	81	2/2	YES	500[c]	NO
manganese	300	86	95	2/2	NO	7,800	NO
nickel	14.1	13	16	2/2	YES	1,600	NO
vanadium	28.7	7.2	8.3	2/2	NO	550	NO
zinc	35.5	21	23	2/2	NO	23,000	NO

NOTES:

[a] Base–wide background soil inorganics database.

[b] Surface soil samples from sampling stations 09E–92–03X and 09E–92–04X.

[c] Lead value from USEPA interim guidance on establishing soil lead cleanup levels at superfund sites. (OSWER Directive 9355.4–02)

NA = Not available, not applicable.

Table 5–11
Human Health PRE Evaluation of Subsurface Soil
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b] Average	Detected Concentration [b] Maximum	Frequency of Detection (out of 7)	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
Organics (ug/g)							
2–methylnaphthalene		3	3	1	NA	NA	NA
acenaphthene		11	20	2	NA	61,000	NO
acenaphthylene		0.3	0.3	1	NA	NA	NA
anthracene		16	30	2	NA	310,000	NO
benzo(a)anthracene		14	40	3	NA	2.7	YES
benzo(a)pyrene		22	40	2	NA	0.39	YES
benzo(b)fluoranthene		22	40	2	NA	3.2	YES
benzo(g,h,i)perylene		11	20	2	NA	18	YES
benzo(k)fluoranthene		11	30	3	NA	7.4	YES
carbazole		10	20	2	NA	140	NO
chrysene		15	40	3	NA	NA	NA
dibenzofuran		5.4	10	2	NA	NA	NA
fluoranthene		37	100	3	NA	41,000	NO
fluorene		11	20	2	NA	41,000	NO
indeno(1,2,3–c,d)pyrene		12	20	2	NA	1.4	YES
naphthalene		11	20	2	NA	41,000	NO
phenanthrene		27	100	4	NA	30,000	NO
pyrene		26	70	3	NA	31,000	NO
TPHC		1,832	5,300	7	NA	NA	NA

Table 5−11
Human Health PRE Evaluation of Subsurface Soil
Study Area 09 − North Post Landfill

Site Investigation Report − Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection (out of 7)	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	7,006	8,910	7	NO	3,000,000	NO
antimony	NA	3.0	3.0	1	NA	410	NO
arsenic	21	16	21	7	NO	1.6	YES
barium	42.5	78	223	7	YES	72,000	NO
beryllium	0.347	1.0	1.0	3	YES	0.67	YES
cadmium	2.00	1.5	1.7	3	NO	510	NO
chromium	31	22	32	7	YES	5,100	NO
cobalt	NA	4.5	5.8	7	NA	NA	NA
copper	8.39	17	29	7	YES	38,000	NO
lead	48.4	121	260	7	YES	NA	NA
manganese	300	161	181	7	NO	100,000	NO
mercury	0.22	0.13	0.18	5	NO	310	NO
nickel	14.0	17	24	7	YES	20,000	NO
silver	0.086	0.79	0.79	1	YES	5,100	NO
vanadium	28.7	15	22	7	NO	7,200	NO
zinc	35.5	211	305	7	YES	310,000	NO

Notes:

[a] Base−wide background soil inorganics database.

[b] Subsurface soil samples from sampling stations 09E−92−01X through 09E−92−03X.

NA = not applicable.

Table 5–12
Human Health PRE Evaluation of Groundwater
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
chloroform		0.585		5	NO
TPHC		313		NA	NA
Inorganics (ug/l)					
aluminum	6,870	70,400	YES	50–200	YES
antimony	3.03	3.84	YES	6	NO
arsenic	10.5	220	YES	50	YES
barium	39.6	266	YES	2,000	NO
calcium	14,700	62,100	YES	NA	NA
chromium	14.7	1,040	YES	100	YES
cobalt	25	93.7	YES	10	YES
copper	8.09	143	YES	1,000	NO
iron	9,100	90,000	YES	300	YES
lead	4.25	81.3	YES	15	YES
magnesium	3,480	93,400	YES	NA	NA
manganese	291	3,270	YES	50	YES
nickel	34.3	369	YES	100	YES
potassium	2,370	11,200	YES	NA	NA
silver	4.60	6.22	YES	50	NO
sodium	10,800	4,450	NO	28,400	NO
vanadium	11.0	189	YES	260	NO
zinc	21.1	258	YES	5,000	NO
Anions/Cations (ug/l)					
nitrate/nitrite		1,000		10,000	NO

NOTES:
[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.
[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.
[c] SA 09 is represented by the following monitoring wells: G5M–92–01X, G5M–92–02X, G5M–92–03B, WWTMW–07, and WWTMW–08.
ND Not detected
NA Not available

Table 5–13
Human Health PRE Evaluation of Surface Water
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Detected Concentration [a]		Frequency of Detection	Drinking Water Standard/Guideline (b) (ug/l)	Maximum Exceeds Drinking Water Standard/Guideline?
	Average	Maximum			
Organics (ug/l)					
bis(2–ethylhexyl)phthalate	6.8	6.8	1/3	6.1	YES
toluene	1.4	1.4	1/3	1,000	NO
Inorganics (ug/l)					
aluminum	229	229	1/3	110,000	NO
arsenic	17	17	1/3	50	NO
barium	8.4	9.3	3/3	2,600	NO
iron	3,133	5,460	3/3	300	YES
lead	2.3	2.5	3/3	50	NO
manganese	265	393	3/3	3,700	NO

NOTES:

[a] Surface water samples from sampling stations 09D–92–01X to 09D–92–03X.

[b] Includes the highest of either the EPA or MA drinking water standards, or the Region III tap water concentrations.

Table 5–14
Human Health PRE Evaluation of Sediment
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Detected Concentration [a]		Frequency of Detection	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
	Average	Maximum			
Organics (ug/g)					
acetone	0.2	0.2	1/3	7,800	NO
Inorganics (ug/g)					
aluminum	4,033	4,360	3/3	230,000	NO
arsenic	7.6	14	3/3	0.97	YES
barium	23	25	3/3	5,500	NO
chromium	8.2	8.5	3/3	390	NO
copper	7.9	12	3/3	2,900	NO
iron	4,060	4,630	3/3	NA	NA
lead	27	46	3/3	500[b]	NO
manganese	50	53	3/3	7,800	NO
mercury	0.083	0.083	1/3	23	NO
nickel	5.8	6.5	3/3	1,600	NO
vanadium	6.3	7.2	3/3	550	NO
zinc	24	30	3/3	23,000	NO

NOTES:

[a] Sediment samples from sampling stations 09D–92–01X through 09D–92–03X.

[b] Lead value from USEPA interim guidance on establishing soil lead cleanup levels at superfund sites. (OSWER Directive 9355.4–02)

SA09SED.WK1

NA = not available, not applicable.

Table 5-15
Ecological PRE Evaluation of Surface Soil
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background ?	Ecological Benchmark (ug/g)	Maximum Exceeds Benchmark ?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	4,375	4,660	2/2	NO	14,964	NO
arsenic	21	19	20	2/2	NO	33	NO
barium	42.5	21	22	2/2	NO	42.6	NO
chromium	31	11	14	2/2	NO	830	NO
cobalt	N/	3.1	3.1	2/2	NA	50	NO
copper	8.39	12	17	2/2	YES	34	NO
lead	34.4	44	81	2/2	YES	48.4	YES
manganese	300	86	95	2/2	NO	1,500	NO
nickel	14.0	13	16	2/2	YES	100	NO
vanadium	28.7	7.2	8.3	2/2	NO	28.7	NO
zinc	35.5	21	23	2/2	NO	640	NO

NOTES:

[a] Base-wide background soil inorganics database.

[b] Surface soil samples from sampling stations 09E-92-03X and 09E-92-04X.

NA = Not available, not applicable.

Table 5–16
Ecological PRE Evaluation of Surface Water
Study Area 09 – North Post Landfill

Site Investigation Report
Fort Devens

Analyte	Detected Concentration [a]		Frequency of Detection	Ecological Benchmark (ug/l)	Maximum Exceeds Benchmark ?
	Average	Maximum			
Organics (ug/l)					
bis(2–ethylhexyl)phthalate	6.8	6.8	1/3	360	NO
toluene	1.4	1.4	1/3	1,750	NO
Inorganics (ug/l)					
aluminum	229	229	1/3	87	YES
arsenic	17	17	1/3	190	NO
barium	8.4	9.3	3/3	NA	NA
iron	3,133	5,460	3/3	1,000	YES
lead	2.3	2.5	3/3	1.4	YES
manganese	265	393	3/3	NA	NA

NOTES:

[a] Surface water samples from sampling stations 09D–92–01X to 09D–92–03X.

NA = Not available.

Table 5–17
Ecological PRE Evaluation of Sediment
Study Area 09 – North Post Landfill

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Detected Concentration [a]		Frequency of Detection	Ecological Benchmark (ug/g)	Maximum Exceeds Benchmark ?
	Average	Maximum			
Organics (ug/l)					
acetone	0.2	0.2	1/3	NA	NA
Inorganics(ug/g)					
aluminum	4,033	4,360	3/3	NA	NA
arsenic	7.6	14	3/3	5	YES
barium	23	25	3/3	NA	NA
chromium	8.2	8.5	3/3	26	NO
copper	7.9	12	3/3	19	NO
iron	4,060	4,630	3/3	24,000	NO
lead	27	46	3/3	27	YES
manganese	50	53	3/3	428	NO
mercury	0.083	0.083	1/3	0.11	NO
nickel	5.8	6.5	3/3	22	NO
vanadium	6.3	7.2	3/3	NA	NA
zinc	24	30	3/3	85	NO

NOTES:

[a] Sediment samples from sampling stations 09D–92–01X through 09D–92–03X.

NA = not available, not applicable.

TABLE 5-18
ANALYTES IN SOIL
SA 21 - SLUDGE DRYING BEDS

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BORING	21S-92-01X	21S-92-02X	21S-93-03X	21S-93-04X	21S-93-05X	21S-93-06X		21S-93-07X
	DEPTH	0	0	0	0	0	0	0D	0
INORGANICS (ug/g)									
	Background								
ALUMINUM	15000	6130	5300	14000	17100	11000	1710	20000	12100
ANTIMONY	NA	3.22	2.86	<1.09	<1.09	<1.09	<1.09	<1.09	<1.09
ARSENIC	21	8.99	30.0	28	37	27	26	25	43
BARIUM	42.5	283	460	57.3	51.4	51.9	<5.18	34.6	290
BERYLLIUM	0.347	<0.500	<0.500	2.57	2.25	1.98	<0.500	2.14	1.75
CADMIUM	2.00	3.14	1.51	2.87	1.27	2.88	<0.700	1.16	7.85
CALCIUM	1400	3980	3230	1240	1090	2030	156	565	3140
CHROMIUM	31	29.5	37.5	36.6	39.7	31.5	<4.05	31.3	56.5
COBALT	NA	5.35	5.35	6.22	6.89	9.03	<1.42	6.34	6.67
COPPER	8.39	242	295	34.9	27	31.7	2.66	17.9	429
IRON	15000	12200	10800	17500	20200	21000	1630	17700	16000
LEAD	34.4	140	130	14.8	92	46	53	35.0	180
MAGNESIUM	5600	2770	2500	3000	2950	4020	293	3050	2550
MANGANESE	300	280	161	614	463	632	40.1	261	341
MERCURY	0.22	5.90	7.70	0.601	0.577	0.410	0.352	0.278	4.6
NICKEL	14.0	18.3	11.8	19.8	18.0	34.7	<1.71	17.3	22.1
POTASSIUM	1700	359	392	847	1050	914	222	913	545
SELENIUM	NA	1.18	1.12	0.604	0.582	<0.250	<0.250	<0.250	1.22
SILVER	0.086	38.0	46.0	1.51	<0.589	1.32	<0.589	<0.589	54.0
SODIUM	131	238	244	339	393	316	367	295	330
VANADIUM	28.7	17.0	15.9	33.3	33.6	22.6	<3.39	29.2	33.5
ZINC	35.5	289	207	152	85.7	109	<8.03	55.7	361
OTHER (ug/g)									
TOTAL PETROLEUM HYDROCARBONS		1310	1490	181	133	112	163	98	470
TOTAL ORGANIC CARBON		131000	43800	NA	NA	NA	NA	NA	NA

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
1. SAMPLES 21D-95-01X AND 21D-95-02X ARE SEDIMENT
NA = NOT ANALYZED
☐ = GREATER THAN BACKGROUND CONCENTRATION

TABLE 5–18
ANALYTES IN SOIL
SA 21 – SLUDGE DRYING BEDS

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BORING	21S–93–08X	21S–93–09X	21S–93–10X	21S–93–11X	21S–93–12X	21S–95–13X	21S–95–14X
	DEPTH	0	0	0	0	0	0	0
INORGANICS (ug/g)								
	Background							
ALUMINUM	15000	14400	7230	13000	10500	11700	8590	8140
ANTIMONY	NA	<1.09	2.01	<1.09	<1.09	<1.09	<1.09	4.04
ARSENIC	21	53	22	35	21	25	13.3	26
BARIUM	42.5	151	229	150	35.7	153	66.5	32.9
BERYLLIUM	0.347	2.13	1.32	2.24	1.67	1.76	<0.500	<0.500
CADMIUM	2.00	3.81	3.71	4.34	3.09	9.44	11.0	3.78
CALCIUM	1400	1100	1590	1310	645	1420	3860	722
CHROMIUM	31	43.5	41.4	48.1	30.1	55	60	41
COBALT	NA	7.08	3.36	11.7	6.60	7.80	6.15	6.32
COPPER	8.39	268	399	274	51.9	197	86.4	41.0
IRON	15000	19500	11800	27100	18900	13200	7500	11900
LEAD	34.4	98	110	220	93	220	187	147
MAGNESIUM	5600	2810	1870	3810	1820	2150	1060	1040
MANGANESE	300	311	124	708	544	589	216	341
MERCURY	0.22	4.3	7.9	6.7	0.778	6.4	0.853	0.82
NICKEL	14.0	16.5	14.6	33.7	20.4	17.6	20.9	9.27
POTASSIUM	1700	700	386	567	449	505	<100	175
SELENIUM	NA	0.915	1.42	1.22	0.544	1.08	1.00	0.603
SILVER	0.086	22	47	29	3.63	21	2.83	<0.589
SODIUM	131	357	328	341	308	395	749	375
VANADIUM	28.7	36.6	28.3	36.8	31.4	27.3	16	24.6
ZINC	35.5	96.8	93.1	109	58.5	131	235	51.2
OTHER (ug/g)								
TOTAL PETROLEUM HYDROCARBONS		795	944	586	193	418	NA	NA
TOTAL ORGANIC CARBON		NA	NA	NA	NA	NA	NA	NA

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
1. SAMPLES 21D–95–01X AND 21D–95–02X ARE SEDIMENT
☐ = ABOVE BACKGROUND CONCENTRATION
NA = NOT ANALYZED

TABLE 5-18
ANALYTES IN SOIL
SA 21 - SLUDGE DRYING BEDS

SITE INVESTIGATION REPORT
FORT DEVENS

ANALYTE	BORING	21S-95-15X	21B-93-01X	21B-93-02X	21D-95-01X[1]	21D-95-02X[1]
	DEPTH	0	2	2	0	0
INORGANICS (ug/g)						
	Background					
ALUMINUM	15000	10400	9590	7670	9120	9100
ANTIMONY	NA	5.13	<1.09	<1.09	5.8	<1.09
ARSENIC	21	$\boxed{28}$	17	12	11.1	9.43
BARIUM	42.5	$\boxed{116}$	19.6	19.2	$\boxed{124}$	$\boxed{55.9}$
BERYLLIUM	0.347	<0.500	$\boxed{1.24}$	$\boxed{1.22}$	<0.500	<0.500
CADMIUM	2.00	$\boxed{9.61}$	<0.700	<0.700	$\boxed{22.7}$	$\boxed{9.50}$
CALCIUM	1400	980	599	788	$\boxed{4070}$	$\boxed{2030}$
CHROMIUM	31	$\boxed{48.7}$	15.0	12.2	$\boxed{73.8}$	$\boxed{71.7}$
COBALT	NA	6.55	4.73	4.09	5.67	4.72
COPPER	8.39	$\boxed{240}$	$\boxed{10.9}$	$\boxed{9.3}$	$\boxed{236}$	$\boxed{86.4}$
IRON	15000	12300	10800	9090	6730	6600
LEAD	34.4	$\boxed{184}$	4.80	4.49	$\boxed{243}$	$\boxed{186}$
MAGNESIUM	5600	1060	2640	1940	1210	1080
MANGANESE	300	203	193	112	142	137
MERCURY	0.22	$\boxed{1.8}$	0.128	<0.050	$\boxed{2.64}$	$\boxed{1.04}$
NICKEL	14.0	10.9	$\boxed{16.1}$	11.3	$\boxed{20.7}$	$\boxed{20.6}$
POTASSIUM	1700	175	518	691	<100	<100
SELENIUM	NA	0.774	<0.250	<0.250	2.06	<0.250
SILVER	0.086	$\boxed{13.5}$	<0.589	<0.589	$\boxed{21}$	$\boxed{2.6}$
SODIUM	131	$\boxed{482}$	$\boxed{230}$	$\boxed{204}$	$\boxed{939}$	$\boxed{637}$
VANADIUM	28.7	$\boxed{37.9}$	13.4	11.3	20.6	12.3
ZINC	35.5	$\boxed{102}$	$\boxed{75.4}$	25.2	$\boxed{254}$	$\boxed{203}$
OTHER (ug/g)						
TOTAL PETROLEUM HYDROCARBONS		NA	<28.5	<28.3	NA	NA
TOTAL ORGANIC CARBON		NA	NA	NA	NA	NA

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY

1. SAMPLES 21D-95-01X AND 21D-95-02X ARE SEDIMENT

☐ = ABOVE BACKGROUND CONCENTRATION

NA = NOT ANALYZED

TABLE 5–19
TRICHLOROETHYLENE IN GROUNDWATER
SA 21 – MONITORING WELL WWTMW–02

SITE INVESTIGATION REPORT
FORT DEVENS

SAMPLING DATE	CONCENTRATION (ug/L)
FEBRUARY 21, 1990	ND [1]
MAY 30, 1990	ND
AUGUST 16, 1990	ND
NOVEMBER 27, 1990	ND
FEBRUARY 12, 1991	ND
MAY 1991 [2]	
MAY 23, 1991	8
JULY 9, 1991 [3]	61
AUGUST 28, 1991	34
NOVEMBER 20, 1991	19
MARCH 18, 1992	< 4
MAY 28, 1992	10
JULY 16, 1992	14
AUGUST 25, 1992	16
NOVEMBER 30, 1992	8
JANUARY 5, 1993	10.3

[1] Not detected above the detection limit of 4 ug/L

[2] Hypalon liner installed

[3] Resampled due to elevated trichloroethylene concentration May 23

Source: Installation quarterly groundwater monitoring reports (various)

TABLE 5–20
HUMAN HEALTH PRE – SURFACE SOIL
STUDY AREA 21 – SLUDGE DRYING BEDS

SITE INVESTIGATION REPORT
FORT DEVENS

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background ?	Region III Residential Soil Concentrations (ug/g)	Maximum Exceeds Region III Concentrations ?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	10,300	20,000	19/19	YES	230,000	NO
antimony	NA	3.29	5.80	6/19	NA	31	NO
arsenic	21	24.9	53.0	19/19	YES	0.97	YES
barium	42.5	124	460	19/19	YES	5,500	NO
beryllium	0.347	1.77	2.57	12/19	YES	0.4	YES
cadmium	2.00	5.95	22.7	17/19	YES	39	NO
chromium	31	41.4	73.8	19/19	YES	390	NO
cobalt	NA	6.18	11.7	19/19	NA	NA	NO
copper	8.39	156	429	19/19	YES	2,900	NO
lead	34.4	123	243	19/19	YES	500	NO
manganese	300	330	708	19/19	YES	7,800	NO
mercury	0.22	2.97	7.90	18/19	YES	23	NO
nickel	14.0	18.2	34.7	19/19	YES	1,600	NO
selenium	NA	0.955	2.06	14/19	NA	NA	NO
silver	0.086	20.2	54.0	14/19	YES	390	NO
vanadium	28.7	24.6	37.9	19/19	YES	550	NO
zinc	35.5	140	361	19/19	YES	23,000	NO

NOTES:

[a] Base–wide background soil inorganics database.

[b] Surface soil samples from locations 21S–92–01X, 21S–92–02X, 21S–93–03X through 21S–93–12X, 21S–95–13X through 21S–95–15X, 21B–93–01X, and 21B–93–02X; and sediment samples from locations 21D–95–01X and 21D–95–02X.

NA = not available.

Table 5–21
Human Health PRE Evaluation of Groundwater
SA 19, 20, and 21 Monitoring Wells (Infiltration Beds and Sludge Drying Beds)

Site Investigation Report
Fort Devens

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
acetone		18.0		3,000	NO
trichloroethylene		14.0		5	YES
carbon tetrachloride		1.40		5	NO
chloroform		2.7		5	NO
bis(2–ethylhexyl)phthalate		37.0		6.1	YES
toluene		0.54		1,000	NO
1,1,1–trichloroethane		2.2		200	NO
Inorganics (ug/l)					
aluminum	6,870	6,150	NO	50–200	YES
arsenic	10.5	69.7	YES	50	YES
barium	39.6	122	YES	2,000	NO
cadmium	4.01	14.9	YES	5	YES
calcium	14,700	145,000	YES	NA	NA
chromium	14.7	9.40	NO	100	NO
copper	8.09	11.0	YES	1,000	NO
iron	9,100	7,430	NO	300	YES
lead	4.25	8.03	YES	15	NO
magnesium	3,480	11,800	YES	NA	NA
manganese	291	1,530	YES	50	YES
nickel	34.3	87.2	YES	100	NO
potassium	2,370	15,600	YES	NA	NA
sodium	10,800	48,400	YES	28,400	YES
zinc	21.1	503	YES	5,000	NO
Anions/Cations (ug/l)					
nitrate/nitrite		68,000		10,000	YES

NOTES:

[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.

[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.

[c] SA 19,20, and 21 are represented by the following monitoring wells: WWTMW–01A, WWTMW–02, WWTMW–02A, WWTMW–03, WWTMW–04, WWTMW–09, and WWTMW–10.

ND Not detected

NA Not available

TABLE 5-22
ECOLOGICAL PRE - SURFACE SOIL
STUDY AREA 21 - SLUDGE DRYING BEDS

SITE INVESTIGATION REPORT
FORT DEVENS

Analyte	Soil Background Concentration [a]	Detected Concentrations [b]			Frequency of Detection	Maximum Exceeds Background ?	Ecological Benchmark (mg/kg)	95th % UCL Exceeds Ecological Benchmark?	Maximum Exceeds Ecological Benchmark?
		Average	95th % UCL	Maximum					
Inorganics (mg/kg)									
Aluminum	15,000	10,312	11,849	20,000	19/19	YES	15,000 [c]	NO	YES
Antimony	NA	1.6	2.6	5.8	6/19	NA	1,531	NO	NO
Arsenic	21	24.9	32.1	53	19/19	YES	193	NO	NO
Barium	42.5	124	240	460	19/19	YES	11,511	NO	NO
Beryllium	0.347	1.2	2.5	2.6	12/19	YES	390	NO	NO
Cadmium	2.00	5.4	13.3	22.7	17/19	YES	3.3	YES	YES
Chromium	31	41.5	54.1	73.8	19/19	YES	27,629	NO	NO
Cobalt	NA	6.2	7.1	11.7	19/19	NA	83	NO	NO
Copper	8.39	156	429 [d]	429	19/19	YES	1,192	NO	NO
Lead	48.4	123	243 [d]	243	19/19	YES	397	NO	NO
Manganese	300	330	459	708	19/19	YES	11,963	NO	NO
Mercury	0.22	2.8	7.9 [d]	7.9	18/19	YES	19	NO	NO
Nickel	14.0	18.2	21.8	34.7	19/19	YES	746	NO	NO
Selenium	NA	0.79	1.7	2.1	14/19	NA	2.1	NO	NO
Silver	0.086	16.1	54 [d]	54	14/19	YES	350	NO	NO
Vanadium	28.7	24.6	30.3	37.9	19/19	YES	351	NO	NO
Zinc	35.5	140	217	361	19/19	YES	452	NO	NO
Other Parameters (mg/kg)									
Total Organic Carbon	NA	87,400	NA	131,000	2/2	NA	NA	NA	NA
Total Petroleum Hydrocarbons	NA	485	1,490 [d]	1,490	12/14	NA	NA	NA	NA

NOTES:

[a] Base-wide background soil inorganics database.

[b] Sample locations include 21S-92-01X, 21S-92-02X, 21S-93-03X through 21S-93-12X, 21S-95-13X through 21S-95-15X, 21D-95-01X, 21D-95-02X, 21B-93-01X, and 21B-93-02X.

[c] Benchmark is less than background, therefore, background was used instead.

[d] Maximum detected concentration is less than 95th % UCL; therefore the maximum was used instead.

NA = Not Available.

6.0 GROUP 6 STUDY AREA INVESTIGATIONS

The Group 6 SAs are located at Moore Army Airfield (MAAF), which is in the northernmost part of the North Post (Figures 1-1 and 6-1). The four SAs identified at MAAF are the drum storage area (SA 30), the fire-fighting training area (SA 31), the leaking UST site at Building 3816 (SA 47), and the World War II Fuel Point (SA 50).

The airfield occupies an extensive, comparatively flat kame-plain remnant. The landform terminates on all sides in a bluff that slopes steeply downward 30 to 50 feet to grades established by postglacial fluvial drainage.

The soils are generally stratified sands and gravels transported by glacial meltwater streams and deposited in deltas in a glacial lake. These soils have significantly high hydraulic conductivities. Deeper soils beneath the northeastern end of the kame are siltier and have lower conductivities. The depth to bedrock beneath the northeastern end of the airfield is on the order of 130 feet bgs. On the western side of the airfield, the bluff is bounded by the north-flowing Nashua River.

6.1 SA 30 - MOORE ARMY AIRFIELD DRUM STORAGE AREA

Three small locations in the northern part of the airfield were reportedly used for temporary storage of containerized hazardous waste between 1975 and 1990. Two of the storage locations are near one another at the end of the aircraft defueling pad (McMaster et al., 1982). This area is referred to hereinafter as the "west drum storage area". When ABB-ES began the SA 30 field investigation, the west drum storage area was the only known location. More recently, however, it was learned that drums were stored in that location for only the past few years (Reynolds, 1991). Prior to that, and for a longer period, drums of hazardous waste were stored at a location farther east. This location will be referred to as the "east drum storage area". Hazardous wastes are no longer stored at the airfield.

6.1.1 Study Area Background and Conditions

The east and west drum storage areas (collectively SA 30) are located about 650 feet apart at the northern end of the MAAF taxiway (Figure 6-1).

According to Biang et al. (1992), the west drum storage area was used for temporary storage (less than 90 days) of containerized hazardous waste between 1975 and 1990. Space was available for the outdoor storage of approximately ten to fifteen 55-gallon drums on wooden pallets. Stored materials included fuel samples, waste methyl ethyl ketone, naphtha, and other petroleum-based paint thinners generated by aircraft maintenance activities (McMaster et al., 1982), as well as alkaline cleaners, dry cleaning solution, aircraft cleaning compounds, lube oil, and waste solvents (Biang et al., 1992). Pavement in the west drum storage area was observed to be broken and in poor condition. According to Reynolds (1991), drums were also stored in a grassy area adjacent to the west side of the defueling pad. The west drum storage area was closed in 1990 after a centralized 90-day storage facility was constructed elsewhere at Fort Devens.

The east drum storage area was not identified by Biang et al. (1992) or McMaster et al. (1982). According Reynolds (1991), the east drum storage area (unpaved) was used before, and for a longer period than, the west drum storage area. The east drum storage area has not been used since approximately 1975. Although no visible evidence of the former storage area remains, Reynolds identified the location.

Future use of SA 30 is not expected to change from its current use.

6.1.2 SA Investigation Program Summary

The investigation specific to SA 30 focused on identifying potential incidental releases of waste at each of the drum storage areas resulting in soil contamination and possibly groundwater contamination. Because of the proximity of the drums to the Nashua River, impacts to surface water from contaminated runoff and groundwater were also considered.

Because of the proximity of all four of the MAAF SAs, the groundwater beneath the airfield and surface water and sediment in the Nashua River were investigated on a group-wide basis. Groundwater monitoring well locations were selected to provide both local coverage of SA-specific contaminants and collectively to provide Group-wide monitoring of water table elevations and groundwater flow directions. Similarly, surface water and sediment sampling locations were selected to provide samples that were representative of downstream stormwater runoff discharge points from the airfield, as well as samples that were spaced along the Nashua River so that the possible impact of groundwater discharge to the river from the Group 6 SAs could be evaluated.

Eleven monitoring wells (G6M-92-01X through G6M-92-11X) were installed in boring locations throughout Group 6, and the well screens were set at the water table. Well locations were selected based on the assumption that groundwater flowed radially outward from beneath the airfield. Wells G6M-92-02X and G6M-92-03X were specifically located at the west and east drum storage sites of SA-30; the remaining wells in the series are Group-wide, not SA 30-specific. Monitoring well locations are shown in Figure 6-1. The monitoring well soil borings G6M-92-02X and G6M-92-03X were drilled with HSAs to 10 feet below the water table (73 and 70 feet bgs, respectively), and soil samples were collected at 5-foot intervals for field screening by PID and for field classification.

Soil samples were collected at 5-foot intervals in all SA Group 6 borings except at G6M-92-01X, where samples were collected continuously down to the water table. At a minimum, one soil sample was collected from the saturated zone of each monitoring well boring and analyzed for TOC. In addition, at G6M-92-02X and G6M-92-03X, five split-spoon samples were also selected for analysis for PAL organics, PAL inorganics, and TPHC. In both borings, one analytical sample was collected at the ground surface (from 0 to 2 feet bgs) and one from the saturated zone at the approximate depth of the water table. The other three samples were selected from intermediate depths in each boring.

Two rounds of groundwater samples were collected, three months apart, from the 11 Group 6 monitoring wells. The samples were analyzed for PAL organics, PAL inorganics (unfiltered), PAL anions/cations, TSS, and TPHC. Because of the cross-contamination issue previously discovered during Round 2 (and discussed in Section 3.2.3), a third round of groundwater samples was collected and analyzed for PAL VOCs.

In addition to the monitoring well borings, eight shallow (10-foot-deep) soil borings (30B-92-01X through 30B-92-08X) were drilled in and around the west and east drum storage areas to identify possible near-surface soil contamination (Figure 6-2). Continuous split-spoon soil samples were collected for field screening by PID and for field classification. Three split-spoon samples from each boring were sent to ESE for analysis for PAL organics, PAL inorganics, and TPHC. In each boring, one analytical sample was collected at the ground surface (0 to 2 feet bgs) or immediately beneath pavement, one sample from the bottom of the boring, and the third sample was selected from an intermediate depth. Analytical sample depths were selected based on observation and screening results. In the absence of observed contamination, samples were selected at roughly even intervals, where possible, from the intermediate depth zone.

Surface water and sediment sampling locations G6D-92-02X, G6D-92-03X, and G6D-92-04X were located near outfalls of the MAAF storm water system, and location G6D-92-01X is upstream of the storm water outfalls (Figure 6-1). Sampling locations were adjusted in the field to facilitate better access. Sediment samples were submitted for analysis of PAL organics, PAL inorganics, and TPHC. Sediment samples were analyzed for PAL organics, PAL inorganics, and TPHC. Surface water samples were analyzed for the same parameters in addition to PAL water quality parameters and TSS. Sediment samples were also analyzed for TOC and tested for grain-size distribution.

6.1.3 Field Investigation Results and Observations

No staining, stressed vegetation, or other visible evidence of hazardous waste storage was observed.

Sediments from the Nashua River in the vicinity of the Group 6 SAs were tested for grain size. The samples were silty sands and silts, with the fine fraction ranging from 19.5 to 71.3 percent and with organic (vegetative) contents ranging from trace to high. Water contents varied from 59.5 to 191.7 percent. The classification of the sediment samples from the Nashua River is summarized in Table 6-1. The results of sediment sample grain size analysis are included in Appendix J.

Eleven monitoring wells were installed at MAAF during the investigation of four SAs in Group 6. Soil data from borings and monitoring wells installed at MAAF are summarized in the field boring logs included in Appendix B. The soils generally consist of sand with variable gravel and silt content. Well completion details are included in Appendix C. All wells are screened at the water table.

ABB-ES has conducted quarterly installation-wide water-level surveys from Sept. 1992 to Jan. 1995. Included in the surveys were the 11 monitoring wells at MAAF and a nearby surface-water measurement on the Nashua River (station SWEL-01). Water-table elevations are summarized in Appendix I. Water levels and inferred groundwater flow directions are shown in Figure 6-3. Groundwater flow is toward the Nashua River. The river has a dominant effect on groundwater flow in the area, and the influence of the kame-plain landform is negligible.

Aquifer hydraulic conductivities at the water table were determined in the eleven SA Group 6 monitoring wells, and are summarized in Appendix A. Average calculated conductivities range from 4.65×10^{-5} cm/sec (at G6M-92-10X) to 3.85×10^{-2} cm/sec (at G6M-92-04X). Most conductivities at MAAF are on the order of 10^{-2} to 10^{-3} cm/sec. The lowest conductivities are at the base of the slope at monitoring wells G6M-92-10X and G6M-92-11X (10^{-4} to 10^{-5}).

Average horizontal hydraulic gradients in the general area of SA 30 range from approximately 0.002 ft/ft to approximately 0.009 ft/ft. One inferred groundwater flow path would be approximately from well G6M-92-03X, past well G6M-92-02X, to the Nashua River. The average hydraulic gradient along that path was approximately 0.0063 ft/ft on September 15, and the geometric average of the measured hydraulic conductivities at those two wells is 3×10^{-3} cm/sec. Under those conditions, and assuming an aquifer effective porosity of 0.30, the average rate of groundwater flow at the water table in this area would be approximately 65 ft/yr.

6.1.4 Nature and Extent of Contamination (Laboratory Results)

The analytical results for SA 30/Group 6 sampling events are summarized by medium in the following sections.

6.1.4.1 Soils. Three soil samples were collected for laboratory analysis from each of the eight soil borings advanced in SA 30 (24 samples total). Five soil samples were collected from each of the two borings (10 samples total) advanced for the purpose of installing groundwater monitoring wells (G6M-92-02X and G6M-92-03X) in SA 30. The laboratory results for organic and inorganic analytes in the 34 soil samples collected in SA 30 are provided in Tables 6-2 and 6-3, respectively. Figures 6-4, 6-5, and 6-6 show the distribution of total VOCs, SVOCs, and TPHC in soils. Figures 6-7, 6-8, and 6-9 show the distribution of those inorganic analytes at each depth interval exceeding calculated background concentrations. Appendix G of the SI Report (ABB-ES, 1993) contains the calculations used in determining background concentrations. For clarity, the three deeper subsurface samples taken from the two groundwater monitoring well borings are not depicted in Figures 6-4 through 6-9 but are listed in Tables 6-2 and 6-3.

With the exception of beryllium and sodium, no significant concentrations of inorganic analytes were widely detected. Copper, zinc, lead, and calcium were also rarely detected above background at isolated sampling locations. Concentrations of beryllium ranged from 0.552 to 0.847 μg/g in the 12 samples in which it was detected. The source of the slightly elevated beryllium in soil is not known. Sodium was detected in virtually all samples collected with concentrations ranging from less than the detection limit to 487 μg/g. Elevated concentrations of sodium in soil may be the result of runway and taxiway de-icing. No apparent lateral or vertical distribution pattern of these inorganic analytes is evident.

Organic compounds (toluene, xylene, TPHCs, and PAHs) were observed predominantly in surface soils in unpaved areas. In most cases, concentrations of these analytes decrease with, or are absent at depth. Toluene and xylene (typical petroleum product compounds) were detected at low (0.0013 to 0.0057 μg/g) concentrations in 18 of the 34 samples. There is no apparent horizontal distribution pattern evident; the compounds are generally equally distributed between the east- and west drum storage areas. Likewise, no consistent vertical distribution in the soil column is evident though concentrations were highest near the surface. Concentrations were detected as deep as 65 feet below the surface. Toluene and xylene are likely to be SA activity-derived compounds and may be related to the paint and paint thinner stored at the site. The absence of chlorinated solvents in all of the soils suggests that releases of those compounds have not occurred in this study area.

TPHC concentrations were observed to be generally low; the highest concentration of 171 μg/g was detected at G6M-92-03X. Many of the other samples exhibited TPHC concentrations near or below the detection limit. There does not appear to be a clear correlation between the PAH concentrations and TPHC and no obvious lateral or vertical distribution is evident.

SVOCs, mostly PAHs, were detected predominantly in the east drum storage area. The highest concentrations of these PAHs appear in surface soils. Concentrations in these subsurface soils were generally an order of magnitude less than the surface concentrations in the east drum storage area. PAHs were detected in surface soils (defined as 0-2 feet) in the east drum storage area at concentrations between 14 μg/g and 145 μg/g of total PAHs. No PAHs were reported in surface soils at the west drum storage area, however concentrations of 1.35 μg/g and 0.179 μg/g were reported at 2-8 feet and 8-10 feet respectively. Potentially PAH-containing substances (JP-4, gasoline, naphtha, petroleum-based paint thinners, lube oil and waste solvents) were reportedly stored at both drum storage locations. However, the Army has concluded that because the specific types and relative abundances of PAHs found in surface soil are characteristic of a pyrogenic origin, the source of the PAH detections at SA 30, most notably in the east drum storage area, is atmospheric deposition of petroleum combustion by-products associated with the normal operation of aircraft. The proximity of the airfield runways and taxiways, which provide a source of combustion particles, and the abundance of PAHs in exposed surface soils supports airborne deposition as a source. The absence of other closely associated petroleum compounds, such as branched alkanes, alkenes, and isoprenoids; and lower total petroleum hydrocarbon values than would be expected if this contamination were attributable to historical spillage, further supports the Army's position.

It was further reasoned that if the PAH compounds were the result of airborne deposition, then they should be ubiquitously distributed in airfield surface soils. Because an extensive storm drainage network exists at the airfield, sediment samples collected at the storm drain outfalls could be used to characterize the nature and distribution of airfield surface contaminants periodically washed down during runoff events. Comparison of contaminant compounds common to all storm drain sediments would provide information on the types and relative concentrations of contaminants common to all drained surfaces at the airfield.

Data collected during the AREE 70 investigation (Storm Sewer System Evaluation; ADL, 1994) from storm drain outfalls were used to characterize the nature of surface contaminants washed down from the airfield. Six outfalls distributed geographically around the airfield were selected to collect representative samples (Figure 6-10). A summary of the concentrations of the 17 PAH compounds detected in soil and sediment are provided in Table 6-4. The average normalized concentrations of 17 selected PAH compounds in these sediment samples were compared to the SA 30 surface soils (Figures 6-11 and 6-12). A strong correlation between most of the relative concentrations of PAH compounds was identified. Minor variations in specific compounds such as elevated concentrations of phenanthrene and fluoranthene can be explained by contributions of bituminous concrete pavement debris in the sediments. A typical suite of PAH compounds in bituminous concrete pavement is shown in Figure 6-13. The storm drain sediment findings suggest that PAHs are wide-spread on the surface of the airfield and the types and relative concentrations are similar to those detected in SA 30 surface soils.

6.1.4.2 Groundwater. Eleven groundwater monitoring wells were installed and sampled as part of the SA Group 6 groundwater quality assessment. Analytical results for groundwater are provided in Tables 6-5 and 6-6.

Two of these wells, G6M-92-02X and G6M-92-03X (Figure 6-2), were installed to assess groundwater impacts due specifically to the drum storage activities. Figure 6-14 shows the distribution of analytes detected in groundwater at SA 30. No organic compounds were detected in groundwater samples collected from these wells during Round 1; BIS, however, was detected at both locations in Round 2 groundwater samples. BIS is a suspected laboratory contaminant; it was present in water method blank samples, but at a lower concentration (see Section 1.2 of Appendix F). Except for potassium and sodium in Round 1 samples and barium and zinc in Round 2 samples, none of the detected inorganic analytes exhibited concentrations above calculated background concentrations.

6.1.4.3 Surface Water and Sediment. Surface water and sediment samples were collected at four locations along the Nashua River in locations downgradient of the Group 6 SAs and near storm water outfalls (Figure 6-1). Surface water samples were analyzed for organic and inorganic analytes, TPHC, water quality parameters, and TSS. Analytical results for surface water and sediment samples are provided in Tables 6-7 and 6-8, respectively.

No organic compounds were found above detection limits in any surface water samples; nine of the 23 inorganic analytes were detected (arsenic, barium, calcium iron, lead, magnesium, manganese, potassium, and sodium). Both total and fecal bacteria counts decreased downstream in the SA Group 6 surface water samples. Figure 6-15 shows the distribution of contaminants detected in SA Group 6 surface water samples.

Detected organic compounds in Nashua River sediments included acetone, toluene, three PAHs, BIS, and TPHC. Both toluene and BIS were likely laboratory contaminants as described in Section 1.2 of Appendix F. TPHC concentrations were highest in the upstream sample. The distributions of organic compounds, TPHC, and selected inorganic analytes for sediment samples are provided in Figures 6-16 through 6-18.

6.1.5 Source Evaluation and Migration Potential

Organic compounds (toluene, xylene, and PAHs) were observed predominantly in surface soils in unpaved areas. Concentrations of these analytes decrease with, or are absent at depth. The current VOC distribution suggests that downward migration may have occurred in borings G6M-92-02X and G6M-92-03X, but significant concentrations are not observed at depth. The poor correlation between PAH and TPHC distribution in surface soils suggests that airborne combustion product deposition is a likely source for the PAHs. The absence of PAHs in the west are is likely the result of pavement there. The absence of chlorinated solvents in all of the soils suggests that releases of those compounds have not occurred in this study area.

Inorganic analyte concentrations in SA 30 soil samples were observed to be generally at or below calculated background concentrations for Fort Devens soils. Elevated concentrations of sodium in soil may be the result of runway and taxiway de-icing. The source of the slightly elevated beryllium in soil is not known.

No observable contamination of groundwater has occurred as a result of potential releases from drummed waste in SA 30. The BIS detected in Round 2 samples is likely laboratory-introduced contamination. Because groundwater is clean, adverse impact to the Nashua River due to contaminated groundwater discharge from SA 30 is unlikely. However, surface runoff from the airfield is discharged to the Nashua River via storm drainage, and the general migration of contaminants is possible via this mechanism. The results of sediment sampling support the conclusion that contaminant migration via storm and surface water runoff from Fort Devens and other upstream sources is the likely cause of sediment contamination in the Nashua River. Due to the large number of connections to the stormwater drainage system, it is impossible to determine the exact source of specific contaminants.

Surface runoff from the airfield is discharged to the Nashua River via storm drainage and general migration of contaminants is possible through this mechanism. The results of sediment sampling support the conclusion that contaminant migration via storm and surface water runoff from the airfield and other upstream sources is a likely cause of sediment contamination in the Nashua River. Due to the large number of connections to the stormwater drainage system, it is impossible to determine the exact source(s) of specific contaminants. Surface water and sediment in the Nashua River have been investigated in detail under AREE 70.

6.1.6 Preliminary Human Health Risk Evaluation

SA 30, was reportedly used for temporary storage of containerized hazardous waste between 1975 and 1990. The east and west drum storage areas are located about 650 feet apart at the northern end of the MAAF taxiway. Hazardous wastes are no longer stored at the airfield. SA 30 is expected to remain as part of the airfield in the foreseeable future.

Tables 6-9 through 6-11 present summary statistics and human health standards and guidelines used in the PRE for SA 30.

6.1.6.1 Soils. The human health PRE considered all soils to a depth of 3 feet as accessible under a residential future use exposure scenario. This approach is conservative (i.e., health protective) because the most likely future use of SA 30 is as an airfield. All subsurface soil (defined as 3-10 feet in depth) was considered as accessible under a commercial/industrial future use exposure scenario.

Surface Soil

Table 6-9 presents summary statistics on surface soil at SA 30 and USEPA Region III residential soil concentrations for comparison. Surface soil at SA 30 is represented by samples 30B-92-01X to 30B-92-08X, G6M-92-02X, and G6M-92-03X. An assessment of the inorganic data for SA 30 soils showed that there is no apparent gross contamination present. Additionally, these is no clear areal or depth concentration pattern. Maximum detected concentrations of beryllium, copper, lead, and zinc exceed the statistical background. However, for copper, lead, and zinc, their average concentrations are below the statistical background. Beryllium average concentration of 0.66 μg/g and maximum concentration of 0.85 μg/g are near the statistical background concentration of 0.357 μg/g.

The maximum detected concentrations of all but two inorganic analytes (arsenic and beryllium) are below the USEPA Region III residential soil concentrations. Although arsenic was detected at a concentration above the residential soil concentration, its average and maximum detected concentrations are below the statistical background. The average of detected concentrations of beryllium (0.66 μg/g) is essentially equal to the USEPA Region III commercial/industrial soil concentration of 0.67 μg/g. In the case of SA 30, the commercial/industrial soil concentrations are actually more appropriate for comparison than the residential soil concentrations.

Of the organic compounds detected in surface soil at SA 30, six analytes were detected at concentrations above the USEPA Region III residential soil concentrations. These include benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

Soil boring locations 30B-92-01X through -05X and monitoring well boring location G6M-92-02X are in the west drum storage area. Samples at all depths from these borings show little, if any, organic compound contamination (including TPHC).

Soil borings 30B-92-06X through 30B-92-08X and monitoring well G6M-92-03X are in the east drum storage area. The PAHs reported above are the primary organic compounds in the area soils. In general, organic compound detections were limited to the surficial soil sample at each sampling location. This pattern is indicative of the deposition of airborne combustion products, most likely from aircraft engines at the airfield as opposed to SA 30 activities as detailed in Section 6.1.4.1.

When considering the SA activity-derived aromatic compounds (toluene and xylene), the USEPA Region III Risk-Based Concentration Table values are many orders of magnitude above the concentrations found in the SA during the SI activity.

Subsurface Soil

Table 6-10 presents summary statistics on subsurface soil at SA 30, and USEPA Region III commercial/industrial soil concentrations for comparison. Subsurface soil at SA 30 is represented by sampling 30B-92-01X to 30B-92-08X, G6M-92-02X and G6M-92-03X.

Only one analyte in Table 6-10, arsenic, was detected at a concentration above its respective USEPA Region III commercial/industrial soil concentration. Although the average (8.3 μg/g) and maximum (16 μg/g) detected arsenic concentrations exceed the commercial/industrial soil concentrations of 1.6 μg/g, both are below the base-wide statistical background concentration of 21.1 μg/g.

6.1.6.2 Groundwater. Table 6-11 presents summary statistics on groundwater around SA 30 and drinking water standards and guidelines for comparison. Monitoring well locations G6M-92-02X and -03X have been used to define the groundwater quality in the vicinity of the former drum storage areas. Organic contaminants in soils at the subject areas were not detected in groundwater during the SI. Only one organic analyte, BIS, was detected in SA 30 monitoring wells. It was detected at concentrations (17.0 and 33.0 μg/L) that exceed the USEPA Region III tap water concentration (6.1 μg/L) but is suspected as being a laboratory-introduced contaminant. Three inorganic analytes, aluminum, iron, and manganese, were detected at maximum concentrations that exceed their respective drinking water standard or guideline. For all three inorganics, only secondary MCLs have been promulgated. No health-based drinking water standards exist for these compounds. It should also be noted that the maximum detected concentrations of these compounds are well below the statistical background levels.

6.1.7 Preliminary Ecological Risk Evaluation

SA 30 consists of two small areas of broken pavement and mowed grassy areas, separated by approximately 650 feet, at the northern end of the MAAF. The two portions of SA 30 (the east- and west drum storage areas) are connected by a paved driveway and are bordered to the north by a chain-link fence atop a slope adjacent to the Nashua River. Non-paved portions of SA 30 are devoid of woody cover and contain herbaceous species typical of disturbed old field uplands, including goldenrod (*Solidago* sp.), various grass species, evening primrose (*Oenothera biennis*), and shepherd's purse (*Capsella bursa-pastoris*).

Because of the limited habitat available at this site, minimal use of SA 30 by resident or migratory wildlife species is anticipated. However, occasional American robins (*Turdus migratorius*) and small mammals may periodically forage at this site. A review of the Fort Devens rare and endangered species database indicates that no rare or endangered species are known to occur in the vicinity of MAAF.

Ten surface soil samples were obtained at SA 30 (from stations 30B-92-01X through 30B-92-08X, G6M-92-02X, and G6M-92-03X). Twenty organic compounds were detected, including toluene, xylenes, and 18 SVOCs. All detected organic analytes were chosen as CPCs. The maximum concentrations of beryllium, copper, lead, and zinc exceeded background concentrations; therefore, these four inorganics were chosen as CPCs. Although SA 30 contains little ecological habitat, a potential contaminant exposure pathway exists for terrestrial receptors via incidental surface soil ingestion and terrestrial food web exposure. A screening-level evaluation of potential effects from surface soil exposure was conducted by comparing the maximum CPC concentrations to their respective surface soil benchmark values (PCLs) (Table 6-12). Of the four inorganic CPCs, only lead occurred at a concentration (45.0 μg/g) in excess of its respective surface soil PCL. However, because of the rare occurrence of lead at elevated concentrations in surface soil above the PCL (once in 11 samples), lead is not considered to be posing significant ecological risks at SA 30.

The maximum levels of benzo(a)pyrene and benzo(a)anthracene at SA 30 exceeded the PCLs derived for these two analytes. Benzo(a)pyrene was found in three of ten surface soil samples at concentrations ranging from 1.2 to 20 μg/g. Benzo(a)anthracene was found in four of ten surface soil samples at concentrations ranging from 0.91 to 10 μg/g. The average benzo(a)anthracene concentration at SA 30 is 5.7 μg/g, considerably less than the PCL of 8.9 μg/g established for this analyte. Although the PCLs used as screening tools in this ecological PRE were the values derived for the short-tailed shrew, the dry and disturbed conditions at SA 30 are unlikely to provide any habitat for this insectivorous mammal. The maximum concentrations of benzo(a)pyrene and benzo(a)anthracene detected at SA 30 are well below the respective PCLs derived for all other receptor species evaluated in the food web model. Furthermore, the lack of suitable habitat minimizes any risks to ecological receptors from these two SVOCs.

6.1.8 Conclusions and Recommendations

No further action is recommended for SA 30. This recommendation is based on historical information on the use of the study area as confirmed by physical observations, sampling, chemical analysis, and the results of human health and ecological PREs.

The primary concerns at SA 30 have been the residual contamination due to releases from leaking drums. Sampling and analysis during the SI confirmed that some soil contamination may have been derived from VOCs associated with paint or paint thinners; however, the ecological and human health PREs found no unacceptable risk associated with these contaminants. Similarly, no unacceptable human health or ecological risks were identified for ecological analytes detected in soil above background concentrations. PAH concentrations detected in surficial soils exceeded both human health and ecological guidelines, but are likely the results of combustion product deposition and not historical SA 30 activities. Water samples from monitoring well locations G6M-92-02X and G6M-92-03X in the subject areas do not indicate that contamination from former drum storage has impacted groundwater. BIS was detected in groundwater samples collected from these wells, but it was detected only during Round 2 and is suspected to be a laboratory-introduced contaminant.

Surface water and sediment in the Nashua River will be further investigated under AREE 70.

6.2 SA 31 - MOORE ARMY AIRFIELD FIRE-FIGHTING TRAINING

Study Area 31 is a fire-fighting training area located at the western end of the abandoned east-west runway at MAAF (Figure 6-1). The facility consists of an approximately 100-by-100-foot asphalt-covered concrete area, surrounded by a 12-inch-high by 24-inch-wide earthen containment berm.

6.2.1 Study Area Background and Conditions

Approximately once a year between 1975 and 1986, as part of training exercises, an abandoned aircraft was doused with fuel and paint thinner and was open-burned within the bermed area of SA 31 (Biang et al., 1992; McMaster et al., 1982; and Reynolds, 1991).

Because cracks in the asphalt-covered concrete are present at the surface within the bermed area, the effectiveness of the asphalt-covered concrete as a liner may have been compromised. Releases of flammable product during the fire training exercises could thus have resulted in contamination of the underlying soil and groundwater. Although most of the fuel was burned during the exercises, the potential exists for some fuel/solvent seepage beneath the concrete. Additionally, due to the high permeability of the soils, there is a potential for migration of free-phase contaminants to the water table.

6.2.2 SA Investigation Program Summary

In order to assess groundwater contamination resulting from SA 31 fire training activities, two of the SA Group 6 groundwater monitoring wells (G6M-92-04X and G6M-92-05X) were installed in locations presumed to be downgradient of the fire-fighting training pad. The monitoring well soil borings G6M-92-04X and G6M-92-05X were drilled with HSAs, to 10 feet below the water table (72 and 70 feet bgs, respectively). Split-spoon samples were collected at 5-foot intervals for field screening by PID and for field classification. In both borings, one analytical sample was collected from the saturated zone at the approximate depth of the water table and analyzed for TOC. Two rounds of groundwater samples were collected from these wells and analyzed for PAL organics, PAL inorganics, PAL anions/cations, TSS, and TPHC. As with other monitoring wells, a third round of groundwater samples was collected and analyzed for PAL VOCs only due to the cross-contamination which occurred during Round 2 (see Section 3.2.3).

To identify possible near-surface soil contamination, four shallow soil borings (31B-92-01X through 31B-92-04X) were drilled at SA 31 through the asphalt/concrete pad to depths of 10 feet (Figure 6-19). Continuous split-spoon soil samples were collected from these borings for field screening by PID and for field classification. Three split-spoon samples from each boring were selected for laboratory analysis of PAL organics, PAL inorganics, and TPHC. One analytical sample was collected from directly beneath the concrete, one sample from the bottom of the boring, and the other sample was collected from an intermediate depth.

One deep soil boring (31B-92-05X) was also drilled to the water table (62 feet) in the approximate center of the pad, to evaluate whether contaminants have affected the deeper soils. Split-spoon soil samples were collected at 5-foot intervals, and five of the split-spoon samples were sent for laboratory analysis for PAL organics, PAL inorganics, and TPHC. The five samples sent for laboratory analysis included one collected from immediately beneath the pavement, one from the approximate depth of the water table, and three from intermediate depths.

Boring logs are presented in Appendix B and monitoring well completion diagrams are presented in Appendix C.

6.2.3 Field Investigation Results and Observations

The facility and is no longer in use (Biang et al., 1992). No abandoned aircraft remain. The berm and asphalt-covered concrete pad are still in place with sparse vegetative cover. The asphalt liquefies in hot weather, particularly in the southeast corner of the pad.

General SA Group 6 surficial geologic deposits and groundwater characteristics are discussed in Section 6.1.3.

The soils of SAS 31 are high conductivity sands, with no significant or continuous stratification and no observed layers of silt or clay. Bedrock was not encountered in any of the boreholes.

Groundwater beneath the fire-fighting training pad at SA 31 flows roughly west (toward well G6M-92-04X) to the Nashua River. The average horizontal hydraulic gradient beneath the pad was approximately 0.0022 ft/ft in September 1992, and the geometric average of the measured hydraulic conductivities at the two nearest wells (G6M-92-04X and G6M-92-05X) is 0.020 cm/sec. Under those conditions, and assuming an aquifer effective porosity of 0.30, the average rate of groundwater flow at the water table in SA 31 would be approximately 152 ft/yr.

6.2.4 Nature and Extent of Contamination (Laboratory Results)

The analytical results of samples collected in SA 31 are summarized by medium in the following sections.

6.2.4.1 Soils. A total of 17 soil samples were collected for laboratory analysis from the five borings advanced through the asphalt pad at SA 31. The samples were analyzed for organics, inorganics, and TPHC. The laboratory results for organic compounds are provided in Table 6-13. Figures 6-20, 6-21, and 6-22 show the distribution of total VOCs, total SVOCs, and TPHC in soils collected at three depth intervals from 0 to 10 ft.

Toluene was observed at a concentration of 0.0019 μg/g in the soil sample collected from immediately beneath the concrete in 31B-92-03X. Toluene was also detected, at a greater concentration, in the soil method blank and, therefore, is likely attributable to laboratory contamination (ABB-ES, 1993, Appendix F). No other VOCs were detected in any of the other soil samples collected. SVOCs, mostly polynuclear aromatic hydrocarbons (PAHs), were detected in almost all soil samples collected except those collected from 31B-92-03X and the deep samples (30 ft and below) collected from 31B-92-05X. Borings 31B-92-01X and 31B-92-02X exhibited the highest concentrations of PAHs between 2 and 4 ft and 4 and 6 ft, respectively. TPHC concentrations generally mirrored the distribution of the SVOCs except in 31B-92-05X, where low concentrations of TPHC were detected at depth. SVOCs are not present at depth in 31B-92-05X. The highest TPHC concentration was 2,090 μg/g detected in the 8-foot depth sample from boring 31B-92-04X. No other significant lateral or vertical distribution of these analytes was found.

The soil samples were collected from beneath the pad, particularly in boring 31B-92-05X, along the probable contaminant migration path and are representative of the potential "worst case" soil conditions at SA 31. Any potential contaminant migration is expected to have been vertically downward to the water table from releases through the pad, because no significant stratification of silt and clay in the soil column was observed. The concentrations of TPHC in soil at depth beneath the pad (40 μg/g at 30 ft bgs and 35.1 μg/g at 60 ft bgs) represent concentrations just above the detection limit for TPHC (roughly 28 to 29 μg/g) and are considered low. Because TPHC was not detected at 45 ft bgs, no continuous connection between surface contamination and TPHC detected at depth was observed. Further, no associated VOCs or SVOCs were observed in the samples exhibiting TPHC contamination below 20 ft bgs.

With the exception of beryllium, calcium, copper, and sodium, no significant concentrations of inorganic analytes were detected above calculated Fort Devens background concentrations (Table 6-14). Concentrations of beryllium ranged from 0.572 to 0.608 μg/g in the three samples in which it was detected (borings 31B-92-02X, 31B-92-03X, and 31B-92-05X). These naturally occurring beryllium concentrations are only marginally greater than the analytical method detection limit and the Fort Devens background concentration. Similarly, calcium was detected above the background soil concentration in three samples in three separate borings. Sodium was detected in nine of the 17 samples collected with concentrations ranging from 112 to 172 μg/g. Elevation sodium and calcium concentrations are likely the result of runway deicing. Copper was detected just above the background concentration in the surface soil sample collected from 31B-92-05X and is likely representative of natural background. No apparent lateral or vertical distribution of these inorganic analytes is evident. Figures 6-23, 6-24, and 6-25 show the distribution at each depth interval of inorganic analytes exceeding calculated background concentrations for typical Fort Devens soils.

6.2.4.2 Groundwater. Eleven groundwater monitoring wells were installed and sampled as part of the SA Group 6 groundwater quality assessment. Analytical results are provided in Tables 6-5 and 6-6. Two of these wells, G6M-92-04X and G6M-92-05X, were installed to assess groundwater impacts due to fire-fighting training activities. BIS was detected in groundwater samples collected from these wells during both rounds of sampling. It is possible that BIS is a laboratory contaminant because in most instances the detected concentration was the same order of magnitude as the detected concentration in a water method blank sample (see Section 1.2 of Appendix F). TPHC was detected in the Round 2 sample collected from G6M-92-05X. No VOCs were detected in either the Round 1 or Round 3 samples collected from the two wells. Calcium, copper, lead, manganese, and zinc were all detected at concentrations above the calculated background concentrations in groundwater collected at G6M-92-04X during both sampling rounds. The filtered sample collected from G6M-92-04X in Round 2 showed elevated calcium only. The elevated concentrations detected in unfiltered samples are likely caused by the high TSS concentration recorded for the sample. After filtering, only the more soluble inorganic analytes (calcium) was detected above background supporting the contention that the other inorganic analytes are suspended solids (undissolved) in groundwater. No inorganic analytes were detected above background in G6M-92-05X groundwater except for zinc in Round 2. Analytical results for groundwater are shown in Figure 6-26.

6.2.4.3 Surface Water and Sediment. Surface water and sediment sampling results for SA Group 6 are discussed in Subsection 6.1.4.3.

6.2.5 Source Evaluation and Migration Potential

At most sampling locations, the petroleum-related organic compounds (TPHC and PAHs) were detected in soil samples located immediately below the concrete pad. These detected analytes are consistent with those presumed to have been used there. Higher concentrations of the compounds were generally found in the near surface soils. The fact that PAHs and TPHC are found in soil samples deeper than immediately below the asphalt-covered concrete pad suggests that the organic contamination in the study area soils is not due totally to asphalting and may be the result of fuel releases. The lateral TPHC distribution indicates that liquids (both fuels and rainwater) may have concentrated in the southeast corner of the bermed area near boring location 31B-92-04X. These liquids may have percolated through the soils at that location resulting in a TPHC level as high as 2090 μg/g at the 8-foot sample depth. The absence of chlorinated solvents in all of the soils suggests that releases of those compounds have not occurred in this study area.

Inorganic analyte concentrations were observed to be generally at or below calculated background concentrations for Fort Devens soils. Elevated levels of calcium and sodium in soil may be the result of runway and taxiway de-icing. No obvious source for the beryllium has been determined.

No observable contamination of groundwater has occurred as a result of potential releases associated with fire-fighting training activities at SA 31. The isolated occurrence and low concentration of TPHC detected in the Round 2 groundwater sample collected from G6M-92-05X is typical of sporadic low concentration TPHC detections in other Group 6 airfield wells. No obvious petroleum hydrocarbon source can be identified given the current groundwater flow regime. Because groundwater is clean downgradient (G6M-92-04X), contaminant migration from SA 31 via groundwater flow to the Nashua River is unlikely.

As stated previously, surface runoff from the airfield is discharged to the Nashua River via storm drainage and migration of contaminants to the river is possible through this mechanism. The results of sediment sampling support the conclusion that contaminant migration via storm and surface water runoff is a likely source of sediment contamination in the Nashua River. It is impossible, however, to differentiate contaminants from surface soils in SA 31 from the other numerous sources located adjacent to, and connected to the storm water drainage systems discharging to the Nashua River.

6.2.6 Preliminary Human Health Risk Evaluation

The future use of SA 31 is expected to be industrial/commercial. Tables 6-15, 6-16, and 6-17 present summary statistics and human health standards and guidelines used in the PRE for SA 31. Average values presented in the following discussions reflect the average of detected concentrations only.

6.2.6.1 Soils. This preliminary risk evaluation considered all soils to a depth of 3 ft as accessible under a residential future use exposure scenario. This approach is conservative (i.e., health-protective) because the most likely future use of SA 31 is industrial/commercial. All subsurface soil (defined as 3 to 10 ft in depth) was considered as accessible under a commercial/industrial future use exposure scenario.

Surface Soils

Table 6-15 presents summary statistics on surface soil at SA 31 and USEPA Region III residential soil concentrations for comparison. Surface soil at SA 31 is represented by samples collected 31B-92-01X to 31B-92-05X between 0 and 3 ft.

An assessment of the inorganic data for SA 31 surface soils shows that there is no apparent gross contamination present. As shown in Table 6-15, the maximum detected concentrations of only two compounds, beryllium and copper, slightly exceeded the statistical background. However, the maximum concentration of copper is well below the USEPA Region III residential soil concentration. The maximum concentration of beryllium (0.57 μg/g) only slightly exceeds the residential soil concentration of 0.4 μg/g and is below the more applicable commercial/industrial soil concentration of 0.67 μg/g. Although arsenic was detected at a maximum concentration (8.8 μg/g) above the residential soil concentration (0.97 μg/g), its average and maximum detected concentrations are well below the statistical background.

Of the 17 organic analytes reported in Table 6-15, only one (benzo[a]pyrene) was detected at a concentration (average: 0.47 μg/g; maximum 0.62 μg/g) slightly above the USEPA Region III residential soil concentration (0.23 μg/g).

Subsurface Soils

Table 6-16 presents summary statistics on subsurface soil at SA 31 and USEPA Region III commercial/industrial soil concentrations for comparison. Subsurface soil at SA 31 is represented by samples 31B-92-01X to 31B-92-05X.

The maximum detected concentration of only one inorganic analyte (arsenic) in Table 6-16 exceeds the USEPA region III commercial/industrial concentration. Arsenic, however, was detected at levels (average: 7.8 μg/g; maximum 10 μg/g) well below the statistical background (21.1 μg/g).

Only two detected organic analytes (benzo(a)anthracene and benzo(a)pyrene) are present at concentrations above the USEPA Region III commercial/industrial concentrations. Both PAHs were detected in only one of nine samples. The single detection of benzo(a)anthracene (3 μg/g) only slightly exceeds the commercial/industrial concentration of 2.7 μg/g. The single detection of benzo(a)pyrene (4 μg/g) exceeds a commercial/industrial soil concentration of 0.39 μg/g.

TPHC was also detected in SA 31 subsurface soil at an average and maximum detected concentration of 318 and 2,090 μg/g, respectively. To evaluate the health risk associated with TPHC in soil, ABB-ES developed risk-based concentrations for petroleum products. These concentrations were calculated using the same exposure assumptions as those used by USEPA toxicologists in the USEPA Region III Risk-Based Concentration Table, First Quarter, 1993, for commercial/industrial soils and residential oils. For SAs 44 and 52, JP-4 (a jet fuel) is the type of fuel oil most likely used in fire training exercises. The dose/response value used for JP-4 is a provisional value developed by USEPA, Environmental Criteria and Assessment Office (USEPA, 1992). The following are the risk-based concentrations for JP-4:

Analyte	Residential Soil (μg/g)	Commercial/Industrial Soil (μg/g)
JP-4	630	8180

The maximum detected TPHC concentration of 2,090 μg/g is above the residential soil concentration of 630 μg/g, but is well below the more applicable commercial/industrial soil concentration of 8,180 μg/g. The average detected concentration of TPHC (318 μg/g) is well below both the residential and commercial/industrial soil concentrations.

6.2.6.1 Groundwater. Table 6-17 presents summary statistics on groundwater at SA 31 and drinking water standards for comparison. Monitoring well locations G6M-92-04X and G6M-92-05X have been used to define the groundwater quality in the vicinity of the former fire-fighting training area. Except for TPHC, organic contaminants in soils at the subject areas have not been detected in groundwater during the SI. BIS was detected in both monitoring well at concentrations in excess of the USEPA Region III tap water concentration. However, BIS is suspected of being a laboratory contaminant and the concentrations detected in these samples are not likely representative of actual groundwater contamination. Only the federal secondary standard for aluminum and manganese of 50 μg/L was exceeded at monitoring well location G6M-92-04X. These concentrations were accompanied by high TSS values. Filtered groundwater samples from Round 2 show significant decreases in the levels of both inorganics.

6.2.7 Preliminary Ecological Risk Evaluation

Mowed grass surrounds this area. Several weedy species characteristic of old field habitat occur around the perimeter of SA 31, including Queen Anne's lace (*Daucus carota*), evening primrose (*Oenothera biennis*), goldenrods (*Solidago* spp.), asters (*Aster* spp.), shepherd's purse (*Capsella bursa-pastoris*), ragweed (*Ambrosia artemisiifolia*), and upland grasses.

Because SA 31 is a paved site, no significant habitat for resident or migratory ecological receptors occurs at this site. A review of the Fort Devens biological database indicates that no rare or endangered species are known to occur in the vicinity of SA 31. Therefore, based on the lack of ecological habitat at SA 31, and the resulting lack of ecological exposure pathways, no comparison of surface soil analytes to PCL reference values was conducted.

6.2.8 Conclusions and Recommendations

No further action is recommended for SA 31. This recommendation is based on historical information on the use of the SA as confirmed by physical observations, sampling, and chemical analysis. It is also based on the results of a preliminary risk evaluation.

The contaminant profile established during the SI is consistent with the reported military activity in the study area and with observations made during the installation of soil borings in the fire-fighting training area. Sampling and analysis during the SA 31 SI indicated that contaminants detected were likely derived from petroleum hydrocarbon fuels. Chlorinated solvents were not detected. The distribution of these contaminants suggests that downward migration has occurred, but is limited in extent. It is unlikely that the detected soil contaminants from SA 31 activities have or will have significantly affect groundwater quality. Groundwater was detected at 62 feet below ground surface. The concentrations of TPHC in soil at depth beneath the pad were just above detection limits. These concentrations are very low (just above the detection limit) and not a significant source of groundwater contamination. Because TPHC was not detected in soil at 45 feet, no continuous connection between the surface contamination and groundwater is evident (Figure 6-27). Additionally, TPHC was not detected in either round of groundwater collected directly downgradient from the pad.

The human health PRE identified two organic compounds (benzo[b]fluoranthene and benzo[a]anthracene) and one inorganic analyte (beryllium) in surface and subsurface soil as possible human health threats. The beryllium is likely naturally occurring and not representative of contamination from SA 31. The infrequent detection of benzo(b)fluoranthene and benzo(a)anthracene with the limited exposure potential (paved) suggests that they pose no significant threat to human health. Further, the limited habitat and lack of exposure pathways identified in the ecological PRE suggests no threat to the environment exists at SA 31. Thus no unacceptable threats to human health or the environment due to hazardous waste contamination were identified at SA 31.

6.3 SA 47 - MOORE ARMY AIRFIELD UNDERGROUND STORAGE TANK

The UST at Study Area 47 was located at the base of the flight control tower (Building 3816) at MAAF (Figure 6-1). The 500-gallon tank was used to store No. 2 fuel oil between 1970 and 1989.

6.3.1 Study Area Background and Conditions

The UST was removed and replaced in January 1989 by Petroleum and Chemical Equipment Service of New Hampshire, Inc. (subcontractor to C-Q Construction Corporation of Watertown, MA). After tank removal, excavation was continued to remove contaminated soil. At a depth of 8.5 feet, the decision was made to stop digging because of the potential that further excavation might affect the stability of the flight-control tower. The sides of the excavation were clean, but the bottom was judged to be still contaminated (Sharma, 1988). Two confirmatory samples were collected, but the analytical results have not been located. The location of the tank excavation is evident at the surface by a small area of newer pavement. A replacement 500-gallon fuel oil UST installed in the former tank grave is currently in use.

SA 47 is located on a part of the airfield expected to remain an airfield for the foreseeable future.

6.3.2 Study Area Investigation Program Summary

Because of the limited size of SA 47, a single monitoring well soil boring (G6M-92-07X) was drilled adjacent to the former UST excavation as close to the existing replacement UST as possible. The boring was advanced to 10 feet below the water table (65.2 feet bgs). Split-spoon soil samples were collected at 5-foot intervals for field screening by PID and for field classification. Five split-spoon samples were selected for analysis for PAL VOCs, lead, and TPHC: one sample was collected at the ground surface (from 0 to 2 feet bgs), one was collected in saturated soil at the approximate depth of the water table (60 to 62 feet bgs), and the other three samples were selected from intermediate depth intervals. The water table soil sample was analyzed for TOC in addition to the analytes listed above.

One of the eleven Group 6 monitoring wells (G6M-92-07X) was installed in this borehole. Two other wells, G6M-92-01X and G6M-92-06X, were installed as part of the group-wide water quality assessment, but were near enough to and roughly downgradient of the former UST location to provide additional relevant data on impacts due to potential releases from that tank. Two rounds of groundwater samples, three months apart, were collected from the three wells and analyzed for PAL VOCs, PAL SVOCs, TPHC, inorganic analytes, and anions/cations. A third round of samples was collected from the wells and analyzed for PAL VOCs to replace cross-contaminated Round 2 VOC results.

Additionally, to evaluate the potential impact of contaminant migration from SA 47 to the Nashua River, surface water and sediment samples were collected from the Nashua River and analyzed for PAL organics, inorganics, and TPHC. Surface water samples were also analyzed for PAL water quality parameters and total suspended solids, and sediment samples were analyzed for TOC and were tested for grain size distribution.

The Group-wide groundwater and surface-water/sediment sampling program is described in Section 6.1.2.

6.3.3 Field Investigation Results and Observations

The former UST tank excavation is evident at the surface by a small area of newer pavement. The replacement 500-gallon fuel oil UST is currently in use.

General SA Group 6 surficial geologic deposits and groundwater characteristics are discussed in Section 6.1.3. Groundwater beneath SA 47 flows roughly southwest through downgradient well G6M-92-07X. The hydraulic conductivity at monitoring well G6M-92-07X is 0.020 cm/sec. With an average local hydraulic gradient of 0.003 ft/ft and an assumed effective porosity of 0.30, the average groundwater velocity at the water table near SA 47 would be approximately 200 ft/yr. No other wells are located immediately downgradient of the former UST, however, wells G6M-92-01X and G6M-92-06X (installed for group-wide groundwater table elevation data) were used to assess general downgradient water quality.

6.3.4 Nature and Extent of Contamination (Laboratory Results)

The SA 47 analytical results are discussed by medium in the following subsections.

6.3.4.1 Soils. A total of five soil samples were collected from boring G6M-92-07X installed adjacent to the former tank location. Samples were collected at the surface and 10, 25, 40, and 60 feet below the surface. The laboratory results for these five soil samples are provided in Table 6-18.

No VOCs were detected in any soil samples collected from the boring. Very low TPHC concentrations were detected in the two shallowest samples (39.3 μg/g and 38.1 μg/g, respectively). Lead was detected in all five samples ranging in concentration from 0.989 to 4.7 μg/g, all below the calculated Fort Devens background soil concentration of 48.4 μg/g. Figure 6-28 illustrates the distribution of contaminants by depth.

TPHC concentrations, though expected in soil contaminated with fuel oil, were at concentrations lower than what would be expected for overtly contaminated soil. The current distribution may indicate that fuel-related contamination occurred. However, the absence of TPHC in deeper soils suggests that migration was not extensive in this SA.

6.3.4.2 Groundwater. G6M-92-07X was installed to assess groundwater quality directly beneath the former leaking UST. Two other wells, G6M-92-01X and G6M-92-06X, were installed as part of the group-wide water quality assessment, but are near enough to and roughly downgradient of the former UST location to provide additional relevant data on impacts due to potential releases from that tank. Groundwater analytical results are summarized in Table 6-19. Figure 6-29 shows the distribution of organic and inorganic analytes detected in these three wells.

Except for BIS, no organic compounds were detected in the groundwater sample collected from G6M-92-07X. During Round 1, acetone (the only VOC observed in groundwater at MAAF) was detected at a concentration of 21 μg/L in G6M-92-01X, located roughly 700 feet downgradient of SA 47. TPHC was also detected in the Round 1 sample collected from this well at a concentration of 1,550 μg/L, but was not detected in Round 2. In Round 2, BIS was detected in groundwater form G6M-92-01X. BIS (8.8 μg/L) was the only organic compound detected in groundwater from G6M-92-06X during Round 1. In Round 2, BIS was absent in this well, but TPHC was detected at a concentration just above the detection limit. G6M-92-06X is located 500 feet to the south of SA 47. It is likely that the BIS and acetone detected during various sampling rounds at all three well locations are laboratory contaminants (see Section 1.2 of Appendix F). The isolated occurrences of TPHC in G6M-92-01X and G6M-92-06X are not considered significant.

Inorganic analytes detected above the calculated groundwater background concentration in these three wells included calcium, silver, and zinc. Calcium was observed in G6M-92-07X at a concentration of 16,200 μg/L in Round 1 and 17,000 and 18,800 μg/L in Round 2. Silver (93.6 μg/L) was detected in G6M-92-01X during Round 1, but not in Round 2. No inorganic analytes exceeded background concentrations in G6M-92-06X except for zinc during Round 2. Zinc was present above background in most of the groundwater samples collected (installation-wide) during Round 2.

6.3.4.3 Surface Water and Sediment. Surface water and sediment sampling results for SA Group 6 were discussed in Subsection 6.1.4.3.

6.3.5 Source Evaluation and Migration Potential

TPHC concentrations, though expected in soil contaminated with fuel oil, are at concentrations lower than what would be expected for overtly contaminated soil. The current distribution may indicate that fuel-related contamination occurred. However, the absence of TPHC in deeper soils suggests that migration was not extensive in this study area.

No observable contamination of groundwater has occurred as a result of potential releases associated with the former UST at SA 47. Because no organic contaminants were detected in groundwater at G6M-92-07X, contaminant migration from Study Area 47 via groundwater flow to wells G6M-92-01X or G6M-92-06X, or the Nashua River is unlikely. There is no identified source for the contaminants detected in G6M-92-01X; furthermore, there is little correlation between Rounds 1 and 2 sampling results of these wells. Surface runoff from the airfield is discharged to the Nashua River via storm drainage and migration of contaminants is possible through this mechanism. The results of sediment sampling support the conclusion that contaminant migration via storm and surface water runoff is a likely source of sediment contamination in the Nashua River; the specific source area for this contamination cannot be determined however, due to the large number of stormwater connections.

6.3.6 Preliminary Human Health Risk Evaluation

SA 47, the MAAF UST, was used to store fuel oil between 1970 and 1989: it was removed and replaced in 1989. SA 47 is part of the MAAF and is located on a part of the airfield expected to remain an airfield for the foreseeable future.

Tables 6-20 through 6-22 present summary statistics and human health standards and guidelines used in the PRE for SA 47.

6.3.6.1 Soils. The preliminary risk evaluation considered all soils to a depth of 3 ft as accessible under a residential future use exposure scenario. This approach is conservative (i.e. health protective) because the most likely future use of SA 47 is to house the UST for airfield use. All subsurface soil (defined as 3-10 ft in depth) was considered as accessible under a commercial/industrial future use exposure scenario.

The inorganic analyses of soil at SA 47 were restricted to lead since that analyte may have been an indicator of fuel contamination. Sampling location G6M-92-07X represented soil at SA 47. An assessment of the lead data for SA 47 soils showed that there is no apparent contamination present. Additionally, there is no clear pattern over sample depth. When comparing soil concentrations to the statistical background lead concentration, there are no exceedances.

When considering lead levels in soil, the USEPA interim guidance on Superfund soil lead cleanup value of 500 μg/g (USEPA, 1989) is considerably above the concentrations found in the SA during the SI activity. Therefore, it is clear that lead at SA 47 does not pose a significant risk to human health.

TPHC and VOCs were used a the primary organic compound indicators for the study area soils. Under the tarmac in the vicinity of the UST, at monitoring well boring location G6M-92-07X, no VOCs were detected. The TPHC levels range from approximately 40 μg/g just below the tarmac and drop off to less than the detection limit at the 25-foot sample depth and below. The TPHC levels indicate that contamination from fuel spillage has not significantly occurred in that area.

To evaluate the health risk associated with TPHC in soil, ABB-ES developed risk-based concentrations for petroleum products. These concentrations were calculated using the same exposure assumptions as those used by USEPA toxicologists in the USEPA Region III Risk-Based Concentration Table, First Quarter, 1993 (USEPA, 1993) for commercial/industrial soils and residential soils. Dose response values for gasoline and marine diesel used in the calculations are provisional values developed by USEPA, Environmental Criteria and Assessment Office (USEPA, 1992). USEPA suggests using the reference dose value for diesel oil as a surrogate for No. 2 fuel oil.

The table below presents the risk-based concentrations for petroleum products:

Analyte	Residential Soil (μg/g)	Commercial/Industrial Soil (μg/g)
Gasoline	1,000	1,800
No. 2 Fuel Oil	630	8,180

The maximum detected TPHC concentration in soil at SA 47 (39 μg/g) is well below the risk-based residential soil concentration of 630 μg/g.

6.3.6.2 Groundwater. Monitoring well location G6M-92-07X was used to define the groundwater quality in the vicinity of the UST. Except for BIS, organic contaminants were not detected in groundwater at SA 47 during the SI. BIS was detected at 20 μg/L, a concentration above the USEPA Region III tap water concentration of 6.1 μg/L, but is a suspected laboratory contaminant. Considering inorganic compounds, statistical background concentrations were not exceeded except for calcium and zinc. The de-icing of the airfield tarmac readily explains the presence of calcium in groundwater. Although the concentration of zinc in G6M-92-07X exceeds the statistical background, it is well below the secondary MCL for zinc. Concentrations of aluminum and iron exceeded their respective secondary MCLs in Round 2 only. Both concentrations, however, are well below the statistical background levels.

6.3.7 Preliminary Ecological Risk Evaluation

SA 47 consists of approximately an eighth of an acre area of asphalt driveway, adjacent to the Moore Army Airfield flight control tower (Building 3816). Mowed grass surrounds this developed site.

No significant habitat for resident or migratory ecological receptors occurs at this paved site. A review of the Fort Devens biological database indicates that no rare and endangered species are known to occur in the vicinity of SA 47. Therefore, based on the lack of ecological habitat at SA 47, and the resulting lack of ecological exposure pathways, no comparison of surface soil analytes to PCL reference values was conducted.

6.3.8 Conclusions and Recommendations

No further action is recommended for SA 47. This recommendation is based on historical site use as confirmed by physical observations, sampling, and chemical analysis. It is also based on the results of a preliminary risk evaluation.

BIS concentrations were detected in groundwater samples from monitoring well G6M-92-07X in the SA at concentrations exceeding USEPA Region III drinking water guidelines, but is a suspected laboratory contaminant. Aluminum and iron concentrations at this location exceed secondary MCLs in the Round 2 sampling only, but are well below calculated background concentrations.

As noted above, the primary concern at SA 47 has been possible residual contamination due to releases from a leaking underground tank which has since been removed and replaced. Sampling and analysis of soil and groundwater during the SI found no significant petroleum hydrocarbon concentrations associated with fuel.

6.4 SA 50 - MOORE ARMY AIRFIELD WWII FUEL POINT

Study Area 50 is located at the northern end of MAAF (Figure 6-1). During World War II, there were two gasoline fueling systems at the airfield, one for fueling aircraft and trucks and the other for fueling trucks. According to Prior

(1991, as cited by Biang et al., 1992), these systems have not been used since the late 1940s.

6.4.1 Study Area Background and Conditions

Information about the fueling systems was gathered from direct field observations; geophysical surveys; and engineering design, construction, and operating plans obtained from Fort Devens files.

During World War II there were two gasoline fueling systems at the airfield. One of the systems (referred to as Fueling System A) was for fueling aircraft and trucks on the airfield, and the other system (referred to as Fueling System B) was for fueling trucks near the base of a slope at the northern margin of the airfield (see Figure 6-30).

The two separate fueling systems were filled by gasoline shipments on a Boston & Maine Railroad spur (which no longer exists) located adjacent to Fueling System B. For Fueling System A, a rotary pump located in a pit near the railroad spur pumped gasoline through a 2½-inch pipe to two 25,000-gallon USTs located on the airfield (beneath what is now the north ramp). That transfer involved a vertical lift of approximately 42 feet. From the USTs the gasoline was piped under water pressure through a water-control and separator pit to four aircraft fueling-pit boxes and to one truck-fill stand at the airfield (Construction Division, 1941 and 1942).

Fueling System B consisted of three 25,000-gallon USTs located at the base of the slope, beside the railroad spur. Gasoline was piped from these tanks, under water pressure, to a truck fueling stand located approximately 150 feet away (west) along the base of the slope (U.S. Engineer Office, 1940, 1942a, and 1942b; Aqua Systems, Inc., 1943).

Releases of fuel associated with incidental spills at the aircraft fuel pits, truck-fill stands, and railroad fuel-delivery points were considered possible sources of contamination. Because the systems are approximately 50 years old, additional continuing releases were also considered possible from the then-existing USTs. With the Nashua River nearby, migration of contaminated groundwater was a significant concern.

At the time of the initial SI in 1992, the following fueling system components were still visible in their original locations:

FUELING SYSTEM A	FUELING SYSTEM B
Gasoline transfer-pump pit and hose pits	Water-control pit and associated piping
Four aircraft fueling pits	Piping from tanks to truck fueling stand
	Tank-valve housings
	Three 25,000-gallon USTS

6.4.2 Study Area Investigation Program Summary

The initial SI was conducted between May 1992 and January 1993 and focussed on potential gasoline releases associated with the fueling systems. The SI results confirmed that the three original USTs remained in the ground at Fueling System B, and in December 1992 they were removed. During removal, tetrachloroethylene (PCE) was detected in soil from an associated pipeline excavation.

Based on the SI results for both fueling systems, and the preliminary data from tank removal, PREs were conducted (ABB-ES, April 1993a). It was concluded that while contaminants detected at SA 50 posed no unacceptable human health or ecological risks, contaminant distribution (specifically PCE) was not fully characterized at Fueling System B. It was recommended that no further action be taken at Fueling System A and that an SSI be conducted to further characterize the nature and extent of PCE contamination at Fueling System B.

A supplemental SI program was conducted in May-June 1993, during which elevated concentrations of PCE, as well as free-phase PCE, were observed in soil.

Two actions were consequently undertaken. The first was to conduct an immediate interim removal action for PCE in soil (December 1993 to present), and the second was to conduct a Phase III SI to address uncertainties in groundwater flow directions and contaminant migration (August 1993 to February 1995).

These various program phases are summarized in the following subsections.

6.4.2.1 Initial Site Investigation. A geophysical survey was conducted as the first task at SA 50. The primary objective of the survey was to identify the location of the two 25,000-gallon fuel tanks of Fueling System A and all piping associated with the World War II aircraft- and truck-fueling systems. (The locations of the three USTs in Fueling System B at the base of the slope were known based on direct observations.) Various underground utilities (including storm sewer, sanitary sewer, water supply, electrical, and telephone) were known to exist in the area of the old fueling systems (Cameron & Assoc. Inc., 1985; U.S. Department of the Army, 1984a, 1984c, 1984d, and 1984e), and the geophysical surveys provided information on actual locations for drilling clearance. The magnetometer survey was conducted in the grid area shown in Figure 6-31. The GPR survey followed, to confirm the results of the magnetometer survey and to trace piping from the magnetometer grid to other components of Fueling System A. Details of the geophysical survey data collection efforts and the resulting interpretations are provided in Appendix L.

Ten soil borings (50B-92-01X through 50B-92-10X) were drilled in areas adjacent to likely release points (i.e., fuel delivery points, USTs, and fuel dispensing points) at SA 50, to evaluate whether soil contamination exists (Figure 6-31).

Six shallow soil borings (50B-92-02X through 50B-92-07X) were installed to identify possible near-surface soil contamination adjacent to fuel-dispensing points. Continuous split-spoon soil samples were collected for field screening by PID and for field classification. Three split-spoon samples from each boring were selected for analysis for PAL VOCs, TPHC, and lead. One analytical sample was collected from the ground surface (from 0 to 2 feet bgs) or from directly beneath the pavement, one sample from the bottom of the boring, and the other sample was selected from an intermediate depth.

Four intermediate soil borings (50B-92-01X, 50B-92-08X, 50B-92-09X, and 50B-92-10X) were advanced to the water table with depths ranging from 12 to 17 feet bgs. Boring 50B-92-01X did not encounter the water table and was completed at a depth of 32 feet bgs. Soil was sampled in each of these borings at 5-foot intervals, and analyzed for PAL VOCs, lead, and TPHC.

The monitoring well soil borings associated with SA 50 (G6M-92-08X, G6M-92-10X, and G6M-92-11X) are located at potential contaminant release points (Figure 6-31). Split-spoon samples were collected at 5-foot intervals. Three split-spoon samples were selected for analysis for PAL VOCs, TPHC, and lead. In each boring, one analytical sample was collected at the ground surface (from 0 to 2 feet bgs) or immediately beneath pavement, one sample was collected in saturated soil at the approximate depth of the water table, and the final sample was collected from an intermediate depth. Water table soil samples were analyzed for TOC in addition to the analytes listed above.

6.4.2.2 UST Removal. Between December 10 and 15, 1992 the gasoline transfer-pump pit and hose pits of Fueling System A and all remaining components of Fueling System B (Figure 6-32) were removed by Zenone, Inc., under contract to Fort Devens (Zenone, 1993).

Prior to excavation, 75,000 gallons of gasoline-contaminated water and 1,900 gallons of sludge were removed from the Fueling System B tanks. Two 600-gallon tanks were also found and removed from beneath the water-separator and water-control pits at Fueling System B. The gasoline tanks were observed to be in relatively good condition, with the asphalt coating generally still intact. Groundwater in the excavation appeared to have a thin film of hydrocarbon contamination on its surface (Zenone, 1993).

During the removal process, Zenone, Inc. field-screened for soil contamination by measuring total VOCs in soil-jar headspace using a PID. Approximately 450 tons of contaminated soil were removed from under the water-separator and water-control pits and from directly under the three 25,000-gallon USTs. Because of water in the excavation, it was not possible to excavate below a depth of approximately 18 feet. All excavations were backfilled to grade. Contaminated soil was temporarily stored in a parking lot near SA 50, and it was later batch-recycled by United Retek Corporation and transported to the Main Post (Zenone, 1993; Ostrowski, 1993).

Zenone, Inc. collected confirmatory soil samples from the excavations for all system components. Two water samples were also collected from the UST excavation. Based on field-screening results for total VOCs, selected samples (including two water samples) were sent for off-site laboratory analysis. Figure 6-33 shows the sampling locations and the distribution of field-screening results from the UST excavation. Refer to Table 6-23 for a compilation of Zenone's field-screening and laboratory results.

The highest concentrations of total VOCs detected in PID-screened soils were 519 parts per million (ppm) and 535 ppm, collected from the water-separator and water-control pits, respectively. TPHC concentrations of 16 mg/kg in the water-separator-pit sample and "not detected" (ND) in the water-control pit sample were measured. The water-separator-pit sample also contained ethylbenzene at 121 μg/kg and xylene at 326 μg/kg. No VOCs were detected in the water-control pit sample. In soil collected from the bottom of the UST excavation, PID field-screening revealed total VOC concentrations ranging from less than 1 ppm to 278 ppm (Figure 6-33). The highest TPHC concentration (3,285 mg/kg) was measured in a soil sample collected near the west side of the UST excavation. All other TPHC concentrations at the site were less than 20 mg/kg, and most were ND. Lead concentrations in soil were in all cases less than the calculated Fort Devens background concentration of 34.4 mg/kg.

The two water samples from the UST excavation had benzene concentrations of 38.8 μg/L and 297 μg/L. Insofar as the only benzene detected in groundwater was 5.0 μg/L in nearby monitoring well G6M-93-14X (installed during a later phase of investigation), it is likely that the benzene concentrations reported for the excavation water samples came from agitation and mixing with contaminated soil during soil removal. Lead concentrations were above the calculated Fort Devens background concentration for groundwater (4.25 μg/L) in both samples. These elevated lead concentrations may have been the result of the same agitation and mixing with contaminated soil that resulted in benzene contamination.

Confirmatory soil samples were collected during the UST excavation effort from areas where elevated soil headspace readings were observed. The samples obtained during the excavation of a buried pipeline (referred by Zenone [1993] as Pipeline Area B; see Figure 6-32) at the former PCE drum storage location had elevated head space readings. Samples were collected for laboratory analysis, and PCE was detected (Table 6-23).

6.4.2.3 Supplemental Site Investigation. The SSI field program focused on characterizing the distribution of PCE in soil and groundwater, and assessing the potential for downgradient migration of both PCE and possible residual gasoline compounds associated with the former USTs (ABB-ES, September 1993).

ABB-ES interviewed rigging staff from the 10th Special Forces Airborne Unit. It was learned that in or around 1988 several troops hand-carried a full drum of PCE out to the storage location adjacent to Building 3801. In the process a spigot broke off the drum, and before the crew could stop the flow "several" gallons of PCE were spilled onto the ground (ABB-ES, April 17, 1993). The incident was not reported, and no steps were taken to remove contaminated soil. With the additional information provided in that interview, the primary source of PCE in the soil was assumed to be from the major spill and perhaps other similar releases that occurred in the past. Incidental releases resulting from the day-to-day use of PCE were assumed to be secondary sources of soil contamination.

Prior to the start of subsurface investigations during the SSI, a GPR survey was conducted to locate buried utilities and to verify that all components of Fueling System B had been removed by Zenone, Inc. None were found.

Soil-vapor samples were collected at 30 locations from a depth of 3 feet bgs (Figure 6-34). Using a portable GC, the samples were screened for target VOCs in the field to indicate areas with elevated concentrations of PCE and gasoline compounds (benzene, toluene, ethylbenzene, and xylenes) in shallow soil. Concentrations were highest in the UST excavation and at the suspected PCE source (Table 6-24 and Figure 6-34).

Six soil borings (50B-93-11X through 50B-93-16X) were advanced during the SSI in locations exhibiting elevated soil vapor concentrations (Figure 6-35). Boring 50B-93-11X was drilled adjacent to the UST excavation and near the suspected PCE source area. Borings 50B-93-12X and 50B-93-14X were drilled in the suspected PCE source area. Borings 50B-93-13X, 50B-93-15X, and 50B-93-16X were drilled at locations intended to identify the distribution of PCE contamination. All of the soil reference samples from the borings and monitoring wells were GC-screened for purgeable halocarbons and purgeable aromatics, and the results were used as a basis for selecting samples for laboratory analysis. The laboratory samples were analyzed for PAL VOCs, and the samples from 50B-93-11X were also analyzed for TPHC.

Soil boring data, including sampling and GC screening results, are summarized in Table 6-25 and provided in detail on the soil boring logs in Appendix B.

Three monitoring wells (G6M-93-12X through G6M-93-14X) were installed based in part on the groundwater flow patterns inferred from synoptic water-level rounds (ABB-ES, 1993a), and all of the wells were screened at the water table (Table 6-26). Monitoring wells G6M-93-12X and G6M-93-13X were installed at locations that were assumed to be downgradient from the UST excavation and the suspected PCE source (Figure 6-35). Monitoring well G6M-93-14X (installed in boring 50B-93-11X) is located between both the UST excavation and the suspected PCE source area.

The new monitoring wells were developed, and two hydraulic conductivity tests were performed in each (Table 6-27). Two rounds of groundwater samples were collected from these wells (June and September 1993), and the samples were analyzed for PAL VOCs (including methy tertiary butyl ether [MTBE]), PAL SVOCs, lead (in both filtered and unfiltered samples), TPHC, TSS, anions/cations, and hardness.

6.4.2.4 Interim Removal Action. Based on the combined findings of the SI, UST removal, and SSI it was determined that PCE-contaminated soil and groundwater was posing an unacceptable potential threat to human health. Further, the free-phase PCE observed in vadose-zone soils was possibly contributing to continued contamination of groundwater beneath SA 50. An immediate interim removal action on PCE contaminated soil at the presumed source area was recommended. This action would constitute a source control measure while additional (Phase III) investigation activities could focus on addressing the uncertainties in groundwater flow directions and contaminant migration.

An in-situ soil vapor extraction (SVE) system was installed at SA 50 in December 1993 and January 1994. Several soil borings were advanced in the presumed source area in an effort to identify the location of the highest concentration of vadose zone PCE, as well as to test the effectiveness of SVE as a PCE removal method. Five vapor extraction wells were ultimately installed, one in the center of the presumed PCE source and four on the periphery of the contaminated area, in an effort to capture vadose zone PCE. Five vadose zone piezometers were also installed to measure pressure during the operation of the SVE system to monitor its recovery performance.

The system has been in operation since its construction and is effectively removing vadose-zone PCE.

6.4.2.5 Phase III Site Investigation. In August 1994, after the installation and startup of the SVE system, the Phase III SI at SA 50 was initiated. The Phase III SI field investigation was designed to further characterize groundwater flow conditions and the vertical distribution of PCE near the source area and in downgradient groundwater (ABB-ES, June 1995).

As part of the Phase III SI field effort, six borings were drilled and converted to monitoring wells (G6M-94-15A through G6M-95-20X), and two piezometers were installed (G6P-95-01X and G6P-95-02X). Phase III SI exploration locations are illustrated with explorations from earlier investigations in Figure 6-36.

One soil boring (50B-94-17X) was drilled to the surface of bedrock at the presumed center of the PCE source area. Soil samples were collected continuously and screened for VOCs and TPHC. The results were used to select ten soil samples for off-site analysis. The selected samples were analyzed for PAL VOCs, and TPHC. In addition, grain-size distribution tests were performed on soil samples from selected intervals.

Elevated concentrations of PCE detected in soils collected from below the water table at 50B-94-17X prompted the subsequent conversion of this soil boring to a monitoring well (G6M-94-18X). The well screen was set at 22.5 to 27.5 feet bgs (10 to 15 feet below the water table), spanning the zone where the highest concentrations of PCE were detected. Bedrock was encountered at a depth of 92.5 feet bgs.

Three soil borings (G6M-94-15A, G6M-94-16X, and G6M-94-17A) were drilled south of the apparent source area in what was interpreted to be a downgradient location based on the data available at the conclusion of the SSI. Soil samples were collected at approximately five-foot intervals and were analyzed for VOCs and TPHC. Monitoring wells were installed in all three borings and were screened across the water table.

An elevation survey was conducted on all water-table wells in the Fueling System B area mid-way through the Phase III well installation program to confirm suspected groundwater flow directions prior to installing the remaining deep wells.

Based on the results of this survey, the previously inferred local groundwater flow directions were found to be incorrect. Flow at the water table was determined to be locally to the north, not to the south with the regional flow. The well installation program was suspended until the inconsistency could be resolved. Nine rounds of weekly water level measurements were conducted on all the SA 50 wells to determine if the re-interpreted flow direction was a transient response to a recent precipitation event. The results indicated that very little change in the relative head values occurred during this period (ABB-ES, 1994b, Table 1). Based on these new findings, a Work Plan Addendum for Phase III Site Investigation (ABB-ES, 1994b) was issued in December 1994 to outline modifications to the remaining Phase III well installation plan.

Two borings (G6M-95-19X and G6M-95-20X), drilled as substitutes for G6M-94-15B and G6M-94-17B, were advanced to the top of bedrock north and northwest of the apparent source area in the newly-interpreted downgradient locations (Figure 6-36). Samples were collected continuously in each boring and screened for VOCs. A monitoring well was installed in each of these borings with well screens positioned to span the zones of highest soil contamination based on the VOC screening results. In addition, 0.75-inch-ID piezometers were installed adjacent to each of the borings and screened across the water table to characterize vertical gradients in this area.

Soil boring data, including sampling and GC-screening results are summarized in Table 6-25 and provided in detail in the Appendix A boring logs. Monitoring well completion details are summarized in Table 6-26.

One round of groundwater samples was collected from the six Phase III monitoring wells and the four existing wells nearby. The samples were analyzed for PAL VOCs and SVOCs.

6.4.3 Field Investigation Results and Observations

World War II fueling systems locations are shown in Figure 6-30. Field locations of observed components of both systems correspond very closely to the locations shown on the available engineering plans. Results of the geophysical survey conducted as part of the initial SI verified that the fuel tanks associated with Fueling System A had been removed.

General SA Group 6 surficial geologic deposits and groundwater characteristics are discussed in Section 6.1.3. SA 50 borings completed on the airfield (G6M-94-15A, G6M-94-16X, and G6M-94-17A) encountered poorly graded sands to a depth of approximately 35 feet bgs. Below that depth, sandy silt and silty sand layers were observed similar to those in borings installed at the base of the slope in the PCE source area. Jahns (1953) mapped the upland landform on which the airfield is located as a kame. Kame deposits consist of gravel and coarse sand (delta topset beds) and medium to fine sand, silt, and clay (delta foreset beds). Jahns (1953) mapped the soil at the base of the slope as late- or post-Lake Nashua river terrace or floodplain deposits, stratified and characterized by lensing and lateral facies changes.

Calculated hydraulic conductivities in the monitoring wells installed at SA 50 in the SSI and Phase III SI were in the range 10^{-5} to 10^{-4} cm/sec.

The new and existing monitoring wells and piezometers at SA 50 were included in the January 1995 installation-wide water-level survey at Fort Devens (see Appendix I). The water table as interpreted from these data is characterized by converging flow at the base of the slope (Figure 6-37), caused possibly by local groundwater mounding near G6M-94-16X superimposed on regional southwesterly flow. The source of the apparent mounding near G6M-94-16X is not known; however, it may be due to increased infiltration of run-off from paved areas of the airfield, and/or the lower permeability of soils as indicated by calculated hydraulic conductivities and grain-size results.

Groundwater elevation differences between wells screened below the water table (G6M-94-18X, G6M-95-19X, G6M-95-20X), and adjacent piezometers and monitoring wells screened at the water table, indicate significant downward gradients.

6.4.4 Nature and Extent of Contamination

The SA 50 analytical results are discussed in the following subsections.

6.4.4.1 Soils. Three soil samples were collected from each of the 14 soil borings advanced during the initial SI at Fueling Systems A and B. Analytical results are presented in Tables 6-28. The distribution of TPHC and lead in soil is shown in Figures 6-38 and 6-39. PCE was the only VOC detected by ABB-ES. The compound was found in two samples from boring 50B-92-08X (0.3 μg/g at 10 feet bgs and 0.00616 μg/g at the surface) and in the sample from boring G6M-92-11X at a depth of 12 feet bgs (0.0041 μg/g in the duplicate sample only). The distribution of PCE detected in soil in the initial SI at SA 50 is shown in Figure 6-40.

Laboratory results for soil samples collected at Fueling System B during the SSI are summarized in Table 6-28, and the distribution of contaminants detected in all soil borings (except 50B-94-167X) is illustrated in Figure 6-41. Where analyzed, PCE was detected in soil samples from all of these borings except 50B-93-16X. The highest PCE concentrations were 3,000 μg/g in the 7-foot bgs sample from boring 50B-93-12X (the sample interval in which free-phased PCE was observed during drilling) and 3.0 μg/g in the 2-foot-bgs sample from 50B-93-14X.

With the exception of 0.500 μg/g of xylene in the 2- to 4-foot bgs sample collected from 50B-93-14X, PCE was the only VOC detected in soils collected during the SI and SSI.

The Phase III SI analytical soil data consist of eleven samples (ten plus one duplicate) collected from soil boring 50B-94-17X. Laboratory results for soils from explorations completed in 1992 and 1993 are presented in Table 6-28. PCE was the only VOC detected with the exception of trichlorofluoromethane (six detections from 0.017 μg/g to 0.052 μg/g) and benzene (one detection at 0.002 μg/g). PCE detections ranged from 0.0018 μg/g to 0.039 μg/g, with the highest detections in samples from 22 to 26 feet bgs. PCE was not detected in boring 50B-94-17X soil samples collected below 40 feet bgs. Trichlorofluoromethane has been identified as a laboratory contaminant in past investigations and is not likely a site-related contaminant at SA 50. The trace concentration of benzene was observed in a near-surface sample possibly associated with the UST removal effort. TPHC was not detected above the sample quantitation limit in any of the soil samples analyzed.

6.4.4.2 Groundwater. Four of the 11 groundwater monitoring wells installed as part of the initial SI at SA Group 6 are in or near the SA 50 Fueling Systems (G6M-92-08X through G6M-92-11X). All four wells were sampled and analyzed for PAL VOCs, SVOCs, inorganics, TPHC, anions/cations, and TSS. The results are provided in Tables 6-5 and 6-6. No organic compounds were detected above the detection limits in any of the four SA 50 groundwater samples in Round 1. In

Round 2, only BIS was detected. It is likely that BIS is a laboratory contaminant, as the compound was detected in a water method blank at a similar concentration (see Section 1.2 of Appendix F). Except for elevated concentrations of inorganic analytes such as barium, calcium, magnesium, potassium, sodium, chloride, and sulfate in monitoring well G6M-92-10X, no notable concentrations of inorganic analytes or anions/cations were observed in the groundwater during Round 1. In addition, lead (in G6M-92-09X) and zinc (in all four wells) were detected above calculated background concentrations during Round 2.

Laboratory results for groundwater samples from SA 50 monitoring wells G6M-92-10X through G6M-95-20X are presented in Table 6-29, and the distribution of analytes detected in monitoring wells G6M-93-10X through G6M-93-14X (the SI and SSI wells) is illustrated in Figure 6-42. With the exception of a few low concentrations of compounds mostly determined to be laboratory contaminants (BIS and chloroform), PCE was the only organic compound detected. Between June and September 1993 PCE concentrations decreased from 10,000 μg/L to 5,000 μg/L in monitoring well G6M-93-14X (located in the PCE source area) and from 1,300 μg/L to 1,000 μg/L in nearby well G6M-93-12X.

PCE was the only VOC detected in Phase III SI groundwater samples, and it was detected in six of the ten samples at concentrations ranging from 1.9 μg/L to 20,000 μg/L (Figure 6-43 and Table 6-29).

6.4.4.3 Surface Water and Sediment. Surface water and sediment sampling results for SA Group 6 are discussed in Section 6.1.4.3.

6.4.5 Source Evaluation and Migration Potential

The contaminants that would likely be present from incidental releases due to operational spills or leaks from the UST and piping systems, would consist of various VOCs and SVOCs including petroleum hydrocarbons, and possibly lead as an additive to gasoline. None of these analytes were detected in groundwater and soil in the vicinity of either fueling system at concentrations that would suggest major releases have occurred. The highest TPHC concentrations detected in soil samples (collected immediately under the tarmac in the former UST locations for Fueling System A), are likely related to small incidental releases from surface spills. Contrary to ABB-ES' earlier findings during the soil boring program, a significant concentration of TPHC was detected in one of the tank excavation soil samples collected from for Fueling System B (Zenone, Inc.) suggesting the likelihood of a historical release in this area. TPHC detections are restricted to the former tank excavation.

Analytes detected, but not likely related to historical fueling system operation include the soluble inorganics in groundwater and PCE in soils. The inorganic analytes in groundwater at G6M-92-10X are likely due to road de-icing along Route 2A.

The distribution of PCE in soil and groundwater is consistent with the description of its storage and use, and with the account of the release in 1988. It also corresponds closely to the pattern of PCE concentrations revealed by the soil vapor survey.

Field screening and laboratory analysis of soil samples collected at 50B-94-17X in the presumed source area have shown evidence of downward migration of PCE to a maximum depth of 40 feet bgs (roughly 28 feet below the water table). The highest concentrations in soils appear just above the water table, at approximately 11 feet bgs (where free-phase product was encountered during the SSI) and in the interval from 22 feet bgs to 30 feet bgs. The absence of free-phase product in the vadose zone of this boring suggests that the SVE system has effectively controlled the presumed PCE source in soil. The groundwater sample from the well installed at this location (G6M-94-18X) exhibited the highest concentration of PCE (20,000 μg/L) suggesting that the well is screened in, or very near, the groundwater contaminant source.

Away from the presumed source area, PCE was detected in soils between 10 feet bgs (the water table) and 38 feet bgs in monitoring well G6M-95-20X, with the highest detections occurring at 20 feet bgs. PCE was also detected in soil collected from 20 feet to 60 feet bgs in monitoring well G6M-95-19X, with the highest detections occurring around 50 feet bgs. Given what is known about the contaminant distribution and the interpreted groundwater flow directions, contaminant migration pathways from the source area to these wells is not clear. The detection of PCE in deep (below 40 feet bgs) soil and groundwater at G6M-94-19X (110 μg/L) suggests that contaminants have migrated downward away from the source area. Downward migration of contaminants may be the results of measured downward hydraulic gradients, as well as, possible dense nonaqueous-phase liquid (DNAPL) migration at the source area. The absence of PCE in the upgradient wells G6M-94-15A, G6M-94-16X, G6M-94-17A, however, suggests that contaminants have not migrated to the south of the presumed source area at the water table. The extent of PCE migration in saturated soils has not been fully determined to the north and west, and at depth to the south of the apparent source area.

During the performance period of the various investigations at SA 50, PCE concentrations in groundwater collected from G6M-93-14X and G6M-93-12X dropped from highs of 10,000 μg/L and 1,300 μg/L, respectively, to 3,000 μg/L and 21 μg/L, respectively. This is likely attributable to a combination of source control measures that include the elimination of continuing releases from the former 55-gallon drum, and the reduction of vadose-zone contaminants by the SVE system, in conjunction with the continuing dilution due to groundwater flow.

6.4.6 Preliminary Human Health Risk Evaluation

This PRE is based on data gathered during the SI from borings and monitoring wells at and near the former Fueling System B, on confirmatory sampling results from the tank removal conducted by Zenone, Inc., and on all the data collected during the SSI and the Phase III SI. Tables 6-30 through 6-32 present summary statistics, background concentrations, and human health standards and guidelines used in the PRE for SA 50. The health standards and guidelines have been updated and are current through May 1995.

6.4.6.1 Soils. This PRE considers all soil to a depth of 3 feet as surface soil and, therefore, accessible under a residential future use scenario. This is a conservative approach because the future use of SA 50 is as part of the airfield. Soils between 3 and 15 feet are considered to be subsurface soil, accessible under a commercial/industrial future use exposure scenario. Samples were analyzed for VOCs, lead, and TPHC. Lead was analyzed for because it may have been present in fuels. TPHC was analyzed for as the primary indicator of a fuel release.

Surface Soil

Table 6-30 presents summary statistics on surface soil at SA 50 and human health standards and guidelines for comparison. The maximum detected concentration of lead (20 μg/g) was below the base-wide background concentration (34.4 μg/g), the USEPA interim guidance on Superfund soil lead screening value of 400 μg/g for a residential exposure scenario, and the MCP Method 1 S-1/GW-1 soil standard of 300 μg/g. The maximum concentration of PCE (3.4 μg/g) is below the Region III risk-based concentrations for residential soils (12 μg/g), but above the MCP Method 1 S-1/GW-1 soil standard (0.5 μg/g). PCE was detected in five surface soil samples; however, in only one sampling location (50B-93-14X) was PCE detected at a concentration above a screening guideline. In consideration of the significant soil reworking in the 50B-93-14X area conducted during the SVE system installation, and because this boring location is within the capture zone of the currently operating SVE system, this isolated concentration of PCE has likely been significantly reduced through volatilization. Xylenes were detected in one sample (0.50 μg/g) at well below the Region III residential soil concentration (160,000 μg/g) and the MCP Method 1 S-1/GW-1 soil standard (500 μg/g).

To evaluate the health risk associated with TPHC in soil, ABB-ES developed risk-based concentrations for petroleum products. These concentrations were calculated using the same exposure assumptions as those used by USEPA toxicologists in the USEPA Region III Risk-Based Concentration Table, Third Quarter 1994, for residential soils and commercial/industrial soils. Dose response values for gasoline and marine diesel used in the calculations are provisional values developed by USEPA, Environmental Criteria and Assessment Office (USEPA, 1992). USEPA suggests using the reference dose value for diesel oil as a surrogate for No. 2 fuel.

The table below presents the risk-based concentrations for petroleum products:

Analyte	Residential Soil (μg/g)	Commercial/Industrial Soil (μg/g)
Gasoline	380	1,680
No. 2 Fuel Oil	630	8,180

The maximum detected TPHC concentration in surface soil (109 μg/g) is below the risk-based residential soil concentration of 380 μg/g for gasoline, which is the likely source of the TPHC based on the site history. It is also below the MCP Method 1 S-1/GW-1 soil standard for TPHC of 500 μg/g.

In summary, none of the surface soil contaminants detected during the SA 50 investigations are expected to pose an unacceptable risk to human health.

Subsurface Soil

Table 6-31 presents summary statistics on subsurface soil at SA 50 and human health standards and guidelines for comparison. The maximum detected concentration of lead (12 μg/g) was below the base-wide soil background concentration of 34.4 μg/g (see Appendix G), USEPA interim guidance for soil lead cleanup based on a residential exposure scenario (400 μg/g), and the MCP Method 1 S-2/GW-1 soil standard (600 μg/g). The maximum concentration of TPHC (3,285 μg/g in Zenone's confirmatory sampling from the UST excavation) is above the risk-based concentration for industrial/commercial soil (1,680 μg/g for gasoline-derived TPHC) and the MCP Method 1 S-2/GW-1 soil standard (2,500 μg/g). The depth at which this confirmatory sample was collected was not documented; however, because soil was reportedly removed down to a depth of 18 feet bgs in the tank excavation, it was likely greater than 15 feet bgs. At this depth, soil contamination is not expected to pose a significant exposure threat.

Toluene, ethylbenzene, and xylenes were detected by Zenone, Inc. in confirmatory soil samples at concentrations well below their respective Region III risk-based guidelines. A single detection of PCE (2,600 μg/g at a depth of 7 feet in boring 50B-93-12X) exceeds the Region III risk-based guideline for industrial/commercial soil (110 μg/g) and the MCP Method 1 S-2/GW-1 soil standard (0.5 μg/g). This boring is located within the currently operating SVE system capture zone. The other 13 detects of PCE out of 30 samples analyzed are very low (0.3 μg/g is the second highest detected concentration).

Trichlorofluoromethane and benzene were detected at one boring location (50B-94-17X) during Phase III SI sampling, but they were detected at concentrations well below their Region III risk-based industrial/commercial soil guidelines and the MCP Method 1 S-2/GW-1 soil standard for benzene. Neither compound is expected to pose an unacceptable threat to human health.

Zenone, Inc. reported a PCE concentration of 176 μg/g from the fueling system pipeline excavation. The sample depth was not reported, and consequently it is not known whether the residential guideline (12 μg/g) or the commercial/industrial guideline (110 μg/g) applies. Nevertheless the detected concentration exceeds both guidelines as well as the respective MCP Method 1 soil standards. The elevated concentrations were detected in soil samples collected near the former storage location of the PCE drum in an area which is now within the capture zone of the SVE system. Concentrations of PCE in soils are expected to be reduced to the MCP Method 1 S-2/GW-1 soil standard for 0.5 μg/g.

6.4.6.2 Groundwater. Table 6-32 presents summary statistics on groundwater at SA 50 and human health standards and guidelines for comparison. Only unfiltered samples were used in the PRE. Eight monitoring well locations were used to evaluate groundwater quality in the area of SA 50 (monitoring wells G6M-92-10X through G6M-92-14X, and G6M-94-18X through G6M-94-20X). Except for toluene, the maximum concentrations of all four organics detected exceed their respective drinking water standard/guideline. PCE (up to 20,000 μg/L) exceeds its Massachusetts drinking water standard and MCP Method 1 GW-1 standard of 5 μg/L in nine out of ten samples in which it was detected. Chloroform (7.1 μg/L) slightly exceeds the Massachusetts drinking water guideline and MCP Method 1 GW-1 standard of 5 μg/L in the one of the two samples in which it was detected. BIS (18.0 and 5.10 μg/L) exceeds the Massachusetts drinking water standard and Method 1 GW-1 standard (6 μg/L) in one out of the two samples in which it was detected. Both chloroform and BIS, however, are likely laboratory contaminants, often detected in laboratory method blanks.

Not all of the inorganics were analyzed for at each location. Several of the inorganics exceed their groundwater background concentration: barium, calcium, lead, magnesium, manganese, potassium, sodium, and zinc. Barium (208 μg/L) and zinc (41.2 μg/L) do not exceed their respective standard/guidelines of 2,000 μg/L and 5,000 μg/L. The maximum concentrations of aluminum (2,340 μg/L) and iron (2,600 μg/L), which do not exceed background, exceed their secondary MCLs (SMCLs) of 50-200 μg/L and 300 μg/L, respectively. SMCLs are federal standards promulgated for aesthetic reasons, not health effects. Manganese (309 μg/L), detected above background in only one well, also exceeds its SMCL of 50 μg/L and the Region III risk-based concentration for tap water (180 μg/L). Sodium (1,200,000 μg/L) exceeds its Massachusetts drinking water guideline of 20,000 μg/L. Lead (24.0 μg/L) has a single exceedance out of seven samples of the federal drinking water action level of 15 μg/L, but in no case was lead detected above background in the filtered samples.

With the exception of lead, none of the inorganic analytes detected in groundwater can be directly linked to either the operation of the fueling system or the release of PCE. Because lead was not detected at significant concentrations in filtered groundwater samples, the elevated concentrations detected in unfiltered samples are likely the result of sample turbidity.

Based on these findings for organic and inorganic analytes, PCE has been identified as the only compound likely to pose an unacceptable threat to human health.

6.4.7 Preliminary Ecological Risk Evaluation

The purpose of the PRE at SA 50 is to provide a screening-level evaluation of actual and potential risks that environmental contaminants may pose to the resident and migratory ecological receptors at the site.

SA 50 consists of an area of approximately 5 acres at the far northern end of Moore Army Airfield. Several structures are located on the site, and much of the area is used for parking automobiles. A mixed oak/pitch pine woodland occurs to the southeast of the Fueling System B portion of SA 50.

A review of the Fort Devens database indicates that no rare and endangered flora or fauna are known to occur in the vicinity of SA 50. However, the Commonwealth of Massachusetts has established an unofficial "Watch List" of uncommon or rare plants (Massachusetts Natural Heritage Program, 1990). This list includes flora which are believed to be uncommon but for which insufficient information exists documenting the true status of the plant in the state. One Watch List species is known to occur in the vicinity of SA 50 (Hunt and Zaremba, 1992); however, this species is not located in the developed area that characterizes the area of contamination at SA 50.

Eleven surface soil samples collected from SA 50 were evaluated in the ecological PRE. Lead was analyzed for and detected in six surface soil samples (Table 6-33). The concentrations of lead were all below soil background (34.4 μg/g) and ranged from 2.58 to 20 μg/g. PCE was detected in five of the 11 surface soil samples analyzed from SA 50. Concentrations ranged from 0.0062 to 3.4 μg/g. The mean surface soil PCE concentration at SA 50 was 0.69 μg/g; however, this arithmetic average is misleading, because four of the five samples collected contained less than 0.008 μg/g PCE. Excluding sample 50B-93-14X, which contained 3.0 μg/g PCE, the average PCE concentration in SA 50 surface soils was 0.007 μg/g.

Potential contaminant exposure pathways exist at SA 50 for terrestrial ecological receptors by incidental ingestion of surface soils and food web exposure. A screening-level evaluation of potential effects from PCE and lead through surface soil exposures was conducted by comparison of the maximum concentrations of these analytes with their respective ecological benchmark values (PCLs) (Table 6-33).

All surface soil lead concentrations at SA 50 were less than the Fort Devens background levels; therefore, exposure to lead at SA 50 is unlikely to result in ecological effects. The maximum concentration of PCE in SA 50 surface soils (3.4 μg/g) was greater than an order of magnitude less than the ecological PCL derived from the food web model. Therefore, it is unlikely that exposure to contaminants at SA 50 is resulting in significant ecological risk.

6.4.8 Conclusions and Recommendations

The concentrations of contaminants detected in the surface soil at SA 50 were compared to health-based standards and guidelines. With the exception of PCE, the maximum detected concentrations of analytes in surface soil at SA 50 were below their respective health standards and/or guidelines. PCE was detected in five of 11 surface soil samples, but at only one sampling location (50B-93-14X) was it detected at a concentration above a screening guideline.

In subsurface soil, the concentrations of analytes generally at SA 50 were below the health screening guidelines. TPHC was detected in only one soil sample exceeding the risk-based concentration for industrial/commercial soil, but its depth appears to have been greater than 15 feet bgs and consequently it is not expected to pose a significant exposure threat. PCE was detected in 14 of 30 subsurface soil samples, and at two locations (50B-93-12X and at the fueling system pipeline excavation) it was detected at concentrations above the screening guideline.

Thus, soils at SA 50 do pose a potential threat to human health. The operation of the SVE system, however, is expected to eliminate the potential threat by reducing soil concentrations below the MCP Method 1 S-1, GW-1 standard.

In the ecological PRE, which focuses on surface soil contaminants, no significant ecological risks would be expected from detected contaminants. The screening-level evaluation concluded that contaminant concentrations detected in the surface soil would not pose an unacceptable risk to ecological receptors. Further, much of SA 50 is paved and provides limited habitat for ecological receptors.

In groundwater, PCE at SA 50 represents a potentially significant health risk if the groundwater were to be used for drinking water. In nine of 10 groundwater samples, at five monitoring wells, the concentrations of PCE exceeded the drinking water standard. The concentrations of several inorganic analytes exceeded their respective secondary MCLs set for aesthetic reasons, and thus do not pose an unacceptable human health risk. The maximum concentration of sodium exceeded its drinking water guideline, developed as a notification requirement for water distribution systems. It is unlikely, however, that sodium is related to the operation of the SA 50 gasoline fueling systems or the PCE release. Lead had an exceedance in one of seven unfiltered groundwater samples, but no exceedances in the filtered samples. The elevated concentrations of lead were determined to be the result of sample turbidity and not due to releases from the fueling system.

The evaluation of the cumulative data collected during three SI phases at SA 50 has revealed that the fuel-related contaminants associated with the abandoned gasoline fueling systems have not contributed significant contamination to soil and groundwater, and likely pose no significant threat to human health or the environment. PCE contamination, however, unrelated to the fueling systems, was detected in soil and groundwater at concentrations that could pose a potential threat to human health. With the SVE system in operation, only groundwater contamination remains a potential threat.

Significant PCE migration in groundwater has been observed at SA 50. Although the PCE release mechanism has been reasonably well characterized, the complexity in groundwater hydrology at SA 50 makes mapping actual migration pathways difficult. The nature of local groundwater flow is not fully understood and further hydrogeologic characterization is necesary.

Therefore, in order to fully understand the nature of contaminant migration at SA 50 and assess risk to human health, further characterization of local and regional hydrologic conditions is necessary. It is recommended that a remedial investigation (RI) be conducted at SA 50 addressing the following items:

- Further characterize local and regional groundwater flow,
- further characterize the distribution of PCE in soils at the presumed source and in groundwater to the north and west of the apparent source area,
- assess the risk to potential downgradient receptors, and
- gather data needed to support an FS.

6.5 ANALYTICAL DATA QUALITY CONTROL

Laboratory water method blanks contained the following PAL compounds: lead (1.8 μg/L), iron (143 μg/L), potassium (578 μg/L), BIS (6.6 μg/L, 5.1 μg/L, and 6.2 μg/L), toluene (0.15 μg/L), acetone (18 μg/L), chloroform (1.3 μg/L and 0.73 μg/L), and 1,1,1-TCA (2.5 μg/L). Laboratory soil method blanks contained the following PAL compounds (exclusive of inorganic compounds): toluene (0.2 μg/g and 0.00086 μg/g), BIS (1.1 μg/g), acetone (0.036 μg/g), TCFM (0.008 μg/g), chloroform (0.002 μg/g), and diethylphthalate (0.27 μg/g). Any compounds detected in a method blank sample are considered laboratory-introduced contamination.

6.5.1 Group 6 Field Quality Control Blank Sample Results

Field quality control samples analyzed from Group 6 include rinsate blanks and trip blanks. Rinsate results were used to evaluate the extent of carry over contamination introduced from sampling equipment. Group 6 rinsates were analyzed for inorganics, SVOCs and VOCs. Trip blanks were used to evaluate whether there was VOC cross contamination during the shipment and storage of samples.

The rinsate blank data show that no significant concentrations of any of the target analytes were present. Iron, manganese and lead were found in one of the two blanks analyzed. SVOCs were not reported in any of the blanks. The only VOCs found in the rinsates were determined to be laboratory contaminants. A discussion of Group 6 blank results is presented in Section 1.3.3 and 1.3.4 of Appendix F. The rinsate results are tabulated and presented in Table F-7 of Appendix F.

Rinsate blanks collected during the supplemental site investigations contained the metals cobalt, chromium, copper, iron, potassium, and manganese and the VOCs and SVOCs TCA, 1,2-dichloroethane, acetone, methylene chloride, chloroform, toluene, 2-ethyl-1-hexanol, BIS, and dodecanoic acid. Additional information on rinsate blanks collected during the supplemental site investigation is presented in Table FS-5 of Appendix F, and the frequency of detection and the minimum and maximum detected concentrations are shown in Table FS-6.

Trip blank data indicate no cross contamination of VOCs. Only methylene chloride was reported in these results and this compound was determined to be a laboratory contaminant. Trip blank results are presented in Table F-7 of Appendix F.

The following target compounds were detected in trip blanks collected during the supplemental investigations at concentrations above the CRLs: trifluorochloromethane, methylene chloride, chloroform, and toluene. The results are presented in Table FS-3, and the frequency of detection and the minimum and maximum detections are reported in Table FS-4. A more detailed discussion of trip blank results from the Supplemental Site Investigation is presented in Section 2.3.1 of Appendix FS.

All holding times for the various methodologies were met for Group 6 sample lots. In addition, there were no lots from the group rejected due to control limits being exceeded. The blank data obtained from the Group 6 blanks provide additional evidence that the completeness and representativeness components of the data quality objectives were met.

6.5.2 Matrix Spike/Matrix Spike Sample Results

MS/MSD samples were analyzed to provide data about possible matrix effects on sample concentrations. The only parameter for which these effects were measured was inorganics. MS/MSD samples provided information as to the representativeness, precision and accuracy of the data. All MS/MSD results for Group 6 are presented in Table F-12 of Appendix F and in Table FS-7 of Appendix FS. The group specific discussion of these results is located in Section 2.6 of Appendix F and Section 3.2 of Appendix FS.

The recoveries for all elements except arsenic, selenium, lead, and antimony were considered acceptable based on the criteria that was specified as being used in Section 2.1 of Appendix F. For MS/MSD data collected during the supplemental investigation all recoveries were within the control limits with the exception of aluminum, antimony, arsenic, iron, lead, manganese, mercury, selenium, silver, and zinc in soil samples.

The concentrations of elements recovered generally agree as seen from the relatively low RPDs shown in Table F-12. These results coupled with generally acceptable spike recoveries, support requirements set forth in the data quality objectives for representativeness, precision, and accuracy of the data set for Group 6.

6.5.3 Duplicate Sample Results

Duplicate samples were analyzed to measure the precision and accuracy of sample results. The RPD was calculated to measure these DQO parameters. Parameters for which duplicates were analyzed include inorganics, SVOCs, VOCs, TOC and TPHC. Duplicate sample results for Group 6 are presented in Table F-13 of Appendix F, and duplicate results from the supplemental investigation are presented in Tables FS-9 and FS-10 of Appendix FS. Group-specific discussions of these results are located in Section 2.7 of Appendix F and in Section 3.3 of Appendix FS.

Inorganic concentrations showed excessive variability for the elements lead, aluminum, chromium, potassium, magnesium, nickel, vanadium, and zinc. The RPDs calculated for these elements exceeded the USEPA Region I criteria of

50 percent for RPD values of inorganics in soils. The results for other parameters generally show agreement between sample and duplicate results.

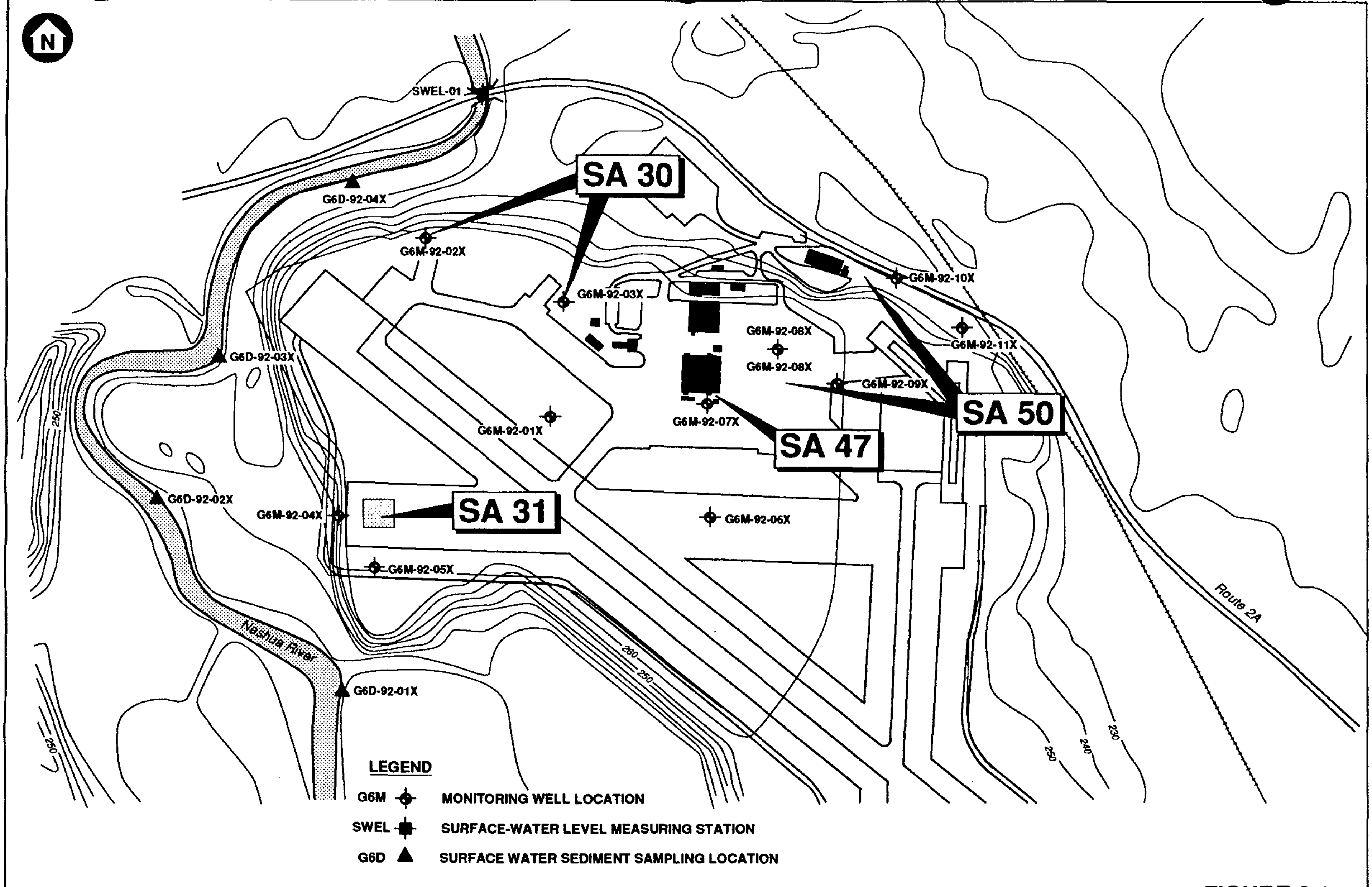


FIGURE 6-1
LOCATION OF SAS 30, 31, 47, & 50
GROUP 6 STUDY AREAS
FORT DEVENS, MA

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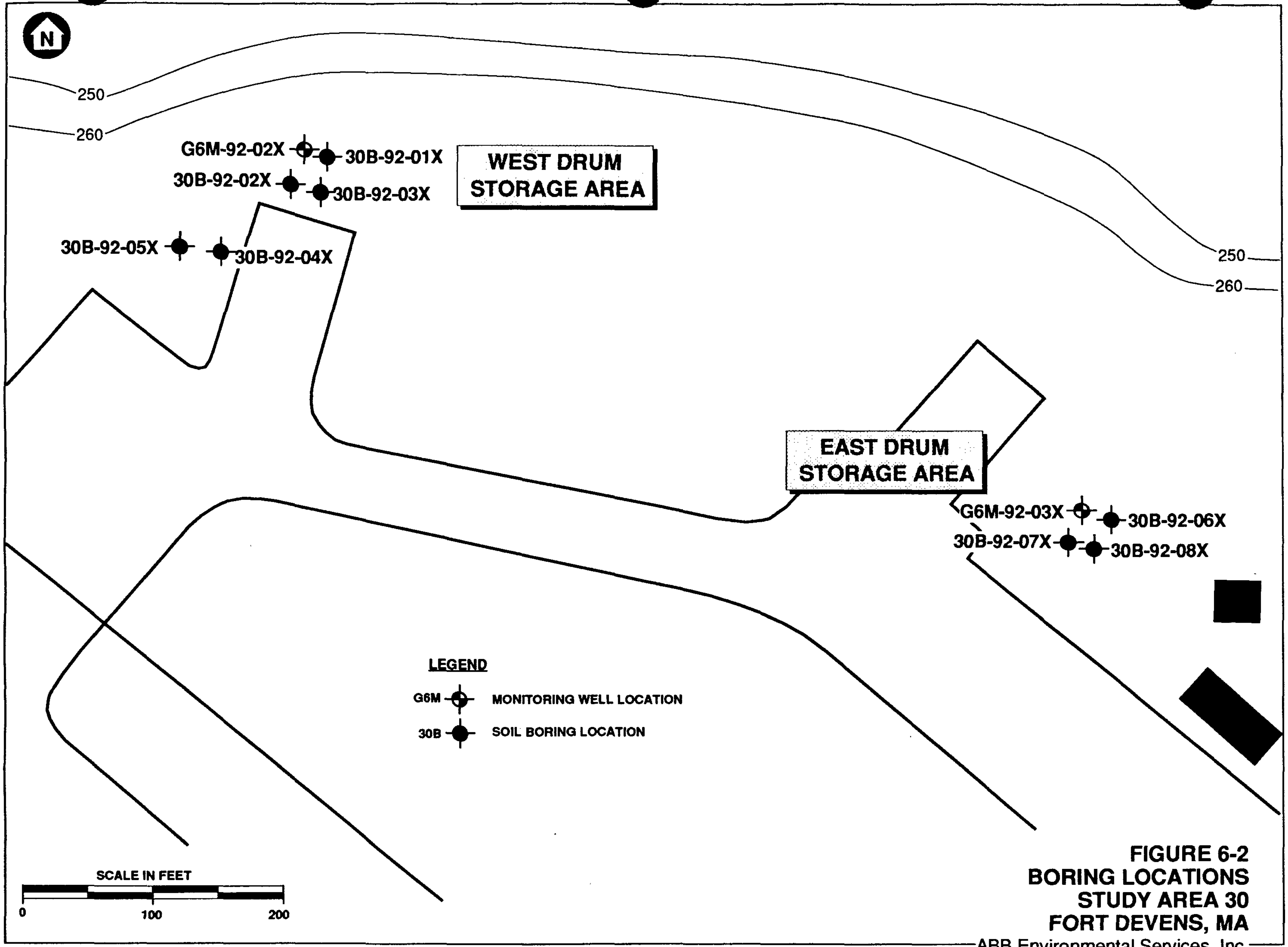

FIGURE 6-2
BORING LOCATIONS
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)12

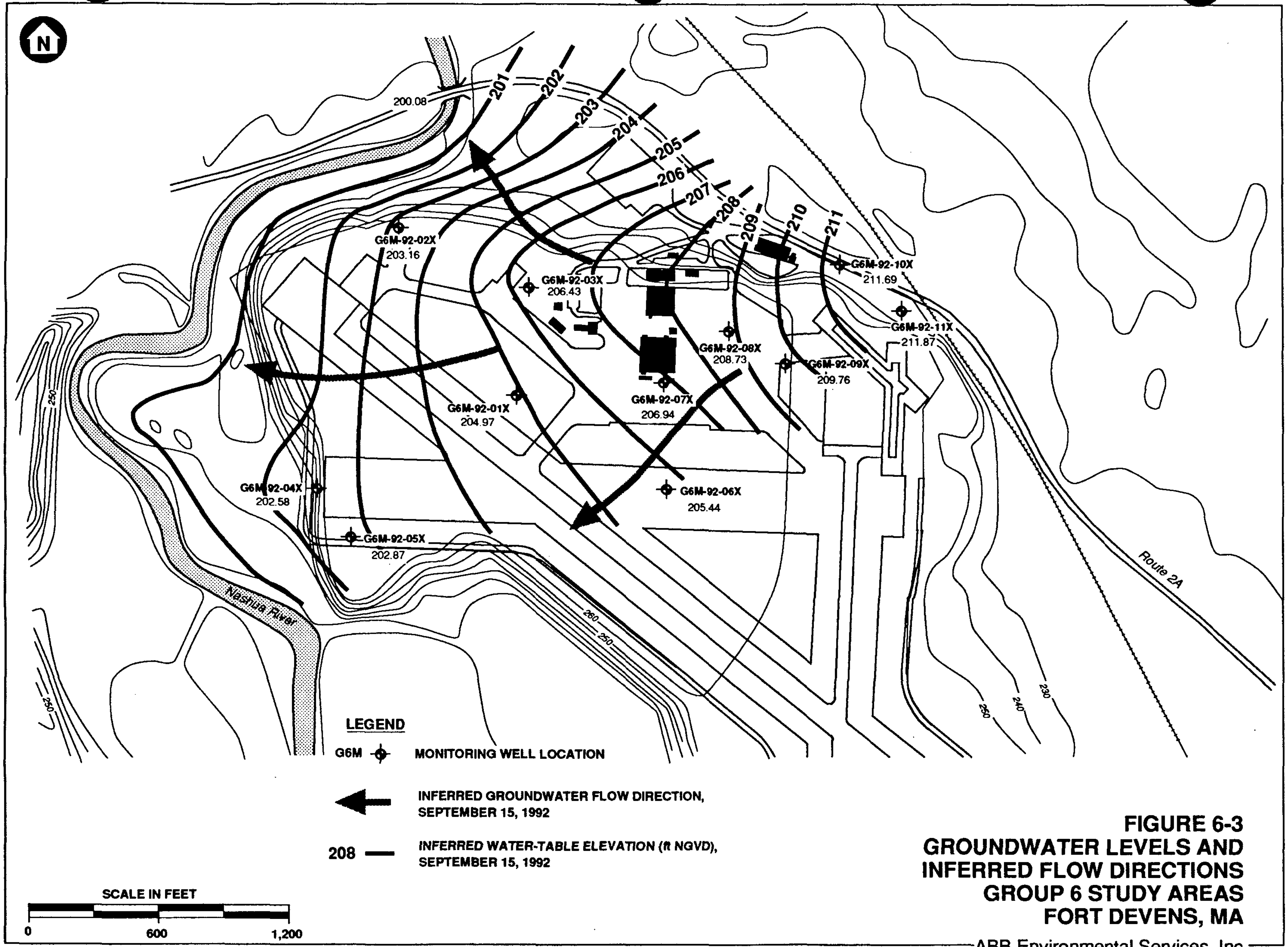

FIGURE 6-3
GROUNDWATER LEVELS AND
INFERRED FLOW DIRECTIONS
GROUP 6 STUDY AREAS
FORT DEVENS, MA

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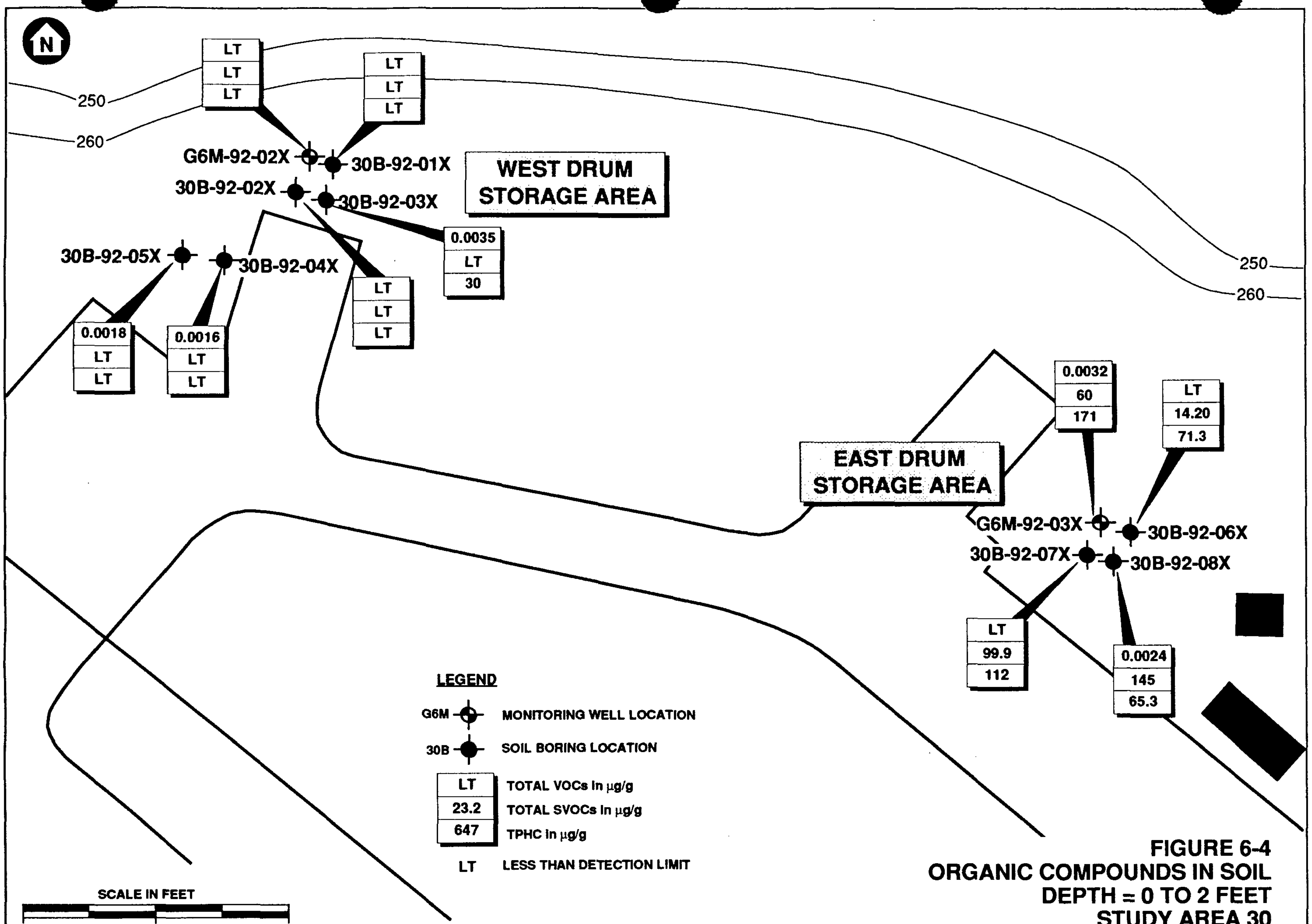


FIGURE 6-4
ORGANIC COMPOUNDS IN SOIL
DEPTH = 0 TO 2 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)123

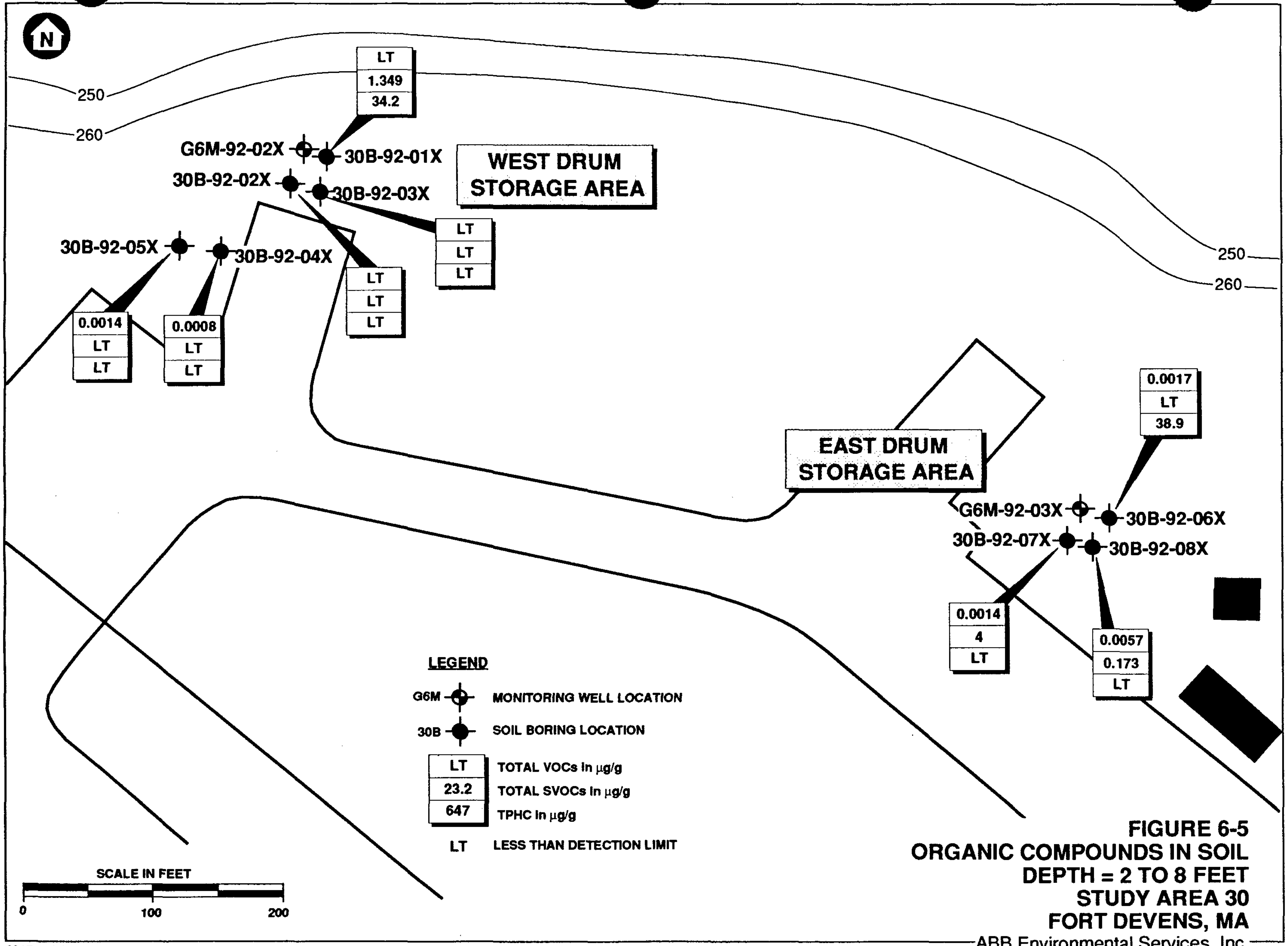


FIGURE 6-5
ORGANIC COMPOUNDS IN SOIL
DEPTH = 2 TO 8 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)124

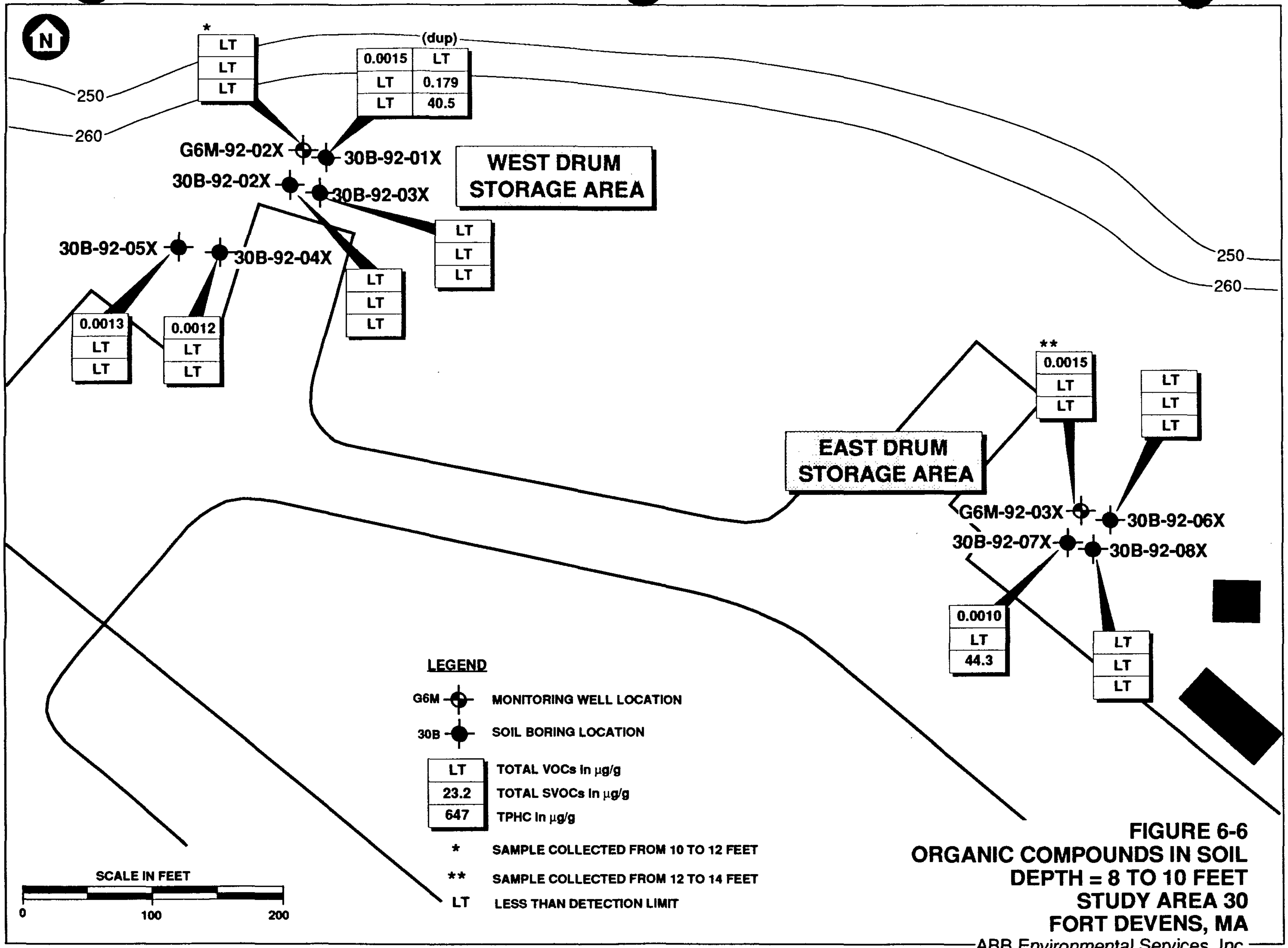


FIGURE 6-6
ORGANIC COMPOUNDS IN SOIL
DEPTH = 8 TO 10 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)125

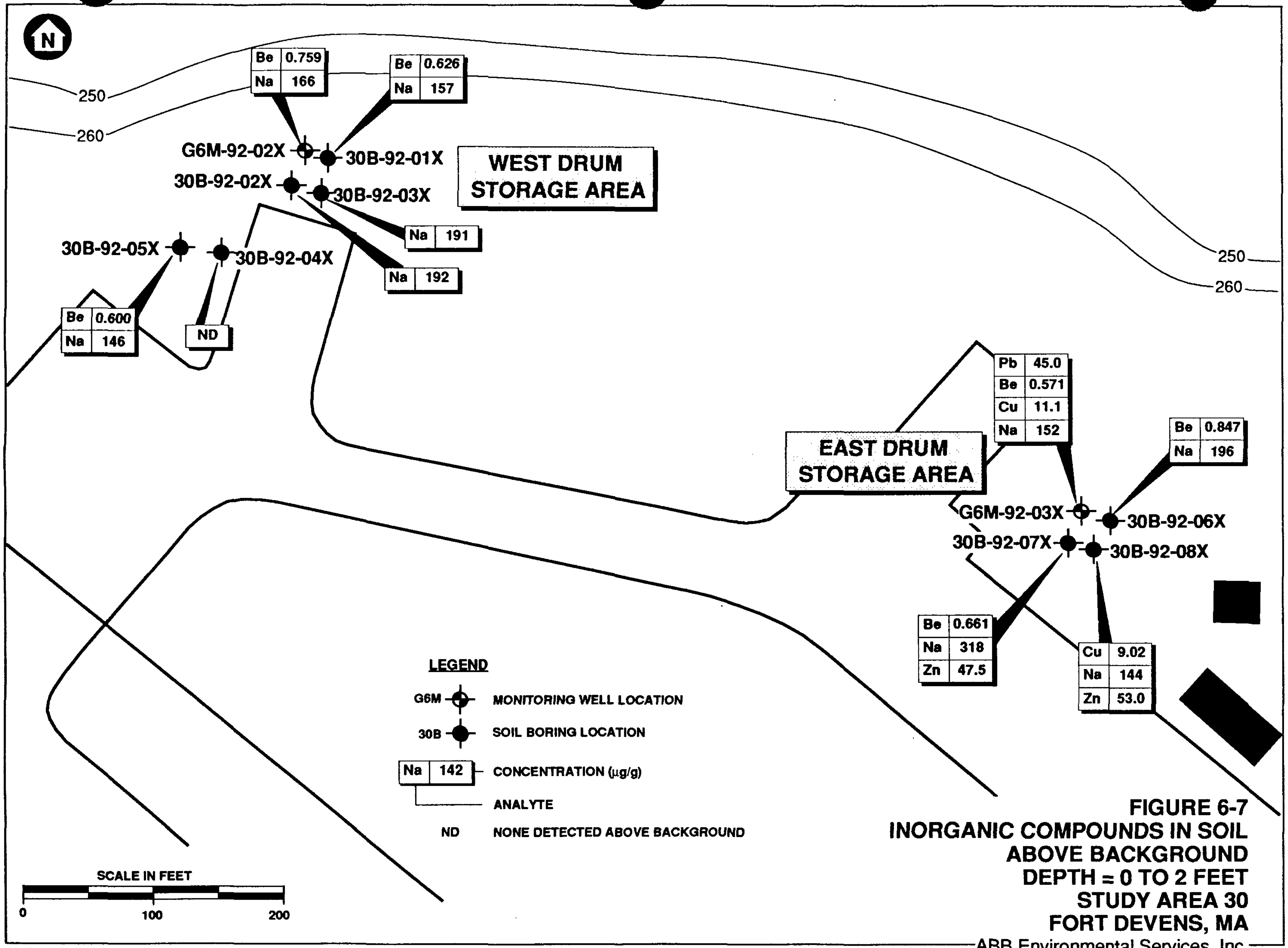


FIGURE 6-7
INORGANIC COMPOUNDS IN SOIL
ABOVE BACKGROUND
DEPTH = 0 TO 2 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)126

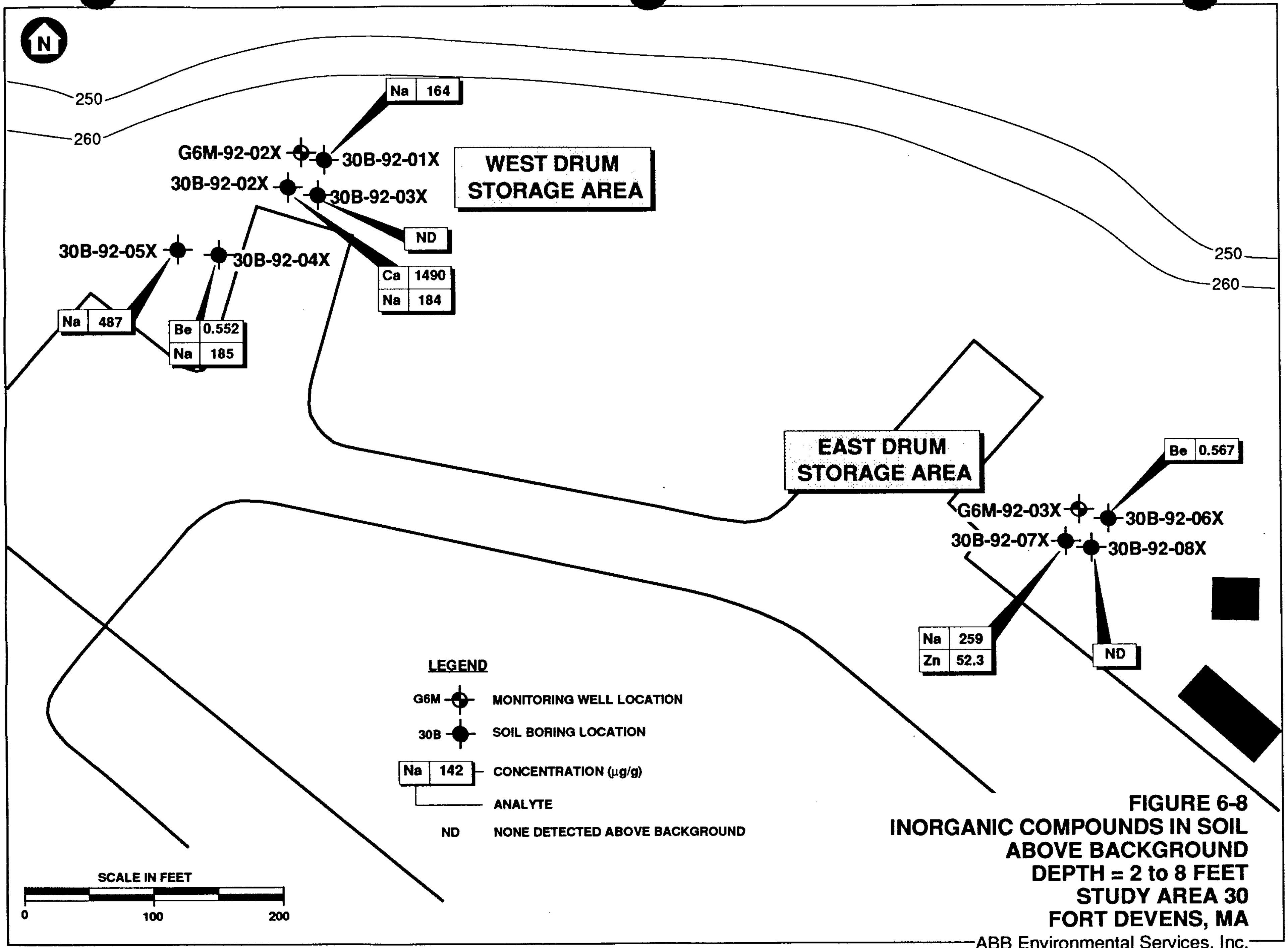


FIGURE 6-8
INORGANIC COMPOUNDS IN SOIL
ABOVE BACKGROUND
DEPTH = 2 to 8 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)127

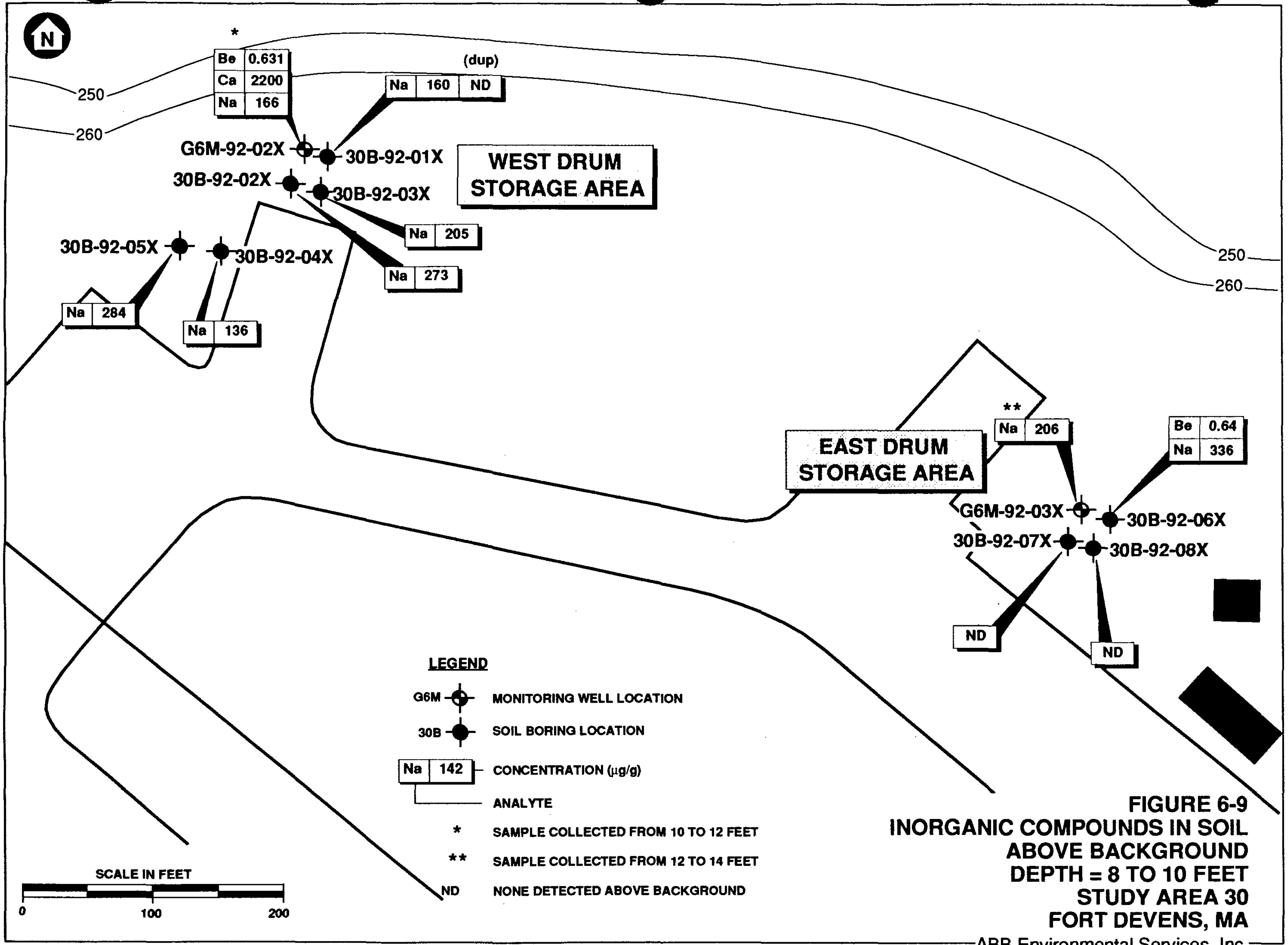
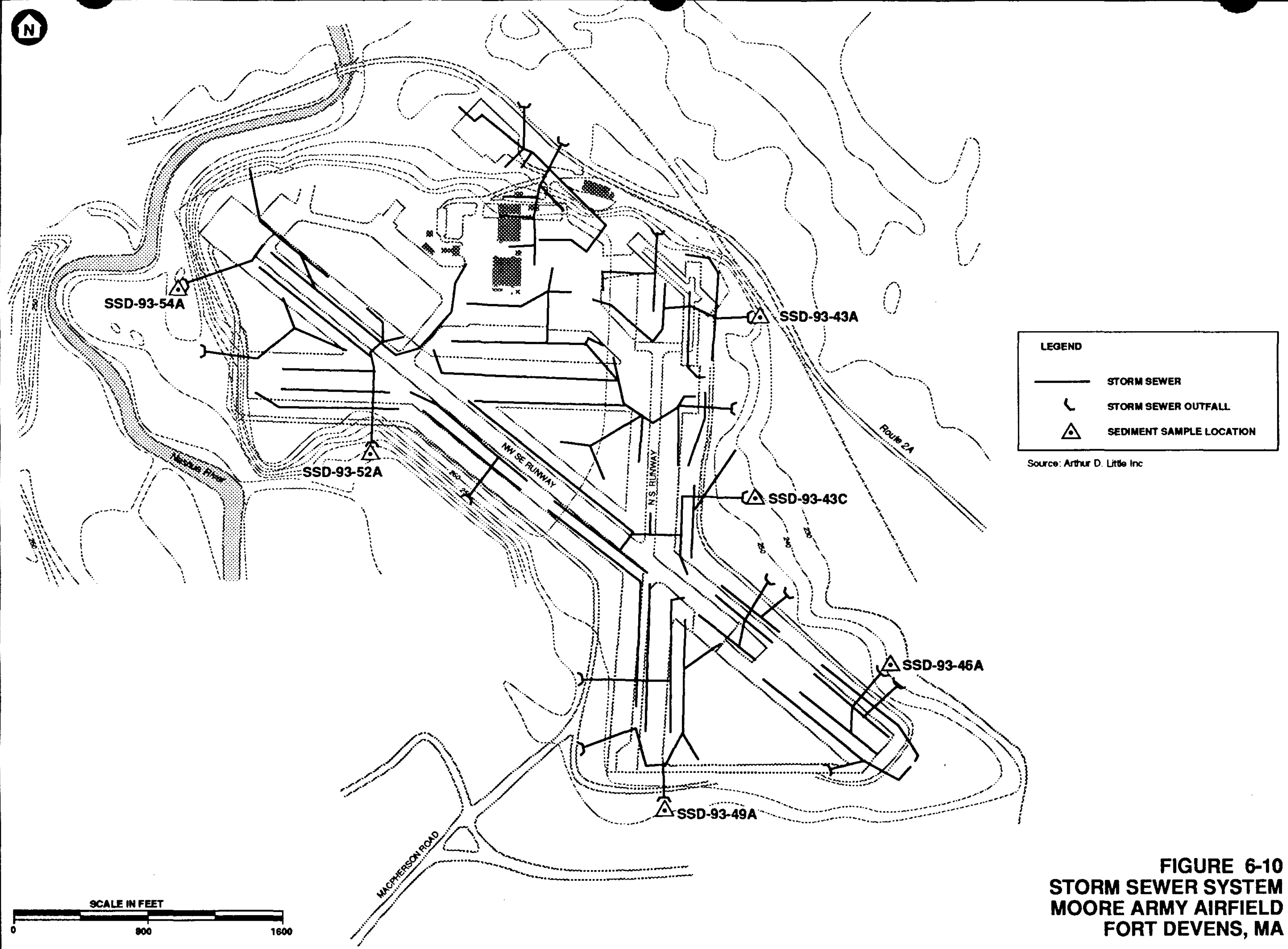


FIGURE 6-9
INORGANIC COMPOUNDS IN SOIL
ABOVE BACKGROUND
DEPTH = 8 TO 10 FEET
STUDY AREA 30
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(e)128



Source: Arthur D. Little Inc

FIGURE 6-10
STORM SEWER SYSTEM
MOORE ARMY AIRFIELD
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(a) 2/95

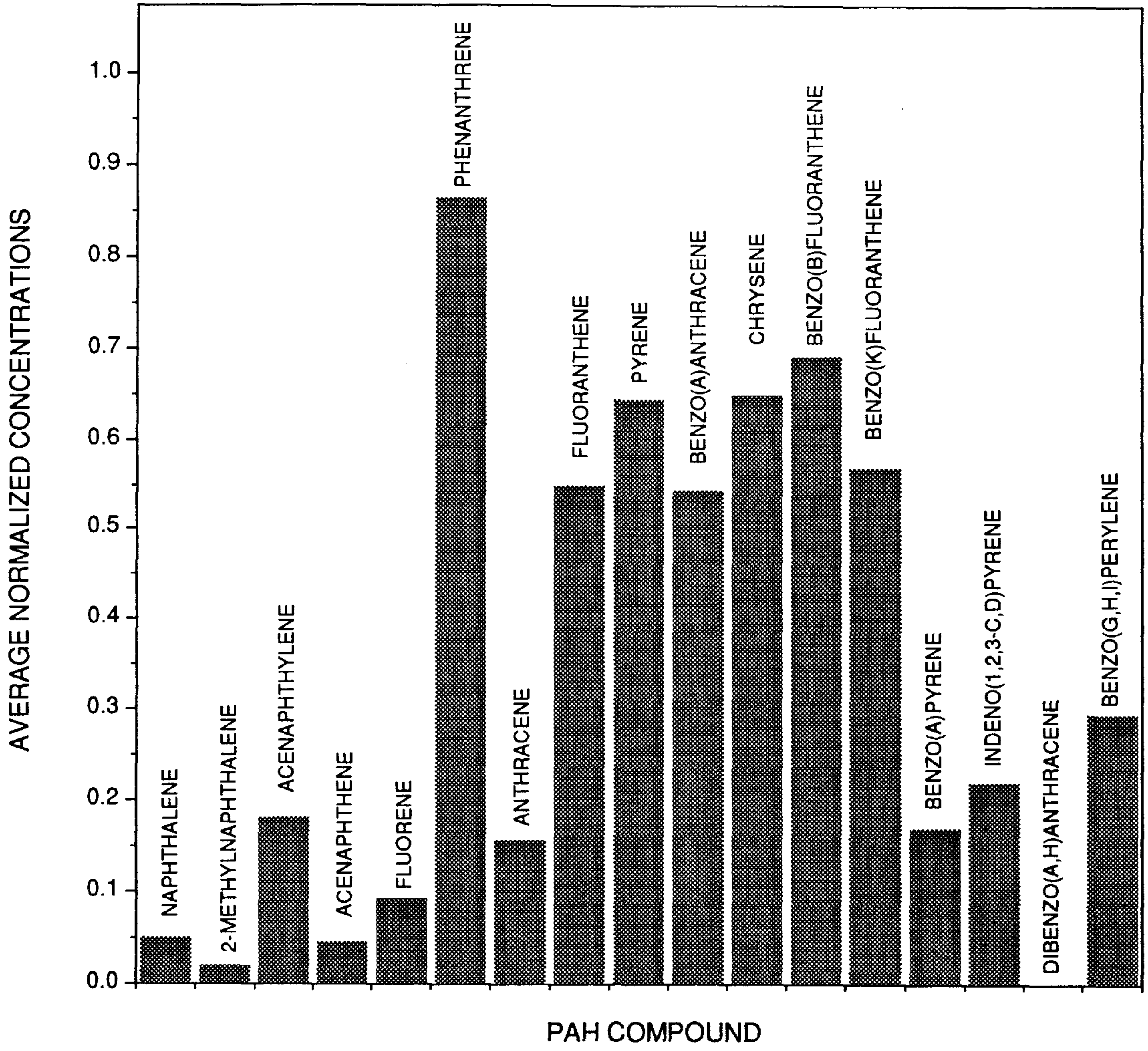


FIGURE 6-11
MAAF STORM DRAIN OUTFALL SEDIMENTS
FORT DEVENS, MA

Note:
The concentrations shown reflect the average of normalized concentrations detected in six selected sediment samples and their respective duplicates (SSD-93-43A, -43C, -46A, -49A, -49A(dup), -52A, -54A, and -54A(dup)).

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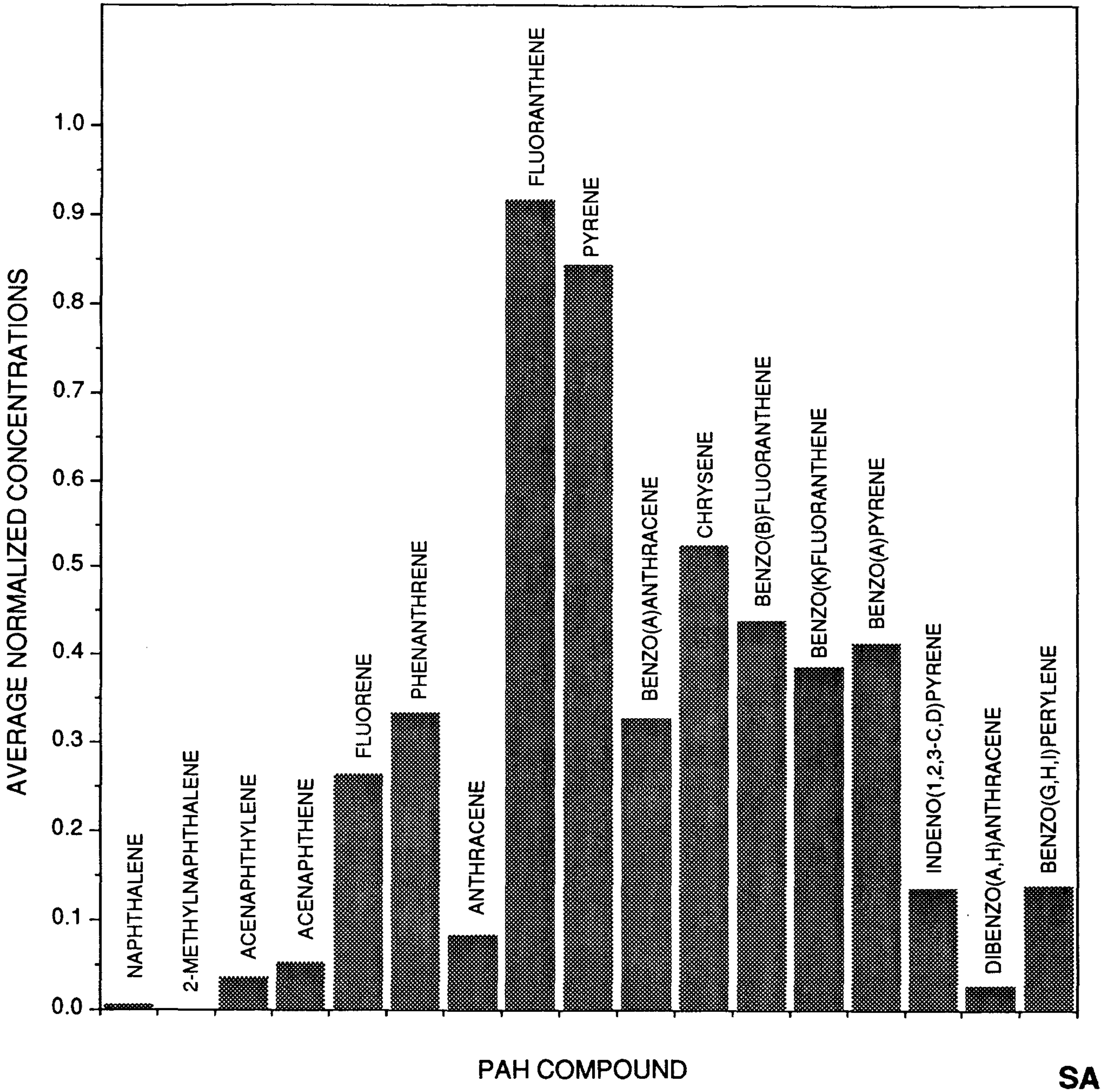
6917-plot



Note:
The concentrations shown reflect the average of normalized concentrations detected in the four surface soil samples collected at the East Drum Storage Area (30B-92-06X, -07X, -08,X and G6M-92-03X).

FIGURE 6-12
SA 30 SURFACE SOILS
EAST DRUM STORAGE AREA
FORT DEVENS, MA

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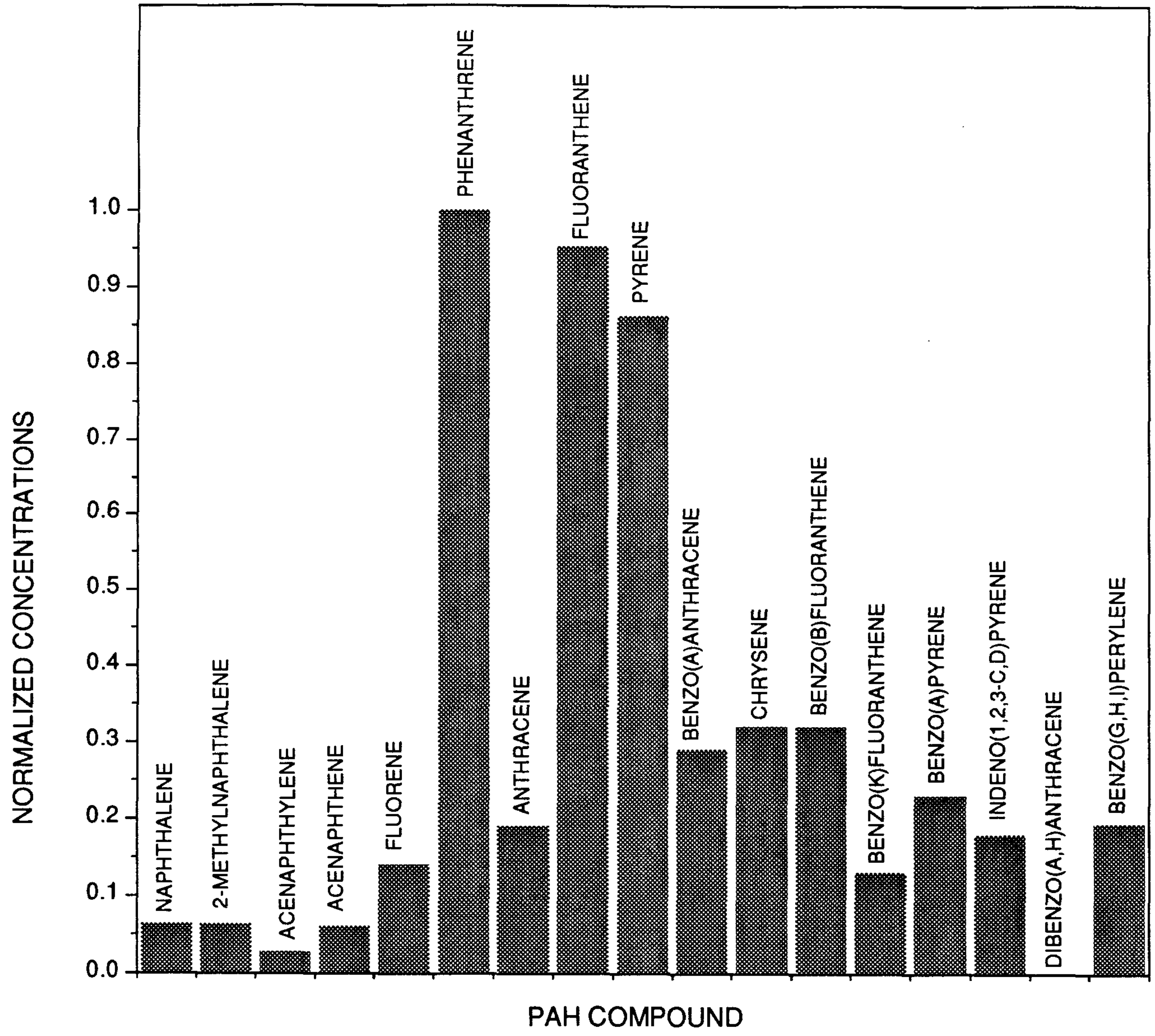

Note:
The concentrations shown reflect the average of normalized concentrations detected in a typical bituminous concrete pavement sample.

FIGURE 6-13
BITUMINOUS CONCRETE PAVEMENT
FORT DEVENS, MA

ABB ENVIRONMENTAL SERVICES, INC.

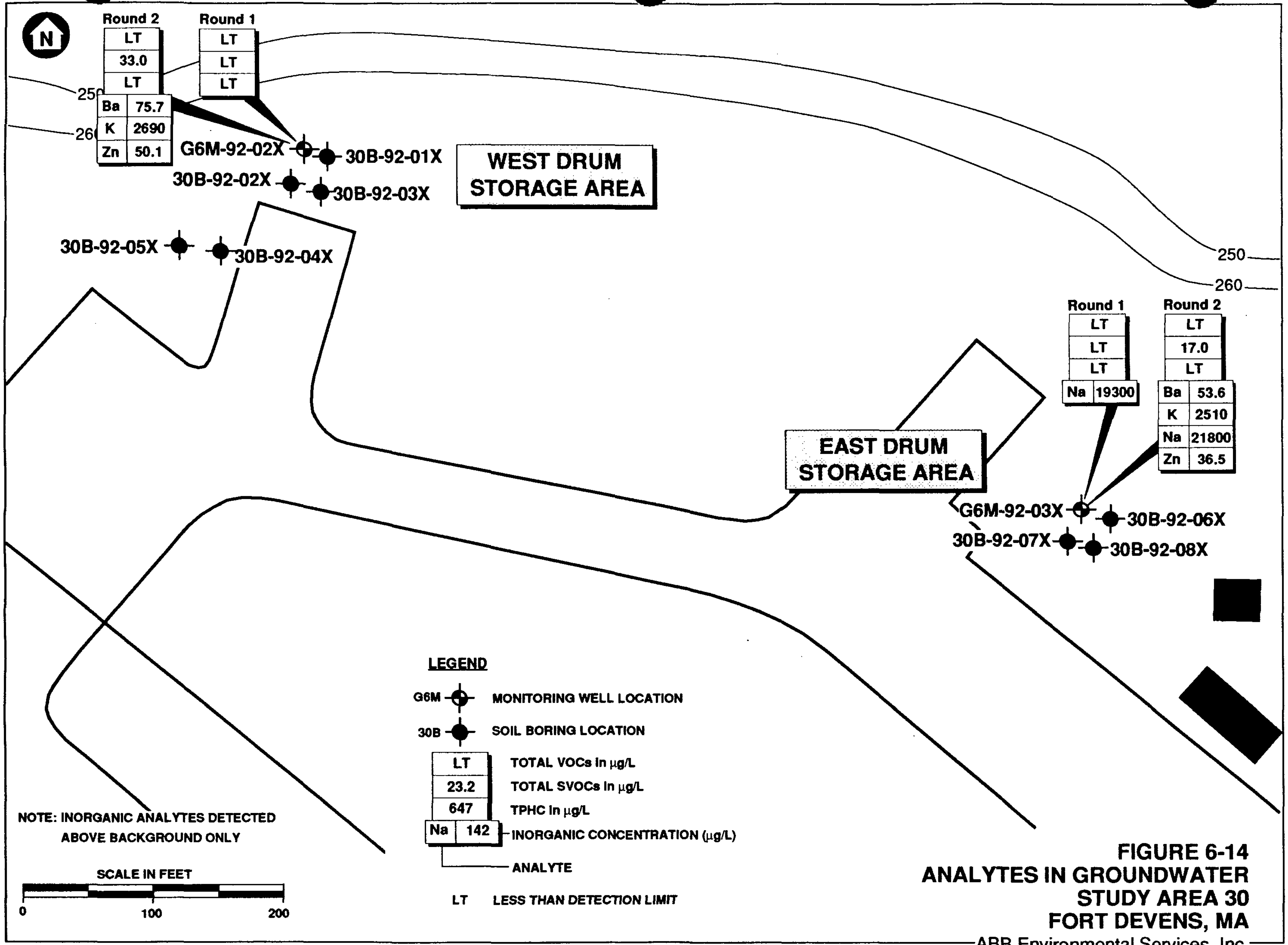

FIGURE 6-14
ANALYTES IN GROUNDWATER
STUDY AREA 30
FORT DEVENS, MA

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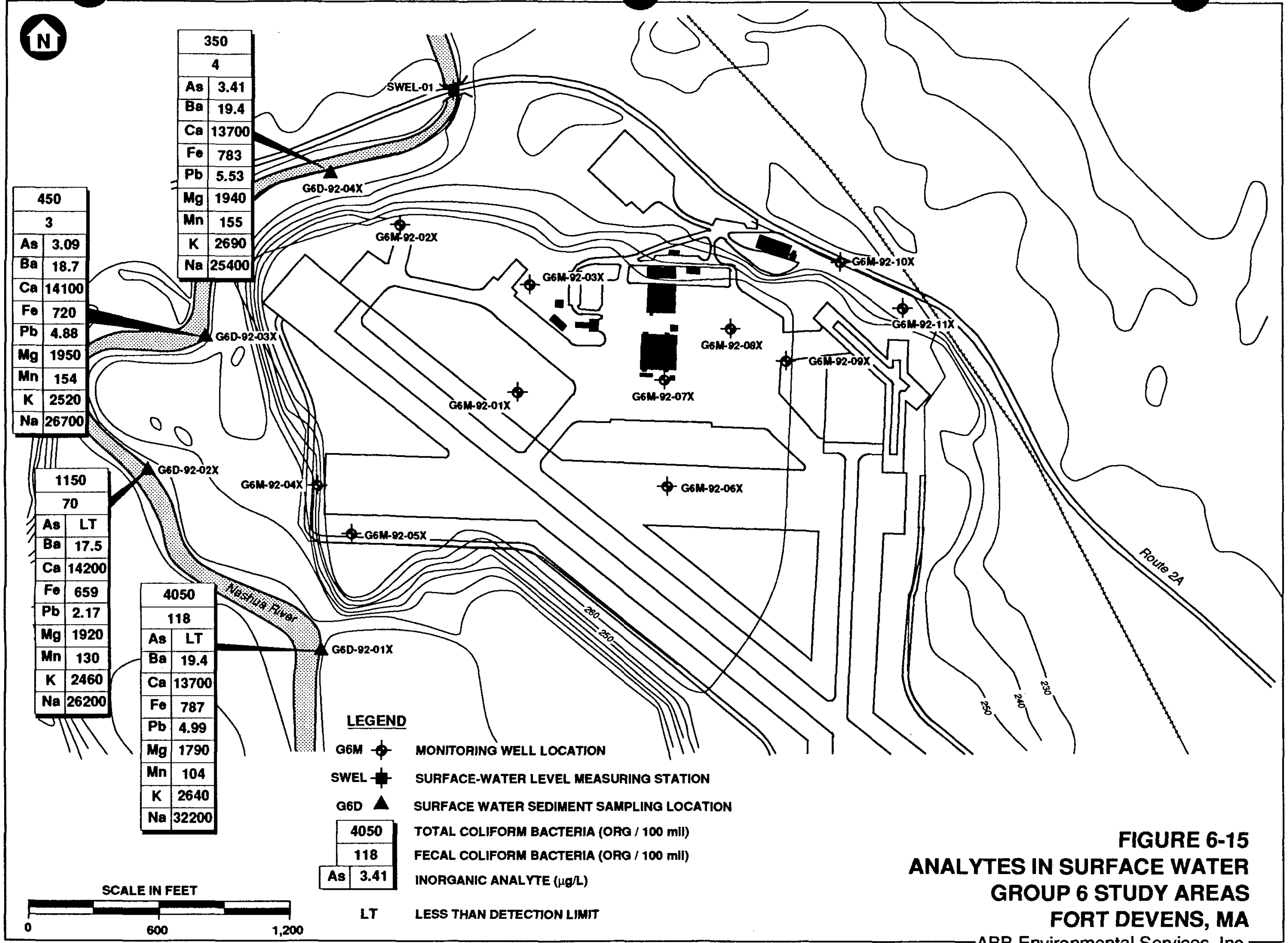

G6D-92-04X

350	
4	
As	3.41
Ba	19.4
Ca	13700
Fe	783
Pb	5.53
Mg	1940
Mn	155
K	2690
Na	25400

G6D-92-03X

450	
3	
As	3.09
Ba	18.7
Ca	14100
Fe	720
Pb	4.88
Mg	1950
Mn	154
K	2520
Na	26700

G6D-92-02X

1150	
70	
As	LT
Ba	17.5
Ca	14200
Fe	659
Pb	2.17
Mg	1920
Mn	130
K	2460
Na	26200

G6D-92-01X

4050	
118	
As	LT
Ba	19.4
Ca	13700
Fe	787
Pb	4.99
Mg	1790
Mn	104
K	2640
Na	32200

FIGURE 6-15
ANALYTES IN SURFACE WATER
GROUP 6 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(a)-123 0

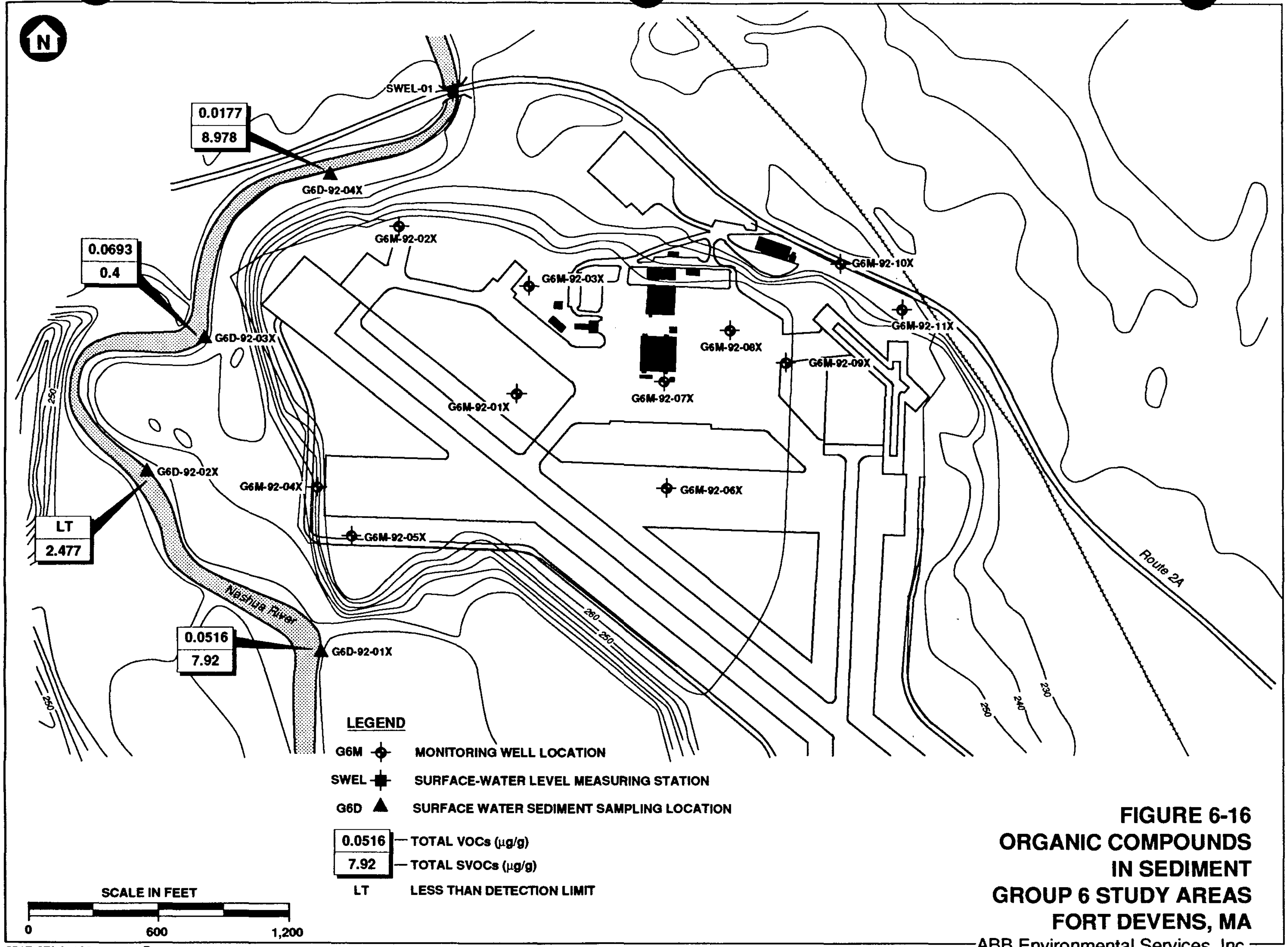

FIGURE 6-16
ORGANIC COMPOUNDS
IN SEDIMENT
GROUP 6 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(a)-123 B

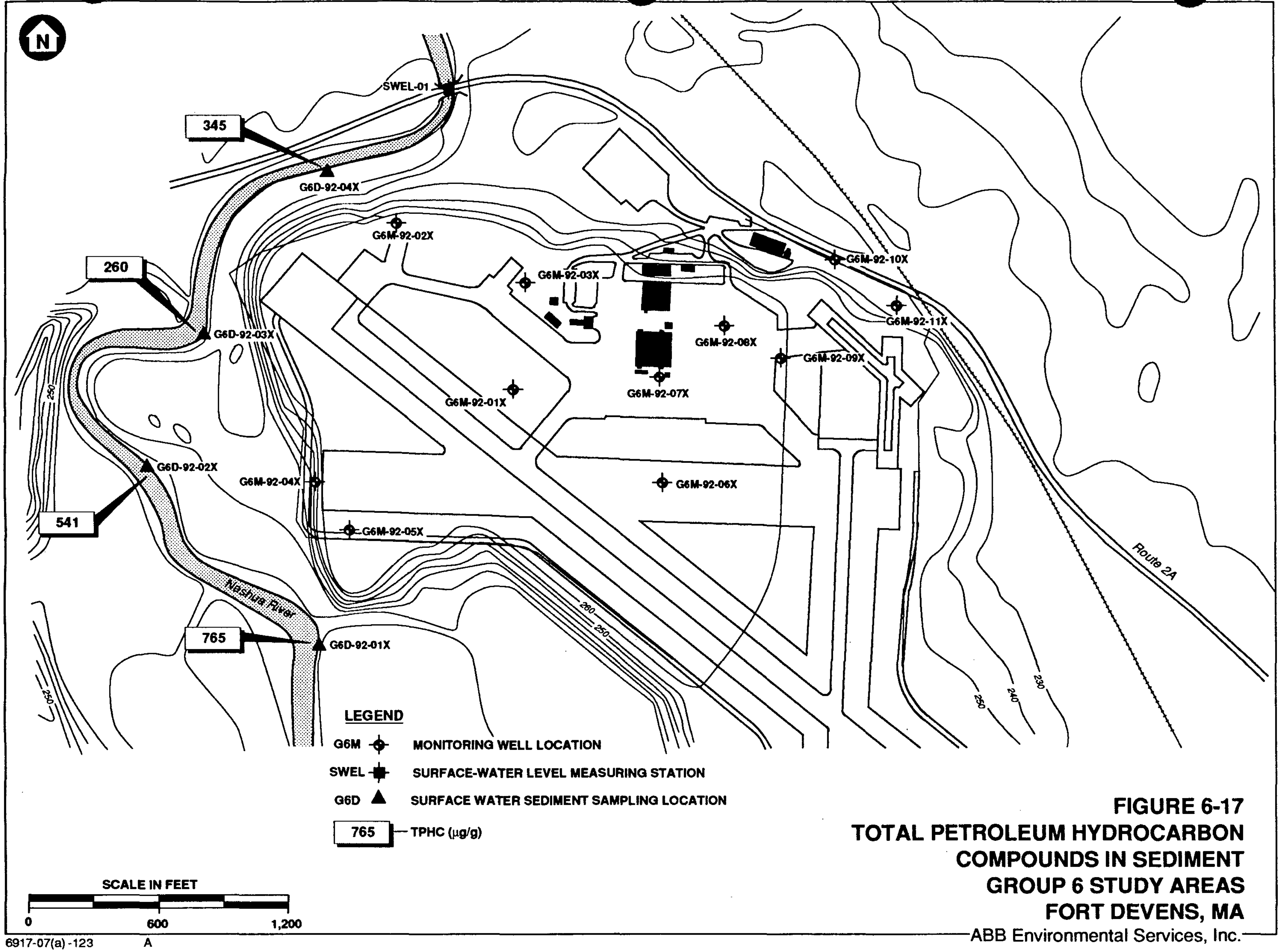

FIGURE 6-17
TOTAL PETROLEUM HYDROCARBON COMPOUNDS IN SEDIMENT
GROUP 6 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

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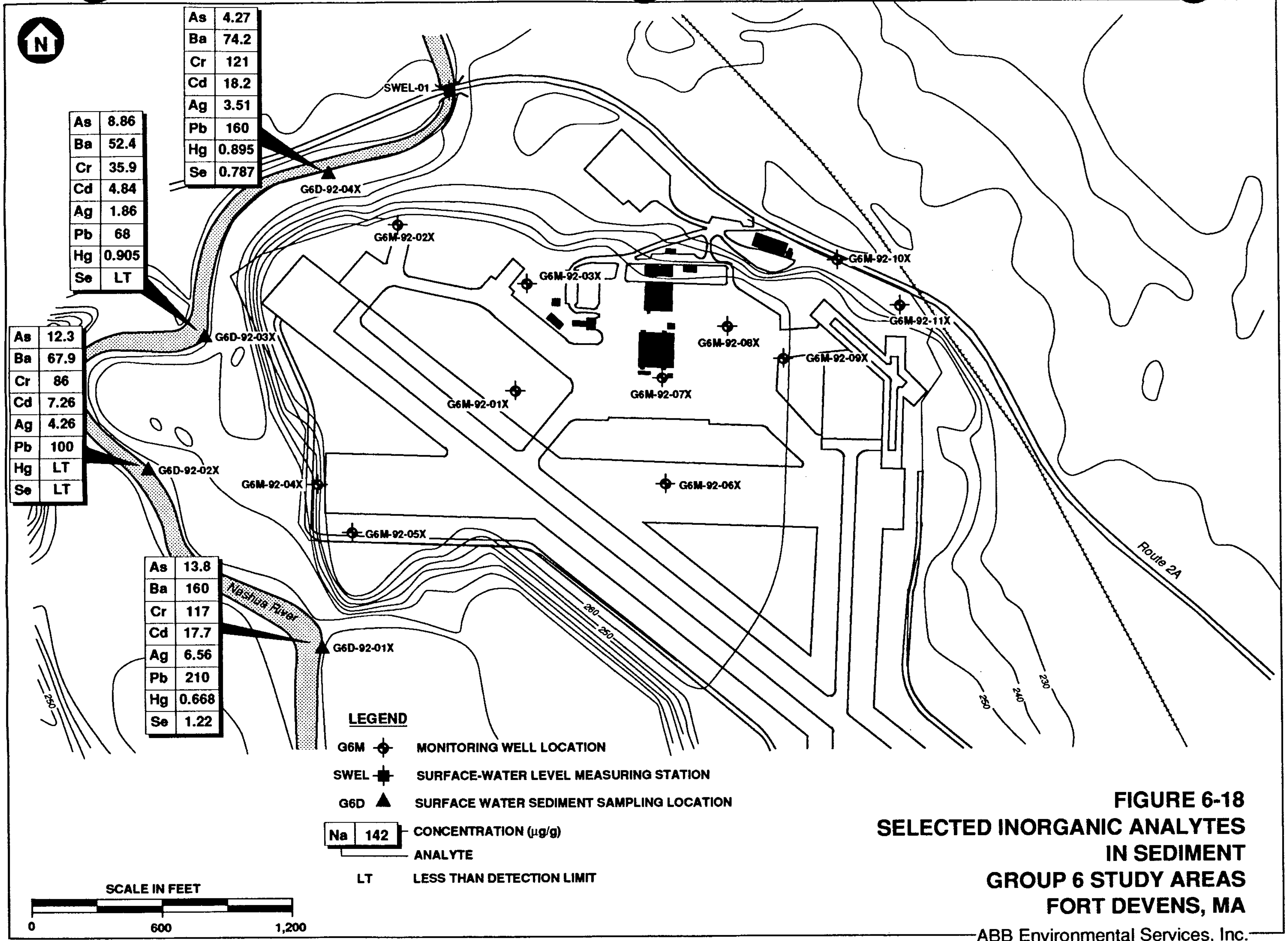


As	4.27
Ba	74.2
Cr	121
Cd	18.2
Ag	3.51
Pb	160
Hg	0.895
Se	0.787

As	8.86
Ba	52.4
Cr	35.9
Cd	4.84
Ag	1.86
Pb	68
Hg	0.905
Se	LT

As	12.3
Ba	67.9
Cr	86
Cd	7.26
Ag	4.26
Pb	100
Hg	LT
Se	LT

As	13.8
Ba	160
Cr	117
Cd	17.7
Ag	6.56
Pb	210
Hg	0.668
Se	1.22

FIGURE 6-18
SELECTED INORGANIC ANALYTES
IN SEDIMENT
GROUP 6 STUDY AREAS
FORT DEVENS, MA

ABB Environmental Services, Inc.

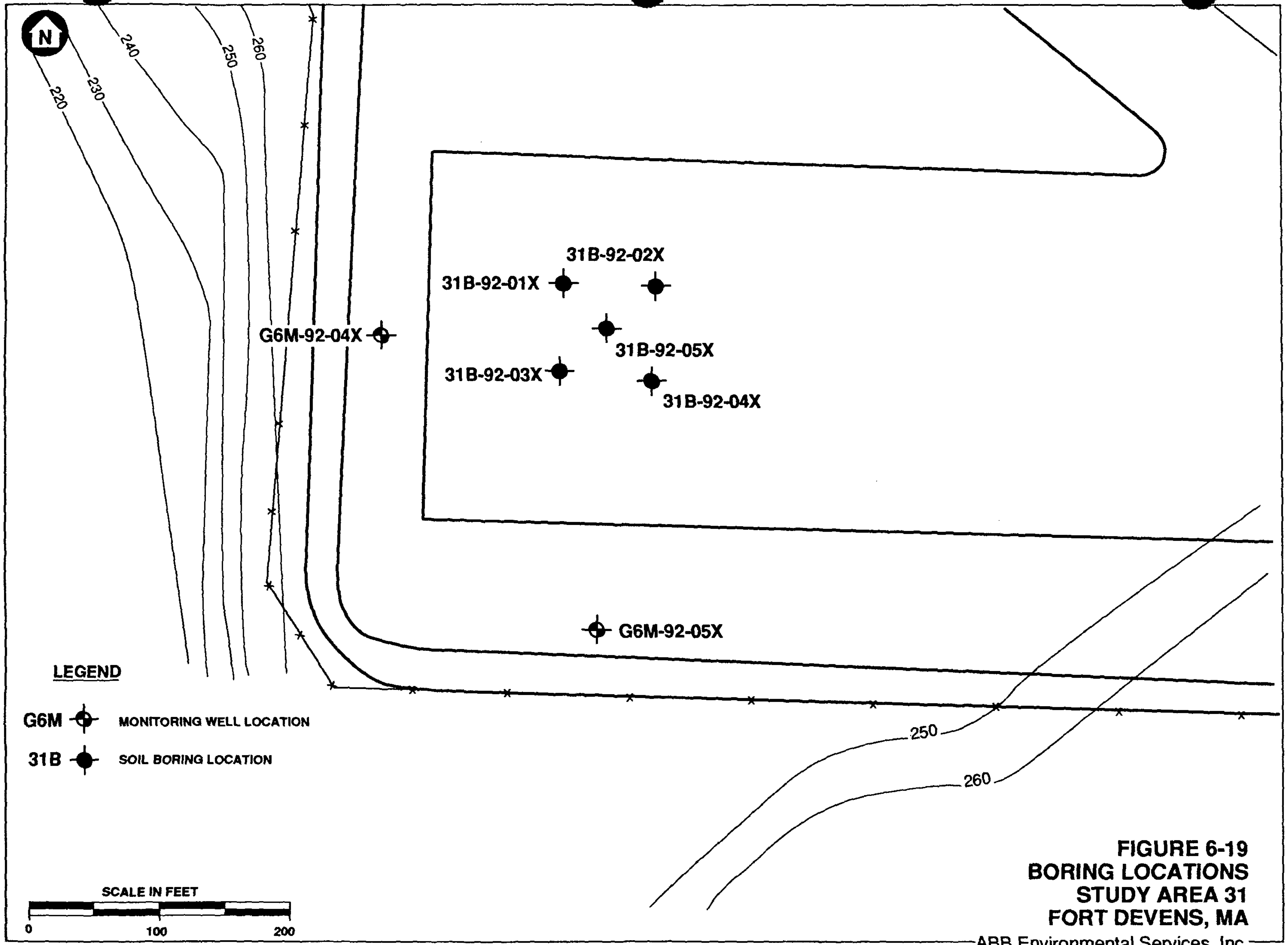


FIGURE 6-19
BORING LOCATIONS
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 12

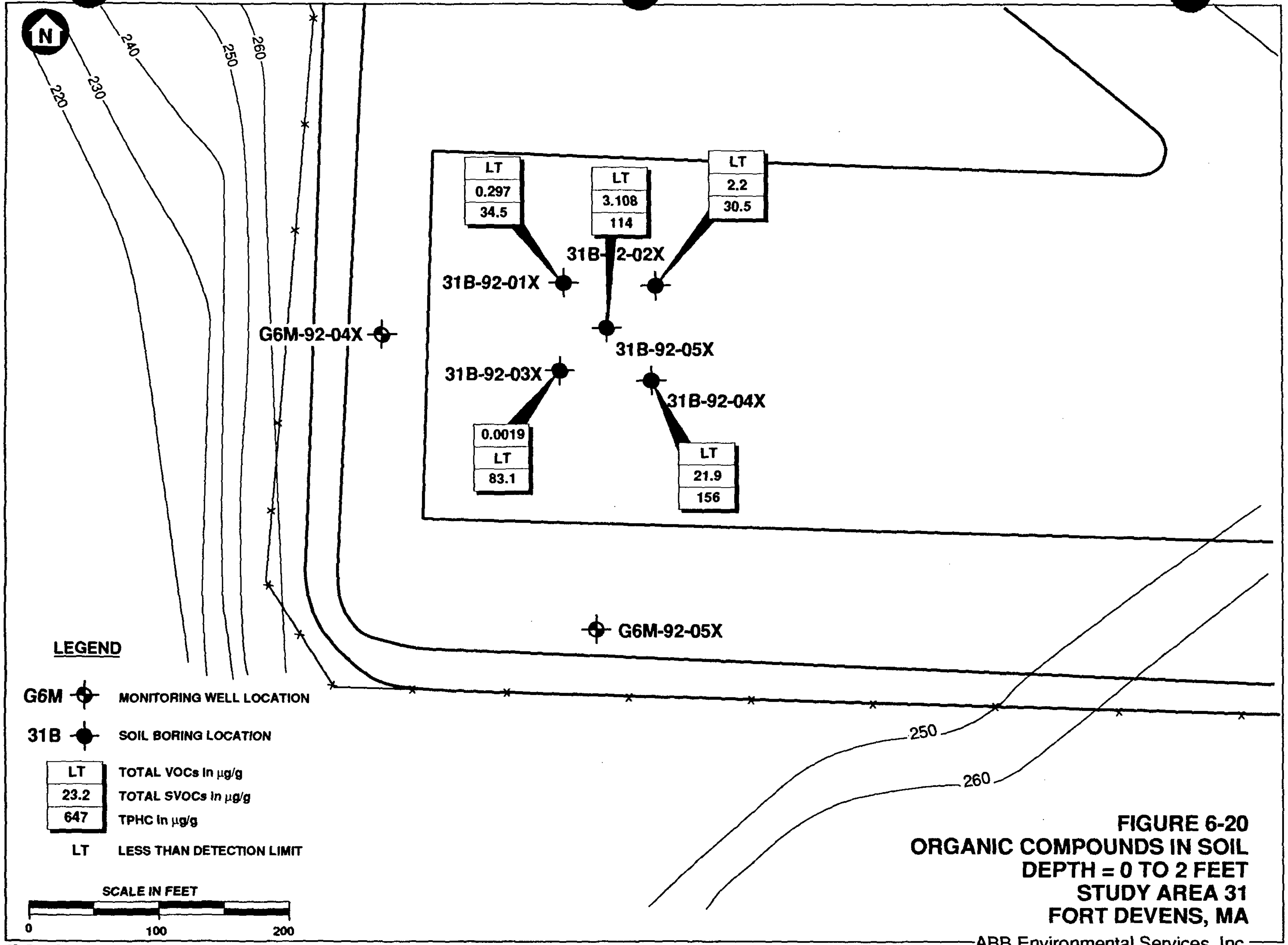


FIGURE 6-20
ORGANIC COMPOUNDS IN SOIL
DEPTH = 0 TO 2 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 123

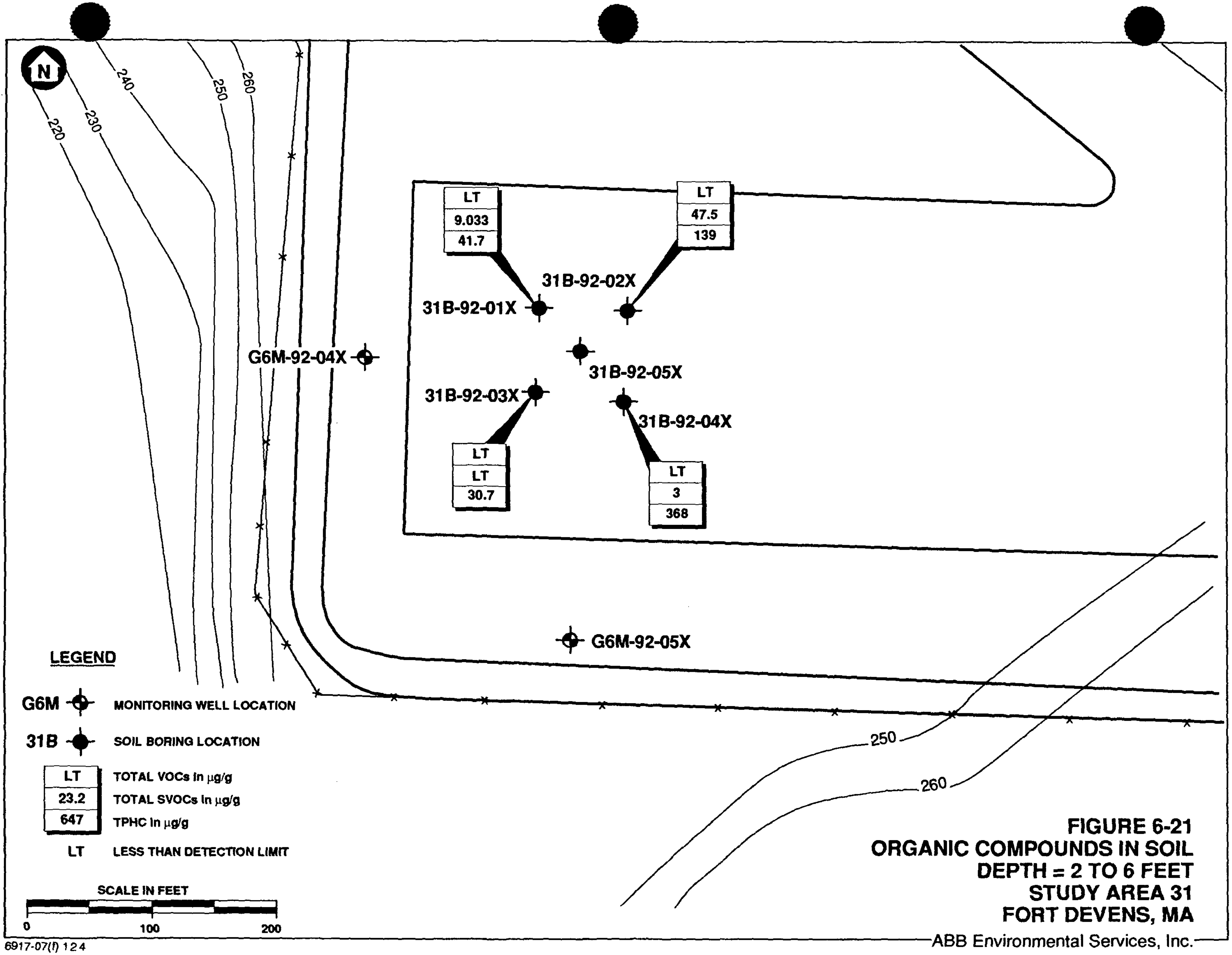
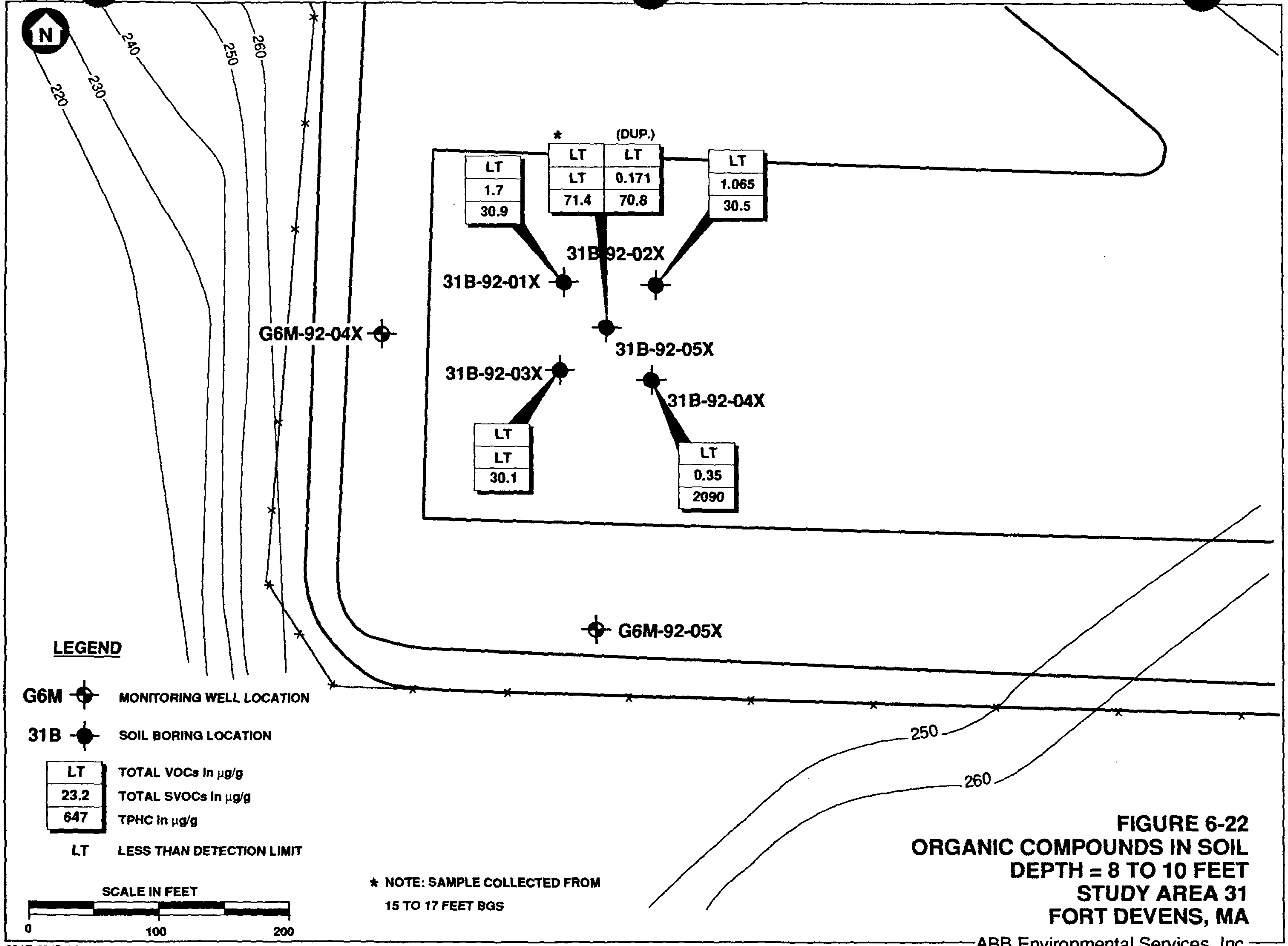


FIGURE 6-21
ORGANIC COMPOUNDS IN SOIL
DEPTH = 2 TO 6 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.



* NOTE: SAMPLE COLLECTED FROM 15 TO 17 FEET BGS

FIGURE 6-22
ORGANIC COMPOUNDS IN SOIL
DEPTH = 8 TO 10 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 125

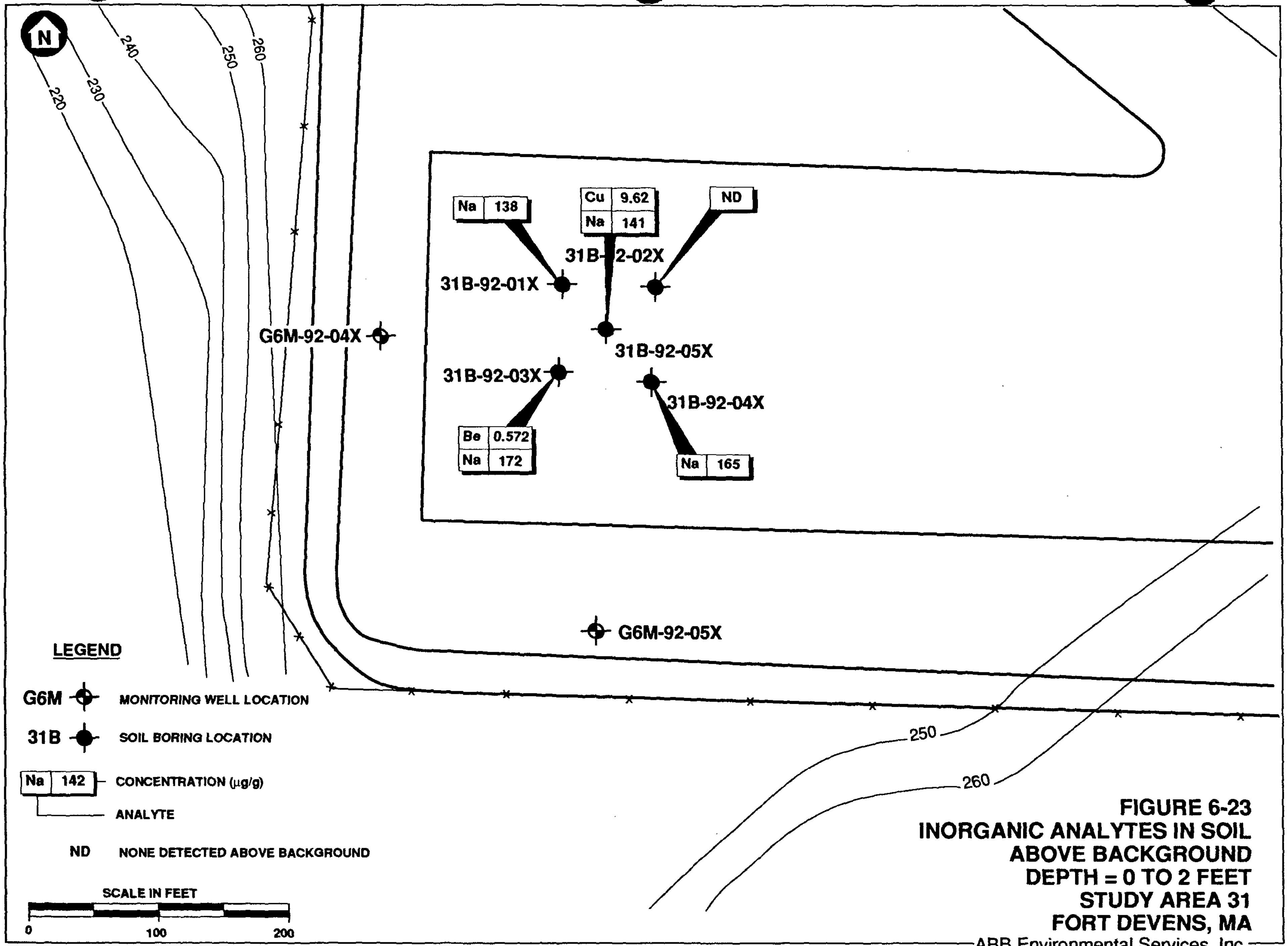


FIGURE 6-23
INORGANIC ANALYTES IN SOIL
ABOVE BACKGROUND
DEPTH = 0 TO 2 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 126

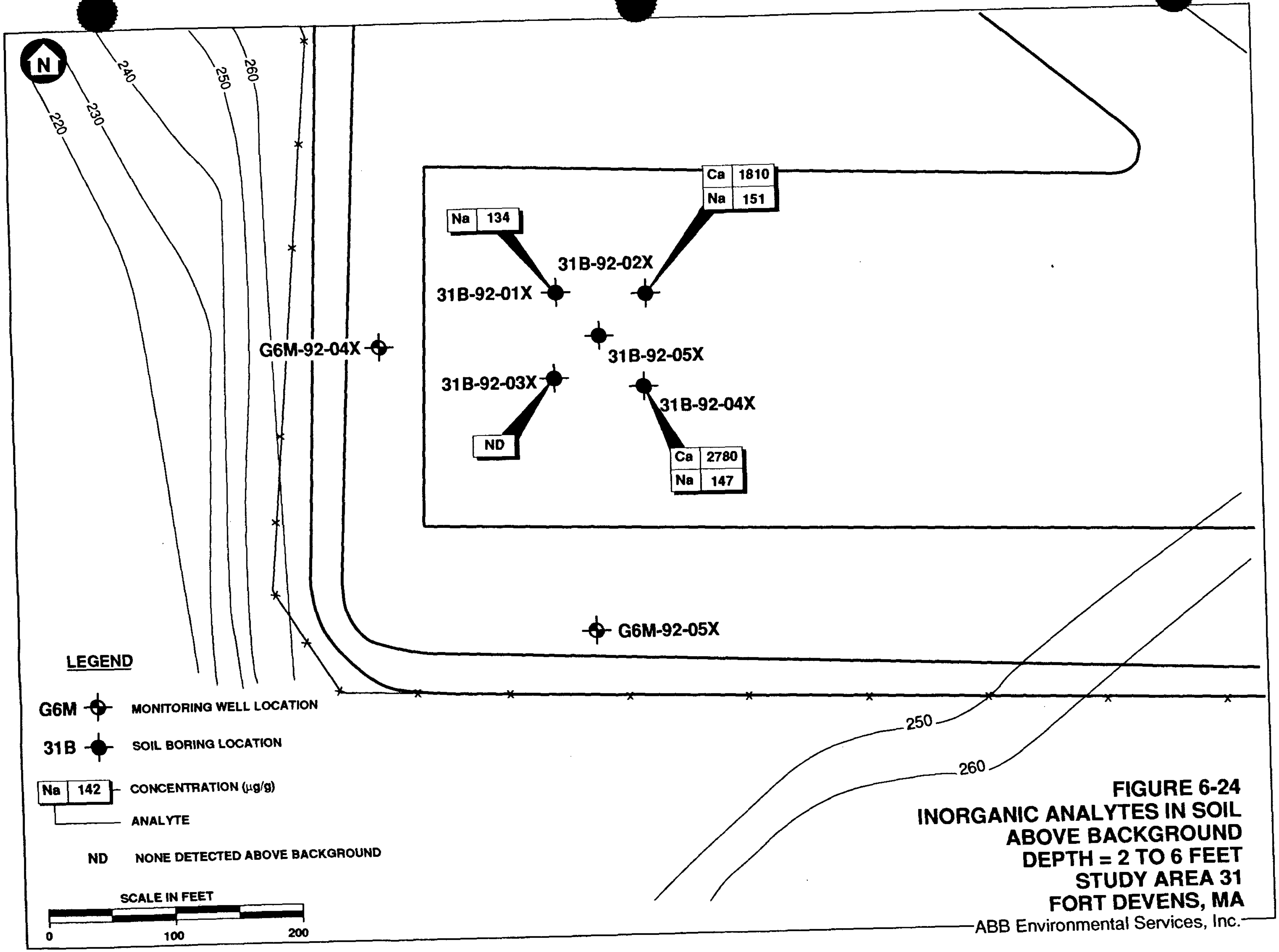


FIGURE 6-24
INORGANIC ANALYTES IN SOIL
ABOVE BACKGROUND
DEPTH = 2 TO 6 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 127

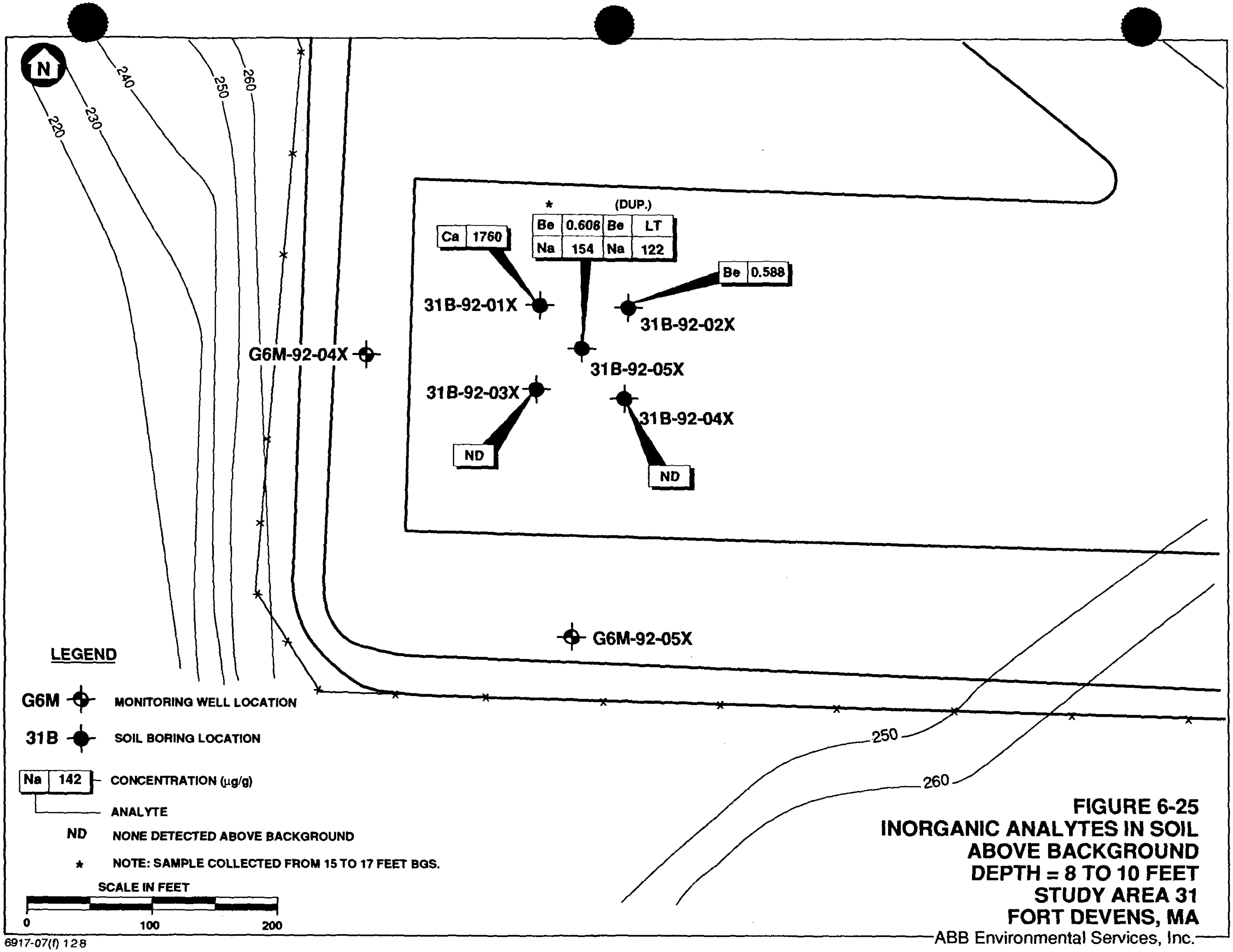


FIGURE 6-25
INORGANIC ANALYTES IN SOIL
ABOVE BACKGROUND
DEPTH = 8 TO 10 FEET
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 128

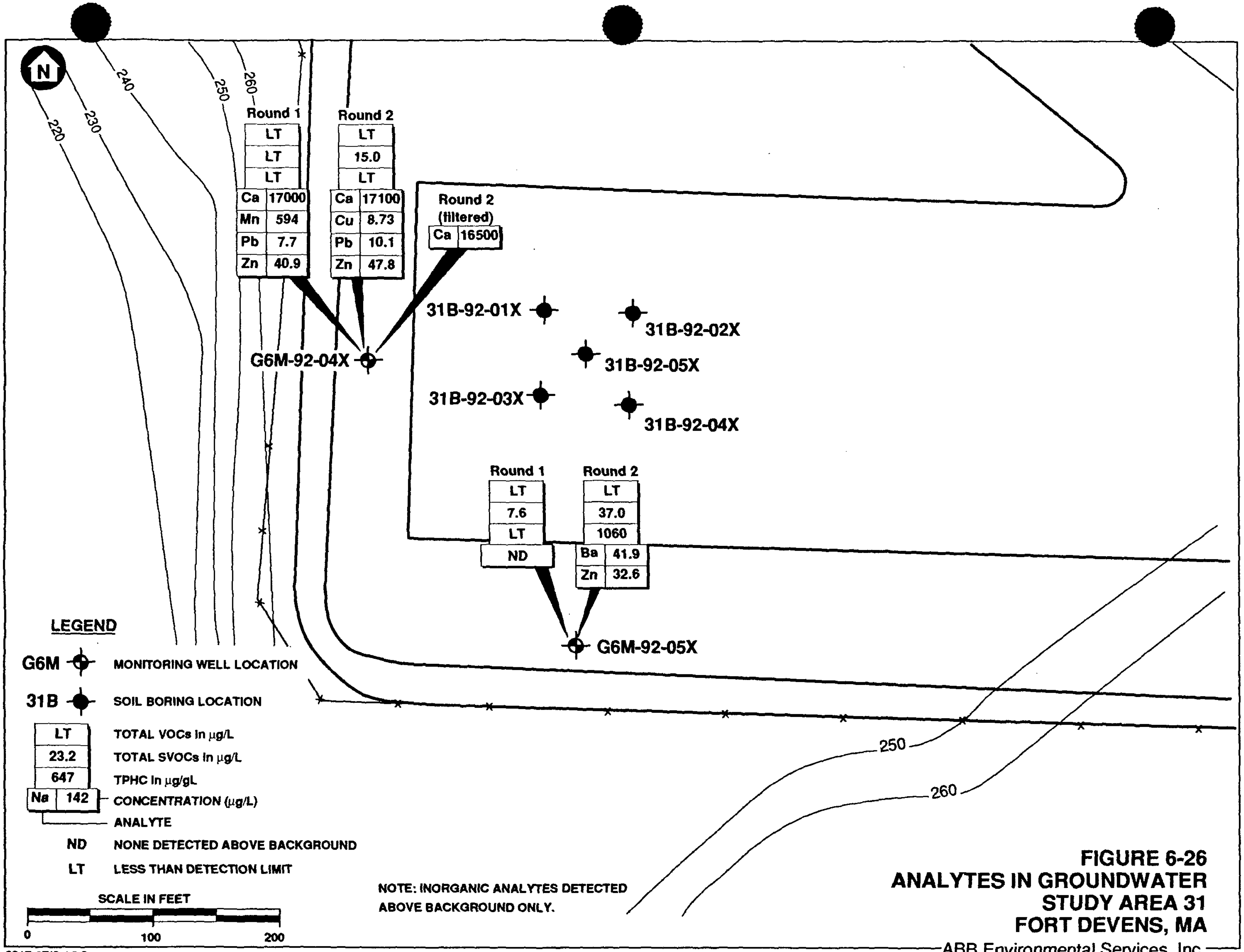


FIGURE 6-26
ANALYTES IN GROUNDWATER
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(f) 129

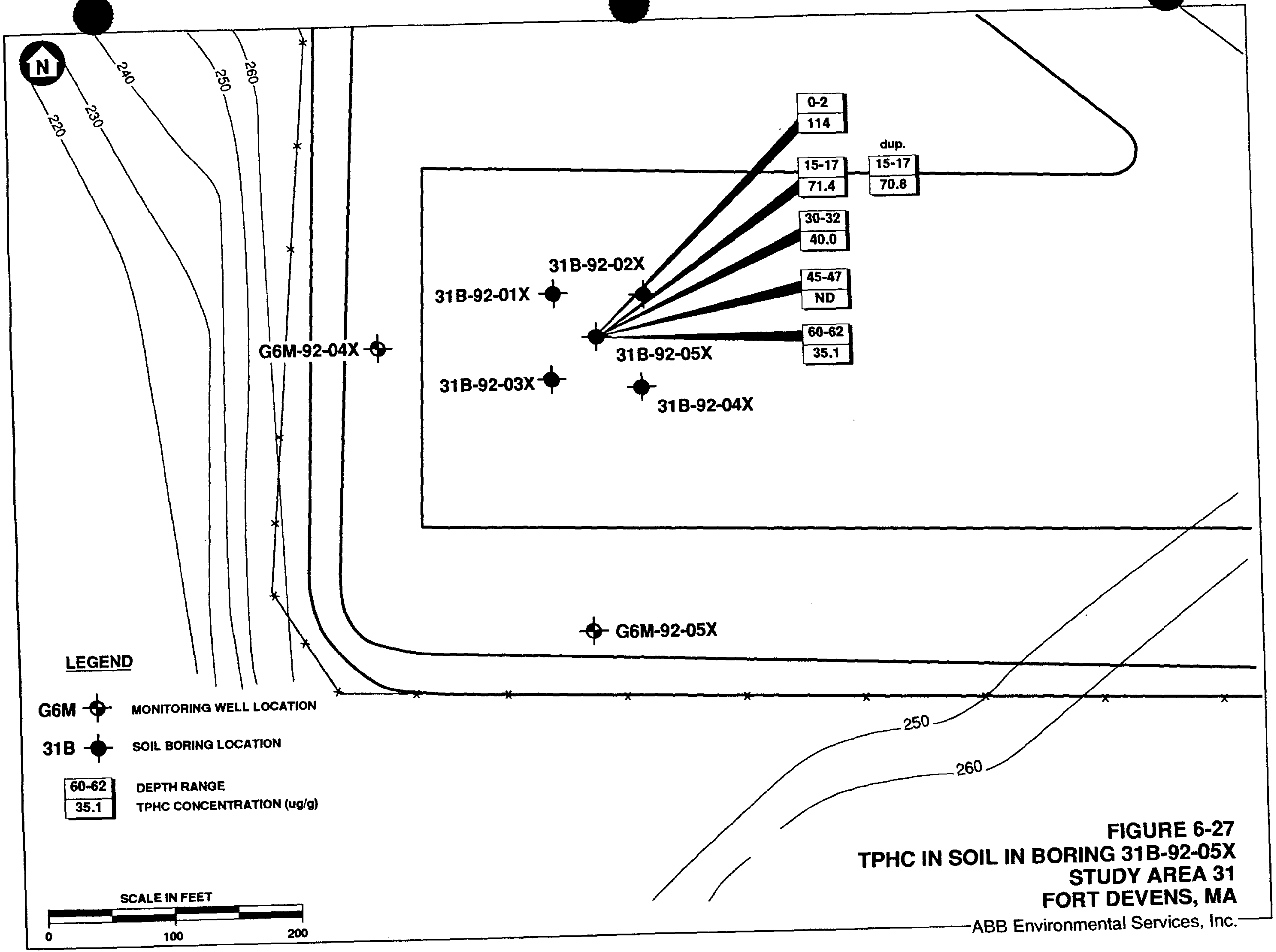


FIGURE 6-27
TPHC IN SOIL IN BORING 31B-92-05X
STUDY AREA 31
FORT DEVENS, MA

ABB Environmental Services, Inc.

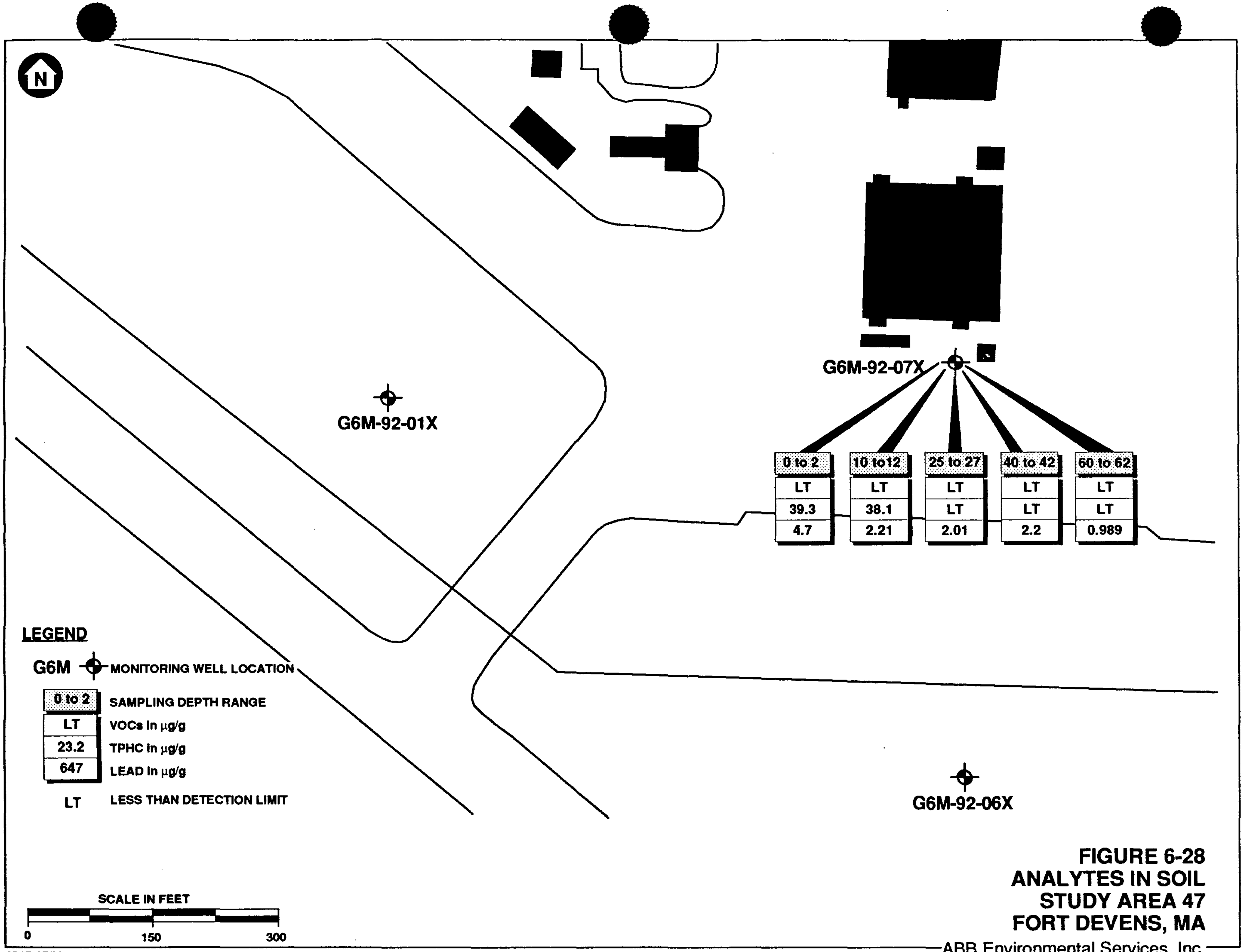


FIGURE 6-28
ANALYTES IN SOIL
STUDY AREA 47
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(h) 1

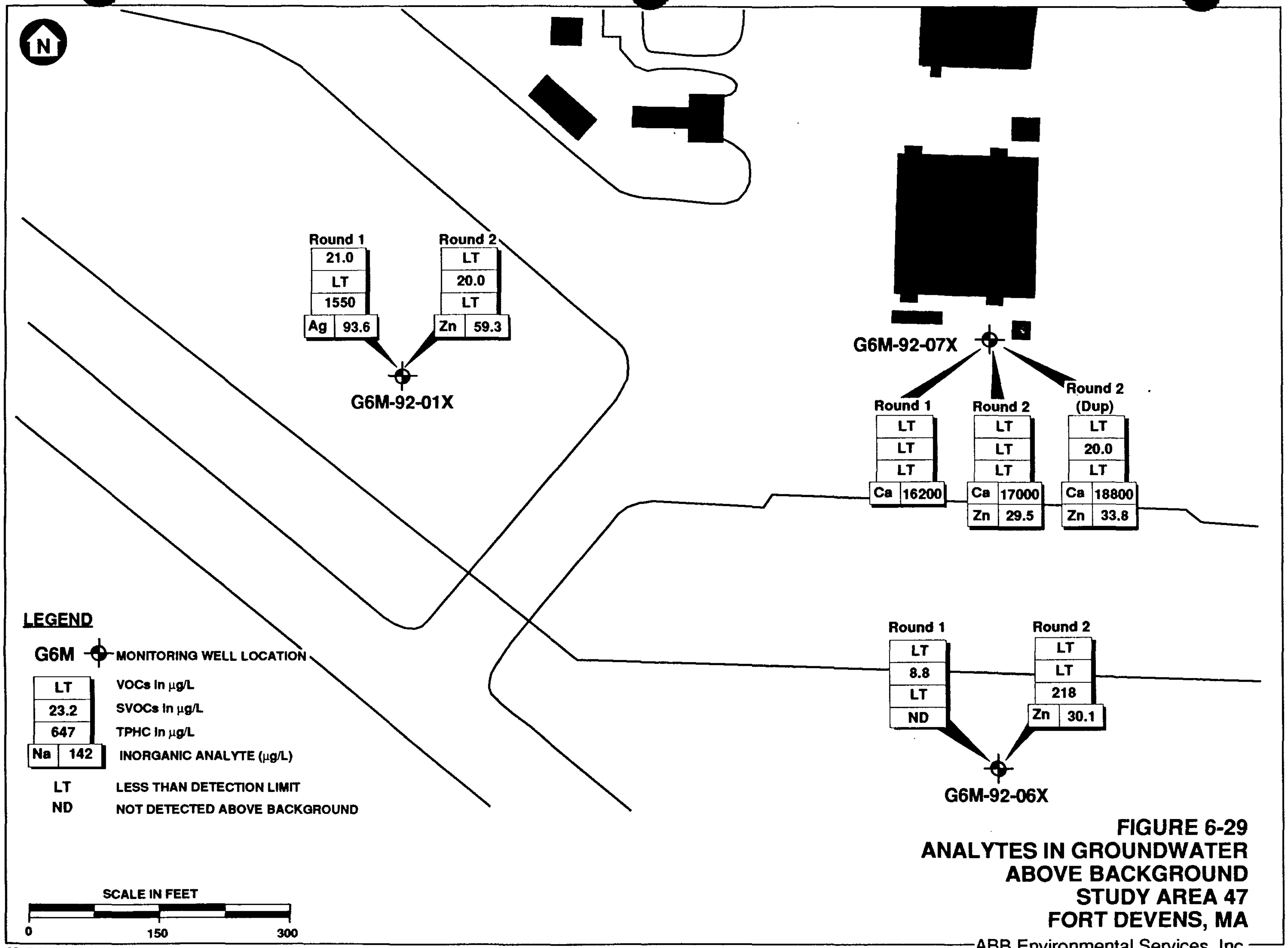


FIGURE 6-29
ANALYTES IN GROUNDWATER
ABOVE BACKGROUND
STUDY AREA 47
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(h) 3

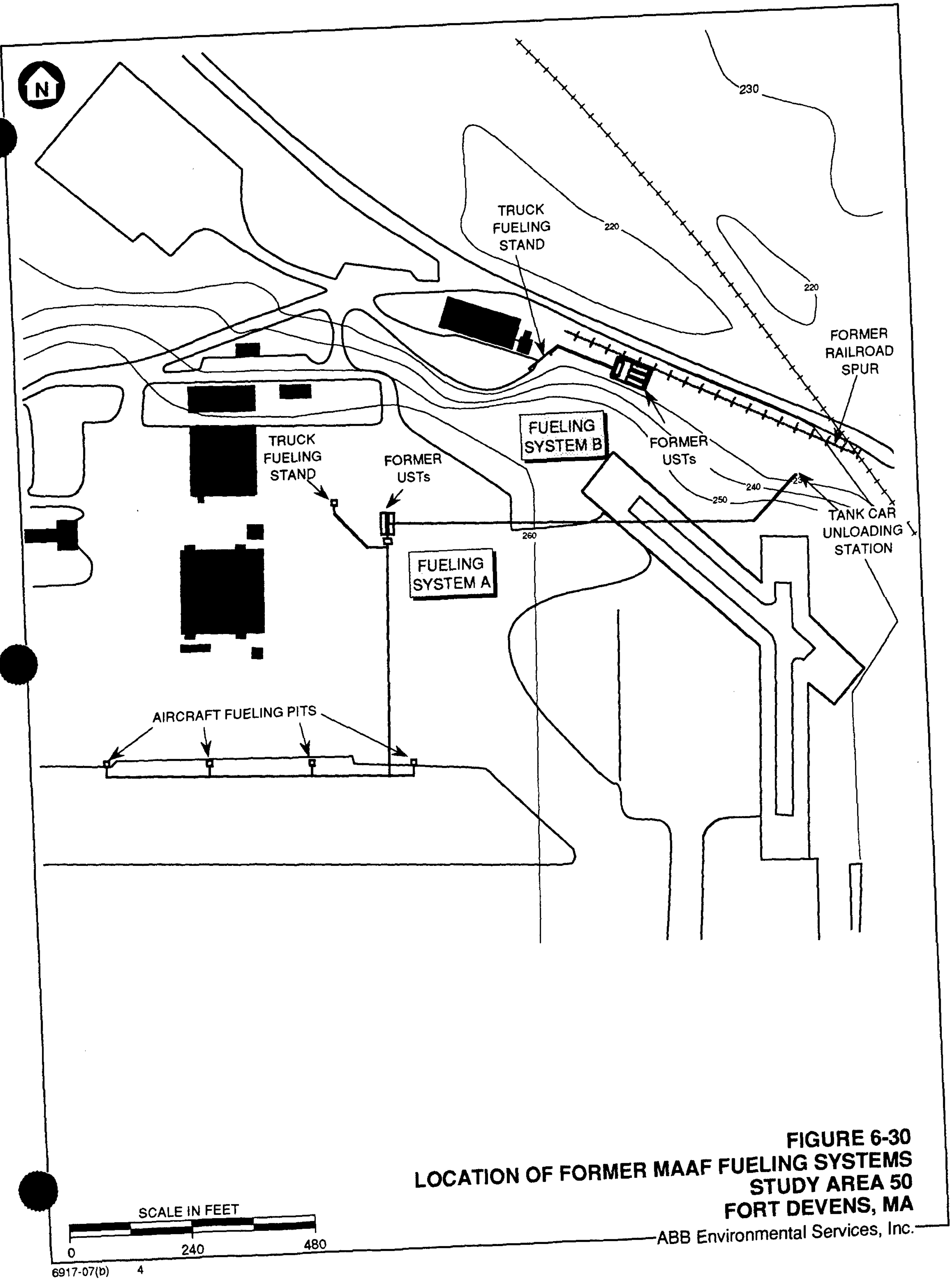


FIGURE 6-30
LOCATION OF FORMER MAAF FUELING SYSTEMS
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(b) 4

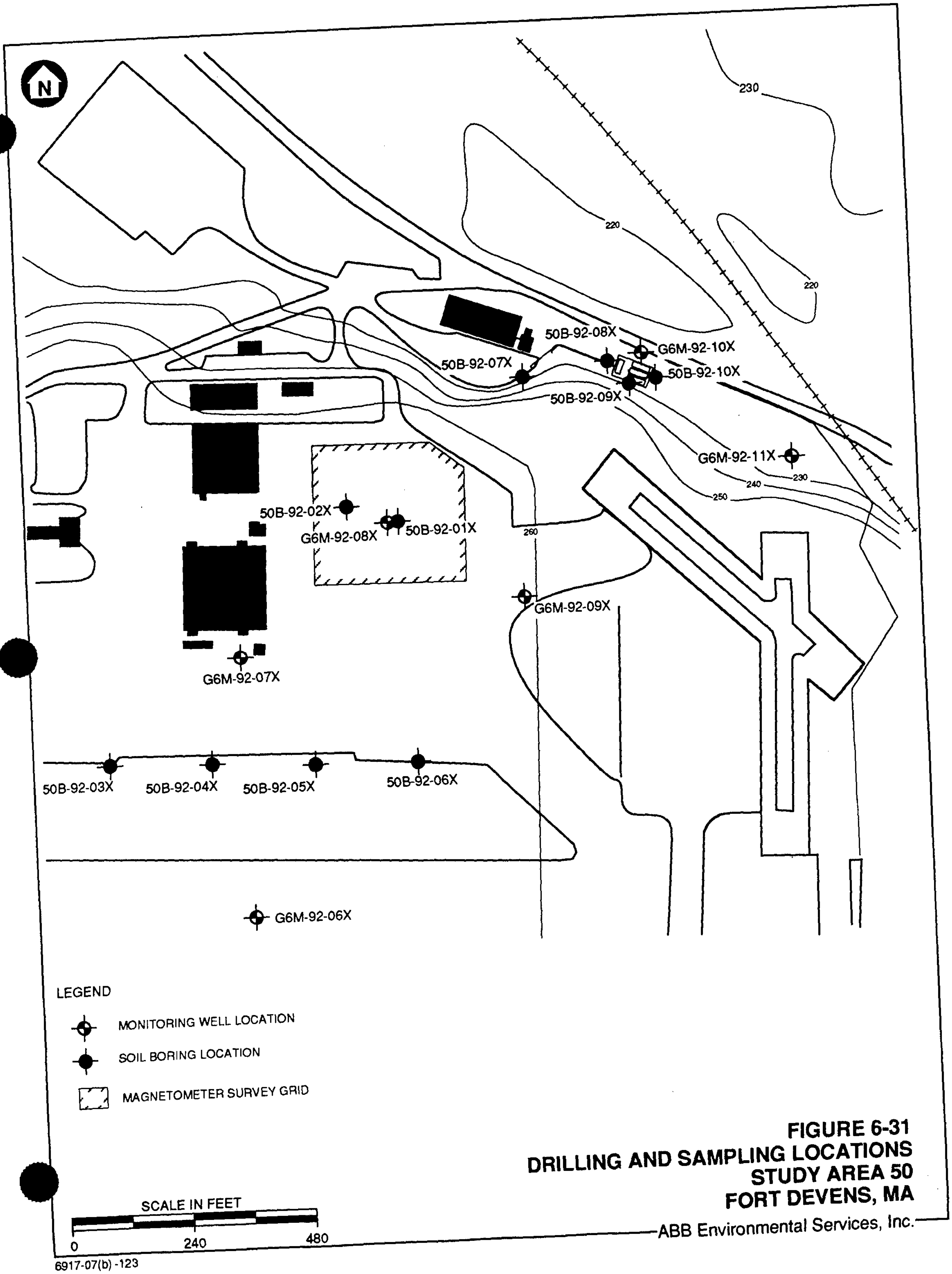
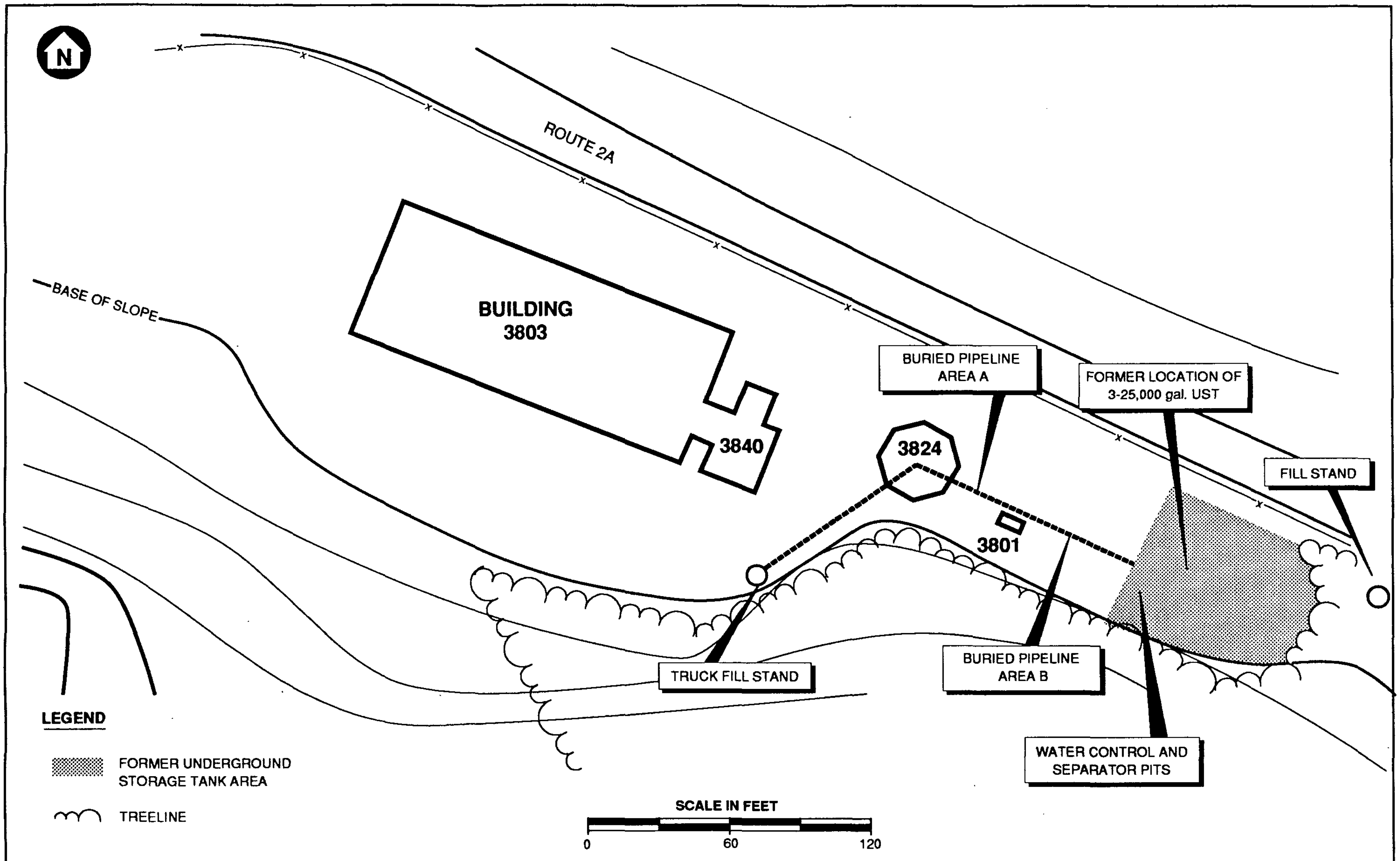


FIGURE 6-31
DRILLING AND SAMPLING LOCATIONS
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

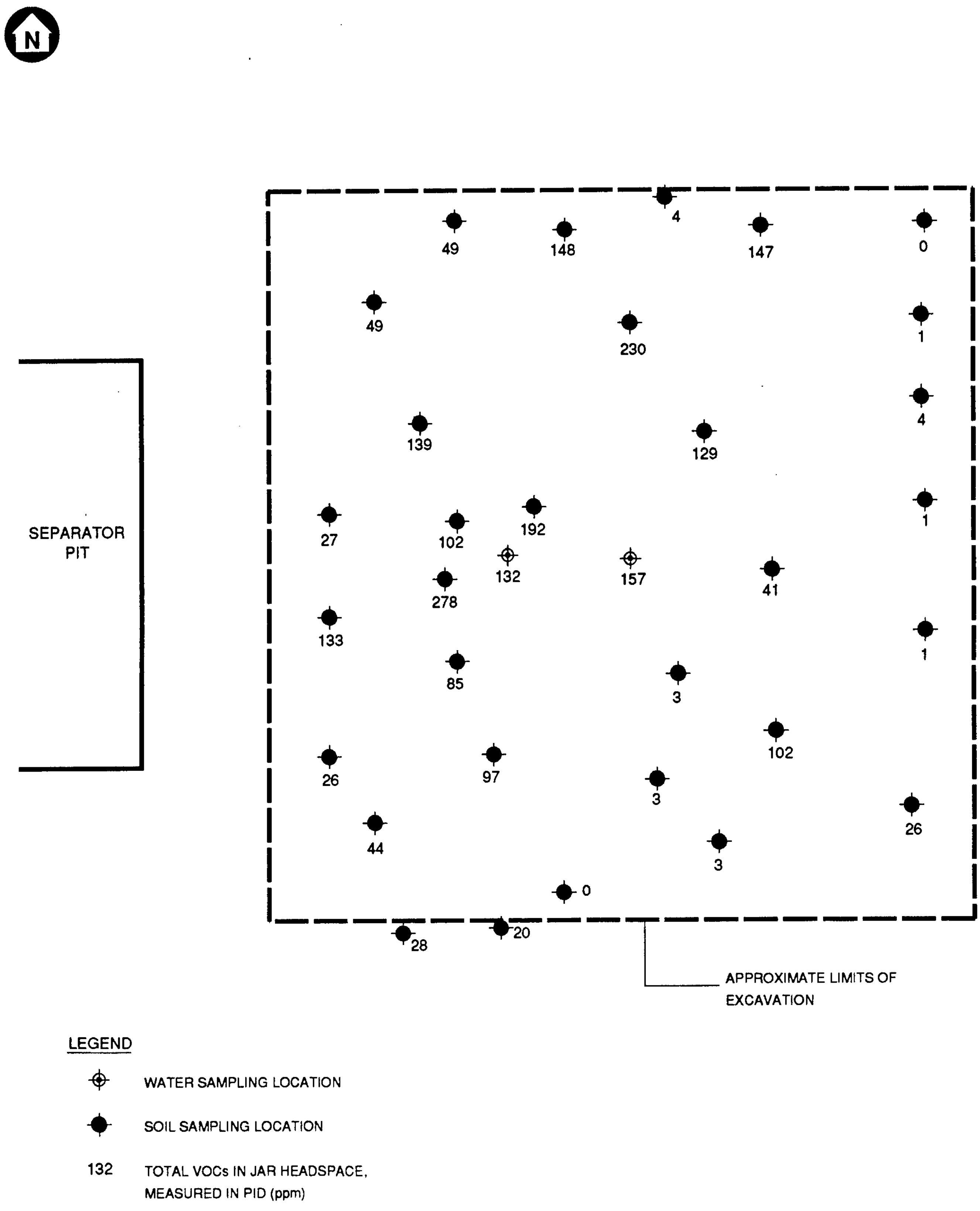
6917-07(b) -123



LOCATIONS APPROXIMATE

SOURCE: ZENONE (1993, FIGURE 4)

FIGURE 6-32
LOCATIONS FOR FUELING SYSTEM B SYSTEM COMPONENTS
STUDY AREA 50
FORT DEVENS, MA



SOURCE: ZENONE (1993, APPENDIX "SOIL HEADSPACE RESULTS")

APPROXIMATE SCALE IN FEET

0 10 20

FIGURE 6-33
CONFIRMATORY PID HEADSPACE RESULTS FOR UST EXCAVATION
STUDY AREA 50
FORT DEVENS, MA

9308015W

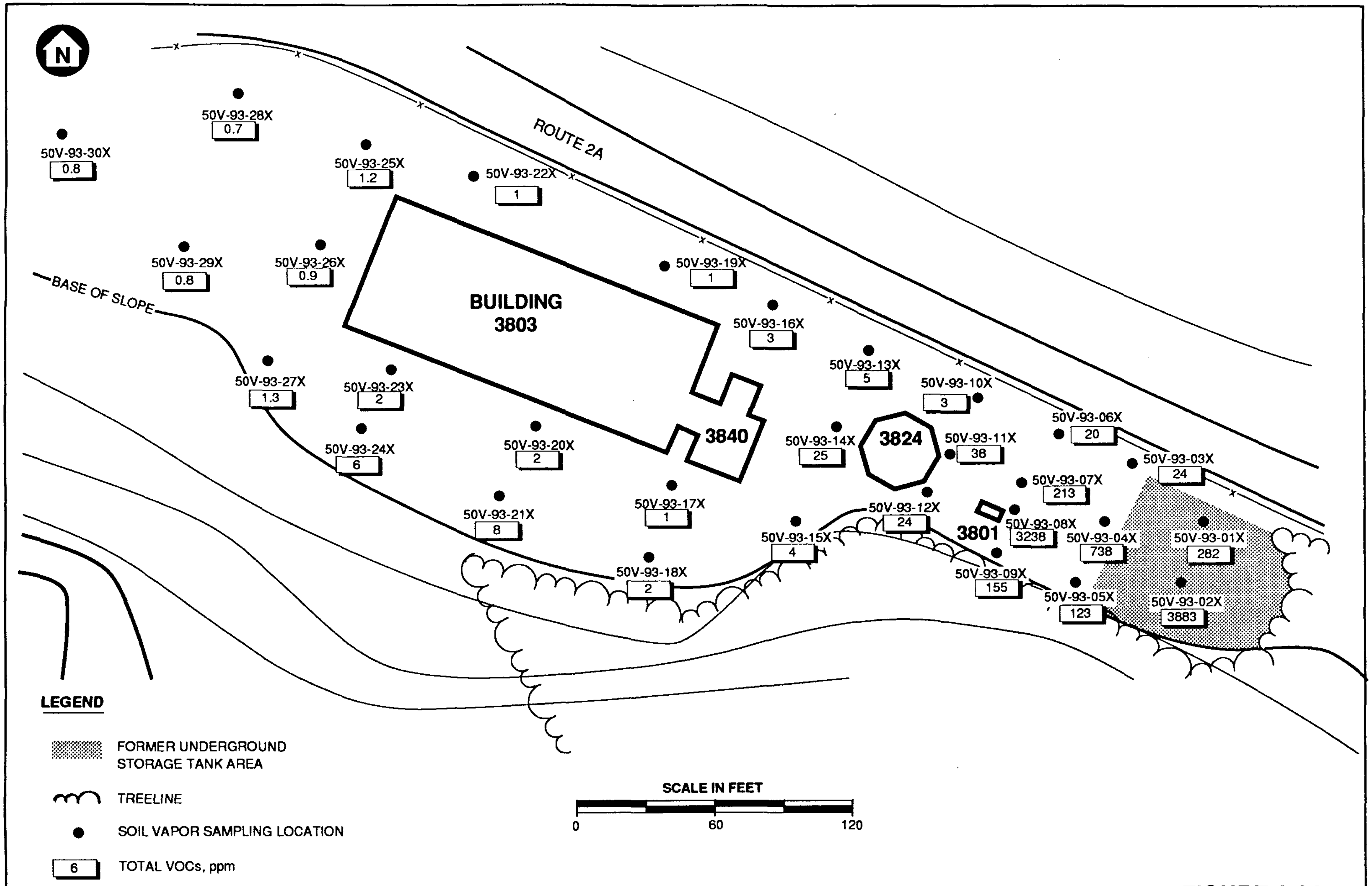


FIGURE 6-34
SOIL VAPOR SCREENING RESULTS
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

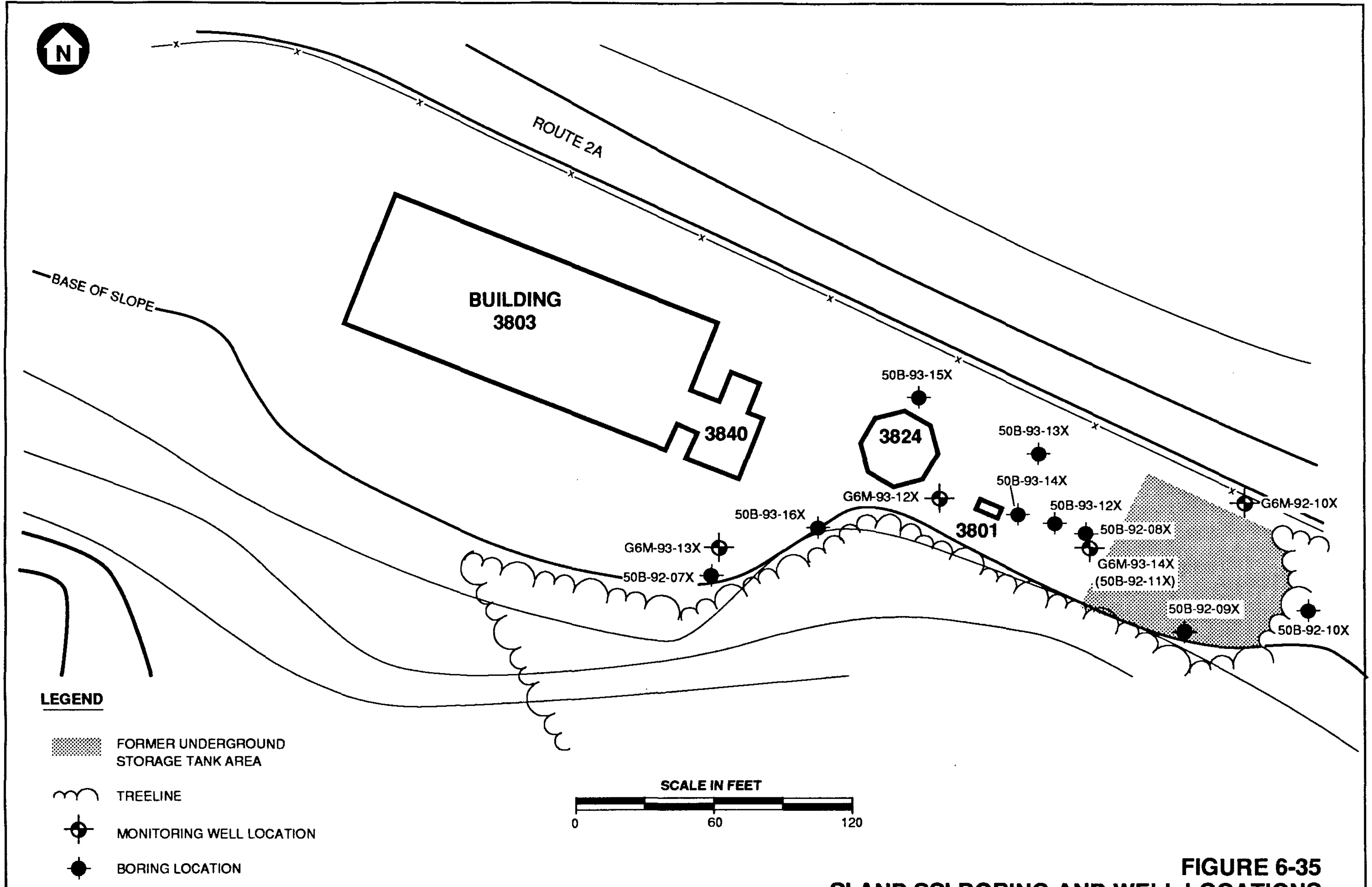


FIGURE 6-35
SI AND SSI BORING AND WELL LOCATIONS
FUELING SYSTEM B
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

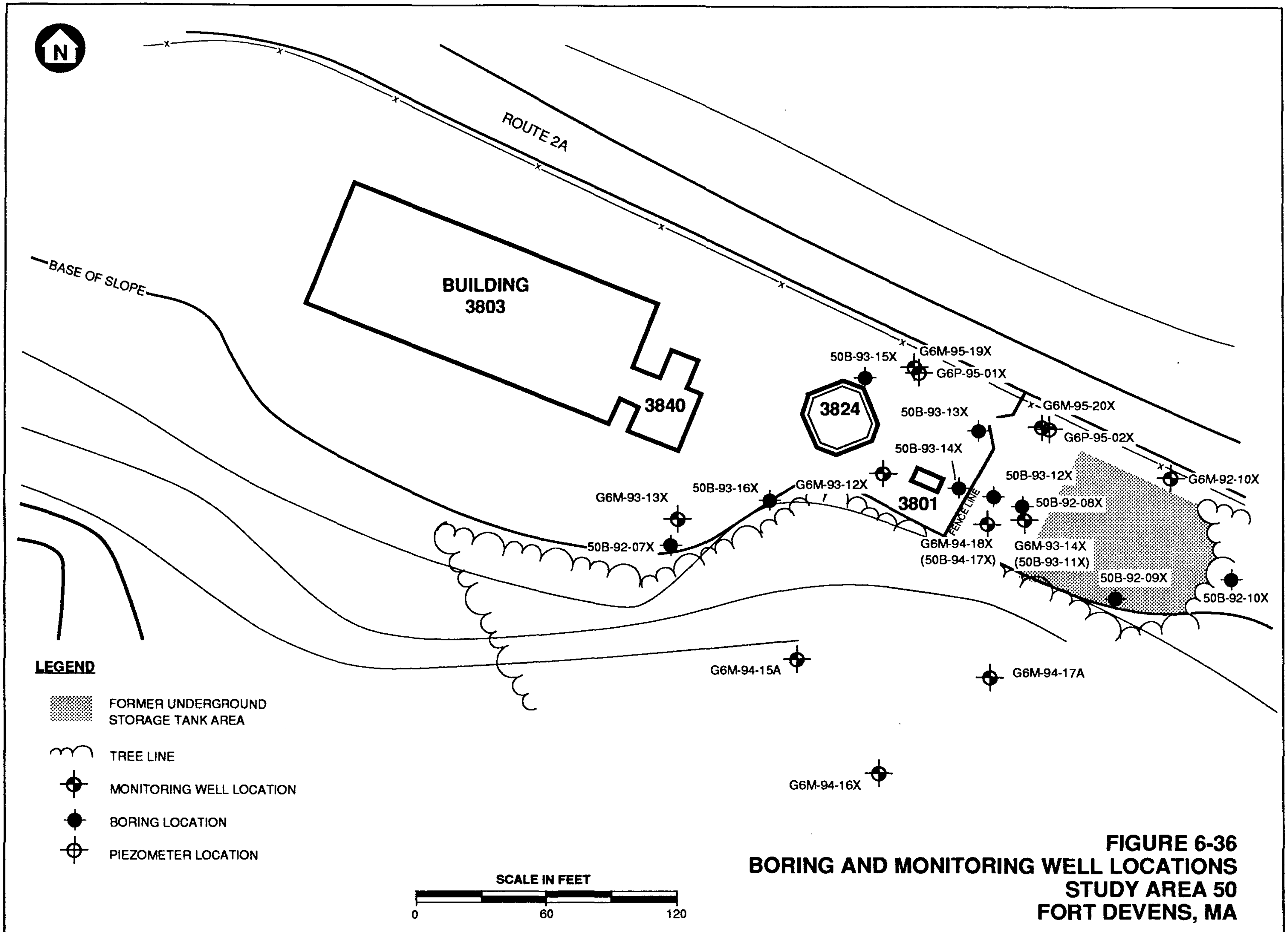


FIGURE 6-36
BORING AND MONITORING WELL LOCATIONS
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-13A 123 6 9

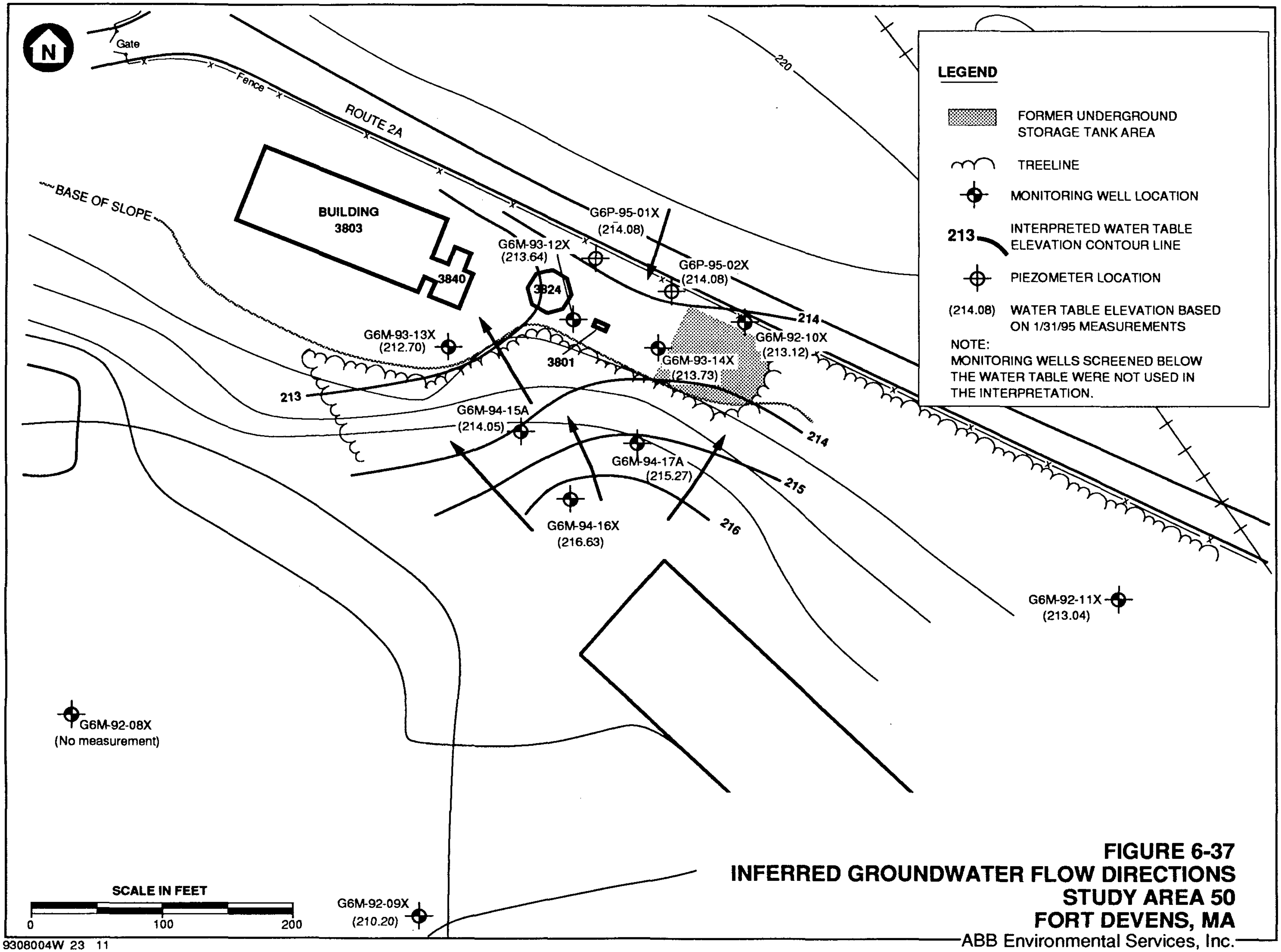


FIGURE 6-37
INFERRED GROUNDWATER FLOW DIRECTIONS
STUDY AREA 50
FORT DEVENS, MA
ABB Environmental Services, Inc.

9308004W 23 11

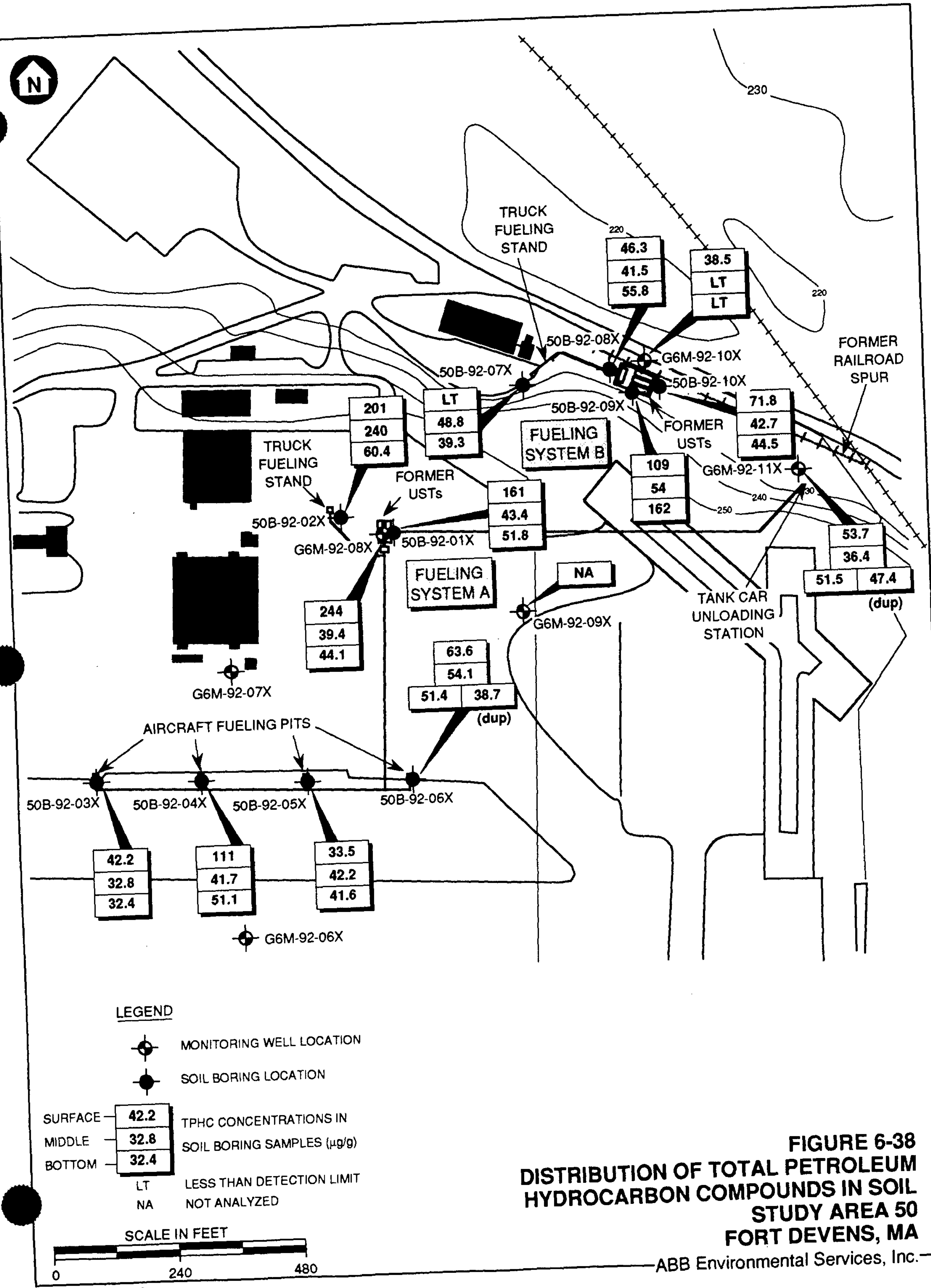


FIGURE 6-38
DISTRIBUTION OF TOTAL PETROLEUM HYDROCARBON COMPOUNDS IN SOIL
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(b) 234 6

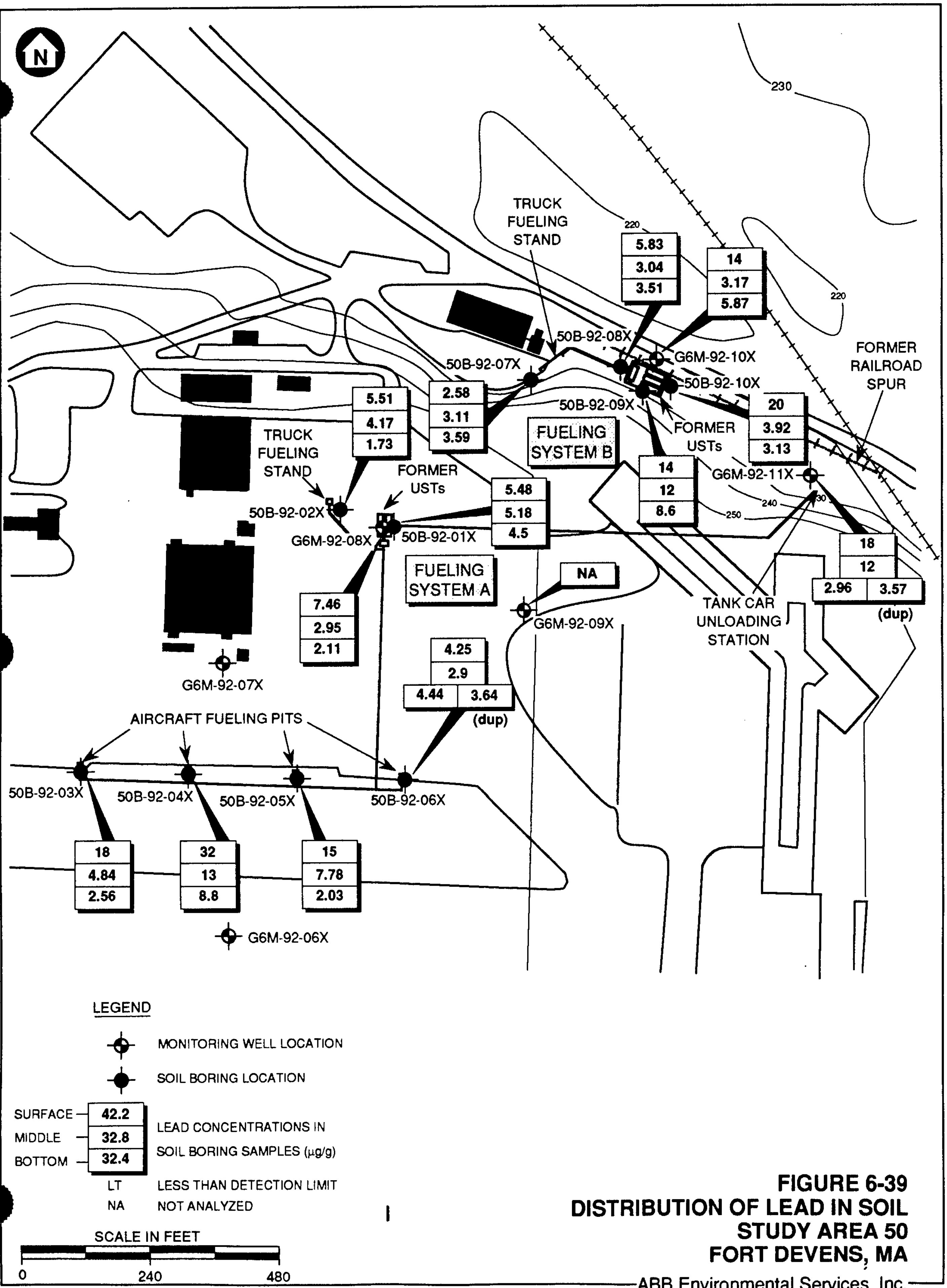


FIGURE 6-39
DISTRIBUTION OF LEAD IN SOIL
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

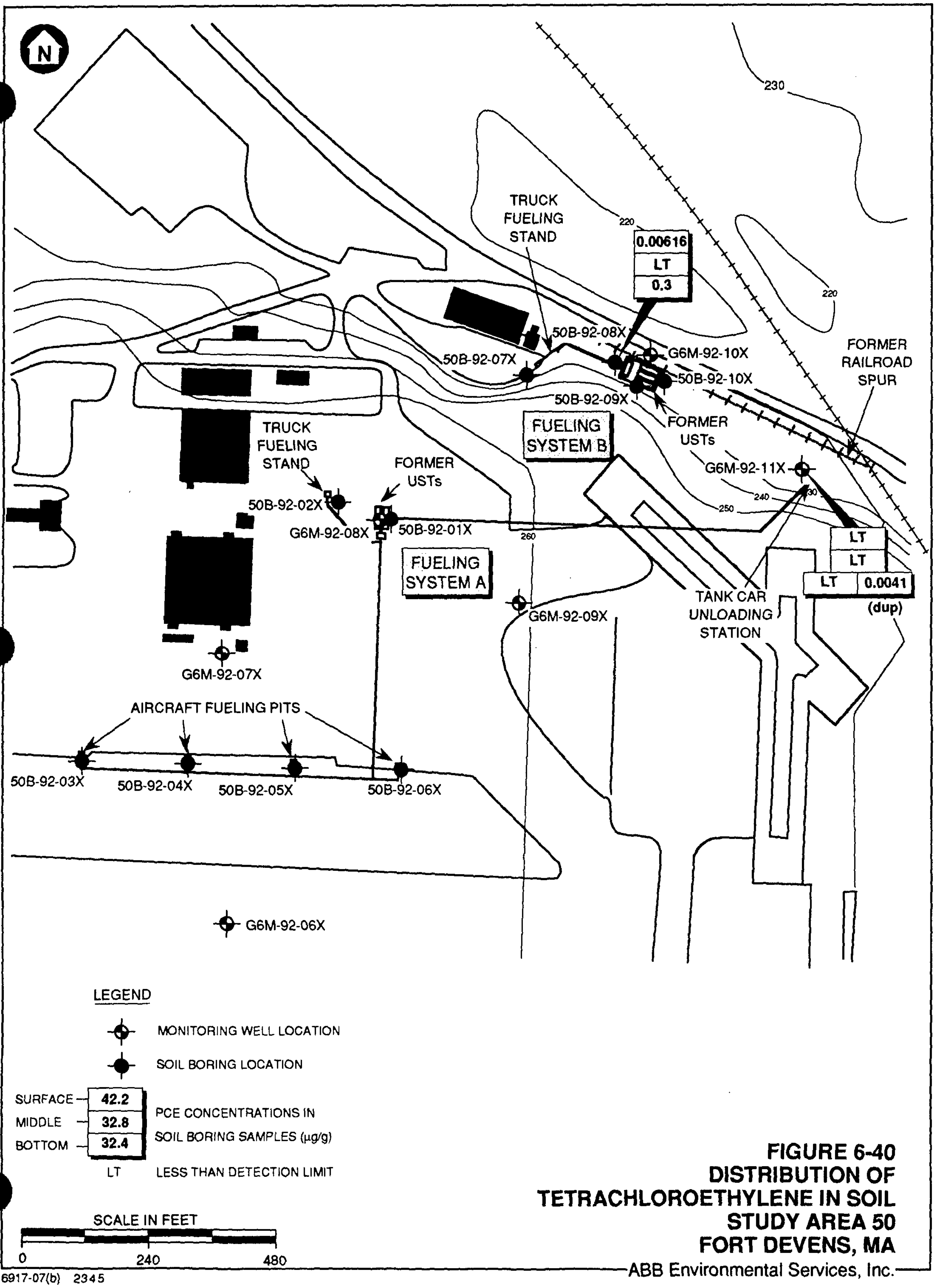


FIGURE 6-40
DISTRIBUTION OF TETRACHLOROETHYLENE IN SOIL
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

6917-07(b) 2345

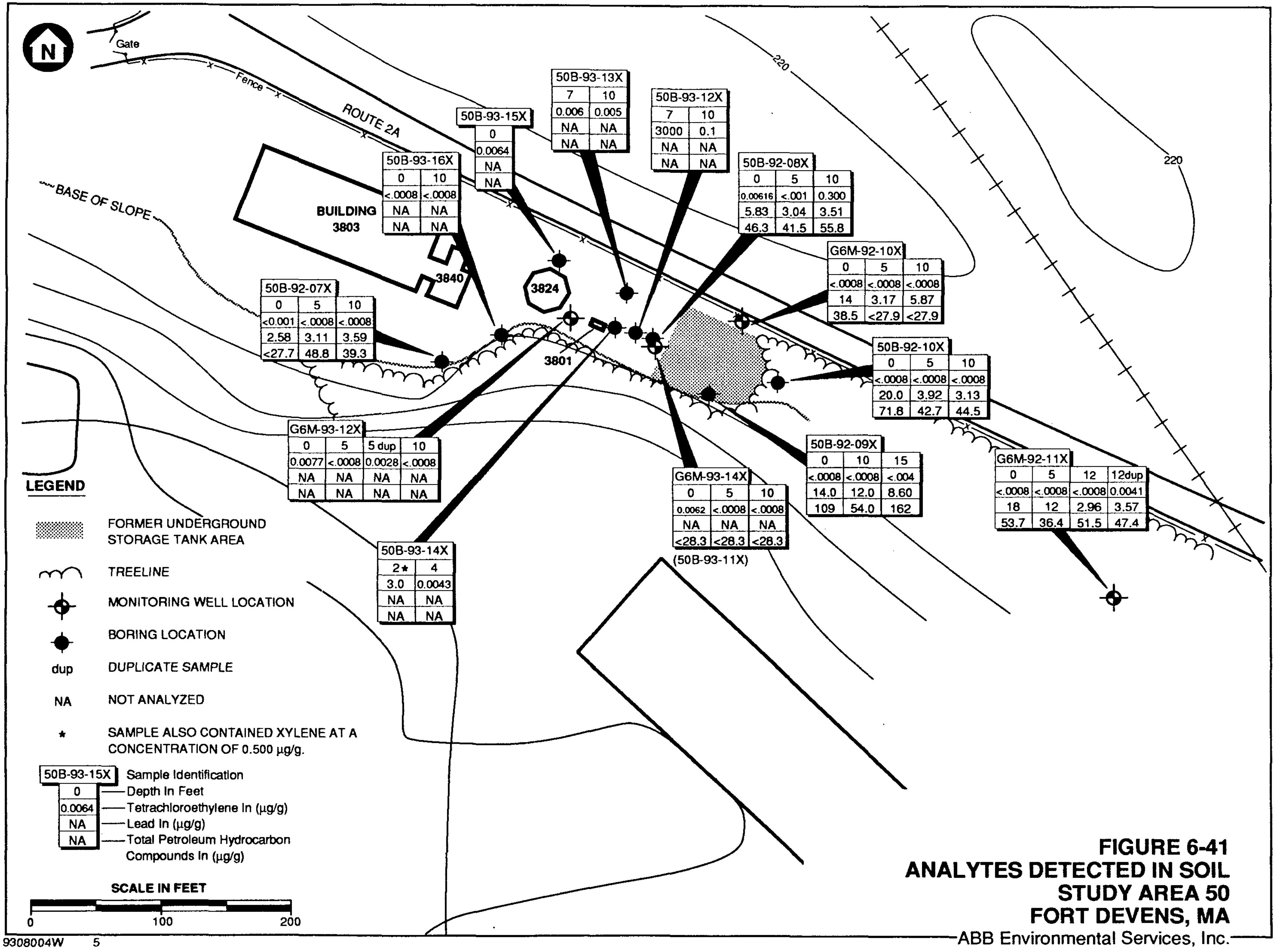
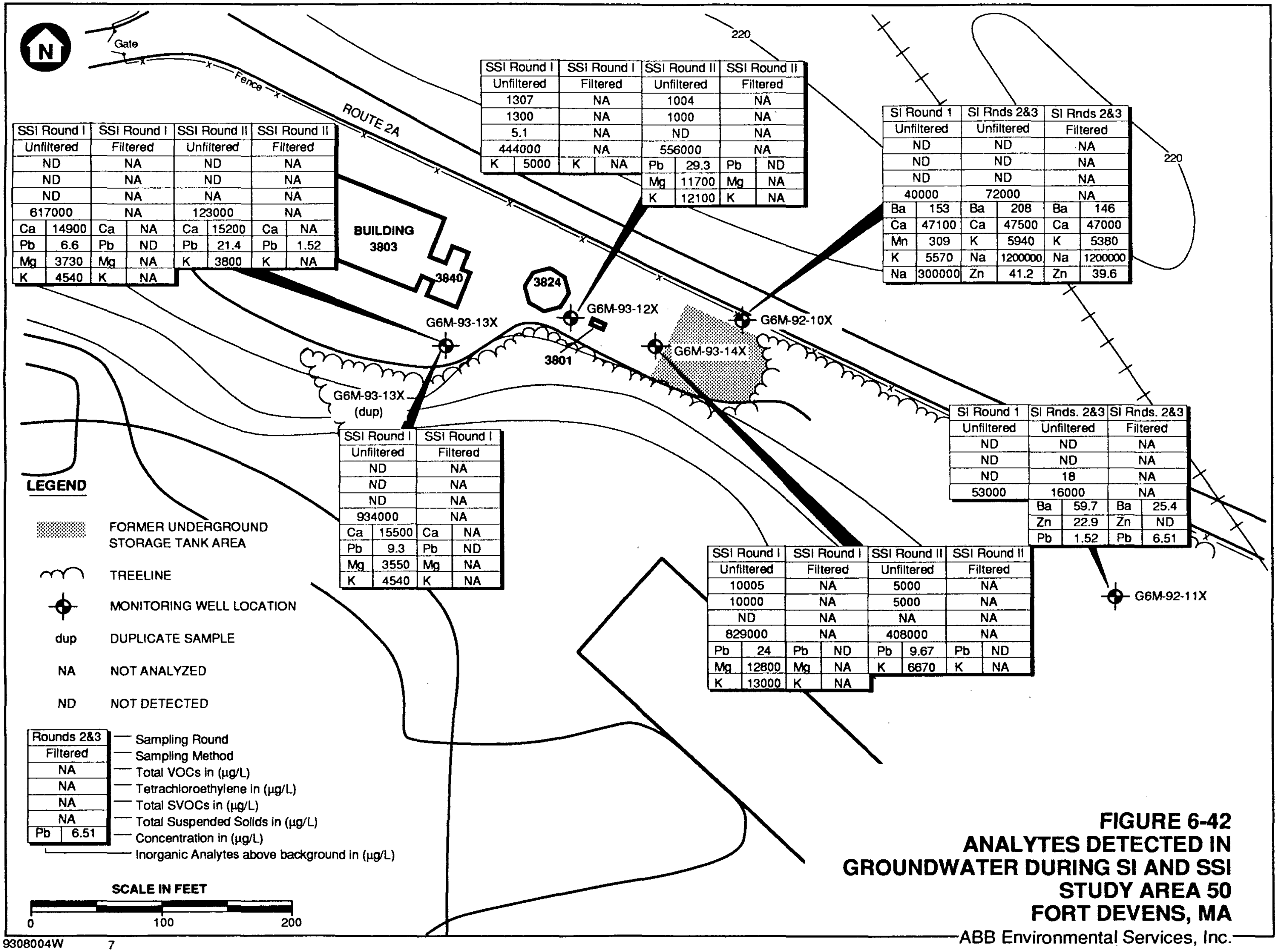


FIGURE 6-41
ANALYTES DETECTED IN SOIL
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

9308004W 5



SSI Round I	SSI Round I	SSI Round II	SSI Round II
Unfiltered	Filtered	Unfiltered	Filtered
ND	NA	ND	NA
ND	NA	ND	NA
ND	NA	NA	NA
617000	NA	123000	NA
Ca 14900	Ca NA	Ca 15200	Ca NA
Pb 6.6	Pb ND	Pb 21.4	Pb 1.52
Mg 3730	Mg NA	K 3800	K NA
K 4540	K NA		

SSI Round I	SSI Round I	SSI Round II	SSI Round II
Unfiltered	Filtered	Unfiltered	Filtered
1307	NA	1004	NA
1300	NA	1000	NA
5.1	NA	ND	NA
444000	NA	556000	NA
K 5000	K NA	Pb 29.3	Pb ND
		Mg 11700	Mg NA
		K 12100	K NA

SI Round 1	SI Rnds 2&3	SI Rnds 2&3
Unfiltered	Unfiltered	Filtered
ND	ND	NA
ND	ND	NA
ND	ND	NA
40000	72000	NA
Ba 153	Ba 208	Ba 146
Ca 47100	Ca 47500	Ca 47000
Mn 309	K 5940	K 5380
K 5570	Na 1200000	Na 1200000
Na 300000	Zn 41.2	Zn 39.6

SSI Round I	SSI Round I
Unfiltered	Filtered
ND	NA
ND	NA
ND	NA
934000	NA
Ca 15500	Ca NA
Pb 9.3	Pb ND
Mg 3550	Mg NA
K 4540	K NA

SI Round 1	SI Rnds. 2&3	SI Rnds. 2&3
Unfiltered	Unfiltered	Filtered
ND	ND	NA
ND	ND	NA
ND	18	NA
53000	16000	NA
	Ba 59.7	Ba 25.4
	Zn 22.9	Zn ND
	Pb 1.52	Pb 6.51

SSI Round I	SSI Round I	SSI Round II	SSI Round II
Unfiltered	Filtered	Unfiltered	Filtered
10005	NA	5000	NA
10000	NA	5000	NA
ND	NA	NA	NA
829000	NA	408000	NA
Pb 24	Pb ND	Pb 9.67	Pb ND
Mg 12800	Mg NA	K 6670	K NA
K 13000	K NA		

LEGEND

▨	FORMER UNDERGROUND STORAGE TANK AREA
⌒⌒	TREELINE
⊕	MONITORING WELL LOCATION
dup	DUPLICATE SAMPLE
NA	NOT ANALYZED
ND	NOT DETECTED

Rounds 2&3	Sampling Round
Filtered	Sampling Method
NA	Total VOCs in (µg/L)
NA	Tetrachloroethylene in (µg/L)
NA	Total SVOCs in (µg/L)
NA	Total Suspended Solids in (µg/L)
Pb 6.51	Concentration in (µg/L)
	Inorganic Analytes above background in (µg/L)

FIGURE 6-42
ANALYTES DETECTED IN
GROUNDWATER DURING SI AND SSI
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

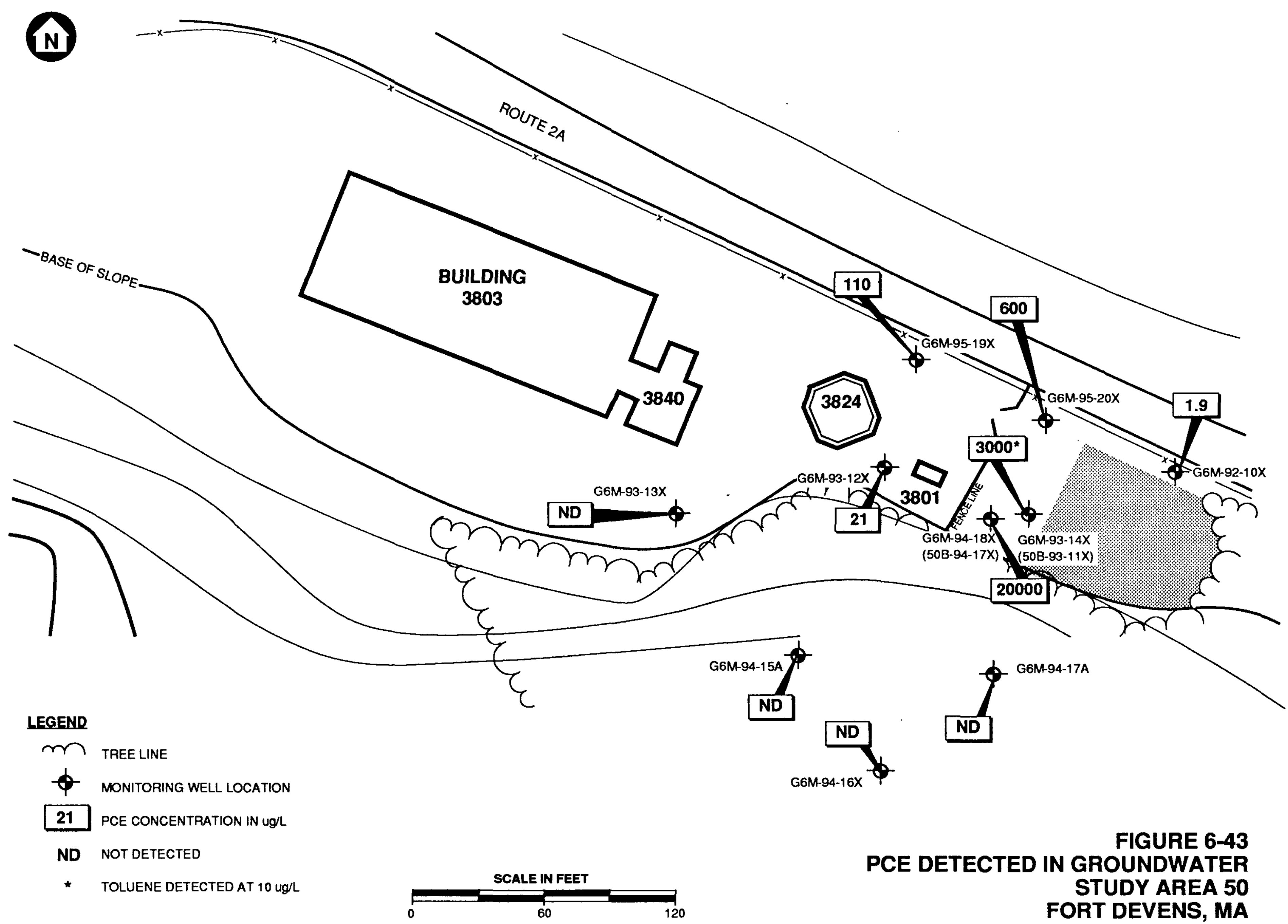


FIGURE 6-43
PCE DETECTED IN GROUNDWATER
STUDY AREA 50
FORT DEVENS, MA

ABB Environmental Services, Inc.

TABLE 6-1
SOIL CLASSIFICATION OF SEDIMENT SAMPLES
GROUP 6 STUDY AREAS

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

SITE ID	SAMPLE ID	USCS SYMBOL	PERCENT SOLIDS	GRAVEL (1) DRY WT %	FINES (1) DRY WT %	COMMENTS
G6D-92-01X	DXG600100	ML	34.28	0.0	71.3	High organic content
G6D-92-02X	DXG600200	SM	48.74	0.0	32.2	Little organics
G6D-92-03X	DXG600300	SM	62.70	7.2	29.5	Some organics
G6D-92-04X	DXG600400	SM	61.77	5.3	19.5	Trace organics

NOTE (1) WT % OF SOIL FRACTION = 100 x DRY WEIGHT OF SOIL FRACTION / TOTAL DRY WEIGHT OF SOIL

TABLE 6-2
ORGANIC COMPOUNDS IN SOIL
SA 30 - MOORE ARMY AIRFIELD DRUM STORAGE AREA
SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BORING	30B-92-01X				30B-92-02X			30B-92-03X			30B-92-04X			30B-92-05X			30B-92-06X		
	DEPTH	0	4	8	8D	0	4	8	0	4	8	0	4	8	0	6	8	0	2	8
VOLATILES (ug/g)																				
TOLUENE		<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	0.0016	0.00084	0.0012	0.0018	0.0014	0.0013	<0.00078	0.0017	<0.00078
XYLENES		<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	0.0015	<0.00150	0.0035	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150
SEMIVOLATILES (ug/g)																				
2-METHYLNAPHTHALENE		< 0.049	0.100	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049
ACENAPHTHENE		< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036	0.061	< 0.036	< 0.036
ACENAPHTHYLENE		< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	0.150	< 0.033	< 0.033
ANTHRACENE		< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	0.280	< 0.033	< 0.033
BIS(2-EH)PHTHALATE		< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620
BENZO[A]ANTHRACENE		< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170	0.910	< 0.170	< 0.170
BENZO[A]PYRENE		< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	1.20	< 0.250	< 0.250
BENZO[B]FLUORANTHENE		< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	1.50	< 0.210	< 0.210
BENZO[G,H,I]PERYLENE		< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250	0.710	< 0.250	< 0.250
BENZO[K]FLUORANTHENE		< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066	1.00	< 0.066	< 0.066
CARBAZOLE		ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033	0.170	ND 0.033	ND 0.033
CHRYSENE		< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120	1.30	<0.120	<0.120
DIBENZO[A,H]ANTHRACENE		< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210	0.260	< 0.210	< 0.210
DIBENZOFURAN		< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035	0.083	< 0.035	< 0.035
FLUORANTHENE		< 0.068	0.250	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068	2.40	< 0.068	< 0.068
FLUORENE		< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	0.150	< 0.033	< 0.033
INDENO[1,2,3-C,D]PYRENE		<0.290	<0.290	<0.290	<0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290	0.750	< 0.290	< 0.290
NAPHTHALENE		< 0.037	0.049	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037	0.074	< 0.037	< 0.037
PHENANTHRENE		< 0.033	0.430	< 0.033	0.099	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	1.10	< 0.033	< 0.033
PYRENE		< 0.033	0.520	< 0.033	0.080	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033	2.10	< 0.033	< 0.033
OTHER (ug/g)																				
TOTAL ORGANIC CARBON		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPHC		< 28.3	34.2	< 28.5	40.5	< 28.5	< 28.5	< 28.5	30.0	< 28.3	< 28.3	< 28.7	< 28.5	< 28.3	< 28.5	< 28.7	< 28.3	71.3	38.9	< 28.7

NOTES:

TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

O30BORE.WK1
06/21/95

TABLE 6-2 (continued)
ORGANIC COMPOUNDS IN SOIL
SA 30 - MOORE ARMY AIRFIELD DRUM STORAGE AREA
SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BORING	30B-92-07X			30B-92-08X			G6M-92-02X					G6M-92-03X					
	DEPTH	0	6	8	0	4	8	0	10	25	40	65	0	12	25	40	40D	55
VOLATILES (ug/g)																		
TOLUENE		<0.00078	0.0014	0.0010	0.0024	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	0.0032	0.0015	0.0010	0.0017	<0.00078	<0.00078
XYLENES		<0.00150	<0.00150	<0.00150	<0.00150	0.0057	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	0.0042	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150	<0.00150
SEMIVOLATILES (ug/g)																		
2-METHYLNAPHTHALENE		< 1.00	< 0.200	< 0.049	< 1.00	< 0.049	< 0.049	< 0.049	< 0.200	< 0.200	< 0.049	< 0.049	< 1.00	< 0.049	< 0.049	< 0.049	< 0.049	< 0.049
ACENAPHTHENE		< 0.700	< 0.200	< 0.036	< 0.700	< 0.036	< 0.036	< 0.036	< 0.200	< 0.200	< 0.036	< 0.036	< 0.700	< 0.036	< 0.036	< 0.036	< 0.036	< 0.036
ACENAPHTHYLENE		1.00	< 0.200	< 0.033	1.00	< 0.033	< 0.033	< 0.033	< 0.200	< 0.200	< 0.033	< 0.033	< 0.700	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
ANTHRACENE		2.00	< 0.200	< 0.033	2.00	< 0.033	< 0.033	< 0.033	< 0.200	< 0.200	< 0.033	< 0.033	1.00	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
BIS(2-EH)PHTHALATE		< 10.0	4.00	< 0.620	< 10.0	< 0.620	< 0.620	< 0.620	< 3.00	< 3.00	< 0.620	< 0.620	< 10.0	< 0.620	< 0.620	< 0.620	< 0.620	< 0.620
BENZO[A]ANTHRACENE		8.00	< 0.800	< 0.170	10.0	< 0.170	< 0.170	< 0.170	< 0.800	< 0.800	< 0.170	< 0.170	4.00	< 0.170	< 0.170	< 0.170	< 0.170	< 0.170
BENZO[A]PYRENE		10.0	< 1.00	< 0.250	20.0	< 0.250	< 0.250	< 0.250	< 1.00	< 1.00	< 0.250	< 0.250	< 5.00	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250
BENZO[B]FLUORANTHENE		10.0	< 1.00	< 0.210	10.0	< 0.210	< 0.210	< 0.210	< 1.00	< 1.00	< 0.210	< 0.210	6.00	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210
BENZO[G,H,I]PERYLENE		< 5.00	< 1.00	< 0.250	8.00	< 0.250	< 0.250	< 0.250	< 1.00	< 1.00	< 0.250	< 0.250	< 5.00	< 0.250	< 0.250	< 0.250	< 0.250	< 0.250
BENZO[K]FLUORANTHENE		9.00	< 0.300	< 0.066	10.0	< 0.066	< 0.066	< 0.066	< 0.300	< 0.300	< 0.066	< 0.066	7.00	< 0.066	< 0.066	< 0.066	< 0.066	< 0.066
CARBAZOLE		0.90	ND 0.200	ND 0.033	ND 0.700	ND 0.033	ND 0.033	ND 0.033	ND 0.200	ND 0.200	ND 0.033	ND 0.033	ND 0.700	ND 0.033	ND 0.033	ND 0.033	ND 0.033	ND 0.033
CHRYSENE		10.0	< 0.600	< 0.120	20.0	< 0.120	< 0.120	< 0.120	< 0.600	< 0.600	< 0.120	< 0.120	8.00	< 0.120	< 0.120	< 0.120	< 0.120	< 0.120
DIBENZO[A,H]ANTHRACENE		< 4.00	< 1.00	< 0.210	< 4.00	< 0.210	< 0.210	< 0.210	< 1.00	< 1.00	< 0.210	< 0.210	< 4.00	< 0.210	< 0.210	< 0.210	< 0.210	< 0.210
DIBENZOFURAN		< 0.700	< 0.200	< 0.035	< 0.700	< 0.035	< 0.035	< 0.035	< 0.200	< 0.200	< 0.035	< 0.035	< 0.700	< 0.035	< 0.035	< 0.035	< 0.035	< 0.035
FLUORANTHENE		20.0	< 0.300	< 0.068	20.0	0.086	< 0.068	< 0.068	< 0.300	< 0.300	<0.068	<0.068	20.0	< 0.068	< 0.068	< 0.068	< 0.068	< 0.068
FLUORENE		< 0.700	< 0.200	< 0.033	< 0.700	< 0.033	< 0.033	< 0.033	< 0.200	< 0.200	< 0.033	< 0.033	< 0.700	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
INDENO[1,2,3-C,D]PYRENE		< 6.00	< 1.00	< 0.290	7.00	<0.290	<0.290	<0.290	< 1.00	< 1.00	< 0.290	< 0.290	< 6.00	< 0.290	< 0.290	< 0.290	< 0.290	< 0.290
NAPHTHALENE		< 0.700	< 0.200	< 0.037	< 0.700	< 0.037	< 0.037	< 0.037	< 0.200	< 0.200	< 0.037	< 0.037	< 0.700	< 0.037	< 0.037	< 0.037	< 0.037	< 0.037
PHENANTHRENE		9.00	< 0.200	< 0.033	7.00	< 0.033	< 0.033	< 0.033	< 0.200	< 0.200	< 0.033	< 0.033	4.00	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
PYRENE		20.0	< 0.200	< 0.033	30.0	0.087	< 0.033	< 0.033	< 0.200	< 0.200	< 0.033	< 0.033	10.0	< 0.033	< 0.033	< 0.033	< 0.033	< 0.033
OTHER (ug/g)																		
TOTAL ORGANIC CARBON		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	717	NA	NA	NA	NA	NA	580
TPHC		112	< 28.3	44.3	65.3	< 28.5	< 28.3	< 28.5	< 28.3	< 28.5	< 28.7	< 28.7	171	< 28.7	< 28.5	< 28.7	44.7	< 28.3

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED
NA = NOT ANALYZED

TABLE 6-3
INORGANIC ANALYTES IN SOIL
SA 30 – MOORE ARMY AIRFIELD DRUM STORAGE AREA
SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	BORING	30B-92-01X				30B-92-02X			30B-92-03X			30B-92-04X			30B-92-05X			30B-92-06X		
		DEPTH	0	4	8	8D	0	4	8	0	4	8	0	4	8	0	6	8	0	2	8
ALUMINUM	15000		3370	3710	2600	2090	3120	3640	2510	3990	2910	2230	4260	3480	2870	4500	3340	2910	6330	5850	2350
ARSENIC	21		9.73	10.6	5.14	8.07	10.7	8.88	5.13	10.0	7.03	7.12	8.52	9.06	7.12	7.11	16.0	10.6	9.59	6.78	6.36
BARIUM	42.5		11.2	13.9	14.6	12.2	14.8	20.3	15.5	15.5	13.3	14.2	18.7	14.1	12.1	11.1	18.3	13.7	20.1	12.8	13.0
BERYLLIUM	0.347		0.626	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.552	<0.500	0.600	<0.500	<0.500	0.847	0.567	0.640
CALCIUM	1400		290	984	480	415	1390	1490	572	422	538	295	544	370	354	<0.700	452	376	599	249	559
CHROMIUM	31		4.86	8.21	7.39	5.67	8.01	8.91	5.79	5.65	5.37	5.65	8.11	7.19	5.48	5.83	6.40	5.62	7.22	7.65	<4.05
COBALT	NA		2.11	2.78	2.19	2.50	2.73	2.57	2.25	2.30	2.09	2.27	2.80	2.50	2.30	2.04	2.58	2.48	1.99	2.02	2.10
COPPER	8.39		5.04	6.17	3.69	4.20	5.79	7.01	4.08	5.58	4.27	5.19	6.36	5.56	3.70	3.96	6.36	5.63	7.15	4.50	7.19
IRON	15000		4320	5440	4180	3480	4600	6220	3930	4880	3490	4360	5650	5140	4210	4540	5550	5230	6070	4960	4510
LEAD	34.4		2.87	4.69	3.07	2.91	3.13	3.54	2.07	3.62	2.70	2.58	5.97	4.94	3.76	3.41	3.19	2.93	10.3	3.33	2.15
MAGNESIUM	5600		829	1430	1130	847	1210	1530	1050	1130	863	920	1260	1250	977	990	1180	1130	908	1150	860
MANGANESE	300		51.6	85.8	86.9	87.0	68.6	98.8	104	85.0	58.2	110	100	84.5	84.2	48.8	99.2	108	114	50.9	43.2
MERCURY	0.22		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.069	0.057	<0.050
NICKEL	14.0		4.71	7.38	5.28	5.76	5.73	8.54	6.51	6.45	6.21	5.95	6.45	6.79	5.13	4.55	8.51	7.34	6.98	5.78	4.53
POTASSIUM	1700		467	546	479	385	535	991	480	460	493	524	634	542	514	295	471	428	280	415	480
SODIUM	131		157	164	160	<100	192	184	273	191	<100	205	<100	185	136	146	487	284	196	116	336
VANADIUM	28.7		5.44	6.71	5.52	3.82	6.14	7.50	4.73	5.31	4.45	4.18	6.76	5.37	4.75	5.77	5.06	4.35	6.94	6.91	4.35
ZINC	35.5		11.3	18.7	14.6	11.7	13.8	19.1	12.8	15.5	11.6	13.3	18.2	16.5	14.4	16.3	24.4	15.8	27.8	19.2	15.6

NOTES: TABLE LIST DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYEZED

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TABLE 6−3 (continued)
INORGANIC ANALYTES IN SOIL
SA 30 − MOORE ARMY AIRFIELD DRUM STORAGE AREA
SITE INVESTIGATION REPORT − GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	BORING	30B−92−07X			30B−92−08X			G6M−92−02X					G6M−92−03X					
		DEPTH	0	6	8	0	4	8	0	10	25	40	65	0	12	25	40	40D	55
ALUMINUM	15000		5700	3940	2640	5370	3090	1540	4190	4090	2520	3370	6100	5630	2860	4280	4020	3010	4240
ARSENIC	21		8.55	6.09	6.28	11.9	7.20	5.35	8.10	15.0	6.33	3.99	8.18	9.94	8.86	5.68	7.20	7.72	18.0
BARIUM	42.5		29.8	14.6	10.9	26.1	9.84	9.93	15.9	23.0	13.6	20.8	30.4	21.0	11.9	29.2	20.7	20.7	19.3
BERYLLIUM	0.347		0.661	<0.500	<0.500	<0.500	<0.500	<0.500	0.759	0.631	<0.500	0.580	<0.500	0.571	<0.500	<0.500	<0.500	0.594	<0.50
CALCIUM	1400		583	648	426	660	255	236	963	2200	2630	1050	1060	828	497	1130	1110	830	1020
CHROMIUM	31		10.2	6.70	5.90	12.6	5.43	<4.05	9.24	15.1	5.08	7.11	12.6	10.7	5.30	7.71	7.21	6.13	9.83
COBALT	NA		2.32	1.87	1.89	2.86	<1.42	<1.42	2.93	3.54	2.53	2.52	4.00	3.86	<1.42	2.05	3.58	2.82	5.58
COPPER	8.39		7.88	4.64	4.71	9.02	4.04	3.98	6.51	7.95	3.78	3.93	7.56	11.1	4.42	4.13	4.80	4.14	7.24
IRON	15000		6280	5390	3570	6440	3190	2460	5900	7000	4760	5270	9020	8080	4500	6940	6680	4990	8020
LEAD	34.4		17.0	2.72	2.98	23	2.96	2.35	3.26	3.89	2.75	2.28	3.70	45.0	2.86	2.55	2.93	2.43	4.67
MAGNESIUM	5600		1460	1300	863	1710	786	487	1540	1860	1020	1220	2190	1690	934	1420	1500	989	1770
MANGANESE	300		95.9	77.1	39.4	126	35.5	24.9	85.6	142	120	129	270	144	49.8	78.3	114	118	401
MERCURY	0.22		0.141	<0.050	<0.050	0.068	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
NICKEL	14.0		10.1	5.65	5.60	10.5	4.01	3.62	8.20	9.50	6.98	5.70	9.64	12.5	4.81	4.16	7.56	7.58	14.0
POTASSIUM	1700		448	533	489	578	475	377	614	989	465	1040	1650	469	548	1400	834	697	765
SODIUM	131		318	259	127	144	<100	122	166	208	160	174	171	152	206	178	161	134	138
VANADIUM	28.7		8.06	6.47	3.90	9.18	4.15	<3.39	7.14	8.20	4.67	7.21	12.0	9.04	4.49	9.00	7.50	5.75	7.67
ZINC	35.5		47.5	52.3	21.9	53.0	10.3	10.6	18.9	22.2	13.8	15.8	25.9	32.8	13.0	17.8	19.1	15.5	21.7

NOTES: TABLE LIST DETECTED ANALYTES ONLY − SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZEZED

TABLE 6–4
PAHs IN EAST DRUM STORAGE AREA SURFACE SOIL AND STORM DRAIN OUTFALL SEDIMENTS
SA30 – MOORE ARMY AIRFIELD DRUM STORAGE AREA
SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

	COMPOUND (μg/g)	SA 30 SURFACE SOIL				MAAF STORM DRAIN OUTFALL SEDIMENTS							
		30B–92 –06X	30B–92 –07	30B–92 08X	G6M–92 –03X	SSD–93 –43A	SSD–93 –43C	SSD–93 –46A	SSD–93 –49A	SSD–93 –49A(dup)	SSD–93 –52A	SSD–93 –54A	SSD–93 –54A(dup)
1	NAPHTHALENE	0.061	<0.70	<0.70	<0.70	<0.74	2.8	<0.74	<0.74	<0.74	<0.74	2.0	2.3
2	2–METHYLNAPHTHALENE	<0.049	<0.10	<0.10	<0.10	<0.032	1.1	<0.032	<0.032	<0.032	0.25	0.56	0.62
3	ACENAPHTHYLENE	0.15	1.0	1.0	<0.70	0.15	9.3	0.26	0.34	0.28	3.8	2.3	3.0
4	ACENAPHTHENE	0.28	2.0	0.0	<0.70	<0.041	2.1	<0.041	<0.041	<0.041	0.55	2.0	1.6
5	FLUORENE	0.15	0.0	0.0	20	0.15	<0.065	0.28	0.28	0.39	1.7	4.6	4.5
6	PHENANTHRENE	1.1	9.0	7.0	4.0	2.6	12	3.5	4.5	4.5	20	12	12
7	ANTHRACENE	0.28	2.0	2.0	1.0	<0.71	6.2	<0.71	<0.71	<0.71	4.1	6.2	6.6
8	FLUORANTHENE	2.4	20	20	20	2.1	6.2	2.8	3.6	3.2	6.2	6.2	6.2
9	PYRENE	2.1	20	30	10	2.8	6.2	3.6	3.8	3.5	10	6.2	6.2
10	BENZO(A)ANTHRACENE	0.91	8.0	10	4.0	0.89	12	1.4	1.6	1.6	9.5	17	18
11	CHRYSENE	1.3	10	20	8.0	1.5	12	2.0	2.3	2.1	9.5	22	17
12	BENZO(B)FLUORANTHENE	1.5	10	10	6.0	1.7	12	2.1	2.3	1.6	9.6	22	26
13	BENZO(K)FLUORANTHENE	1.0	9.0	10	7.0	1.6	12	2.1	1.4	1.5	5.3	19	16
14	BENZO(A)PYRENE	1.2	10	20	<5.0	<1.2	6.2	<1.2	<1.2	<1.2	6.5	6.2	6.2
15	INDENO(1,2,3–C,D)PYRENE	0.75	<6.0	7.0	<6.0	<2.4	12	<2.4	<2.4	<2.4	<2.4	8.9	9.1
16	DIBENZO(A,H)ANTHRACENE	0.26	<0.70	<0.70	<0.70	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31
17	BENZO(G,H,I)PERYLENE	0.71	<5.0	8.0	<5.0	<0.18	12	1.1	1.1	<0.18	<0.18	9.3	10

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TABLE 6-5
ANALYTES IN GROUNDWATER – ROUND 1 (July 1992)
GROUP 6 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	G6M-92-01X	G6M-92-02X	G6M-92-03X	G6M-92-04X	G6M-92-05X	G6M-92-06X	G6M-92-07X	G6M-92-08X	G6M-92-09X	G6M-92-10X	G6M-92-11X
ORGANICS (ug/L)												
ACETONE		21.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0
BIS(2-ETHYLHEXYL)PHTHALATE		<4.80	<4.80	<4.80	<4.80	7.60	8.80	<4.80	<4.80	<4.80	<4.80	<4.80
TPHC		1550	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
INORGANICS (ug/L)												
ALUMINUM	6870	1290	<141	150	2590	<141	<141	<141	178	230	850	1920
ARSENIC	10.5	<2.54	<2.54	<2.54	5.44	<2.54	<2.54	<2.54	<2.54	<2.54	<2.54	<2.54
BARIUM	39.6	14.9	<5.00	10.3	14.5	<5.00	<5.00	<5.00	9.18	7.60	153	16.1
CALCIUM	14700	10400	4520	12500	17000	4020	7240	16200	13100	18200	47100	5940
CHROMIUM	14.7	11.8	<6.02	<6.02	6.88	<6.02	<6.02	<6.02	<6.02	<6.02	<6.02	6.36
IRON	9100	1890	96.3	240	3580	102	53.4	132	208	332	816	2390
LEAD	4.25	<1.26	<1.26	<1.26	7.70	<1.26	<1.26	<1.26	<1.26	<1.26	1.52	2.28
MAGNESIUM	3480	1050	<500	1340	1650	512	688	1350	738	1600	2430	855
MANGANESE	291	66.8	18.5	42.5	594	37.4	7.64	9.80	31.9	22.7	309	99.0
POTASSIUM	2370	2340	2260	1820	1930	1040	1210	<375	1280	1990	5570	645
SILVER	4.60	93.6	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60
SODIUM	10800	4020	3120	19300	3310	2540	5860	5590	2180	2000	300000	2420
ZINC	21.1	<21.1	<21.1	<21.1	40.9	<21.1	<21.1	<21.1	<21.1	<21.1	<21.1	<21.1
ANIONS/CATIONS (ug/L)												
BICARBONATE		<5000	12200	14600	34200	9760	24400	23200	51200	127000	8540	28100
CHLORIDE		<2120	<2120	29700	<2121	<2120	<2120	4130	<2120	<2120	200000	3480
SULFATE		<10000	<10000	15400	17900	<10000	12100	14100	<10000	24700	47000	<10000
NITRATE/NITRITE		7400	2000	3800	2000	380	850	5500	550	2400	1400	78.5
ALKALINITY		<5000	10000	12000	28000	8000	20000	19000	42000	104000	7000	23000
OTHER (ug/L)												
TSS		21000	13000	5000	84000	4000	6000	5000	13000	37000	40000	53000

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY

TABLE 6-6
ANALYTES IN GROUNDWATER - ROUNDS 2 & 3 (Oct 1992/Jan 1993)
GROUP 6 GROUNDWATER MONITORING WELLS
SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	G6M-92-01X	G6M-92-02X	G6M-92-03X	G6M-92-04X	G6M-92-04X filt	G6M-92-05X	G6M-92-06X	G6M-92-07X	G6M-92-07X dup	G6M-92-08X	G6M-92-09X	G6M-92-10X	G6M-92-10X filt	G6M-92-11X	G6M-92-11X filt
ORGANICS (ug/L)																
BIS(2-E,H)PHTHALATE		20.0	33.0	17.0	15.0	NA	37.0	< 4.80	< 4.80	20.0	< 4.80	15.0	< 4.8	NA	18.0	NA
TPHC		< 192	< 193	< 182	< 182	NA	1060	218	<188	< 184	< 195	< 188	< 177	NA	< 192	NA
INORGANICS (ug/L)																
ALUMINUM	6870	387	250	1620	2300	< 141	331	1460	248	291	315	1120	2340	264	148	< 141
ARSENIC	10.5	< 2.54	< 2.54	4.05	10.0	< 2.54	< 2.54	8.21	< 2.54	< 2.54	< 2.54	< 2.54	2.98	< 2.54	< 2.54	< 2.54
BARIUM	39.6	6.82	75.7	53.6	38.7	14.7	41.9	31.7	16.2	< 5.00	13.4	37.7	208	146	59.7	25.4
CALCIUM	14700	7910	3380	9550	17100	16500	4460	8990	17000	18800	8110	13400	47500	47000	12600	11400
CHROMIUM	14.7	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	< 6.02	9.88	< 6.02	< 6.02	< 6.02	< 6.02	7.44	< 6.02	< 6.02	< 6.02
COPPER	8.09	< 8.09	< 8.09	< 8.09	8.73	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09	< 8.09
IRON	9100	535	291	2380	3260	< 38.8	1020	2320	393	451	341	1430	2600	< 38.8	205	58.7
LEAD	4.25	< 1.26	3.36	< 1.26	10.1	< 1.26	2.17	4.01	1.63	< 1.26	1.41	4.56	2.06	< 1.26	1.52	6.51
MAGNESIUM	3480	825	500	1300	1530	1090	626	1030	1410	1550	766	1420	2820	2350	766	671
MANGANESE	291	22.5	22.7	75.9	592	20.2	25.0	102	15.6	16.7	29.6	37.4	263	216	99.6	97.1
POTASSIUM	2370	2290	2690	2510	2020	1520	1510	1920	1420	1510	1930	2410	5940	5380	1710	1360
SODIUM	10800	3230	2750	21800	3000	1360	3100	5000	4410	5140	1930	2140	1200000	1200000	5560	4380
ZINC	21.1	59.3	50.1	36.5	47.8	< 21.1	32.6	30.1	29.5	33.8	23.6	42.9	41.2	39.6	22.9	< 21.1
ANIONS/CATIONS (ug/L)																
BICRABONATE		6000	6000	13000	34000	NA	12000	22000	24000	23000	26000	24000	9000	NA	12000	NA
CHLORIDE		< 2120	< 2120	31200	< 2120	NA	< 2120	< 2120	< 2120	< 2120	< 2120	< 2120	2100000	NA	15800	NA
SULFATE		< 10000	< 10000	13300	16700	NA	< 10000	11700	13500	13300	< 10000	16600	50300	NA	< 10000	NA
NITRATE/NITRITE		4400	1800	3300	2400	NA	730	990	8000	7000	620	1800	1400	NA	97.7	NA
ALKALINITY		5000	5000	11000	28000	NA	10000	18000	20000	19000	21000	20000	7000	NA	10000	NA
OTHER (ug/L)																
TSS		245000	34000	47000	170000	NA	17000	21000	15000	48000	23000	111000	72000	NA	16000	NA

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

G6WELLS2.WK1
06/21/95

TABLE 6-7
ANALYTES IN GROUP 6 SURFACE WATER
NASHUA RIVER

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	G6D-92-01X	G6D-92-02X	G6D-92-03X	G6D-92-04X
INORGANICS (ug/L)				
ARSENIC	<2.54	<2.54	3.09	3.41
BARIUM	19.4	17.5	18.7	19.4
CALCIUM	13700	14200	14100	13700
IRON	787	659	720	783
LEAD	4.99	2.17	4.88	5.53
MAGNESIUM	1790	1920	1950	1940
MANGANESE	104	130	154	155
POTASSIUM	2640	2460	2520	2690
SODIUM	32200	26200	26700	25400
ANIONS/CATIONS (ug/L)				
CHLORIDE	60000	46000	47000	46000
SULFATE	14100	11600	14100	14000
NITRATE/NITRITE	1000	1000	980	1000
KJELDAHL NITROGEN	952	657	810	819
TOTAL PHOSPHOROUS	139	119	148	139
ALKALINITY	37000	23000	35000	31000
OTHER (ug/L)				
HARDNESS	46600	41000	45600	45800
TSS	7000	<4000	6000	6000
TOTAL COLIFORM (org/100ml)	4050	1150	450	350
FECAL COLIFORM (org/100ml)	118	70	3	4

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY

G6SURF.WK1
06/21/95

TABLE 6-8
ANALYTES IN GROUP 6 SEDIMENTS
NASHUA RIVER

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	G6D-92-01X	G6D-92-02X	G6D-92-03X	G6D-92-04X
INORGANICS (ug/g)				
ALUMINUM	12200	7820	7290	6800
ANTIMONY	11.4	4.38	3.64	13.5
ARSENIC	13.8	12.3	8.86	4.27
BARIUM	160	67.9	52.4	74.2
BERYLLIUM	2.16	1.05	1.20	<0.500
CADMIUM	17.7	7.26	4.84	18.2
CALCIUM	1880	1880	1040	1050
CHROMIUM	117	86.0	35.9	121
COBALT	6.79	6.45	4.08	2.79
COPPER	128	74.7	43.7	100
IRON	17500	13100	10500	6600
LEAD	210	100	68.0	160
MAGNESIUM	3010	2140	2050	1710
MANGANESE	364	855	160	73.1
MERCURY	0.668	<0.050	0.905	0.895
NICKEL	22.3	13.8	15.5	12.5
POTASSIUM	1240	857	519	604
SELENIUM	1.22	<0.250	<0.250	0.787
SILVER	6.56	4.26	1.86	3.51
SODIUM	550	340	276	<100
VANADIUM	26.0	15.7	11.8	13.6
ZINC	284	115	106	121
ORGANICS (ug/g)				
ACETONE	<0.0170	<0.0170	0.0658	<0.0170
TOLUENE	0.0516	<0.00078	0.00353	0.0177
BIS(2-ETHYLHEXYL)PHTHALATE	<3.10	<3.10	<3.10	6.74
FLOURANTHENE	3.21	0.770	<0.340	0.856
PHENATHRENE	1.43	0.587	<0.165	0.508
PYRENE	3.28	1.12	0.400	0.874
OTHER (ug/g)				
TOTAL PETROLEUM HYDROCARBONS	765	541	260	345
TOTAL ORGANIC CARBON	31600	14300	9460	9880

NOTES: TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY

Table 6–9
Human Health PRE Evaluation of Surface Soil
Study Area 30 – Moore Army Airfield Drum Storage Area

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency Of Detection	Maximum Exceeds Backgrouound?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15000	4,755	6,330	11/11	NO	230,000	NO
arsenic	21	9.2	12	11/11	NO	0.97	YES
barium	42.5	18	30	11/11	NO	5,500	NO
beryllium	0.347	0.66	0.85	7/11	YES	0.4	YES
chromium	31	8.2	13	11/11	NO	390	NO
cobalt	NA	2.5	3.9	11/11	NA	NA	NA
copper	8.39	6.6	11	11/11	YES	2,900	NO
lead	48.4	11	45	11/11	NO	500	NO
manganese	300	88	144	11/11	NO	7,800	NO
mercury	0.22	0.084	0.14	4/11	NO	23	NO
nickel	14.0	7.5	13	11/11	NO	1,600	NO
vanadium	28.7	7.0	9.2	11/11	NO	550	NO
zinc	35.5	25	53	11/11	YES	23,000	NO
Organics (ug/g)							
toluene		0.0021	0.0032	5/11	NA	16,000	NO
xylenes		0.0035	0.0035	1/11	NA	160,000	NO
acenaphthene		0.061	0.061	1/11	NA	4,700	NO
acenapthylene		0.72	1	3/11	NA	NA	NA
anthracene		1.3	2	4/11	NA	23,000	NO
benzo(a)anthracene		5.7	10	4/11	NA	1.6	YES
benzo(a)pyrene		10	20	3/11	NA	0.23	YES
benzo(b)fluoranthene		6.9	10	4/11	NA	1.9	YES
benzo(g,h,i)perylene		4.4	8	2/11	NA	11	NO
benzo(k)fluoranthene		6.8	10	4/11	NA	4.4	YES
carbazole		0.54	0.9	2/11	NA	85	NO
chrysene		9.8	20	4/11	NA	NA	NA
dibenzo(a,h)anthracene		0.26	0.26	1/11	NA	0.21	YES
dibenzofuran		0.083	0.083	1/11	NA	NA	NA
fluoranthene		16	20	4/11	NA	3,100	NO
fluorene		0.15	0.15	1/11	NA	3,100	NO
indeno(1,2,3–c,d)pyrene		3.9	7	2/11	NA	0.84	YES
naphthalene		0.074	0.074	1/11	NA	3,100	NO
phenanthrene		5.3	9	4/11	NA	2,300	NO
pyrene		16	30	4/11	NA	2,300	NO

Notes:
[a] Base–wide background soil inorganics database.
[b] Surface soil samples from sampling stations 30B–92–01X to 30B–92–08X, G6M–92–02X, and G6M–92–03X.
NA = not available.

30DATA

Table 6–10
Human Health PRE Evaluation of Subsurface Soil
Study Area 30 – Moore Army Airfield Drum Storage Area

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection (Out of 18)	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	2,828	3,940	18	NO	3,000,000	NO
arsenic	21	8.3	16	18	NO	1.6	YES
barium	42.5	14	23	18	NO	72,000	NO
beryllium	0.347	0.61	0.64	3	YES	0.67	NO
chromium	31	6.9	15	16	NO	5,100	NO
cobalt	NA	2.4	3.5	15	NA	NA	NA
copper	8.39	5.2	8.0	18	NO	38,000	NO
lead	48.4	3.1	4.9	18	NO	500	NO
manganese	300	72	110	18	NO	100,000	NO
nickel	14.0	6.2	9.5	18	NO	20,000	NO
vanadium	28.7	5.2	8.2	17	NO	7,200	NO
zinc	35.5	18	52	18	YES	310,000	NO
Organics (ug/g)							
toluene		0.0012	0.0015	7	NA	200,000	NO
xylenes		0.0036	0.0057	2	NA	2,000,000	NO
2–methylnaphthalene		0.1	0.1	1	NA	NA	NA
bis(2–ethylhexyl)phthalate		4	4	1	NA	200	NO
fluoranthene		0.17	0.25	2	NA	41,000	NO
naphthalene		0.049	0.049	1	NA	41,000	NO
phenanthrene		0.26	0.43	2	NA	30,000	NO
pyrene		0.23	0.52	3	NA	31,000	NO
TPHC		40	44	3	NA	NA	NA

Notes:

[a] Base–wide background soil inorganics database.

[b] Subsurface soil samples from sampling locations 30B–92–01X to 30B–92–08X, G6M–92–02X and G6M–92–03X.

NA = not available.

Table 6-11
Human Health PRE Evaluation of Groundwater
SA 30 - Moore Army Airfield/Drum Storage Area Monitoring Wells

Site Investigation Report - Groups 3, 5, and 6
Fort Devens

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
bis(2-ethylhexyl)phthalate		33.0		6.1	YES
Inorganics (ug/l)					
aluminum	6,870	1,620	NO	50-200	YES
arsenic	10.5	4.05	NO	50	NO
barium	39.6	75.7	YES	2,000	NO
calcium	14,700	12,500	NO	NA	NA
iron	9,100	2,380	NO	300	YES
lead	4.25	3.36	NO	15	NO
magnesium	3,480	1,340	NO	NA	NA
manganese	291	75.9	NO	50	YES
potassium	2,370	2,690	YES	NA	NA
sodium	10,800	21,800	YES	28,400	NO
zinc	21.1	50.1	YES	5,000	NO
Anions/Cations (ug/l)					
nitrate/nitrite		3,800		10,000	NO

NOTES:

[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.

[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.

[c] SA 30 is represented by monitoring wells G6M-92-02X and G6M-92-03X.

ND Not detected

NA Not available

Table 6–12
Ecological PRE for Surface Soil
Study Area 30 – Moore Army Airfield Drum Storage Area

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency Of Detection	Maximum Exceeds Backgrouond?	Ecological Benchmark (ug/g)	Maximum Exceeds Benchmark?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15000	4,755	6,330	11/11	NO	14,964	NO
arsenic	21	9.2	12	11/11	NO	33	NO
barium	42.5	18	30	11/11	NO	42.6	NO
beryllium	0.347	0.66	0.85	7/11	YES	0.88	NO
chromium	31	8.2	13	11/11	NO	830	NO
cobalt	NA	2.5	3.9	11/11	NA	50	NO
copper	8.39	6.6	11	11/11	YES	34	NO
lead	34.4	11	45	11/11	YES	34.4	YES
manganese	300	88	144	11/11	NO	1,500	NO
mercury	0.22	0.084	0.14	4/11	NO	3.6	NO
nickel	14.0	7.5	13	11/11	NO	100	NO
vanadium	28.7	7.0	9.2	11/11	NO	28.7	NO
zinc	35.5	25	53	11/11	YES	640	NO
Organics (ug/g)							
toluene		0.0021	0.0032	5/11	NA	1,800	NO
xylenes		0.0035	0.0035	1/11	NA	2,100	NO
acenaphthene		0.061	0.061	1/11	NA	5,000	NO
acenapthylene		0.72	1	3/11	NA	2,600	NO
anthracene		1.3	2	4/11	NA	14,000	NO
benzo(a)anthracene		5.7	10	4/11	NA	8.9	YES
benzo(a)pyrene		10	20	3/11	NA	5.5	YES
benzo(b)fluoranthene		6.9	10	4/11	NA	180	NO
benzo(g,h,i)perylene		4.4	8	2/11	NA	440	NO
benzo(k)fluoranthene		6.8	10	4/11	NA	320	NO
carbazole		0.54	0.9	2/11	NA	43	NO
chrysene		9.8	20	4/11	NA	440	NO
dibenzo(a,h)anthracene		0.26	0.26	1/11	NA	5.5	NO
dibenzofuran		0.083	0.083	1/11	NA	10	NO
fluoranthene		16	20	4/11	NA	1,100	NO
fluorene		0.15	0.15	1/11	NA	1,100	NO
indeno(1,2,3–c,d)pyrene		3.9	7	2/11	NA	320	NO
naphthalene		0.074	0.074	1/11	NA	170	NO
phenanthrene		5.3	9	4/11	NA	510	NO
pyrene		16	30	4/11	NA	550	NO

Notes:

[a] Base–wide background soil inorganics database.

[b] Surface soil samples from sampling stations 30B–92–01X to 30B–92–08X, G6M–92–02X, and G6M–92–03X.

NA = not available.

TABLE 6-13
ORGANIC COMPOUNDS IN SOIL
SA 31 - MOORE ARMY AIRFIELD FIRE-FIGHTING TRAINING AREA
SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BORING	31B-92-01X			31B-92-02X			31B-92-03X			31B-92-04X			31B-92-05X					
	DEPTH	0	2	8	0	4	8	0	4	8	0	4	8	0	15	15D	30	45	60
VOLATILES (ug/g)																			
TOLUENE		<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	0.0019	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078	<0.00078
SEMIVOLATILES (ug/g)																			
ANTHRACENE		<0.033	0.200	<0.200	<0.200	1.00	0.054	<0.033	<0.033	<0.033	0.600	<0.300	<0.033	0.048	<0.200	<0.033	<0.033	<0.033	<0.033
BENZO[A]ANTHRACENE		<0.170	0.550	<0.800	<0.800	3.00	<0.170	<0.170	<0.170	<0.170	<2.00	<2.00	<0.170	0.170	<0.800	<0.170	<0.170	<0.170	<0.170
BENZO[A]PYRENE		<0.250	0.620	<1.00	<1.00	<2.00	<0.250	<0.250	<0.250	<0.250	<2.00	<2.00	<0.250	0.320	<1.00	<0.250	<0.250	<0.250	<0.250
BENZO[B]FLUORANTHENE		<0.210	0.660	<1.00	<1.00	4.00	<0.210	<0.210	<0.210	<0.210	<2.00	<2.00	<0.210	0.560	<1.00	<0.210	<0.210	<0.210	<0.210
BENZO[G,H,I]PERYLENE		<0.250	0.360	<1.00	<1.00	<2.00	<0.250	<0.250	<0.250	<0.250	<2.00	<2.00	<0.250	0.300	<1.00	<0.250	<0.250	<0.250	<0.250
BENZO[K]FLUORANTHENE		<0.066	0.530	<0.300	<0.300	2.00	<0.066	<0.066	<0.066	<0.066	0.900	<0.700	<0.066	0.290	<0.300	<0.066	<0.066	<0.066	<0.066
CARBAZOLE		ND 0.033	0.180	ND 0.200	ND 0.200	1.00	ND 0.033	ND 0.033	ND 0.033	ND 0.033	0.700	ND 0.300	ND 0.033	ND 0.033	ND 0.200	ND 0.033	ND 0.033	ND 0.033	ND 0.033
CHRYSENE		<0.120	0.750	<0.600	<0.600	4.00	<0.120	<0.120	<0.120	<0.120	3.00	<1.00	<0.120	0.360	<0.600	<0.120	<0.120	<0.120	<0.120
DIBENZOFURAN		<0.035	0.073	<0.200	<0.200	1.00	<0.035	<0.035	<0.035	<0.035	<0.40	<0.400	<0.035	<0.035	<0.200	<0.035	<0.035	<0.035	<0.035
FLUORANTHENE		0.150	2.00	0.600	0.600	10.0	0.370	<0.068	<0.068	<0.068	6.00	1.00	0.130	0.460	<0.300	0.097	<0.068	<0.068	<0.068
FLUORENE		<0.033	0.150	<0.200	<0.200	3.00	0.061	<0.033	<0.033	<0.033	0.70	<0.300	<0.033	<0.033	<0.200	<0.033	<0.033	<0.033	<0.033
INDENO[1,2,3-C,D]PYRENE		<0.290	0.360	<1.00	<1.00	<3.00	<0.290	<0.290	<0.290	<0.290	<3.00	<3.00	<0.290	<0.290	<1.00	<0.290	<0.290	<0.290	<0.290
NAPHTHALENE		<0.037	<0.037	<0.200	<0.200	0.500	<0.037	<0.037	<0.037	<0.037	1.00	<0.400	<0.037	<0.037	<0.200	<0.037	<0.037	<0.037	<0.037
PHENANTHRENE		0.047	1.10	0.500	1.00	10.0	0.310	<0.033	<0.033	<0.033	5.00	1.00	0.120	0.220	<0.200	<0.033	<0.033	<0.033	<0.033
PYRENE		0.100	1.50	0.600	0.600	8.00	0.270	<0.033	<0.033	<0.033	4.00	1.00	0.100	0.380	<0.200	0.074	<0.033	<0.033	<0.033
OTHER (ug/g)																			
TPHC		34.5	41.7	30.9	30.5	139	30.5	83.1	30.7	30.1	156	368	2090	114	71.4	70.8	40.0	<28.5	35.1

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
ND = NOT DETECTED

O31BORE.WK1
06/21/95

TABLE 6-14
INORGANIC ANALYTES IN SOIL
SA 31 - MOORE ARMY AIRFIELD FIRE-FIGHTING TRAINING AREA
SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-	BORING	31B-92-01X			31B-92-02X			31B-92-03X			31B-92-04X			31B-92-05X					
(ug/g)	GROUND	DEPTH	0	2	8	0	4	8	0	4	8	0	4	8	0	15	15D	30	45	60
ALUMINUM	15000		5430	7180	2630	4780	6940	3290	6470	5650	2820	4220	5240	3070	4920	4370	2930	1980	2090	1920
ARSENIC	21		6.36	7.03	7.31	5.90	8.84	9.26	7.00	10.3	7.02	6.85	7.04	6.28	8.79	7.68	6.66	8.74	5.17	9.10
BARIUM	42.5		20.1	16.9	16.1	14.9	21.4	15.9	17.7	13.4	12.9	15.3	22.9	12.8	16.4	20.1	13.1	13.1	13.4	12.7
BERYLLIUM	0.347		<0.500	<0.500	<0.500	<0.500	<0.500	0.588	0.572	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.608	<0.500	<0.500	<0.500	<0.500
CALCIUM	1400		951	676	1760	624	1810	350	567	374	326	846	2780	464	1210	735	626	434	389	530
CHROMIUM	31		6.69	8.78	6.01	7.06	10.6	8.66	7.41	8.18	5.21	6.73	7.50	6.29	10.2	18.8	7.88	6.88	6.00	4.82
COBALT	NA		<1.42	2.05	1.88	<1.42	2.55	2.66	2.34	2.59	3.28	2.39	1.99	2.26	2.48	3.66	2.98	2.34	2.38	2.24
COPPER	8.39		3.92	4.37	3.81	4.60	5.57	4.28	4.19	5.06	7.11	4.56	4.28	4.70	9.62	6.70	5.73	4.07	5.52	4.00
IRON	15000		4120	5230	3580	4670	6470	4710	5320	4980	4320	4040	4490	4100	5530	6570	4470	3650	4350	3710
LEAD	34.4		5.22	7.39	7.58	7.46	5.38	3.36	7.22	4.41	2.40	4.17	4.46	2.85	8.08	4.59	5.58	2.97	3.56	2.90
MAGNESIUM	5600		754	883	790	899	1600	1410	1010	1020	977	898	1070	980	1220	2050	964	886	966	760
MANGANESE	300		63.1	61.9	69.6	78.0	97.6	86.9	72.1	61.8	92.0	60.9	61.8	75.0	65.2	126	99.6	87.2	91.7	76.8
MERCURY	0.22		0.08	0.118	<0.050	0.14	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
NICKEL	14.0		4.63	6.69	5.04	4.14	8.42	7.10	5.45	6.97	6.00	5.53	5.48	5.78	6.98	12.0	5.52	5.38	6.52	5.23
POTASSIUM	1700		237	300	388	385	560	649	462	306	536	421	437	453	425	850	444	440	444	413
SODIUM	131		138	134	130	125	151	120	172	117	116	165	147	126	141	154	122	144	112	126
VANADIUM	28.7		5.47	6.82	3.94	5.46	8.89	6.62	6.81	5.87	5.05	4.95	6.39	4.78	6.77	8.72	4.32	4.19	4.12	<3.39
ZINC	35.5		14.7	19.7	11.2	17.3	16.2	12.5	17.8	14.0	12.6	13.2	12.5	19.9	24.6	26.5	15.3	11.6	13.2	11.2

NOTES: TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
NA = NOT ANALYZED

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TABLE 6–15
HUMAN HEALTH PRELIMINARY RISK EVALUATION – SURFACE SOIL
STUDY AREA 31 – MOORE ARMY AIRFIELD FIRE FIGHTING TRAINING AREA

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency Of Detection	Maximum Exceeds Background?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	5,500	7,180	6/6	NO	230,000	NO
arsenic	21	7.0	8.8	6/6	NO	0.97	YES
barium	42.5	17	20	6/6	NO	5,500	NO
beryllium	0.347	0.57	0.57	1/6	YES	0.4	YES
chromium	31	7.8	10	6/6	NO	390	NO
cobalt	NA	2.3	2.5	4/6	NA	NA	NA
copper	8.39	5.2	9.6	6/6	YES	2,900	NO
lead	34.4	6.6	8.1	6/6	NO	500	NO
manganese	300	67	78	6/6	NO	7,800	NO
mercury	0.22	0.11	0.14	3/6	NO	23	NO
nickel	14.0	5.6	7.0	6/6	NO	1,600	NO
vanadium	28.7	6.0	6.8	6/6	NO	550	NO
zinc	35.5	18	25	6/6	NO	23,000	NO
Organics (ug/g)							
toluene		0.0019	0.0019	1/6	NA	16,000	NO
anthracene		0.28	0.6	3/6	NA	23,000	NO
benzo[a]anthracene		0.36	0.55	2/6	NA	1.6	NO
benzo[a]pyrene		0.47	0.62	2/6	NA	0.23	YES
benzo[b]fluoranthene		0.61	0.66	2/6	NA	1.9	NO
benzo[g,h,i]perylene		0.33	0.36	2/6	NA	11	NO
benzo[k]fluoranthene		0.57	0.9	3/6	NA	4.4	NO
carbazole		0.44	0.7	2/6	NA	85	NO
chrysene		1.4	3	3/6	NA	NA	NA
dibenzofuran		0.073	0.073	1/6	NA	NA	NA
fluoranthene		1.8	6	5/6	NA	3,100	NO
fluorene		0.43	0.7	2/6	NA	3,100	NO
indeno[1,2,3–c,d]pyrene		0.36	0.36	1/6	NA	0.84	NO
naphthalene		1	1	1/6	NA	3,100	NO
phenanthrene		1.5	5	5/6	NA	2,300	NO
pyrene		1.3	4	5/6	NA	2,300	NO
TPHC		77	156	6/6	NA	NA	NA

Notes:

[a] Base–wide background soil inorganic database

[b] Surface soil samples from sampling station 31B–92–01X to 31B–92–05X.

NA = not available.

TABLE 6–16
HUMAN HEALTH PRELIMINARY RISK EVALUATION – SUBSURFACE SOIL STUDY AREA 31 – MOORE ARMY AIRFIELD FIRE FIGHTING TRAINING AREA

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection (out of 9)	Maximum Exceeds Background ?	Region III Commercial/Industrial Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
aluminum	15,000	4,104	6,940	9	NO	3,000,000	NO
arsenic	21	7.8	10	9	NO	1.6	YES
barium	42.5	17	23	9	NO	72,000	NO
beryllium	0.347	0.60	0.61	2	YES	0.67	NO
chromium	31	8.8	19	9	NO	5,100	NO
cobalt	NA	2.7	3.7	9	NA	NA	NA
copper	8.39	5.2	7.1	9	NO	35,000	NO
lead	34.4	4.5	7.6	9	NO	500	NO
manganese	300.0	86	126	9	NO	100,000	NO
nickel	14.0	6.9	12	9	NO	20,000	NO
vanadium	28.7	6.1	8.9	9	NO	7,200	NO
zinc	35.5	16	27	9	NO	310,000	NO
Organics (ug/g)							
anthracene		0.53	1	2	NA	310,000	NO
benzo(a)anthracene		3	3	1	NA	2.7	YES
benzo(b)fluoranthene		4	4	1	NA	3.2	YES
benzo(k)fluoranthene		2	2	1	NA	7.4	NO
carbazole		1	1	1	NA	140	NO
chrysene		4	4	1	NA	NA	NA
dibenzofuran		1	1	1	NA	NA	NA
fluoranthene		2.0	10	6	NA	41,000	NO
fluorene		1.5	3	2	NA	41,000	NO
naphthalene		0.5	0.5	1	NA	41,000	NO
phenanthrene		2.4	10	5	NA	30,000	NO
pyrene		1.7	8	6	NA	31,000	NO
TPHC		318	2,090	9	NA	NA	NA

Notes:

[a] Base–wide background soil inorganics database.

[b] Subsurface soil samples from sampling stations 31B–92–01X to 31B–92–05X.

NA = not available.

TABLE 6-17
HUMAN HEALTH PRELIMINARY RISK EVALUATION – GROUNDWATER
STUDY AREA 31 – MOORE ARMY AIRFIELD FIRE FIGHTING TRAINING AREA

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
bis(2-ethylhexyl)phthalate		37.0		6.1	YES
TPHC		1,060		NA	NA
Inorganics (ug/l)					
aluminum	6,870	2,590	NO	50-200	YES
arsenic	10.5	10.0	NO	50	NO
barium	39.6	41.9	YES	2,000	NO
calcium	14,700	17,100	YES	NA	NA
chromium	14.7	6.88	NO	100	NO
copper	8.09	8.73	YES	1,000	NO
iron	9,100	3,580	NO	300	YES
lead	4.25	10.1	YES	15	NO
magnesium	3,480	1,650	NO	NA	NA
manganese	291	594	YES	50	YES
potassium	2,370	2,020	NO	NA	NA
sodium	10,800	3,310	YES	28,400	NO
zinc	21.1	47.8	YES	5,000	NO
Anions/Cations (ug/l)					
nitrate/nitrite		2,400		10,000	NO

NOTES:

[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.

[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.

[c] SA 31 is represented by monitoring wells G6M-92-04X and G6M-92-05X.

ND Not detected

NA Not available

31HHGW

TABLE 6–18
ANALYTES IN SOIL
STUDY AREA 47 – MOORE ARMY AIRFIELD UNDERGROUND STORAGE TANK

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SAMPLE DEPTH					
	BACKGROUND	0 ft	10 ft	25 ft	40 ft	60 ft
LEAD (ug/g)	48.4	4.70	2.21	2.01	2.20	0.989
VOCs (ug/g)		ND	ND	ND	ND	ND
OTHER		ug/g				
TOTAL PETROLEUM HYDROCARBONS		39.3	38.1	<27.9	<28.1	<27.7
TOTAL ORGANIC CARBON		NA	NA	NA	NA	134

NOTES: TABLE LISTS DETECTED ANALYTES ONLY IN ug/g
ND = NONE DETECTED
NA = NOT ANALYZED

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TABLE 6-19
ANALYTES IN GROUNDWATER
STUDY AREA 47 - MOORE ARMY AIRFIELD UNDERGROUND STORAGE TANK

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK-GROUND	G6M-92-01X		G6M-92-06X		G6M-92-07X		
		ROUND 1	ROUND 2/3	ROUND 1	ROUND 2/3	ROUND 1	ROUND 2/3	ROUND 2/3 dup
ORGANICS (ug/L)								
ACETONE		21.0	<13.0	<13.0	<13.0	<13.0	<13.0	<13.0
BIS(2-ETHYLHEXYL)PHTHALATE		<4.80	20.0	8.80	<4.80	<4.80	<4.80	20.0
TPHC		1550	<192	<200	218	<200	<188	<184
INORGANICS (ug/L)								
ALUMINUM	6870	1290	387	<141	1460	<141	248	291
ARSENIC	10.5	<2.54	<2.54	<2.54	8.21	<2.54	<2.54	<2.54
BARIUM	39.6	14.9	6.82	<5.00	31.7	<5.00	16.2	<5.00
CALCIUM	14700	10400	7910	7240	8990	16200	17000	18800
CHROMIUM	14.7	11.8	<6.02	<6.02	9.88	<6.02	<6.02	<6.02
IRON	9100	1890	535	53.4	2320	132	393	451
LEAD	4.25	<1.26	<1.26	<1.26	4.01	<1.26	1.63	<1.26
MAGNESIUM	3480	1050	825	688	1030	1350	1410	1550
MANGANESE	291	66.8	22.5	7.64	102	9.80	15.6	16.7
POTASSIUM	2370	2340	2290	1210	1920	<375	1420	1510
SILVER	4.60	93.6	<4.60	<4.60	<4.60	<4.60	<4.60	<4.60
SODIUM	10800	4020	3230	5860	5000	5590	4410	5140
ZINC	21.1	<21.1	59.3	<21.1	30.1	<21.1	29.5	33.8
ANIONS/CATIONS (ug/L)								
BICARBONATE		<5000	6000	24400	22000	23200	24000	23000
CHLORIDE		<2120	<2120	<2120	<2120	4130	<2120	<2120
SULFATE		<10000	<10000	12100	11700	14100	13500	13300
NITRATE/NITRITE		7400	4400	850	990	5500	8000	7000
ALKALINITY		<5000	5000	20000	18000	19000	20000	19000
OTHER (ug/L)								
TSS		21000	245000	6000	21000	5000	15000	48000

TABLE LISTS DETECTED ANALYTES ONLY - SEE PROJECT ANALYTE LIST FOR SUMMARY
CONCENTRATIONS WITHIN BOXES EXCEED BACKGROUND

SA47GW
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Table 6–20
Human Health Preliminary Risk Evaluation of Surface Soil
Study Area 47 – Moore Army Airfield Underground Storage Tank

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Soil Background Concentration [a]	Detected Concentration [b]		Frequency of Detection	Maximum Exceeds Background?	Region III Residential Soil Concentration (ug/g)	Maximum Exceeds Region III Concentration?
		Average	Maximum				
Inorganics (ug/g)							
Lead	48.4	4.7	4.7	1/1	NO	500	NO

NOTES:

[a] Base–wide soil inorganics database.

[b] Surface soil sample from sampling station G6M–92–07X.

47DATA

Table 6–21
Human Health Preliminary Risk Evaluation of Subsurface Soil
Study Area 47 – Moore Army Airfield Underground Storage Tank

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	**Soil Background Concentration [a]**	**Detected Concentration [b]**		**Frequency of Detection**	**Maximum Exceeds Background ?**	**Region III Commercial/Industrial Concentration (ug/g)**	**Maximum Exceeds Region III Concentration?**
		Average	**Maximum**				
Inorganics (ug/g)							
lead	48.4	2.2	2.2	1/1	NO	500	NO
Other (ug/g)							
TPHC	NA	38	38	1/1	NA	8180	NO

Notes:
[a] Base–wide background soil inorganics database.
[b] Subsurface soil sample from sampling location G6M–92–07X.
NA = not applicable.

47SSS

Table 6–22
Human Health Preliminary Risk Evaluation of Groundwater
SA 47 – Moore Army Airfield/Underground Storage Tank Monitoring Well

Site Investigation Report – Groups 3, 5, and 6
Fort Devens

Analyte	Groundwater Background Concentration	Maximum Detected Concentration [a]	Maximum Exceeds Background?	Drinking Water Standard/Guideline [b] (ug/l)	Maximum Exceeds Standard/Guideline?
Organics (ug/l)					
bis(2–ethylhexyl)phthalate		20.0		6.1	YES
Inorganics (ug/l)					
aluminum	6,870	291	NO	50–200	YES
barium	39.6	16.2	NO	2,000	NO
calcium	14,700	18,800	YES	NA	NA
iron	9,100	451	NO	300	YES
lead	4.25	1.63	NO	15	NO
magnesium	3,480	1,550	NO	NA	NA
manganese	291	16.7	NO	50	NO
potassium	2,370	1,510	NO	NA	NA
sodium	10,800	5,590	NO	28,400	NO
zinc	21.1	33.8	YES	5,000	NO
nitrate/nitrite		8,000		10,000	NO

NOTES:
[a] Maximum from either Round 1 or Rounds 2 & 3. Only unfiltered samples are used for inorganics.
[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, EPA drinking water standard, Region III Tap Water Concentration.
[c] SA 47 is represented by monitoring well G6M–92–07X.
ND Not detected
NA Not available

TABLE 6-23
CONFIRMATORY SAMPLES – UST AND ANCILLARY EQUIPMENT REMOVAL
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

			LABORATORY ANALYSIS							
AREA	SAMPLE NO.	TOTAL VOCs (PID) (ppm)	BENZENE (μg/kg)	TOLUENE (μg/kg)	ETHYL–BENZENE (μg/kg)	TOTAL XYLENES (μg/kg)	PCE (μg/kg)	TOTAL SVOCs (μg/kg)	TPHC (mg/kg)	TOTAL LEAD (mg/kg)
TANK HOLE (SOIL) [1]	TNK-19	133	ND	ND	ND	ND	ND	5.1	14	13.2
	TNK-25	139	ND	ND	ND	ND	ND	2.65	3,285	17.3
	TNK-26	85	ND	ND	ND	ND	ND	0.95	ND	12.8
	TNK-27	97	ND	ND	ND	19	ND	1.97	ND	11.7
TANK HOLE (WATER) [2]	TKH-1	157	38,8	119	ND	291	ND	240.2	ND	0.007
	ES-1	ND	297	137	ND	900	ND	33.7	ND	0.035
WATER CONTROL PIT (SOIL)	WCP-1	52	NA	NA	NA	NA	NA	NA	NA	NA
	WCP-2	109	NA	NA	NA	NA	NA	NA	NA	NA
	WCP-3	3	NA	NA	NA	NA	NA	NA	NA	NA
	WCP-4	535	ND	ND	ND	ND	ND	NA	ND	7.1
	WCP-5	166	NA	NA	NA	NA	NA	NA	NA	NA
WATER SEPARATOR PIT (SOIL)	WSP-1	16	NA	NA	NA	NA	NA	NA	NA	NA
	WSP-2	33	NA	NA	NA	NA	NA	NA	NA	NA
	WSP-3	243	NA	NA	NA	NA	NA	NA	NA	NA
	WSP-4	519	ND	ND	121	326	ND	NA	16	7.2
	WSP-5	52	NA	NA	NA	NA	NA	NA	NA	NA
PIPELINE, AREA A (SOIL)	PL-A-1	4	NA	NA	NA	NA	NA	NA	NA	NA
	PL-A-2	0	NA	NA	NA	NA	NA	NA	NA	NA
	PL-A-3	2	NA	NA	NA	NA	NA	NA	NA	NA
PIPELINE, AREA B (SOIL)	PL-B-4	113	ND	ND	ND	ND	175,850	ND	ND	10.5
	PL-B-5	34	NA	NA	NA	NA	NA	NA	NA	NA
	PL-B-6	242	ND	798	ND	ND	4,167	105	ND	5
TRUCK STAND (SOIL)	TS-1	0	NA	NA	NA	NA	NA	NA	NA	NA
	TS-2	3	NA	NA	NA	NA	NA	NA	NA	NA
	TS-3	3	NA	NA	NA	NA	NA	NA	NA	NA
	TS-4	14	ND	ND	ND	ND	197	ND	ND	2.8
	TS-5	3	NA	NA	NA	NA	NA	NA	NA	NA
	TS-6	8	ND	ND	ND	ND	ND	ND	ND	2.1
FILL STAND (SOIL)	FS-1	0	NA	NA	NA	NA	NA	NA	NA	NA
	FS-2	2	NA	NA	NA	NA	NA	NA	NA	NA
	FS-3	0	NA	NA	NA	NA	NA	NA	NA	NA

Source: Zenone (1993, Table 3)

Notes: ND = Not Detected
NA = Not Analyzed

[1] other PID screening results shown in Figure 4

[2] concentrations in μg/l (organic analytes) and mg/l (TPHC and lead)

TABLE 6-24
FIELD GAS CHROMATOGRAPH-SCREENING OF SOIL VAPOR
SA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION IDENTIFICATION	SAMPLE DEPTH (Feet bgs)	TOTAL VOCs (ppm)	COMMENTS
50V-93-01X	3	282	Gasoline; possible PCE 4 ppm.
50V-93-02X	3	3,883	Gasoline.
50V-93-03X	3	24	Gasoline.
50V-93-04X	3	738	Gasoline; possible PCE 28 ppm.
50V-93-05X	3	123	Gasoline; possible PCE 29 ppm.
50V-93-06X	3	20	Gasoline; possible PCE 8 ppm.
50V-93-07X	3	213	Gasoline; possible PCE 75 ppm.
50V-93-08X	3	3,138	Gasoline; possible PCE 625 ppm.
50V-93-09X	3	155	Gasoline (?); possible PCE 61 ppm.
50V-93-10X	3	3	Gasoline (?); possible PCE 8 ppm.
50V-93-11X	3	38	Gasoline / PCE (?).
50V-93-12X	3	24	Gasoline / PCE (?) 7 ppm.
50V-93-13X	3	5	Possible PCE 2 ppm.
50V-93-14X	3	25	Gasoline (?); possible PCE 0.08 ppm.
50V-93-15X	3	4	Possible PCE 1 ppm.
50V-93-16X	3	3	Possible PCE 1 ppm.
50V-93-17X	3	1	Possible PCE 0.4 ppm.
50V-93-18X	3	2	Possible PCE 0.6 ppm.
50V-93-19X	3	1	Possible PCE 0.01 ppm.
50V-93-20X	3	2	Possible PCE 0.04 ppm.
50V-93-21X	3	8	Possible TCE 0.09 ppm; possible PCE 0.1 ppm.
50V-93-22X	3	1	Possible PCE 0.4 ppm.
50V-93-23X	3	2	Possible PCE 0.2 ppm.
50V-93-24X	3	6	Possible PCE 0.5 ppm.
50V-93-25X	3	1.2	Possible PCE 0.04 ppm.
50V-93-26X	3	0.9	Possible PCE 0.06 ppm.
50V-93-27X	3	1.3	Possible PCE 0.2 ppm.
50V-93-28X	3	0.7	
50V-93-29X	3	0.8	
50V-93-30X	3	0.8	

NOTES: bgs = below ground surface
VOCs = Volatile Organic Compounds
ppm = parts per million
PCE = Tetrachloroethylene

TABLE 6-25
SUMMARY OF SOIL BORINGS
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION IDENTIFICATION	COMPLETION DEPTH Feet (bgs)	REFERENCE SAMPLE INTERVALS Feet (bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	GC SCREENING RESULTS (ug/kg)	COMMENTS
50B-93-12X	12	0 – 2	NO	SP	<1	PCE >240; benzene 2.5	
		5 – 7	NO	SP	BKG	NA	Poor recovery
		7 – 9	YES	ML / SM	100	PCE 459,700; fuel high	Strong odor; product present within silt.
		10 – 12	YES	SM	100	PCE 35,782	
50B-93-13X	12	0 – 2	NO	SP – SM	BKG	PCE 131	
		5 – 7	NO	SM	BKG	PCE 45	
		7 – 9	YES	SM – ML	2	PCE 497	
		10 – 12	YES	ML	<1	PCE 11,140	
50B-93-14X	12	0 – 2	NO	SM	9	PCE 1,743	
		2 – 4	YES	ML	70	PCE 1,924; fuel	
		4 – 6	YES	ML – SM	10	PCE 2,006; fuel	
		6 – 8	NO	ML – SM	20	PCE 1,940	
		8 – 10	NO	ML – SM	40	PCE 747	
		10 – 12	NO	ML – SM	10	PCE 897	
50B-93-15X	12	0 – 2	YES	SP – SM	BKG	PCE 419	
		5 – 7	NO	SW	BKG	PCE 152	
		7 – 9	NO	SM – SL	BKG	NA	
		10 – 12	NO	ML – SM	BKG	PCE 190	
50B-93-16X	12	0 – 2	YES	SP	BKG	PCE 160	
		5 – 7	NO	ML / SM – ML	BKG	PCE 137	
		10 – 12	YES	ML – SM	BKG	PCE 150	

TABLE 6-25
SUMMARY OF SOIL BORINGS
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION IDENTIFICATION	COMPLETION DEPTH Feet (bgs)	REFERENCE SAMPLE INTERVALS Feet (bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	GC SCREENING RESULTS (ug/kg)	COMMENTS
G6M-93-12X	20	0 - 2	YES	SP	BKG	PCE 42	
		5 - 7	YES	SM - ML	BKG	PCE 43	Rust discoloration.
		10 - 12	YES	ML - SM	BKG	PCE 101	
		15 - 17	NO	ML	BKG	ND	
G6M-93-13X	19	0 - 2	NO	SM	BKG	ND	
		5 - 7	NO	ML / SM	BKG	ND	
		10 - 12	NO	SM - ML	1	ND	
		15 - 17	YES	SM - ML	BKG	ND	
G6M-93-14X (50B-93-11X)	20	0 - 2	YES	SP - SM	1.5	PCE >1	
		5 - 7	YES	SM	7	PCE 202; benzene 3.4	Odor present.
		10 - 12	YES	SM - ML	BKG	PCE >164	
G6M-94-15A[2]	44.5	0-2	NO	SP-SM / SW	<1	Toluene 37	
		5-7	NO	SP	<1	ND	
		10-12	NO	SP	<1	ND	
		15-17	NO	SP	BKG	Toluene 26	
		20-22	NO	SP	BKG	Toluene 31	
		25-27	NO	SP	BKG	ND	
		30-32	NO	SP / SP-SM	BKG	ND	Iron staining
		35-37	NO	SP / SM-CL	BKG	ND	Iron staining
		40-42	YES[1]	SM / SP-SM	NR	Xylene 49	

TABLE 6-25
SUMMARY OF SOIL BORINGS
SA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION IDENTIFICATION	COMPLETION DEPTH Feet (bgs)	REFERENCE SAMPLE INTERVALS Feet (bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	GC SCREENING RESULTS (ug/kg)	COMMENTS
G6M-94-16X[2]	44	0-2	NO	SP / SW	BKG	ND	
		5-7	NO	SP	BKG	ND	
		10-12	NO	SP	BKG	ND	
		15-17	NO	SP	BKG	ND	
		20-22	NO	SP	BKG	ND	
		25-27	NO	SP	BKG	ND	
		30-32	NO	SP	BKG	ND	
		35-37	NO	SM / SP	BKG	ND	Iron staining
		40-42	YES[1]	SP - SM	BKG	NA	Iron staining
G6M-94-17X[2]	44	0-2	NO	SP	<1	ND	Some fibrous roots
		4-6	NO	SP	<1	Xylene 57	
		9-11	NO	SP	BKG	Xylene 24	
		14-16	NO	SP	BKG	Xylene 55	
		19-21	NO	SP	BKG	Chlorobenzene 85	Fine statification / color bands
		24-26	NO	SP	BKG	Chlorobenzene 63	Fine statification / color bands
		29-31	NO	SP	BKG	ND	Finely statified
		34-36	NO	SP - SM / ML	BKG	ND	Finely statified
		39-41	YES[1]	SM - ML / CL	BKG	Xylene 42	
		41-44	NO	SM - ML	BKG	NA	
G6M-94-18X[2] (50B-94-17X)	93	CONTINOUS AT 2 FOOT INTERVALS	4, 6, 8, 10, 12, 22, 24, 26, 40, 90 ft/bgs	See Appendix A	BKG TO 192	PCE (ND - 1450)	See Appendix A
G6M-95-19X[2]	87	CONTINOUS AT 2 FOOT INTERVALS	YES[1] AT 50 ft/bgs	See Appendix A	BKG AND NR	PCE (ND - 173)	See Appendix A

TABLE 6-25
SUMMARY OF SOIL BORINGS
SA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

EXPLORATION IDENTIFICATION	COMPLETION DEPTH Feet (bgs)	REFERENCE SAMPLE INTERVALS Feet (bgs)	ANALYTICAL SAMPLES COLLECTED	SOIL TYPE (USCS)	TOTAL VOCs BY PID (ppm)	GC SCREENING RESULTS (ug/kg)	COMMENTS
G6M-95-20X[2]	89	CONTINOUS AT 2 FOOT INTERVALS	YES[1] AT 20 ft/bgs	See Appendix A	NR	PCE (ND - 1872)	See Appendix A

(bgs) = below ground surface
USCS = Unified Soil Classification System
ppm = parts per million
ug/kg = micro grams per kilogram

VOCs = Volatile Organic Compounds
PID = Photoionization Detector
GC = Gas chromatography
PCE = Tetrachloroethylene

NR = Not Recorded

NA = Not Analyzed

[1] = Sample analyzed for Total Organic Carbon only

[2] = Explorations (shaded) completed as part of the Phase III Site Investigation; GC screening results (estimated concentrations not shown)

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TABLE 6–26
MONITORING WELL COMPLETION DETAILS
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

WELL IDENTIFICATION	SOIL DRILLING METHOD	MEDIA SCREENED	WELL SCREEN INTERVAL (Feet bgs)	WELL SCREEN ELEVATION (Feet above msl)	COMPLETION DEPTH (Feet bgs)	WELL CONSTRUCTION MATERIAL
G6M–92–08X	HOLLOW STEM AUGER	SOIL	53 – 63	210.2 – 200.2	63	4" ID PVC
G6M–92–09X	HOLLOW STEM AUGER	SOIL	48 – 58	210.6 – 200.6	58	4" ID PVC
G6M–92–10X	HOLLOW STEM AUGER	SOIL	9 – 19	218.2 – 208.2	20	4" ID PVC
G6M–92–11X	HOLLOW STEM AUGER	SOIL	8.5 – 18.5	214.7 – 204.7	20	4" ID PVC
G6M–93–12X	HOLLOW STEM AUGER	SOIL	9 – 19	214.1 – 204.1	20	4" ID PVC
G6M–93–13X	HOLLOW STEM AUGER	SOIL	9 – 19	214.7 – 204.7	20	4" ID PVC
G6M–93–14X	HOLLOW STEM AUGER	SOIL	9 – 19	214.2 – 204.2	20	4" ID PVC
G6M–94–15A[1]	HOLLOW STEM AUGER	SOIL	33 – 43	218.5 – 208.5	44	4" ID PVC
G6M–94–16X[1]	HOLLOW STEM AUGER	SOIL	34 – 44	218.9 – 208.9	44	4" ID PVC
G6M–94–17A[1]	HOLLOW STEM AUGER	SOIL	33.5 – 43.5	219.5 – 209.5	44	4" ID PVC
G6M–94–18X[1]	DRIVE AND WASH	SOIL	22.5 – 27.5	201.1 – 191.1	92[2]	2" ID PVC
G6M–95–19X[1]	HOLLOW STEM AUGER / DRIVE AND WASH	SOIL	48 – 58	174.8 – 164.8	87[2]	2" ID PVC
G6M–95–20X[1]	HOLLOW STEM AUGER / DRIVE AND WASH	SOIL	18 – 23	205.0 – 200.0	89[2]	2" ID PVC

NOTES: [1] Explorations installed as part of the Phase III Site Investigation

[2] Boring completion depth. Portion of boring completed below the bottom of the well screen was sealed with grout or grout and bentonite.

bgs = below ground surface msl = mean sea level NA = Not Applicable

4" ID PVC = 4–inch internal diameter schedule 40 polyvinyl chloride pipe

TABLE 6-27
SUMMARY OF WATER LEVELS AND HYDRAULIC CONDUCTIVITIES
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

WELL IDENTIFICATION	ELEVATION REFERENCE (Feet above msl)		DEPTH TO WATER (Feet bgs)	ELEVATION OF WATER (Feet above msl)	HYDRAULIC CONDUCTIVITY (cm/sec)
G6M-92-08X	PVC RISER	262.94	Access Problem	Not Available	1.4E-03
G6M-92-09X	PVC RISER	261.25	51.05	210.20	1.3E-03
G6M-92-10X	PVC RISER	225.81	12.69	213.12	4.7E-05
G6M-92-11X	PVC RISER	225.62	12.58	213.04	1.4E-04
G6M-93-12X	PVC RISER	224.73	11.09	213.64	1.0E-03
G6M-93-13X	PVC RISER	225.58	12.88	212.70	9.3E-04
G6M-93-14X	PVC RISER	224.89	11.16	213.73	9.9E-04
G6M-94-15A	PVC RISER	253.67	39.62	214.05	1.2E-04 [1]
G6M-94-16X	PVC RISER	254.77	38.14	216.63	6.9E-05 [1]
G6M-94-17A	PVC RISER	256.15	40.88	215.27	9.7E-05 [1]
G6M-94-18X	PVC RISER	225.78	13.25	212.53	5.5E-04 [1]
G6M-95-19X	PVC RISER	224.59	12.17	212.42	2.5E-04 [1]
G6M-95-20X	PVC RISER	225.31	12.54	212.77	1.5E-04 [1]

NOTES: The reported water levels were measured on January 31, 1995

Two hydraulic conductivity tests were condected for each well, and conductivites reported above were calculated using the Hvorslev (1951) method. The conductivity listed for each well is the average of the two tests.

[1] = Test conducted as part of the Phase III Site Investigation.

PVC = Polyvinyl chloride
bgs = below ground surface
cm/sec = centimeter per second
msl = mean sea level

TABLE 6–28
ANALYTES DETECTED IN SOIL
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

SITE IDENTIFICATION	SAMPLE DEPTH	ANALYTE CONCENTRATION (ug/g)		
		PCE	LEAD	TPHC
50B–92–01X	1	<0.00081	5.48	161
	5	<0.00081	5.18	43.4
	9	<0.00081	4.50	51.8
50B–92–02X	1	<0.00081	5.51	201
	5	<0.00081	4.17	240
	9	<0.00081	1.73	60.4
50B–92–03X	0	<0.00081	18.0	42.2
	4	<0.00081	4.84	32.8
	8	<0.00081	2.56	32.4
50B–92–04X	0	<0.00081	32.0	111
	4	<0.00081	13.0	41.7
	8	<0.00081	8.80	51.1
50B–92–05X	0	<0.00081	15.0	33.5
	4	<0.00081	7.78	42.2
	8	<0.00081	2.03	41.6
50B–92–06X	0	<0.00081	4.25	63.6
	4	<0.00081	2.90	54.1
	8	<0.00081	4.44	51.4
	8 (dup)	NA	3.64	38.7
50B–92–07X	0	<0.001	2.58	<27.7
	5	<0.00081	3.11	48.8
	10	<0.00081	3.59	39.3
50B–92–08X	0	0.00616	5.83	46.3
	5	<0.001	3.04	41.5
	10	0.300	3.51	55.8
50B–92–09X	0	<0.00081	14.0	109
	10	<0.00081	12.0	54.0
	15	<0.004	8.60	162
50B–92–10X	0	<0.00081	20.0	71.8
	5	<0.00081	3.92	42.7
	10	<0.00081	3.13	44.5
50B–93–11X	0	0.0062	NA	<30.9
(G6M–93–14X)	5	<0.00081	NA	<32.0
	10	<0.00081	NA	<35.9
50B–93–12X	7	3000	NA	NA
	10	0.100	NA	NA

TABLE 6–28
ANALYTES DETECTED IN SOIL
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

SITE IDENTIFICATION	SAMPLE DEPTH	ANALYTE CONCENTRATION (ug/g)		
		PCE	LEAD	TPHC
50B–93–13X	7	0.006	NA	NA
	10	0.005	NA	NA
50B–93–14X	2 *	3.00	NA	NA
	4	0.0043	NA	NA
50B–93–15X	0	0.0064	NA	NA
50B–93–16X	0	<0.00081	NA	NA
	10	<0.00081	NA	NA
G6M–92–10X	0	<0.00081	14.0	38.5
	5	<0.00081	3.17	<27.9
	10	<0.00081	5.87	<27.9
G6M–92–11X	0	<0.00081	18.0	53.7
	5	<0.00081	12.0	36.4
	12	<0.00081	2.96	51.5
	12 (dup)	0.0041	3.57	47.4
G6M–93–12X	0	0.0077	NA	NA
	5	<0.00081	NA	NA
	5 (dup)	0.0028	NA	NA
	10	<0.00081	NA	NA
50B–94–17X [1] (G6M–94–18X)	4 ** ++	0.0026	NA	<28
	6 **	0.017	NA	<28
	8 **	0.0024	NA	<28
	8 (dup) **	0.0021	NA	<28
	10	0.016	NA	<28
	12	0.0018	NA	<28
	22	0.039	NA	<28
	24	0.038	NA	<28
	26 **	0.0017	NA	<28
	40 **	<0.00081	NA	<28
	90	<0.00081	NA	<28

NOTES: ug/g = micrograms per gram DUP = Duplicate sample

PCE = Tetrachloroethylene NA = Not Analyzed

TPHC = Total Petroleum Hydrocarbon Compounds

[1] = Samples collected as part of the Phase III Site Investigation

* = Xylene was detected in this sample at a concentration of 0.50 ug/g.

** = Trichlorofluoromethane was detected in these six samples at concentrations ranging from 0.017 ug/g to 0.052 ug/g.

++ = Benzene was detected in this sample at a concentration of 0.002 ug/g.

TABLE 6–29
ANALYTES DETECTED IN GROUNDWATER
SA – 50 MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK–GROUND	G6M–92–10X				G6M–92–11X			G6M–93–12X				
		SI	SI Rounds 2 & 3		Phase III	SI	SI Rounds 2 & 3		SSI Round 1		SSI Round 2		Phase III
		Round 1	unfiltered	filtered	SI	Round 1	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	SI
ORGANICS (ug/L)													
BENZENE		<5.0	<5.0	NA	<0.50	<5.0	<5.0	NA	<5.0	NA	<2	NA	<0.50
BIS(2–ETHYLHEXYL)PHTHALATE		<4.80	<4.80	NA	NA	<4.80	18.0	NA	5.10	NA	<4.80	NA	NA
CHLOROFORM		<5.0	<5.0	NA	<0.50	<5.0	<5.0	NA	7.1	NA	4	NA	<0.50
TETRACHLOROETHYLENE		<1.60	<1.60	NA	1.9	<1.60	<1.60	NA	1300	NA	1000	NA	21
TOLUENE		<0.50	<0.50	NA	<0.50	<0.50	<0.50	NA	<5.0	NA	<2	NA	<0.50
INORGANICS (ug/L)													
ALUMINUM	6870	850	2340	264	NA	1920	148	<141	NA	NA	NA	NA	NA
ARSENIC	10.5	<2.54	2.98	<2.54	NA	<2.54	<2.54	<2.54	NA	NA	NA	NA	NA
BARIUM	39.6	153	208	146	NA	16.1	59.7	25.4	NA	NA	NA	NA	NA
CALCIUM	14700	47100	47500	47000	NA	5940	12600	11400	6020	NA	10200	NA	NA
CHROMIUM	14.7	<6.02	7.44	<6.02	NA	6.36	<6.02	<6.02	NA	NA	NA	NA	NA
IRON	9100	816	2600	<38.8	NA	2390	205	58.7	NA	NA	NA	NA	NA
LEAD	4.25	1.52	2.06	<1.26	NA	2.28	1.52	6.51	4.00	<1.3	29.3	<1.3	NA
MAGNESIUM	3480	2430	2820	2350	NA	855	766	671	2780	NA	11700	NA	NA
MANGANESE	291	309	263	216	NA	99.0	99.6	97.1	NA	NA	NA	NA	NA
POTASSIUM	2370	5570	5940	5380	NA	645	1710	1360	5000	NA	12100	NA	NA
SODIUM	10800	300000	1200000	1200000	NA	2420	5560	4380	NA	NA	NA	NA	NA
ZINC	21.1	<21.1	41.2	39.6	NA	<21.1	22.9	<21.1	NA	NA	NA	NA	NA
ANIONS/CATIONS (ug/L)													
BICARBONATE		8540	24000	NA	NA	28100	12000	NA	10000.0	NA	18300	NA	NA
CHLORIDE		200000	2100000	NA	NA	3480	15800	NA	4650	NA	3420	NA	NA
SULFATE		47000	50300	NA	NA	<10000	<10000	NA	<10000	NA	<10000	NA	NA
NITRATE/NITRITE		1400	1400	NA	NA	78.5	97.7	NA	102	NA	82.6	NA	NA
ALKALINITY		7000	7000	NA	NA	23000	10000	NA	NA	NA	15000	NA	NA
OTHER (ug/L)													
TSS		40000	72000	NA	NA	53000	16000	NA	444000	NA	5560000	NA	NA

TABLE 6–29
ANALYTES DETECTED IN GROUNDWATER
SA – 50 MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	BACK–GROUND	G6M–93–13X					G6M–93–13X DUP		G6M–93–14X				
		SSI Round 1		SSI Round 2		Phase III	SSI Round 1		SSI Round 1		SSI Round 2		Phase III
		unfiltered	filtered	unfiltered	filtered	SI	unfiltered	filtered	unfiltered	filtered	unfiltered	filtered	SI
ORGANICS (ug/L)													
BENZENE		<0.50	NA	<0.50	NA	<0.50	<0.50	NA	5	NA	<10	NA	<10
BIS(2–ETHYLHEXYL)PHTHALATE		<4.80	NA	NA	NA	NA	<4.80	NA	<4.80	NA	NA	NA	NA
CHLOROFORM		<0.50	NA	<0.50	NA	<0.50	<0.50	NA	<2	NA	<10	NA	<10
TETRACHLOROETHYLENE		<1.6	NA	<1.6	NA	<1.6	<1.6	NA	10000	NA	5000	NA	3000
TOLUENE		<0.50	NA	<0.50	NA	<0.50	<0.50	NA	<2	NA	<10	NA	10
INORGANICS (ug/L)													
ALUMINUM	6870	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ARSENIC	10.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
BARIUM	39.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CALCIUM	14700	14900	NA	15200	NA	NA	15500	NA	12800	NA	4560	NA	NA
CHROMIUM	14.7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
IRON	9100	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LEAD	4.25	6.60	<1.3	21.4	1.52	NA	9.30	<1.3	24.0	<1.3	9.67	<1.26	NA
MAGNESIUM	3480	3730	NA	3340	NA	NA	3550	NA	12800	NA	3320	NA	NA
MANGANESE	291	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
POTASSIUM	2370	4540	NA	3800	NA	NA	4540	NA	13000	NA	6670	NA	NA
SODIUM	10800	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ZINC	21.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
ANIONS/CATIONS (ug/L)													
BICARBONATE		10000	NA	7320	NA	NA	<5000	NA	6000	NA	17100	NA	NA
CHLORIDE		29300	NA	31800	NA	NA	29700	NA	2580	NA	4320	NA	NA
SULFATE		12700	NA	13800	NA	NA	12500	NA	<10000	NA	<10000	NA	NA
NITRATE/NITRITE		349	NA	630	NA	NA	39	NA	1060	NA	290	NA	NA
ALKALINITY		NA	NA	6000	NA	NA	NA	NA	NA	NA	14000	NA	NA
OTHER (ug/L)													
TSS		617000	NA	1230000	NA	NA	934000	NA	829000	NA	408000	NA	NA

TABLE 6–29
ANALYTES DETECTED IN GROUNDWATER
SA – 50 MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE ***	G6M–94–15A	G6M–94–16X	G6M–94–17A	G6M–94–18X	G6M–95–19X	G6M–95–20X
	Phase III SI	Phase III SI	Phase III SI	Phase III SI	Phase III SI	Phase III SI
ORGANICS (ug/L)						
BENZENE	<0.5	<0.5	<0.5	<50	<0.5	<2
BIS(2–ETHYLHEXYL)PHTHALATE	NA	NA	NA	NA	NA	NA
CHLOROFORM	<0.5	<0.5	<0.5	<50	<0.5	<2
TETRACHLOROETHYLENE	<1.6	<1.6	<1.6	20000	110	600
TOLUENE	<0.5	<0.5	<0.5	<50	<0.5	<2

NOTES:

1) TABLE LISTS DETECTED ANALYTES ONLY – SEE PROJECT ANALYTE LIST FOR SUMMARY
2) HARDNESS VALUES WERE REPORTED FOR SOME SAMPLES BUT RESULTS ARE NOT INCLUDED IN THIS TABLE
NA = NOT ANALYZED
☐ = GREATER THAN BACKGROUND CONCENTRATION
ug/L = MICROGRAMS PER LITER
*** = PHASE III SAMPLES ANALYZED FOR VOLATILE ORGANIC COMPOUNDS ONLY

TABLE 6-30
HUMAN HEALTH PRELIMINARY RISK EVALUATION FOR SURFACE SOIL STUDY AREA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	MAXIMUM DETECTED CONCENTRATION [b]	FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND ?	REGION III RESIDENTIAL SOIL CONCENTRATION (ug/g)	MCP METHOD 1 S-1/GW-1 SOIL STANDARD (ug/g)	MAXIMUM EXCEEDS SCREENING GUIDELINE
INORGANICS (ug/g)							
lead	34.4	20	6/6	NO	400 [c]	300	NO
ORGANICS (ug/g)							
xylene		0.50	1/11	NA	160,000	500	NO
tetrachloroethylene		3.40	5/11	NA	12	0.5	YES
TPHC		109	5/7	NA	380 [d]	500	NO

NOTES:

[a] Base-wide backgound soil inorganics database.

[b] Surface soil samples from sampling stations 50B-92-07X to 50B-92-10X, 50B93-11X, 50B-93-14X to 50B-93-16X, G6M-92-10X, G6M-92-11X, and G6M-93-12X.

[c] USEPA interim guidance for Superfund soil lead cleanup based on a residential exposure scenario.

[d] Calculated risk-based concentration for residential soil based on TPHC originating from gasoline.

NA = available.

Shading indicates exceedance of a screening guideline

TABLE 6-31
HUMAN HEALTH PRELIMINARY RISK EVALUATION FOR SUBSURFACE SOIL STUDY AREA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	MAXIMUM DETECTED CONCENTRATION [a]	FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND ?	REGION III INDUSTRIAL/ COMMERCIAL SOIL CONCENTRATION (ug/g)	MCP METHOD 1 S-1/GW-1 SOIL STANDARD (ug/g)	MAXIMUM EXCEEDS SCREENING GUIDELINE
INORGANICS (ug/g)							
lead	34.4	12	12/12	NO	400[c]	600	NO
ORGANICS (ug/g)							
tetrachloroethylene		2600	14/30	NA	110	0.5	YES
TPHC		162	11/21	NA	1680 [d]	2,500	NO
trichlorofluoromethane		0.02	4/30	NA	610,000	NA	NO
benzene		0.002	1/30	NA	200	10	NO

NOTES:

[a] Base-wide backgound soil inorganics database.

[b] Subsurface soil samples from sampling stations 50B-92-07X to 50B-92-10X, 50B-93-11X to 50B-93-14X, 50B-93-16X, G6M-92-10X, G6M-92-11X, G6M-93-12X, and 50B-94-17X (G6M-94-18X).

[c] USEPA interim guidance for Superfund soil lead cleanup based on a residential exposure scenario.

[d] Calculated risk-based concentration for industrial/commercial soil based on TPHC originating from gasoline.

NA = available.

Shading indicates exceedance of a screening guideline

TABLE 6-32
HUMAN HEALTH PRELIMINARY RISK EVALUATION FOR GROUNDWATER
SA 50 – MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT – GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	GROUNDWATER BACKGROUND CONCENTRATION	MAXIMUM DETECTED CONCENTRATION [a]	MAXIMUM EXCEEDS BACKGROUND	DRINKING WATER STANDARD/GUIDELINE [b] (ug/L)	MCP METHOD 1 GW-1 STANDARD (ug/l)	MAXIMUM EXCEEDS STANDARD/GUIDELINE ?
ORGANICS (ug/L)						
benzene		5		5	5	NO
tetrachloroethylene		20,000		5	5	YES
chloroform		7.1		5	5	YES
bis(2-ethylhexyl)phthalate		18		6	6	YES
toluene		10		1,000	1,000	NO
INORGANICS (ug/L)						
aluminum	6,870	2,340	NO	50 - 200	NA	YES
arsenic	10.5	2.98	NO	50	50	NO
barium	39.6	208	YES	2,000	2,000	NO
calcium	14,700	47,500	YES	NA	NA	NA
chromium	14.7	7.44	NO	100	50	NO
iron	9,100	2,600	NO	300	NA	YES
lead	4.25	24.0	YES	15	15	YES
magnesium	3,480	12,800	YES	NA	NA	NA
manganese	291	309	YES	50	NA	YES
potassium	2,370	13,000	YES	NA	NA	NA
sodium	10,800	1,200,000	YES	20,000	NA	YES
zinc	21.1	41.2	YES	5,000	2,000	NO
ANIONS/CATIONS (ug/L)						
nitrate/nitrite		1,400	NA	10,000	NA	NO

NOTES:

[a] Maximum from either SI, Supplemental SI, or Phase III SI. Only unfiltered samples used.

[b] Standard/Guideline selected in order of the following preference: MA drinking water standard, USEPA drinking water standard, Region III Tap Water Concentration.

[c] SA 50 is represented by the following monitoring wells: G6M-92-10X, G6M-92-11X, G6M-93-12X, G6M-93-13X, G6M-93-14X, G6M-94-18X, G6M-95-19X, and G6M-95-20X.

ND Not detected

NA Not available

Shading indicates exceedance of a screening guideline.

TABLE 6-33
ECOLOGICAL PRELIMINARY RISK EVALUATION FOR SURFACE SOIL
STUDY AREA 50 - MOORE ARMY AIRFIELD WORLD WAR II FUEL POINT

SITE INVESTIGATION REPORT - GROUPS 3, 5, AND 6
FORT DEVENS

ANALYTE	SOIL BACKGROUND CONCENTRATION [a]	DETECTED CONCENTRATION [b]		FREQUENCY OF DETECTION	MAXIMUM EXCEEDS BACKGROUND ?	ECOLOGICAL BENCHMARK (ug/g)	MAXIMUM EXCEEDS BENCHMARK ?
		AVERAGE	MAXIMUM				
ORGANICS (ug/g)							
PCE		0.69	3.4	5/11	NA	280	NO
Xylene		0.05	0.50	1/11	NA	2100	NO
INORGANICS (ug/g)							
lead	34.4	12.4	20	6/6	NO	34.4	NO

NOTES:

[a] Base-wide background soil inorganics database.

[b] Surface soil samples from from sampling stations 50B-92-07X through 50B-92-10X, 50B-93-11X, 50B-93-14X through 50B-93-16X, G6M-92-10X, G6M-92-11X, and G6M-93-12X.

NA = not available.

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ABB-ES	ABB Environmental Services, Inc.
ACEC	area of critical environmental concern
ADL	Arthur D. Little, Inc.
AEC	U.S. Army Environmental Center
AEHA	U.S. Army Environmental Hygiene Agency
AMCCOM	U.S. Army Armament, Munitions, and Chemical Command
ANL	Argonne National Laboratory
AOC	area of contamination
ARAR	applicable or relevant and appropriate requirement
AREE	area requiring environmental evaluation
ARF	analysis request form
AWQC	Ambient Water Quality Criteria (federal)
BTEX	benzene, toluene, ethylbenzene, and xylenes
BIS	bis(2-ethylhexyl)phthalate
4-BFB	4-bromofluorobenzene
bgs	below ground surface
BRAC	Defense Base Closure and Realignment Act of 1990
°C	degrees Celsius
CCC	Civilian Conservation Corps
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CH2CL2	methylene chloride
CLP	Contract Laboratory Program
cm	centimeter
CMR	Code of Massachusetts Regulations
CMTC	Civilian Military Training Corps
COC	chain of custody
COR	Contracting Officer's Representative
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CPC	chemical of potential concern
CRL	certified reporting limit
DOL	Directorate of Logistics
DNAPL	dense nonaqueous-phase liquid

DQO	data quality objective
ECS	Equipment Concentration Site
E&E	Ecology and Environment, Inc.
EMO	Environmental Management Office, Fort Devens
ER-L	Effects Range - Long
ER-M	Effects Range - Medium
ESE	Environmental Science and Engineering, Inc.
°F	degrees Fahrenheit
FESA	Federal Endangered Species Act
FORSCOM	U.S. Army Forces Command
FS	feasibility study
FSP	Field Sampling Plan
ft	foot or feet
GC	gas chromatograph
GC/FID	gas chromatograph/flame ionization detector
GC/MS	gas chromatograph/mass spectrometer
gpm	gallons per minute
GPR	ground-penetrating radar
HASP	Health and Safety Plan
HI	hazard index
HSA	hollow-stem auger
ID	inside diameter
IDW	investigation-derived waste
IRDMIS	Installation Restoration Data Management Information System
IRIS	USEPA Integrated Risk Information System
ISA	initial site assessment
LOEL	lowest observed effects level
MAAF	Moore Army Airfield
MADEP	Massachusetts Department of Environmental Protection

MADFW	Massachusetts Division of Fisheries and Wildlife
MCL	Maximum Contaminant Level (federal)
MCLG	Maximum Contaminant Level Goal (federal)
MCP	Massachusetts Contingency Plan (310 CMR 40.000)
MESA	Massachusetts Endangered Species Act
MEP	Master Environmental Plan
mg/kg	milligrams per kilogram
MGD	million gallons per day
MMCL	Massachusetts Maximum Contaminant Level
MNG	Massachusetts National Guard
MNHP	Massachusetts Natural Heritage Program
mph	miles per hour
MS/MSD	matrix spike/matrix spike duplicate
MTBE	methyl tertiary butyl ether
ND	not detected
NED	New England Division, U.S. Army Corps of Engineers
NFA	no further action
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanographic and Atmospheric Administration
NWR	National Wildlife Refuge
NYSDEC	New York State Department of Environmental Conservation
OD	outside diameter
ORSG	Office of Research and Standards Guidelines (Massachusetts)
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response (U.S. Environmental Protection Agency)
OVA	organic vapor analyzer
PAH	polycyclic aromatic hydrocarbon
PAL	project analyte list
PARCC	precision, accuracy, representativeness, completeness, and comparability
PC	personal computer
PCB	polychlorinated biphenyls
PCE	tetrachloroethylene

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

PCL	protective contaminant level
PCR	performance and cost reports
PID	photoionization detector
POP	Project Operations Plan
POTW	publicly owned treatment works
ppm	parts per million
PRC	Project Review Committee
PRE	preliminary risk evaluation
PRI	Potomac Research, Inc.
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAC	Quality Assurance Coordinator
QAPP	Quality Assurance Project Plan
QC	quality control
RAF	relative absorption factor
RAS	routine analytical services
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RI	remedial investigation
ROTC	Reserve Officer Training Corps
RPD	relative percent difference
RTS	Regional Training Service
SA	study area
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SAS	special analytical services
SCS	Soil Conservation Service
sec	second
SI	site investigation
SMCL	secondary maximum contaminant level (federal)
SOW	scope of work
SQC	sediment quality criteria
SSI	supplemental site investigation
SVE	soil vapor extraction

SVOC	semivolatile organic compound
SWMU	solid waste management unit
TBC	to be considered
TCA	1,1,1-trichloroethane
TCE	trichloroethylene
TCFM	trichlorofluoromethane
TCLP	Toxicity Characteristic Leachate Procedure
TDA	Table of Distribution and Allowances
TEF	toxic equivalency factor
TPHC	total petroleum hydrocarbons
TOC	total organic carbon
TRC	Technical Review Committee
TSS	total suspended solids
μg/g	micrograms per gram
μg/gC	micrograms per gram of organic carbon
μg/L	micrograms per liter
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UST	underground storage tank
VOC	volatile organic compound
WPA	Works Progress Administration
WWTP	wastewater treatment plant

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